Environmental Support to Drilling in Irish Waters – Article 12 Assessment Screening

Document No: **IE-EXP-52/04-IOLAR-HS-00029-RP-01**

Rev: **U1**

Rev	Date	Reason for Revision
U1	09/04/19	Issued for Use

Authorisation Record		Environmental Specialist	Acting Environment Division Manager	Acting Environment Division Manager
		Xodus signed	Xodus signed	Xodus signed
U1	09/04/19	Annette Woodham	Kenneth Couston	Kenneth Couston
Rev	Date	Prepared by	Checked by	Approved by

Iolar Exploration Well

Article 12 Assessment Screening

CNOOC Petroleum Europe Limited

Assignment Number: A100460-S00
Document Number: A-100460-S00-REPT-011

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Client: CNOOC Petroleum Europe Limited
Document Type: Report
Document Number: A-100460-S00-REPT-011

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A01	09/04/2019	Issued for Use	AW	KC	KC	-
Rev	**Date**	**Description**	**Issued By**	**Checked By**	**Approved By**	**Client Approval**

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1 INTRODUCTION

This document is submitted to assist the competent authority, the Minister for Communications, Climate Action and the Environment (the "Minister"), in determining whether the Project, either individually or in combination with other activities, plans or projects will have an adverse effect on the conservation status of animal species listed in Annex IV(a) to the Habitats Directive in their natural range pursuant to Article 12 of the Habitats Directive. It is submitted alongside an updated Appropriate Assessment Screening Report and Natura Impact Statement.

1.1 Background and History of the Document

CNOOC Petroleum Europe Limited (CNOOC) (previously known as Nexen Petroleum U.K. Limited) plans to drill a single exploration well in the Iolar prospect in Block 52/04 which forms part of Frontier Exploration Licence (FEL) 3/18 in the Porcupine Basin offshore southwest Ireland (termed the 'Project').

The Department of Communication, Energy and Natural Resources (DCENR) (now the Department of Communications, Climate Action and Environment, DCCAE) completed the Irish Offshore Strategic Environmental Assessment (IOSEA) 5 in 2015. The geographical range of the IOSEA5 includes Ireland's Designated Continental Shelf out to the 200-nautical mile (nm) limit and includes all authorisations and activities within the Porcupine Basin. IOSEA5 (DCENR, 2015) supersedes the previous four regional SEAs conducted including that undertaken specifically for the Porcupine Basin, IOSEA2 (DCENR, 2007).

European Community (EC) Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna, commonly known as the Habitats Directive, under Article 6, affords protection to habitats and species of community interest through the designation of an EU-wide network of protected sites known collectively as European sites. Article 12 of the Habitats Directive affords protection to animal species listed in Annex IV(a) to the Habitats Directive in their natural range.

The requirement for an assessment related to Article 12 was transposed into Irish law in Regulation 29 (1)(e)(i) of the European Communities (Birds and Natural Habitats) Regulations 2011 (SI No. 477/2011), which requires that:

(1) Where the Minister has reason to believe that any activity, either individually or in combination with other activities, plans or projects, is of a type that may—

[…]

(e) have an adverse effect on the conservation status of—

(i) animal species listed in Annex IV(a) to the Habitats Directive in their natural range pursuant to Article 12 of the Habitats Directive,

[…]

the Minister shall, by notice, subject to paragraph (2), where he or she considers appropriate, direct that the activity shall not be carried out, caused or permitted to be carried out or continue to be carried out by any person in the European Site or part thereof or at any other specified land or may restrict or regulate the activity in the European Site or part thereof or at any other specified land, and each such notice shall be accompanied by a statement of the Minister's reasons for making the decision."

On 14th November 2018, CNOOC submitted an Appropriate Assessment Screening Report to the DCCAE which included assessments in relation to both the Article 6 (Appropriate Assessment screening) and the Article 12 requirements. An Appropriate Assessment Screening Decision was made by the competent authority on March 27th 2019 relating to the Article 6 requirements. The determination concluded that an Appropriate Assessment was required. On the same date, the EAU advertised the notice of the requirement to prepare a Natura Impact Statement (NIS).

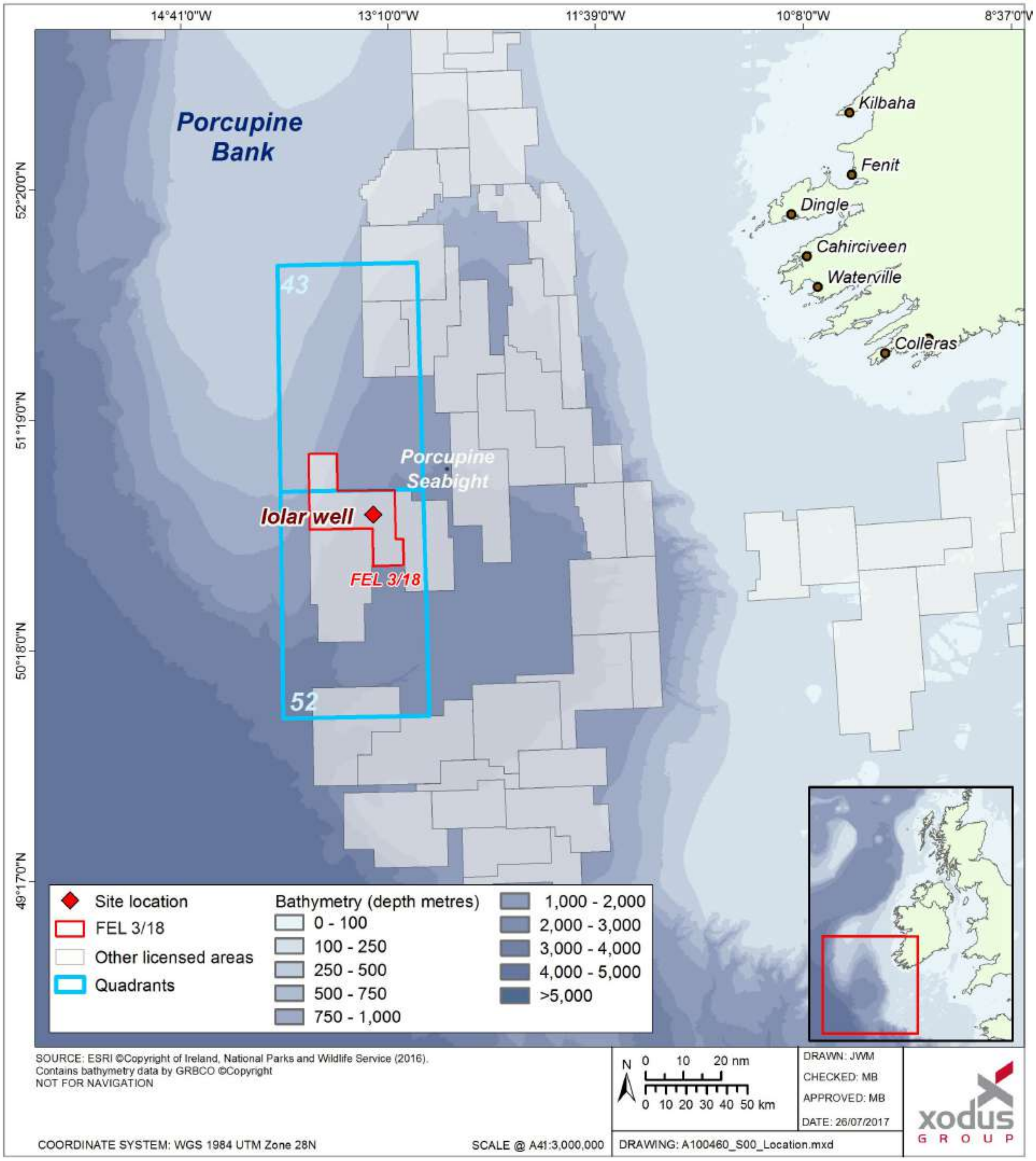
Following this screening decision and notice, CNOOC prepared a revised Appropriate Assessment Screening Report which included an updated screening assessment of the Project in accordance with the requirements of Article 6(3) of the Habitats Directive, in the absence of mitigation measures, which was submitted alongside the requested NIS. In addition, this document is submitted to assist the competent authority, the Minister for Communications, Climate Action and the Environment (the "Minister"), in determining whether the Project, either individually or in combination with other activities, plans or projects will have an adverse effect on the conservation status of animal species listed in Annex IV(a) to the Habitats Directive in their natural range pursuant to Article 12 of the Habitats Directive.

1.1 Project Overview

The Project is located within FEL 3/18 approximately 232 km southwest of the Irish mainland, in a water depth of approximately 2,200 m (Figure 1.1). The purpose of the proposed well is to gather data on the reservoir characteristics, hydrocarbon presence, pressures and temperatures in order to inform the hydrocarbon potential, in fulfilment of CNOOC's licensing condition. Once exploration drilling operations are complete, the well will be abandoned, whether or not commercially viable quantities of hydrocarbons are found.

The exploration well will be drilled by a specialist drill ship, the IceMAX, with drilling operations now expected to start in May 2019. The total duration of the drilling and abandonment operations (on location) is expected to be around 100 to 150 days. The most favourable weather window for the drilling activities is between 1st April and 30th September.

Figure 1.1 Project Location



1.2 The Applicant

CNOOC is a well-established upstream oil and gas company with a global portfolio. A key focus of CNOOC is exploration and appraisal of interests in the North Sea, offshore West Africa and the north east Atlantic.

Contact details are provided below.

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1.3 Structure of this Article 12 Assessment

The Article 12 Assessment is presented in the following sections:

Section 1	*Introduction* – provides a background to the Project and the purpose of the Article 12 Assessment.
Section 2	*Project Description* – describes the facilities and activities associated with the Project.
Section 3	*Assessment of Annex IV species under Article 12 obligations* – identifies and assesses the potential impacts on Annex IV species from the Project and determines whether, in view of best scientific knowledge, the Project individually or in combination with another plan or project is likely to have an adverse effect on the conservation status of animal species listed in Annex IV(a) to the Habitats Directive in their natural range.
Section 5	*Conclusions*
Section 6	*References*
Appendix A	*Source noise data for the underwater noise propagation modelling*

2 PROJECT DESCRIPTION

This section describes the proposed programme for drilling a deep-water exploration well at the Iolar Prospect.

2.1 Purpose and Objectives

The purpose of the Project is to gather data on the reservoir characteristics, hydrocarbon presence, pressures and temperatures. Once exploration drilling operations are complete, the well will be abandoned, whether or not potentially commercially viable quantities of hydrocarbons are found. The information gathered from the exploration well, together with data obtained previously such as seismic data, will be used to help inform decisions on any future development at the Iolar prospect, as well as contributing to the broader understanding of the potential reserves in the Porcupine basin. Undertaking exploration drilling is a commitment CNOOC is required to meet following award of FEL 3/18.

The primary objective of the Project is to verify and evaluate the hydrocarbon potential, fluid properties and reservoir quality in the Middle to Upper Jurassic age fault block, in the Iolar prospect, in FEL 3/18. The two secondary objectives are to verify and evaluate the hydrocarbon potential, fluid properties and reservoir quality in the interpreted J3L Top Oxfordian reservoir and to evaluate the hydrocarbon potential, fluid properties and reservoir potential of the Cretaceous succession in the FEL 3/18 area.

2.2 Project Overview and Schedule

The co-ordinates of the proposed Iolar 52/04-A well are provided in Table 2.1. The exploration well will be of high pressure / high temperature (HP/HT)[1] and will be drilled using a dynamically positioned drill ship.

Table 2.1 Iolar well details

Well name	Well Number	Surface coordinates (UTM28N ED50)	Water depth (datum Lowest astronomical tide (LAT)[2]
Iolar	52/04-A	50° 53' 31.16"N 13° 21' 24.38"W	2,162 m

The overall footprint of the Project will be limited to the drill ship itself and the 500 m radius safety exclusion zone which will be in place around the drill ship whilst on location. This safety exclusion zone will be approximately 0.8 km^2.

Drilling of the exploration well is now planned to start in May 2019. The total duration of the drilling and abandonment operations (on location) is expected to be in the range of 100 (in the event of a dry hole) to 150 days (in the event of a success case where hydrocarbons are encountered, which will undergo additional formation evaluation that would not be conducted if the well is dry). The most favourable weather window for the drilling activities is between 1st April and 30th September.

[1] The Energy Institute defines a high pressure / high temperature (HP/HT) as:

"High temperature in this context can be defined as when the undisturbed bottom hole temperature at prospective reservoir depth (or total depth) is greater than 300ºF (149ºC). High pressure can be defined as either when the maximum anticipated pore pressure of any porous formation to be drilled through exceeds a hydrostatic gradient of 0.8psi/ft. (representing an Equivalent Mud Weight (EMW) of 1.85SG or 15.4ppg) or, needing deployment of pressure control equipment with a rated working pressure in excess of 10,000psi (690bar, 69MPa). Note that areas of high pressure (abnormal pressure) need not necessarily be accompanied by high temperatures and vice versa."

The Iolar well can be considered a HP/HT well under this definition because the temperature and the surface wellhead pressure is above the designated 300°F and 10,000psi respectively. The Iolar well has a maximum bottom hole static temperature of 323°F and a base case wellhead pressure of 10,300psi; maximum wellhead pressure of +/-12,000psi.
[2] LAT = Mean sea level (MSL) -1.9 m.

2.3 Drill Ship

The Iolar exploration well will be drilled using the IceMax drill ship (Figure 2.1). Drill ships are purpose-built seagoing vessels. The IceMax has proven capability to drill HP / HT wells and to operate in the deep water and harsh metocean conditions such as those present west of Ireland. It will maintain position over the drilling location for the duration of exploration drilling activity using a dynamic positioning (DP) system.

Drilling equipment is located on the deck, with the derrick normally placed in the middle of the ship. The well is drilled through an opening (called a "moon pool") that extends to the water's surface below the derrick and allows the ship to swing around the well to maintain station in all wind directions. As part of the DP system, computer-controlled thrusters will be operating more-or-less continuously to keep the drill ship precisely over the drilling location as required.

Dynamically-positioned drill ships navigate under their own steam and position themselves at the drilling location. In addition to the drill ship, the operations will require support vessels for supply of materials and for safety standby duties, and helicopter transfer of personnel to and from the drill ship. Helicopters may be used occasionally to supply the drill ship with equipment required at short notice. Otherwise, all transport of drilling equipment, supplies, water, fuel and food will be undertaken by supply vessels, which will also return waste materials and surplus equipment to shore. Table 2.2 shows an overview of the estimated fuel consumption of the drill ship and its associated support vessels and aircraft for the duration of the Project. These durations do not include mobilisation, demobilisation or transit times, and also do not include allowance for weather delays.

The drill ship design exceeds the 100-year return extreme and highest significant wave heights recorded in Fugro (2017a). These wave height records run to 2015 and therefore incorporate any changes in metocean conditions due to climate change up to this date.

Figure 2.1 Stena IceMax - the drill ship proposed to be used for exploration drilling at Iolar

Table 2.2 Vessel requirements and estimated fuel consumption

Activity	Vessel	Fuel type	Consumption rate	Duration	Total fuel consumption (tonnes)
DP drill ship on location	IceMax	Diesel	50 tonnes/day	150 days	7,500
Support shipping	Standby vessel	Diesel	1.7 tonnes/day	150 days	255
Support shipping	Supply vessels (x3)	Diesel	10 tonnes/day	150 days per vessel	4,500
Transport personnel and freight (5 x 1 hour 15-minute return flights from Kerry per week)	S92 Helicopter	Jet fuel	1.56 tonnes/per return trip	85 return trips	132.6

2.4 Well Engineering

The drilling activity proposed is a single deviated well with an option to drill a short side track for coring purposes. The proposed Iolar well will be to a total depth of either 6,310 m total vertical depth subsea (TVDSS) in the success case (i.e., if hydrocarbons are encountered) and 5,923 m in the dry hole case. Figure 2.2 illustrates the well design and main dimensions.

Drilling of the well will be conducted in a number of phases. The first is the drilling or jetting of a 36" diameter "top hole" section into the surface of the seabed, a process known as spudding. This first section is the widest of all the sections that will be drilled; each subsequent section that is drilled will be of successively smaller diameter. Once the top hole is drilled, a 36" conductor pipe will be inserted into the hole and set in place. A 26" section will then be drilled through the conductor and will be lined with a 20" casing, also cemented in place. The conductor and casing will create a seal between the exposed rock of the upper wellbore sections and the inside of the well, and provide an attachment point for the wellhead assembly. The wellhead assembly will be installed and will in turn provide a mechanism to attach the blowout preventer (BOP) and to hang subsequent casing strings inside the well. The BOP is an arrangement of valves installed, in this case on top of the wellhead on the seabed, to prevent an uncontrolled release of gas and/or oil from the formation during drilling Once the BOP is installed on the wellhead, a surface riser will be connected from the BOP back to the drill ship; this will isolate the drill string from the marine environment and provide a conduit to return the mud and cuttings from the deeper sections of the well back to the drill ship.

The deeper 19", 17½", 12¼" and 8½" sections of the well will then be drilled with the drilling fluids circulated back to the drill ship. A 16" liner and 13⅝" x 13⅜' and 9⅝" x 9⅞" casings and will be installed and cemented in place for the third, fourth and fifth sections in the drilling sequence, respectively. The 8½" section will not have a casing or liner installed (Figure 2.2).

If the well is deemed to be a success, the well may be plugged below the 9⅝" casing and a side track drilled through the same formations as the main well bore, from which core samples will be obtained to provide further information on the hydrocarbon-bearing formations.

2.5 Data gathering

Once the required well depth is reached, the exposed rock formations will be evaluated by running wireline logs, which take a series of measurements from inside the wellbore. The measurements are used to characterise rock formation properties and the potential presence of hydrocarbons. Wireline sampling may also be undertaken to collect in-situ fluids downhole at reservoir conditions, from the rock formations. These fluid samples are recovered to surface in sealed containers for future analysis.

If required, wireline logs may include vertical seismic profiling (VSP) to establish the geological structure of the formations through which the well passes, and to calibrate previously acquired surface seismic data to the wellbore, for future analysis. This involves the deployment of an array of geophones at regular intervals, throughout the wellbore. To undertake VSP the sound source is suspended from deck in the water column, and the recorders (geophones), located down hole, provide a high-resolution seismic image of the immediate vicinity of the well. Further details on the VSP operation are provided in Section 2.8 below.

In a success case a side track core is planned to collect reservoir rock - coring is a way of cutting a cylindrical sample of rock and recovering the sample to surface for future laboratory testing for rock properties and presence of hydrocarbons. Up to 150 m of core will be cut in maximum 4 coring runs, and in this case the core will be collected from a new secondary wellbore (side track) drilled in parallel to the original well.

2.6 Mud System and Cuttings Disposal

The first two sections of the well (36" and 26") will be drilled before a marine riser is installed. This means that all drilling fluids, rock cuttings and residual cement returns from these sections will be discharged directly onto the seabed in the immediate vicinity of the well. These sections will be jetted/drilled using seawater and pre-hydrated bentonite sweeps (a type of WBM).

The deeper sections (19", 17½", 12¼" and 8½") will be drilled using OBM. The mud will be pumped downhole and then circulated back to the surface via the annulus (the space between the drill stem and the wall of the bore hole) and through the BOP stack and the marine riser back to the drill ship. On board the drill ship, drill cuttings are separated out and the mud recycled back into the well. Drill cuttings and associated residual oil from the sections drilled with OBM will be collected and stored onboard, prior to being shipped to shore for management and eventual disposal.

Table 2.3 provides an estimate of the amounts of cuttings and WBM that will be generated/used and subsequently discharged to sea. The estimate is based on modelling, which was carried out using quantities higher than what is expected from the current well design, and therefore the values presented in Table 2.3 are a conservative, worst case estimate.

