An Roinn
Ealaíon, Oidhreachta agus Gaeltachta
Department of
Arts, Heritage and the Gaeltacht

Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters

January 2014

Table of Contents

1. Introduction

1.1 Background

There has been increasing concern internationally about the potentially harmful effect of man-made sound on the marine environment and species therein that could be sensitive to it. Sound that is derived from human activities (i.e., anthropogenic sound) is not the sole noise source above or below the sea surface. Nevertheless, the level of man-made sound in coastal and marine environments is commonly reported to be increasing, a trend that is partly attributed to a growth in commercial shipping activity[1].

Whether it is intended or not, the introduction of man-made sound into the environments occupied by marine mammals (e.g., whales, dolphins, seals) carries with it a potential adverse impact[2]. The properties of water allow sounds of various kinds to travel great distances[3] across diverse habitats and depth strata.

Marine mammals, having evolved from terrestrial predecessors, have adapted to life in the sea by being able to exploit sound properties in water very effectively for their own primary sensory use[4]. For example, they depend on and utilise sound for a wide range of critical natural functions including navigation and perception of their environment, communication, prey identification and capture, and the detection of predators.

The hearing system of marine mammals, being highly sensitive and adapted to respond to changes in pressure in an aquatic environment, is particularly susceptible to damage[3]. The possibility of permanent or even lethal injury in marine mammals as a result of man-made sound has received considerable attention in the scientific and public spheres, due to a number of beaked whale stranding events apparently associated with military use of mid-frequency sonar in the area[1,5,6,7,8]. Yet many more routine anthropogenic sounds in the sea, for example seismic surveys[9], pile driving or chemical explosions[3,10], can also cause significant disruption of normal behaviour by marine mammal species.

At least 26 species of marine mammal are known to occur in Irish waters. Two seal species, the Grey seal (*Halichoerus grypus*) and Harbour seal (*Phoca vitulina*, also known as Common seal) breed around all shorelines of Ireland and use the coastal and offshore waters in their daily lives for foraging, transit between terrestrial resting places (known as *haul-out sites*), and other behaviours linked to their annual life cycles (e.g., social behaviour, territoriality).

Twenty-four species of cetacean (i.e., whales, dolphins and porpoises) have been recorded from Ireland[11], 18 of which are more commonly observed, while the remaining six species have rarely been recorded and are currently classed as *vagrant* (i.e., species well outside their normal natural range). Some species can occur close to shore, and may be found within enclosed bays, harbours and estuaries, such as Dingle Harbour or the Shannon Estuary. Others (e.g., Blue whale, Sperm whale, Humpback whale) may be highly migratory and show a preference for deeper water offshore habitats, or travel hundreds or thousands of kilometres between winter breeding and summer foraging locations, occupying Irish waters during part of their annual cycle.

Marine mammals occurring in Ireland have been the focus of considerable research effort over the last three decades and the understanding of species occurrence, abundance and distribution has improved markedly. While detailed knowledge of breeding, foraging, movements and other aspects of the natural history of many Irish species remain to be described, some useful sources summarising the current knowledge and distribution of Irish populations include:

<u>Cetaceans</u>

NPWS (2008): *The status of EU Protected Habitats and Species in Ireland*
Pollock *et al.* (1997): *Distribution of seabirds and cetaceans in the waters around Ireland*
Reid *et al.* (2003): *Atlas of cetacean distribution in north-west European waters*
Ó Cadhla *et al.* (2004): *Cetaceans & seabirds of Ireland's Atlantic Margin - Volume II*

O'Brien *et al.* (2009): *Cetaceans in Irish waters: a review of recent research*
DEHLG (2009): *Conservation Plan for Cetaceans in Irish Waters*
Berrow *et al.* (2010): *Irish Cetacean Review (2000-2009)*
Wall *et al.* (2013): *Atlas of the distribution &relative abundance of marine mammals in Irish offshore waters*

Seals

NPWS (2008): *The status of EU Protected Habitats and Species in Ireland*
Cronin *et al.* (2004): *Harbour seal population assessment in the Republic of Ireland - August 2003*
Ó Cadhla *et al.* (2008): *An assessment of the breeding population of grey seals in the Republic of Ireland*
Ó Cadhla & Strong (2007): *Grey seal moult population survey in the Republic of Ireland*

Due to concerns regarding the potential detrimental effect on these animals from certain types of acoustic survey equipment, the Department of the Environment, Heritage and Local Government, through review and consultation with key stakeholders, developed a "Code of Practice for the Protection of Marine Mammals during Acoustic Seafloor Surveys in Irish Waters" in August 2007.

The following guidance sets out to address several key potential sources of anthropogenic sound that may impact detrimentally upon marine mammals in Irish waters. It incorporates a re-examination of the Code of Practice for acoustic surveys and thereby provides replacement guidance and mitigation measures in this respect. The document will be subject to periodic review to allow its efficacy to be reassessed, to consider new scientific findings and incorporate further developments in best practice.

1.2 Legislation and regulation

Legal protection for marine mammals in Ireland began with the enactment of the Whale Fisheries Act in 1937, which gave effect in this jurisdiction to the International Convention for the Regulation of Whaling (1931). Thereafter the Wildlife Act, 1976 provided a legal framework for the conservation of Irish wildlife and their habitats, conferring specific protection on seals, whales, dolphins and porpoises. Under the 1976 Wildlife Act and its subsequent Amendments (2000, 2005, 2010 and 2012), it is an offence to hunt[*] (except in some instances under licence or Ministerial permit), injure (except when hunting under such licence) or wilfully interfere with, disturb or destroy the resting or breeding place of a protected species. With regard to the marine environment, the Wildlife Acts 1976 to 2012 currently extend in scope to waters within Ireland's Territorial Sea (i.e., within the 12 nautical mile limit from the baselines).

The EC Directive on the conservation of natural habitats and of wild flora and fauna (i.e., the Habitats Directive, Council Directive 92/43/EEC) is transposed into national law by the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477 of 2011). These consolidate the earlier European Communities (Natural Habitats) Regulations 1997 to 2005 and the European Communities (Birds and Natural Habitats)(Control of Recreational Activities) Regulations 2010. Under the Directive all marine mammal species normally occurring in Ireland must be given protection. The two species of seal breeding in Ireland (Grey seal; Harbour seal) and two cetacean species (Harbour porpoise *Phocoena phocoena* and Bottlenose dolphin *Tursiops truncatus*) were listed in Annex II of the Directive as species whose conservation requires the designation of Special Areas of Conservation. The *Cetacea* (all species of whales, dolphins & porpoises) were listed under Annex IV as species requiring strict protection.

The Habitats Directive applies within Ireland's 200 nautical mile limit for the protection of species (i.e., within the Exclusive Fishery Zone, also termed the Exclusive Economic Zone or EEZ) and to the Continental Shelf for habitats. It requires various conservation measures to be undertaken to protect Special Areas of Conservation (SACs), among them to avoid "the deterioration of natural habitats and the habitats of species as well as disturbance of the species for which the areas have been designated".

[*] The word "hunt" was formally defined in the Wildlife Act, 1976 and its meanings include "stalk, pursue, chase, drive, capture, attract, follow, take and trap".

Under Article 6(3) of the Habitats Directive and the corresponding Birds and Natural Habitats Regulations 2011 (i.e., S.I. 477 of 2011), plan- or project-related activities within designated conservation sites must be assessed with regard to their implications for the site and its conservation objectives. The legal obligation under Article 6(3) also extends to *ex situ* activities. In other words, Licensing Authorities are legally obliged to ensure activities outside a SAC, either alone or in combination with other activities, are unlikely to adversely affect the integrity of the site concerned.

Guidance on this assessment process can be found within the document *"Assessment of plans and projects significantly affecting Natura 2000 sites: Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC*" published by the European Commission (2001). In 2009 the Department of the Environment, Heritage & Local Government published additional guidance *"Appropriate Assessment of Plans and Projects in Ireland: Guidance for Planning Authorities*.

Article 12 of the Habitats Directive further requires that Member States take the requisite measures to establish a system of strict protection for Annex IV listed species, including all cetaceans, in their natural range, prohibiting

(i) all forms of deliberate capture or killing of specimens of these species in the wild;

(ii) deliberate disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration;

(iii) deliberate destruction or taking of eggs from the wild;

(iv) deterioration or destruction of breeding sites or resting places.

In this context the term 'deliberate' has been interpreted by the European Commission, in its 2007 *"Guidance document on the strict protection of animal species of community interest under the Habitats Directive 92/43/EEC"*, to not only incorporate the intention to commit an offensive action but also, separately, the conscious acceptance of the foreseeable results of such an action.

Article 12 applies to all life stages of the listed species. It also requires that Member States establish a system to monitor the incidental capture and killing of these animals, taking further research or conservation measures as required to ensure that incidental capture and killing does not have a significant negative impact on the species concerned (i.e., affecting the maintenance or restoration of their favourable conservation status [FCS]).

An exception from complying with the legislative requirements under Article 12 and the 2011 Regulations may be permitted via a specific derogation licence granted by the Minister in certain cases:

(a) in the interests of protecting wild fauna and flora and conserving natural habitats;

(b) to prevent serious damage, in particular to crops, livestock, forests, fisheries and water and other types of property;

(c) in the interests of public health and public safety, or for other imperative reasons of overriding public interest, including those of a social or economic nature and beneficial consequences of primary importance for the environment;

(d) for the purpose of research and education, of repopulating and reintroducing these species and for the breeding operations necessary for these purposes, including the artificial propagation of plants, or

(e) to allow, under strictly supervised conditions, on a selective basis and to a limited extent, the taking or keeping of certain specimens of the species to the extent specified therein.

However (1) it must be demonstrated that there is no satisfactory alternative and the derogation is not detrimental to the maintenance of the populations of the species to which the Habitats Directive relates at a favourable conservation status in their natural range, and (2) a derogation licence will be subject to such conditions, restrictions, limitations or requirements as the Minister considers appropriate.

With regard to additional regulations in Ireland, in June 2008 the European Union published its Marine Strategy Framework Directive (2008/56/EC – *establishing a framework for community action in the field of marine environmental policy*) which aims to improve the condition of all European seas and ensure that human use of and activity within these seas is sustainable. This Directive which is given effect in Ireland by the European Communities (Marine Strategy Framework) Regulations 2011 (i.e., S.I. 249 of 2011) requires Member States to take necessary measures to achieve or maintain good environmental status (GES) in the marine environment by the year 2020 at the latest. A series of objectives for the eleven descriptors of good environmental status will be required to be set by Member States.

1.3 Aims and legal context of this guidance

The aims of this guidance are

(i) to give an understanding of selected sound sources introduced into the environment by specific human activities, which may impact detrimentally on protected marine mammal populations or individuals of those species,

(ii) to describe a structured, staged process for the informed assessment of risk and decision-making with regard to such sources, and

(iii) to outline practical risk avoidance and/or risk reduction measures which in the Department's view must be considered in order to minimise the potential effects of sound sources on the natural ecology of marine mammal species whether in Ireland's extensive and diverse coastal/marine waters or in designated conservation sites therein.

This document deals only with the potential or described direct effects on marine mammals (e.g., physical harm, detrimental changes to or interference with natural behaviour) of man-made sound arising from licensable plans or projects. Other underwater sounds arising from human maritime activity (e.g., from shipping, leisure craft, aircraft, fish-finders, depth-sounders) are beyond the scope of this document. Secondary or indirect effects on marine mammals (e.g., changes in prey distribution) might also occur as a result of the introduction of a sound source into the marine environment. These must also be considered in the process of risk assessment, where appropriate.

In all cases, in order to reduce the unnecessary introduction of artificial sound signals and associated energy into the marine environment every effort should be made by marine users and operators to (a) minimise the duration and power/energy output of their sound-producing activity, and (b) seek greater technical efficiencies for the removal of unnecessary or unwanted signals/frequencies and for the benefit of the aquatic acoustic environment.

With regard to the legal context of this document, the information, measures and actions described herein are issued by the Minister for Arts, Heritage and the Gaeltacht as official guidelines and codes of practice under Regulation 71 of the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477 of 2011).

2. Sound and Marine Mammals

2.1 Background

The issue of anthropogenic sound in marine mammal environments has received increasing attention in the international scientific and public spheres, particularly in the last two decades. Interest and concern about the effects of anthropogenic sound have led to new research being performed and several reviews[1,3,10,22,23,24] have examined in detail the various known effects of and responses to different sound sources shown by marine mammals, both in laboratory situations and in the wild. Studies have included the examination of marine mammal audition (i.e., hearing[4,25]) and it is widely acknowledged that considerable further work is required to better understand (a) anthropogenic sound occurrence and propagation in the marine environment, (b) the mechanisms of hearing, processing and response to various sound sources in all species, and (c) the mechanisms of effect on this diverse group of animals and their populations.

In its 2006 report[26], the UK Inter-Agency Committee on Marine Science and Technology listed some of the possible effects of underwater sound on marine life. A summary is transcribed below:

Physical (Non-auditory)	Damage to body tissue (e.g., tissue rupture, internal haemorrhage) Induction of gas embolism or decompression sickness
Physical (Auditory)	Gross damage to ears Permanent threshold shift (PTS) in hearing Temporary threshold shift (TTS) in hearing
Perceptual	Masking of communication with conspecifics Masking of other biologically important sounds Interference with the ability to acoustically interpret the environment Adaptive shifting of vocalisations (with efficiency and energetic effects)
Behavioural	Gross interruption of normal behaviour (i.e., temporarily changed) Behaviour modified (i.e., behaviour becomes less effective/efficient) Displacement from an area (short or long-term) Disruption of social bonds, including mother-young associations
Chronic/Stress	Decreased viability of an individual Increased vulnerability to disease Increased potential for impacts from negative cumulative effects Sensitisation to sound (or other stresses) – exacerbating other effects Habituation to sound – causing animals to remain within damage range
Indirect Effects	Reduced availability of prey Increased vulnerability to predation or other hazards (e.g., stranding) Behavioural changes leading to physical damage (e.g., ship collision) Behavioural changes leading to physiological effects (e.g., “the bends”)

While there is growing evidence that some anthropogenic sounds have played a role in the stranding of deep-diving beaked whales[2,8,27], well-described 'cause-and-effect' cases linking specific man-made sound sources and lethal effects on marine mammals are uncommon. The work of Richardson *et al.*[3] published in 1995, and extensive reviews of sound events and their effect on marine mammals[10,23] outline the range of evidence for lethal and non-lethal effects of anthropogenic sound including death, permanent injury, temporary injury, physiological and behavioural responses to introduced sound (e.g., stress, reduced vocalisation rates, avoidance).

2.2 Factors involved in the determination of impact

To determine the impact of any man-made sound on protected species or habitats it is important to understand (1) the physical characteristics of the sound produced, (2) the physical and chemical properties of the receiving environment whether it is water or air, and (3) the biological characteristics and components of that environment, including species and their responses to anthropogenic sound events. Many physical elements can play a role in determining the effect a specific sound source has on a receiving marine organism. These include:

(i) Frequency - measured in *hertz* (Hz) or *kilohertz* (kHz). 1 kHz=1,000 Hz.

(ii) Bandwidth – the range of operational frequencies of a source's sound wave (Hz or kHz).

(iii) Duration – the length of a sound signal measured in seconds (s) or milliseconds (ms).

(iv) Duty cycle – the proportion of time that the source is in an active state (measured in %).

(v) Directionality – vertical / horizontal / omnidirectional.

(vi) Sound Pressure Level (SPL) – A logarithmic measure in decibels (dB) of the average pressure level in water/air, with respect to a standard reference pressure (i.e., re. 1μPa in water or 20μPa in air). Commonly standardised to a distance of 1 metre from the source (i.e., @ 1m), SPL represents the amplitude of a sound's waveform and it may be measured in a number of ways including *peak* or *peak-to-peak* (for short duration sounds) and *root mean square (i.e., rms)* estimates (for continuous sounds).

(vii) Sound Exposure Level (SEL) – A measure of sound energy over a given duration, i.e., time integral of instantaneous sound pressure squared, normalised to a 1 second period (dB re. μPa^2-s or $\mu Pa^2 \cdot s$).

(viii) Sound Received Level (RL) – the pressure level measured at the receiver, e.g., mammal.

(ix) Energy output – measured in Watts (W), equivalent to 1 Joule of energy per second.

(x) Rise time – time taken for a source's signal to reach a prescribed high point from a lower baseline (e.g., from 10-90% of its highest peak value).

(xi) Persistence – with respect to temporal and geographic scales.

(xii) Ambient sound - i.e., background sound levels from all sources including natural sources.

(xiii) Water depth and stratification - e.g., presence/absence of a thermocline.

(xiv) Seabed characteristics – e.g., topography, substrate type, slope.

Underwater sound, and the use of appropriate metrics for its description, have not yet been subject to explicit standardisation as is the case with aerial signals[3,23]. Two fundamental discrete sound types are described however, based on at-source empirical definition and mathematical procedure: (1) *pulse* (or *impulsive*) and (2) *non-pulse* (*non-impulsive*) sounds[23]; these may have differing potential to cause physical effects on receiving animals, especially on hearing. In practice, the difference between pulse and non-pulse sounds is not always clear-cut, depending on factors such as (a) the source type, (b) the sound's propagation characteristics in the environment into which it is introduced and (c) distance to the receiver. Some signals have characteristics of both pulse and non-pulse sounds, while both sound types may also coincide with one another (e.g., motorised vessel travelling with towed airguns firing serially). Other signals may be distinct pulse sounds at source but with distance from the source may take on characteristics of continuous non-pulse sound. Therefore a prudent approach is to rely on classifying the sound type based on its acoustic characteristics at source.

The number of discrete sound introduction events (i.e., single or multiple), and the accumulation of such events, are also likely to be important factors in the degree of exposure and response shown by an organism. While multiple events may increase the chance of an animal's habituation to certain anthropogenic sounds, the persistence and increased probability of detection of a sound source may also bring about a greater negative response, resulting in more significant biological consequences.

The table below briefly summarises pulse and non-pulse sounds, giving some features and examples of anthropogenic sources of each type (*after* Southall *et al.*[23]):

Sound Type	Acoustic characteristics (at source)	Examples
Single pulse	Single sound event Rapid rise time to maximum pressure followed by decay that may include oscillating maximum-minimum pressures	Single explosion; sonic boom; single airgun, watergun, pile strike or sparker pulse; single ping of certain sonars, depth sounders and pingers
Multiple pulse	Multiple discrete pulse sound events within 24 hrs Rapid rise time to maximum pressure in each pulse followed by decay that may include oscillating maximum-minimum pressures	Serial explosions; sequential airgun, watergun, pile strikes or sparker pulses; certain active sonars; some depth sounder signals
Non-pulses	Single or multiple discrete sound events within 24 hrs Intermittent or continuous sound event, tonal and/or broadband, but without rapid rise time of pulse type	Vessel or aircraft passes; drilling, many construction or other industrial operations; certain sonar systems (LFA[†], tactical mid-frequency); acoustic harassment/deterrent devices; acoustic tomography sources (e.g., ATOC[‡]); some depth sounder signals

Knowledge of the range, features and propagation of anthropogenic sound sources in the environment of marine mammals is expanding[10]. A table listing some examples of such sources in the marine environment is set out in Appendix 1. Although such information is available in the literature and can provide initial general guidance towards evaluating the potential impact of a certain source (e.g., the acoustic energy output of a drilling operation), the situations and biological contexts in which man-made sound-producing equipment are used can be quite variable. Therefore, in addressing issues of impact management and mitigation, it is necessary to consider each introduced sound via an activity-specific, case-by-case approach.

