GDG
GAVIN & DOHERTY
GEOSOLUTIONS

Allod Energy Ltd Risk Assessment for Annex IV Species (RAAIVS) for Geophysical Marine Site Investigation Activities

Allód
HYDROGEN
STORAGE

Client	**Allod Energy Ltd.**
Document Ref.	24084-REP-004-00
Project Title	Allód Geophysical marine SI activities
Date	17/09/2024

Project Title:	Allód Geophysical marine SI activities
Report Title:	Allod Energy Ltd Risk Assessment for Annex IV Species (RAAIVS) for Geophysical Marine Site Investigation Activities
Document Reference:	24084-REP-004-00

Client:	Allod Energy Ltd.
Ultimate Client:	Allod Energy Ltd.
Confidentiality	Non Confidential

REVISION HISTORY

Rev	Date	Reason for Issue	Originator	Checker	Reviewer	Approver
00	13/08/2024	Draft for client review	[redacted]			
01	17/09/2024	Amendments to client comments				

DISCLAIMER

Gavin & Doherty Geosolutions Ltd. (GDG) has prepared this report for the sole use of Allod Energy Ltd. (hereafter the "Client") in accordance with the terms of a contract between the Client and GDG. No other warranty, express or implied, is made as to the professional advice contained in the report or any other services provided by GDG. Non Confidential GDG assumes no liability or duty of care to any third party in respect of or arising out of or in connection with this report and/or the professional advice contained within.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

ADD	Acoustic deterrent device
AIMU	Assessment of Impact on the Maritime Usage
CETS	Cumulative Effects Temporal Scope
CESS	Cumulative Effects Spatial Scope
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DAHG	Department of Arts, Heritage and the Gaeltacht
DCENR	Department of Communications, Energy and Natural Resources
DCCAE	Department of Communications, Climate Action and Environment
DHLGH	Department of Housing, Local Government and Heritage
EPS	European Protected Species
EU	European Union
GDG	Gavin & Doherty Geosolutions Ltd.
GPS	Global Positioning System
ICRW	International Convention for the Regulation of Whaling
IWDG	Irish Whale and Dolphin Group
JNCC	Joint Nature Conservation Committee
LSE	Likely Significant Effect
MAP	Maritime Area Planning
MBES	Multibeam Echosounder
MMO	Marine Mammal Observer
MUL	Maritime Usage Licence
NPWS	National Parks and Wildlife Service

ORESS	Offshore Renewable Support Scheme
PAM	Passive Acoustic Monitoring
QI	Qualifying Interest
RAAIVS	Risk Assessment for Annex IV Species
SAC	Special Area of Conservation
SBP	Sub-Bottom Profiling
SISAA	Supporting Information for Screening for Appropriate Assessment
SSS	Side Scan Sonar
USBL	Ultra-Short Baseline

1 INTRODUCTION

1.1 BACKGROUND

Gavin and Doherty Geosolutions (GDG) have been commissioned by Allod Energy Ltd (the applicant) to undertake an Annex IV Risk Assessment in support of an application for a Maritime Usage Licence (MUL) under the Maritime Area Planning Act (2021) to undertake marine geophysical site investigations, with the objective of assessing an area in the Celtic Sea for potential hydrogen storage. The investigations look to define the extent and internal character of halite rock beneath the seafloor to assess and de-risk potential suitability for hydrogen storage development within the halite. This Article 12 Assessment has been prepared to further assess the impacts of the proposed works on species listed under Annex IV of the Habitats Directive.

The Licence Application Area comprises the proposed indicative survey area, which includes the anticipated turning circle of the vessel. The distance from the indicative survey area to the nearest landfall is 65 km. The total Maritime Licence Application Area covers 1481 km2 (148,100 ha) and lies within a water column depth ranging from 70 to 125 metres.

This report should be read in conjunction with the Supporting Information for Screening for Appropriate Assessment (SISAA) document (document number 24084-REP-002) and Assessment of Impacts on the Maritime Usage (AIMU) document (document number 24084-REP-001) accompanying this Application.

1.2 PROPOSED ACTIVITIES AND LOCATION

The objective of the proposed Allód survey activities is to undertake geophysical marine site investigation activities to assess an area in the Celtic Sea for potential hydrogen storage. Seismic surveys offer a detailed, volumetric image of the geological formations, including the shape and size of subsurface features that is critical for accurate resource assessment and development planning. The proposed investigations look to define the extent and internal character of halite rock beneath the seafloor to assess and de-risk potential suitability for hydrogen storage development in halite. This document has been prepared in support of the MUL Application.

It must be noted that this proposal is solely for the purpose of surveying and will not involve the construction of any temporary or permanent infrastructure. Furthermore, the investigative survey works are planned to take place only within the indicative survey area shown below (Figure 1.1).

1.2.1 SITE LOCATION

The MUL application area spans a total of 1481 km² (148,100 hectares), encompasses the proposed survey area, and lies within a water column depth ranging from 74.43 to 124.25 metres. This area accounts for the potential length and width of streamers that may be used during the survey, as well as the anticipated turning radius of the vessels involved. – see Figure 1.1.

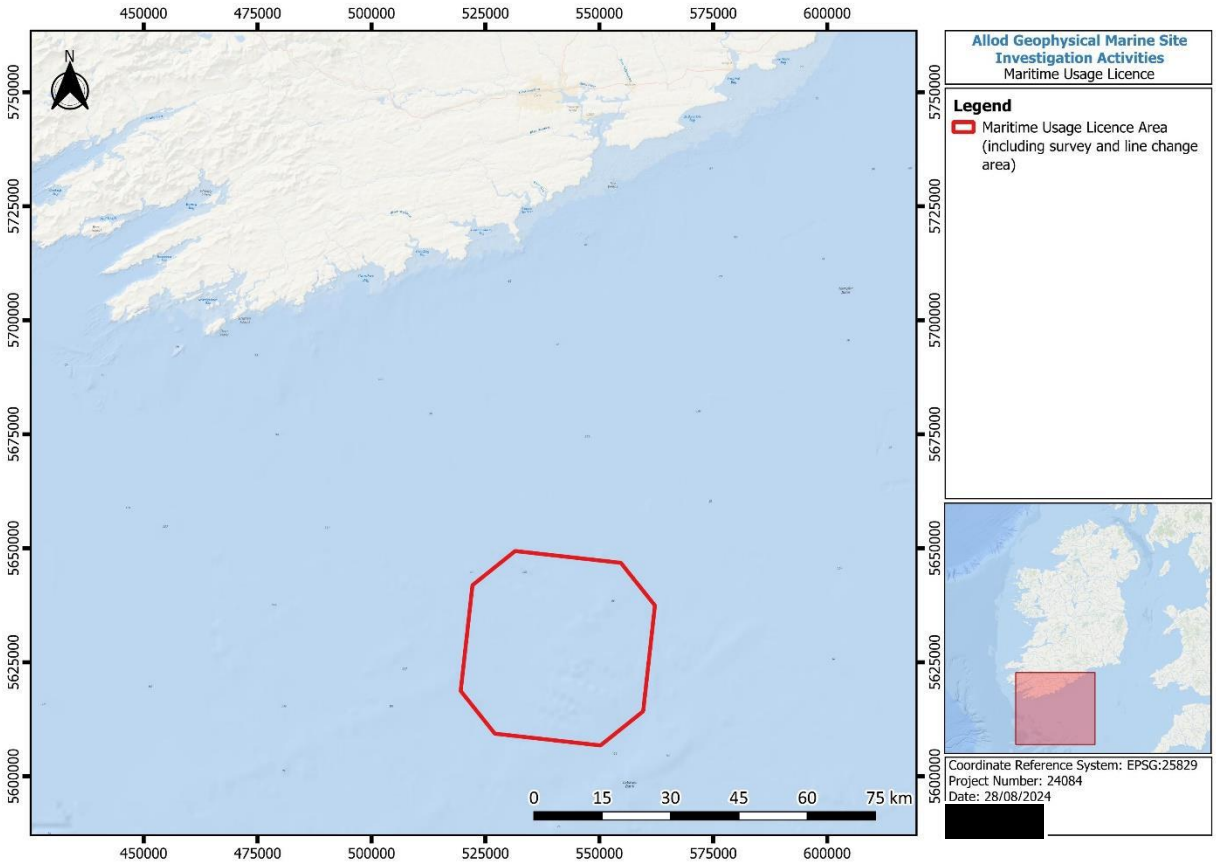

Figure 1.1 Site Location. The redline indicates the survey area.

1.2.2 SURVEY SCHEDULE

The intention is to begin survey activities as soon as practicable following license award, allowing for a tender process, vessel availability and anticipated suitable weather conditions (April to September). It is the intent to acquire all data within a single survey campaign, which is planned to last for a short period of approximately 3 weeks; however, weather or vessel and equipment availability may dictate a staged programme of surveying over the licence duration. The approximate durations of each of the survey activities are provided in Table 2-3 in Section 2.2 of the AIMU document accompanying this application. The exact mobilisation dates for the survey will not be known until the process of procuring survey contractors is complete.

Timing of the site investigation activities is dependent on many factors including weather, availability of vessels and the grant of a licence but is anticipated to be within the months of April to September. The granting of a licence will have a direct effect on the timing of site investigation activities; therefore, two theoretical survey schedules (see Table 1.1) are presented to support the MUL Application

Table 1.1 Proposed survey schedules (ideal and licence timing/weather impacted scenarios) to carry out geophysical marine site investigations in the Celtic Sea.

Schedule 1 – Ideal Scenario	
November 2024	MUL granted
December 2024	Tender process
January 2025	Contractor Award
May 2025	Vessel mobilised
June 2025	Vessel demobilised; data acquisition complete
June 2026	3D data processing complete, ready for evaluation
August 2026	Commencement of desktop data evaluation
August 2027	Assessment/Desk studies complete
Survey Schedule 2 – Licence Timing/Weather Impacted Scenario	
January 2025	MUL granted
February 2025	Judicial Review required
February 2026	Judicial Review finalised, MUL upheld
February 2026	Tender process
March 2026	Contractor Award
May 2027	Vessel mobilised (in the event of no availability 2026)
June 2027	Vessel demobilised; data incomplete due to bad weather conditions
May 2028	Vessel re-mobilised for survey completion

June 2028	Vessel demobilised; data acquisition complete
June 2029	3D data processing complete
August 2029	Commencement of desktop data evaluation
December 2029	Unexpected hazards/anomalies/environmental constrains identified requiring further surveying
May 2030	Smaller survey targeting unexpected potential hazards/anomalies/ environmental assessments
December 2030	Additional data processing complete
December 2031	Assessment/Desk studies complete

1.2.3 PROPOSED SI ACTIVITIES

Marine seismic surveys usually employ airgun arrays towed behind vessels, which emit high-intensity, low-frequency impulsive sounds at regular intervals. The airgun arrays are comprised of metal cylinders which released compressed air into the water. The release of the compressed air creates a bubble, which then collapses (bursts) creating a sound. These sounds are designed to be directed down towards the substrate and are used to generate detailed images of the seafloor and its underlying geological formations (Gausland, 2003; McCauley *et al*., 2000).

The proposed survey will involve the following equipment:

- 15m x 15m array of approximately 40 small airguns with a combined volumetric capacity of c. 4500 cubic inches (cu.in.)
- 10 streamers (each 8km in length, spaced 100m apart, giving a total width of 1km and total length of 8km)
    - Over 10,000 hydrophones encased within the streamers
- Up to 500 Ocean Bottom Nodes (OBN's) on the seabed (if deployed)
    - Placed on the seabed using a Remotely Operated Vehicle (ROV)
    - Remain on the seabed whilst the survey vessel sails a predetermined survey pattern.
- Multibeam Echosounders (MBES).
- Ultra-Short Baseline (USBL).

- Sub-Bottom Profiling (Boomer, Sparker, Parametric Pinger).
- Side Scan Sonar (SSS).
- Magnetometer.

The proposed programme of site investigations (SI) to be undertaken within the MUL area is described in detail in the Programme of Works section of the AIMU document accompanying this Application. The exact technical specifications of the equipment to be used will not be known until the survey contracts have been awarded. However, a description of typical equipment and expected survey parameters is provided in the Programme of Works section of the AIMU (Appendix A).

If the MUL application area SI activities, together with desktop studies and stakeholder engagement, indicates the feasibility of developing hydrogen storage, the project will be progressed at that point in accordance with the National Marine Planning Framework and other relevant legislation. This MUL application is for consent to conduct SI activities and should not be confused with a Maritime Area Consent (MAC) application for planned development consent, which would be subject to the Maritime Area Planning Act 2021 (MAPA) and the Planning and Development Act, 2000-2021. This is not a MAC application for a planned development.

1.2.4 PROPOSED VESSEL

As detailed in Appendix A of the the AIMU document accompanying this application, geophysical survey vessels are typically between 90 m and 130 m in length and have an endurance of up to 120 days. These vessels are large and designed to operate all year round. Depending on the previous contract and weather conditions, the survey vessel may use a local port for mobilisation. It will utilise support vessels for replenishment and support vessels or helicopter for crew transfer if required.

The exact vessels to be used will be confirmed following a tender process to procure the survey contractor. All vessels will be fit for purpose, certified, and capable of safely undertaking all required survey work. The survey contractor and vessels will comply with international and national statute as appropriate, as listed in Appendix A of the AIMU.