Figure 2.2 Iolar exploration well

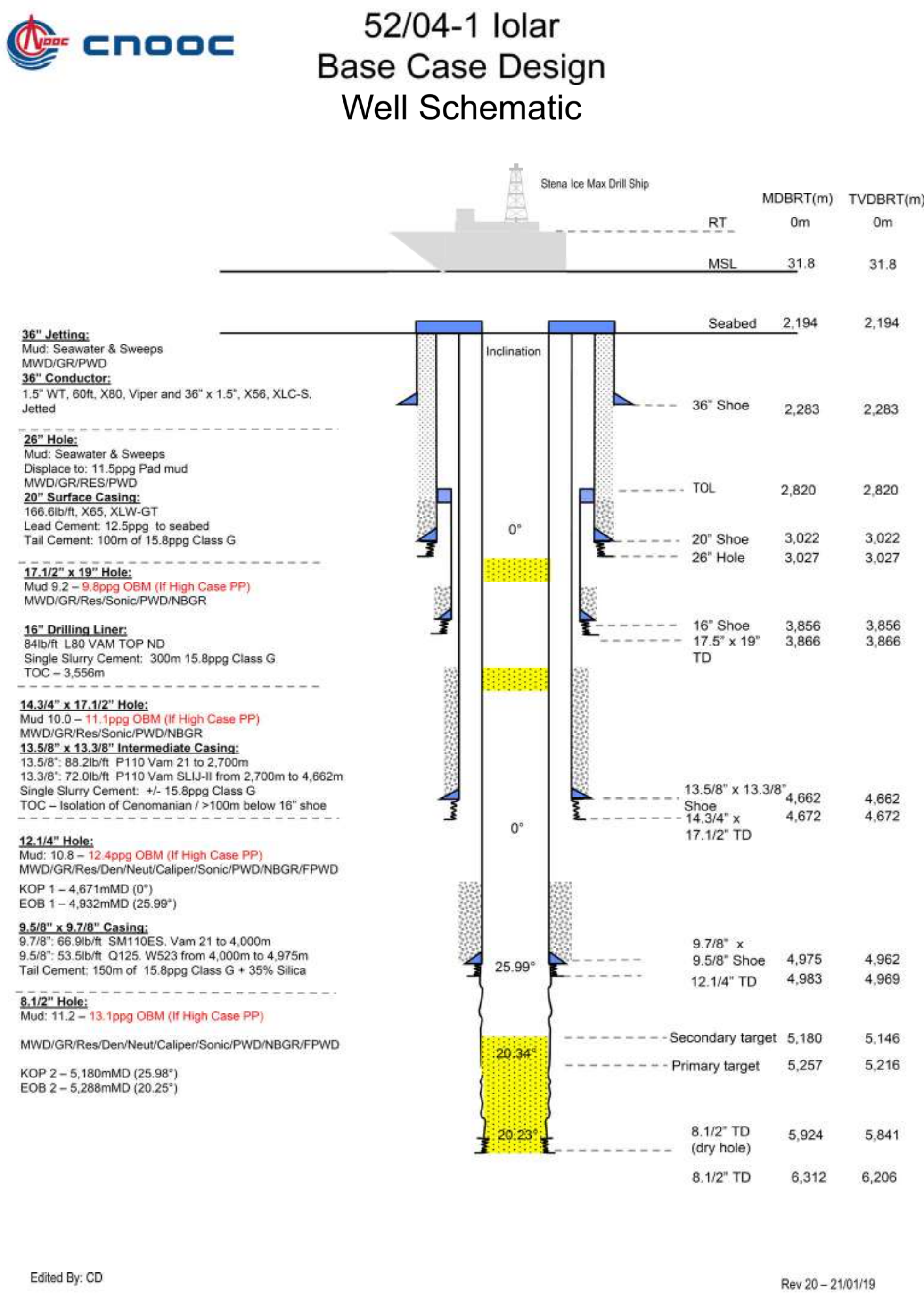


Table 2.3 Use / generation and fate of drilling mud and cuttings

Section	Mud/fluid type	Cuttings generated (tonnes)	Fate	Mud discharged (tonnes)	Cuttings discharged (tonnes)
36"	Seawater with sweeps (WBM)	152	Discharged at seabed	941	152
26"		662		2,168	662
19"	OBM	443	Shipped to shore for processing and disposal	0	0
17½"		325		0	0
12¼"		615		0	0
8½"		872		0	0

2.7 Cement and Other Chemicals

The steel casings run into each of the well sections will be cemented in place by circulating cement through the gap between the casing and surrounding formation. During cementing operations, it is normal practice to use a certain amount of excess cement to ensure the integrity of the cement job. It is therefore likely that a small amount of cement will be deposited on the seabed around the wellhead when cementing in place the 36" conductor and the 20" casing, before the BOP is installed. The amount discharged in this fashion is kept to a minimum by the cementing method used and by visually monitoring the operation from the rig via a remotely operated vehicle (ROV).

During the subsequent cement jobs there will be no cement returns to seabed or surface. When cleaning the cement unit after each of the cementing operations is completed, heavily diluted residual cement slurry will be discharged to sea.

The chemicals and additives to be used during drilling will be determined on the basis of the mud composition, which in turn will be determined by the down-hole conditions encountered whilst drilling. They will be selected on their technical specifications as well as their potential environmental impacts, which will be assessed using the CHARM (Chemical Hazard Assessment and Risk Management) risk assessment model where appropriate. The CHARM risk assessment process is designed to ensure that the selection of chemicals and additives minimises environmental toxicity and maximises biodegradability. The use (and discharge) of chemicals is subject to the prior approval of DCCAE, and subsequent usage and discharge records submitted in accordance with Ireland's obligations under OSPAR. Contingency chemicals will be stored on the drill ship to deal with potential difficulties encountered such as stuck drill pipe or loss of circulation.

2.8 Vertical Seismic Profiling

It is possible that vertical seismic profiling (VSP) will be required for the exploration well to ensure that the best possible data are obtained from the well in order to benefit fully from the exploration drilling. The decision on whether or not VSP is needed will be made during the course of the drilling programme. The NIS has therefore fully considered the potential effects arising from VSP. The technique generates energy waves by compressed air from an airgun array (the source). These are directed into the well bore at the geological strata downhole and generate a much smaller footprint than typical seismic surveys. The activity uses a small airgun array, comprising an air gun volume of 250 cu inch, 2000 psi, and with a maximum shot rate of 10 secs. During VSP operations, four to five receivers (geophones) are positioned in a section of the wellbore and the airgun array is discharged into the water column approximately five times at 20 second intervals. The generated sound pulses are reflected through the seabed and recorded by the receivers to generate a profile of the wellbore. The VSP source is expected to generate a noise level of around 220 dB re 1uPa @ 1 m, with the majority of the noise concentrated at low (<100 Hz) frequencies. The total VSP operation will take 6 to 12 hours to complete.

The worst case maximum peak to peak sound pressure level from the VSP, which was used to inform the noise propagation modelling is 235 dB re 1 μPa. This is discussed further in Section 3.5.1 and Appendix A. VSP activities will be undertaken from the drill ship at the end of the drilling operations and no additional VSP survey vessel is anticipated to be used during the Project. Once the survey is complete, the data can be used by reservoir engineers to firm up interpretations of formation structure and topography.

2.9 Well Abandonment

Once exploration drilling operations are complete, the exploration well will be permanently plugged and abandoned. Mechanical and cement plugs will be placed along the well, plugging off all points where hydrocarbons could possible enter the wellbore, thus isolating them from surface. The wellhead will be severed and pulled a minimum of 3 m below the seabed in accordance with DCCAE's requirements.

3 ASSESSMENT OF ANNEX IV SPECIES UNDER ARTICLE 12 OBLIGATIONS

3.1 Overview of Relevant Protected Species

Annex IV species that could be present in Irish offshore and coastal waters within the area potentially affected by the Project are presented below and the requirement for further assessment is discussed:

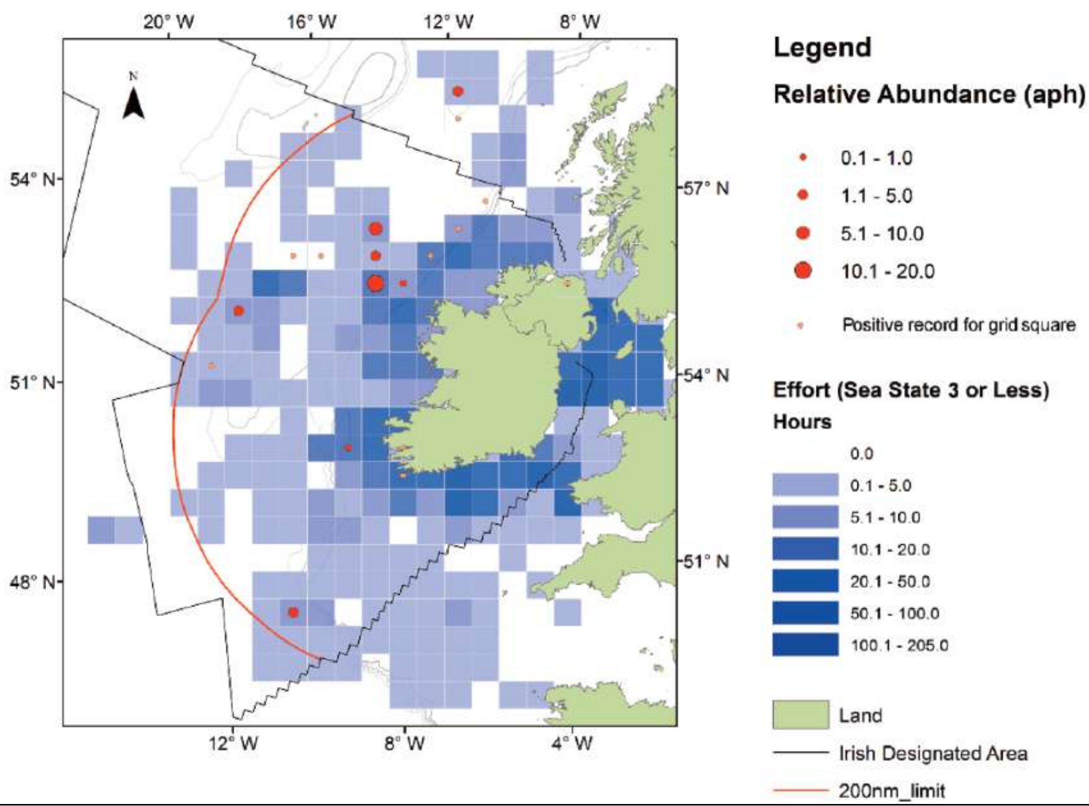
- Marine reptiles
  - Marine turtles are the only reptiles which occur in Irish waters, where five species have been recorded (leatherback turtle *Dermochelys coriacea,* loggerhead turtle *Caretta caretta*, Kemp's Ridley turtle *Lepidochelys kempii,* hawksbill turtle *Eretmochelys imbricatai* and *green turtle Chelonia mydas*). All five species of marine turtles are listed as Annex IV species but the leatherback turtle is the only species observed with enough regularity to be considered native to Irish waters (DCENR, 2015). Data from tagged turtles suggest that leatherback turtles move into Irish waters from the south and west before moving northwards around the west coast of Ireland or through the Irish Sea (Pierpoint, 2000) following swarms of jellyfish (their main prey species) (Reeds, 2004). As such, abundance and occurrence rates will be low in the FEL 3/18 area (DCENR, 2015) and there will be no adverse impact upon the population status of this (or any other) turtle species and no further assessment is required.
- Fish
  - The European sea sturgeon *Acipenser sturio* is listed on Annex IV of the Habitats Directive and is found in some offshore waters off the coast of Ireland. However, OSPAR (2009) report the offshore area west of Ireland to be outwith the range of this species. As a result, there will therefore be no adverse impact upon the population status of this species and no further assessment is required.
- Marine mammals
  - All cetacean species are listed on Annex IV of the Habitats Directive. Of these, 24 species of cetacean have been recorded in Irish waters, of which the pygmy sperm whale *Kogia breviceps*, beluga *Delphinapterus leucas*, northern right whale *Eubalaena glacialis*, and humpback whale *Megaptera novaeangliae* are considered not likely to be found in the FEL 3/18 area (DCENR, 2015) and there is thus no mechanism for impact. There will therefore be no adverse impact upon the population status of these species and no further assessment is required. The possibility of the remaining 20 species being present in the FEL 3/18 area cannot be ruled out and these species are assessed below. Further information on these 20 species, including on occurrence and distribution, is provided in Section 3.2.
- Mammals
  - The majority of other mammal species (in addition to the marine mammals mentioned above) listed on Annex IV of the Habitats Directive are terrestrial and therefore there will be no adverse impact upon the population status of these species as a result of the Project and no further assessment is required. However, the European otter *Lutra lutra* (although listed as a terrestrial mammal on Annex IV of the Habitats Directive) has marine habits and uses the nearshore coastal waters of the west coast of Ireland, which could potentially be exposed to an accidental hydrocarbon release from the Project. Therefore, the potential for injury or disturbance to European otter cannot be ruled out and this species is also reviewed below.

3.2 Detailed Information on Presence of Relevant Cetacean Species around the Project area.

Information on the distribution and seasonal presence of each of the 20 cetacean species requiring further assessment is provided in Table 3.1; this information has been derived from a range of available sources and draws on recent scientific evidence as outlined in the table.

Table 3.1 Cetacean sightings within the vicinity of FEL 3/18 (DCENR, 2007[3]; Reid *et al.*, 2003; Wall *et al.*, 2013; Rogan *et al.*, 2018).

Atlantic white-sided dolphin
Atlantic white-sided dolphins are mostly confined to the North Atlantic but have also been observed in the North Sea in a number of surveys, particularly in the western part of the North Sea. Their presence is seasonal and peaks between May and September. They are usually observed in groups of tens to hundreds, sometimes up to 1,000 offshore, forming subgroups of 2-15 individuals. DCENR (2007) report that Atlantic white-sided dolphin occur along the edges of the continental shelf at depths of 100-500 m, and generally does not occur in coastal waters. O'Cadhla *et al*. (2004) have records of sightings during summer months all along the Irish Atlantic margin with one sighting in the Porcupine region. Density at the well location is approximately 0.003 individuals/km^2 (Rogan *et al*., 2018). This species is present all year, with peaks of sightings in summer and autumn around the south-west coast of Ireland. Favourable conservation status [4]: Favourable
Distribution and relative abundance of Atlantic white-sided dolphin within the Irish EEZ 2005 – 2011 (Wall *et al*., 2013)



Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

[3] Reference is made to the IOSEA2 documents prepared by DCENR (2007) to assist in preparation of the baseline environment and not as basis for any environmental risk assessment work. Where quantitative data have been used in the assessment, they are from more recent sources.
[4] The favourable conservation statuses presented in this section have been derived from DAHG (2013b).

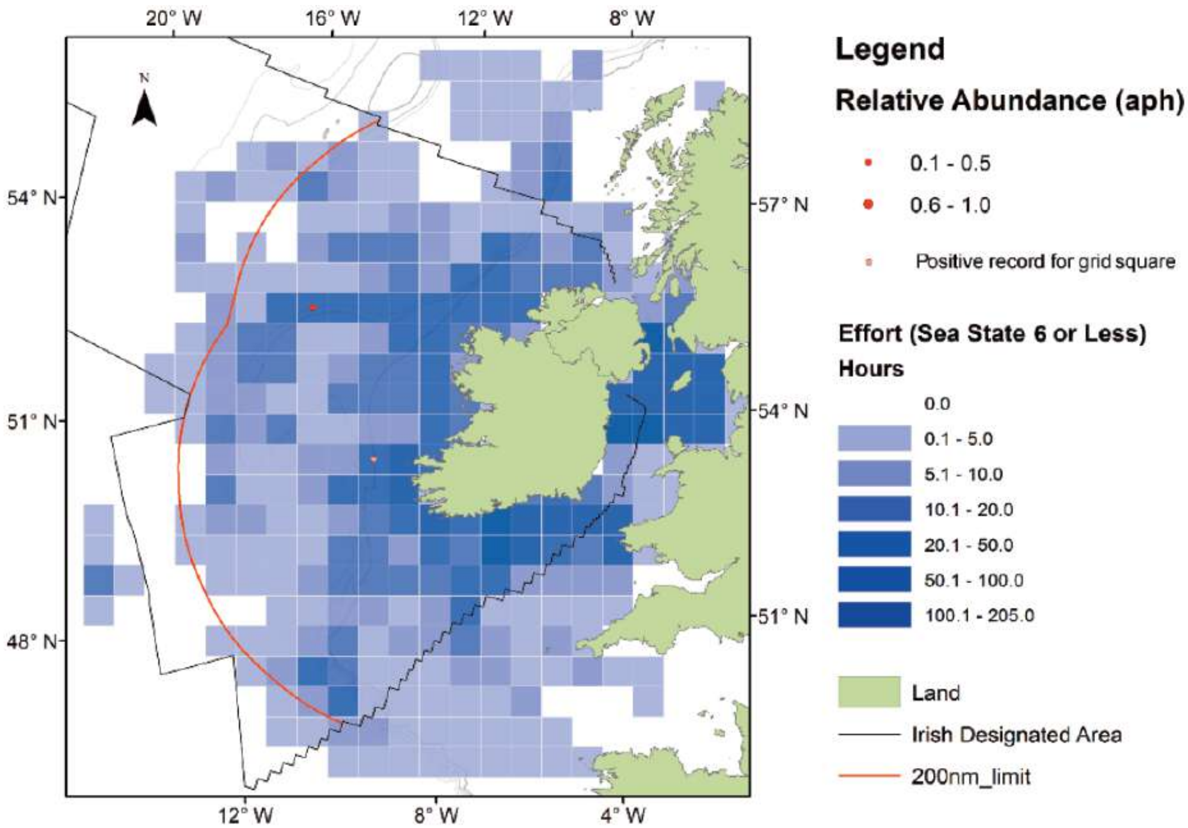
Blue whale

Blue whales occur in deep water, between 100 and 1,000 m water depth, although in some regions they have been recorded in shallower waters of less than 200 m. O'Cadhla *et al*. (2004) have recorded a single individual sighting in the north of the Porcupine Basin in May. They also report previous acoustic records using military sonar systems, and previous sparse sightings in the Irish Atlantic Margin.

Recent acoustic surveys have shown that deep-water individuals may occur between October and January, while previous sighting records suggest that they occur between July and September. This discrepancy between studies might be due to increased survey efforts during summer months.

Favourable conservation status: Unknown

Distribution and relative abundance of blue whale within the Irish EEZ 2005 – 2011 (Wall *et al*., 2013)



Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

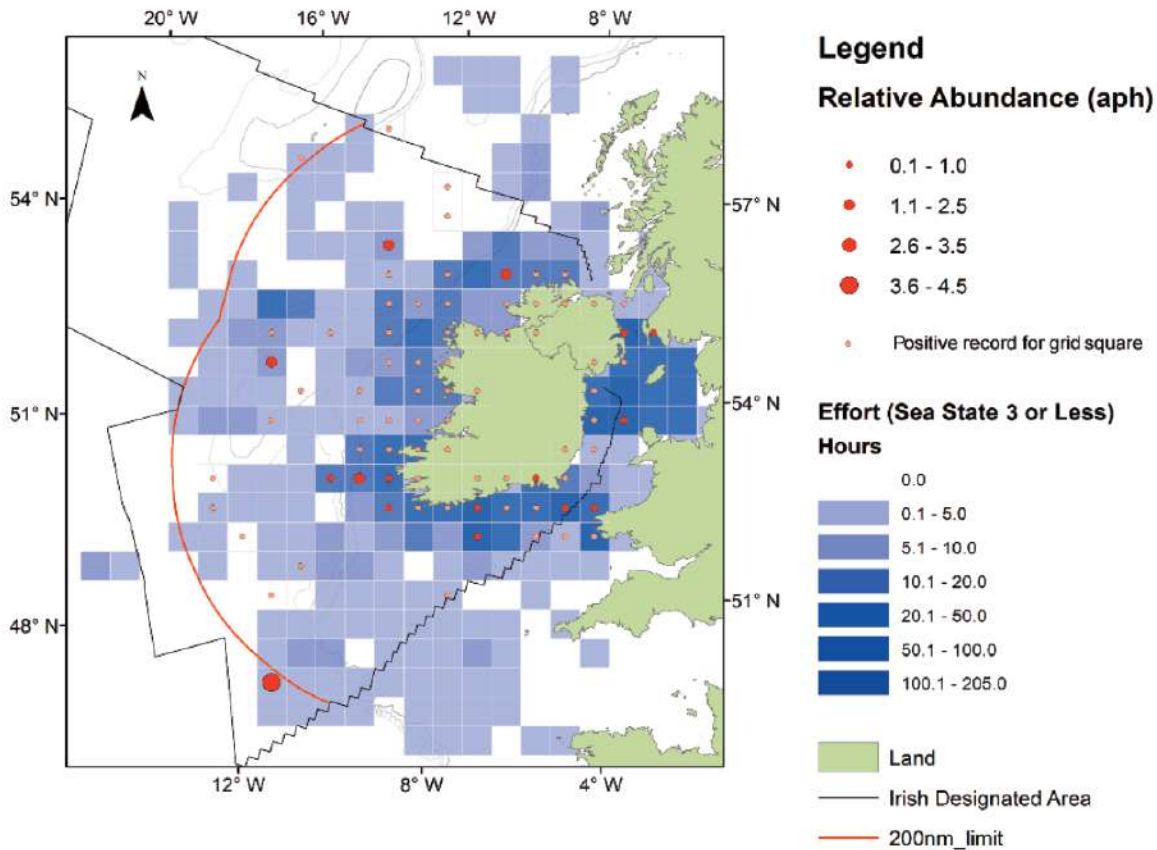
Bottlenose dolphin

Bottlenose dolphins are the third most frequently recorded species in Irish waters (Berrow *et al*., 2010). There is increasing evidence to suggest that an offshore ecotype of bottlenose dolphin exists in Irish waters (Wall *et al*., 2013), and during spring/summer months (April-August), and again in high numbers in November by O'Cadhla *et al*. (2004). This species has been recorded in the wider region all year round predominantly in the shelf break, and waters to the south and south-west of Ireland and further offshore in deep North Atlantic waters. Off the west coast of Ireland, the Shannon Estuary is also home to at least one resident bottlenose dolphin population year-round (DCENR, 2007). Density at the well location is approximately 0.435 individuals/km^2 (Rogan *et al*., 2018).