2.3 Marine mammal hearing

Marine mammal sensory systems are adapted to life in the water or, in the case of seals, both in water and on land. The sound receiving systems of marine mammals have become specialised to meet the physical demands of water and to diving to considerable depth[4], while retaining many of the characteristics of land mammals (e.g., ear canal, air-filled middle ear, spiral cochlea of the inner ear[25]). Marine mammals rely on sound to navigate, to communicate with one another and to sense and interpret their surroundings. The ability of an individual marine mammal to hear a certain sound in the ocean is a complex task involving at least six abilities and processes: (1) Absolute hearing threshold; (2) Individual variation in sensitivity; (3) Individual motivation; (4) Ability to overcome the masking (i.e., obscuring/interference) effect of background sound; (5) Sound source localisation; (6) Frequency and intensity discrimination[3]. Thereafter behavioural responses to a sound, once detected, are known to be

[†] LFA Low Frequency Active sonar - used for military and research purposes.

[‡] ATOC Acoustic Thermometry of Ocean Climate - an experimental use of sound to measure temperature in ocean basins.

strongly influenced by the context of the event and individual factors such as the animal's experience, motivation, conditioning and activity[10,23,28].

Aquatic auditory tests of hearing response in relation to frequency, in individuals of several marine mammal groups to date (i.e., seals, fur seals, sea lions, toothed whales, dolphins and porpoises), generally describe a 'U-shaped' response curve (Fig. 1) with a relatively broad frequency range of best hearing sensitivity (i.e., lowest hearing threshold) and frequencies above and below this range where apparent sensitivity is relatively poor.

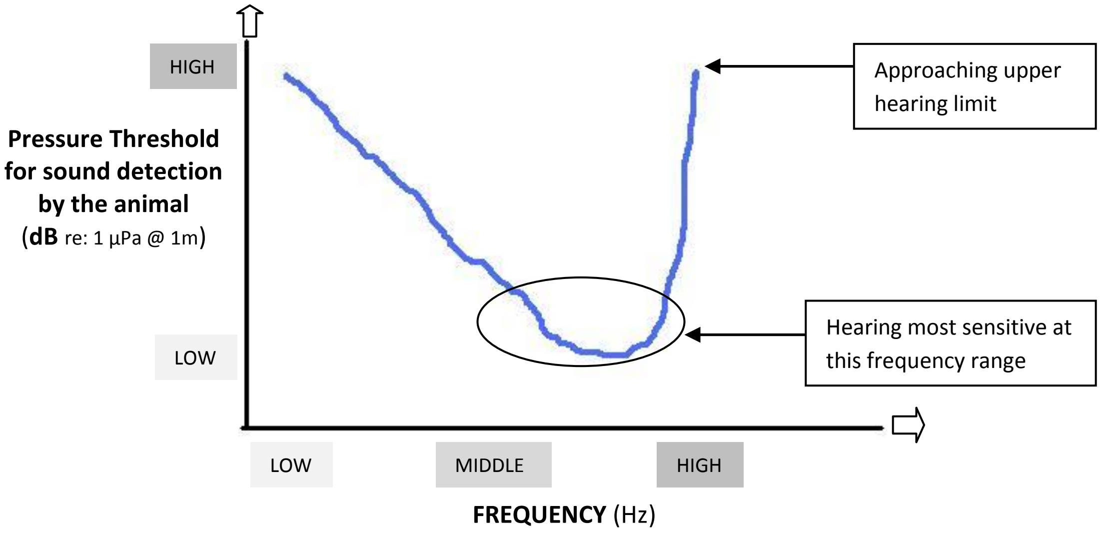


Figure 1. Simplified schematic example of a marine mammal audiogram, showing upper and lower thresholds for sound detection in water and a broad frequency range which the animal can detect at lower sound pressure levels.

Identical sounds may be experienced in very different ways by individual marine mammals of different species. In addition, as in humans and other mammals, variation in hearing ability between individual animals is common. Thus healthy newborn and younger animals may have the greatest hearing sensitivity while individual hearing ability declines progressively with age and prior exposure to harmful sound levels, disease, etc. Such features and variability may also require consideration in the case-specific assessment of impact on marine mammals from introduced sound sources.

In comparison with the knowledge of hearing in terrestrial animals, information on that of marine mammals is comparatively limited. Cetaceans and seals have recently been categorised into five functional groups based on audiometric data, comparative anatomy and the results of laboratory studies[23]. As knowledge of the hearing sense in individual species improves and moves from the laboratory to field measurement in the open sea, the functional means by which marine mammals are classified may be refined further. Cetacean species may currently be distinguished by three groupings related to their known auditory ability and functional frequencies. Seals and other Pinnipeds demonstrate differing auditory ability in air and in water[3,4,25], so from a functional point of view they may be subdivided into two groups: (i) pinnipeds in water, and (ii) pinnipeds in air:

Cetaceans			Pinnipeds	Pinnipeds
Low frequency 7 Hz-22 kHz	*Mid-frequency* 150 Hz-160 kHz	*High frequency* 200 Hz-180 kHz	*in water* 75 Hz-75 kHz	*in air* 75 Hz-30 kHz
Baleen whales	Most toothed whales, dolphins	Certain toothed whales, porpoises	All species	All species
Species- Ireland Humpback whale Blue whale Fin whale Sei whale Minke whale	*Species- Ireland* Sperm whale Killer whale Long-finned pilot whale Beaked whale species Dolphin species	*Species- Ireland* Pygmy sperm whale Harbour porpoise	*Species- Ireland* Grey seal Harbour seal	*Species- Ireland* Grey seal Harbour seal

Because of variation in hearing ability across its full frequency range, with apparent sensitivity reduced at the extremes of that range (Fig. 1), an animal's functional hearing of a known sound source may be "frequency-weighted" to model its differential response to that source. In humans, this takes the form of A-weighting or C-weighting which consider both the frequency bandwidth and loudness perception of the receiver's auditory system. Frequency-weighting functions for marine mammals ("M-weighting") were developed by Southall and colleagues[23] in order to address issues of acoustic impact, particularly for high amplitude (i.e., high SPL) sound events and potential auditory damage. Using their procedure, the level of risk to a marine mammal from a particular anthropogenic sound may be better evaluated by relating the characteristics of a sound source to the animals' hearing ability at the operating signal frequency (or frequencies). However further research will continue to inform and clarify as to the appropriateness of such M-weighting functions for different species within each functional group.

2.4 Levels of exposure

Due to the concern regarding levels of anthropogenic sound associated with human activities in the marine environment, there is a growing body of literature and metrics describing the sound pressure level (SPL), sound exposure level (SEL) and other acoustic characteristics associated with specific machinery, vessels and operations. These important data help to provide an indication of the potential impact of anthropogenic sound on marine biota and to promote technologies that can reduce this form of environmental degradation. In general terms, "high energy" sources that transmit sound with a comparatively high SEL, high SPL and a low frequency penetrate considerably further into the marine environment than sources transmitting at comparatively low SELs, low pressure or high frequencies.

However, the mechanisms by which a particular sound event causes a significant effect remain to be fully explained, whether it is a low or high frequency signal and whether a *pulse* or *non-pulse* type of sound. Only a very small proportion of the 128 marine mammal species and subspecies listed globally[29] have undergone empirical research into their hearing, much of it in captive situations, while vocalisation characteristics and capabilities of many species remain to be fully described. Since precise measures of the underwater sound energy received by animals in the wild are less available, the exact impact or response is more difficult to determine or predict.

Theoretically if an animal is in very close proximity to a high energy sound source, the received energy may be of a sufficient level to cause death or serious injury (e.g., Appendix 2). With increasing distance from the sound source, where it is audible by the animal, the effect is expected to diminish through identifiable stages (e.g., Permanent Threshold Shift [PTS] or Temporary Threshold Shift [TTS] in hearing, avoidance, masking, reduced vocalisation) to a point at which no significant response occurs. It should be remembered that this is a somewhat simplistic model, that factors such as local propagation and individual hearing ability can influence the actual effect elicited and that hypothetical zones of impact may merge with or overlap one another.

In comparison to tests and trials dealing with hearing impairment in marine mammals before, during and after exposure to sound events, documented cases of non-auditory tissue damage (e.g., via trauma or bubble formation and bubble growth in body tissues)[2,30,31] or induced mortality due to man-made sounds (e.g., via concussion, drowning, stranding) are currently scarce or lacking in conclusive detail. Yet their potential occurrence should also be considered in the management of certain anthropogenic sound events (e.g., underwater explosive blasting[30]).

Measuring and understanding the effects of an anthropogenic sound source on marine mammals are complex tasks and gaps in scientific information, for a range of species and scenarios, will continue to take time to be addressed. Under these circumstances an element of caution by way of risk management[32] is required to ensure that adequate protection may be given to animals at risk from a specific sound-producing activity. The implementation of such a management approach consists of three key elements: (i) risk assessment, (ii) risk management, and (iii) risk communication.

Determining thresholds

Finding the correct balance whereby effective management action can be taken, requires a structured decision-making process based on scientific and other objective information. Some measurable criteria, describing the biological response to a known introduced sound source, can assist in determining its potential or likely effect in the open sea. The measurement of sound-induced temporary threshold shift or TTS (i.e., a temporary loss of hearing due to auditory tissue impairment) and estimation of sound exposure levels likely to cause permanent threshold shift or PTS (i.e., permanent auditory injury and loss of hearing) deliver methods for evaluating introduced sound against primary biological responses in marine mammal species. In humans and other mammals, TTS occurs where a subject has been exposed to high energy sounds for a short duration or lower energy sounds for a longer duration. In marine mammals for example, TTS has been described in pinnipeds exposed to comparatively lower SPL sounds for periods of up to fifty minutes[33] and in Bottlenose dolphins exposed to a single high SPL pulse of 1-second duration[34].

Southall *et al.*[23] estimated and proposed levels of peak sound pressure (SPL) and sound exposure (SEL) from discrete sound events (single or multiple, within a 24-hr period) that would be expected to elicit TTS and/or PTS in a receiving marine mammal. Measures were given as initial criteria for (i) auditory injury or (ii) significant behavioural disturbance of marine mammal species exposed to sonic events (see Appendix 3). The estimates carry a detailed series of technical considerations, based on data available from laboratory and free-ranging situations, known auditory responses of species within the various functional hearing groups for which data are available, and an underlying level of precaution set out by the authors. No marine mammal data were available regarding the effects of inter-event time interval on recovery from auditory effects induced by anthropogenic sound, so criteria for permanent injury from single and multiple events were determined to be the same (i.e., the lower threshold for the onset of PTS was selected), until data become available.

It should be remembered that these estimates have been developed in a discipline with limited data (across a diverse range of species and habitats) and requiring substantial continued scientific work, laboratory and field experimentation. Indeed recent research has demonstrated that SPL and SEL levels required to produce TTS in Bottlenose dolphin[35] and Harbour porpoise[36] respectively, may be lower than those proposed by Southall and colleagues[23] (Appendix 3) and the duration of sound exposure may play a critical role in this respect[35]. Therefore care should be taken in interpreting and applying such criteria, particularly with respect to TTS-onset and behavioural responses to different sound types, which may be highly context- and species-specific. The criteria described for significant behavioural disturbance may not be a good descriptor for all species if based on sound levels causing TTS-onset alone. Accordingly, although explicit behavioural disturbance criteria are given for single pulse events, the potentially significant measures summarised by Southall *et al.*[23] are listed in Appendix 3.

Summary

Under current legislation in Ireland, it is an offence to disturb or injure a marine mammal (see section 1.2) whether this occurs via introduced sound or another anthropogenic source. The induction of temporary or permanent tissue damage and a Temporary Threshold Shift in hearing sensitivity, which can have negative effects on the ability to use natural sounds (e.g., to communicate, navigate, locate prey) for a period of minutes, hours or days[3] may constitute such an injury. It is therefore considered that anthropogenic sound sources with the potential to induce TTS in a receiving marine mammal contain the potential for both (a) disturbance, and (b) injury to the animal.

Given these concerns, this document sets out a generalised framework below for the consideration of risk from particular sound-producing activities in the waters of Ireland's Exclusive Economic Zone (EEZ) and offers guidance for planning and risk management, where necessary. While the current scientific literature provides some guidance for management and conservation purposes, ongoing flexibility will be necessary in (a) the evaluation of specific cases of anthropogenic sound introduction into the marine environment and (b) the continued development of guidance measures to mitigate the potential impacts of such events.

3. Risk Characterisation

3.1 Introduction

The evaluation of risk to protected marine mammal species arising from anthropogenic sound depends on three basic elements, namely the (1) Source, (2) Species and (3) Environment.

The introduction of anthropogenic sound into Ireland's coastal and marine environment occurs in an extensive, dynamic and biologically diverse system. Irish waters contain an array of potential habitats for marine mammals, including comparatively shallow coastal (<50 m deep) and continental shelf waters (<200 m deep), those overlying the continental slope (200-2500 m), deep ocean basins off the western seaboard (c. 2,500-4000 m depth), gullies and canyons along the continental slope, and shallow offshore banks (<200 m depth). Within such habitats, key areas for life history activities such as breeding, foraging and seasonal migration may occur. For seals there is also a considerable terrestrial and intertidal area of conservation concern, which includes specific uninhabited islands, rocky skerries or outcrops, sandbanks and caves that are used by these semi-aquatic mammals for breeding, moulting, resting and social activity, for example.

It is possible from the intensive survey effort conducted in Ireland in the last 10-15 years to identify the likely habitat of individual cetacean and seal species within Irish waters. Generalised range and distribution maps showing the main areas of occurrence for each marine mammal species are given in Appendix 4. For some rarely-encountered or vagrant cetacean species it is not yet possible to determine the likely habitat and a more general conclusion must be drawn that Irish waters represent a potential or occasional habitat for such species.

Within the known, likely or potential environment occupied by a marine mammal species the operation of certain sound sources, whether deliberate or involuntary, may introduce the risk of adverse effects on individuals, groups or populations of that species. The task of establishing whether a plan or project (i.e., the sound source) is likely to have an effect on a species in a particular area is based on a preliminary consideration of the likely impact of the proposed plan or project. This is followed by the determination of whether there is a risk that the effects identified could be significant.

While general conclusions may be made in relation to some sound sources, species and operating environments, a case-by-case approach with respect to introduced man-made sound is particularly important in relation to designated sites for Annex II marine mammals (i.e., SACs for Harbour Porpoise, Bottlenose dolphin, Harbour seal, Grey seal). It is also important to consider particular parts of the year or life cycle when the activities and/or use of sound by various species themselves may be most critical (e.g., breeding season, nursing of young, territoriality).

3.2 Risk identification

Ireland's coastal and marine environment is one in which a range of human activities (e.g., transport, fishing, recreation, development) proceed on a daily basis. Development and maritime operations are an essential component of public and private socio-economic activity in the coastal zone and further offshore. However, situations can arise (e.g., disturbance, environmental degradation, pollution, etc) that may lead to adverse impacts on the marine ecology of an area and on marine mammals as protected species within these environments. With knowledge of the anthropogenic sound source and of animal life cycles and distribution, it is possible to develop general guidance to inform the authorisation, planning and/or operation of certain human activities regularly occurring in the marine environment.

Factors to be considered in the identification of risk

Information is widely available on underwater sounds produced by the most common anthropogenic sources. Appendix 1 provides some reference information for a variety of sound-producing human activities in the marine environment. Nevertheless for a proper evaluation of impact and risk to inform the decision-making process it is important that the following are fully considered:

(1) Information related to the specific sound source (e.g., pulse/non-pulse, peak frequency, bandwidth or ancillary signal frequencies, peak or peak-to-peak sound pressure level, signal duration, sound exposure level, likely propagation and attenuation within the operational environment);

(2) The likely effect of the produced sound on a marine mammal exposed to that sound source;

(3) Consideration must also be given to the combined or cumulative impacts of multiple coincident sound sources, e.g., other activities in the area.

With the exception of certain military sonars, higher energy pulse sounds such as that produced by an underwater explosion, a seismic air-gun array or impact pile driving operation tend to present the greatest concern in the protection of marine mammals from underwater noise. Explosions of underwater blasting and the hammering or impacting action of some pile driving operations (e.g., wind turbine monopiles) can introduce single or multiple sound pulses with rapid rise times and at sound pressure levels (SPLs) exceeding 220-250 dB re: 1 µPa (Appendix 1). In the case of some pile driving operations, a persistent high degree of sound energy may be introduced into the environment in the form of many hundreds or thousands of pile strikes. This presents the possibility of tissue damage, permanent hearing loss or even lethal injury in a receiving marine mammal due to the activity. Such activities can also introduce sound exposure levels (SELs) high enough to cause behavioural responses several or tens of kilometres from the source[37,38,39]. For some deep-diving marine mammals (e.g., beaked whales) extra caution may be necessary in evaluating the level of risk from a sound-producing activity, since anthropogenic disturbance of normal diving activity could in theory cause abnormal surfacing behaviour or induce the onset of decompression sickness[6,7].

Other static seabed-related activities such as dredging, drilling or small-scale coastal pile driving (e.g., for the fixing of floating pontoons or temporary structures), while generally of less concern, may nevertheless produce underwater sound at sound pressure levels up to 190 dB re: 1 µPa (Appendix 1) and at frequencies overlapping marine mammal hearing, thereby increasing the potential for auditory masking, avoidance and other disturbance effects.

The further inland from the coast a sound-producing activity occurs, whether in water or in air, the less likely it is to expose marine mammals to anthropogenic sound at a level sufficient to cause behavioural disturbance or physical harm. Bottlenose dolphins, Grey seals and Harbour seals are known to occur in estuarine environments in Ireland (e.g., Shannon Estuary, River Moy estuary[19,20,21]) while Harbour porpoises also commonly occur in continental shelf waters, larger bays and shallow coastal habitats[17], even where waters may be less than 20m deep[40]. Some marine mammal species (e.g., Harbour porpoise, Atlantic white-sided dolphin, Minke whale[41]; Harbour seal[42,43]) are also known to avoid vessels. Thus one or more operational activities in an important habitat (e.g., industrial vessel traffic + static rock-breaking and dredging) might result in temporary displacement of some species from that area, thereby introducing a level of risk from the activity as a whole.

In all cases, it cannot be assumed that individual marine mammals exposed to comparatively high levels of man-made sound possess the ability to protect themselves from the detrimental effects of such sources, either by avoidance or other means. Indeed their reason for occurring in a chosen habitat (e.g., for breeding or foraging) may preclude them from doing so. Therefore it is necessary to identify activities which have the potential to cause such effects giving due consideration to potential site-specific sensitivities, and to offer effective guidance to avoid or minimise their potential risk.

Specific maritime activities that should be considered in relation to introduced sound and the prevention of injury or disturbance to marine mammals are outlined below. A generalised description is provided in each case. However the exact nature and scale of risks to marine mammals due to a sound-producing activity may be variable and case-specific (see also sections 2.2, 2.3, 2.4).