1.3 AIM OF THIS REPORT

A RAAIVS Report is prepared to evaluate the potential impacts of proposed projects or activities on species listed under Annex IV of the European Union (EU) Habitats Directive (Directive 92/43/EEC). This report supports the MUL application process and includes information to inform the risk assessment for Annex IV species (RAAIVS), which includes the Qualifying Interests (QI) of Special Areas of Conservation (SACs).

The report aims to provide the necessary information to the competent authorities to assist them in making an informed decision on whether the proposed activities remove the system of strict protection established for Annex IV species, whether a derogation licence is required, and if so, whether the criteria for derogation are met.

The primary purpose of a RAAIVS Report is to ensure that any planned development or activity complies with the stringent protection measures mandated by the Habitats Directive by prohibiting actions that could cause those species to decline in the wild or which would impair their chances of successful breeding. Disturbance during breeding, migration or hibernation can have a detrimental effect on species survival. The measures taken to protect individual species must relate to the threats experienced by that species, within its natural range.

It should be noted, other non-Annex IV species such as the phocid species, Grey Seal (*Halichoerus grypus*) and Harbour (Common) seal (*Phoca vitulina*), and potential impacts from this Proposed Project have been assessed in the accompanying AIMU report and SISAA report to ensure no adverse effects occur to any protected species that have been identified within the MUL area. Furthermore, basking sharks (*Cetorhinus maximus*) are not an Annex IV listed species although they are legally protected under Section 23 of Ireland's Wildlife Act since October 2022. Basking sharks are considered within the AIMU report which accompanies this MUL application.

Within this report, the term **No Likely Significant Effect (LSE)** will be used where the proposed activities, or a specified source of impact from the proposed activities, are not likely to have a significant effect on a Natura 2000 site.

1.4 LEGISLATIVE AND REGULATORY CONTEXT

1.4.1 INTERNATIONAL DIRECTIVES

As directed by Article 12 of the Habitats Directive (Directive 92/43/EEC), species listed in Annex IV are considered species of community interest in need of strict protection across their entire natural range within the EU, both within and outside Natura 2000 sites. In addition to cetaceans, other European Protected Species (EPS) occurring in Irish waters are the Eurasian otter (*Lutra lutra*), leatherback turtle (*Dermochelys coriacea*) and loggerhead turtle (*Caretta caretta*).

The Habitats Directive has been transposed into Irish 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.

These Regulations provide for the strict protection of Annex IV listed species, including all cetaceans, in their natural range. As such, it is an offence to:

- Deliberately capture or kill any specimen of these species in the wild;
- Deliberately disturb these species particularly during the period of breeding, rearing, hibernation and migration;
- Deliberately take or destroy eggs of those species from the wild;
- Damage or destroy a breeding site or resting place of such an animal; or
- Keep, transport, sell, exchange, offer for sale or offer for exchange any specimen of these species taken in the wild, other than those taken legally as referred to in Article 12(2) of the Habitats Directive.

'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', as follows:

"'Deliberate' actions are to be understood as actions by a person who knows, in light of the relevant legislation that applies to the species involved, and the general information delivered to the public, that his action will most likely lead to an offence against a species, but intends this offence or, if not, consciously accepts the foreseeable results of his action".

Therefore, anyone carrying out an activity which they should reasonably have known could cause injury as defined in the Regulations, could be committing an offence.

Under Article 16 of the Habitats Directive, a derogation licence may be granted by the Minister, which would allow otherwise illegal activities to go ahead provided that:

- There is no satisfactory alternative; and,
- The action authorised will not be detrimental to the maintenance of the population of the species concerned at a Favourable Conservation Status in their natural range.

In addition, Ireland is also signatory to conservation agreements such as the Bonn Convention on Migratory Species (1983), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Berne Convention on Conservation of European Wildlife and Natural Habitats (1979), the OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic (1992) and the International Convention for the Regulation of Whaling (ICRW). Cetaceans are also provided protection under the Whale Fisheries Act 1937.

1.4.2 GUIDANCE

In 2007, the National Parks and Wildlife Service (NPWS) of the Department of Arts, Heritage and the Gaeltacht (DAHG) published 'Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters' DAHG, 2014).

This DAHG (2014) guidance recommends that listed coastal and marine activities, including geophysical acoustic surveys, undergo a risk assessment for anthropogenic sound-related impacts on relevant protected marine mammal species to address any area-specific sensitivities, both in temporal and spatial extent, and to inform the consenting process.

GDG understand the DAHG (2014) guidance is currently under review; any updated Irish government guidance published to replace the DAHG (2014) guidance by the time the proposed activities are to be undertaken will be considered during the proposed surveys.

1.5 STATEMENT OF AUTHORITY

The report has been completed by [redacted] (BSc. (Hons) Marine Sciences, International MSc. (Hons) Marine Biological Resources). [redacted] is an Oceanographer and Marine Mammal Ecologist, specialised in Marine Conservation and Applied Megafauna Conservation. Her research is mainly focused on animal behaviour, telemetry and bioacoustics, working with international teams and being involved in European projects (SeaMonitor, STRAITS). She is also a JNCC certified Marine Mammal Observer (MMO), and currently works for GDG preparing marine licences and environmental assessments.

This report has been checked by [redacted] (BSc. (Hons) Marine Sciences. [redacted] is a Marine Ecologist and Ornithologist with experience in terrestrial, aquatic and marine/coastal ecology and is a trained Marine Mammal Observer (MMO). Her current work includes ecological and environmental desktop studies for terrestrial, aquatic and marine environments, specialised mammal surveys, ornithological surveys, and map preparation.

This report has been reviewed by [redacted] (BSc. Hons Biology, MSc. Applied Environmental Science, Chartered Environmentalist). [redacted] is Head of the Offshore and Marine Advisory Team at GDG and an experienced environmental professional, who previously held scientific and regulatory roles within the Scottish Government Directorate of Marine Scotland. He has undertaken multiple environmental assessments under both the Habitats and Environmental Impact Assessment Directives for GDG and as a regulator with Marine Scotland.

This report has been approved by [redacted] (BSc. Hons Marine Science, MSc. Engineering in the Coastal Environment). [redacted] is a Marine Ecologist with coastal engineering expertise and extensive experience of offshore benthic survey and Marine Protected Area monitoring who has undertaken multiple environmental assessments under the Habitats Directive for GDG and as a statutory adviser to the UK government and its devolved administrations with the Joint Nature Conservation Committee.

2 BASELINE INFORMATION

Irish waters are home to and refuge for several Annex IV species including at least twenty-six (26) species of cetaceans (IWDG, accessed June 2024 online), five (5) out of the seven (7) known species of sea turtles and the Eurasian otter.

This report addresses marine species listed under Annex IV of the Habitats Directive which are known to occur in Irish waters and are identified as being relevant to the proposed activities.

2.1 RELEVANT ANNEX IV SPECIES

All relevant species listed under Annex IV with the potential to be impacted by the proposed SI works are included in this assessment, including those separately assessed in the AA process.

Annex IV species are those of European Community interest that require strict protection due to their vulnerability, rarity, or declining populations. All species listed under Annex IV of the Habitats Directive with the potential to be impacted by the proposed works have been considered in this report, including species assessed in the SISAA report which accompanies this application.

All species of cetacean (whales, dolphins and porpoises) occurring in EU waters are considered EPS under Annex IV of the Habitats Directive. Marine turtles, such as leatherback turtle and loggerhead turtle are also listed under Annex IV of the Habitats Directive.

Of the animal and plant species listed as Annex IV known to occur in Ireland[1] , the following Annex IV species were identified as relevant (known to occur in the MUL area) to the proposed development:

- Cetacean species; and
    - Common dolphin (*Delphinus delphis*)
    - Common bottlenose dolphin (*Tursiops truncatus*)
    - Risso's dolphin (*Grampus griseus*)
    - Killer whale (*Orcinus orca*)
    - Common minke whale (*Balaenoptera acutorostrata*)
    - Fin whale (*Balaenoptera physalus*)
    - Humpback whale (*Megaptera novaeangliae*)
    - Long-finned pilot whale (*Globicephala melas*)
    - Harbour porpoise (*Phocoena Phocoena*)
- Marine turtle species.
    - Leatherback turtle (*Dermochelys coriacea*)

[1] https://www.npws.ie/legislation

- Loggerhead turtle (*Caretta caretta*)

It should be noted, the proposed MUL area is located 65 km offshore (from closest point), therefore otters will be excluded from this report as there is no Source-Pathway-Receptor[2] to these strictly semi-aquatic mammals (i.e. coastal otters mostly feed close to the shore within 80-100m of the coastline, typically in depths of <3m with a diving depth limit of up to 10-12m (Kruuk, 2006). This report addresses the relevant Annex IV species as outlined in Section 1.4 above.

Additionally, bat species in Ireland do not undertake large-scale migrations to Britain or Europe. In continental Europe, Leisler's Bat (*Nyctalus leisleri*) and Nathusius' pipistrelle (*Pipistrellus nathusii*) will migrate long distances, however they have not been recorded migrating from Ireland (Vincent Wildlife, accessed online 2024). Given the location of the proposed MUL area (i.e. approx.70km offshore), bats will be excluded from this report as there is no Source-Pathway-Receptor to these strictly coastal volant mammals.

Although not considered specifically in this assessment due to their lower likelihood of occurrence, any assessment of, or mitigation measures put in place for, the species assessed here are considered to be appropriate for other less commonly occurring species.

2.2 ANNEX IV SPECIES

2.2.1 CETACEANS

The Celtic Sea hosts a wide range and high abundance of cetacean species (O'Brien *et al.,* 2009; Wall *et al.,* 2013; Whooley & Berrow, 2019). Of the 26 species of cetaceans found in Irish waters, at least 9 have been recorded off the south and south-west coasts and may be present within the MUL area, since they are especially abundant during autumn and winter, when small pelagic fish concentrate in schools before migrating to spawning grounds (Evans & Waggitt, 2020, 2023; Molloy, 2006; Wall *et al.,* 2013; Waggitt *et al.,* 2020).

Common dolphins (*Delphinus delphis*), harbour porpoises (*Phocoena phocoena*) and bottlenose dolphins (*Tursiops truncatus*) are the most common toothed cetaceans found in the area, sighted year-round (Wall *et al.,* 2013). Risso's dolphins (*Grampus griseus*) are occasionally seen in this region, primarily in summer, while a small number of killer whale (*Orcinus orca*) sightings have occurred close to the coast. Moreover, fin (*Balaenoptera physalus*), minke (*Balaenoptera acutorostrata*) and humpback (*Megaptera novaeangliae*) whales are recorded in this important foraging area (Whooley *et al*., 2011; Ryan *et al*., 2016; Volkenandt *et al.,* 2015), with minkes being the most commonly sighted baleen whales in summer and fin whales in late summer-autumn. Minkes are also frequently reported during late summer to autumn but in lower abundance. Humpback whale sightings peak from late summer through to January (Rogan *et al.,* 2018). Although inshore sightings of long-finned pilot whales (*Globicephala melas*) are less common, these deep-diving, highly social cetaceans are occasionally

[2] The source of impact (e.g. pollution) is the activity that leads to the impact causing an effect. The pathway (e.g. water) is the part of the environment that an impact (e.g. pollution) travels on its journey towards the receptor. The receptor is the thing (e.g. species, habitat and non-living things such as monuments) that is being harmed by the source.

observed in the region. Their presence is often more apparent through strandings along the coast, which reflect the species' strong social bonds that sometimes lead entire pods to strand together. These whales, typically found in deeper offshore waters, may venture closer to shore when pursuing prey or due to navigational errors (IWDG, 2024c; Olson, 2018).

2.2.1.1 COMMON DOLPHIN

The common dolphin is Ireland's most abundant cetacean species and the second most frequently reported species after the harbour porpoise (Berrow *et al.,* 2010). It occurs in all Irish waters including offshore waters and the Irish Sea, but it is most abundant off the south and southwest coasts, mainly in waters deeper than 50 metres, where it is often seen in very large groups (DAHG, 2009; Evans & Waggitt, 2020, 2023; Wall *et al.,* 2013).

Common dolphins typically move further offshore in the summer and are seen in large groups, moving to inshore waters in autumn, probably linked to the presence of large numbers of schooling pelagic fish (Marine Institute, 2013). They tend to move east over the winter, with sightings peaking off County Kerry towards late summer, off County Cork between September and January, and off County Waterford between November and February (Berrow *et al.* 2010). Rogan *et al.* (2018) reported sightings of common dolphins in neritic waters, primarily off the southern and western coasts of Ireland, during the ObSERVE Aerial surveys. However, fewer sightings were recorded in the summer and winter of 2016 compared to 2015, resulting in insufficient data to generate abundance estimates for those periods (Table 2.1).

2.2.1.2 COMMON BOTTLENOSE DOLPHIN

Bottlenose dolphins are a large, robust, and gregarious species found in tropical and temperate waters worldwide (Wall *et al.,* 2013). In Ireland, this species shows both a coastal and offshore distribution with most sighting records off the western seaboard and in the Celtic Sea, although it is also found in the Irish Sea and in waters along the edge of the continental shelf further to the south (DAHG, 2009; Rogan *et al.,* 2018; Waggitt *et al*., 2020). They are uncommon but regularly seen along the south coast without showing any particular site fidelity, except for a small semi-resident population reported in Cork Harbour, with larger numbers visiting the area during the summer (Ryan *et al.,* 2010).