This species is present all year, with peaks of sightings in May.

.Favourable conservation status: Favourable

Distribution and relative abundance of bottlenose dolphin within the Irish exclusive economic zone (EEZ) 2005 – 2011 (Wall *et al*., 2013)



Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

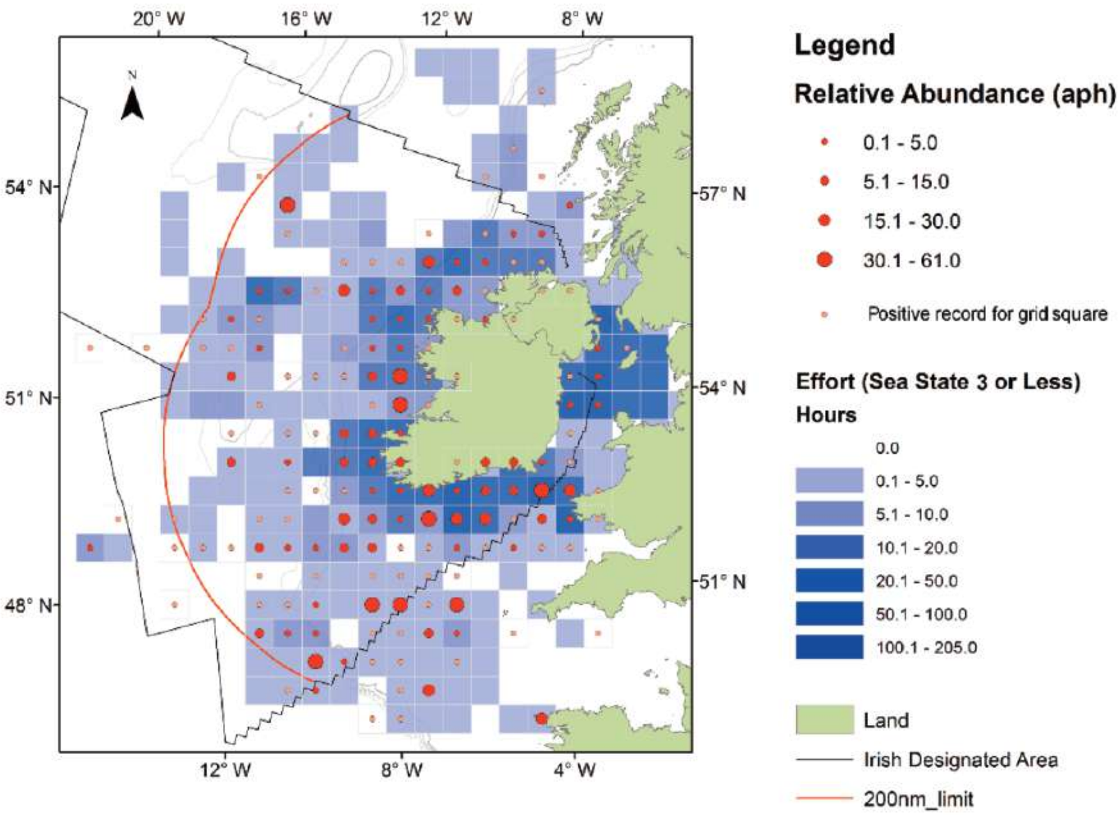
Common dolphin

Common dolphins also known as the short beaked common dolphins, are the second most frequently recorded cetaceans in Irish waters (Reid *et al*., 2003). They have been observed over deeper waters across the continental shelf but rarely in water depths exceeding 200 m (Reid *et al*., 2003). Although the biggest concentrations in Ireland are over the continental shelf and in deeper waters, individuals are frequently observed in shallow inshore waters off the south and south-west coasts and around the Aran Islands (IWDG, 2017). There is evidence of a strong inshore winter peak in numbers along the south coast, possibly associated with movements of sprat (IWDG, 2018). They have been reported in high abundances around the edges of the Porcupine Basin and in the wider region year-round, with sightings being made in coastal waters, along the continental slope, as well as over deeper areas (DCENR, 2007). Density at the well location is approximately 0.246 individuals/km^2 (Rogan *et al*., 2018).

This species is present all year, with peaks of sightings in summer around the south-west coast of Ireland.

Favourable conservation status: Favourable

Distribution and relative abundance of common dolphin within the Irish EEZ 2005 – 2011 (Wall *et al*., 2013)

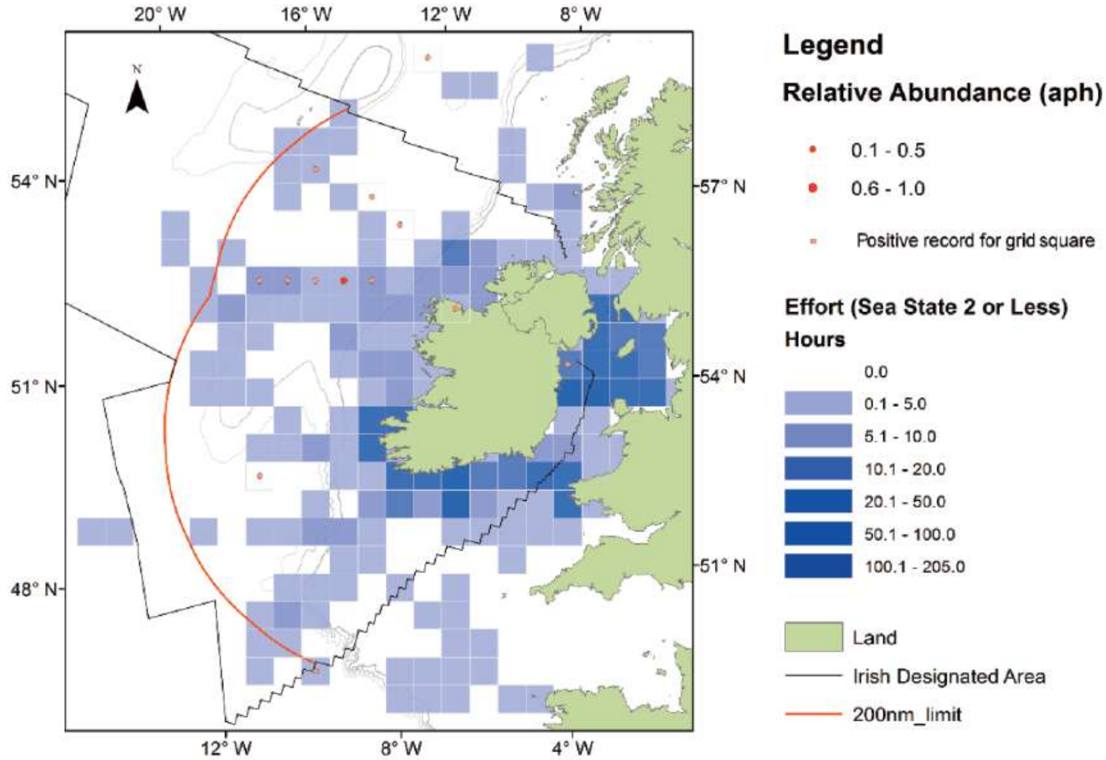


Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

Cuvier’s beaked whale
While the edge of the entire continental shelf is considered important, an area of high importance on the northern edge of the Porcupine Bank and into the Rockall Trough, and the Porcupine Seabight are predicted to have the highest densities of beaked whales. Density at the well location is approximately 0.0032 individuals/km^2 (Rogan *et al*., 2018). The majority of sightings within the Porcupine Seabight reported in Rogan *et al*. (2018) occurred during winter. Favourable conservation status: Unknown
Northern bottlenose whale
Northern bottlenose whales are a deep-diving species typically found offshore in waters deeper than 1,000 m. It is believed that this species migrates north in spring and south in autumn (DCENR, 2007). Berrow *et al*. (2010) reported sightings within the Porcupine Seabight, and Rogan *et al*. (2018) recorded one sighting in the wider vicinity of the proposed well, at the southern margin of the Porcupine Seabight. A further two sightings were made by Rogan *et al*. (2018) in the Rockall Basin. All three records in Rogan *et al*. (2018) were from winter surveys. Favourable conservation status: Unknown
True’s beaked whales
Although there are very few confirmed sightings of True’s beaked whale *Mesoplodon mirus*, strandings have occurred along the West coast of Ireland. It is thought that this species may occur year round in the Irish Atlantic Margin (DCENR, 2007). Favourable conservation status: Unknown
Sowerby’s beaked whale
Although there are very few confirmed sightings of live Sowerby’s beaked whale, strandings have occurred along the west coast of Ireland. It is thought that this species may occur year-round in the Irish Atlantic Margin (DCENR, 2007). Rogan *et al*. (2018) recorded four sightings, of which three were over the Rockall Trough shelf edge, and one was over the northern shelf edge of the Porcupine Seabight, fairly close to the proposed well location. Rogan *et al*. (2018) recorded sightings in winter and summer, although total sightings were very low. Favourable conservation status: Unknown

Distribution and relative abundance of beaked whales within the Irish EEZ 2005 – 2011 (Wall *et al*., 2013)



Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

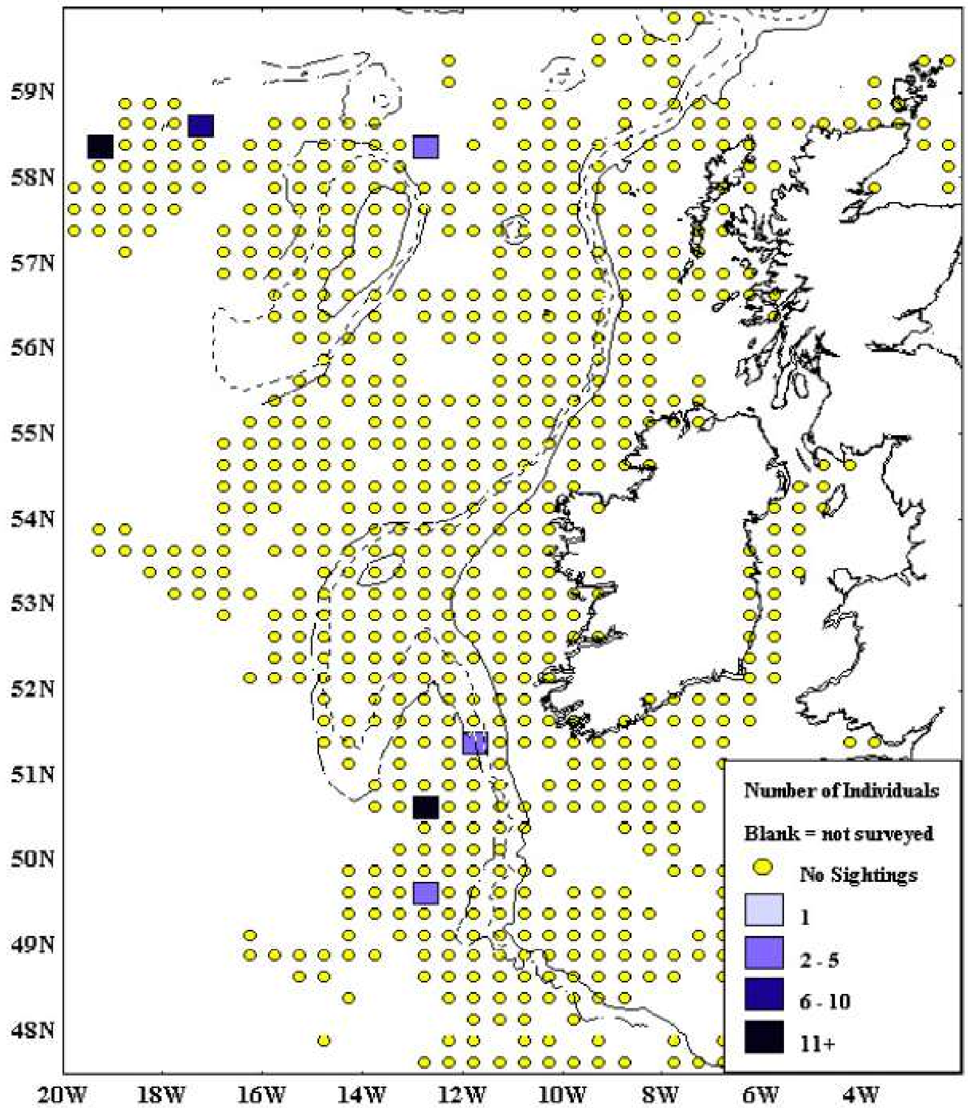
False killer whale

O'Cadhla *et al*. (2004) reported false killer whale sightings in the southern region of the Porcupine Basin between June and November. Rogan *et al*. (2018) recorded zero sightings of this species over two years of aerial survey effort.

Most sightings recorded by O'Cadhla *et al*. (2004) were between July and September.

Favourable conservation status: Favourable

Sighting distribution and total numbers of false killer whales observed between July 1999 and September 2001 (O' Cadhla *et al*., 2004)



Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

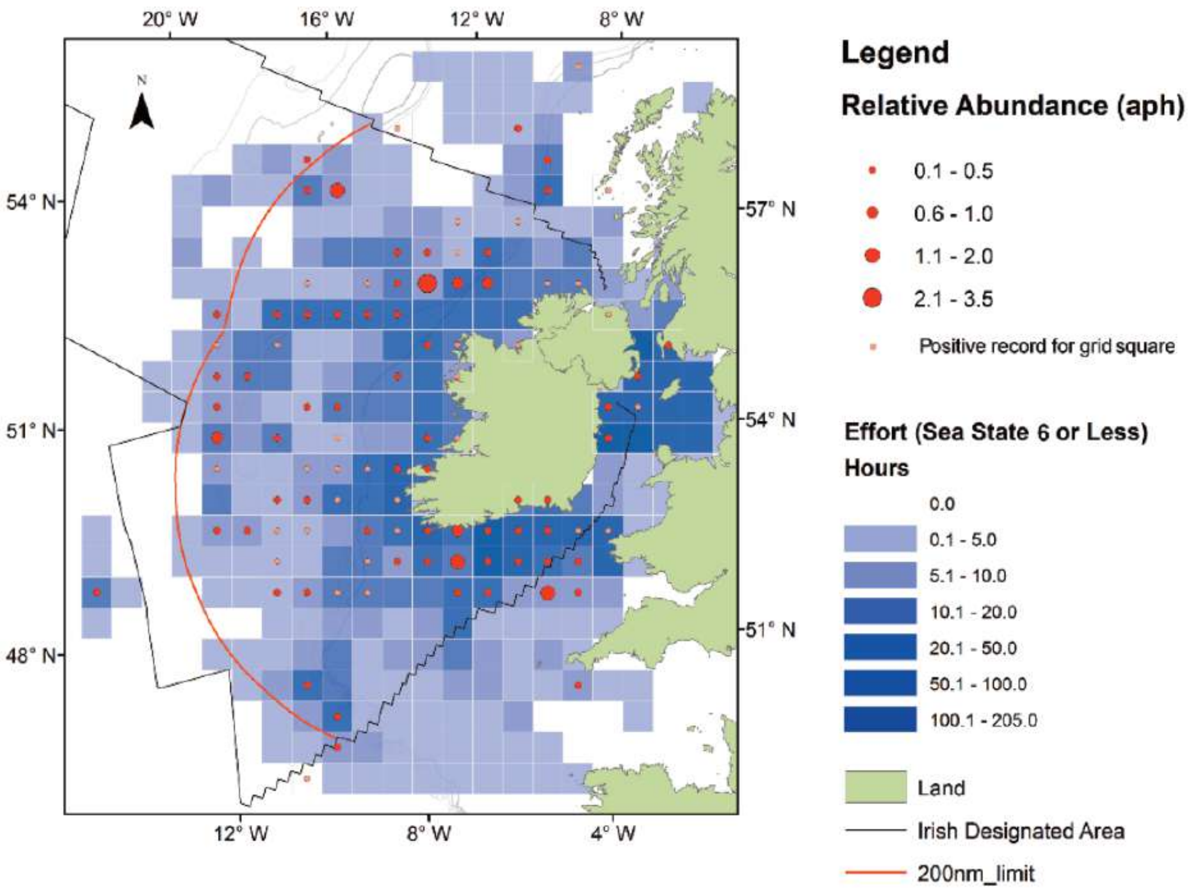
Fin whale

Fin whales are seasonally abundant in shelf edge waters off the coast of Ireland; however, the species tend to prefer the deep waters beyond the edge of the continental shelf (Reid *et al*., 2003). The annual movements of fin whale remain largely unknown, although sightings have been made throughout the Irish Atlantic Margin. Wall *et al*. (2013) shows that fin whales appeared to be largely absent from Irish shelf waters during the winter and early spring, though a few animals remained foraging in inshore waters off the south-east coast during the early winter. Fin whale abundance and distribution increased in the waters of the Irish shelf slopes in late summer and autumn (Wall *et al*., 2013). Density at the well location is approximately 0.001 individuals/km^2 (Rogan *et al*., 2018). Relatively few sightings were recorded inside the Porcupine Seabight, with the majority occurring within or on the margins of the Rockall Trough.

Most sightings within the Porcupine Seabight occurred in winter.

Favourable conservation status: Favourable

Distribution and relative abundance of fin whale within the Irish EEZ 2005 – 2011 (Wall *et al*., 2013)



Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

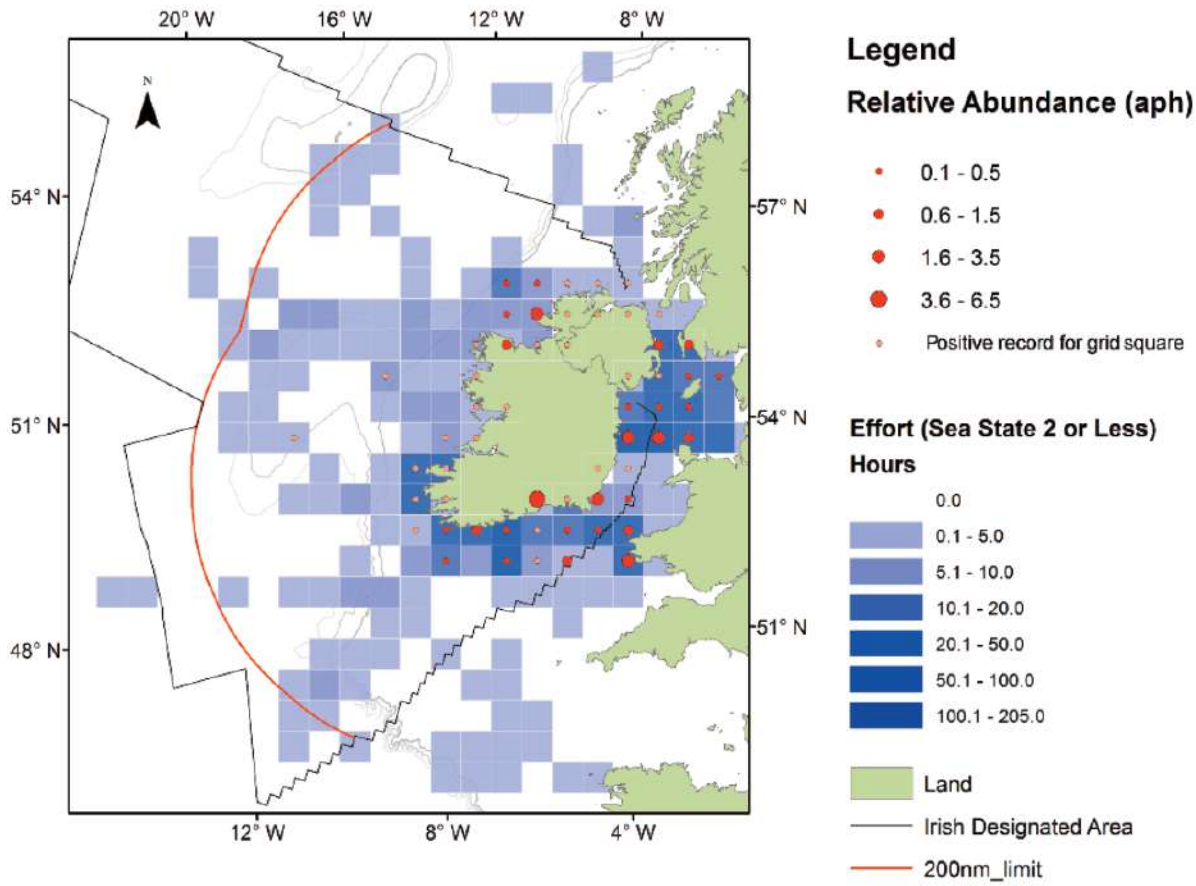
Harbour Porpoise

The harbour porpoise is a predominantly coastal species. They typically occur in the European continental shelf in waters up to 200 km from the coast (DCENR, 2007). Although these are the smallest cetaceans in Irish waters, they are abundant and widespread. Density at the well location is approximately 0.049 individuals/km^2 (Rogan *et al*., 2018), although this is an average within Stratum 3 (see Rogan *et al*., 2018), and actual sightings within the Porcupine Seabight are very rare. The majority of sightings in the area occurring over the continental shelf to the east and the north of the proposed well site.