(i) Dredging

The excavation of sand, gravel, loose rock and other material from the seabed during dredging operations is common, particularly in coastal waters where harbour works and channel maintenance commonly require such activity. Many different types of dredging device are in operation worldwide ranging from hopper dredges to suction-, bucket- or grab-type arrangements.

In addition to the sound from attendant vessels, dredging operations have been reported to produce low frequency omnidirectional sound of several tens of Hz to several thousand Hz (and up to approximately 20 kHz) at sound pressure levels of 135-186 dB re: 1 µPa[3,44,45]. Therefore some coastal dredging operations can be detected at received levels (RL) exceeding ambient sound more than 10km from shore[3]. While sound exposure levels from such operations are thought to be below that expected to cause injury to a marine mammal, they have the potential to cause lower level disturbance, masking or behavioural impacts, for example.

Dredging activity tends to occur in a fixed area for a prolonged period of days or weeks. Therefore it has the potential to introduce continuous anthropogenic sound at levels that may impact upon marine mammal individuals and/or local populations and the risk of acoustic impacts associated with this activity should be considered to ensure good environmental management.

(ii) Drilling

Drilling activity is common in coastal and marine construction and infrastructure works (e.g., harbour, pier or bridge construction, foundation development, creation of boreholes for explosive blasting). It can also be part of highly specialised oil & gas exploration and development (e.g., site appraisal). Conventional drilling operations take place from both fixed and moveable platforms (i.e., drill rigs, semi-submersible platforms, barges and ships) but the scale of drilling activity and associated acoustic output can be very variable depending on the type of development, drill depth and substrates involved, for example. The use of fixed or dynamically-positioned platforms and associated vessel activity can combine further to make drilling operations a potentially significant source of anthropogenic sound.

Drilling is generally acknowledged to produce moderate levels of continuous omnidirectional sound at low frequency (several tens of Hz to several thousand Hz and up to c.10 kHz). Source sound pressure levels have generally been reported to lie within the 145-190 dB re: 1 µPa range[3,44,45]. While sound exposure levels from such operations are thought to be below that expected to cause injury to a marine mammal, they have the potential to cause lower level disturbance, masking or behavioural impacts, for example.

Drilling operations comprise a static activity that tends to take place in a fixed area for a prolonged or intermittent period of days, weeks or several months depending on the required operation. This activity therefore has the potential in most circumstances to introduce continuous sounds at levels that may impact upon marine mammal individuals and/or populations, the degree of which will also depend on operational features such as the location, water depth, time-scale, etc. An evaluation of risk to marine mammals from such plans or projects either in coastal situations or further offshore is essential in all cases.

Drilling undertaken as part of offshore petroleum exploration and appraisal operations is risk assessed and risk managed on a case-by-case, context-specific basis by the appropriate Regulatory Authority due to the varied and challenging operational nature of this activity in the open ocean.

(iii) Pile driving

As part of many coastal and marine construction activities (e.g., infrastructure development, harbour or bridge construction, wind farm foundation works), structural piles are commonly driven into the seashore or seabed using industrial hammering equipment. While the scale of environmental impact is variable depending on the method and type of development under construction, pile driving is widely acknowledged to produce substantial levels of anthropogenic sound both in air and in water with quite rapid rise times in each pile strike impulse.

Pile driving strikes have generally been reported to produce low frequency pulse sounds of several tens of Hz to several thousand Hz (and up to approximately 20 kHz), with some technologies introducing underwater sound at comparatively high sound pressure levels exceeding 220 dB re: 1 µPa (Appendix 1). This presents the possibility of permanent hearing injury (i.e., PTS), temporary hearing loss (i.e., TTS) or other injury for some marine mammals in close proximity to such operations. The multiple pulses of some pile driving works can also be detected at received levels (RL) well exceeding ambient sound (>120 dB re: 1 µPa) more than 10km from the operating source[3,39], sufficiently high therefore to potentially cause significant behavioural disturbance to marine mammals at distances of several kilometres.

Pile driving is a static activity that tends to take place in a fixed area for a prolonged period of days or weeks, depending on the required scale of development. In some cases, e.g., wind farm construction, it may take place over a protracted period of one or more seasons (i.e., several months at a time over successive years)[46] and may involve hundreds or thousands of individual pile strikes per foundation. Therefore this activity, particularly where large infrastructure is concerned, has the potential in most circumstances to introduce persistent anthropogenic sound at levels that may impact upon marine mammal individuals and/or populations, constituting an important conservation risk.

(iv) Geophysical acoustic surveys

Geophysical acoustic surveys in marine or coastal waters involve the systematic collection of information on the physical environment by means of sound signal production, reception, analysis and interpretation. Such techniques may be used, for example, to investigate bathymetry, to analyse the structure and composition of the seabed substrate, to explore extensively for and investigate subsurface geological structures or to survey specific targets (e.g., hydrocarbon reservoirs, wrecks, oceanographic features). Such methods commonly involve the use of ships or smaller vessels fitted with specialised equipment or from which such equipment can be deployed or towed. The level of environmental impact associated with this acoustic activity is variable depending on a number of factors including the type of the equipment being used, its sound signal and propagation characteristics, and the depth in which it is operating. However a number of geophysical acoustic survey techniques (e.g., the use of seismic airgun arrays or certain sonars) are acknowledged to produce significant levels of anthropogenic sound in water.

Acoustic instruments and equipment used in targeted marine geophysical investigations have been reported to produce sound at frequencies within the range of marine mammal hearing and at sound pressure levels exceeding 190-220 dB re: 1 µPa, and in the case of seismic airgun arrays, considerably higher[3,44,45,47]. This introduces the potential for significant adverse impact on these species by auditory (e.g., induction of TTS or PTS) and perhaps even non-auditory means (e.g., tissue damage)(see sections 2.1, 2.4), in addition to disturbance and other significant behavioural effects. Sound transmission from such equipment may vary significantly in individual signal duration (see Appendix 1), be directed in a relatively narrow vertical cone beneath the source (e.g., via a hull-mounted instrument) or in broader horizontal or omnidirectional planes, depending on system specifications and survey requirements.

Geophysical surveys in coastal and marine waters are commonly mobile, taking the form of a systematic series of survey lines within an overall target area. Depending on the location and scale of this area and the data objectives such acoustic surveys may require a period of hours, days or weeks, with many surveys being performed on a 24-hour basis once they have begun. These activities, particularly where accurate geophysical data are required via a deep acoustic penetration into the seafloor, in substantial water depths or at high resolutions, have the potential in many circumstances to introduce persistent pulse and/or non-pulse sound at levels that may impact upon marine mammal individuals and/or populations, constituting an important conservation risk.

Due to concerns regarding the potential risk to and detrimental effect on marine mammals from certain types of geophysical acoustic survey equipment, the Department of the Environment, Heritage and Local Government, through review and consultation with key stakeholders, developed a "Code of Practice for the Protection of Marine Mammals during Acoustic Seafloor Surveys in Irish Waters" (2007). The development of the updated guidance presented herein incorporated a re-examination of this earlier code of practice which it now replaces.

(v) Blasting

The use of explosives or other blasting methods to remove structures from the seabed or to blast and break sections of coastal bedrock or seabed (e.g., for pier construction) is relatively common. Man-made explosions mainly produce pulsed sounds at low frequencies (several Hz to several kHz), which are detectable by a wide range of marine mammal species. Active blasting normally occurs intermittently in a fixed area for a prolonged period of hours, days or weeks depending on the required operation, with intervening periods of preparation, substrate removal, evaluation and often drilling. Preparation for underwater blasting usually takes place from fixed platforms (i.e., rig, platform or barge) which are normally moved a safe distance away for the time of explosion.

Pulsed sounds created by coastal or underwater explosions have been reported to contain significantly high SPLs, high SELs and very rapid rise times[3] and they are acknowledged to be among the highest energy, man-made sounds introduced into the sea. While the duration and extent of underwater sound transmission from an individual explosion is variable depending on the type of plan or project, blast location features and the mass of explosive charges used, source sound pressure levels may be significantly higher than from many other anthropogenic sources (Appendix 1), commonly ranging between 250-300 dB re: 1 µPa[1,3,44,45]. Such plans or projects can incur the highest known level of risk to marine mammals from an anthropogenic sound source, with energy introduced at sufficient magnitude and velocity to cause immediate PTS in a receiving marine mammal. Explosions also produce a physical shock wave at close distances that propagates differently through the environment than does the acoustic energy and can result in direct traumatic or lethal injury to marine mammals[3,30].

Blasting activity in the marine environment therefore has the potential in most, if not all, circumstances to introduce pulsed sounds at levels that may impact very significantly upon marine mammal individuals and/or populations. Therefore it commonly requires the operation of very stringent mitigation measures for the protection of these species.

3.3 Risk assessment

An assessment of risk[48] forms an important part of the decision-making framework for mitigating the effects of anthropogenic sound in the marine environment[49]. It is recommended that all aforementioned coastal and marine activities (see section 3.2) undergo a risk assessment for anthropogenic sound-related impacts on relevant protected marine mammal species to address any area-specific sensitivities, both in timing and spatial extent, and to inform the consenting process. This requirement is already in place for offshore petroleum exploration and appraisal operations within the associated Rules and Procedures Manual of the Department of Communications, Energy and Natural Resources.

In order to be effective such an assessment must competently identify the risks according to the available evidence and consider (i) direct, (ii) indirect and (iii) cumulative effects of anthropogenic sound. It might also employ marine mammal and possibly marine acoustics expertise in order to comprehensively and scientifically evaluate the issue of risk to individual species. A conservative approach is fundamental and, in cases of uncertainty, it must be assumed that the effect of the introduced sound source(s) could be significant.

An evidence-based risk assessment for each marine mammal species that occurs in and around the proposed works area needs to consider the nature of the sound source (see section 3.2), its likely and/or potential effects on individuals and/or populations and on their likely habitats, and could usefully address the following questions where appropriate:

- ✓ Do individuals or populations of marine mammal species occur within the proposed area?
- ✓ Is the plan or project likely to result in death, injury or disturbance of individuals?
- ✓ Is it possible to estimate the number of individuals of each species that are likely to be affected?
- ✓ Will individuals be disturbed at a sensitive location or sensitive time during their life cycle?
- ✓ Are the impacts likely to focus on a particular section of the species' population, e.g., adults vs. juveniles, males vs. females?
- ✓ Will the plan or project cause displacement from key functional areas, e.g., for breeding, foraging, resting or migration?
- ✓ How quickly is the affected population likely to recover once the plan or project has ceased?

Some short worked examples of assessments of risk are provided for illustrative purposes in Appendix 5.

Where an assessment identifies the likelihood of a risk to protected marine mammal species, either by virtue of (a) the proposed plan or project and/or (b) the sensitivity of a particular site in which the sound-producing plan or project is proposed, it is recommended that appropriate risk management actions and measures are pursued by the relevant Regulatory Authority (see sections 4.1, 4.2, 4.3).

Those measures that might be adopted to minimise and/or eliminate the likely effects of anthropogenic sound on protected marine mammal species must be clearly outlined. Both general and plan- or project-specific guidance for risk management, including arrangements for monitoring and reporting, are presented in section 4 for consideration by relevant Public Authorities.

4. Risk Management

4.1 Introduction

As described above, there are certain human activities which introduce sound into broader coastal and marine environments at levels that may harm and/or disturb species legally protected from such human impacts. While the physical nature of some sound introductions (e.g., due to commercial shipping or a single explosion of known charge mass) may be inferred to a general extent from international knowledge and background research, efforts to describe and document this complex issue continue on a variety of levels. Indeed properly conducted, site-specific sound propagation/attenuation studies under controlled conditions may usefully inform the development of bespoke management actions to be taken.

Following the initial identification and assessment of risk arising from a plan or project (see section 3), a menu of management options is available for consideration by Regulatory Authorities in their decision-making process (Fig. 2) and it includes:

A1. **Consent without mitigation** (e.g., where the risk of any adverse effects has been ruled out)

A2. **No consent given for the activity**

A3. **Avoid critical habitats for marine mammals** (e.g., designated sites or other locations identified as sensitive via the risk assessment process)**, and/or**

A4. **Avoid operations during key periods of the species' life cycle** (e.g., breeding/resting, migration)**, and/or**

A5. **Avoid time periods when effective impact mitigation is not possible, and/or**

A6. **Risk minimisation measures where appropriate, namely**

A6.1. Minimise the duration over which the sound-producing activity is intended to take place;

A6.2. Minimise the individual and cumulative sound pressure and exposure levels delivered into the environment by the activity. If necessary the use of alternative, lower impact equipment and methods could be explored (e.g., vibratory hammer, gravity base piles).

A6.3. Incorporate the use of clear "ramp-up" (i.e., "soft-start") procedures, whereby sound energy input to the marine environment is gradually or incrementally increased from levels unlikely to cause significant behavioural impact on marine mammals to the full output necessary for completion of the activity.

A6.4. Incorporate the use of fully enclosing or confined bubble curtains, encircling absorptive barriers (e.g., isolation casings, cofferdams) or other demonstrably effective noise reduction methods at the immediate works site, in order to reduce underwater sound propagation from on-site operations. Studies have shown that such methods can provide a significant reduction in sound input to the wider aquatic environment in the order of 10-30 dB[50,51].

A6.5. Use trained and experienced marine mammal observers[§] (MMOs) to provide effective means of detecting marine mammals in the vicinity of coastal and marine plans or projects. Associated operational considerations must also be taken into account (see section 4.2).

[§] In the context of this guidance a qualified marine mammal observer (MMO) is defined as a visual observer who has undergone formal marine mammal observation and distance estimation training (JNCC MMO training course or equivalent) and also has a minimum of 6 weeks full-time marine mammal survey experience at sea over a 3-year period in European waters.

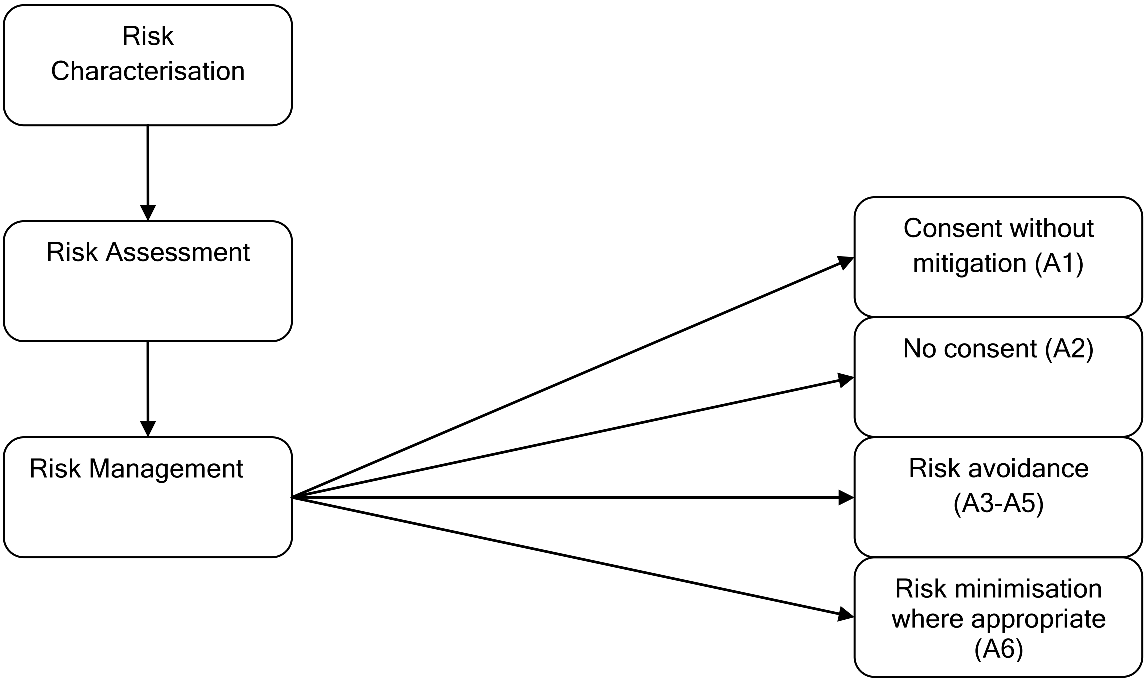


Figure 2. Flow diagram illustrating the staged process towards managing risk.

Passive acoustic monitoring (PAM)

In some cases involving the persistent significant risk of injury to marine mammals in Ireland (e.g., during explosive blasting works), the supplementary use of passive acoustic monitoring[**] may be recommended or required as part of the licence/consent conditions in order to optimise marine mammal detection around the site of a plan or project.

PAM is currently used primarily as a cetacean detection and localisation tool. Trained PAM operators may accompany international offshore seismic surveys or undertake site monitoring during certain coastal and marine plans or projects in Europe and elsewhere in order to provide an additional means of detecting and estimating the distance to cetaceans.

While the use of PAM in Ireland is broadly encouraged as a helpful and beneficial tool for detecting and monitoring certain cetacean species the Department does not believe it is sufficiently developed to be regarded as the primary or sole monitoring approach for risk management purposes. This is because the method in its current state of development is not yet capable of reliably detecting all marine mammal species in many practical field situations (e.g., aboard a moving motorised vessel) and its use as a detection tool is dependent solely on vocalising individuals that occur within the detection/range capability of the equipment.

Site-specific surveys

While knowledge of marine mammal occurrence in Irish marine and coastal environments has increased substantially, particularly in the last two decades (see section 1.1), there may be circumstances where site-specific information is limited and the appropriate risk avoidance measures are uncertain. In such cases Regulatory Authorities may request properly conducted, site-specific baseline surveys to help inform the specific risk management actions to be taken. For major plans or projects presenting a risk of significant anthropogenic noise, baseline surveys of 1-year duration (minimum) are likely to be required in order to provide effective coverage for all marine mammal species and stages of the annual cycle.

[**] Passive acoustic monitoring (PAM) involves the use of acoustic monitoring hardware (e.g., hydrophone array(s), associated computer & electronic systems), analytical software and trained expertise for the detection and localisation of vocalising marine mammals.

4.2 Operational requirements concerning Marine Mammal Observers (MMOs)

(i) MMOs must be familiar with the Irish regulatory procedures and be provided with full details of all licence/consent conditions relevant to the performance of their role in advance of activity commencement, in order to ensure compliance.

(ii) MMOs must be dedicated to and engaged solely in monitoring an operator's implementation of the technical guidance set out below and in conducting survey effort for marine mammals in accordance with the guidance. The use of a crew member or team member with other responsibilities in the prescribed pre-start-up period and/or during commencement, breaks in, or resumption of, the sound-producing activity is not considered to be a satisfactory substitute for a dedicated MMO.

(iii) A sufficient number of MMO personnel must be assigned to ensure that the role is performed effectively. Avoidance of observer fatigue is essential.

(iv) General conditions for effective visual monitoring by MMOs are: (1) during daylight hours and (2) in good visibility extending 1km or more beyond the limits of the assigned Monitored Zone (see sections 4.3.1-4.3.5), while (3) sea conditions for effective visual monitoring by MMOs are WMO Sea State 4 (≈*Beaufort Force 4* conditions) or less. Efficacy in the visual detection of marine mammal species improves considerably below Sea State 3 (≈*Beaufort Force 3* conditions).