Photo-identification data from groups of bottlenose dolphins at several locations around the coast of Ireland have revealed movement of animals between sites separated by 130-650km over durations of 26-760 days, providing evidence that many individuals should be considered highly mobile and transient (O'Brien *et al.,* 2009). During the ObSERVE surveys in 2015-16 (Rogan, *et al.,* 2018), there were considerably more sightings of bottlenose dolphins in 2016 compared to 2015 and in winter than in summer with abundance estimates twice as high. Densities were highest in winter 2016, occurring in the Celtic Sea with a predicted high-density area offshore in the southern part (Table 2.1; Rogan *et al.,* 2018).

2.2.1.3 RISSO'S DOLPHIN

In Ireland, Risso's dolphins exhibit a distinct preference for inshore waters and offshore islands, especially the Saltee Islands off County Wexford, the County Cork coast and the Blasket Islands off

County Kerry, during the summer months. These preferences contrast with their typical habitat in deep-water regions elsewhere in the world (IWDG, 2024a).

This species is occasionally observed in the wider area, most commonly in the summer months, suggesting a late spring inshore movement, and within a few kilometres of the coast (Berrow *et al*., 2010; Wall *et al.,* 2013). Although Risso's dolphins have been reported off all coasts in Ireland, their distribution is more clustered with regular sightings inshore off the northwest and southeast coasts, with most records of Risso's dolphins in the UK and Ireland being within 11 km of the coast (DAHG, 2009; Evans & Waggitt, 2020, 2023). In 2010, Berrow *et al.* reported Risso's dolphins regularly in the Irish sea, with counties Wicklow and Wexford accounting for 41% of all inshore Risso's dolphin sightings. During the 2014 Celtic Sea Herring Acoustic Survey (Nolan, *et al.*, 2014), one Risso's dolphin was recorded outside Cork Harbour (Nolan *et al.,* 2014), while none were seen off the south coast of Ireland in 2016-2020. During the ObSERVE Aerial surveys, most sightings were made in the summer of 2016, with group size ranging from 1 to 10 (Table 2.1; Rogan *et al*., 2018).

2.2.1.4 KILLER WHALE

Killer whales represent the largest members of the delphinid family, reaching lengths of up to 9.5 meters. They are easily identifiable by their striking coloration and prominent dorsal fins, especially notable in adult males. Such a species, recognized as the most widely distributed cetacean in the world (Shirihai & Jarrett, 2006), has been recorded off all Irish coasts in all seasons, but mainly in shallow continental shelf waters (DAHG, 2009; Wall *et al.,* 2013). Off the south coast, a small number of killer whales have also been recorded, primarily during summer (Wall *et al*., 2013). In addition, photo identification studies have linked killer whales sighted off Ireland with the "West Coast Community" resident off Scotland (Berrow *et al*., 2010).

2.2.1.5 COMMON MINKE WHALE

The minke whale is the smallest species of baleen whale, with an average length of 8.5 meters. Commonly observed singly or in small groups, minke whales are the most common and widely distributed of the baleen whales in Ireland and the most likely to be encountered in shallow waters. They occur off all coasts, but most records are from southern and southwestern coastal waters, usually in depths exceeding 50 metres, in spring and autumn (Evans & Waggitt, 2020, 2023; Wall *et al*., 2013). This species has also been observed over offshore banks (DAHG, 2009).

Peak numbers in the Celtic Deep and southern Irish Sea occur between July and September declining markedly between October and March (Evans & Waggitt, 2023). Off the south coast of Ireland, minke whales have been sighted in all months of the year, although are most frequently recorded from April to November (Berrow *et al.,* 2010). Dedicated surveys (in June and July 2015, November 2015 and February 2016, May and July 2016, and November 2016 and March 2017) showed highest minke whale predicted densities off south-west Ireland (west Cork and Kerry). Along the south coast of Ireland, design-based density estimates were highest in summer (Table 2.1; Rogan *et al*., 2018).

2.2.1.6 FIN WHALE

Reaching lengths of up to 24 meters, fin whales are the second-largest animals in the world, surpassed only by the blue whale (*Balaenoptera musculus*). With a worldwide distribution in mainly temperate and polar sea (Shirihai & Jarrett, 2006), they are also the largest baleen whales likely to be present close to shore off Ireland.

Sightings of fin whales in British and Irish shelf seas are clustered within the Celtic Sea, from the south-west coast of Ireland along its south coast eastwards to the western edge of the Celtic Deep, with peak sightings occurring in November (Berrow *et al.,* 2010; Evans & Waggitt, 2020, 2023; Whooley *et al.*, 2011). The larger fin whales are regularly observed in small numbers both close to the coast and further offshore, primarily in autumn and winter when these waters are a known foraging ground (Marine Institute, 2013). Photo-identification data were collected from whale-watching vessels over 79 trips from 2003-2008, which resulted in the identification of 62 individual fin whales, of which 11 were sighted across multiple years. Furthermore, it is noticeable that on occasions, group sizes in the region have numbered more than twenty individuals, higher than recorded anywhere else in British and Irish waters (Berrow *et al.,* 2010; Evans & Waggitt, 2020, 2023; Whooley *et al.,* 2011).

2.2.1.7 HUMPBACK WHALE

The humpback whale is a global species that can be found in all the major ocean basins. In Ireland, humpback whales have been recorded in small numbers close inshore mainly off the south and southwest coasts, although all coasts are represented; however, records offshore are relatively scarce (DAHG, 2009). This species is regularly observed in small numbers both close to the coast and further offshore, primarily in autumn and winter when these waters are a known foraging ground (Marine Institute, 2013).

Sightings of the iconic humpback have increased recently in Irish waters, with a total of 126 humpback whales identified and included in the Irish Whale and Dolphin Group Photo-ID catalogue up to February 2024 (IWDG, 2024b). Between 1999 and 2022, images of individual humpback whales were collected in Irish coastal waters, the great majority coming from within the Celtic Sea (Blazquez *et al.,* 2023). Resighting rates have been high and consistent, reaching over 80% in some years, while the mean resighting rate over the period 1999-2020 was 63%, with relatively high site fidelity (Berrow & Whooley, 2022). Photo-identification of humpback whales was also used to establish an annual easterly movement along the southern coast of Ireland over the autumn, mirroring that of their preferred prey of herring and sprat. Most sightings in the south-west occurred in August but further east sightings peaked in November. Two photo-identified individuals were recorded travelling between Ireland and Iceland, Norway and the Netherlands (Ryan *et al*., 2016). Furthermore, Blazquez *et al.* (2023) found an increased presence of humpback whales in inshore Irish waters across the years, especially during the last decade although numbers still remain low.

2.2.1.8 LONG-FINNED PILOT WHALE

Pilot whales, the second largest members of the dolphin family (*Delphinidae*), possess a robust body and a prominent bulbous head. They are characterized by their elongated flippers, a backswept, rounded dorsal fin—broader in adult males than in females—and distinctive coloration. The body is

predominantly black, with a light grey "bib" present on the throat. In Ireland, they predominantly inhabit deep-water environments along the Rockall Trough and the continental shelf throughout the year. Occasional sightings have been recorded from waters over the Irish Shelf, especially off the southwest coast. Sightings of this species in inshore waters are infrequent and typically associated with live stranding events. They are the species most prone to mass strandings in the country, yet they may also be suitable candidates for rescue and refloat attempts (Berrow *et al*., 2010; IWDG, 2024c; Wall *et al*., 2013).

2.2.1.9 HARBOUR PORPOISE

Harbour porpoises are generally found in the northern latitudes of the Pacific and Atlantic oceans, predominantly along the continental margins. In Ireland, they are the most widely distributed cetacean species, observed in all inshore waters around the entire coastline and almost all recorded sightings occur within 10 km of the coast (Berrow *et al*., 2010). They are also the smallest cetacean species found in Irish waters, generally exhibiting a shy behaviour, tending to avoid interactions with other species and rarely approaching boats. This can make observations challenging, except in calm water conditions (IWDG, 2024d).

They are commonly seen in shallow coastal waters in the summer, although surveys suggest highest densities along the south coast occur in autumn (Marine Institute, 2013). Recorded moving further offshore in the spring, possibly linked to calving (DCENR, 2015), harbour porpoises are generally less often encountered in the Celtic Sea than in the Irish Sea, although it may be a result of a lower survey effort and higher sea states off the south coast (Wall *et al*., 2013), since more sightings were recorded in the summer months in Irish and Celtic waters (Table 2.1; Rogan *et al.*, 2018). In addition, harbour porpoises rarely occur over deep water but have been observed over relatively shallow (<200m) offshore banks (DAHG, 2009). A comparison of the results of the broad-scale SCANS and SCANS-II surveys (SCANS-II, 2008) indicate there has been a general shift to the southwest and an increase in the harbour porpoise population in the region over the period between the surveys.

Table 2.1 Cetacean Estimates in the Celtic Sea during the summer (Rogan *et al*., 2018).

Species	Year	Density (D; animals per km^2)	Abundance (N)	Coefficient of Variation (CV)	95% Confidence Interval	
Common dolphin*	2015	0.044	2759.6	75.03	1164.0	6542.2
	2016	-	-	-	-	-
Bottlenose dolphin	2015	0.062	3,885	64.33	1,210	12,473
	2016	0.088	5,549	47.72	2,241	13,739

Species	Year	Density (D; animals per km²)	Abundance (N)	Coefficient of Variation (CV)	95% Confidence Interval	
Risso's dolphin¥	2015	-	-	-	-	-
	2016	0.0128	809.0	94.75	163	4,012
Killer whale¥	2015	-	-	-	-	-
	2016	-	-	-	-	-
Minke whale	2015	0.013	835.9	66.57	382.3	1827.9
	2016	0.012	760.5	63.32	359.2	1610.0
Fin whale¥	2015	-	-	-	-	-
	2016	-	-	-	-	-
Humpback whale¥	2015	-	-	-	-	-
	2016	-	-	-	-	-
Pilot whale¥	2015	-	-	-	-	-
	2016	-	-	-	-	-
Harbour porpoise	2015	0.227	14189.8	27.4	10791.6	18658.2
	2016	0.227	14195.8	37.2	9362.5	21524.3

* There were insufficient sightings of these species to generate abundance estimates.

¥ There were no sightings of these species during the summer season.

2.2.2 MARINE TURTLES

This Risk Assessment has also considered the potential for any impacts from the proposed SI activities on any of the five (5) species of turtles that have been recorded in Irish waters: Leatherback Turtle (*Dermochelys coriacea*), Loggerhead Turtle (*Caretta caretta*), Kemp's Ridley Turtle (*Lepidochelys kempii*), Green Turtle (*Chelonia mydas*), and Hawksbill Turtle (*Eretmochelys imbricata*). Of these 5 species, the leatherback turtle and loggerhead turtle are the only two Annex IV turtle species that have been recorded in the proposed MUL area.

Most turtle sightings recorded in Irish waters are of the leatherback turtle (King and Berrow, 2009), which migrates during the summer months into the Celtic and Irish Seas in response to the distribution of the gelatinous zooplankton which constitute their preferred diet (Doyle *et al.*, 2008; Fossette *et al*., 2010; NPWS, 2019). The southwest coast of Ireland provides a seasonal foraging ground for marine turtles, especially leatherbacks. Key characteristics of this habitat include:

- Food Availability: High abundance of jellyfish during the summer months attracts leatherbacks to the area.
- Migratory Pathways: The region is part of the migratory route for turtles traveling between tropical breeding grounds and temperate foraging areas.

Loggerhead turtles can also be found in Irish waters, despite an observed decline in records of this species between 1960 and 1980, which Botterell *et al.* (2020) suggested was prior to the classification of loggerheads as an endangered species in the USA (1978), when rapid conservation measures were implemented for the species. Nevertheless, from the 1980s onwards, there has been a significant increase in the decadal totals of loggerhead turtle sightings and strandings in the UK and Ireland. This trend is attributed to successful conservation measures leading to enhanced hatchling recruitment (Botterell *et al*., 2020).

2.2.2.1 LEATHERBACK TURTLE

The leatherback turtle is the most widely distributed living reptile species, being found in all oceans except the Southern Ocean. Within the North Atlantic its range extends from the tropics to the high latitudes of Newfoundland right across to Europe's north-easterly fringe. It is a widely roaming species, with individuals making extensive pan-oceanic movements. Breeding is confined to warm tropical regions because of thermal constraints on egg incubation, but the species has many unique anatomical and physiological adaptations that permit it, unlike other marine turtles, to forage seasonally into cooler temperate waters. Consequently, leatherback populations have a very dynamic range. During the summer months their range is at its greatest extent with individuals located throughout the North Atlantic, whereas during the winter months their range is restricted to areas where the sea surface temperature is >15°C. (NPWS, 2019).