Most sightings occur in summer (Rogan *et al*. (2018).

Favourable conservation status: Favourable

Distribution and relative abundance of harbour porpoise within the Irish EEZ 2005 – 2011 (Wall *et al*., 2013)



Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

Humpback whale
Humpback whale sightings are relatively uncommon in the waters off the west coast of Ireland, and most of them have been observed during summer months. However, they appear to use the offshore waters of the British Isles as a migration corridor between November and March, including the Atlantic margin region of Ireland. While it is possible that the species is under-recorded in Ireland due to difficulties in distinguishing it from other large whale species in the open sea, it's seasonal and mainly oceanic occurrence off western Europe may also explain why sighting records remain low compared to more wide-ranging whale species. In recent years however, records have increased close to the Irish coast and some individuals have been shown to return repeatedly to forage in waters off the southwest, south and southeast coasts (Wall *et al*., 2013). A single sighting was recorded over the shelf margin to the north of the proposed well location by Rogan *et al*. (2018) during the winter 2015-2016 survey. Most older records occurred in summer months; the single Rogan *et al*. (2018) sighting occurred in winter. Favourable conservation status: Unknown
Distribution and relative abundance of humpback whale within the Irish EEZ 2005 – 2011 (Wall *et al*., 2013)

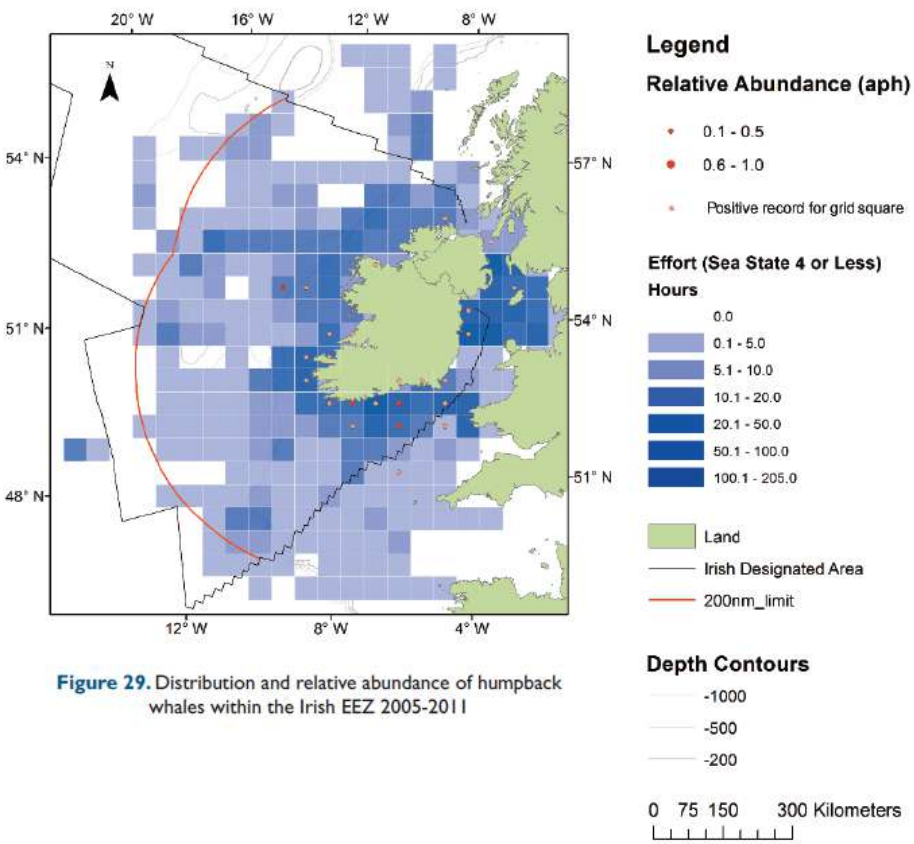


Figure 29. Distribution and relative abundance of humpback whales within the Irish EEZ 2005-2011

Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

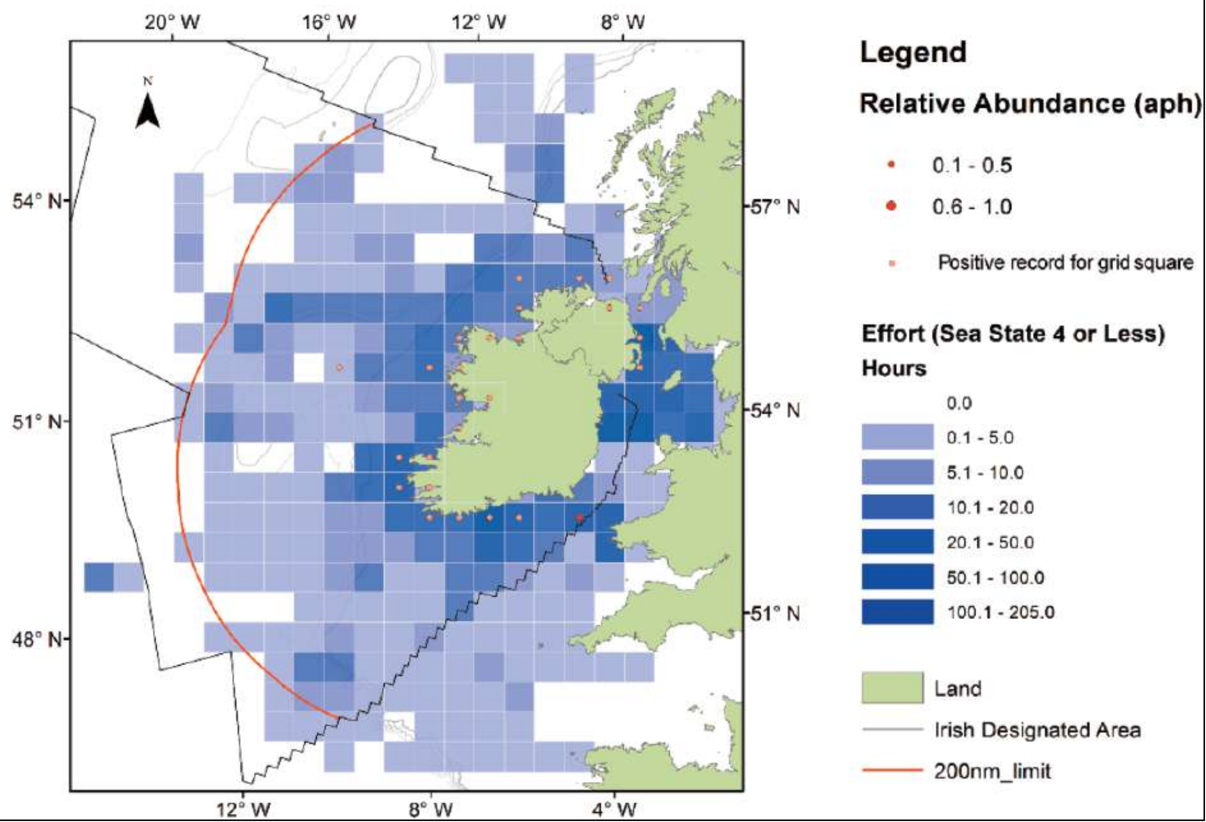
Killer whale

It has been reported that this species is present in the West of Ireland region year-round, predominantly to the west and south of Ireland, as well as in the Irish Atlantic margin waters between spring and autumn (DCENR, 2007). However, no sightings were made near the Project by Wall *et al*., (2013), and Rogan *et al*. (2018) recorded zero sightings of this species over two years of aerial survey effort.

Not expected to occur regularly in any season.

Favourable conservation status: Unknown

Distribution and relative abundance of killer whale within the Irish EEZ 2005 – 2011 (Wall *et al*., 2013)



Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

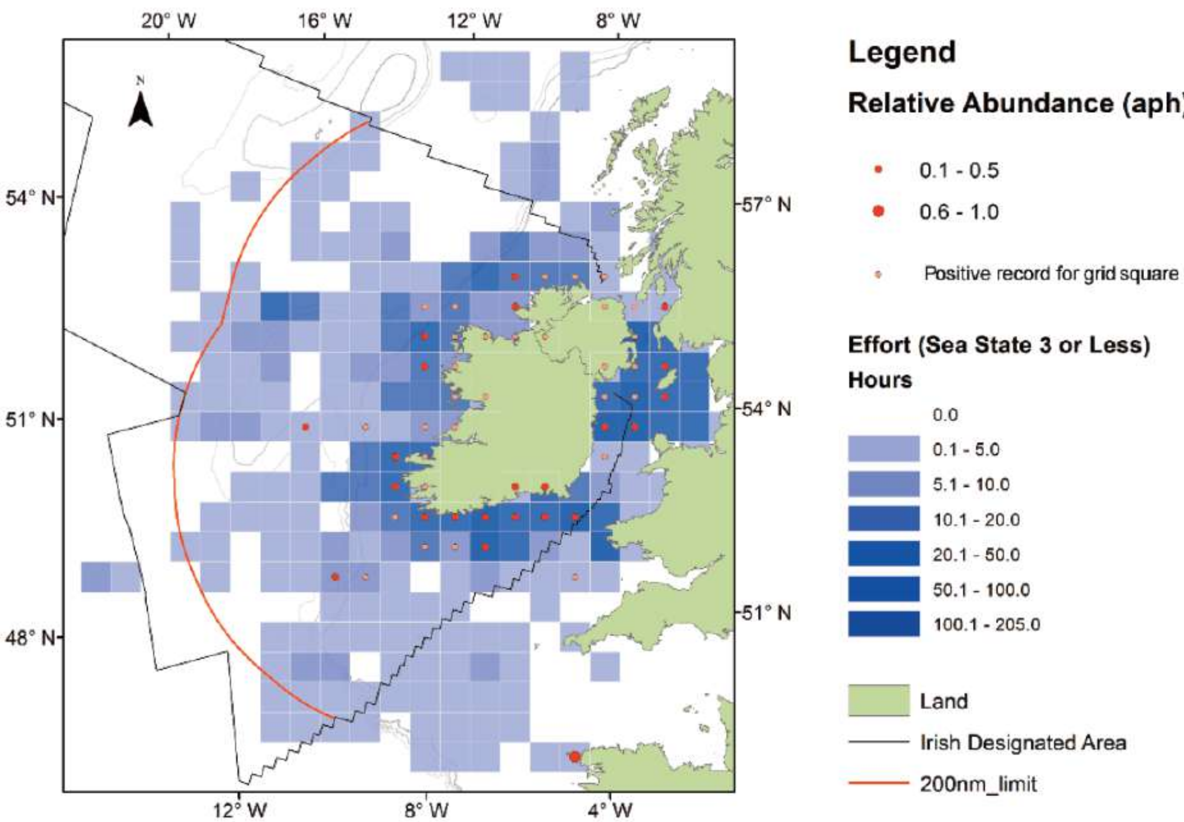
Minke whale

Minke whales *Balaenoptera acutorostrata* are the smallest and most frequently sighted and stranded baleen whale in Irish waters (Berrow *et al*., 2010). Minke whales were recorded as far offshore as the Project in June by Reid *et al*. (2003). Rogan *et al*. (2018) reports that minke whales favour the coastal waters off the southwest of Ireland during summer, with limited use of the shelf edge to the east of the Porcupine Seabight. They appear to move away from the coast during winter, and increase their use of the continental shelf and shelf edge to the east of the proposed well location. Density at the well location is approximately 0.031 individuals/km^2 (Rogan *et al*., 2018).

Favour southwestern Irish coastal waters during summer, dispersing offshore during winter (Rogan *et al*., 2018).

Favourable conservation status: Favourable

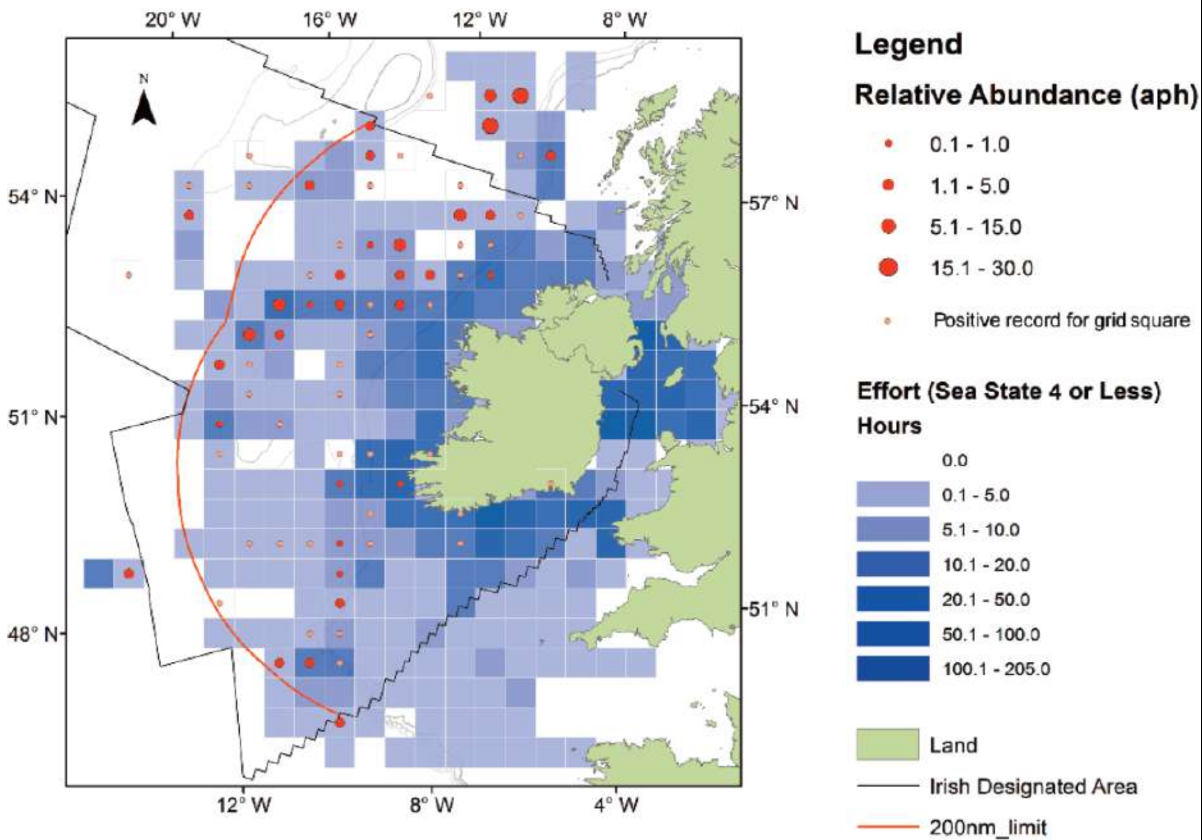
Distribution and relative abundance of minke whale within the Irish EEZ 2005 – 2011 (Wall *et al*., 2013)



Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

Pilot whale
Pilot whales *Globicephala melas* are predominantly found over the continental shelf and in coastal areas. It is thought that this species is present year-round in the wider Porcupine Basin (DCENR, 2007). Wall *et al*. (2013) noted that high relative abundances of pilot whales are recorded in the vicinity of deep water bathymetric features such as sea mounts. The highest concentrations in the area are found over the Rockall Trough and Goban Spur (which forms the southern margin of the Porcupine Seabight) (Rogan *et al*., 2018). Density at the well location is approximately 0.017 individuals/km^2 (Rogan *et al*., 2018). There was no apparent change in seasonal distribution recorded in Rogan *et al*. (2018). Favourable conservation status: Favourable
Distribution and relative abundance of pilot whale within the Irish EEZ 2005 – 2011 (Wall *et al*., 2013)



Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

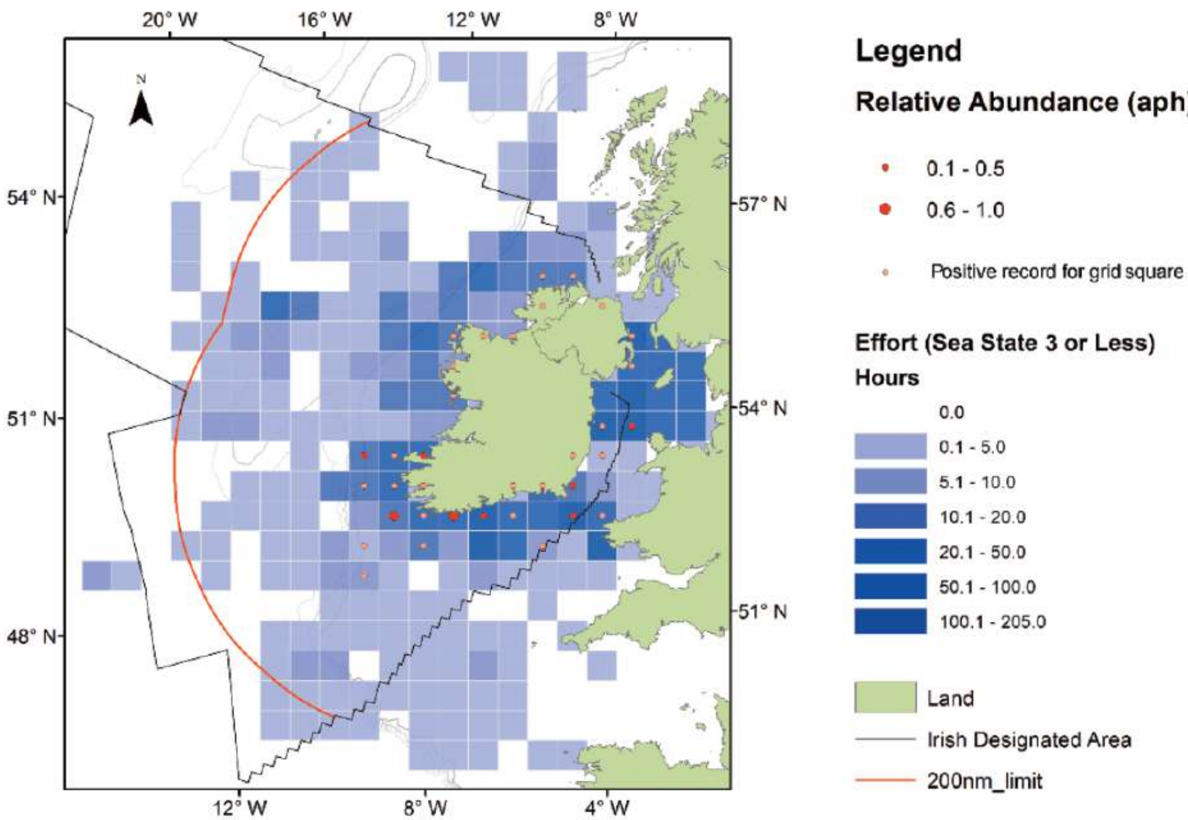
Risso's dolphin

Records from Rogan *et al*. (2018) indicate Risso's dolphin *Grampus griseus* is more common away from the coast but over the continental shelf rather than in very deep water. Some reports indicate this species is present year-round in the wider Porcupine Basin (DCENR, 2007), however Rogan *et al*., (2018) only recorded sightings within the Porcupine Seabight during the winter 2015-2016 survey. Predicted density at the well location is approximately 0.0047 individuals/km^2 (Rogan *et al*., 2018).

All sightings recorded in the vicinity of the proposed well by Rogan *et al*. (2018) were during the winter months.