(v) MMOs must concentrate their efforts on the measures to be taken in advance of and during commencement, breaks in and resumption of the sound-producing activity. The guidance presented in this document does not imply that MMOs must monitor the area of operations during all daylight hours. However MMOs may be required to work for extended periods within the hours of daylight as identified via the risk assessment process and its resulting risk management actions.

(vi) MMOs must be located on an appropriate elevated platform from which the entire Monitored Zone (see sections 4.3.1-4.3.5) can be effectively covered without any obstruction of view. Ideally MMOs should be positioned near the centre of the Monitored Zone, i.e., adjacent to the sound source.

(vii) In the case of geophysical acoustic surveys (see section 4.3.4) and other moving platforms from which a sound-producing activity is taking place, MMOs must be located on the source vessel.

(viii) MMOs must have appropriate equipment for their required role. MMOs must use a distance measuring (i.e., range-finding) stick, reticle binoculars or other accurate range-finding mechanism to determine the distance to any marine mammals seen.

4.3 Plan/project-specific guidance

The consideration of measures for risk minimisation, as outlined in A6 above, has been used as a basis for developing the following technical guidance in relation to specific maritime sound-producing plans or projects (see sections 4.3.1-4.3.5).

> N.B:
>
> **The consideration and/or application of the following guidance, whether alone or in addition to risk avoidance measures outlined above (i.e., A3, A4, A5), should be informed by the risk assessment.**

4.3.1 DREDGING

1. A qualified and experienced marine mammal observer (MMO) shall be appointed to monitor for marine mammals and to log all relevant events using standardised data forms (Appendix 7).
2. Unless information specific to the location and/or plan/project is otherwise available to inform the mitigation process (e.g., specific sound propagation and/or attenuation data) and a distance modification has been agreed with the Regulatory Authority, dredging activity shall not commence if marine mammals are detected within a 500m radial distance of the dredging sound source, i.e., within the Monitored Zone.

Pre-Start Monitoring

3. Dredging activities shall only commence in daylight hours where effective visual monitoring, as performed and determined by the MMO, has been achieved. Where effective visual monitoring, as determined by the MMO, is not possible the sound-producing activities shall be postponed until effective visual monitoring is possible.
4. An agreed and clear on-site communication signal must be used between the MMO and the Works Superintendent as to whether the relevant activity may or may not proceed, or resume following a break (see below). It shall only proceed on positive confirmation with the MMO.
5. **In waters up to 200m deep**, the MMO shall conduct pre-start-up constant effort monitoring at least 30 minutes before the sound-producing activity is due to commence. Sound-producing activity shall not commence until at least 30 minutes have elapsed with no marine mammals detected within the Monitored Zone by the MMO.
6. This prescribed Pre-Start Monitoring shall subsequently be followed immediately by normal dredging operations. The delay between the end of Pre-Start Monitoring and the necessary full dredging output must be minimised.

Dredging operations

7. Once normal dredging operations commence, there is no requirement to halt or discontinue the activity at night-time, nor if weather or visibility conditions deteriorate nor if marine mammals occur within a 500m radial distance of the sound source, i.e., within the Monitored Zone.

Breaks in sound output

8. If there is a break in dredging sound output for a period greater than 30 minutes (e.g., due to equipment failure, shut-down or location change) then all Pre-Start Monitoring must be undertaken in accordance with the above conditions prior to the recommencement of dredging activity.

Reporting

9. Full reporting on MMO operations and mitigation undertaken must be provided to the Regulatory Authority as outlined in Appendix 7.

4.3.2 DRILLING

The measures outlined below should be considered applicable in relation to

(i) conventional coastal and marine drilling operations [with the exception of drilling activity undertaken as part of offshore petroleum exploration and appraisal operations. Such drilling projects are risk assessed and risk managed on a case-by-case, context-specific basis by the appropriate Regulatory Authority due to the operational nature of such activity in the open ocean].

(ii) or as advised by the relevant Regulatory Authority.

1. A qualified and experienced marine mammal observer (MMO) shall be appointed to monitor for marine mammals and to log all relevant events using standardised data forms (Appendix 7).
2. Unless information specific to the location and/or plan/project is otherwise available to inform the mitigation process (e.g., specific sound propagation and/or attenuation data) and a distance modification has been agreed with the Regulatory Authority, drilling activity shall not commence if marine mammals are detected <u>within a 500m radial distance of the drilling sound source</u>, i.e., within the Monitored Zone.

<u>Pre-Start Monitoring</u>

3. Drilling activities shall only commence in daylight hours where effective visual monitoring, as performed and determined by the MMO, has been achieved. Where effective visual monitoring, as determined by the MMO, is not possible the sound-producing activities shall be postponed until effective visual monitoring is possible.
4. An agreed and clear on-site communication signal must be used between the MMO and the Works Superintendent as to whether the relevant activity may or may not proceed, or resume following a break (see below). It shall only proceed on positive confirmation with the MMO.
5. **In waters up to 200m deep**, the MMO shall conduct pre-start-up constant effort monitoring at least <u>30 minutes</u> before the sound-producing activity is due to commence. Sound-producing activity shall not commence until at least 30 minutes have elapsed with no marine mammals detected within the Monitored Zone by the MMO.
6. **Where operations occur in waters greater than 200m depth (i.e., >200m)**, pre-start-up monitoring shall be conducted at least <u>60 minutes</u> before the sound-producing activity is due to commence. Sound-producing activity shall not commence until at least 60 minutes have elapsed with no marine mammals detected within the Monitored Zone by the MMO.
7. This prescribed Pre-Start Monitoring shall subsequently be followed immediately by normal drilling operations. The delay between the end of Pre-Start Monitoring and the necessary full drilling output must be minimised.

<u>Drilling operations</u>

8. Once normal drilling operations commence, there is no requirement to halt or discontinue the activity at night-time, nor if weather or visibility conditions deteriorate nor if marine mammals occur within a 500m radial distance of the sound source, i.e., within the Monitored Zone.

<u>Breaks in sound output</u>

9. If there is a break in drilling sound output for a period greater than 30 minutes (e.g., due to equipment failure, shut-down or location change) then all Pre-Start Monitoring must be undertaken in accordance with the above conditions prior to the recommencement of drilling activity.

<u>Reporting</u>

10. Full reporting on MMO operations and mitigation undertaken must be provided to the Regulatory Authority as outlined in Appendix 7.

4.3.3 Pile Driving

1. A qualified and experienced marine mammal observer (MMO) shall be appointed to monitor for marine mammals and to log all relevant events using standardised data forms (Appendix 7).
2. Unless information specific to the location and/or plan/project is otherwise available to inform the mitigation process (e.g., specific sound propagation and/or attenuation data) and a distance modification has been agreed with the Regulatory Authority, pile driving activity shall not commence if marine mammals are detected within a 1,000m radial distance of the pile driving sound source, i.e., within the Monitored Zone.

Pre-Start Monitoring

3. Pile driving activities shall only commence in daylight hours where effective visual monitoring, as performed and determined by the MMO, has been achieved. Where effective visual monitoring, as determined by the MMO, is not possible the sound-producing activities shall be postponed until effective visual monitoring is possible.
4. An agreed and clear on-site communication signal must be used between the MMO and the Works Superintendent as to whether the relevant activity may or may not proceed, or resume following a break (see below). It shall only proceed on positive confirmation with the MMO.
5. **In waters up to 200m deep**, the MMO shall conduct pre-start-up constant effort monitoring at least 30 minutes before the sound-producing activity is due to commence. Sound-producing activity shall not commence until at least 30 minutes have elapsed with no marine mammals detected within the Monitored Zone by the MMO.
6. This prescribed Pre-Start Monitoring shall subsequently be followed by an appropriate Ramp-Up Procedure which should include continued monitoring by the MMO.

Ramp-Up Procedure

7. In commencing a pile driving operation where the output peak sound pressure level (in water) from any source including equipment testing exceeds 170 dB re: 1μPa @1m an appropriate Ramp-up Procedure (i.e., “soft-start”) must be used. The procedure for use should be informed by the risk assessment undertaken giving due consideration to the pile specification, the driving mechanism, the receiving substrate, the duration of the activity, the receiving environment and species therein, and other information (see section 3).
8. Where it is possible according to the operational parameters of the equipment and materials concerned, the underwater acoustic energy output shall commence from a lower energy start-up (i.e., a peak sound pressure level not exceeding 170 dB re: 1μPa @1m) and thereafter be allowed to gradually build up to the necessary maximum output over a period of 20-40 minutes.
9. This controlled build-up of acoustic energy output shall occur in consistent stages to provide a steady and gradual increase over the ramp-up period.
10. Where the measures outlined in steps 8 and 9 are not possible, alternatives must be examined whereby the underwater output of acoustic energy is introduced in a consistent, sequential and gradual manner over a period of 20-40 minutes prior to commencement of the full necessary output.
11. In all cases where a Ramp-Up Procedure is employed the delay between the end of ramp-up and the necessary full output must be minimised to prevent unnecessary high-level sound introduction into the environment.
12. Once an appropriate and effective Ramp-Up Procedure commences, there is no requirement to halt or discontinue the procedure at night-time, nor if weather or visibility conditions deteriorate nor if marine mammals occur within a 1,000m radial distance of the sound source, i.e., within the Monitored Zone.

Breaks in sound output

13. If there is a break in pile driving sound output for a period greater than 30 minutes (e.g., due to equipment failure, shut-down or location change) then all Pre-Start Monitoring and a subsequent Ramp-up Procedure (where appropriate following Pre-Start Monitoring) must be undertaken.

14. For higher output pile driving operations which have the potential to produce injurious levels of underwater sound (see sections 2.4, 3.2) as informed by the associated risk assessment, there is likely to be a regulatory requirement to adopt a shorter 5-10 minute break limit after which period all Pre-Start Monitoring and a subsequent Ramp-up Procedure (where appropriate following Pre-Start Monitoring) shall recommence as for start-up.

<u>Reporting</u>

15. Full reporting on MMO operations and mitigation undertaken must be provided to the Regulatory Authority as outlined in Appendix 7.

4.3.4 GEOPHYSICAL ACOUSTIC SURVEYS

The measures outlined below are applicable to

(ii) all seismic surveys (including the testing and full operational use of airguns, water guns, sparkers, boomers and vertical seismic profiling [VSP] or checkshot systems) in inshore[††] and offshore Irish waters;

(iii) all multibeam, single beam, side-scan sonar and sub-bottom profiler (e.g., pinger or chirp system) surveys within bays, inlets or estuaries[‡‡] and within 1,500m of the entrance of enclosed bays/inlets/estuaries;

(iii) or as advised by the relevant Regulatory Authority.

4.3.4 (i). Seismic surveys

1. A qualified and experienced marine mammal observer (MMO) shall be appointed to monitor for marine mammals and to log all relevant events using standardised data forms (Appendix 6).
2. Unless information specific to the location and/or plan/project is otherwise available to inform the mitigation process (e.g., specific sound propagation and/or attenuation data) and a distance modification has been agreed with the Regulatory Authority, seismic surveying shall not commence if marine mammals are detected within a 1,000m radial distance of the sound source intended for use, i.e., within the Monitored Zone.

Pre-Start Monitoring

3. Sound-producing activities shall only commence in daylight hours where effective visual monitoring, as performed and determined by the MMO, has been achieved. Where effective visual monitoring, as determined by the MMO, is not possible the sound-producing activities shall be postponed until effective visual monitoring is possible.
4. An agreed and clear on-site communication signal must be used between the MMO and the Works Superintendent as to whether the relevant activity may or may not proceed, or resume following a break (see below). It shall only proceed on positive confirmation with the MMO.
5. **In waters up to 200m deep**, the MMO shall conduct pre-start-up constant effort monitoring at least 30 minutes before the sound-producing activity is due to commence. Sound-producing activity shall not commence until at least 30 minutes have elapsed with no marine mammals detected within the Monitored Zone by the MMO.
6. **Where operations occur in waters greater than 200m depth (i.e., >200m)**, pre-start-up monitoring shall be conducted at least 60 minutes before the activity is due to commence. Sound-producing activity shall not commence until at least 60 minutes have elapsed with no marine mammals detected within the Monitored Zone by the MMO.
7. This prescribed Pre-Start Monitoring shall subsequently be followed by a Ramp-Up Procedure[§§] which should include continued monitoring by the MMO.

Ramp-Up Procedure

8. In commencing a seismic survey operation, the following Ramp-up Procedure (i.e., "soft-start") must be used, including during any testing of seismic sound sources, where the output peak sound pressure level from any source exceeds 170 dB re: 1µPa @1m:

   (a) Seismic energy output shall commence from a lower energy start-up (i.e., starting with a single seismic device/airgun which is the smallest in the array and gradually adding others; In the case of sparkers/boomers, starting with the lowest electric discharge

[††] Seismic survey activity in coastal waters should be planned to commence at the innermost part of any bay, inlet or estuary to be surveyed and thereafter work outwards, to ensure that marine mammals are not driven into or artificially confined within an enclosed comparatively shallow area.

[‡‡] Survey activity should be planned to commence at the innermost part of any bay, inlet or estuary to be surveyed and thereafter work outwards, to ensure that marine mammals are not driven into or artificially confined within an enclosed comparatively shallow area.

[§§] Except during certain line changes as outlined in point 11(b).

possible) and thereafter be allowed to gradually build up to the necessary maximum output over a period of 40 minutes.

(b) This controlled build-up of seismic energy output shall occur in consistent stages to provide a steady and gradual increase over the ramp-up period.

9. In all cases the delay between the end of ramp-up (i.e., the necessary full seismic output) and the start of a survey line or station must be minimised to prevent unnecessary high-level sound introduction into the environment.

10. Once the Ramp-Up Procedure commences, there is no requirement to halt or discontinue the procedure at night-time, nor if weather or visibility conditions deteriorate nor if marine mammals occur within a 1,000m radial distance of the sound source, i.e., within the Monitored Zone.

Line Changes

11. Where the duration of a survey line or station change will be greater than 40 minutes the activity shall, on completion of the line/station being surveyed, either

    (a) shut down and undertake full Pre-Start Monitoring, followed by a Ramp-Up Procedure for recommencement, or

    (b) undergo a major reduction in seismic energy output to a lower energy state[***] where the output peak sound pressure level from any operating source is 165-170 dB re: 1μPa @1m, and then undertake a full Ramp-Up Procedure for recommencement.

12. Where the duration of a survey line or station change will be less than 40 minutes the activity may continue as normal (i.e., under full seismic output).

Breaks in sound output

13. If there is a break in sound output for a period of 5-10 minutes (e.g., due to equipment failure, shut-down, survey line or station change), MMO monitoring must be undertaken to check that no marine mammals are observed within the Monitored Zone prior to recommencement of the sound source at full power.

14. Where a marine mammal is observed within the Monitored Zone during such a break of 5-10 minutes, then all Pre-Start Monitoring and a subsequent Ramp-up Procedure (where appropriate following Pre-Start Monitoring) shall recommence as in a normal start-up operation.

15. In any case, if there is a break in sound output for a period greater than 10 minutes (e.g., due to equipment failure, shut-down, survey line or station change) then all Pre-Start Monitoring and a subsequent Ramp-up Procedure (where appropriate following Pre-Start Monitoring) must be undertaken.

Reporting

16. Full reporting on MMO operations and mitigation undertaken must be provided to the Regulatory Authority as outlined in Appendix 6.

[***] It is important that this significant reduction in sound output is to a minimum point (i.e., minimum peak sound pressure level) that in theory remains audible above most ambient sound and shipping noise and yet is also consistent with the Ramp-up Procedure.

4.3.4 (ii). Multibeam, single beam, side-scan sonar & sub-bottom profiler surveys

1. A qualified and experienced marine mammal observer (MMO) shall be appointed to monitor for marine mammals and to log all relevant events using standardised data forms (Appendix 6).
2. Unless information specific to the location and/or plan/project is otherwise available to inform the mitigation process (e.g., specific sound propagation and/or attenuation data) and a distance modification has been agreed with the Regulatory Authority, acoustic surveying using the above equipment shall not commence if marine mammals are detected within a 500m radial distance of the sound source intended for use, i.e., within the Monitored Zone.

Pre-Start Monitoring

3. Sound-producing activities shall only commence in daylight hours where effective visual monitoring, as performed and determined by the MMO, has been achieved. Where effective visual monitoring, as determined by the MMO, is not possible the sound-producing activities shall be postponed until effective visual monitoring is possible.
4. An agreed and clear on-site communication signal must be used between the MMO and the Works Superintendent as to whether the relevant activity may or may not proceed, or resume following a break (see below). It shall only proceed on positive confirmation with the MMO.
5. **In waters up to 200m deep**, the MMO shall conduct pre-start-up constant effort monitoring at least 30 minutes before the sound-producing activity is due to commence. Sound-producing activity shall not commence until at least 30 minutes have elapsed with no marine mammals detected within the Monitored Zone by the MMO.
6. This prescribed Pre-Start Monitoring shall subsequently be followed by a Ramp-Up Procedure which should include continued monitoring by the MMO.

Ramp-Up Procedure

7. In commencing an acoustic survey operation using the above equipment, the following Ramp-up Procedure (i.e., “soft-start”) must be used, including during any testing of acoustic sources, where the output peak sound pressure level from any source exceeds 170 dB re: 1μPa @1m:
   (a) Where it is possible according to the operational parameters of the equipment concerned, the device’s acoustic energy output shall commence from a lower energy start-up (i.e., a peak sound pressure level not exceeding 170 dB re: 1μPa @1m) and thereafter be allowed to gradually build up to the necessary maximum output over a period of 20 minutes.
   (b) This controlled build-up of acoustic energy output shall occur in consistent stages to provide a steady and gradual increase over the ramp-up period.
   (c) Where the acoustic output measures outlined in steps (a) and (b) are not possible according to the operational parameters of any such equipment, the device shall be switched “on” and “off” in a consistent sequential manner over a period of 20 minutes prior to commencement of the full necessary output.
8. In all cases where a Ramp-Up Procedure is employed the delay between the end of ramp-up and the necessary full output must be minimised to prevent unnecessary high-level sound introduction into the environment.
9. Once the Ramp-Up Procedure commences, there is no requirement to halt or discontinue the procedure at night-time, nor if weather or visibility conditions deteriorate nor if marine mammals occur within a 500m radial distance of the sound source, i.e., within the Monitored Zone.

Breaks in sound output

10. If there is a break in sound output for a period greater than 30 minutes (e.g., due to equipment failure, shut-down, survey line or station change) then all Pre-Start Monitoring and a subsequent Ramp-up Procedure (where appropriate following Pre-Start Monitoring) must be undertaken.
11. For higher output survey operations which have the potential to produce injurious levels of underwater sound (see sections 2.4, 3.2) as informed by the associated risk assessment, there is likely to be a regulatory requirement to adopt a shorter 5-10 minute break limit after which period all Pre-Start Monitoring and a subsequent Ramp-up Procedure (where appropriate following Pre-Start Monitoring) shall recommence as for start-up.