Recent studies have shown that after nesting in the tropics the majority of North Atlantic leatherbacks head north towards cooler temperate waters. They are generally spotted off the south and southwest coasts of Ireland during the summer months, with live sightings peaking in August (Doyle, 2007; King & Berrow, 2009; NPWS, 2019; OSPAR, 2009). The decadal trend of records in the UK and Ireland for leatherback turtles generally increased, peaking in the 1990s from which it has since decreased (Botterell *et al*., 2020). Data from the National Biodiversity Data Centre reflects these patterns with the predominance of sightings in the south and west of Ireland. Moreover, aerial surveys for the ObSERVE project from 2015-2016 recorded a handful of leatherback turtle sightings at the southern limits of Irish offshore waters in summer (Rogan *et al.,* 2018).

2.2.2.2 LOGGERHEAD TURTLE

Loggerheads are a highly mobile species that breed on NW Atlantic, Gulf of Mexico and Caribbean coasts. Their distribution seems to be limited to waters of about 10°C, since they may become stunned, drift helplessly and strand on nearby shores when they encounter colder waters. They are

also the most common Mediterranean species with most nesting sites in Libya, Greece, Turkey and Tunisia. After hatching, young turtles of about 5 cm carapace length swim offshore where the Gulf Stream/Azores current carries them to the eastern Atlantic, including the areas around the Azores, Madeira, and Canary Islands (Carr, 1986; OSPAR, 2015; Santos, 2007).

This species is known to occur in large numbers around the Azores and in the seas north of these islands, as well as along the Atlantic coast of the Iberian Peninsula especially southern Portugal in spring and summer and year-round in Spain (Bellido *et al.,* 2009, 2010; Camiñas & Valeiras, 2003). Its occurrence in Irish, British and French waters is considered a result of winter storms, when winds and currents overwhelm the swimming abilities of post-hatchling cold-stunned or mutilated loggerhead turtles, transporting them to habitats which cannot sustain them (Bolten *et al*., 2004; Monzon-Arguello *et al*., 2012). Despite this, they have been reported all over the coasts of Ireland every month of the year, with the majority found between November and March (OSPAR, 2015), and therefore may be present in the proposed survey area at least on a seasonal basis (Botterell *et al*., 2020; National Biodiversity Data Centre, 2024).

3 RISK ASSESSMENT

The potential effects on the relevant species from the proposed SI activities was addressed by assessing the likelihood that Annex IV species would be exposed, or interact, with the activity.

3.1 IDENTIFICATION OF POTENTIAL IMPACTS

Assessment of likelihood of potential impacts from the proposed activities has been undertaken considering the following aspects:

- Type of activity;
- Duration and frequency of the activity;
- Extent of the activity;
- Timing and location of the activity; and
- Other known activities in the area at the same time (i.e. cumulative impacts).

The following potential impacts that could arise have been identified:

- Changes to underwater noise associated with geophysical surveys
- Injury or death due to entanglement with towed equipment
- Injury or death due to collision with survey vessels/towed equipment
- Pollution Event

Therefore, these potential impacts will be taken forward for further consideration and appropriate mitigation measures will be implemented, as required.

3.2 NOISE RISK ASSESSMENT

In section 4.3 of the SISAA accompanying this application (GDG, 2024), the disturbance and noise criteria associated with the potential for impact on marine mammals and reptiles is clearly set out. This report identified noise from the airgun arrays and from the survey vessel as potentially causing disturbance to marine mammals and reptiles.

Potential effects of underwater noise on marine mammals and reptiles can be summarised as:

- Lethal effects and physical injury;
- Acoustic Disturbance/Masking of biologically important noises;
- Auditory injury; and
- Behavioural response/change such as displacement from feeding, resting and breeding grounds.

The main impacts from the proposed SI associated with noise disturbance would be from the use of a c. 4500 cu. airgun array and other geophysical equipment including SBP, SSS, vessel noise and USBL, which are discussed below.

3.2.1 MORTALITY/INJURY DUE TO UNDERWATER NOISE FROM GEOPHYSICAL SURVEYS

Marine mammals, such as whales and dolphins rely heavily on sound for communication, navigation, and foraging as these species live in an environment that is more suited for hearing than vision. The use of geophysical survey techniques, particularly seismic surveys, can significantly impact these animals. The level of environmental impact associated with this acoustic activity is variable depending on several factors including the type of equipment being used, its sound signal and propagation characteristics, and the depth in which it is operating (DAHG, 2014).

Marine turtles are the only reptiles found in Irish waters; however, the leatherback turtle is the only marine turtle species observed frequently enough to be considered a regular visitor to Irish waters. Leatherback turtles are known to hear in the very low frequency range, with a range of 50 - 1200 Hz with maximum sensitivity between 100-400 Hz in water (Piniak *et al.*, 2012).

In Table 3.1 below, the audible surveys to the different hearing groups of marine mammals and reptiles have been assessed and surveys with potential to induce Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) per hearing group are detailed.

Table 3.1 A

Table 3.1 Annex IV species auditory band width and relevant surveys.

Hearing Frequency Group	Estimated Auditory Band Width (kHz)	Audible Survey	Surveys inducing PTS and/or TTS
Low Frequency Cetaceans Baleen whales (fin, minke, humpback whale)	0.007 – 35	SBP (Sparker) SBP (Boomer) USBL Vessel Noise Airgun Array	SBP (Sparker) Airgun Array
Mid Frequency Cetaceans Most toothed whales and dolphins (bottlenose, common & Risso's dolphin, killer & pilot whale)	0.15 - 160	SBP (Parametric Pinger) SBP (Sparker) SBP (Boomer) USBL Vessel Noise SSS Airgun Array	SSS SBP (Parametric Pinger) SBP (Sparker) Airgun Array
High Frequency Cetaceans	0.2 - 180	SBP (Parametric Pinger) SBP (Sparker)	SSS SBP (Parametric Pinger)

Hearing Frequency Group	Estimated Auditory Band Width (kHz)	Audible Survey	Surveys inducing PTS and/or TTS
Certain toothed whales and porpoises (harbour porpoise)		SBP (Boomer) USBL Vessel Noise SSS	SBP (Sparker) SBP (Boomer) USBL Airgun Arrayð
Very Low Frequency Leatherback turtle	0.05 – 1.2	SBP (Sparker) SBP (Boomer) USBL Airgun Array Vessel Noise	n/a

ð High-frequency cetaceans can still be affected by airgun noise due to the broad spectrum of impulsive sound emissions. While the primary frequencies produced by airguns are outside their optimal hearing range, some components of the sound can overlap with the higher frequencies they detect. As a result, these species may still experience auditory impacts, though the risk of PTS or TTS is typically lower than for low- and mid-frequency cetaceans, whose hearing aligns more closely with the dominant frequencies of the airgun pulses.

Noise from seismic surveys can interfere with the echolocation and communication of marine mammals. This can result in disorientation, increased stress levels, and difficulty in locating prey. Additionally, changes in prey behaviour or migration patterns due to seismic surveys can force marine mammals to expend more energy in their search for food, potentially leading to reduced health and reproductive success (Gordon *et al.,* 2003). Underwater sound waves generated by the airguns can cause short-term disruptions to fish behaviour, such as altering schooling patterns and migration routes, potentially leading to reduced prey availability (Slabbekoorn, *et al*., 2010) in the immediate vicinity of the survey area. Studies have shown that certain fish species exposed to seismic airgun noise can suffer from barotrauma, resulting in internal injuries or death (McCauley, *et al.,* 2003). Plankton populations may also experience localized impacts, with some studies indicating increased mortality rates in close proximity to the sound source (McCauley, *et al.,* 2017). However, these effects are expected to be confined to a relatively small area surrounding the survey operations. Given that the seismic survey is planned to last only 2 to 3 weeks, the impacts on prey availability for cetaceans are anticipated to be localized and short-lived.

3.2.2 CONCLUSION

By understanding sound attenuation and implementing effective mitigation strategies, the potential adverse effects can be minimised. The thresholds identified by Parvin *et al*. (2007) serve as critical guidelines to ensure the safety and protection of marine life during these activities. Standard mitigation measures, as detailed by "*Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters*" (DAHG, 2014), shall (Section 3.6) be implemented for these pieces of noise emitting equipment (e.g. pre-work marine mammal surveys and soft start procedures).

The temporary scale of the survey activities means that any disruptions to marine mammals and prey populations will likely be minor and not significant in areal extent or in the long term.

Therefore, considering the temporary scale of the planned survey activities and the mitigation measures outlined below, the proposed activities will not offend the system of strict protection of cetaceans and marine turtles under Article 12 of the Habitats Directive.

3.3 COLLISION RISK ASSESSMENT

The main impacts associated with collision as a result of the proposed activities on cetaceans and marine turtles are detailed and assessed below.

3.3.1 MORTALITY/INJURY DUE TO COLLISION

Cetaceans often surface to breathe, making them vulnerable to vessel strikes, especially in areas with high maritime traffic. Marine turtles, similar to marine mammals, need to breathe and frequently bask at the surface of the water, making them also susceptible to collisions.

Survey vessels used for site investigations may pose a collision risk to these species, especially if the vessel(s) operates in previously low-traffic zones, introducing traffic in specific areas of importance for these species. Survey vessels often follow specific transects and patterns, which can overlap with the habitats or migratory routes of Annex IV species. Transects can be repeated, and passing over the same area multiple times potentially increases the chance of collision. During seismic surveys transects are rarely repeated, however, the planned survey will operate within the MUL application area over a period of weeks. Noise generated by survey equipment can deter marine species from the area reducing collision risk, but could also disorient or attract marine species, which may increase collision risks.

Marine mammals accustomed to vessel movements may exhibit localised avoidance rather than large-scale displacement. They might move temporarily away from the survey vessel and return once the activity ceases, thereby reducing the impact on their overall behaviour and habitat use. Vessel strikes are a known cause of mortality in marine mammals (Laist *et al*., 2001). The key factors contributing to collision between marine mammals and vessels are the presence of both in the same area and vessel speed (see Schoeman *et al*., 2020 for review). Non-lethal collisions have also been documented with vessels (Laist *et al*., 2001; Van Waerebeek *et al*., 2007). Injuries from such collisions can be divided into two broad categories: blunt trauma from impact and lacerations from propellers. Injuries may result in individuals becoming vulnerable to secondary infections or predation, leading to death. However, it is largely recognised that the key factors contributing to collision between marine mammals and vessels is speed (see Schoeman *et al*., 2020 for review). Injuries to marine mammals from vessel strikes are species-dependent but are generally more severe at higher impact speeds, with ships travelling at 14 knots or faster being the most likely to cause lethal or serious injuries (Wang *et al*., 2007). Vessels involved in survey activities, including support vessels, will be travelling through the MUL area at less than 5 knots.

3.3.2 CONCLUSION

The vessels undertaking these surveys will be travelling at less than 5 knots while engaged in the survey activities, thus allowing both the vessel and any animal in the area time to avoid collision. The predictable trajectory of geophysical survey vessels has an additional benefit of further reducing the risk of collision with marine mammal species. Slower vessels following a consistent trajectory allow cetaceans the opportunity to avoid collisions.

Neutral reactions of marine mammals have been observed with larger, slower moving vessels (e.g. cargo ships) compared to fast, unpredictable boats (e.g. speedboats) where marine mammals exhibit avoidance behaviour (Leung & Leung, 2003; Sini *et al.,* 2005).

In addition, Annex IV species in the area are exposed to marine traffic on a regular basis and should therefore be accustomed to vessel movements. Therefore, the collision risk posed by the proposed survey is likely to be significantly lower than that posed by existing shipping activity. The limited number of vessels (three; a survey vessel and two chase/guard vessels using the area) that will be required for these surveys will not significantly increase vessel traffic in the area.

The risk assessment for Annex IV species indicates that **No Likely Significant Effects (LSE)** are anticipated from the proposed activities. The addition of two to three relatively slow-moving vessels in the area will not pose a collision risk to marine mammals foraging in the area who are accustomed to vessel movements in the area. Therefore, the proposed activities do not offend the system of strict protection of cetaceans and marine turtles under Article 12 of the Habitats Directive.

3.4 ENTANGLEMENT RISK ASSESSMENT

The main impacts associated with the entanglement as a result of the proposed activities on cetaceans and turtles are detailed and assessed below.

3.4.1 MORTALITY/INJURY DUE TO ENTANGLEMENT WITH GEOPHYSICAL EQUIPMENT (AIRGUN ARRAY)

Marine species are at risk of physically interacting with towed geophysical equipment such as airgun arrays. This section explores the nature of these entanglement risks and the implications for affected species.

Cetaceans and marine turtles often engage in feeding, breeding, and migratory activities that bring them near the surface and into potential contact with towed geophysical devices. Species like humpback and minke whales engage in behaviours like breaching and lunge feeding, which involve rapid movements and contact with the water surface, increasing the likelihood of entanglement in surface-deployed devices. Marine turtles are vulnerable to entanglement with equipment such as airgun arrays as these species have limited manoeuvrability, making avoidance difficult and can trap turtles, leading to severe consequences such as restricted movement, injuries, or mortality (Nelms *et al*., 2016).

Cetaceans, with their long pectoral fins and tails, can become wrapped in lines, especially if they swim through slack or loose cables. The large size and powerful movements of these animals can make

entanglement incidents severe, often resulting in injury or death. The spatial arrangement and density of deployed devices can also influence the likelihood of entanglement.