Favourable conservation status: Unknown

Distribution and relative abundance of Risso's dolphin within the Irish EEZ 2005 – 2011 (Wall *et al*., 2013)



Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

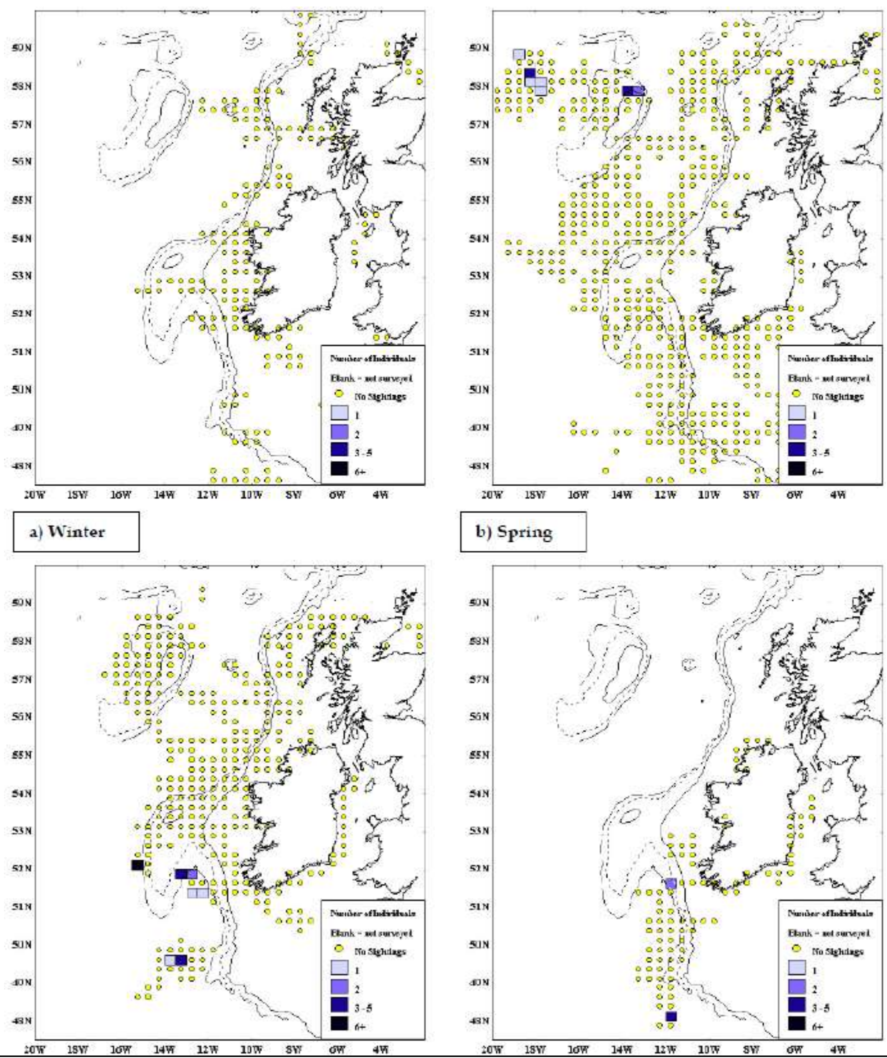
	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

Sei whale

It is thought that sei whale *Balaenoptera borealis* migrate through Irish waters in spring, before returning southward in autumn and winter. Sei whale sightings have been made in the West of Ireland offshore area throughout the year (DCENR, 2007). Rogan *et al*. (2018) recorded two sei whales during the winter 2016-2017 survey, over the Porcupine Bank to the north of the proposed well location. DCENR (2007) indicates presence offshore in the west of Ireland throughout the year, however Rogan *et al*. (2018) recorded sightings in winter only. Sei whales have also been observed near Erris Head in Broadhaven Bay SAC (inshore of West Connacht Coast SAC) in September 2009 in three separate sightings. There were at least two animals present of which one was a juvenile.

Favourable conservation status: Unknown

Seasonal sighting distribution and total numbers of sei whales observed between July 1999 and September 2001 (Ó Cadhla *et al*., 2004)



Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

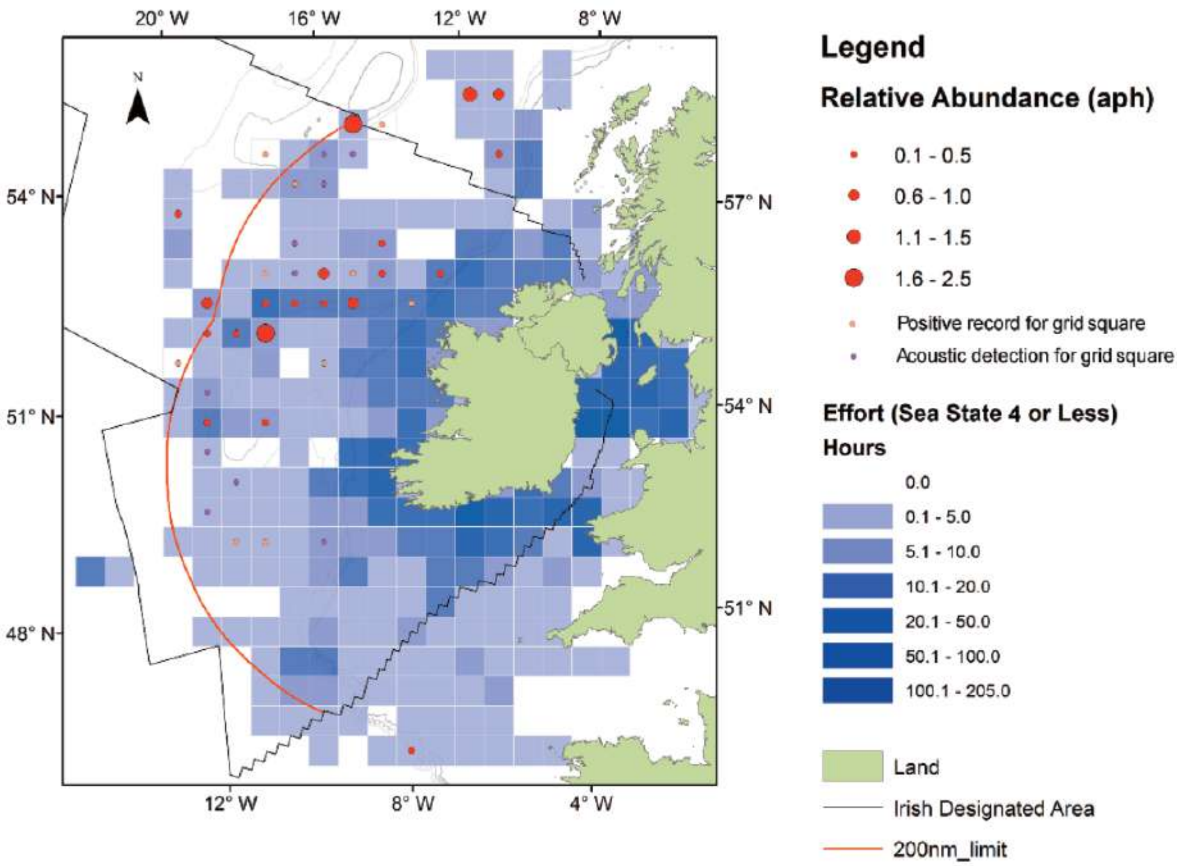
Sperm whale

Sperm whales are common in deep waters offshore Ireland (DCENR, 2007; 2015). While sightings and landings records show them to be most abundant during summer and autumn, stranding records suggest males may be present all year round (DCENR, 2007). O'Cadhla *et al*. (2004) recorded sightings in the vicinity of the Project during spring and summer, however the closest sightings recorded by Rogan *et al*. (2018) were at the far west edge of the Porcupine Bank.

Sightings occur in all seasons, but more commonly in summer (Rogan *et al*., 2018).

Favourable conservation status: Unknown

Distribution and relative abundance of sperm whale within the Irish EEZ 2005 – 2011 (Wall *et al*., 2013)



Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

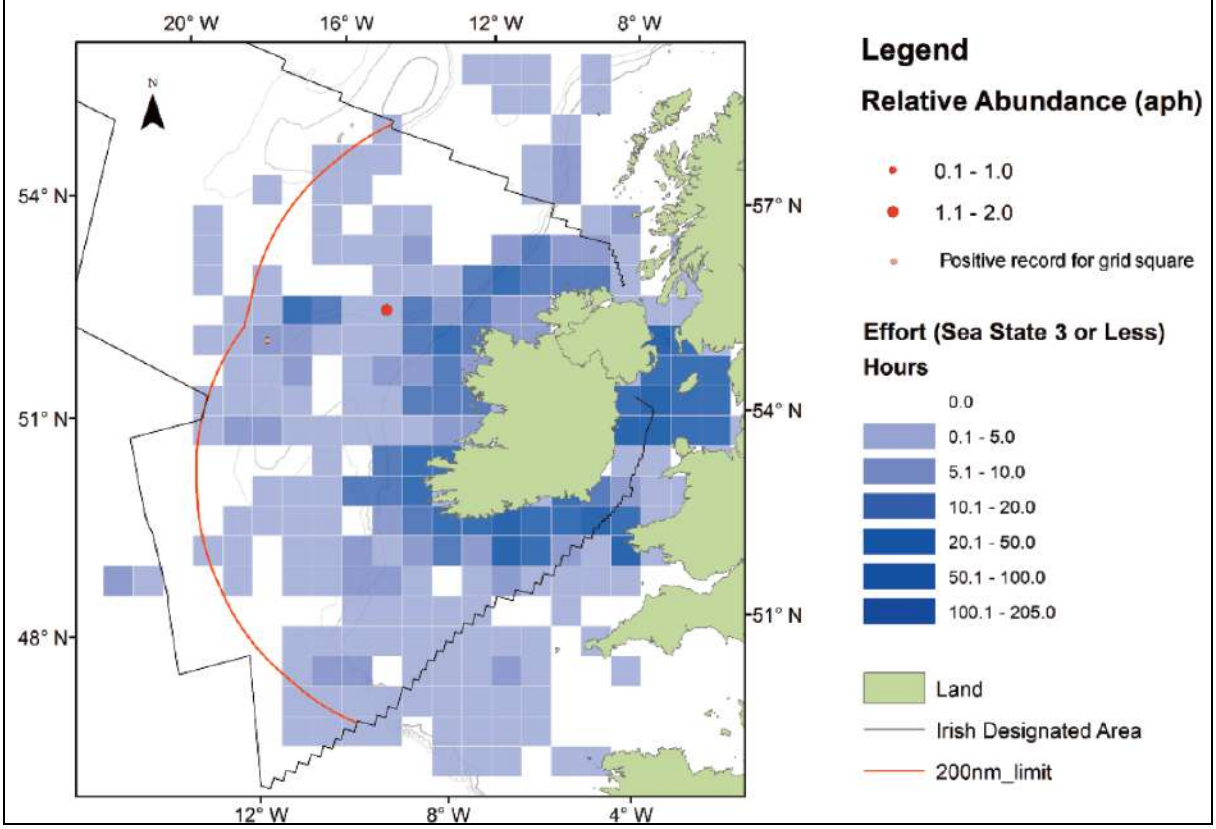
Striped dolphin

Striped dolphins tend to reside beyond the continental shelf in depths of greater than 1,000 m. However, specimens occasionally occur over the shelf into waters less than 60 m deep. O'Cadhla *et al*. (2004) recorded sightings of this species along the Irish Atlantic Margin in summer and early autumn with higher numbers of records in the southern part of the Porcupine Basin. Rogan *et al*. (2018) only recorded two confirmed sightings of striped dolphin, both of which were off the continental shelf to the west of the Porcupine Bank. Rogan *et al*. (2018) acknowledged difficulties in differentiating striped and common dolphins.

Both records in Rogan *et al*. (2018) were from the winter 2015-2016 survey.

Favourable conservation status: Favourable

Distribution and relative abundance of striped dolphin within the Irish EEZ 2005 – 2011 (Wall *et al*., 2013)



Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

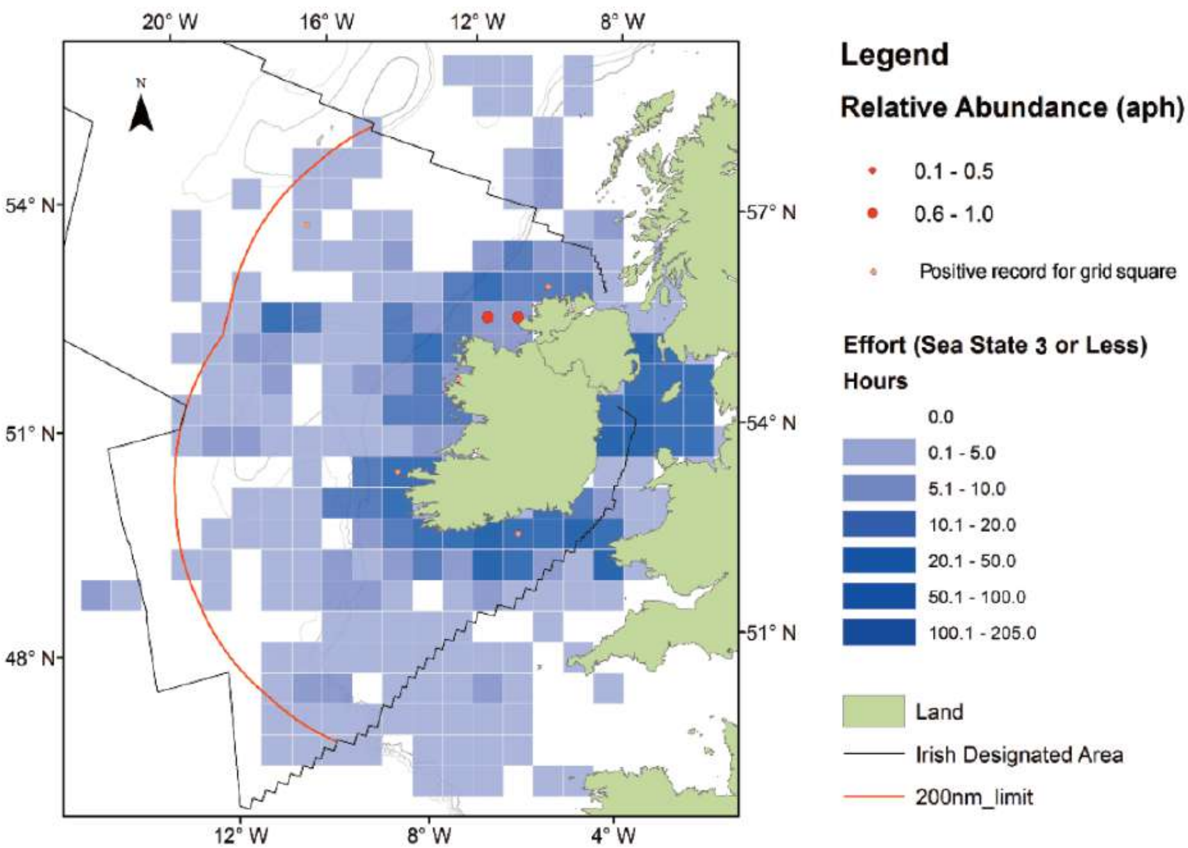
White beaked dolphin

White-beaked dolphins occur widely over the northern European continental shelf with more frequent records in the western sector of the northern and central North Sea across to western Scotland and south to western Ireland. Although it has been recorded in the UK continental shelf all year-round, there are higher numbers of records between June and October (Reid *et al*., 2003). There are records of white-beaked dolphins between June and November in the IOSEA2 area (Wall *et al*., 2013). Rogan *et al*. (2018) recorded most sightings over the Porcupine Bank and the shelf edge to the west. A few sightings occurred in the southest corner of the Porcupine Seabight, and others occurred over the shelf closer to the west Irish coast. Estimated density at the well location is approximately 0.039 individuals/km^2 (Rogan *et al*., 2018)

The majority of sightings from Rogan *et al*. (2018) were recorded during the summer surveys.

Favourable conservation status: Favourable

Distribution and relative abundance of white beaked dolphin within the Irish EEZ 2005 – 2011 (Wall *et al*., 2013)



Key (number to individuals sighted per hour of effort) (Reid *et al*., 2003)

	High (10 – 100)		Medium (1 – 10)		Low (0.01 – 1)		Very low (0 – 0.01)		No sightings
	Presence reported in West of Ireland offshore waters (DCENR, 2007)								

3.3 Information on the Presence of European Otters along the west and south coast of Ireland

Ireland has long been considered to hold one of the most important remaining populations of European otter in Western Europe and surveys carried out in the early 1980's and again in the early 1990s confirmed the species to be widespread throughout the country. Populations in coastal areas utilise shallow, inshore marine areas for feeding but also require fresh water for bathing and terrestrial areas for resting and breeding holts.

During 2010 and 2011 a national survey of otter populations was undertaken by NPWS and reported by Reid *et al* (2013). The outcomes of this national survey indicate that there are many locations along the Irish west and south coast that are habited by otters (Figure 3.1). The assessment of the diets of coastal otters in Ireland indicate that those individuals which inhabit the coastal marine waters of Ireland feed predominantly on marine species such as rocklings (Gadidae), wrasse (Labridae), Crustacea, Mollusca, Atlantic eel, goby (Gobiidae), sea scorpions (Cottidae) and blennies, but also travel inland to estuaries to feed on brackish or freshwater food resources as well (Reid *et al*., 2013).

Figure 3.1 Otter survey results during the NPWS 2010 and 2011 national survey. Otter survey sites in the Republic of Ireland (during 2010/11) augmented by those surveyed Northern Ireland in 2010 showing otter occurrence as closed circles and absence of tracks or signs as open circles. (From Reid *et al*., 2013).

3.4 Sources of Potential Impacts

Considering the proposed Project activities (see Section 2) and the baseline condition of the receptors of interest (Sections 3.2 and 3.3), two potentially significant impact mechanisms on cetaceans and otters have been identified; these are summarised in Table 3.2.

Table 3.2 Potential environmental impacts on protected species

Source of impact	Description of potential impact mechanism	Relevant protected species
Underwater noise	Acoustic disturbance resulting from VSP and vessel emissions	Cetaceans
Accidental releases	Accidental release of chemicals or hydrocarbons to the marine environment leading to toxic effects on marine species, smothering and reduction in water quality.	Cetaceans and otters

The assessment of the potential impacts on the relevant protected species is presented in Section 3.5 below.

3.5 Assessment of Potential Impacts

3.5.1 Underwater noise - cetaceans

Many species found in the marine environment use sound to understand their surroundings, track prey and communicate with members of their own species. Some species, mostly toothed whales, dolphins and porpoise, also use sound to build up an image of their environment and to detect prey and predators through echolocation. Exposure to natural sounds in the marine environment may elicit responses in marine species; for example, harbour seals have been shown to respond to the calls of killer whales with anti-predator behaviour (Deecke *et al*., 2002). In addition to responding to natural sounds, marine mammals may also respond to man-made noise, and if Project activities elicit responses in cetaceans, this could amount to deliberate disturbance of Annex IV species in contravention of Article 12.

In order to assess the potential for deliberate disturbance of cetaceans by Project noise, it is necessary first to define the threshold at which disturbance occurs.

Richardson *et al.* (1995) proposed a simplified means of defining noise impacts on marine mammals as four 'zones of influence' which vary with the distance from the source and magnitude of the sound; they are:

> The zone of audibility: This is the area within which the animal can detect the sound. Audibility itself does not implicitly mean that the sound will have an effect on the marine mammal.

> The zone of masking: This is defined as the area within which noise can interfere with detection of other sounds such as communication or echolocation clicks. This zone is very hard to estimate due to a paucity of data relating to how marine mammals detect sound in relation to masking levels (for example, humans can hear tones well below the numeric value of the overall noise level).

> The zone of responsiveness: This is defined as the area within which the animal responds either behaviourally or physiologically. The zone of responsiveness is usually smaller than the zone of audibility because, as stated previously, audibility does not necessarily evoke a reaction. The zone of responsiveness will not necessarily be a zone from which animals are excluded, but rather one in which normal behaviour might be affected across a range of potential responses, from a simple noticing of the sound, to a startle response and return to normal behaviour, through to exclusion from an area.

> The zone of injury/hearing loss: This is the area where the sound level is high enough to cause tissue damage in the animal's hearing mechanism. This can be classified as either temporary threshold shift or permanent threshold shift. At even closer ranges, and for very high intensity sound sources (e.g. underwater explosions), additional physical trauma or even death is possible.

In this report, injury or a strong behavioural response are considered to meet the definition of "disturbance" in Article 12. To determine the range at which Project activities could cause injury or elicit a strong response from marine mammals, noise propagation modelling was undertaken, coupled with a review of national and international guidance and relevant scientific literature. The modelling reports are summarised below.