Reporting

12. Full reporting on MMO operations and mitigation undertaken must be provided to the Regulatory Authority as outlined in Appendix 6.

4.3.5 BLASTING

1. Only the minimum quantities of explosives to achieve the desired result must be used. While the duration of individual blasting events must also be minimised, a series of smaller explosions should be undertaken rather than fewer larger explosions.
2. Where possible, blasting events must be scheduled to occur early in the daytime to allow a buffer for delays caused by marine mammal presence within the immediate area of operations.
3. Where possible, individual explosive charges should be placed within a borehole drilled into the substratum or an excavated depression and covered or packed with stemming material (e.g., loose gravels, clean angular crushed rock and/or overburden).
4. At least one qualified and experienced marine mammal observer (MMO) shall be appointed as necessary, to monitor for marine mammals and to log all relevant events using standardised data forms (Appendix 7).
5. The use of sound propagation modelling, sound-absorbing barriers and/or passive acoustic monitoring (see section 4.1) may be recommended or required as part of the licence/consent conditions in order to optimise marine mammal protection and detection around the blasting site. Passive acoustic monitoring must not be regarded as the primary or sole monitoring approach, however.
6. Unless information specific to the location and/or plan/project is otherwise available to inform the mitigation process (e.g., specific sound propagation and/or attenuation data) and a distance modification has been agreed with the Regulatory Authority, blasting activity shall not commence if marine mammals are detected <u>within a 1,000m radial distance of the sound source</u>, i.e., within the Monitored Zone.

<u>Pre-Start Monitoring</u>

7. Blasting activities shall only commence in daylight hours where effective visual monitoring, as performed and determined by the MMO, has been achieved. Where effective visual monitoring, as determined by the MMO, is not possible the sound-producing activities shall be postponed until effective visual monitoring is possible.
8. An agreed and clear on-site communication signal must be used between the MMO and the Works Superintendent as to whether the relevant activity may or may not proceed. It shall only proceed on positive confirmation with the MMO.
9. **In waters up to 200m deep**, the MMO shall conduct pre-start-up constant effort monitoring at least <u>30 minutes</u> before the sound-producing activity is due to commence. Sound-producing activity shall not commence until at least 30 minutes have elapsed with no marine mammals detected within the Monitored Zone by the MMO.
10. **Where operations occur in waters greater than 200m depth (i.e., >200m)**, pre-start-up monitoring shall be conducted at least <u>60 minutes</u> before the sound-producing activity is due to commence. Sound-producing activity shall not commence until at least 60 minutes have elapsed with no marine mammals detected within the Monitored Zone by the MMO.
11. This prescribed Pre-Start Monitoring shall subsequently be followed by a pre-arranged Ramp-Up Procedure wherever possible. This should include continued monitoring by the MMO.

<u>Ramp-Up Procedure</u>

12. The use of a clear Ramp-Up Procedure must be considered; for example, whereby charges of smaller mass are detonated first in a progressive series of blasts aimed at reducing the acoustic/environmental impact caused by individual high energy pulse sounds, and allowing animal avoidance, surfacing or other potential safeguarding behaviour of marine mammals to occur.
13. Sequential detonations within an overall blast cycle should employ a short inter-charge time delay (of milliseconds in duration) in order to minimise the cumulative effect of separate individual blast pulses.
14. In all cases where a Ramp-Up Procedure is employed the delay between the end of ramp-up and the necessary full output must be minimised.

15. Any proposed Ramp-Up Procedure should be informed by the risk assessment undertaken giving due consideration to all technical and operational specifications, the size/weight and scale of the intended detonation(s), the receiving substrate, the duration of the blasting activity, the receiving environment and species therein, and other information (see section 3).

<u>Reporting</u>

16. Full reporting on MMO operations and mitigation undertaken must be provided to the Regulatory Authority as outlined in Appendix 7.

5. References

1. Hildebrand, J. A. (2005). Impacts of anthropogenic sound. In J.E. Reynolds et al. (Eds.) *Marine Mammal Research: Conservation beyond Crisis*. (pp.101-124). Baltimore, Maryland: The Johns Hopkins University Press.

2. NRC. (2005). *Marine mammal populations and ocean noise: Determining when noise causes biologically significant effects.* Washington, DC: The National Academies Press. 126 pp.

3. Richardson, W. J., Greene, C. R., Jr., Malme, C. I., & Thomson, D. H. (1995). *Marine mammals and noise.* New York: Academic Press. 576 pp.

4. Dehnhart, G. (2002). Sensory systems. In A.R. Hoelzel (Ed.) *Marine mammal biology - An evolutionary approach.* (pp. 116-141). Oxford: Blackwell Publishing.

5. Evans, D. L., & England, G. R. (2001). *Joint interim report/Bahamas marine mammal stranding event of 14-16 March 2000.* Washington, DC: National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and U.S. Navy. 61 pp.

6. Jepson, P. D., Arbelo, M., Deaville, R., Patterson, I. A. P., Castro, P., Baker, J. R., Degollada, E., Ross, H., Herraez, P., Pocknell, A.M., Rodriguez, F., Howiell, F. E., Reid, R. J., Jaber, J. R., Martin, V., Cunningham, A. A. and Fernandez, A. (2003). Gas-bubble lesions in stranded cetaceans: Was sonar responsible for a spate of whale deaths after an Atlantic military exercise? *Nature 425*: 575-576.

7. Fernández, A., Edwards, J. F., Rodríguez, F., Espinosa de los Monteros, A., Herráez, P., Castro, P., Jaber, J. R., Martin, V. and Arbelo, M. (2005). Gas and fat embolic syndrome involving a mass stranding of beaked whales (Family Ziphiidae) exposed to anthropogenic sonar signals. *Veterinary Pathology 42*: 446-457.

8. Cox, T. M., Ragen, T. J., Read, A. J., Vos, E., Baird, R. W., Balcomb, K., Barlow, J., Caldwell, J., Cranford, T., Crum, L., D'Amico, A., D'Spain, G., Fernandez, A., Finneran, J., Gentry, R., Gerth, W., Gulland, F., Hildebrand, J., Houser, D., Hullar, T., Jepson, P. D., Ketten, D., MacLeod, C. D., Miller, P., Moore, S., Mountain, D. C., Palka, D., Ponganis, P., Rommel, S., Rowels, T., Taylor, B., Tyack, P., Wartzok, D., Gisiner, R., Mead, J. and Benner, L. (2006). Understanding the impacts of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management 7(3)*: 177-187.

9. Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M. P., Swift, R. and Thompson, D. (2004). A review of the effects of seismic surveys on marine mammals. *Marine Technology Society Journal 37*: 14-32.

10. Nowacek, D. P., Thorne, L. H., Johnston, D. W. and Tyack, P. L. (2007). Responses of cetaceans to anthropogenic noise. *Mammal Review 37 (2)*: 81-115.

11. NPWS. (2008). *The status of EU protected habitats and species in Ireland. Conservation status in Ireland of habitats and species listed in the European Council Directive on the Conservation of Habitats, Flora and Fauna 92/43/EEC.* Dublin: National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government and Brunswick Press. 138 pp.

12. Pollock, C., Reid, J. B., Webb, A. and Tasker, M. L. (1997). *The distribution of seabirds and cetaceans in the waters around Ireland*. Report No. 267. Peterborough: Joint Nature Conservation Committee.

13. Reid, J. B., Evans, P. G. H. and Northridge, S. P. (2003). *Atlas of cetacean distribution in north-west European waters*. Peterborough: Joint Nature Conservation Committee 76 pp.

14. Ó Cadhla, O., Mackey, M., Aguilar de Soto, N., Rogan, E. and Connolly, N. (2004). *Cetaceans and Seabirds of Ireland's Atlantic Margin. Volume II-Cetacean distribution and abundance*. Report on research carried out under the Irish Petroleum Infrastructure Programme (PIP): Rockall Studies Group (RSG) projects98/6 and 00/13, Porcupine Studies Group project P00/15 and Offshore Support Group (OSG) project 99/38. Cork: University College Cork. 89 pp.

15. O'Brien, J., Berrow, S., McGrath, D. and Evans, P. G. H. (2009). Cetaceans in Irish waters: A review of recent research. *Biology and Environment: Proceedings of the Royal Irish Academy 109B (2):* 63-88.

16. DEHLG. (2009). *Conservation Plan for Cetaceans in Irish waters.* Dublin: Department of the Environment, Heritage and Local Government. 97 pp.

17. Berrow S. D., Whooley, P., O'Connell, M. and Wall, D. (2010). *Irish Cetacean Review (2000-2009).* Irish Whale and Dolphin Group. 60pp.

18. Wall, D., Murray, C., O'Brien, J., Kavanagh, L., Wilson, C., Ryan, C., Glanville, B., Williams, D., Enlander, I., O'Connor, I., McGrath, D., Whooley, P. and Berrow, S. (2013). *Atlas of the distribution and relative abundance of marine mammals in Irish offshore waters 2005 – 2011*. Irish Whale and Dolphin Group, Kilrush, Co. Clare. 58 pp.

19. Cronin, M., Duck, C., Ó Cadhla, O., Nairn, R., Strong, D. and O' Keeffe, C. (2004). *Harbour seal population assessment in the Republic of Ireland: August 2003*. *Irish Wildlife Manuals* No. 11. Dublin: National Parks & Wildlife Service, Department of the Environment, Heritage and Local Government. 34 pp.

20. Ó Cadhla, O., Strong, D., O'Keeffe, C., Coleman, M., Cronin, M., Duck, C., Murray, T., Dower, P., Nairn, R., Murphy, P., Smiddy, P., Saich, C., Lyons, D. and Hiby, A. R. (2008). *An assessment of the breeding population of grey seals in the Republic of Ireland, 2005.* Irish Wildlife Manuals No. 34. Dublin: National Parks & Wildlife Service, Department of the Environment, Heritage and Local Government. 60 pp.

21. Ó Cadhla, O. and Strong, D. (2007). *Grey seal moult population survey in the Republic of Ireland, 2007.* Dublin: National Parks & Wildlife Service, Department of the Environment, Heritage and Local Government. 22 pp.

22. NRC. (2003). *Ocean noise and marine mammals.* Washington, DC: The National Academies Press. 192 pp.

23. Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene., C. R. Jr., Kastak, D., Ketten, D. R., Miller, J. H., Nachtigall, P. E., Richardson, W. J., Thomas, J. A., and Tyack, P. L. (2007). Marine mammal noise exposure criteria: Initial scientific recommendations**.** *Aquatic Mammals 33(4)*: 411-521.

24. Thomsen, F., Lüdemann, K., Kafemann, R. and Piper, W. (2006). *Effects of offshore wind farm noise on marine mammals and fish*. Report to COWRIE Ltd. 62 pp.

25. Wartzok, D. and Ketten, D. R. (1999). Marine mammal sensory systems. *In* J. E. Reynolds II & S. A. Rommel (Eds.) *Biology of marine mammals* (pp. 117-175). Washington, DC: Smithsonian Institution Press.

26. IACMST. (2006). *Underwater sound and marine life.* Southampton: Inter-agency Committee on Marine Science and Technology working group report No.6. 19 pp.

27. MMC. (2006). *Report of the Advisory Committee on acoustic impacts on marine mammals*. USA: Marine Mammal Commission.136 pp.

28. Wartzok, D., Popper, A. N., Gordon, J., & Merrill, J. (2004). Factors affecting the responses of marine mammals to acoustic disturbance. *Marine Technology Society Journal 37*: 6-15.

29. Rice, D. W. (1998). *Marine mammals of the world: Systematics and distribution* (Special Publication 4). Lawrence, KS: Society for Marine Mammalogy. 231 pp.

30. Ketten, D. (1995). Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions. *In* Kastelein, R.A., Thomas, J.A. & P.E. Nachtigall (eds.) *Sensory systems of aquatic mammals*. De Spil Publishers. The Netherlands. p391-407.

31. Crum, L. A. and Mayo, Y. (1996). Acoustically enhanced bubble growth at low frequencies and its implications for human diver and marine mammal safety. *Journal of the Acoustical Society of America* 99: 2898-2907.

32. Commission of the European Communities. (2000). *Communication from the Commission on the precautionary principle*. COM (200)1. Brussels: European Commission. 28 pp.

33. Kastak, D., Southall, B. L., Schusterman, R. J. and Reichmuth Kastak, C. (2005). Underwater temporary threshold shift in pinnipeds: Effects of noise level and duration. *Journal of the Acoustical Society of America 118 (5):* 3154-3163.

34. Finneran, J. J., Carder, D. A., Schlundt, C. E. and Ridgway, S. H. (2005). Temporary threshold shift in bottlenose dolphins exposed to mid-frequency tones. *Journal of the Acoustical Society of America 118 (4):* 2696-2705.

35. Mooney, T. A., Nachtigall, P. E.., Breese, M., Vlachos, S. and Au, W. W. L. (2009). Predicting temporary threshold shifts in a bottlenose dolphin (*Tursiops truncatus*): The effects of noise level and duration. *Journal of the Acoustical Society of America 125 (3):* 1816-1826.

36. Lucke, K., Siebert, U., Lepper, P. A. and Blanchet, M-A. (2009). Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. *Journal of the Acoustical Society of America 125 (6):* 4060-4070.

37. Madsen, P. T., Wahlberg, M., Tougaard, J., Lucke, K. and Tyack, P. (2006). Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. *Marine Ecology-Progress Series 309:* 279-295.

38. Tougaard J., Carstensen J., Teilmann J., Skov H. and Rasmussen, P. (2009). Pile driving zone of responsiveness extends beyond 20 km for harbor porpoises (*Phocoena phocoena,* (L.)). *Journal of the Acoustical Society of America 126 (1):* 11-14.

39. Bailey, H., Senior, B., Simmons, D., Rusin, J., Picken, G and Thompson, P. M. (2010). Assessing underwater noise levels during pile-driving at an offshore windfarm and its potential effects on marine mammals. *Marine Pollution Bulletin 60 (6):* 888-897.

40. Ó Cadhla, O., Englund, A., Philpott, E., Mackey, M. and Ingram, S. (2003). *Marine mammal monitoring in the waters of Broadhaven Bay and northwest Mayo: 2001-2002*. Dublin: Enterprise Energy Ireland Ltd. - available from SEPIL Ltd. 74 pp.

41. Palka, D., & Hammond, P. S. (2001). Accounting for responsive movement in line transect estimates of abundance. *Canadian Journal of Fisheries and Aquatic Sciences 58(4)*: 777-787.

42. Henry, E. and Hammill, M. O. (2001). Impact of small boats on the haul-out activity of harbour seals (*Phoca vitulina*) in Metis Bay, Saint Lawrence Estuary, Quebec, Canada. *Aquatic Mammals 27(2)*: 140-148.

43. Johnson, A. and Acevedo-Guttiérez, A. (2007). Regulation compliance by vessels and disturbance of harbour seals (*Phoca vitulina*). *Canadian Journal of Zoology 85(2)*: 290-294.

44. OSPAR. (2009a). *Assessment of the environmental impact of underwater noise.* London: OSPAR Commission Biodiversity Series. Publication no. 436/2009. 43 pp.

45. OSPAR. (2009b). *Overview of the impacts of anthropogenic underwater sound in the marine environment*. London: OSPAR Commission Biodiversity Series. Publication no. 441/2009. 133 pp.

46. JNCC. (2008). *The deliberate disturbance of marine European protected species – Guidance for English and Welsh territorial waters and the UK offshore marine area*. Draft report for consultation. Peterborough: Joint Nature Conservation Committee. 34 pp.

47. SCAR. (2005). Risks posed to the Antarctic marine environment by acoustic instruments: a structured analysis. *Antarctic Science 17*: 533-540.

48. Harwood, J. (2000). Risk assessment and decision analysis in conservation. *Biological Conservation 95*: 219-226.

49. Harwood, J. (2002). Mitigating the effects of acoustic disturbance in the oceans. *Aquatic conservation: Marine and Freshwater Ecosystems 12*: 484-488.

50. CALTRANS. (2009). *Technical guidance for assessment and mitigation of the hydroacoustic effects of pile driving on fish.* Report prepared for the California Department of Transportation. ICF Jones & Stokes, Sacramento and Illingworth and Rodkin, Inc., Petalumna, California. 298 pp.

51. Grießmann, T., Rustemeier, J., Betke, K., Gabriel, J., Neumann, T., Nehls, G., Brandt, M., Diederichs, A. and Bachmann, J. (2010). *Erforschung und Anwendung von Schallminimierungsmaßnahmen beim Rammen des FINO3-Monopiles.* Report to the Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Berlin. Institut Statik und Dynamik der Leibniz Universität Hannover. 145pp.

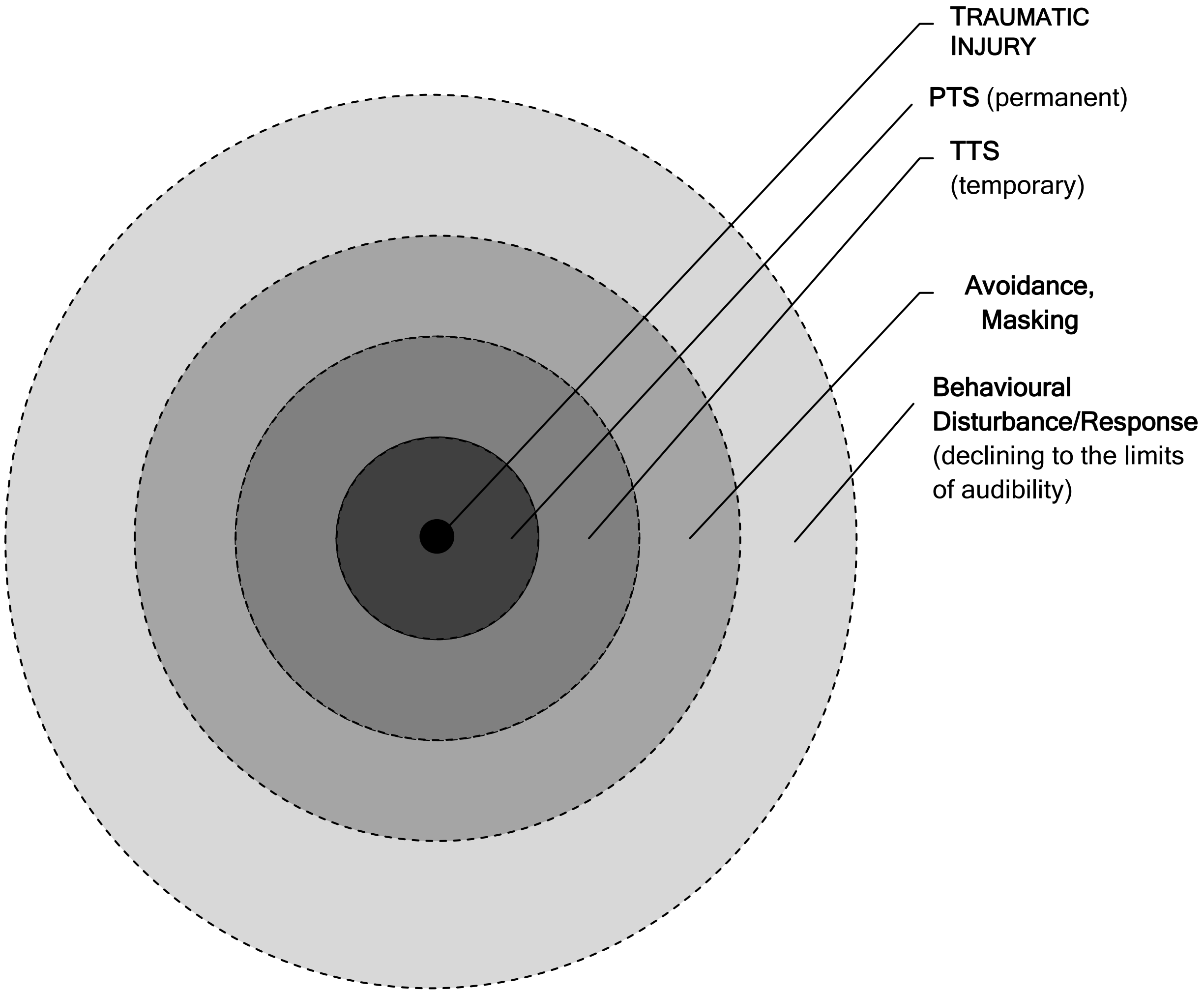
52. Nedwell, J. and Howell, D. (2004). *A review of offshore windfarm related underwater noise sources*. Report No.544 R 0308 to Cowrie Ltd., London. 63 pp.