The airgun array is expected to be 15m wide and 15m long, accompanied by 10 streamers, each 8km in length, with a 100m spacing between each, giving a total width of 1km and total length of 8km.

3.4.2 CONCLUSION

While the risk of entanglement with airgun arrays is generally low, it is essential to conduct a thorough risk assessment and implement mitigation strategies tailored to the specific environment and species present. By taking a proactive approach, the potential for entanglement can be minimized, ensuring the protection of marine life during seismic surveys.

Proper spacing and alignment of the airguns, as well as the management of towing cables, are essential to minimize the likelihood of marine species, such as cetaceans and sea turtles, becoming entangled. Environmental conditions, such as water depth, current strength, and visibility, can influence the risk of entanglement. Additionally, operational factors, including the speed and course of the survey vessel, must be managed to reduce interactions with marine life. Slower speeds and predictable movements can help avoid sudden encounters that may lead to entanglement.

Standard mitigation measures, as detailed by "*Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters*" (DAHG, 2014), shall (Section 3.6) be implemented for the geophysical noise emitting equipment (e.g. pre-work marine mammal surveys and soft start procedures, where possible). Utilizing marine mammal observers (MMOs) and passive acoustic monitoring (PAM) to detect the presence of marine species in the vicinity of the airgun array, will allow for prompt response actions, such as delaying or halting operations. Furthermore, the survey vessel will be moving at a maximum speed of approximately 5 knots during surveys to allow marine mammal species to move away from the vessel. Additionally, the predictable trajectory of geophysical survey vessels further reduces the risk of entanglement, as it provides cetaceans with the opportunity to anticipate and avoid the vessel's path. Integrating Acoustic Deterrent Devices (ADDs) into the proposed SI activities would be an effective strategy to reduce the risk of injury or death from entanglement to marine mammals and reptiles. Such devices could be used during the survey operations (subject to relevant regulatory guidelines at the time of acquisition), helping to deter vulnerable species from the vessel operations.

3.5 POLLUTION EVENT RISK ASSESSMENT

The main impacts associated with a pollution event as a result of the proposed survey on cetaceans and marine turtles are detailed and assessed below.

3.5.1 MORTALITY/INJURY DUE TO POLLUTION EVENT

Proposed site investigation activities will result in a temporary increase in vessels (three; a survey vessel and two chase/guard vessels using the area) and the survey vessel may require refuelling at sea, which would therefore theoretically increase the risk of accidents and resultant fuel spills.

The International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (MARPOL 73/78 MARPOL is short for maritime pollution and 73/78 short for the years 1973 and 1978) is one of the most important international marine environmental conventions. It aims to prevent both operational and accidental discharge into the marine from sea going vessels. Ireland ratified the various elements of the MARPOL Convention through the Sea Pollution Act 1991, the Sea Pollution (Amendment) Act 1999 and the Sea Pollution (Miscellaneous Provisions) Act 2006. It was given further legal effect through several Statutory Instruments under these Acts. The Acts place a legal obligation upon operators of vessels to implement measures to prevent both operational and accidental discharges from ships of substances, which may damage the marine environment as well as human health.

3.5.2 CONCLUSION

While the site investigation activities will temporarily increase vessel traffic in the area (two to three vessels), theoretically raising the risk of accidents and resultant fuel spills, the likelihood of pollution occurring—whether from operational activities or accidental incidents—is considered low. This is due to the stringent legal obligations outlined above, which significantly mitigate the risk of such events.

Strict protocols will be followed for refuelling at sea, including the use of specialized equipment to minimize the risk of spills or leaks. All refuelling operations will be supervised by experienced personnel and carried out in favourable weather conditions to reduce the potential for accidents. Additionally, an emergency response plan will be in place. These measures are designed to safeguard the marine environment.

Vessels used during the survey campaign shall, as required by law, be MARPOL compliant and fully certified by the Maritime Safety Office (if required). This is standard practice for all survey activities, regardless of the survey operator, and is incorporated into the survey design as required by law. Therefore, it is considered not likely that there would be any occurrence of a pollution event either accidental or otherwise that could directly or indirectly affect any Annex IV Species. It is not considered further as an impact to Annex IV species in this report.

3.6 RECOMMENDED MITIGATION MEASURES

The Risk Assessment found that there is potential for the proposed SI activities to impact Annex IV marine mammals and turtles, therefore mitigation measures are required.

In line with Irish best practice guidelines ‘Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters’ from DAHG (2014), which will be incorporated into the standard operating procedures of the proposed survey works, and international best practice, the measures detailed in sections 3.6.1 – 3.6.10 below will be applied, where possible, to prevent and if not reduce injury and disturbance to Annex IV species during all noise emitting site investigation activities which may impact detrimentally upon marine mammals.

The DAHG (2014) protocol is considered appropriate by the NPWS to mitigate for disturbance to marine mammal species. While the measures outlined in DAHG (2014) are not specifically aimed at

leatherback turtle, the mitigation proposed for cetacean species, in particular the soft-start procedure, will also be relevant to leatherback turtles, who have a small maximum sensitivity range for sound detection (100 - 400 Hz in water, Piniak *et al*, 2012).

3.6.1 MARINE MAMMAL MONITORING

A qualified and experienced Marine Mammal Observer (MMO) will be appointed to monitor for marine mammals and to log all relevant events using standardised data forms provided by the DAHG (2014). In addition to this, a Passive Acoustic Monitoring (PAM) Operator will be used as a complementary measure in order to optimise marine mammal detection around the study site. Therefore, continuous visual and passive acoustic monitoring will be conducted during daylight hours to monitor for the presence of marine mammals. In the case where survey activities will continue into hours of darkness, PAM will continue to be used. In the event of initiation of acoustic input into the marine environment, and any species are detected within the relevant mitigation zone, a delay in the commencement of acoustic input will be implemented (see below).

3.6.2 PRE-START MONITORING

Marine mammal monitoring will be conducted for a pre soft-start search of at least 30 minutes i.e. prior to the commencement of marine operations which may impact detrimentally upon marine mammals. This will involve both a dedicated visual observation (required under DHAG 2014) and acoustic monitoring (complementary measure) to determine if any marine mammals are within the relevant zone of mitigation. Sound-producing activities shall only commence in daylight hours where effective visual monitoring, as performed and determined by the MMO, has been achieved.

3.6.3 ACOUSTIC DETERRENT DEVICES

Acoustic deterrent devices (ADDs) are designed to emit sounds that either deter or alert marine mammals, guiding them away from potential hazards or sensitive areas. Despite variations in their sound characteristics, all ADDs share the common goal of protecting marine life. Additionally, ADDs can be used to mitigate collision risks. Therefore, integrating ADDs into the proposed SI activities could be an effective strategy to reduce the risk of injury or death to marine mammals. Such devices could be used during the survey operations (subject to relevant regulatory guidelines at the time of acquisition), helping to clear the mitigation zone of vulnerable species.

Originally developed for use in fish farms and fisheries, many new ADDs have been introduced to the market over the past 15 years, adapted to the specific frequencies of target animals (McGarry *et al*., 2022). An ADD/PAM operator is responsible for deploying these devices, typically positioning the transducer below the maximum draft of the boat to ensure 360° coverage and placing it at a sufficient depth to avoid interference from surface water noise.

The duration of ADD deployment should be tailored to allow all animals to swim twice the distance of the estimated auditory injury zone, as recommended in the JNCC report *'Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation'* (McGarry, *et al*., 2022). This duration can be calculated using the published swim speeds of the focal species, determining the time

it would take for an animal to move twice the distance of the injury zone, assuming it swims in a straight line directly away from the noise source.

The selection of the appropriate ADD should be based on the available evidence regarding the effective displacement distances of key receptors for each device (Table 2-3 in McGarry *et al*., 2022) and the specific mitigation requirements of the project.

If ADDs are used, prior to the activation of ADDs a 30-minute pre-watch will be conducted by the MMO, in accordance with the '*JNCC Guidelines for Minimising the Risk of Injury to Marine Mammals from Geophysical Surveys*' (JNCC, 2017), to ensure no marine mammals or turtles are in close proximity to the devices.

3.6.4 MITIGATION ZONE

For geophysical acoustic surveys the radial distance of 1,000m from the sound source intended for use is designated as the mitigation zone (DAHG 2014).

3.6.5 SOFT START

A soft start is the gradual ramping of power over a set period of time, to give any Annex IV species adequate time to leave the area. A soft start (or Ramp-up Procedure) must also be used during the testing of any seismic sound sources (DAHG, 2014).

If marine mammals are detected within the mitigation zone prior to soft start commencement, the soft start must be delayed until their passage, or the transit of the vessel, results in them being outside of the mitigation zone. A minimum delay of 30 minutes is required between the last detection within the mitigation zone and the start of the soft start. This delay allows animals that were not detected (i.e., those that did not resurface within that time) to move outside of the mitigation zone.

Once the soft start commences, there is no requirement to halt or discontinue the procedure at night-time, if weather or visibility conditions deteriorate, or if Annex IV marine mammal species enter the mitigation zone.

In commencing a seismic survey operation, including any testing of seismic sound sources, where the output peak sound pressure level exceeds 170 dB re: 1µPa @1m, the following ramp up procedure will be undertaken in line with the DAHG (2014) guidance[3]:

a) Energy output will commence from a low energy start-up (e.g. increasing the number of airguns starting with the smallest airgun in the array or increasing the airgun pressure) and be allowed to gradually build up to the necessary maximum output over a period of 40 minutes. A 'soft start' (from commencement of soft start to commencement of the line) should take no longer than 40 minutes.

[3] Where the acoustic output measures outlined in steps (a) and (b) are not possible according to the operational parameters of any such equipment, Allód undertake to ensure the device shall be switched "on" and "off" in a consistent sequential manner over a period of 40 minutes prior to commencement of the full necessary output.

b) This controlled build-up of energy output will occur in consistent stages to provide a steady and gradual increase over the ramp-up period.
c) If marine mammals enter or are detected within the mitigation zone while the ramp-up procedure is under way but incomplete, the energy output will not be increased until the marine mammals are no longer within the mitigation zone.

3.6.6 LINE CHANGES

Seismic data is typically collected along predetermined survey lines. "Line change" or "line turn" refers to the process of turning the vessel at the end of one survey line prior to commencement of the next.

Where the duration of a survey line/station change is greater than 40 minutes, the following procedures will be undertaken:

- The sound source activity will, on completion of the line/station being surveyed, need to be terminated.
- Prior to the start of the next line/station, all pre-survey monitoring measures and soft start procedures will be followed as for start-up (Sections 3.6.2 and 3.6.5).

Where the duration of a survey line/station change is less than 40 minutes the activity will continue as normal.

3.6.7 AIRGUN TESTING

Airgun tests may be necessary to trial new equipment or to evaluate repaired or misfiring airguns. Such tests can involve one or more airguns and may be conducted at different power levels. Where feasible, airgun testing will be incorporated into the soft start procedure and conducted before the start of a survey line to reduce the total amount of noise being introduced into the marine environment.

If testing of seismic devices including airguns cannot be integrated into a soft start procedure, a dedicated soft start must be implemented before testing any seismic sound sources (DAGH, 2014).

3.6.8 BREAKS IN THE SURVEY PERIODS

If there is a break in sound output from survey equipment for a period greater than 5-10 minutes (e.g., due to equipment failure, shut-down, survey line/station change) then all pre-start monitoring measures and ramp-up procedures will recommence prior to re-starting.

Unplanned breaks of less than 10 minutes will not require a soft start and firing can recommence at the same power level as at prior to the break (or lower), provided no marine mammals have been detected in the mitigation zone during the breakdown period. When marine mammals are detected within the Monitored Zone during such a break of 5-10 minutes, the MMO operator will advise to delay recommencement of activities as outlined in Section 3.6.5.

3.6.9 REPORTING

All recordings of Annex IV marine mammal species will be made using standardised data forms provided by the NPWS. Full reporting on operations and mitigation will be provided to the NPWS to facilitate reporting under Article 17 of the EC Habitats Directive and future improvements to guidance (DAHG, 2014). The report will also include feedback on how successful the measures were. This requirement will be communicated to the MMOs at project start up meetings and at crew change.

3.6.10 SURVEY VESSELS SPEED AND COURSE

The project survey vessels will be moving at a speed of approximately 5 knots during surveys to allow marine mammal species to move away from the vessel should they be disturbed by the vessel presence or noise emissions.

3.7 CUMULATIVE IMPACTS

Cumulative impacts, including for marine mammal species, are assessed in the SISAA and NIS documents accompanying this application.

3.8 RESIDUAL IMPACTS

No direct residual impacts are predicted from the proposed SI activities. With implementation of the specified mitigation measures, it is highly unlikely that there will be negative residual impacts from the proposed works on Annex IV species in the area.

4 NPWS ASSESSMENT CRITERIA

In addition to the above risk assessment, the following assessment criteria as outlined in the 'Guidance to Manage the Risk to Marine Mammal from Man-made Sound Sources in Irish Waters' has been completed (DAHG, 2014).

Do individuals or populations of Annex IV species occur within the proposed area?

The likelihood of encountering cetaceans within the proposed MUL application area is high. The depth of the area (74.43 – 124.25 meters) is suitable for cetaceans and there are documented sightings from various sources, as outlined in Section 2.2.1. Cetacean species such as dolphins, porpoises, and whales are commonly recorded in these waters.