The noise propagation modelling simulated the propagation and attenuation through the water column of impulsive and continuous noise generated by Project activities and calculated the distance from the noise source at which the relevant receptors (low-, mid- and high-frequency cetaceans) would experience injury or show a strong behavioural response. To determine the range at which injury or responsiveness could occur, it is necessary to define received sound level thresholds at which the receptor will be either injured or exhibit a response. The modelling used two sets of thresholds: those proposed by Southall *et al*. (2007) as specified by the NPWS (2014) guidance, and the more recent thresholds proposed by NOAA (2018). Results generated using both sets of thresholds are presented in this assessment to allow a comparison.

CNOOC is committed to adhering to the most recent guidance; Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters (NPWS, 2014). These measures will include:

During VSP:

- A qualified and experienced marine mammal observer (MMO) shall be appointed to monitor for marine mammals and to log all relevant events using standardised data forms;
- Sound-producing activities shall only commence in daylight hours where effective visual monitoring, as performed and determined by the MMO, has been achieved. Where effective visual monitoring, as determined by the MMO, is not possible, the sound-producing activities shall be postponed until effective visual monitoring is possible;
- Pre-start-up monitoring shall be conducted at least 60 minutes before the activity is due to commence. Sound-producing activity shall not commence until at least 60 minutes have elapsed with no marine mammals detected within the Monitored Zone by the MMO.
- Pre-Start Monitoring shall subsequently be followed by a Ramp-Up Procedure (where possible) which should include continued monitoring by the MMO. Airguns utilised in VSP generally fire for approximately two minutes and then stop for 5 – 10 minutes before repeating the pattern. To ensure that marine mammals are given the opportunity to move away from the airguns as they commence firing, energy would be slowly increased to the maximum level over a period of 40 minutes, in a process called 'soft-start'.
- If there is a break in sound output for a period of 5-10 minutes (e.g., due to equipment failure, shut-down), MMO monitoring must be undertaken to check that no marine mammals are observed within the Monitored Zone prior to recommencement of the sound source at full power.
- If there is a break in sound output for a period greater than 10 minutes (e.g., due to equipment failure, shut-down or station change) then all Pre-Start Monitoring and a subsequent Ramp-up Procedure (where appropriate following Pre-Start Monitoring) will be undertaken.

While mitigation measures will be strictly followed during operations, in order to present the worst-case potential for injury and responsiveness, the modelling was conducted both with and without mitigation included, and the results of both sets of simulations have been presented in this report.

The ranges at which injury and behavioural response are predicted to occur are summarised in Table 3.3 (Southall *et al*., 2007 thresholds) and Table 3.4 (NOAA, 2018 thresholds). It should be noted that the sound level deemed to cause disturbance is the same in both sets of thresholds, the small difference in the reported disturbance radiuses is caused by a slightly more refined propagation calculation used for the NOAA (2018) thresholds.

Table 3.3 Radius of potential injury and disturbance zones due to vessel, drilling and VSP noise per the Southall *et al.* (2007) thresholds

Activity	Radius of effect (m)		
	Low-frequency cetacean	Mid-frequency cetacean	High-frequency cetacean
SEL radius of potential injury zone (moving mammals are assumed to move with a speed of 1.5 ms^{-1})			
Continuous noise: Drill ship combined with support vessel	-*	-*	-*
VSP	25	9	7
VSP + soft start	6	3	2
Estimated range for onset of strong behavioural response			
Continuous noise: Drilling / DP / support vessel.	590 m		
VSP	2,795 m		

* Threshold not exceeded.

Table 3.4 Radius of potential injury and disturbance zones due to vessel, drilling and VSP noise per the NOAA (2018) thresholds

Activity	Radius of effect (m)		
	Low-frequency cetacean	Mid-frequency cetacean	High-frequency cetacean
SEL radius of potential injury zone (moving mammals are assumed to move with a speed of 1.5 ms^{-1})			
Continuous noise: Drill ship combined with support vessel	-*	-*	-*
VSP	113	31	298
VSP + soft start	41	9	152
Estimated range for onset of strong behavioural response			
Continuous noise: Drilling / DP / support vessel.	590 m		
VSP	2,750 m		

* Threshold not exceeded.

As shown in Table 3.3 and Table 3.4, no injury is predicted to occur to any cetacean group from continuous noise emissions (which comprise combined emissions from drilling activity and the drill ship support vessel), assuming that individuals move away from the source of the noise when it is first detected.

In the absence of a soft start procedure, injury from exposure to VSP noise could occur up to 113 m from the source for LF cetaceans, 31 m for MF cetaceans and 298 m for HF cetaceans, based on the NOAA (2018) thresholds which are more conservative for these receptor groups.

With a soft-start procedure included in the calculations, the injury ranges reduce to 41 m for LF cetaceans, 9 m for MF cetaceans and 152 m for HF cetaceans, again using the more conservative NOAA (2018) thresholds.

In practice, the soft-start will always be used, and in addition would be preceded by active monitoring of a 1,000 m search radius around the drill ship, which would continue until 60 minutes had elapsed without a marine mammal being sighted inside the zone. Only after 60 minutes has elapsed with no sightings recorded will the soft-start begin. The addition of monitoring to the soft-start procedure will effectively eliminate the possibility of injury to marine mammals from VSP operations.

The calculations showed that under both sets of thresholds, the estimated range for onset of a strong behavioural response (as opposed to injury) was 590 m for continuous noise emissions (all receptor groups), while the Southall *et al*. (2007) threshold was slightly more conservative for VSP noise, giving a strong behavioural response radius of 2,795 m.

The radiuses discussed above can be translated into areas around the Project activity within which injury or a behavioural response can be expected. These areas are presented in Table 3.6, using the most conservative threshold for each criterion.

Table 3.5 Areas of potential injury and response zones due to vessel, drilling and VSP noise

Activity	Area of effect (km^2)		
	Low-frequency cetacean	Mid-frequency cetacean	High-frequency cetacean
SEL area of potential injury zone (moving mammals are assumed to move with a speed of 1.5 ms^{-1})			
Continuous noise: Drill ship combined with support vessel	-*	-*	-*
VSP (NOAA, 2018)	0.04	0.003	0.28
VSP + soft start (NOAA, 2018)	0.005	0.0003	0.07
Estimated area of strong behavioural response zone			
Continuous noise: Drilling / DP / support vessel. (thresholds give same result)	1.09 km^2		
VSP (Southall *et al*., 2007)	24.5 km^2		

* Threshold not exceeded.

To translate the injury and response zones presented above into a determination of whether "disturbance" is expected to occur, it is important to consider a number of factors including:

> the size and location of the potential injury / response zones (larger areas mean a greater potential to interact with a greater number of animals);

> length of time for which the sound source will be present (the longer the period the greater potential to have significant effects); and

> the likelihood that a significant proportion of the regional population will be present within the injury or response zones.

A confirmed injury to a single marine mammal as a result of Project activities would be considered significant disturbance. However, behavioural responses such as moving away from an area for short periods of time, reduced surfacing time, masking of communication signals or echolocation clicks, vocalisation changes and separation of mothers from offspring for short periods do not necessarily imply significant disturbance(JNCC, 2010). This is because temporarily causing a behavioural response in a small proportion of a population would be unlikely to result in population level effects. In contrast, causing a behavioural response that is long term or which would affect a large proportion of the population could be considered significant disturbance.

In order to estimate the number of animals that potentially could be injured or caused to show a behavioural response by Project activities, the injury and response areas presented in Table 3.5 can be multiplied by the estimated population density reported for each of the species of interest in Rogan *et al*. (2018).

Once the theoretical number of individuals of each species that could be affected is calculated, a decision must be made on whether the number of individuals affected represent a non-trivial disturbance for the population as a whole. In this report, it has been assumed that a potential behavioural response instigated in less than 1% of the regional population can be considered to be trivial and not significant.

Determining the proportion of the regional population affected is not a simple task since it is not clear how north-east Atlantic marine mammal populations act at a local level. For example, minke whales are likely to make use of the entire north-east Atlantic, so the population can be viewed as one, whilst other species may display more local fidelity and be viewed as a series of sub-populations.

Regional population estimates for the species of interest are available from SCANS-II (detailed in JNCC, 2010 and Hammond *et al*., 2013) and Cetacean Offshore Distribution and Abundance in the European Atlantic II (CODA) survey results (detailed in JNCC, 2010).

Table 3.6 presents the results of the calculations described above. Each species of interest for which density and population estimates are available is listed. For each of these species, the number of individuals and the proportion of the regional population expected to be injured by VSP operations (with and without a soft-start) is presented. The same data is presented for behavioural responses caused by VSP operations (soft-starts are not relevant in this case) and continuous noise emissions (combined drilling, drill ship DP and support vessel emissions), for which no injury zone was defined.

Table 3.6 shows, on the basis of the abundance estimates, that none of the proposed activities will result in an injury zone large enough to injure at least one cetacean, even when excluding the effect of all proposed mitigation measures. The species most at risk of individual injury is the harbour porpoise. For VSP operations with no soft start (and no pre-shoot observations) 0.014 harbour porpoise would be expected to be injured (assuming an even distribution of individuals across the population's geographical range). As such, even without consideration of mitigation measures, there will be no adverse effect on the conservation status of Annex IV species from VSP operations.

The addition of a soft start is predicted to further reduce injury, by ensuring animals are further away from the sound source at start up. With the addition of pre-start monitoring and the other mitigation measures described above, the risk of injury is expected to be effectively eliminated for harbour porpoise and all other cetacean species.

The area within which a behavioural response might be elicited from VSP operations (without a soft start or any other mitigation) was larger than the injury zone for the same activity, and as such there were several species of which one or more individuals would be expected to occur within the response zone (assuming an equal distribution of individuals across the populations' geographical ranges). The species expected to occur in the greatest numbers within the response zone was bottlenose dolphin, followed by common dolphin, striped dolphin and harbour porpoise. However, very few of these animals, and even fewer of the other species listed in Table 3.6 are expected to be in the potential impact zone. As such, for all species, the individuals occurring within the response zone were estimated to represent less than 0.1% of the regional population.

While disturbance to a small number of individuals of several cetacean species (Table 3.6) cannot be ruled out, the number of individual animals that are likely to exhibit some form of behavioural response to sound arising from the Project is so small (all in excess of <0.1%) that it is expected to be undetectable against natural variation and is not expected to have any effect at the population level. Given the short duration of the Project (100 – 150 days) any behavioural response is expected to be temporary and have no lasting effect at the population level. As such, even without mitigation measures, it is considered that the risk of significant disturbance from Project activities can be screened out. With the implementation of soft start, pre-start monitoring and other mitigation measures, the risk of disturbance is expected to be further reduced.

There are several species that may occur in the Project area but have not been included in Table 3.6 due to insufficient data on individual density and regional populations, e.g. killer whale, blue whale and beaked whales. The density and occurrence these species in the wider area are expected to be lower than the species that have been assessed, and as such, they are even less likely to occur within the injury zone and the potential for injury can be discounted. Any behavioural reaction that could be elicited is expected to affect a very small number of individuals for a temporary period and can therefore be considered trivial disturbance and not significant.

The Porcupine Basin may lie along migration pathways for cetaceans given the north-south migration of many species in Irish waters. The small potential disturbance impact zone means that the noise emissions would not represent a barrier to wider, regional movements of marine mammals. Breeding zones have been confirmed in Irish waters for a number of cetacean species, including harbour porpoise, common dolphin, bottlenose dolphin, Risso’s dolphin, white sided dolphin, white-beaked dolphin and pilot whale. Other species, such as the northern bottlenose whale and minke whale are also suspected of breeding in the region (DCENR, 2007). As with the possible barrier to movement, the small potential disturbance impact zone and temporally restricted nature of the noise emissions means that it is improbable that there could be any effect on areas potentially favoured as cetacean breeding grounds.

Given the above, injury or significant disturbance of Annex IV cetacean species that may be present in the area (including during breeding and migration) or deterioration or destruction of breeding sites or resting places is not likely. Thus, in respect of noise emissions, the Project will not, either individually or in combination with other activities, plans or projects have an adverse effect on the conservation status of animal species listed in Annex IV(a) to the Habitats Directive in their natural range.

Table 3.6 Estimated numbers of individuals and percentages of regional species populations experiencing injury of exhibiting behavioural change as a result of Project activities.

Species	Hearing category	Density Estimate (individuals per km²)	Regional population estimate	VSP (no soft start)						VSP (with soft start)			Continuous noise (Drilling / DP / drilling support vessel)		
				Area of injury (km²)	Estimated number of individuals inside injury radius (density x injury area)	Percentage of estimated reference population affected	Area of response (km²)	Estimated number of individuals inside response radius (density x response area)	Percentage of estimated reference population affected	Area of injury (km²)	Estimated number of individuals inside injury radius (density x injury area)	Percentage of estimated reference population affected	Area of response (km²)	Estimated number of individuals inside response radius (density x response area)	Percentage of estimated reference population affected
Atlantic white-sided dolphin	MF	0.003	69,293	0.003	0.000	1.3E-08	24.5	0.07	1.1E-04	0.000	0.000	1.1E-09	1.1	0.003	4.7E-06
White beaked dolphin	MF	0.039	15,895	0.003	0.000	7.4E-07	24.5	0.96	6.0E-03	0.000	0.000	6.2E-08	1.1	0.04	2.7E-04
Bottlenose dolphin	MF	0.435	11,923	0.003	0.001	1.1E-05	24.5	10.68	9.0E-02	0.000	0.000	9.3E-07	1.1	0.48	4.0E-03
Common dolphin	MF	0.246	51,800	0.003	0.001	1.4E-06	24.5	6.04	1.2E-02	0.000	0.000	1.2E-07	1.1	0.27	5.2E-04
Harbour porpoise	HF	0.049	104,695	0.279	0.014	1.3E-05	24.5	1.20	1.1E-03	0.073	0.004	3.4E-06	1.1	0.05	5.1E-05
Striped dolphin	MF	0.16	82,585	0.003	0.000	5.8E-07	24.5	3.93	4.8E-03	0.000	0.000	4.9E-08	1.1	0.17	2.1E-04
Pilot whale	MF	0.017	83,441	0.003	0.000	6.2E-08	24.5	0.42	5.0E-04	0.000	0.000	5.2E-09	1.1	0.02	2.2E-05
Sperm whale	MF	0.003	2,424	0.003	0.000	3.7E-07	24.5	0.07	3.0E-03	0.000	0.000	3.1E-08	1.1	0.003	1.4E-04
Minke whale	LF	0.031	23,163	0.040	0.001	5.4E-06	24.5	0.76	3.3E-03	0.005	0.000	7.1E-07	1.1	0.03	1.5E-04
Fin whale	LF	0.001	7,523	0.040	0.000	5.3E-07	24.5	0.02	3.3E-04	0.005	0.000	7.0E-08	1.1	0.001	1.5E-05

3.5.2 Accidental releases

3.5.2.1 Likelihood of release

There is a very low probability of a major accidental release of hydrocarbons occurring from the exploration well and associated planned vessel operations, as noted in IOSEA 5 (DCENR, 2015). The main potential source of an accidental spill would be either from a blowout scenario or a release of marine diesel fuel contained in the storage tanks, released through accidental vessel collision. Other small volume spills may also occur as a result of leaks during bunkering. The risk of a release occurring from a vessel collision is no greater than that occurring from any other ship in the area over the Project period. Marine fuel contains a high percentage of low molecular weight hydrocarbon compounds, known as 'light ends' and hence tends to disperse (usually via evaporation) within approximately eight to ten hours of being spilt. Given the relatively warm temperatures and the generally fast flowing currents, dispersion of marine fuel is likely to be rapid. A small spill may result in a sheen extending over a considerable area. However, this sheen can be broken up and reduced by wave action. Any marine fuel released in the survey area would disperse offshore. A release resulting from a blowout scenario at the exploration well may potentially spread over a wider area.

To put the accidental event scenarios relevant to the Project into context, the section below presents statistics on historical spill events which have occurred on the UK Continental Shelf (UKCS). These statistics are considered useful to support the assessment due to the relatively large number of wells drilled in the UKCS and the similar geographical conditions between Ireland and the UK. No well blowouts or well releases have occurred in Irish waters. Information is also used from the SINTEF Offshore Blowout Database which summarises worldwide blowout and well release incidents.

3.5.2.1.1 Blowouts and well releases

A well blowout, depending upon the circumstances may occur at the surface or underground. A surface blowout constitutes an uncontrolled flow of formation hydrocarbons from the reservoir to the surface (note the release may occur at the seabed or from the infrastructure at the sea surface) and may lead to release of hydrocarbons to the environment. An underground blowout is when hydrocarbons entering the wellbore cause the wellbore pressure to exceed the fracture pressure at another level in the well, allowing hydrocarbons to flow from the producing formation into the wellbore, and then back into the weaker formation. There may be no release to the environment under these circumstances.

A well release, as opposed to a blowout, is an incident where hydrocarbons flow from a well when flow was not intended. Well releases may also result in release of hydrocarbons to the environment.

Blowouts are extremely rare events in modern drilling (DTI, 2001), although deep water HPHT exploration wells such as the Project are the more challenging wells to drill because the HPHT environment is more challenging to control, and conditions in exploration wells are less predictable than development wells in previously explored formations. Table 3.7 shows the historical frequency of drilling blowouts and well releases for various types of well drilled to North Sea standards. Deep water HPHT exploration wells have a blowout and well release frequency approximately one order of magnitude greater than normally pressured exploration wells and HPHT development wells, and two orders of magnitude higher than normally pressured development wells. The historical frequency of incidents is still low however, equating to one blowout per 667 wells drilled, and one well release per 83 wells drilled.

Table 3.7 Historical frequency of blowouts and well releases (per well drilled) for various types of well in >200 m water depth (IOGP, 2010)

Well type	Pressure regime	Historical frequency per well drilled (IOGP, 2010)[5]		Number of wells drilled per incident	
		Blowout	Well release	Blowout	Well release
Exploration	Normal	2.5×10^{-4}	2.0×10^{-3}	4000	500
	HP/HT	1.5×10^{-3}	1.2×10^{-2}	667	83
Development	Normal	4.8×10^{-5}	3.9×10^{-4}	20833	2564
	HP/HT	3.0×10^{-4}	2.4×10^{-3}	3333	417

3.5.2.1.2 Drill ship spills

The Project will drill the Iolar prospect from a drill ship. Potential accidental releases from drill ships (excluding blowouts discussed above) may include fuel, drilling muds, small accidental oil and chemical releases and hydraulic fluids.

The most notable UK blowout from a drill ship was in 1988 when an explosion led to a fire on a semi-submersible rig drilling a high pressure high temperature field in the central North Sea. Historical data for frequency of blowouts from drill ships on the UKCS between 1990 and 2007 is presented in Table 3.8. The data do not show the severity of each event or whether the blowout led to an oil spill. However, the data do provide an indication of overall frequency of blowouts on the UKCS. The frequency of blowouts declined by almost an order of magnitude from the period 1990-1999 to 2000-2007.

Table 3.7 Blowout frequency per unit per year on UKCS (OGUK, 2009)

Type of facility	Period					
	1990 to 1999		2000 to 2007		1990 to 2007	
	Number	Frequency per year	Number	Frequency per year	Number	Frequency per year
Drill ship	13	0.020	3	0.0066	16	0.014

The information presented in Table 3.8 are based on data submitted to the UK Department of Energy and Climate Change (DECC)[6] for the period 2001 to 2007. During this period, drill ships operating in the UKCS completed a total of 172 operation years. No accidental releases greater than 100 tonnes were recorded in the UKCS between 2001 and 2007 and the majority of accidental releases recorded were less than 1 tonne.

The most common cause of accidental releases from drill ships was drilling operations (42%); of these releases 94% were less than 1 tonne. The second most common cause was maintenance/operational activities (27%); 97% of these releases were also less than 1 tonne.

Review of the statutory spill report data sheets (termed PON1 data) recorded between 2007 and 2017 confirms no releases of >100 tonnes have occurred in the intervening years (BEIS, 2018a; 2018b) and that the majority of drill ship accidental releases remain <1 tonne.

[5] Based on SINTEF international data for wells in water >200 m (OGP, 2010)

[6] The UK government body that records accidental releases within the UKCS. In July 2016 DECC became part of the Department for Business, Energy & Industrial Strategy (BEIS).

Table 3.8 Number of accidental releases from drill ships, based on UKCS historical data by release size and source during the period 2001 to 2007 (TINA Consultants Ltd pers. Comm., 2013)

Accidental release cause	<1 kg	1 to <10 kg	10 to <100 kg	0.1 to <1 tonnes	1 to <10 tonnes	10 to <100 tonnes	All accidental releases[i]
Maintenance/operational activities	10	14	4	5	1	0	**35**
Bunkering	2	9	2	9	0	0	**22**
Subsea releases	1	3	3	1	2	1	**12**
Drilling	12	6	15	15	2	1	**54**
Remote Operated Vehicle (ROV) associated	1	3	1	0	0	0	**5**
Other production	0	0	0	1	0	0	**1**
All accidental releases[ii]	**35**	**42**	**40**	**42**	**8**	**2**	**179**

[i] *Includes accidental releases of unknown size.*

[ii] *Includes accidental releases of unknown cause and accidental releases that could not be categorised.*

The total number of accidental releases from drill ships between 1990 and 2007 in the UKCS, and the frequency of releases per operational year is shown in Table 3.9. The frequency of incidents per operational year decreased by approximately 30% during the period 2000 to 2007 compared to the period 1990 to 1999.