6. Appendices

Appendix 1 – Examples of general underwater sound information from a range of anthropogenic sources, ordered by their potential for introduction of high level sound (based on information in Hildebrand[1]; Richardson *et al.*[3]; OSPAR[45]; Nedwell & Howell[52]).

Source	Sound Pressure Level dB re: 1µPa @1m	Sound Exposure Level dB re: $1µPa^2$-s	Sound Duration seconds	Peak Frequency Hz	Band Width Hz	Direction
Ship Shock Trial (10,000 lbs TNT)	299	302	2 s	Low	Broad	Omni
Explosives (1-100lbs TNT)	272-287	-	0.001-0.01	6-21	2-1,000	Omni
Airgun Array (2000 psi, 8000 in^3)	256	241	0.03 s	50	150	Vertical
Pile-driving (4m diameter monopile)	192-261	210-215	-	-	100-1,000	Omni
Military Sonar (SURTASS/LFA)	235	243	6-100 s	250	30	Horizontal
Multibeam echosounder (hull-moulted)	235	218	0.02 s	12,000	Narrow	Vertical
Super Tanker 337m long @ 18 knots	185	-	constant	23	5-100	Omni
Drilling (Ship/Semi-submersible)	145-191	-	constant	-	1-600	Omni
Dredging (Suction/Hopper dredge)	177	-	constant	80-200	20-8,000	Omni
Acoustic Harassment Device (AHD)	185	185	0.5-2.0 s	10,000	600	Omni
Tug vessel (while towing)	145-170	-	constant	-	37-5,000	Omni
Wind turbine (power output - 1MW)	142-153		constant	16	15-20,000	Omni
Fishing vessel (12m long @ 7 knots)	150		constant	300	250-1000	Omni
Acoustic Deterrent Device (ADD)	132	127	0.3 s	10,000	2000	Omni

Appendix 2 – Schematic diagram showing hypothetical zones of impact around a high energy underwater sound source (at centre) and listing the potential effects upon a receiving animal, assuming spherical spreading. PTS = Permanent Threshold Shift; TTS = Temporary Threshold Shift. (*after* NRC[2]).



Note:

It should be remembered that this is a somewhat simplistic model, that factors such as local propagation and individual hearing ability can influence the actual effect elicited and that hypothetical zones of impact may merge with or overlap one another.

Appendix 3 – Transcription of marine mammal noise exposure criteria given by Southall *et al.*[23]. Table B includes received levels (RL) from multiple pulse and non-pulse sound events reported to elicit significant behavioural responses* in previous studies. [* w.r.t. Irish-occurring species]

A, Criteria for Permanent Injury - estimated values for PTS-onset.

Cetaceans			Pinnipeds	Pinnipeds
Low frequency	*Mid-frequency*	*High frequency*	*in Water*	*in Air*
7 Hz-22 kHz	150 Hz-160 kHz	200 Hz-180 kHz	75 Hz-75 kHz	75 Hz-30 kHz
Baleen whales	Most toothed whales, dolphins	Certain toothed whales, porpoises	All species	All species
Single Pulse: 230 dB SPL 198 dB SEL Multiple Pulse: 230 dB SPL 198 dB SEL Non-pulses: 230 dB SPL 215 dB SEL	Single Pulse: 230 dB SPL 198 dB SEL Multiple Pulse: 230 dB SPL 198 dB SEL Non-pulses: 230 dB SPL 215 dB SEL	Single Pulse: 230 dB SPL 198 dB SEL Multiple Pulse: 230 dB SPL 198 dB SEL Non-pulses: 230 dB SPL 215 dB SEL	Single Pulse: 218 dB SPL 186 dB SEL Multiple Pulse: 218 dB SPL 186 dB SEL Non-pulses: 218 dB SPL 203 dB SEL	Single Pulse: 149 dB SPL 144 dB SEL Multiple Pulse: 149 dB SPL 144 dB SEL Non-pulses: 149 dB SPL 144.5 dB SEL

B. Criteria and values for TTS-onset (single pulses only) and Disturbance/Behavioural Response (multiple pulses and non-pulses).

Cetaceans			Pinnipeds	Pinnipeds
Low frequency	*Mid-frequency*	*High frequency*	*in Water*	*in Air*
7 Hz-22 kHz	150 Hz-160 kHz	200 Hz-180 kHz	75 Hz-75 kHz	75 Hz-30 kHz
Baleen whales	Most toothed whales, dolphins	Certain toothed whales, porpoises	All species	All species
Single Pulse: 224 dB SPL 183 dB SEL Multiple Pulse: 120-180 dB RL Not applicable Non-pulses: 120-160 dB RL Not applicable	Single Pulse: 224 dB SPL 183 dB SEL Multiple Pulse: 120-180 dB RL Not applicable Non-pulses: 90-200 dB RL Not applicable	Single Pulse: 224 dB SPL 183 dB SEL Multiple Pulse: Data unavailable Not applicable Non-pulses: 90-170 dB RL Not applicable	Single Pulse: 212 dB SPL 171 dB SEL Multiple Pulse: 150-200 dB RL Not applicable Non-pulses: 100+ dB RL Not applicable	Single Pulse: 109 dB SPL 100 dB SEL Multiple Pulse: Data unavailable Not applicable Non-pulses: 110-120 dB RL Not applicable

* Units of measurement:
Sound Pressure Level, SPL (in water): measured in dB re: 1 μPa (peak) (flat)
Sound Exposure Level, SEL (in water): measured in dB re: 1 μPa^2-s
Sound Pressure Level, SPL (*in air*): measured in dB re: 20 μPa (peak) (flat)
Sound Exposure Level, SEL (*in air*): measured in dB re: $(20\ \mu Pa)^2$-s

Appendix 4 – Generalised maps of marine mammal range and distribution in Irish waters (SEE OVERLEAF)

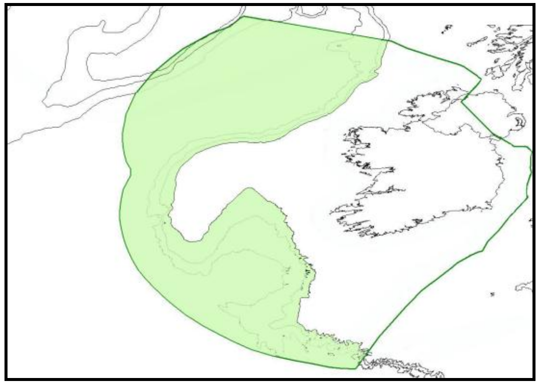
GENERALISED DISTRIBUTION & HABITAT OF CETACEAN SPECIES IN IRISH WATERS

= Cetacean habitat

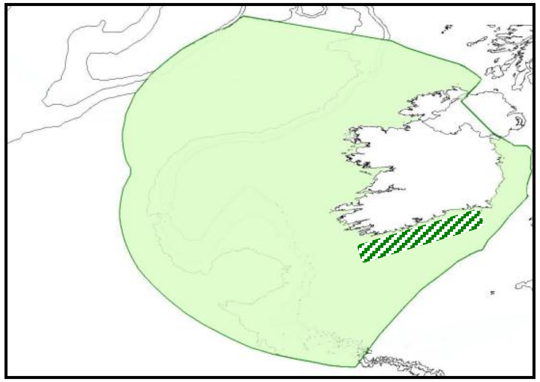
= High number of records

(v) = Vagrant species

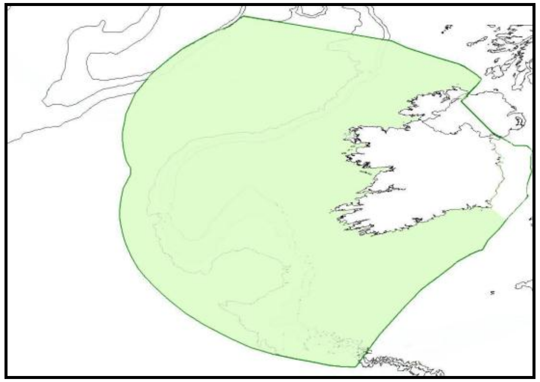
BALEEN WHALE DISTRIBUTION



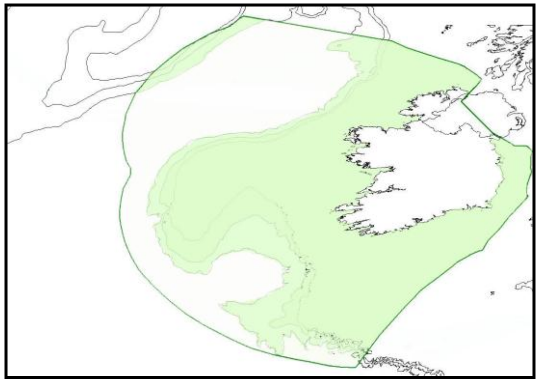
Blue whale



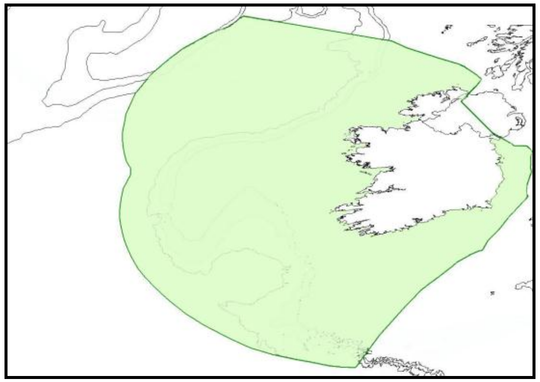
Fin whale



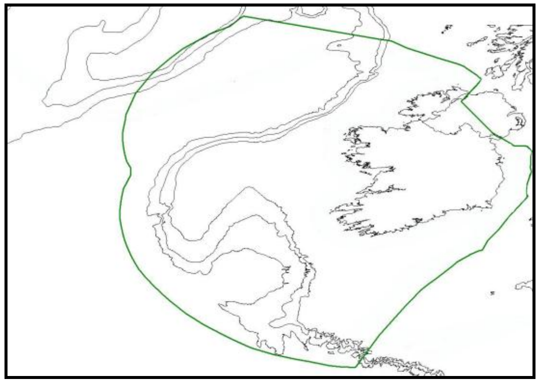
Sei whale



Minke whale

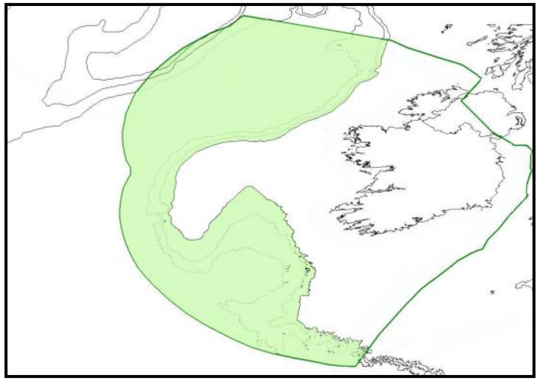


Humpback whale

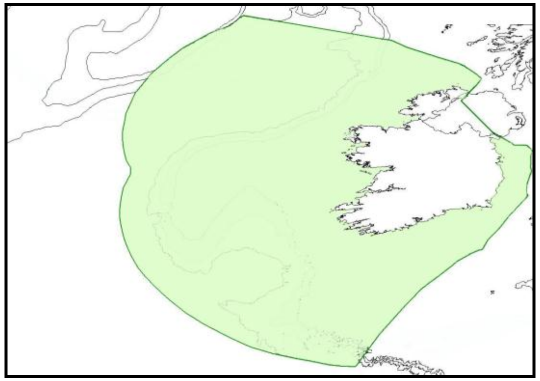


Northern right whale (v)

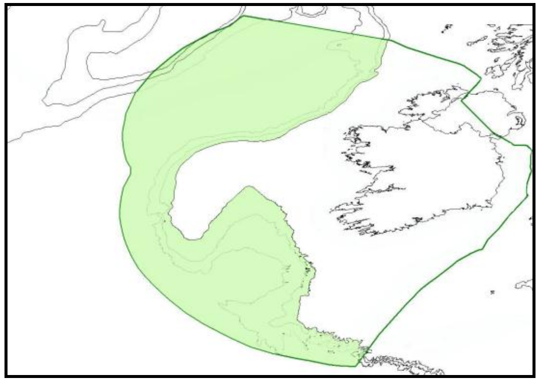
TOOTHED WHALE & DOLPHIN DISTRIBUTION



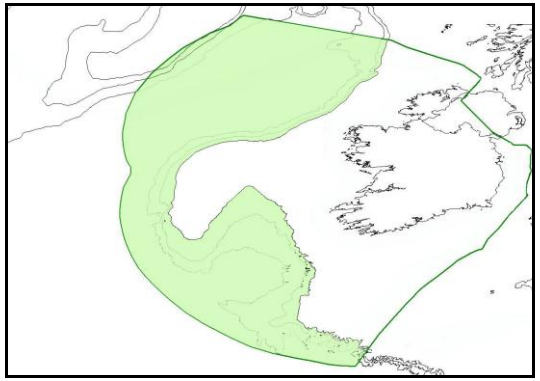
Sperm whale



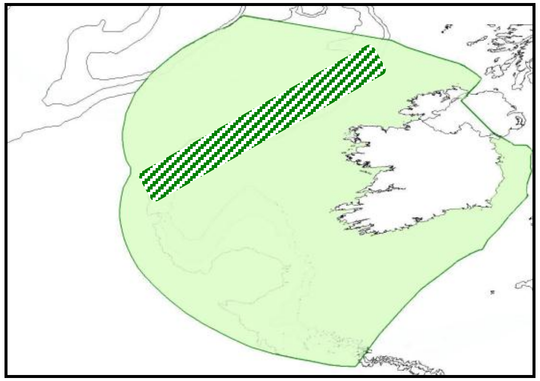
Northern bottlenose whale



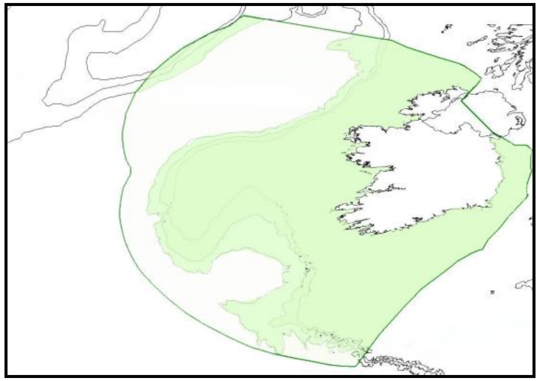
Sowerby's beaked whale



Cuvier's beaked whale

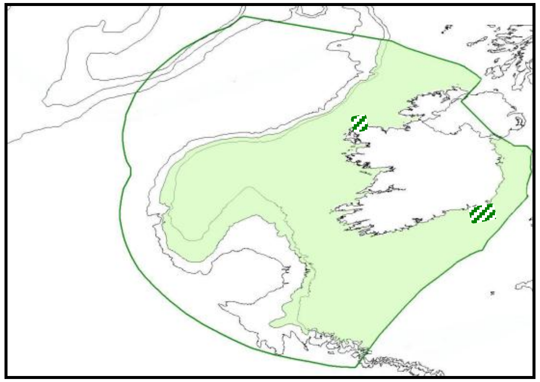


Long-finned pilot whale

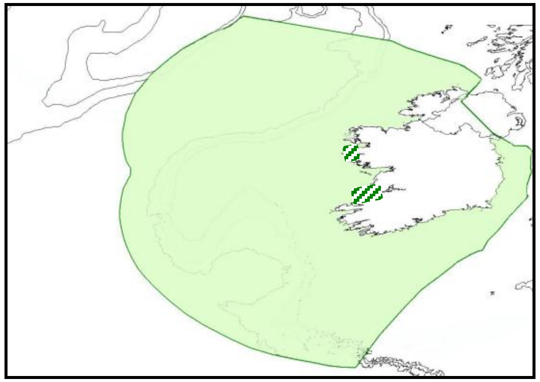


Killer whale

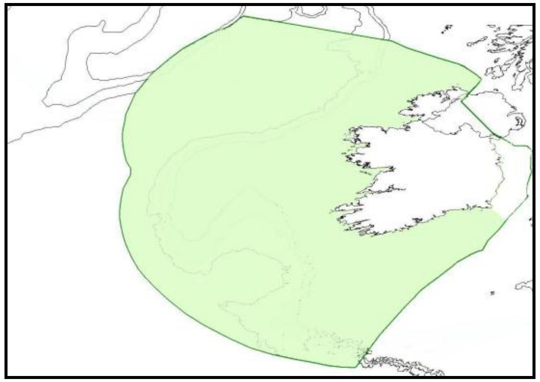
TOOTHED WHALE & DOLPHIN DISTRIBUTION (continued)