In addition to cetaceans, two marine turtle species listed under Annex IV of the Habitats Directive, the leatherback turtle (*Dermochelys coriacea*) and the loggerhead turtle (*Caretta caretta*), have been recorded in the proposed area, as detailed in Section 2.2.2. These turtles utilise the area for feeding and migration.

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

The geophysical activities proposed during this project involve the use of equipment that produces sound, which has the potential to induce temporary threshold shift (TTS) and permanent threshold shift (PTS) in marine mammals. TTS can cause temporary hearing loss, while PTS can lead to permanent hearing damage, both of which are injurious, and in the case of PTS, potentially lethal.

Cetaceans are highly mobile and have large foraging ranges, allowing them to move to more suitable nearby habitats during the S.I. activities. This mobility reduces the likelihood of prolonged exposure to potentially harmful sound levels.

The project will adhere to the stringent mitigation measures and adherence to Irish best practice guidelines 'Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters' (DAHG, 2014) which are designed to minimise the risk of acoustic injury to marine mammals. In addition, given the nature of these works will be short-term and highly localised, it is considered that the proposed S.I. activities will not result in death or injury to any individuals and any disturbance to individuals would not be significant as these are highly mobile species that will move away from the works during the short duration of operations.

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

Estimating the number of individuals likely to be affected by the proposed activity requires current abundance estimates, which are not available beyond those from Rogan *et al.* (2018). During their study, Rogan *et al*. (2018) provided density and abundance estimates for marine mammals and leatherback turtles based on ObSERVE Aerial surveys conducted during 2015-2016 (Table 2.1 in Section 2.21 above). However, no recent abundance estimates specific to these species exposed to the proposed activity are currently available, since phase 2 of ObSERVE programme is currently ongoing (2021-2025).

Section 2 of this report outlines records of sightings and monitoring programs for species within and surrounding the proposed MUL area. These records indicate the presence of various marine mammals and turtles, providing valuable information about their occurrence but not precise population numbers.

It is important to note that marine mammals and turtles are highly mobile species with large ranges, capable of migrating over long distances in response to environmental changes and seasonal variations in food availability. This mobility presents challenges in accurately estimating the number of individuals likely to be affected by the proposed activity.

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

There are no known cetacean calving areas within the vicinity of the proposed MUL site. This significantly reduces the likelihood of disturbing marine mammals at critical times in their life cycle, such as during breeding or nursing periods. In addition, with the implementation of the Irish best practice guidelines 'Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters' from DAHG (2014), and the protection measures as outline in Section 3.6, it is highly unlikely any noise generated from the vessel during the geophysical surveys will disturb individuals 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?

There is no evidence indicating that any specific gender or age group of cetaceans or marine turtles is more likely to be present near the proposed MUL site compared to others. Consequently, it must be assumed that individuals of all genders and age groups could be encountered in the area.

Given the absence of data suggesting a differential presence of specific demographic groups, it is important to consider the potential impacts on the entire population spectrum. The mitigation measures outlined in the Irish best practice guidelines 'Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters' from DAHG (2014), along with the protection measures specified in Section 3.6, are designed to minimise disturbances across all demographic groups.

In conclusion, the impacts of the proposed activities are not likely to disproportionately affect any particular section of the species' populations. The implementation of comprehensive mitigation measures ensures that all individuals, regardless of age or gender, are protected from significant disturbance. This approach helps safeguard the ecological balance and health of the marine species in the area.

Will the plan or project cause displacement from key functional areas, e.g., for breeding, foraging, resting or migration?

As explained in Section 2.2.1 above, the Celtic Sea has been identified as a prey hotspot for baleen whales during autumn (Volkenandt *et al.,* 2015), though survey activities are scheduled for the summer period and should thus not cause any impact.

Although there are records of marine mammals within the MUL application area, there are no known breeding, resting or migration areas for these species within the area proposed for SI activities during the season in which such activities will be performed (April-September).

Irish waters are known for being used as foraging grounds for sea turtles feeding on jellyfish during the summer months, and later on as a migration route (Section 2.2.2). Nevertheless, sightings of turtle species in the region are rare, with only three loggerhead turtles recorded during the ObSERVE Aerial surveys (Rogan *et al.,* 2018). Therefore, it is unlikely that the proposed SI activities will have a significant impact on sea turtles.

Displacement of marine species is likely to occur during the geophysical SI activities, however, the SI activities are of short duration, and it is predicted, once the SI activities have been completed no residual impacts will remain and use of the affected area will resume as normal for these marine species.

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

The recovery of marine populations after seismic surveys can vary widely depending on several factors, including the species involved, the duration and intensity of the survey, and environmental conditions. Species sensitivity plays a crucial role, as marine mammals like whales and dolphins may return to their normal behaviours relatively quickly if disturbances are brief. The duration and intensity of the survey also significantly impact recovery; short-term, lower-intensity surveys generally lead to quicker recovery, whereas prolonged or repeated surveys can cause more extended displacement and impacts. Environmental conditions, such as habitat type and availability of refugia, further affect recovery rates. Resilient habitats and areas providing refuge during surveys support faster recovery, while more sensitive or altered environments may require longer periods to return to baseline conditions. Together, these factors interact to determine the overall recovery time for marine populations following seismic disturbances (e.g. Affatati & Camerlenghi, 2023; Carrol *et al.,* 2017; Gordon *et al.,* 2003).

Research findings indicate varying recovery times for marine populations after seismic surveys, depending on the species and the survey's characteristics. For instance, Castellote *et al.* (2012) revealed that fin whales were displaced from their habitat when a seismic survey started, and the displacement lasted well beyond the 10-day length of the activity. Nowacek *et al.* (2007) also identified groups of whales changing swimming direction to avoid seismic sources of up to 192 dB re 1µPa at one metre. Dunlop *et al.* (2017a) used the effects of an airgun array of 3,130 cu. in during the southward migration of the Eastern Australian humpback whales. Acquisition was preceded by a 30-minute ramp-up phase of the source with volume steps of 40, 250, 500, 1440 cu. in. Focal and control groups of humpback whales were composed of males, females, and calves. All control groups approached the vessel to a minimum distance of 5.5 km. They significantly reduced their dive time (by 45 and almost 60 seconds, respectively), but returned to their usual diving time after the vessel stopped the survey. Individuals had an elevated blow rate (20% increase) that remained significantly elevated after the survey, suggesting a prolonged effect of the airgun stimulus. Focal groups containing a calf and multiple adult groups tended to have shorter dive times than other adult-only cohorts, as did socially interacting groups. The deviance of the group from their prior course and speed

was significantly dependent on the combination of source characteristics, environment variables, and water depth. The general behavioural response to the survey was not considered outside the usual behaviour repertoire.

In another study, Dunlop *et al.* (2017b) investigated the magnitude of the behavioural response of humpback whales to noise using a 20 and a 140 cu. in airgun array in order to determine the existence of a dose-response relationship. The authors found that whales avoided the surveys inside an area of 3 km from the source if noise levels exceeded 140 re. 1 µPa2 s−1. Sarnocińska *et al.* (2020) reported that porpoise acoustic activity varied non-linearly with distance from the seismic source, with echolocation indexes decreasing as a single airgun shot's broadband sound exposure level increased. Pirotta *et al.* (2014) found that the probability of recording a prey capture attempt by harbour porpoise declined by 15% in the 25 km x 25 km area exposed to seismic survey noise compared to a control area and increased the further away the seismic vessel was. In addition, a reduction in vocalisations of bottlenose dolphins was detected during airgun activity, although in this instance vocalisations of bottlenose dolphins recovered to normal levels after a week of seismic pulses continuing, suggesting that individuals became habituated to the noise (Goold, 1996).

Sea turtles exhibit the greatest sensitivity to lower frequency sounds, particularly within the 500-700 Hz range, which closely aligns with the frequencies produced by seismic surveys (Bartol & Ketten, 2006; Dow-Piniak *et al*., 2012a, 2012b; Lavender *et al*., 2012). However, information related to how individuals might respond behaviourally to these sounds is inconclusive (e.g., O'Hara & Wilcox, 1990; Moein *et al*., 1994; McCauley *et al*., 2000) and may be species-specific. For instance, observations from one seismic survey reported no signs of panic or distress and "behaviour consisted of either 'steady swimming' or 'diving' to avoid the vessel" (Pendoley, 1997). Conversely, similar studies have categorised diving as a potential startle response or avoidance behaviour.

The oceanic leatherback turtle (*Dermochelys coriacea*) is of particular concern due to its potential for different auditory responses compared to more coastal species such as the green turtle (*Chelonia mydas*) and the loggerhead turtle (*Caretta caretta*) (Van der Wal *et al.,* 2016). While underwater explosions are known to cause tissue damage and can be lethal to marine fauna, only one study has explored turtle mortality linked to seismic surveys, finding no definitive connection (de Gurjão *et al*., 2005). Note, historically dynamite was used as a sound source for seismic surveys prior to the 1960's, however surveys now utilise air bubbles as a sound source.

With the implementation of the Irish best practice guidelines 'Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters' by DAHG (2014), efforts will be made to reduce the duration and intensity of disruptions caused by site investigation activities.

Any disturbance to species, if it occurs, will be brief and confined to a small area. Any impacted species are expected to recover swiftly once noise produced by the site investigation activities ceases.

5 CONCLUSION

This Risk Assessment of the potential impacts on Annex IV species from activities associated with the proposed site investigations concludes that with the implementation of the proposed mitigation measures:

- The proposed site investigations are highly unlikely to cause any lasting negative effects on Annex IV species in the area.
- It is highly unlikely that any Annex IV species will be harmed or killed due to the site investigations.
- Annex IV species present in the area that may temporarily move away from the survey vessels are expected to return to the area shortly after the work concludes.

Mitigation measures, in accordance with Irish and international best practices, will include marine mammal monitoring, soft-start procedures, airgun testing, and thorough reporting. These measures are designed to prevent or minimise injury and disturbance to Annex IV species. Additionally, vessel speeds and predictable trajectories will further reduce the risk of vessel strikes.

Therefore, it is concluded that the proposed site investigation activities will not result in any offences under Article 12 of the Habitats Directive regarding the Annex IV species likely to occur within the MUL area.

REFERENCES

Affatati, A., & Camerlenghi, A. (2023). Effects of marine seismic surveys on free-ranging fauna: a systematic literature review. *Frontiers in Marine Science, 10*, 1222523. https://doi.org/10.3389/fmars.2023.1222523

Applied Acoustics. (2024). *Easytrak Nexus USBL, Model 2691*. AAE Technologies Group. Retrieved August 1, 2024, from https://www.aaetechnologiesgroup.com/applied-acoustics/products/easytrak-usbl-systems/easytrak-nexus-usbl-model-2691/

Bartol, S. M., & Ketten, D. R. (2006). Turtle and tuna hearing. In: Swimmer, Y., Brill, R. (Eds.), *Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries* Technical Memorandum NMFS-PIFSC-7. National Ocean and Atmospheric Administration (NOAA), US Department of Commerce, pp. 98–105.

Bellido, J.J., Castillo, J.J., Pinto, F., Martín, J.J., Mons, J.L., Báez, J.C., & Real, R. (2009). Differential geographical trends for loggerhead turtles stranding dead or alive along the Andalusian coast, Southern Spain. Journal of the Marine Biological Association of the United Kingdom: 1-7. https://doi.org/10.1017/S0025315409990361

Bellido, J.J., Báez, J.C., Castillo, J.J., Pinto, F., Martín, J.J., Mons, J.L., & Real, R. (2010). Loggerhead strandings and captures along the Southern Spanish coast: body size – bases differences in natural versus anthropogenic injury. *Chelonian Conservation and Biology 9*(2), 276-282. https://doi.org/10.2744/CCB-0802.1

Berrow, S., & Whooley, P. (2022). Managing a dynamic North Sea in the light of its ecological dynamics: Increasing occurrence of large baleen whales in the southern North Sea. *Journal of Sea Research, 182*, 102186. https://doi.org/10.1016/j.seares.2022.102186

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

Blackwell, S.B., Nations, C.S., McDonald, T.L., Thode, A.M., Mathias, D., Kim, K.H., Greene Jr., C.R., & Macrander, A.M. (2015). Effects of airgun sounds on bowhead whale calling rates: evidence for two behavioral thresholds. *PLoS One 10*(6): e0125720. https://doi.org/10.1371/journal.pone.0125720

Blázquez, M., Massett, N., Whooley, P., O'Brien, J., Wenzel, F., O'Connor, I., & Berrow, S. (2023). Abundance estimates of humpback whales (*Megaptera novaeangliae*) in Irish coastal waters using mark-recapture and citizen science. *Journal of Cetacean Research and Management, 24*(1), 209-225. https://doi.org/10.47536/jcrm.v24i1.509

Bolten, A.B., Martins, H.R., Isidro, E., Santos, M.R., Ferreira, R.L., Bettencourt, E., Giga, A., Cruz, A., & Bjorndal, K. (2004). Experiment to evaluate gear modification on rates of sea turtle bycatch in the swordfish longline fishery in the Azores – Phase1 and Phase 2. In: Long KJ, Schroeder BA (eds) Proceedings of the international technical expert workshop on marine turtle bycatch in longline fisheries. NOAA Technical Memorandum NMFS-OPR-26: 139 -153.