Table 3.9 Number of accidental releases from drill ships on the UKCS from 1990 to 2007 and frequency per operational year (OGUK, 2009)

Type of facility	Period				1990 to 2007 (total)	
	1990 to 1999		2000 to 2007			
	Number	Frequency per year	Number	Frequency per year	Number	Frequency per year
Drill ship	160	0.246	78	0.172	238	0.215

Apart from well blowouts, the drill ship incident scenarios in which the greatest impact might be expected would include vessel grounding, collisions or explosions that lead to a total loss of hydrocarbon inventory (most likely to be marine diesel fuel) although this is unlikely as diesel/hydrocarbon stock is stored in multiple locations in separate tanks and containers. Table 3.10 highlights the number of explosions, collisions and vessel contacts for drill ships in the UKCS and the frequency of incidents per operational year. These data also indicate a general reduction in the frequency of incidents between the period 2000 to 2007 compared to the period 1990 to 1999. Whilst it is not indicated whether accidental releases occurred from each incident recorded, the data suggests that the frequency of incidents which could lead to an accidental release has decreased.

Table 3.10 Number of explosions, collisions and vessel contacts from drill ships in the UKCS from 1990 to 2007 and frequency of incidents per operational year (OGUK, 2009)

Type of incident	Period					
	1990 to 1999		2000 to 2007		1990 to 2007 (total)	
	Number	Frequency per operational year	Number	Frequency per operational year	Number	Frequency per operational year
Vessel contact	108	0.166	25	0.055	133	0.120
Collision	14	0.021	1	0.0022	15	0.014
Explosion	10	0.015	-	-	10	0.009

3.5.2.2 OSCAR oil spill modelling

CNOOC's risk assessment process identified three categories of accidental release that could potentially cause environmental damage:

> Accidental release of fuel or chemicals from vessel decks or during bunkering;

> Loss of containment of fuel storage tanks (marine diesel) due to vessel collision; and

> Loss of well integrity resulting in a well blowout and release of crude oil.

The Oil Spill Contingency and Response model (OSCAR) was used to model the possible fate of oil from potential hydrocarbon release scenarios at the Iolar well location as shown in Table 3.11. Each scenario was modelled across three seasons: spring (March to May), summer (June to August) and autumn (September to November), to cover the entire possible drilling window of April to September.

Table 3.11 Summary of accidental hydrocarbon release model scenarios carried out for the Project

Scenario	Hydrocarbon Type	Spill Volume (m^3)	Modelled Depth of Release	Model Type
Instantaneous drill ship diesel inventory spill	Marine diesel	16,565	Surface	Stochastic
Well blowout using the predicted unconstrained well flow rate for 146 days	Iolar crude (OSCAR Gulfaks[7] crude used as surrogate)	2,856,856	Seabed	Stochastic
Well blowout using the predicted unconstrained well flow rate for 15 days	Iolar crude (OSCAR Gulfaks crude used as surrogate)	737,213	Seabed	Stochastic

OSCAR stochastic modelling uses a minimum of 110 different runs per scenario, predicting the fate of the oil under the varying potential metocean conditions during each run. Mapped outputs can be produced showing the probability of contamination of the sea surface, or the probability of shoreline oiling, for the 110 runs combined (N.B. these probabilities are not representative of a single release).

[7] Gulfaks crude was used as a surrogate because it has similar hydrocarbon properties to those predicted at Iolar.

A minimum threshold of 0.3 μm was applied to the sea surface oiling outputs in line with BEIS guidance (BEIS, 2017)[8]. No other thresholds were applied at this stage of the assessment.

An overview of the results of the OSCAR modelling is provided in Table 3.12.

Table 3.12 Summary of accidental hydrocarbon release stochastic modelling results

Scenario	Summary of OSCAR stochastic modelling results
Instantaneous drill ship diesel inventory spill	Stochastic modelling indicated a low probability of sea surface contamination across most of the affected area, with sea surface contamination probabilities of >10% restricted to an area of approximately 150 km diameter concentrated to the southeast of the release point. The thickness of diesel floating on the sea surface was predicted to remain <5 μm across most of the affected area, with simulations indicating that small slicks exceeding 10 μm thick could travel up to 200 km from the release point, although the probability of thick oil occurring decreased with distance from the release. There was a low predicted probability of diesel reaching international waters. The highest probability occurred in Autumn, although the season with the fastest simulated arrival time was Spring (3 d 10 h). Diesel was not predicted to enter other national jurisdictions. The highest probability of diesel beaching was predicted in Summer (2.9%), the minimum predicted beaching time (7 d 13 h) also occurred in summer. The (unlikely) possibility of diesel beaching was predicted to be restricted to the southwest coast of Ireland and arrival time was predicted to be similar across all beaching locations.
Well blowout using the predicted unconstrained well flow rate for 146 days	Modelling indicated that there is a high probability of sea surface oiling across a large proportion of Irish territorial waters to the West of Ireland, with the location of the highest probability areas varying by season. A surface oil sheen exceeding 5 μm thick could travel hundreds of kilometres from the release point, although it should be noted that the total area of thick oil predicted in the modelling outputs represents over 100 individual spill simulations, and the area of thick oil produced by any single spill would be much smaller. Modelling indicated that oil could reach international waters after approximately six days, and UK waters after approximately 30 days, although the probability of oil reaching UK waters was predicted to be <40%. The area with the highest probability of beaching and the fastest minimum beaching time was predicted to be the southwest coast of Ireland, where there was predicted to be a maximum 98.1% probability of beaching for releases occurring during spring, and a minimum beaching time of approximately 18 days for releases occurring during summer. Probability of oil beaching in all other national jurisdictions was generally <5%.
Well blowout using the predicted unconstrained well flow rate for 15 days	Modelling indicated that there is a high probability of sea surface oiling across a large area of sea to the west of southern Ireland, with the location of the highest probability areas varying by season. A surface oil sheen exceeding 5 μm thick could travel hundreds of kilometres from the release point, although it should be noted that the area of thick oil predicted in the modelling represents over 100 individual spill simulations, and the area of thick oil produced by any single spill would be much smaller. Modelling indicated that oil could reach international waters after approximately six days, and UK waters after approximately 30 days (in the summer simulations), although the probability of oil reaching UK waters was predicted to be <5%. Beaching was predicted to occur in Ireland only, with the highest probabilities and fastest minimum arrival times occurring on the southwest coast. Probability of beaching only exceeded 25% in the summer simulations, and the maximum probability of beaching was 51.9%. The minimum predicted arrival time was approximately 16 days.

[8] These are guidance notes for preparing oil pollution emergency plans for offshore oil and gas installations and relevant oil handling facilities. Similar guidance is not yet available for Ireland.

3.5.2.3 Potential effects on relevant Annex IV animal groups

3.5.2.3.1 Cetaceans

As outlined in the Appropriate Assessment Screening Report and Natura Impact Statement, available data suggest that cetaceans are not considered to be highly sensitive to accidentally released hydrocarbons, and in the event of cetaceans coming into contact with a large spill either in the open ocean or in coastal habitats, the predicted impacts are expected to be minor. Taking this into account, together with the remote likelihood of a large accidental hydrocarbon release from the Project, it is unlikely an accidental release would injure or significantly disturb cetacean species at the population level. As such, the Project will not adversely affect the conservation status of any of Annex IV cetacean species present.

While a large hydrocarbon release is considered extremely unlikely, there will be extensive prevention and response measures in place to further reduce the risk and to effectively mitigate any potential effects if an event does occur. These prevention and response measures will further reduce the likelihood of injury or significant disturbance to cetacean species.

3.5.2.3.2 European otter

Otters generally forage close to shore and would only be impacted if a large quantity of spilled hydrocarbons reached the coast. In the unlikely event that oil did reach the coast, there could be impacts on otters including significant disturbance, injury and death. This would likely constitute an adverse effect on the conservation status of this Annex IV species. However, the probability of a large accidental event occurring and subsequently reaching the coast is remote. Furthermore, as outlined in the Natura Impact Statement, a series of robust response measures will be in place to ensure that a large accidental event does not result in hydrocarbons reaching the shoreline in substantial quantities. The comprehensive prevention and response measures that will be in place will therefore further reduce the likelihood of injury or significant disturbance to otters.

As such it is concluded that the Project will not adversely affect the conservation status of European otters in Ireland.

3.5.3 In-combination effects

With regards to in-combination effects of accidental releases with other offshore projects, the effects are anticipated to be limited to oil and gas activities in the surrounding area. The water depths and remote location of the Project means there are no other industrial activities, such as offshore wind farms, located in the vicinity. There is an absence of cables, pipelines, military activity and recreational activities in the vicinity of the Project. Additionally, the IOSEA did not identify any cumulative impacts with fisheries and shipping as a concern (DCENR, 2015).

Current oil and gas applications inshore and offshore the coast of Ireland are listed in Table 3.12; an assessment of the potential for the project to act in-combination with respect to underwater noise and unplanned accidental releases is then provided.

Table 3.13 Current oil and gas exploration and production applications to the DCCAE

Location	Company	Activity	Shared pathway of effect
Frontier Exploration Licenses (FELs) 2/13 (40 km from the Project) FEL 1/17 (215 km) Licensing Option (LO) 16/19 (47.5 km)	Europa Oil & Gas	3D seismic surveys	Underwater noise from acoustic survey equipment Potential accidental release from survey vessels

Location	Company	Activity	Shared pathway of effect
Corrib Field (approximately 414 km to the north of the Project)	Vermilion E&P Ireland Limited	Offshore pipeline survey and inspection of the offshore facilities	Underwater noise from acoustic survey equipment Potential accidental release from survey vessels
Barryroe, North Celtic Sea, South West Coast, Ireland (approximately 313 km from the Project)	Exola DAC	Seabed and shallow geophysical survey and an environmental baseline and habitat assessment survey	Underwater noise from acoustic survey equipment Potential accidental release from survey vessels
Dunquin South, Southern Porcupine Basin, Block 44/29, FEL 3/04 (approximately 61 km from the proposed Iolar well)	Eni Ireland BV	Debris clearance, environmental baseline and habitat assessment site survey	Underwater noise from acoustic survey equipment Potential accidental release from survey vessels
Head / Ballycotton gas fields (approximately 383 km north east of the Project)	PSE Kinsale Energy	Decommissioning	Underwater noise from decommissioning (e.g. mechanical cutting, rock placement, vessel noise, post decommissioning survey Potential accidental release during decommissioning
Seven Heads gas field (approximately 322 km from the Project)	PSE Seven Heads Limited	Decommissioning	Underwater noise from decommissioning (e.g. mechanical cutting, rock placement, vessel noise, post decommissioning survey Potential accidental release during decommissioning

3.5.3.1 Underwater noise

There are three sources of noise from the Project; drill ship and associated drilling, standby vessel and VSP. Annex IV species which could encounter these noise emissions are, as discussed above, cetaceans. As a result of their coastal distribution, otters will be found outside of any potential areas of impact.

No injury to cetaceans will occur from the drill ship and standby vessel due to the low levels of noise emitted, and no injury will occur from VSP as a result of adoption of mitigation measures. Since there will be no injury from the Project, there can be no in-combination effects with any other project.

However, disturbance is possible from the Project activities. Since this is also likely to be true for the other projects shown in Table 3.12, there exists the potential for in-combination effects to occur. The Appropriate Assessment demonstrated that the underwater noise effects from the drilling of the single well are expected to be spatially limited; the modelling has shown a maximum of approximately 3 km radius of behavioural disturbance from the drill ship and support vessel together, and 298 m from the VSP airguns. There are no existing oil and gas projects in the Porcupine Basin nor are there any approved plans for future exploration or seismic activities during 2019 within the region. During 2016, the DCCAE awarded several Licensing Options in the Porcupine Basin in the Phase 1 and 2 Awards from the 2015 Atlantic Margin Licensing Round. There are also a number of active Frontier Exploration Licences (FELs) from the 2011 licensing round which have entered Phase Two, with a commitment to drill an exploration well. There are planned seismic activities during

2019 within FEL 3/04, FEL 2/13, FEL 1/17 and Licensing Option (LO) 16/19. Should these seismic activities, there is unlikely to be any spatial overlap in disturbance zones, since these areas are all in excess of 40 km from the Project activities.

An animal that is affected by the Project activities could find itself compromised, subsequently encountering another area of disturbance in a less able state to then react to that noise source. However, any animal that encounters noise emissions from the Project and which subsequently leaves the area of potential disturbance impact (as a continuation of normal behaviour) will not be continuously affected. There is no 'impact legacy' in an animal once it has left the potential impact area (i.e., the impact will not continue to affect the animal once it has left the impact area). Therefore, the same animal encountering noise emissions from another offshore activity emitting noise will be in the same position in terms of susceptibility to noise as an animal that has previously not experienced the noise emissions. As such, there is no potential for in-combination effects in this respect.

Finally, it is possible that in-combination effects could be exerted if a sufficient number of disturbance zones were present such that animals could not locate a suitable habitat in which to forage, breed, migrate etc. However, the small zones of potential disturbance and the temporally limited nature of the Project activities mean that this will not happen.

In conclusion, based on the details of current applications for other projects inshore and offshore the coast of Ireland, their distance from the Project, the limited spatial extent and duration and location of proposed activities, there will be no in-combination effects on relevant Annex IV animal groups and their conservation status will not be adversely affected.

3.5.3.2 Unplanned accidental release

Section 3.5.2 outlines the potential impacts on individual animals from a single, Project unplanned accidental release, concluding that the low probability of an event occurring and the comprehensive prevention and response measures that will be in place mean the conservation status of any of the Annex IV species that are present (cetaceans offshore and cetaceans and otters in coastal waters) will not be adversely affected. IOSEA 5 concluded that the risk of in-combination impacts from accidental events is low, due to the small probability of occurrence and the small degree of cumulative activity predicted to take place under IOSEA5 (DCENR, 2015). All oil and gas activities with the potential for accidental release, shown in Table 3.12, have, like the Project, appropriate measures in place to both minimise the potential of an accidental release occurring and to ensure the appropriate strategies are in placed to minimise any potential environmental effect if an event does occur. The probability of an accidental release from a single project is very low and the probability of an accidental release event occurring in combination with an event from another project is further reduced. As such, there will be no in-combination effects on relevant Annex IV animal groups and their conservation status will not be adversely affected.

4 CONCLUSIONS

An assessment has been made of the potential for adverse effects of the Oroject, individually and in combination with other activities, plans or projects on the conservation status of animal species listed in Annex IV(a) to the Habitats Directive in their natural range pursuant to Article 12 of the Habitats Directive.

Of the various Annex IV species potentially present in the Project area (Section 3.1 and Section 3.2), 20 cetacean species (Table 3.1) and the European otter were assessed as to whether the Project will have an adverse effect on their conservation status. Other Annex IV species present in Irish waters including four cetacean species, five species of marine turtle and the European sturgeon were deemed not to require assessment due to their absence or low occurrence in the Project area.

Underwater noise from Project activities and a worst-case accidental hydrocarbon release were identified as sources of potential effects.

Modelling of noise propagation from Project activities in the absence of any mitigation measures indicated that there would be no injury, and at worst trivial disturbance to cetaceans in the area and consequently there will be no adverse effect on the conservations status of cetaceans arising from underwater noise.

Accidental hydrocarbon releases are unplanned events which are not part of the Project. Assessment of the potential effects of a worst-case hydrocarbon spill found that there will be no adverse effect on the conservation status of cetaceans arising from an accidental hydrocarbon release due to cetaceans' low sensitivity to surface oil in the offshore environment.

The likelihood of such a spill of a sufficient size to result in hydrocarbons reaching the shore and coming into contact with the European otter is remote, and the likelihood and potential for interaction will be further reduced by the implementation of stringent prevention and response measures. As such, once likelihood and mitigation are taken into account, there will be no adverse effect on the conservation status of the European otter..

It has been demonstrated that the Project will not either individually or in combination with other activities, plans or projects have an adverse effect on the conservation status of animal species listed in Annex IV(a) to the Habitats Directive in their natural range.

5 REFERENCES

Berrow, S.D., Whooley, P., O'Connell, M. and Wall, D. (2010). Irish Cetacean Review (2000-2009). Irish Whale and Dolphin Group, 60pp.Department of Arts, Heritage and Gaeltacht (DaHG) 2014. Site synopsis Hovland Mound Province SAC. Version date: 6.01.2014. 002328_Rev13.Doc.

DCENR (2007) Environmental Report and Technical Annexes for IOSEA2.

DCENR (2015) Environmental Report and Technical Annexes for IOSEA5.

Deecke V.B., Slater P.J.B. & Ford, J.K.B. (2002) Selective habituation shapes acoustic predator recognition in harbour seals. *Nature*, 420, 171-173.

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

Irish Whale and Dolphin Conservation Group (IWDG) (2017). Species Profile. Online: http://www.iwdg.ie/conservation/ [Accessed 31/07/2017].

JNCC (2010). Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise. August 2010.

NOAA (National Oceanic and Atmospheric Administration) (2018). Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing, Technical Memorandum NMFS-OPR-55, 2018.

NPWS. (2014) 'Guidance to Manage the Risk of Marine Mammals from Man-made Sources in Irish Waters', Department of Arts, Heritage and the Gaeltacht, January 2014.

Ó Cadhla, O., Mackey, M., Aguilar de Soto, N., Rogan, E. and Connolly, N. (2004). Cetaceans and Seabirds of Ireland's Atlantic Margin. Volume II – Cetacean distribution & abundance. Report on research carried out under the Irish Infrastructure Programme (PIP): Rockall Studies Group (RSG) projects 98/6 and 00/13, Porcupine Studies Group project P00/15 and Offshore Support Group (OSG) project 99/38. 82pp.

OSPAR (2009). Background Document for the Common sturgeon - *Acipenser sturio*. OSPAR Commission Biodiversity series. Available at: https://www.ospar.org/documents?v=7188 [Accessed 06/04/2019].

PAD (Petroleum Affairs Division) (2014). Rules and Procedures Manual for Offshore Petroleum Exploration and Appraisal Operations. Conducted under an Exploration Licence or other Authorisation. Petroleum Affairs Division. Department of Communications, Energy and Natural Resources. May 2014.

Pierpoint, C (2000). Bycatch of marine turtles in UK and Irish waters. JNCC Report No 310.

Reeds, K.A. (2004). *Dermochelys coriacea* Leatherback turtle. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 06-04-2019]. Available at: https://www.marlin.ac.uk/species/detail/1534 [Accessed 06/04/2019].

Reid, J., Evans, P.G.H. and Northridge, S. (2003). An atlas of cetacean distribution on the northwest European Continental Shelf. Joint Nature Conservation Committee, Peterborough.

Reid, N., Hayden, B., Lundy, M.G., Pietravalle, S., McDonald, R.A. & Montgomery, W.I. (2013). National Otter Survey of Ireland 2010/12. Irish Wildlife Manuals No. 76. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

Richardson, W. J., Greene, C. R., Malme, C. I. and Thomson, D. H. (1995). Marine Mammals and Noise. Academic Press.

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 & Environment and National Parks and Wildlife Service (NPWS), Department of Culture, Heritage and the Gaeltacht, Dublin, Ireland. 297pp.

Southall B.L., Bowles A.E., Ellison W.T., Finneran J.J., Gentry R.L., Greene Jr C.R. & Kastak D. (2007). Marine Mammal Noise-Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals*, 33(4), 411–521.

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

6 ABBREVIATIONS AND ACRONYMS

DCENR	Department of Climate, Energy and Natural Resources
DP	Dynamic Positioning
EEC	European Economic Community
EEZ	Exclusive Economic Zone
FEL	Frontier Exploration License
HF	High-Frequency
IWDG	Irish Whale and Dolphin Conservation Group
JNCC	Joint Nature Conservation Committee
LF	Low-Frequency
MF	Mid-Frequency
MMO	Marine Mammal Observer
NOAA	United States National Oceanic and Atmospheric Administration
NPWS	National Parks and Wildlife Service
OSPAR	Oslo Paris Convention
PAD	Petroleum Affairs Division
SEL	Sound Exposure Level
SI	Statutory Instrument
UK	United Kingdom
VSP	Vertical Seismic Profiling

APPENDIX A SOURCE NOISE DATA FOR THE UNDERWATER NOISE SOUND PROPAGATION MODELLING

Appendix A.1 Summary of Noise Sources

The potential sources of underwater noise associated with the drilling phases of this project are as follows:

1. Drilling a single exploration well in deep water using a drill ship;
2. Vessel activity – e.g. drilling support vessel, supply vessels; and
3. Vertical seismic profiling (VSP).