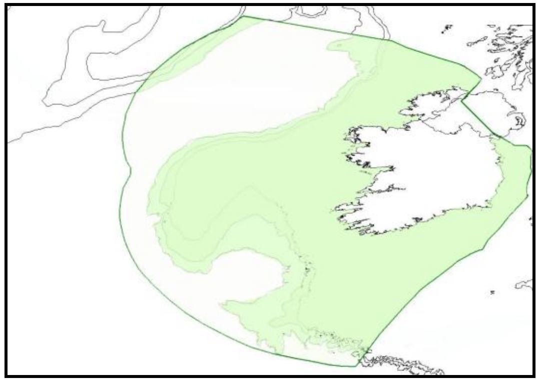
Risso's dolphin



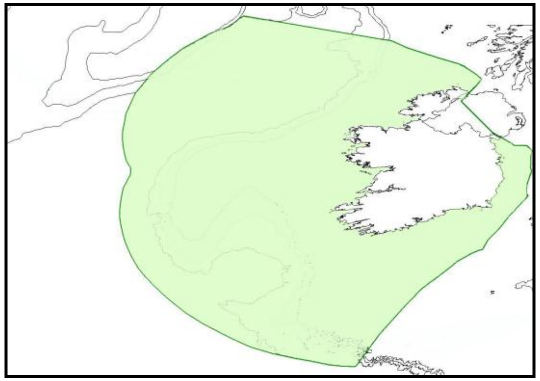
Common bottlenose dolphin



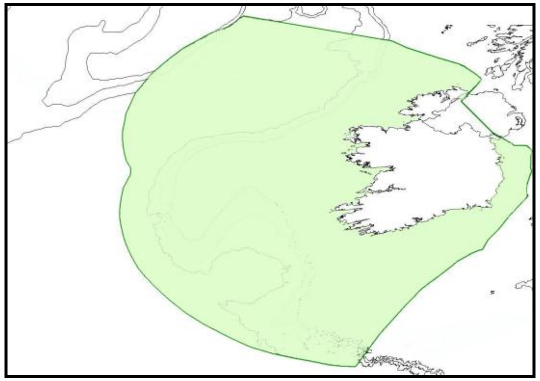
Atlantic white-sided dolphin



White-beaked dolphin

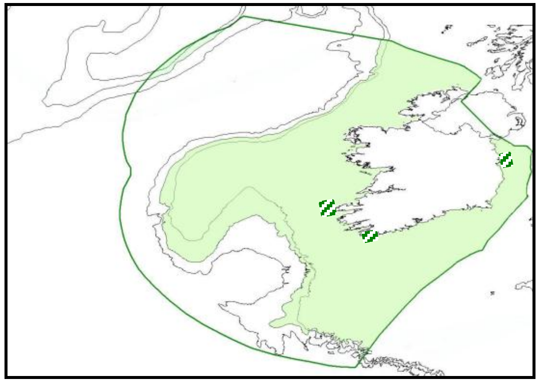


Striped dolphin

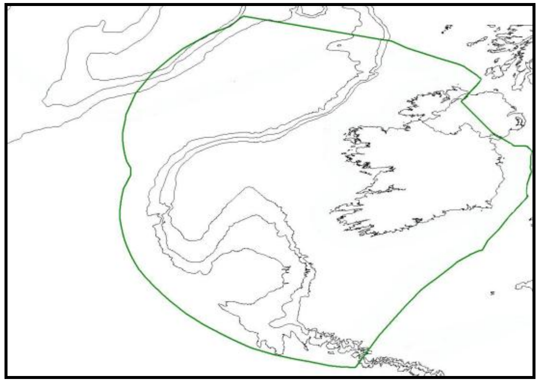


Short-beaked common dolphin

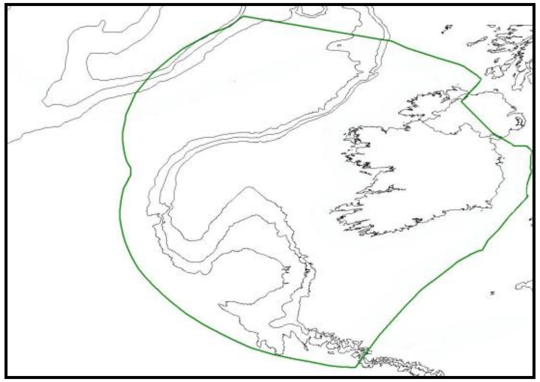
TOOTHED WHALE & DOLPHIN DISTRIBUTION (continued)



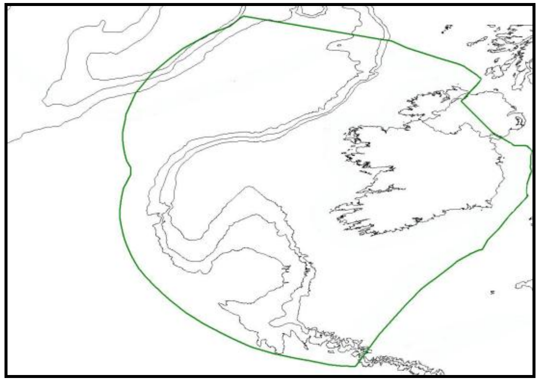
Harbour porpoise



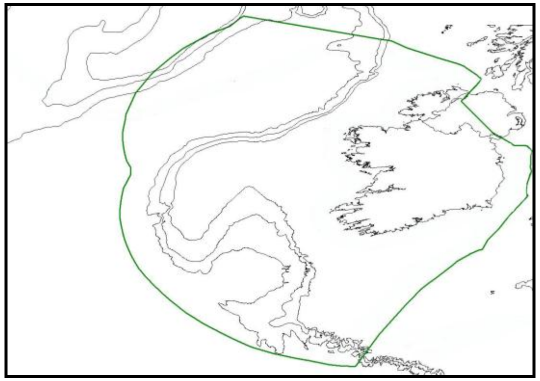
False killer whale (v)



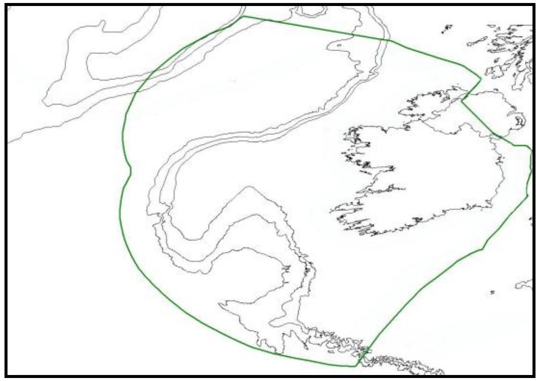
Gervais' beaked whale (v)



True's beaked whale (v)

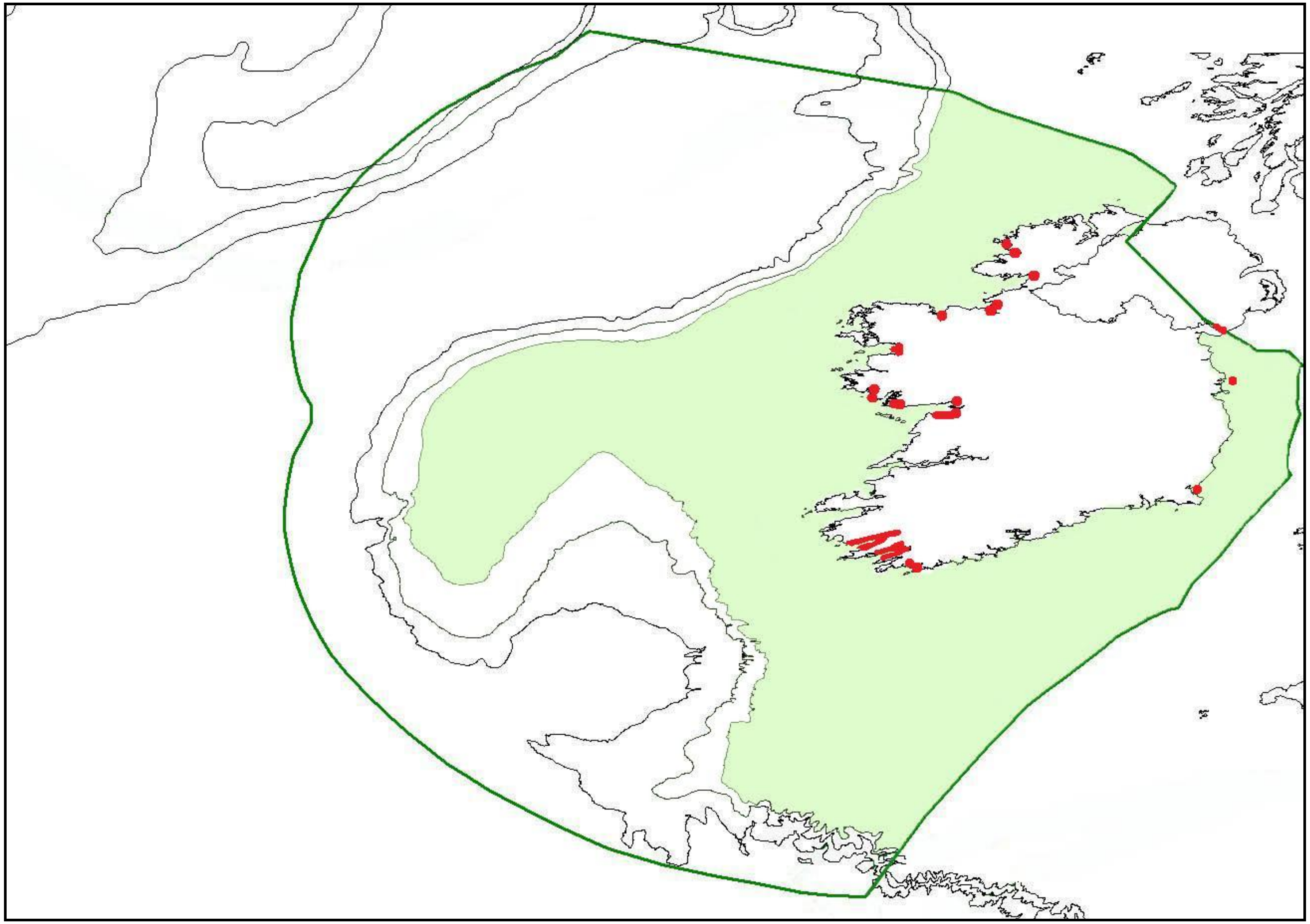


White whale / Beluga (v)

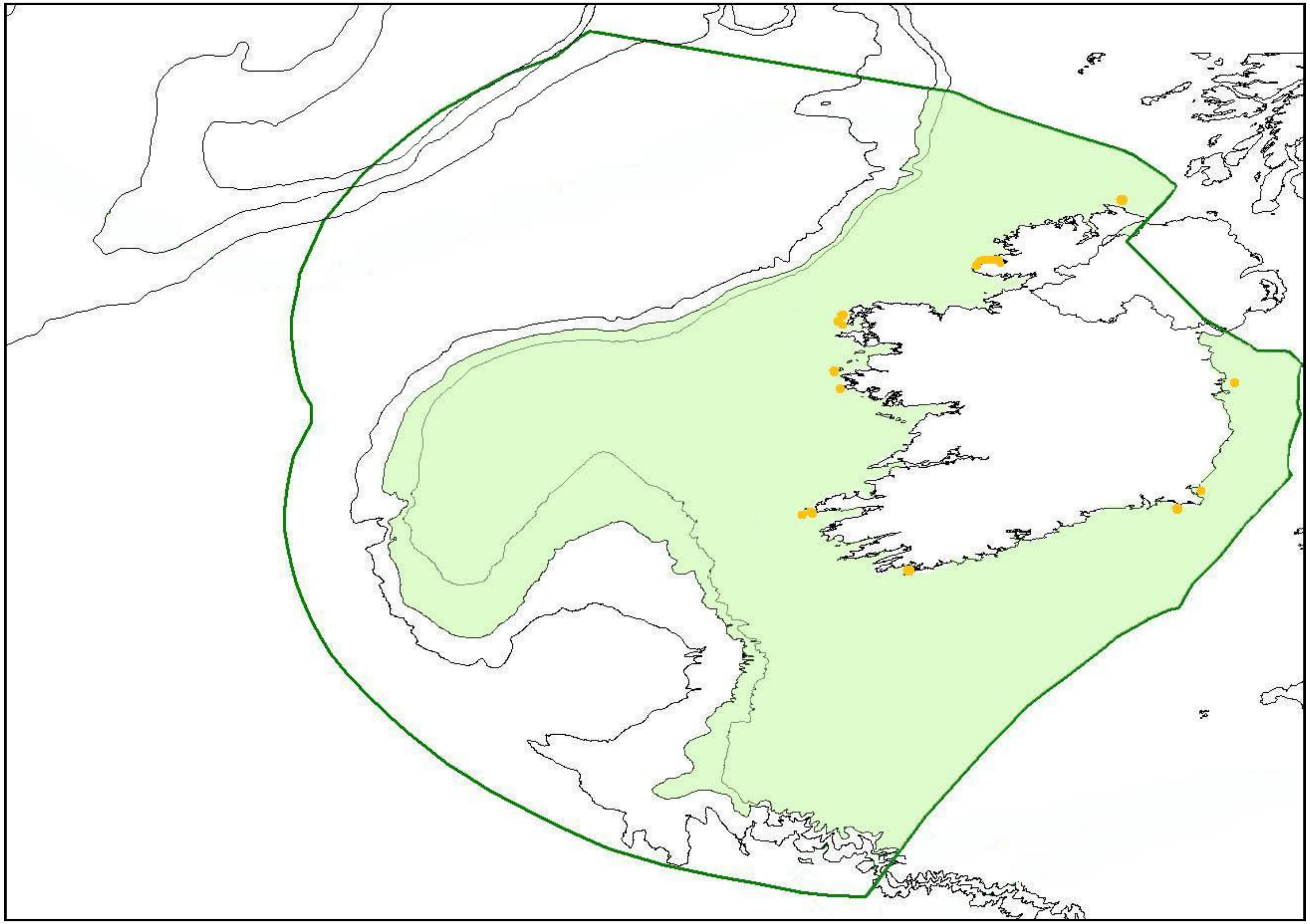


Pygmy sperm whale (v)

GENERALISED DISTRIBUTION & HABITAT OF SEAL SPECIES IN IRISH WATERS



Generalised distribution range (shaded green) postulated for Harbour seal *Phoca vitulina* in the Irish EEZ based on background movement information and knowledge of coastal habitats occupied by the species. Key breeding and non-breeding haul-out locations in Ireland are marked red.



Generalised distribution range (shaded green) postulated for Grey seal *Halichoerus grypus* in the Irish EEZ based on background movement information and knowledge of coastal habitats occupied by the species. Key breeding and non-breeding haul-out locations in Ireland are marked orange.

Appendix 5 – Worked examples of assessment of risk

The following concise examples are for illustrative purposes only. It is envisaged that in reality additional details and factual information would commonly be required, and that supporting information or citations upon which rationales are based would be presented.

SCENARIO 1:	Drilling operation in open marine waters where surveys have recorded cetaceans and seals in the past but the area doesn't appear to represent preferred marine mammal habitat.

3.3.1 General Information

Works profile:	A series of 8 drilled boreholes of the seafloor to prepare for foundation insertion.
Area profile:	The works will be undertaken in a $3km^2$ box in the southern Irish Sea.
Duration:	The proposed works will be undertaken over a three week period in July.

3.3.2 Plans/Projects

Platform(s): The operations will utilise a semi-submersible vessel (details should be provided).

Location(s): Site details (e.g., maps, positional data, depths) for the intended operations should be provided.

Sound source(s): Reported or measured specifications and acoustic characteristics of the sound-producing operations, incl. as a minimum:

- Equipment type: Ship-mounted SeaMaster 80 borehole drilling rig
- Signal type(s) (i.e., aerial/underwater, pulse/non-pulse): Non-pulse
- Acoustic specifications: SPL= 177 dB re 1µPa @ 1m distance from source; 20-300Hz

3.3.3 Marine Mammal Ecology

Details concerning the reported utilisation of the proposed works area and wider region should be presented with supporting information. Further to Section 4.1, site-specific surveys may be required to inform decision-making.

3.3.4 Assessment of Risk

Do individuals or populations of marine mammal species occur within the proposed area?

Bottlenose dolphin, Common dolphin, Harbour porpoise. Humpback whale and Grey seal have been recorded from the proposed works area.

Is the plan or project likely to result in death, injury or disturbance of individuals?

The sound pressure levels of the equipment are considered highly unlikely to cause death to any cetacean or seal. The operating frequencies are at the lower reported auditory range of Bottlenose dolphin, Common dolphin and Harbour porpoise, so it is not likely that these species will be affected in this location.

The proposed activity could theoretically cause injury or disturbance to an individual Grey seal if it was within a couple of metres of the drilling device underwater. However, the species concerned has not been reported to exhibit residency in this location. Therefore, injury or disturbance of individual marine mammals is considered very unlikely.

3.3.5 Mitigation

No mitigation is proposed.

3.3.6 Summary

The proposed works are considered unlikely to present a risk to cetaceans or seals and therefore are not considered to require specific mitigations.

SCENARIO 2: Acoustic survey in a bay where surveys have recorded cetaceans in the past and the area does represent preferred cetacean habitat.

3.3.1 General Information

Works profile: A high resolution sonar survey of the seafloor.

Area profile: The proposed works will be undertaken in a $3km^2$ box in outer [named] Bay on west coast.

Duration: The proposed works will be undertaken over a three week period in June.

3.3.2 Plans/Projects

Platform(s): The survey will utilise a marine survey vessel (details should be provided).

Location(s): Site details (e.g., maps, positional data, depths) for the intended operations should be provided.

Sound source(s): Reported or measured specifications and acoustic characteristics of the sound-producing operations, incl. as a minimum:

- Equipment type: Seasonic ZM 8000
- Signal type(s) (i.e., aerial/underwater, pulse/non-pulse): Pulse
- Acoustic specifications: SPL= 224 dB re 1µPa @ 1 m distance from source; 100-300kHz

- Equipment type: Samron AZ 1000
- Signal type(s) (i.e., aerial/underwater, pulse/non-pulse): Pulse
- Acoustic specifications: SPL= 215 dB re 1µPa @ 1 m distance from source; 30-40kHz

3.3.3 Marine Mammal Ecology

Details concerning the reported utilisation of the proposed works area and wider region should be presented with supporting information. Further to Section 4.1, site-specific surveys may be required to inform decision-making.

3.3.4 Assessment of Risk

Do individuals or populations of marine mammal species occur within the proposed area?

Bottlenose dolphin, Harbour porpoise and Common dolphin have been recorded from the proposed works area.

Is the plan or project likely to result in death, injury or disturbance of individuals?

The sound pressure levels of the equipment are considered unlikely to cause death to any cetacean.

The proposed activity could theoretically cause injury or disturbance to dolphins or porpoises if an animal was within a couple of metres of the transducer. Since the species concerned have been regularly reported in this location, this possibility can't be excluded.

Disturbance of individuals is a possibility and since this is a semi-enclosed bay entrapment of individuals during operations is also a possibility.

Is it possible to estimate the number of individuals of each species that are likely to be affected?

Approximately 200 regularly-occurring porpoise are believed to utilise the area whilst numbers of dolphins are considered to be relatively low. It is not possible to estimate how many are likely to be affected.

Will individuals be disturbed at a sensitive location or sensitive time during their life cycle?

The site is not believed to be a sensitive location for either species of dolphin. Harbour Porpoise are believed to feed and rest at the site but at quite a significant distance from the proposed works area. The time of year proposed for the works coincides with the calving/breeding period for this species.

Are the impacts likely to focus on a particular section of the species' population, e.g., adults vs. juveniles, males vs. females?

The impacts are not likely to focus on a particular section of the population.

Will the plan/project cause displacement from key functional areas?

Whilst Bottlenose dolphin and Common dolphin have been regularly reported from the site, it is not believed to contain key functional areas for these species. Harbour Porpoise are believed to feed and rest at the site but at quite a significant distance from the proposed works area. Displacement is therefore considered unlikely.

How quickly is the affected population likely to recover once the plan/project has ceased?

Given the assessment that displacement is unlikely to occur, the relatively small size of the local populations concerned and the lack of information concerning breeding rates and the wider ecology of these species within this location, it is considered unlikely that any population-level effect will occur.