Botterell, Z.L.R., Penrose, R., Witt, M.J., Godley, B.J. (2020) Long-term insights into marine turtle sightings, strandings and captures around the UK and Ireland (1910–2018). Journal of the Marine Biological Association of the United Kingdom, 100(6), 869-877. https://doi.org/10.1017/S0025315420000843

Camiñas, J.A., & Valeiras, J. (2003). Critical areas for loggerhead and leatherback marine turtles in the Western Mediterranean Sea and the Gibraltar Strait Region. In Proceedings of the First Mediterranean Conference on Marine Turtles. Barcelona Convention – Bern Convention – Bonn Convention (CMS): Nicosia, Cyprus; 80-85.

Carr, A.F. (1986) Rips, FADS, and little loggerheads. *Bioscience, 36*, 92–100.

Castellote, M., Clark, C. W., & Lammers, M. O. (2012). Acoustic and behavioural changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. *Biological Conservation, 147*(1), 115-122. https://doi.org/10.1016/j.biocon.2011.12.021

Christiansen, F. & Lusseau, D. (2014). Understanding the ecological effects of whalewatching on cetaceans. Pages 177-192 in J. Higham, L. Bejder, R. Williams, editors. *Whale-watching, sustainable tourism and ecological management*. Cambridge University Press, Cambridge, UK.

Christiansen, F. & Lusseau, D. (2015). Linking Behavior to Vital Rates to Measure the Effects of Non-Lethal Disturbance on Wildlife. *Conservation Letters, 8*, 424-431. https://doi.org/10.1111/conl.12166

DAHG (2009). Conservation Plan for Cetaceans in Irish Waters. December 2009. Prepared by the National Parks and Wildlife Service of the DAHG

DAHG (2014). Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters. Available from: https://www.npws.ie/sites/default/files/general/Underwater%20sound%20guidance_Jan%202014.pdf

Day, R.D., McCauley, R.D., Fitzgibbon, Q.P., Hartmann, K., & Semmens, J.M. (2017). Exposure to seismic air gun signals causes physiological harm and alters behavior in the scallop *Pecten fumatus*. *PNAS, 114*(40), E8537-E8546. https://doi.org/10.1073/pnas.1700564114

Day, R.D., McCauley, R.D., Fitzgibbon, Q.P., Hartmann, K., & Semmens, J.M. (2019). Seismic air guns damage rock lobster mechanosensory organs and impair righting reflex. *Proceedings of the Royal Society B, 286*(1907), 20191424. https://doi.org/10.1098/rspb.2019.1424

DECC (2021). Seismic Data Acquisition, Reporting & Submission: Mineral Exploration Guidance Document. Geoscience Regulation Office Version 2021.01

DCENR (2015). Irish Offshore Strategic Environmental Assessment (IOSEA) 5. Environmental Report, 210pp. + Appendices

Dow-Piniak, W., Eckert, S.A., Harms, C.A., & Stringer, E.M. (2012a). *Underwater hearing sensitivity of the leatherback sea turtle (Dermochelys coriacea): Assessing the potential effect of anthropogenic noise.* U.S. Department of the Interior, Bureau of Ocean Energy Management, Herndon, VA.

Dow-Piniak, W., Mann, D.A., Eckert, S.A., & Harms, C.A. (2012b). Amphibious hearing in sea turtles. In A. N. Popper & A. Hawkins (Eds.), *The effects of noise on aquatic life* (p. 695). Springer, New York.

Doyle, T.K. (2007). Leatherback Sea Turtles (*Dermochelys coriacea*) in Irish waters. Irish Wildlife Manuals, No. 32. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland.

Doyle, T.K., Houghton, J.D.R., O'Súilleabháin, P.F., Hobson, V.J., Marnell, F., Davenport, J., & Hays, G.C. (2008). Leatherback turtles satellite tagged in European waters. *Endangered Species Research, 4*, 23-31. https://doi.org/10.3354/esr00076

Duffy, O., Chumbinho, R., Coca, I., & Breslin, J. (2023). *Impact of geophysical and geotechnical site investigation surveys on fish and shellfish* (Report No. BD00722001). Report by BlueWise Marine. Report for Wind Energy Ireland.

Dunlop, R.A., Noad, M. J., McCauley, R.D., Kniest, E., Slade, R., Paton, D., & Cato, D.H. (2017a). The behavioural response of migrating humpback whales to a full seismic airgun array. *Proceedings of the Royal Society B, 284*, 20171901. http://doi.org/10.1098/rspb.2017.1901

Dunlop, R. A., Noad, M. J., McCauley, R. D., Scott-Hayward, L., Kniest, E., Slade, R., Paton, D., & Cato, D.H. (2017b). Determining the behavioural dose–response relationship of marine mammals to air gun noise and source proximity. *Journal of Experimental Biology, 220*(16), 2878–2886. https://doi.org/10.1242/jeb.160192

Engås, A., Lokkeborg, S., Ona, E., & Soldal, A.V. (1996). Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). *Canadian Journal of Fisheries and Aquatic Sciences, 53*, 2238–2249. https://doi.org/10.1139/cjfas-53-10-2238.

Evans, P.G.H, & Waggitt, J.J. (2020). Cetaceans. Pp. 134-184. In: Crawley, D., Coomber, F., Kubasiewicz, L., Harrower, C., Evans, P., Waggitt, J., Smith, B., and Mathews, F. (Editors) *Atlas of the Mammals of Great Britain and Northern Ireland*. Published for The Mammal Society by Pelagic Publishing, Exeter. 205pp.

Evans, P.G.H., & Waggitt, J.J. (2023). Modelled distributions and abundance of cetaceans and seabirds of Wales and surrounding waters. NRW Evidence Report No. 646. 354pp.

FAO (Food and Agriculture Organization of the United Nations) (2020). *The State of World Fisheries and Aquaculture 2020. Sustainability in action*. Rome. https://doi.org/10.4060/ca9229en

Fitzgibbon, Q.P., Day, R.D., McCauley, R.D., Simon, C.J., & Semmens, J.M. (2017). The impact of seismic air gun exposure on the haemolymph physiology and nutritional condition of spiny lobster, *Jasus*

edwardsii. *Marine Pollution Bulletin, 125* (1-2), 146-156. https://doi.org/10.1016/j.marpolbul.2017.08.004

Fossette, S., Hobson, V.J., Girard, C., Calmettes, B., Gaspar, P., Georges, J., & Hays, H. (2010). Spatio-temporal foraging patterns of a giant zooplanktivore, the leatherback turtle. *Journal of Marine Systems, 81*, 225-234. https://doi.org/10.1016/j.jmarsys.2009.12.002

Frid, A., & Dill, L. (2002). Human-caused disturbance stimuli as a form of predation risk. *Conservation ecology, 6*(1). https://www.jstor.org/stable/26271862

Gausland, I. (2003). *Seismic surveys: Impact on fish and fisheries* (Statoil, 41 pp.).

Gomez, C., Lawson, J. W., Wright, A. J., Buren, A. D., Tollit, D., & Lesage, V. (2016). A systematic review on the behavioural responses of wild marine mammals to noise: the disparity between science and policy. *Canadian Journal of Zoology*, 94(12), 801-819.

Goold, J.C. (1996). Acoustic assessment of populations of the common dolphin *Delphinus delphis* in conjunction with seismic surveying. *Journal of Marine Biology Association of the UK, 76*, 811-820.

Gordon, J., Gillespie, D., Potter, J.R., Frantzis, A., Simmonds, M.P., Swift, R., & Thompson, D. (2003). A Review of The Effects of Seismic Surveys on Marine Mammals. *Marine Technology Society Journal, 37*(4), 16-34. https://doi.org/10.4031/002533203787536998

de Gurjão, L.M., de Freitas, J.E.P., & Araújo, D.S. (2005). Observations of marine turtles during seismic surveys off Bahia, Northeastern Brazil. *Marine Turtle Newsletter, 108*, 8–9.

Hammond, P.S., Lacey, C., Gilles, A., Viquerat, S., Börjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M.B., Scheidat, M., Teilmann, J., Vingada, J., & Øien, N. (revised 2021). Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. Available from: https://synergy.standrews.ac.uk/scans3/files/2021/06/SCANS-III_design-based_estimates_final_report_revised_June_2021.pdf

Hammond, P.S., Macleod, K., Berggren, P., Borchers, D.L., Burt, M.L., Cañadas, A., Desportes, G., Donovan, G. P., Gilles, A., Gillespie, D. M., Gordon, J. C. D., Hiby, L., Kuklik, I., Leaper, R., Lehnert, K., Leopold, M., Lovell, P., Øien, N., Paxton, C. G. M., Ridoux, V., Rogan, E., Samarra, F., Sheidat, M., Sequeira, M., Siebert, U., Skov, H., Swift, R., Tasker, M.L., Teilmann, J., VanCanneyt, O., & Vazquez, J. (2013). Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. *Biological Conservation, 164*, 107- 122. https://doi.org/10.1016/j.biocon.2013.04.010

Hildebrand, J. (2009). Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series, 395*, 5-20. https://doi.org/10.3354/meps08353

IWDG, "IWDG - Species," Irish Whale and Dolphin Group, 2024. [Online]. Available: https://iwdg.ie/species/

IWDG (2024a, June 19). Risso's dolphin species information page. https://iwdg.ie/rissos-dolphin/

IWDG (2024b, June 19). Irish Humpback Whale Photo Identification Gallery information page. https://iwdg.ie/photo-identification/

IWDG (2024c, June 19). Long-finned pilot whale species information page. https://iwdg.ie/long-finned-pilot-whale/

IWDG (2024d, June 19). Harbour porpoise species information page. https://iwdg.ie/harbour-porpoise/

JNCC. (2017). JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys which can be downloaded from http://jncc.defra.gov.uk/marine/seismic_survey

King, G.L., & Berrow, S.D. (2009). Marine Turtles in Irish waters. *The Irish Naturalists' Journal, 30*, 1-30.

Kongsberg (2024a). *EM 2040 MKII multibeam echo sounder*. Kongsberg Discovery. Retrieved August 1, 2024, from https://www.kongsberg.com/discovery/seafloor-mapping/em/EM2040-Mk2/

Kongsberg (2024b). *HiPAP*. Kongsberg Discovery. Retrieved August 1, 2024, from https://www.kongsberg.com/discovery/navigation-positioning/hipap/

Kruuk, H. (2006). Otters: Ecology, behaviour and conservation, Oxford University Press.

Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S., & Podesta, M. (2001). Collisions between ships and whales. *Marine Mammal Science, 17*, 35-75. https://doi.org/10.1111/j.1748-7692.2001.tb00980.x

Lavender, A. L., Bartol, S. M., & Bartol, I. K. (2012). Hearing capabilities of loggerhead sea turtles (*Caretta caretta*) throughout ontogeny. In *The effects of noise on aquatic life* (pp. 89-92). Springer New York.

Marine Institute (2013). Marine mammals and megafauna in Irish waters – behaviour, distribution and habitat use. Marine Research Sub-Programme, NDP 2007-13 Series, 200pp.

McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M. N., Penrose, J. D., ... & McCabe, K. (2003). Marine seismic surveys—a study of environmental implications. *APPEA Journal*, 43(1), 692-708.

McCauley, R., Day, R. D., Swadling, K. M., Fitzgibbon, Q. P., Watson, R. A., & Semmens, J. M. (2017). Widely used marine seismic survey air gun operations negatively impact zooplankton. *Nature Ecology & Evolution, 1*, 1-8. https://doi.org/10.1038/s41559-017-0195

McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M.-N., Penrose, J. D., Prince, R. I. T., Adhitya, A., Murdoch, J., & McCabe, K. (2000). Marine seismic surveys - A study of environmental implications. *APPEA Journal, 40*, 692–706. https://doi.org/10.1071/AJ99048

McGarry, T., De Silva, R., Canning, S., Mendes, S., Prior, A., Stephenson, S., & Wilson, J. (2022). *Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation (Version 4)*. JNCC Report No. 615. JNCC, Peterborough. ISSN 0963-8091

Miller, P. J., Johnson, M. P., Madsen, P. T., Biassoni, N., Quero, M., & Tyack, P. L. (2009). Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. *Deep Sea Research Part I: Oceanographic Research Papers, 56*(7), 1168–1181. https://doi.org/10.1016/j.dsr.2009.02.008

Moein, S.E., Musick, J.A., Keinath, J.A., Barnard, D.E., Lenhardt, M., & George, R. (1994). *Evaluation of seismic sources for repelling sea turtles from hopper dredges: final report submitted to the U.S. Army Corps of Engineers waterways experiment station*. Gloucester Point, VA. 33 pp.