Noise source data has been taken from a combination of publicly available noise data for similar equipment and activities, empirical calculations and theoretical predictions. It should be noted that even where specific noise measurement data is available, these data are often not in a suitable form for assessing the impacts of noise on wildlife. Consequently, it is often necessary to apply empirical corrections to convert from, for example, rms sound pressure levels to SEL or peak pressure levels.

For vertical seismic profiling (VSP), these operations can be characterised as impulsive i.e. series of repetitive sounds whereas noise from vessels and drilling operations tend to be continuous in nature. It is therefore necessary to model these two types separately and compare the results against their respective threshold limits for continuous noise (non-impulsive) and multi-pulse (impulsive) noise.

Appendix A.2 Drilling Operations

The deep-water drilling will be carried out a purpose-built drill ship which uses thrusters to maintain its position via dynamic positioning; along with noise from drilling operations it is the dynamic positioning systems that contribute significantly to the overall underwater noise signature.

As information relating underwater noise from drilling operations is extremely limited it has been necessary to utilise proxy data based on the Stena Forth drill ship (Kyhn *et al*., 2011). This drill ship is a double hulled, 228 m long, 42 m wide ship with a displacement of 96,000 Mt, equipped with six 5500 kW fixed pitch azimuth thrusters (Rolls Royce Aquamaster AQM UUC 455 L-Drive) and six 7430 kW diesel generators (Wartsilla 16V32). This is considered representative of the type of mobile offshore drilling unit likely to be deployed off the west coast of Ireland in the South Porcupine Basin.

Based on measured data an equivalent source level of 184 dB re 1 μPa (rms) at 1m was determine during drilling operations. Under drilling operations noise levels were comparable in all directions except in the aft direction (180^{o}) where levels were consistently ~5 dB lower than the other directions in the range up to 10 kHz. As a result of this, a worst-case scenario has been assumed i.e. no directionality has been included in the calculations. Noise data for the drill ship includes the use of dynamic positioning systems required to keep the vessel stationary during drilling operations to maintain stability.

The third-octave band spectrum shape for drilling activities for the Stena Forth is shown in Figure A.1.

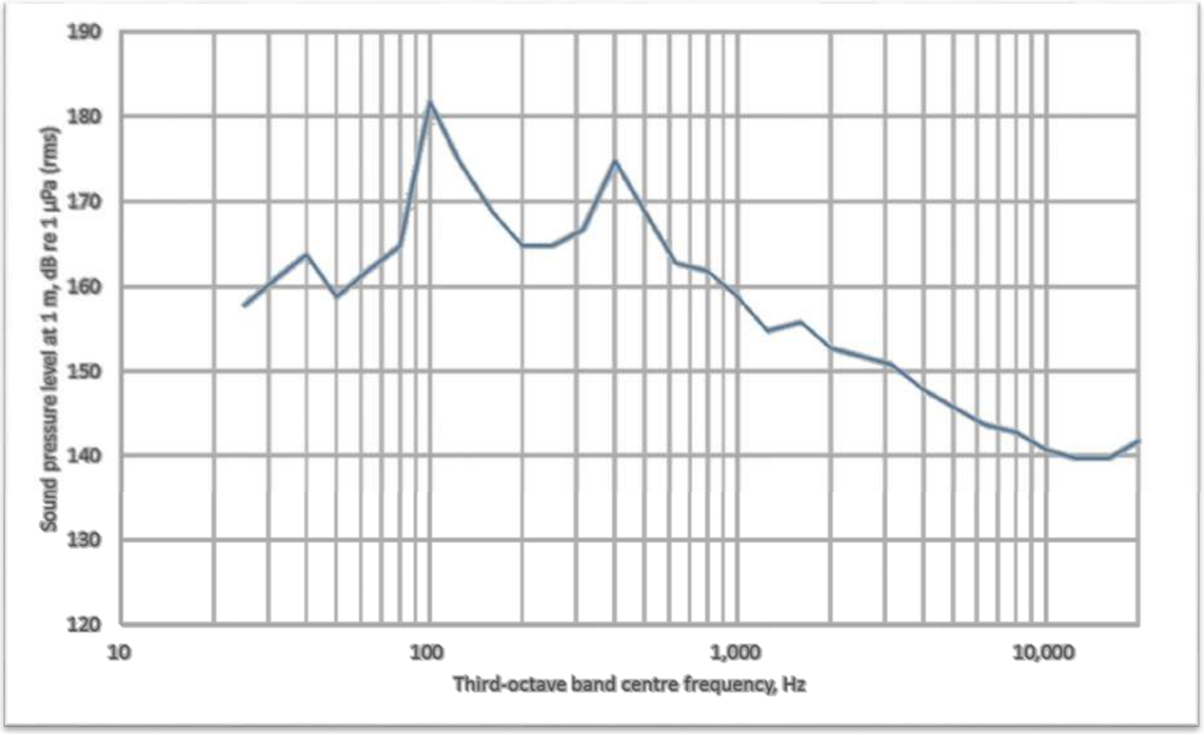


Figure A.1 Third-octave band sound pressure level spectrum of drill ship under drilling operations (Kyhn *et al.,* 2011)

For the source levels a correction of 3 dB has been applied to the rms sound pressure level to derive the peak sound pressure level. The SEL is based on the rms sound pressure level integrated over the exposure time.

The report (Kyhn *et al*., 2011) also stated that during maintenance operations a level of 190 dB re 1 µPa (rms) was obtained although full details of this particular operation were not provided i.e. what equipment was operating and whether other vessels were working in the vicinity. As such this data has not been disregarded.

Drilling is generally acknowledged (NPWS, 2014) to produce moderate levels of continuous omnidirectional sound at low frequency (several tens of Hz up to c.10 kHz). Source sound pressure levels have been reported to lie within the 145-190 dB re 1 µPa range. While sound exposure levels from such operations are thought to be below that expected to cause injury to a marine mammal, they have the potential to cause lower level disturbance, masking or behavioural impacts. However, it is noted that the use of dynamically-positioned platforms and associated vessel activity can combine to make drilling operations a potentially significant source of anthropogenic sound.

Appendix A.3 Support Vessels

A drilling support vessel is likely to be in attendance during drilling operations and a marine survey vessel will also be required during VSP operations.

In the absence of specific underwater data, source noise levels for the standby / support vessel has been based on those presented in Austin & McGillivray (2005). The vessel on which the measurements were carried out is the Maersk Rover which is a Type: R (L) class vessel of 67 m length. This gives a source level of 188 dB re 1 µPa (rms). A correction of 3 dB has been applied to the rms sound pressure level to derive the peak sound pressure level, and the SEL is based on the rms sound pressure level integrated over the exposure time.

Note that noise from shipping movements is not covered by NPWS (2014).

Appendix A.4 Vertical Seismic Profiling

VSP refers to measurements made in a vertical wellbore using geophones inside the wellbore and a source at the surface near the well. Operations vary in terms of 'well configuration', the number and location of sources and geophones, and how they are deployed. In a marine environment, the source used is an air gun which can produce noise levels that are harmful to marine mammals.

There is considerable literature relating to airgun noise underwater (e.g. Breitzke *et al.,* 2008; Tolstoy *et al.*, 2009; Richardson *et al.,* 1995).

The following data was used to inform the modelling:

> Gun deployment: Boat crane, buoyed;

> Type: Sercel G-Gun air gun delta cluster;

> Number of guns: 3;

> Total volume: 250 cu in;

> Deployment depth: 5 m (within the water column);

> Peak amplitude: 3.5 bar-m; and

> Peak-to-peak amplitude: 5.4 bar-m.

A key assumption is that the source data provided above accurately reflects the source level of the array in practice, as encountered in the far field of the source. Zero-to-peak and peak-to-peak sound pressure levels (SPL) have been converted to dB re 1 µPa, resulting in a zero-peak sound pressure level of 235 dB re 1 µPa and a peak-to-peak sound pressure level 231 dB re 1 µPa.

For this study, the source sound levels have been based on a combination of those provided in the data sheet for the seismic energy source, supplemented by measured sound data from Breitzke *et al*., (2008), Tolstoy *et al*., (2009) and Richardson, *et al* (1995), in order to produce low- and mid-frequency data. The low- and mid-frequency data has been extrapolated to derive the third-octave frequency spectra at higher frequencies based on the gradient of the power spectral density and third-octave band plots.

The SEL represents the total energy of an event or number of events normalised to a standardised one second interval. This allows a comparison of the total energy of different sounds lasting for different time periods. As a pressure pulse from a source array propagates towards the receiver, the duration of the pulse increases. Thus, the relationship between the peak SPL and the SEL changes with distance. The SEL was calculated based on the rms SPL normalised to a one second time interval. The single pulse SEL values have been combined for each pulse as part of the various cumulative SEL modelling scenarios.

It is important to note that the rms SPL will depend upon the integration window used or, in other words, the measurement time for the rms. Using a longer duration measurement would result in a lower rms SPL than using a shorter one.

An additional phenomenon occurs where the seismic waveform elongates with distance from the source due to a combination of dispersion and multiple reflections. Measurements presented by Breitzke *et al*. (2008) indicate elongation of the T90 window up to approximately 800 ms at 1 km. This temporal "smearing" reduces the rms amplitude with distance (because the rms window is longer) and has been included within the disturbance modelling scenarios. Since the ear of most marine mammals integrates low frequency sound over a window of around 200 ms (Madsen *et al*., 2006), this duration was used as a maximum integration time for the received rms SPL.

The source levels stated above are likely to be overestimated in the near-field as the model back calculates to 1 m and does not consider the interaction between the source elements. This in turn overestimates near-field received levels, which are then compared to animal thresholds. Near field source sound levels will be lower than that predicted by this vertical far-field calculation. The spatial extent of the near-field effect can be derived from acoustic first principles (e.g. Urick 1983) and is proportional to the square of the largest array dimension and frequency. Over-prediction due to near-field errors can be expected at receiver distances closer than this.

Another important factor affecting the received sound pressure level from seismic source arrays is the source directivity characteristics. Source arrays are designed so that the majority of acoustic energy is directed downwards towards the ocean bottom. Therefore, the amount of energy emitted horizontally will be significantly less (20 dB +) than directed downwards. This is a frequency dependent effect and is more pronounced at higher frequencies than at lower frequencies. When detailed noise modelling is required then specific directivity corrections can be applied to the source sound level data based on the software model output, which provides broadband normalised amplitudes at varying angles of azimuth (angle around the boat parallel to the surface of the water, progressing around the boat from port to starboard) and dip angle (angle under the boat, progressing from prow to stern). Directivity corrections are applied assuming that the animal is directly in-line with the vessel (0º azimuth).

Appendix A.5 Effect of Background Noise

Background or "ambient" underwater noise is generated by a number of natural sources, such as rain, breaking waves, wind acting on the water's surface, seismic noise, biological noise and thermal noise. Biological sources include marine mammals (which use sound to communicate, build up an image of their environment and detect prey and predators) as well as certain fish and shrimp. Anthropogenic sources also add to the background noise, such as fishing boats, ships, industrial noise, seismic surveys and leisure activities. Generalised ambient noise spectra attributable to various noise sources (Wenz, 1962) are shown in Figure A.2.

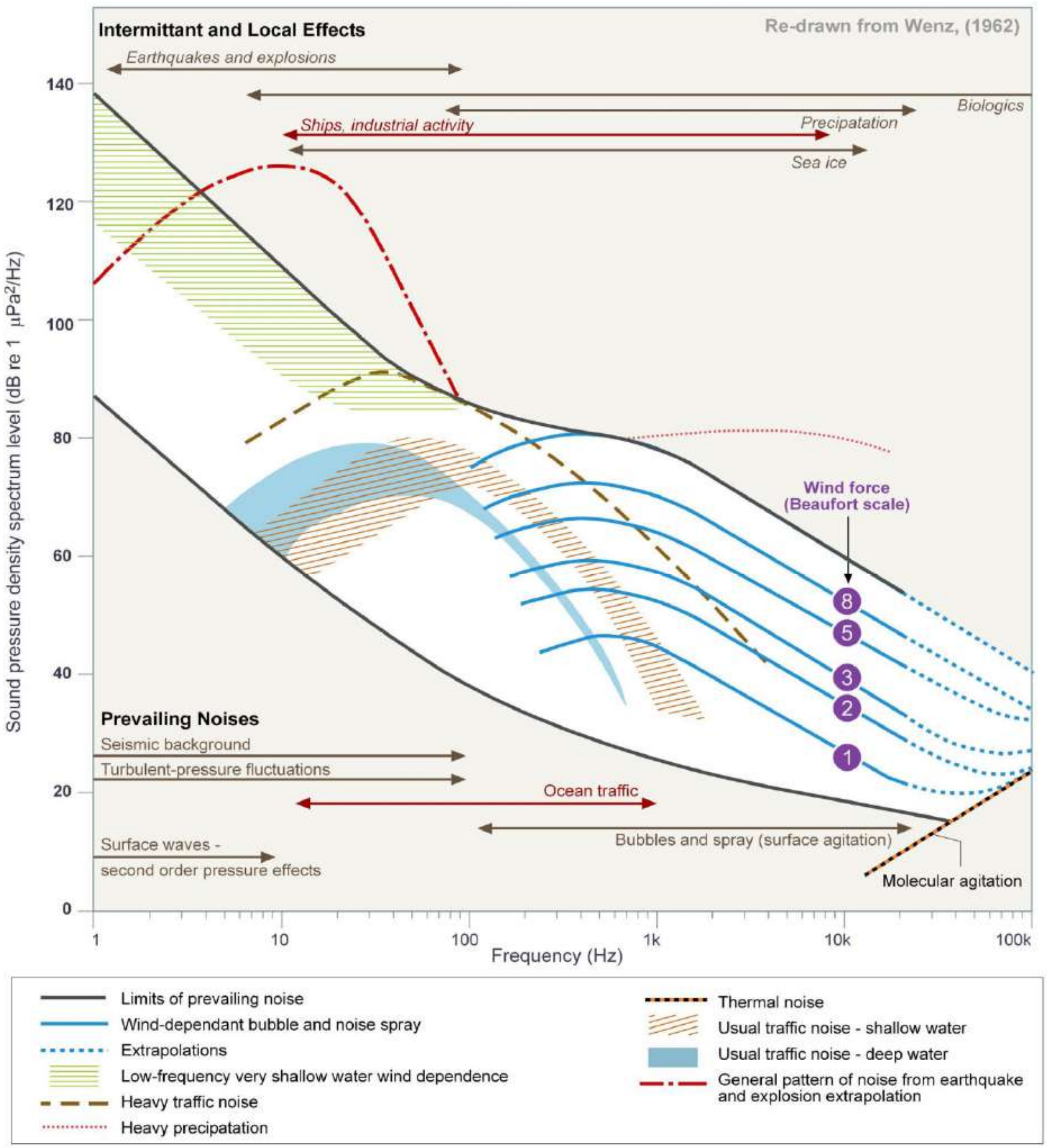


Figure A.2: Generalised ambient noise spectra attributable to various noise sources

Much of the research relating to both physiological effects and behavioural disturbance due to noise on marine species is based on determining the absolute noise level for the onset of that effect. As a result, criteria for assessing the effects of noise on marine mammals and fish tend to be based on the absolute noise criteria, as opposed to the difference between the baseline noise level and the specific noise being assessed (Southall *et al.* 2007; NPWS, 2014). Given the lack of evidence based studies investigating the effects of noise relative to background on marine species, the value of establishing the precise baseline noise level is somewhat diminished. It is important to understand that baseline noise levels will vary significantly depending on, amongst other factors, seasonal variations and different sea states, meaning that the usefulness of establishing such a value would be limited. Nevertheless, it can be useful (though not essential) when undertaking an assessment of underwater noise to understand the range of noise levels likely to be prevailing in the area so that any noise predictions can be placed in the context of the baseline. It is important to note however, that even if an accurate baseline noise level could be determined, there is a paucity of scientific understanding regarding how various species distinguish anthropogenic sound relative to masking noise. An animal's perception of sound is likely to depend on numerous factors including the hearing integration time, the character of the sound and hearing sensitivity. It is not known, for example, to what extent marine mammals and fish can detect tones of lower magnitude than the background masking noise. Therefore, it is necessary to exercise considerable caution if attempting any comparison between noise from the development and the baseline noise level. For example, it does not follow that because the broadband sound pressure level due to the source being considered is below the numeric value of the baseline level that this means that marine mammals or fish cannot detect that sound. This is particularly true where the background noise is dominated by low frequency sound which is outside the animal's range of best hearing acuity. Until such a time as further research is conducted to determine a dose response relationship between the "signal-to-noise" level and behavioural response, a precautionary approach should be adopted.

Ambient noise levels have been recorded in the Porcupine basin by the Centre for Marine Science and Technology (2015) in the absence of noise from seismic / vessel operations. The time-averaged broadband noise levels (between 8 and 2500 Hz, 1/3 octave band limits centre frequencies) ranged from between 74-141 dB re 1μPa with mean and median levels of 107 and 109 dB re 1μPa.

It should therefore be noted that the 120 dB re 1 μPa rms sound pressure level criterion for disturbance from continuous noise lies within the range of likely background noise levels. It is therefore important to understand that exceeding the criteria for potential onset of disturbance effects does not in itself mean that disturbance will occur. Southall *et al*. (2007) notes that:

"…*the available data on behavioural responses do not converge on specific exposure conditions resulting in particular reactions, nor do they point to a common behavioural mechanism. Even data obtained with substantial controls, precision, and standardized metrics indicate high variance both in behavioural responses and in exposure conditions required to elicit a given response. It is clear that behavioural responses are strongly affected by the context of exposure and by the animal's experience, motivation, and conditioning. This reality, which is generally consistent with patterns of behaviour in other mammals (including humans), hampered our efforts to formulate broadly applicable behavioural response criteria for marine mammals based on exposure level alone*."

Consequently, the behavioural disturbance zones should be viewed as the maximum likely extent within which behavioural change could occur. The fact that an animal is within this area does not necessarily mean that disturbance will occur.

Appendix A.6 References used in Appendix A

Austin, M, and A MacGillivray. 2005. “Maersk Rover Acoustic Source Level Measurements.” Sakhalin Energy 12.

Breitzke M., Boebel O., El Naggar S., Jokat W. & Werner B. 2008. Broad-Band Calibration of Marine Seismic Sources Used by R/V Polarstern for Academic Research in Polar Regions. Geophysical Journal International, 174(2), 505-524.

Centre for Marine Science and Technology, 2015. Offshore Irish noise logger program (March to September 2014): analysis of cetacean presence, and ambient and anthropogenic noise sources.

Kyhn, L.A., J. Tougaard and S. Sveegaard, Underwater Noise from the Drillship Stena Forth in Disko West, Baffin Bay, Greenland, NERI Technical Report No. 838, 2011

Madsen, Peter Teglberg, M. Johnson, P. J. O. Miller, N. Aguilar Soto, J. Lynch, and P. L. Tyack. 2006. “Quantitative Measures of Air-Gun Pulses Recorded on Sperm Whales (Physeter Macrocephalus) Using Acoustic Tags during Controlled Exposure Experiments.” *The Journal of the Acoustical Society of America* 120: 2366.

NPWS. 2014 ‘Guidance to Manage the Risk of Marine Mammals from Man-made Sources in Irish Waters’, Department of Arts, Heritage and the Gaeltacht, January 2014.

Richardson, William John, Denis H. Thomson, Charles R. Greene, Jr., and Charles I. Malme. 1995. Marine Mammals and Noise. Academic Press.

Tolstoy, M., J. Diebold, L. Doermann, S. Nooner, S. C. Webb, D. R. Bohnenstiehl, T. J. Crone, and R. C. Holmes. 2009. “Broadband Calibration of the R/V Marcus G. Langseth Four-String Seismic Sources.” *Geochemistry, Geophysics, Geosystems*10(8).http://onlinelibrary.wiley.com/doi/10.1029/2009GC002451/full.

Southall, Brandon L., Ann E. Bowles, William T. Ellison, James J. Finneran, Roger L. Gentry, Charles R. Greene Jr and David Kastak. 2007. “Marine Mammal Noise-Exposure Criteria: Initial Scientific Recommendations.” Aquatic Mammals 33 (4): 411–521.

Urick, Robert J. 2013. Principles of Underwater Sound, 3rd Edition. McGraw-Hill

Wenz, Gordon M. 1962. “Acoustic Ambient Noise in the Ocean: Spectra and Sources.” The Journal of the Acoustical Society of America 34 (12): 1936–56.