3.3.5 Mitigation

DAHG recommended guidance for multibeam, single beam, side-scan sonar & sub-bottom profiler surveys in bays, inlets or estuaries will be fully implemented for the duration of the proposed operation.

3.3.6 Summary

The proposed works with the mitigation outlined are considered unlikely to present a risk to cetaceans.

SCENARIO 3: Acoustic survey in a highly sensitive bay where surveys indicate a high degree of residency with the site being utilised for key ecological functions by a relatively small discrete population of cetaceans.

3.3.1 General Information

Works profile: A high resolution sonar survey of the seafloor.

Area profile: The proposed works will be undertaken in a $3km^2$ box in outer [named] Bay on west coast.

Duration: The proposed works will be undertaken over a three week period in June.

3.3.2 Plans/Projects

Platform(s): The survey will utilise a marine survey vessel (details should be provided).

Location(s): Site details (e.g., maps, positional data, depths) for the intended operations should be provided.

Sound source(s): Reported or measured specifications and acoustic characteristics of the sound-producing operations, incl. as a minimum:

- Equipment type: Seasonic ZM 8000
- Signal type(s) (i.e., aerial/underwater, pulse/non-pulse): Pulse
- Acoustic specifications: SPL= 224 dB re 1µPa @ 1 m distance from source; 100-300kHz

- Equipment type: Samron AZ 1000
- Signal type(s) (i.e., aerial/underwater, pulse/non-pulse): Pulse
- Acoustic specifications: SPL= 215 dB re 1µPa @ 1 m distance from source; 30-40kHz

3.3.3 Marine Mammal Ecology

Details concerning the reported utilisation of the proposed works area and wider region should be presented with supporting information. Further to Section 4.1, site-specific surveys may be required to inform decision-making.

3.3.4 Assessment of Risk

Do individuals or populations of marine mammal species occur within the proposed area?

Bottlenose dolphins have been recorded from the proposed works area. The population concerned is known to be comparatively discrete and distinct from other populations of the species in Ireland.

Is the plan/project likely to result in death, injury or disturbance of individuals?

The sound pressure levels of the equipment are considered unlikely to cause death to any cetacean.

The proposed activity could theoretically cause injury or disturbance to Bottlenose dolphin if an animal was within a couple of metres of the transducer. Since the species concerned have been reported to exhibit residency in this location, this possibility can't be excluded.

Is it possible to estimate the number of individuals of each species that are likely to be affected?

The resident population is estimated at 120 animals. It is not possible to estimate how many are likely to be affected.

Will individuals be disturbed at a sensitive location or sensitive time during their life cycle?

The population is known to utilise this location for breeding, resting and feeding. The time of year proposed for the works coincides with the calving/breeding period for this species.

Are the impacts likely to focus on a particular section of the species' population, e.g., adults vs. juveniles, males vs. females?

The impacts are not likely to focus on a particular section of the population.

Will the plan/project cause displacement from key functional areas?

It is possible that displacement will occur from nursery, feeding and resting areas.

How quickly is the affected population likely to recover once the plan/project has ceased?

Given the relatively small size of this discrete population and the lack of information concerning breeding rates and the wider ecology of the species within this location, it is not possible to indicate when if ever the population may recover.

3.3.5 Mitigation

DAHG recommended guidance for multibeam, single beam, side-scan sonar & sub-bottom profiler surveys in bays, inlets or estuaries will be fully implemented for the duration of the proposed operation.

In addition, in light of the particular sensitivity of this location a full exclusion will operate around the vessel conducting the survey. MMOs will remain on permanent watch and a full shut-down will occur if dolphins enter a specified exclusion zone [this could be precautionary or based on case-specific propagation and attenuation data]. Operations will be restricted to daytime hours only to ensure MMOs may conduct their operations.

3.3.6 Summary

The proposed works with the mitigation outlined are considered unlikely to present a risk to cetaceans.

Appendix 6 – Operator and marine mammal observer (MMO) reporting and standard (JIP) data forms for Geophysical Acoustic Surveys.

Statement of Requirements

The Operator and marine mammal observer(s) (MMOs) tasked with monitoring an operator's implementation of the technical guidance and with conducting survey effort for marine mammals in accordance with this guidance, must submit a report to the relevant Regulatory Authority within 30 days of completion of the relevant geophysical acoustic survey. This shall include a daily log concerning the testing and operation of all relevant sound-producing equipment/activities and a record of all marine mammal detections.

Reporting must be carried out as outlined below and must include use of the standard data forms provided herein:

A. Operations Report – contents:

1) Details of the Client/Contractor involved in the plan/project.
2) Details of the Platform/Vessel type(s) participating in the plan/project.
3) The survey reference number supplied by the Regulatory Authority or other statutory body.
4) Date and location of the plan/project.
5) Latitudes, Longitudes or Grid references for the area of operations.
6) Specifications and acoustic characteristics of all sound-producing equipment used (see also section 2.2).
7) For seismic surveys: number and volume of each airgun used and a calculated total volume of the array.
8) A daily log of how and when the sound-producing equipment was used including during ramp-up (soft-start) procedures, where relevant.
9) Information on any technical problems encountered during Pre-start-up procedures, ramp-up (soft-start) procedures or during full scale operation/activity.

B. Marine Mammal Observer Report – contents:

1) Executive Summary – A concise text at the beginning of the report highlighting the MMO work undertaken and summarising in turn:
   (i) all marine mammal detections made during the survey programme;
   (ii) all detections made prior to the commencement of the operation/activity (e.g., before ramp-up);
   (iii) all operational responses to the presence of animals in the area and the associated outcomes;
   (iv) all occurrences of night-time operation/activity, continuation into poor weather and stoppages;
   (v) any and all problems arising during implementation of the prescribed mitigation, and
   (vi) a concluding statement regarding the operational efficacy of the mitigation measures performed.
2) Date and location(s) of the plan/project.
3) Name, address and qualifications of the MMO(s) on the Platform/Vessel.
4) Name of any other Platform/Vessel involved in the operation/activity.
5) Latitudes, Longitudes or Grid references for the area(s) of operations monitored by the MMO.
6) Details of the observation platform used for marine mammal monitoring, including its height above sea level.
7) Details of all sound-producing operations/activities undertaken during the period of survey.
8) Details of monitoring watches conducted for marine mammals.
9) Details of all marine mammal sightings recorded during monitoring watches.
10) Details of all marine mammal sightings recorded outside monitoring watches (e.g., incidental observations), including records from additional personnel on board.
11) Details of any problems encountered during marine mammal monitoring, start-up procedures, ramp-up (soft-start) procedures or during full scale operation/activity.

MARINE MAMMAL RECORDING FORM - COVER PAGE

Regulatory reference number (e.g. DECC no., MMS permit no., OCS lease no., etc.)	**Country**	**Ship/ platform name**
Client	**Contractor**	**Survey type** ☐ site ☐ 4C ☐ 2D ☐ VSP ☐ 3D ☐ WAZ ☐ 4D ☐ other ☐ OBC
Start date	**End date**	

Number of source vessels	**Type of source** (e.g. airguns)	**Number of airguns** (only if airguns used)	**Source volume** (cu. in.)
Source depth (metres)	**Frequency** (Hz)	**Intensity** (dB re. 1µPa or bar metres)	**Shot point interval** (seconds)
Method of soft start ☐ increase number of guns ☐ increase pressure (where permitted) ☐ increase frequency (where permitted) ☐ other			

Visual monitoring equipment used (e.g. binoculars, big eyes, etc.)	**Magnification of optical equipment** (e.g. binoculars)	**Height of eye** (metres)	**How was distance of animals estimated?** ☐ by eye ☐ with laser rangefinder ☐ with rangefinder stick/ calipers ☐ with reticle binoculars ☐ by relating to object at known distance ☐ other
Number of dedicated MMOs	**Training of MMOs** ☐ JNCC approved MMO induction course for UK waters ☐ PSO training course for the Gulf of Mexico ☐ MMO training course for Irish waters ☐ other ☐ none		

Was PAM used? ☐ yes ☐ no	**Number of PAM operators**	
Description of PAM equipment		
Range of PAM hydrophones from airguns (metres)	**Bearing of PAM hydrophones from airguns** (relative to direction of travel)	**Depth of PAM hydrophones** (metres)

MARINE MAMMAL RECORDING FORM - OPERATIONS

Regulatory reference number .... **Ship/ platform name** ....
(e.g. DECC no., MMS permit no., OCS lease no., etc.)

Complete this form every time the airguns are used, including overnight, whether for shooting a line or for testing or for any purpose.
Times should be in UTC, using the 24 hour clock.

Date	**Reason for firing** l = line t = test x = test followed immediately by line	**Time soft start/ ramp-up began**	**Time of full power**	**Time of start of line**	**Time of end of line**	**Time of reduced output** (if relevant)	**Time airguns/ source stopped**	**Time pre-shooting search began**	**Time search ended**	**Time PAM began**	**Time PAM ended**	**Was it day or night in period prior to firing?** d = day n = night w = dawn k = dusk	**Was any mitigating action required?** (yes/ no)

MARINE MAMMAL RECORDING FORM - EFFORT

Regulatory reference number .... **Ship/ platform name** ....
(e.g. DECC no., MMS permit no., OCS lease no., etc.)

Please record the following for all watches, even if no marine mammals are seen.

Start a new line on form if any one of these changes

Date	**Visual watch or PAM** v = visual watch p = PAM	**Observer's/ operator's name(s)**	**Time of start of watch** (UTC, 24hr clock)	**Time of end of watch** (UTC, 24hr clock)	**Start position** (latitude and longitude)	**Depth at start** (m)	**End position** (latitude and longitude)	**Depth at end** (m)	**Speed of vessel** (knots)	**Source activity** f = full power s = soft start r = reduced power (not soft start) n = not active	**Wind direction**	**Wind force** (Beaufort scale)	**Sea state** g = glassy (like mirror) s = slight (no or few white caps) c = choppy (many white caps) r = rough (big waves, foam, spray) or Beaufort sea states (0 - 7+)	**Swell** o = low (< 2 m) m = medium (2-4 m) l = large (> 4 m)	**Visibility** (visual watch only) p = poor (< 1 km) m = moderate (1-5 km) g = good (> 5 km)	**Sunglare** (visual watch only) n = no glare w = weak glare s = strong glare v = variable

MARINE MAMMAL RECORDING FORM - SIGHTINGS

Regulatory reference number (e.g. DECC no., MMS permit no., OCS lease no., etc.)

Ship/ platform name

Sighting number (start at 1 for first sighting of survey)

Acoustic detection number (start at 500 for first detection of survey)

Date

Time at start of encounter (UTC, 24hr clock)

Time at end of encounter (UTC, 24hr clock)

Were animals detected visually and/ or acoustically?

- ☐ visual
- ☐ acoustic
- ☐ both

How were the animals first detected?

- ☐ visually detected by observer keeping a continuous watch
- ☐ visually spotted incidentally by observer or someone else
- ☐ acoustically detected by PAM
- ☐ both visually and acoustically before operators/ observers informed each other

Observer's/ operator's name

Position (latitude and longitude)

Water depth (metres)

Species/ species group

Description (include features such as overall size; shape of head; colour and pattern; size, shape and position of dorsal fin; height, direction and shape of blow)

Bearing to animal (when first seen or heard)

Range to animal (when first seen or heard) (metres)

Total number

Number of adults (visual sightings only)

Number of calves (visual sightings only)

Behaviour (visual sightings only)

Direction of travel (relative to ship)

- ☐ towards ship
- ☐ away from ship
- ☐ parallel to ship in same direction as ship
- ☐ travelling in opposite direction to ship
- ☐ crossing ahead of ship
- ☐ variable
- ☐ milling
- ☐ other

Direction of travel (compass points)

- ☐ N
- ☐ NE
- ☐ E
- ☐ SE
- ☐ S
- ☐ SW
- ☐ W
- ☐ NW
- ☐ variable

Airgun (or other source) activity when animals first detected

- ☐ full power
- ☐ not firing
- ☐ soft start
- ☐ reduced power (other than soft start)

Airgun (or other source) activity when animals last detected

- ☐ full power
- ☐ not firing
- ☐ soft start
- ☐ reduced power (other than soft start)

Closest distance of animals from airguns (or other source) (metres)

Time of closest approach (UTC, 24hr clock)

If seen during soft start give:

First distance **Closest distance** **Last distance**

during soft start (metres)

What action was taken?
(according to requirements of guidelines/ regulations in country concerned)

- ☐ none required
- ☐ delay start of firing
- ☐ shut-down of active source
- ☐ power-down of active source
- ☐ power-down then shut-down of active source

Length of power-down and/ or shut-down (if relevant) (length of time until subsequent soft start, in minutes)

Estimated loss of production (if relevant) due to mitigating actions (km)

Appendix 7 – Operator and marine mammal observer (MMO) reporting and standard data forms for other Coastal/Marine Works.

Statement of Requirements

The Operator and marine mammal observer(s) (MMOs) tasked with monitoring an operator's implementation of the technical guidance and with conducting survey effort for marine mammals in accordance with this guidance, must submit a report to the relevant Regulatory Authority within 30 days of completion of the relevant coastal/marine plan or project. This shall include a daily log concerning the testing and operation of all relevant sound-producing equipment/activities and a record of all marine mammal detections.

Reporting must be carried out as outlined below and must include use of the standard data forms provided herein:

A. Operations Report – contents:

1) Details of the Client/Contractor involved in the plan/project.
2) Details of the Platform/Vessel type(s) participating in the plan/project.
3) The works reference number supplied by the Regulatory Authority or other statutory body.
4) Date and location of the plan/project.
5) Latitudes, Longitudes or Grid references for the area of operations.
6) Specifications and acoustic characteristics of all sound-producing equipment used (see also section 2.2).
7) A daily log of how and when the sound-producing equipment was used including during ramp-up (soft start) procedures, where relevant.
8) Information on any technical problems encountered during start-up procedures, ramp-up (soft-start) procedures or during full scale operation/activity.

B. Marine Mammal Observer Report – contents:

1) Executive Summary – A concise text at the beginning of the report highlighting the MMO work undertaken and summarising in turn:
   (i) all marine mammal detections made during the programme of works;
   (ii) all detections made prior to the commencement of the operation/activity (e.g., before ramp-up);
   (iii) all operational responses to the presence of animals in the area and the associated outcomes;
   (iv) all occurrences of night-time operation/activity, continuation into poor weather and stoppages;
   (v) any and all problems arising during implementation of the prescribed mitigation, and
   (vi) a concluding statement regarding the operational efficacy of the mitigation measures performed.
2) Date and location(s) of the plan/project.
3) Name, address and qualifications of the MMO(s) on the Platform/Vessel.
4) Name of any other Platform/Vessel involved in the operation/activity.
5) Latitudes, Longitudes or Grid references for the area(s) of operations monitored by the MMO.
6) Details of the observation platform used for marine mammal monitoring, including its height above sea level.
7) Details of all sound-producing operations/activities undertaken during the period of works.
8) Details of monitoring watches conducted for marine mammals.
9) Details of all marine mammal sightings recorded during monitoring watches.
10) Details of all marine mammal sightings recorded outside monitoring watches (e.g., incidental observations), including records from additional personnel on board.
11) Details of any problems encountered during marine mammal monitoring, start-up procedures, ramp-up (soft-start) procedures or during full scale operation/activity.

DATA FORM FOR COASTAL/MARINE WORKS - RECORD OF OPERATION/ACTIVITY

Platform name:.................................. Platform type:.................................. Client: .... Contractor:.................................. MMO:..................................

Complete this form every time the sound-producing operation or activity (e.g., drilling, pile driving, blasting) occurs including overnight, whether for testing, full operation or any other purpose.

Type of operation or activity	Date	Sound-producing operation or activity			Pre-Start Monitoring effort for marine mammals					Action necessary		
		Time when ramp-up/soft-start began [if any]	Time when equipment reached full power	Time when equipment stopped or shut down	Who carried out the monitoring for marine mammals?	Start time of monitoring for marine mammals [Pre-start-up]	End time of monitoring for marine mammals	Reason for non-detection of marine mammals?	Were hydro-phones used?	Were marine mammals present in the 30/60 mins before start-up?	If Yes, give time when marine mammals were last seen	If marine mammals were present, what action was taken?
Dredging, Drilling, Pile driving, Blasting, other	(dd/mm/yyyy)	(GMT/UTC)	(GMT/UTC)	(GMT/UTC)	(Job Title)	(GMT/UTC)	(GMT/UTC)	(e.g. sea state, swell, glare, poor light, fog, rain, etc.)	(Yes/No)	(Yes/No)	(GMT/UTC)	(e.g., delay ramp-up/soft start, delay full start-up)

DATA FORM FOR COASTAL/MARINE WORKS – RECORD OF MONITORING EFFORT

Location:.................................... **Platform name:**.................................... **Platform type:**.................................... **Client:** .... **MMO(s):**..

....

Please record the following information every day (as many lines per day as you wish), even if no marine mammals are seen.

Type of operation or activity Dredging, Drilling, Pile driving, Blasting, other	**Date** (dd/mm/yyyy)	**Marine Mammal Observer** (name/initials)	Time you began monitoring for marine mammals (GMT/UTC)	Time you stopped monitoring for marine mammals (GMT/UTC)	Duration of monitoring watch (minutes)	Duration of the sound-producing operation/activity while you were monitoring for marine mammals (minutes)	Start Lat/Long position (if static/moving)	End Lat/Long position (if moving)	Wind direction & Beaufort wind force (e.g., SW 2)	Sea State (WMO) (0 to 9)	Swell height Choose from: 0 = no Swell L = 0-1 m M = 1-2 m H = 2+ m	Visibility Choose from: P = < 1 km M = 1-5 km G = 5-10 km H = >10 km

DATA FORM FOR COASTAL/MARINE WORKS - MARINE MAMMAL SIGHTING RECORDS

Options in italics should be circled or underlined as appropriate. Complete 1 record per sheet.

Operation/Activity (please tick)	**Dredging**	**Drilling**	**Pile Driving**	**Blasting**	**Other** (specify)

Date (dd/mm/yyyy)	**Time** (Local)	**Time** (GMT/UTC)	**Sighting Record no.**

How did this sighting occur? (please tick)

While you were keeping a continuous watch for marine mammals ___

Spotted incidentally by you or someone else ___

Other (please specify) ___

Details:..

Platform type & name (e.g. ship, rig, headland)	**Observer's name**

Observer's position (Latitude/Longitude or 6-figure Grid reference)	**Water depth** (metres) (if available)

Species recorded	**Certainty of identification** (underline) *Definite / probable / possible*

Total number of animals (best estimate)	**No. of adults**	**No. of juveniles**	**No. of calves**

Maximum number (estimated total)	**Minimum number** (estimated total)

Description (include features such as overall size; shape of head; position, shape and size of dorsal fin; colour and patterning; height, direction, shape of blow)	**Photograph or video taken** *Yes / No*
	Direction of travel of animals in relation to platform/vessel (draw arrow) 

Behaviour	**Direction of travel of animals** (compass points or degrees)

Activity of platform/vessel	**Operation/activity under way** (when animals first seen) *Yes / No / Pre-Start watch*	**Closest distance of animals from platform/vessel** (metres) (Record even if not operating)