Molloy, J. (2006) The Herring Fisheries of Ireland 1900-2005: Biology, Research, Development and Assessment. Marine Institute

Monzón-Argüello, C., Dell'Amico, F., Morinière, P., Marco, A., López-Jurado, L.F., Hays, G.C., Scott, R., Marsh, R., & Lee, P.L.M. (2012). Lost at sea: genetic, oceanographic and meteorological evidence for storm-forced dispersal. *Journal of the Royal Society Interface 9*, 1725-1732. https://doi.org/10.1098/rsif.2011.0788

Nelms, S.E., Piniak, W.E.D., Weir, C.R. & Godley, B.J. (2016). Seismic surveys and marine turtles: An underestimated global threat? *Biological Conservation, 193*, 49-65. https://doi.org/10.1016/j.biocon.2015.10.020

Nolan, C., O'Donnell, C., Lynch, D., Lyons, K., Keogh, N., McAvoy, S., Cronin, C. & Hunt, W. (2014). Celtic Sea Herring Acoustic Survey cruise report 2014. FSS Survey Series 2014/04,51pp.

Nowacek, D.P., Thorne, L.H., Johnston, D.W., & Tyack, P.L. (2007). Responses of cetaceans to anthropogenic noise. *Mammal Review, 37*(2), 81-115. https://doi.org/10.1111/j.1365-2907.2007.00104.x

NPWS (2019). The Status of EU Protected Habitats and Species in Ireland. Volume 3: Species Assessments. Unpublished NPWS report. Edited by: Deirdre Lynn and Fionnuala O'Neill.

O'Brien, J., Berrow, S., McGrath, D., and Evans, P. (2009). Cetaceans in Irish waters: a review of recent research. *Biol. Environ. 109* (2), 63–88. https://doi.org/10.3318/BIOE.2009.109.2.63

O'Hara, J., & Wilcox, J.R. (1990). Avoidance responses of loggerhead turtles, *Caretta caretta*, to low frequency sound. *Copeia, 1990*(2), 564-567. https://doi.org/10.2307/1446362

Olson, P. A. (2018). Pilot Whales *Globicephala melas* and *G. macrorhynchus*. In B. Würsig, J. G. M. Thewissen, & K. M. Kovacs (Eds.), *Encyclopedia of Marine Mammals* (pp. 701-705). Academic Press.

OSPAR (2009). Background Document for Leatherback turtle (*Dermochelys coriacea*). Biodiversity Series. Available online at https://www.ospar.org/documents [Retrieved 19/06/2024]

OSPAR (2015). Background Document for Loggerhead turtle (*Caretta caretta*) – Update. Biodiversity Series. Available online at https://www.ospar.org/documents [Retrieved 19/06/2024]

Parvin, S. J., Nedwell, J. R., & Harland, E. (2007). Lethal and physical injury of marine mammals, and requirements for Passive Acoustic Monitoring. Subacoustech Report 565R0212, report prepared for the UK Government Department for Business, Enterprise and Regulatory Reform.

Paxton, A.B., Taylor, J.C., Nowacek, D.P., Dale, J., Cole, E., Voss, C.M., & Peterson, C.H. (2017). Seismic survey noise disrupted fish use of a temperate reef. *Marine Policy, 78*, 68-73. https://doi.org/10.1016/j.marpol.2016.12.017

Pendoley, K. (1997). Sea turtles and management of marine seismic programs in Western Australia. *PESA J., 25*, 8–16.

Piniak *et al* (2012), Dow Piniak W. E., Eckert, S. A., Harms, C. A., & Stringer, E. M. (2012). *Underwater hearing sensitivity of the leatherback sea turtle (Dermochelys coriacea): Assessing the potential effect of anthropogenic noise*. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Headquarters, Herndon, VA. OCS Study BOEM 2012-01156. 35pp

Pirotta, E., Brookes, K.L., Graham, I.M., & Thompson, P.M. (2014). Variation in harbour porpoise activity in response to seismic survey noise. *Biology Letters*, *10*, 20131090. http://dx.doi.org/10.1098/rsbl.2013.1090

Popper, A. N., Hawkins, A. D., Fay, R. R., Mann, D. A., Bartol, S., Carlson, T. J., Coombs, S., Ellison, W. T., Gentry, R. L., Halvorsen, M. B., Løkkeborg, S., Rogers, P. H., Southall, B. L., Zeddies, D. G., & Tavolga, W. N. (2014). *Sound exposure guidelines for fishes and sea turtles: A technical report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI*. Springer.

Rogan, E., Breen, P., Mackey, M., Cañadas, A., Scheidat, M., Geelhoed, S., & Jessopp, M. (2018). *Aerial surveys of cetaceans and seabirds in Irish waters: Occurrence, distribution and abundance in 2015-2017.* Department of Communications, Climate Action and Environment, National Parks and Wildlife Service (NPWS), Department of Culture, Heritage and the Gaeltacht. Dublin, Ireland. 297pp. Available from NBDC at https://maps.biodiversityireland.ie/Map/Marine/Dataset/322 [Accessed: 17/06/2024]

Ruppel, C. D., Weber, T. C., Staaterman, E. R., Labak, S. J., & Hart, P. E. (2022). Categorizing active marine acoustic sources based on their potential to affect marine animals. *Journal of Marine Science and Engineering, 10*(9), 1278. https://doi.org/10.3390/jmse10091278

Ryan, C., Rogan, E., & Cross, T. (2010). The use of Cork Harbour by bottlenose dolphins (*Tursiops truncatus* (Montagu, 1821)). *Irish Naturalists' Journal 31*(1), 1-9. http://www.jstor.org/stable/41419206

Ryan, C., Whooley, P., Berrow, S., Barnes, C., Masset, N., Strietman, W. J., Broms, F., Stevick, P., Fernald, T.W., & Schmidt, C. (2016). A longitudinal study of humpback whales in Irish waters. *Mar. Biol. Assoc. United Kingdom 96*, 1–7. https://doi.org/10.1017/S0025315414002033

R2Sonic. (2024). *Sonic 2024 multibeam echosounder (MBES)*. R2Sonic. Retrieved August 1, 2024, from https://r2sonic.com/products/sonic-2024/

Santos, M.A., Bolten, A.B., Martins, H.R., Riewald, B., & Bjorndal, K.A. (2007). Air-breathing visitors to seamounts: sea turtles. In Pitcher T.J., Morato T., Hart P.J.B., Clark M.R., Haggan A., & Santos R. (Eds): Seamounts: Ecology Fisheries and Conservation (Fish & Aquatic Resources). University of Azores: Blackwell publishing: 239-243.

Sarnocińska, J., Teilmann, J., Balle, J. D., van Beest, F. M., Delefosse, M., & Tougaard, J. (2020). Harbor porpoise (*Phocoena phocoena*) reaction to a 3D seismic airgun survey in the North Sea. *Frontiers in Marine Science, 6*, 824. https://doi.org/10.3389/fmars.2019.00824

SCANS-II (2008). Small Cetaceans in the European Atlantic and North Sea (SCANS-II) Final Report. St Andrews, Fife.

Shirihai, H., & Jarrett, B. (2006). *Whales, Dolphins and Seals: a field guide to the marine mammals of the world*. Bloomsbury Publishing, London.

Sini, M.I., Canning, S.J., Stockin, K.A., & Pierce, G.J. (2005). Bottlenose dolphins around Aberdeen harbour, northeast Scotland: a short study of habitat utilization and the potential effects of boat traffic. *Journal of the Marine Biological Association of the UK, 85*, 1547-1544. https://doi.org/10.1017/S0025315405012774

Skalski, J.R., Pearson, W.H., & Malme, C.I. (1992). Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes spp*.). *Canadian Journal of Fisheries and Aquatic Sciences, 49*(7), 1357-1365. https://doi.org/10.1139/f92-151

Slabbekoorn, H., Dalen, J., de Haan, D., Winter, H.V., Radford, C., Ainslie, M.A., Heaney, K.D., van Kooten, T., Thomas, L., & Harwood (2019). Population-level consequences of seismic surveys on fishes: An interdisciplinary challenge. *Fish and Fisheries, 20*, 653-685. https://doi.org/10.1111/faf.12367

Slabbekoorn, H., Bouton, N., van Opzeeland, I., Coers, A., ten Cate, C., & Popper, A. N. (2010). A noisy spring: the impact of globally rising underwater sound levels on fish. *Trends in Ecology & Evolution*, 25(7), 419-427.

Slotte, A., Hansen, K., Dalen, J., & One, E., (2004). Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. *Fisheries Research, 67*(2), 143-150. https://doi.org/10.1016/j.fishres.2003.09.046

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., & Tyack, P. L. (2007). Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals, 33*(4), 411-521.

Southall, B., Finneran, J., Reichmuth, C., Nachtigall, P., Ketten, D., Bowles, A., Ellison, W., Nowacek, D., Tyack, P. (2019). Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. *Aquatic Mammals, 45*, 125-232. https://doi.org/10.1578/AM.45.2.2019.125.

Southall, B. L., Nowacek, D. P., Bowles, A. E., Senigaglia, V., Bejder, L., Tyack, P. L. (2021). Marine mammal noise exposure criteria: assessing the severity of marine mammal behavioral responses to human noise. *Aquatic Mammals, 47*(5), 421–464. https://doi.org/10.1578/AM.47.5.2021.421

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

Thomsen, F., Mendes, S., Bertucci, F., Breitzke, M., Ciappi, E., Cresci, A. Debusschere, E., Ducatel, C., Folegot, F., Juretzek, C., Lam, F-P., O'Brien, J., & dos Santos, M. E. (2021) Addressing underwater noise

in Europe: Current state of knowledge and future priorities. Kellett, P., van den Brand, R., Alexander, B., Muniz Piniella, A., Rodriguez Perez, A., van Elslander, J., Heymans, J. J. [Eds.] Future Science Brief 7 of the European Marine Board, Ostend, Belgium. ISSN: 2593-5232. ISBN: 9789464206104. https://doi.org/10.5281/zenodo.5534224.

Van der Wal, S., Eckert, S. A., Lopez-Plana, J. O., Hernandez, W., & Eckert, K. L. (2016). Innovative Measures for Mitigating Potential Impacts on Sea Turtles During Seismic Surveys. SPE International Conference and Exhibition on Health, Safety, Security, Environment, and Social Responsibility. https://doi.org/10.2118/179215-ms

Van Waerebeek, K., Baker, A.N., Félix, F., Gedamke, J., Iñiguez, M., Sanino, G.P., Secchi, E., Sutaria, D., van Helden, A., & Wang, Y. (2007). Vessel collisions with small cetaceans worldwide and with large whales in the Southern Hemisphere, an initial assessment. *Latin American Journal of Aquatic Mammals, 6*(1), 43-69. https://doi.org/10.5597/lajam00109

Vincent Wildlife, Accessed 2024, online @ https://www.vincentwildlife.ie/

Volkenandt, M., O'Connor, I., Guarini, J.-M., Berrow, S., & O'Donnell, C. (2015). Fine-scale spatial association between baleen whales and forage fish in the Celtic Sea. *Canadian Journal of Fisheries and Aquatic Sciences, 73*(2). https://doi.org/10.1139/cjfas-2015-0073

Waggitt, J.J., Evans, P.G.H., Andrade, J., Banks, A.N., Boisseau, O., Bolton, M., Bradbury, G., Brereton, T., Camphuysen, C.J., Durinck, J., Felce, T., Fijn, R.C., Garcia-Baron, I., Garthe, S., Geelhoed, S.C.V., Gilles, A., Goodall, M., Haelters, J., Hamilton, S., Hartny-Mills, L., Hodgins, N., James, K., Jessopp, M., Kavanagh, A.S., Leopold, M., Lohrengel, K., Louzao, M., Markones, N., Martínez-Cedeira, J., Ó Cadhla, O., Perry, S.L., Pierce, G.J., Ridoux, V., Robinson, K.P., Santos, M.B., Saavedra, C., Skov, H., Stienen, E.W.M., Sveegaard, S., Thompson, P., Vanermen, N., Wall, D., Webb, A., Wilson, J., Wanless, S., Hiddink, J.G. (2020). Distribution maps of cetacean and seabird populations in the North-East Atlantic. *Journal of Applied Ecology, 57*, 253–269. https://doi.org/10.1111/1365-2664.13525

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

Wang, C., Lyons, S. B., Corbett, J. J., & Firestone, J. (2007). Using Ship Speed and Mass to Describe Potential Collision Severity with Whales: an Application of the Ship Traffic, Energy and Environment Model (STEEM) [Report by the University of Delaware].

Whooley, P., & Berrow, S. (2019). Bowhead whale (*Balaena mysticetus Linnaeus*), a cetacean species new to Irish waters. *Irish Naturalists' Journal, 36*, 169–172.

Whooley, P., Berrow, S., & Barnes, C. (2011). Photo-identification of fin whales (*Balaenoptera physalus l.*) off the south coast of Ireland. Mar. *Biodiversity Records, 4* (e8). https://doi.org/10.1017/S1755267210001119

GLOBAL PROJECT REACH

Offices

Dublin (Head Office)
Gavin & Doherty Geosolutions
[redacted]

Belfast
Gavin & Doherty Geosolutions (UK) Limited
[redacted]

Cork
Gavin & Doherty Geosolutions
[redacted]

Edinburgh
Gavin & Doherty Geosolutions (UK) Limited
[redacted]

London
Gavin & Doherty Geosolutions (UK) Limited
[redacted]

Rhode Island
Gavin & Doherty Geosolutions Inc.
[redacted]

Utrecht
Gavin & Doherty Geosolutions
[redacted]

Website: www.gdgeo.com
Email: [redacted]

A Venterra Group Plc Member Company