# ISLANDMAGEE GAS STORAGE FACILITY

## Marine Environmental Conditions Update Report

IBE1600/Rpt/01
Marine Environmental
Conditions Update
F02
9 December 2019

rpsgroup.com

## Document status

| Version | Purpose of document | Authored by | Reviewed by | Approved by | Review date |
|---|---|---|---|---|---|
| D01 | Marine Licencing | DH | MB | AGB | 29/10/2019 |
| F01 | Marine Licencing | DH | MB | AGB | 31/10/2019 |
| F02 | Marine Licencing | DH | MB | AGB | 09/12/2019 |

## Approval for issue

| | | |
|---|---|---|
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## Abbreviations

| | |
|---|---|
| AIS | Automatic Identification Systems |
| AOD | Above Ordnance Datum |
| AON | Apparently Occupied Nest |
| ASA | Acoustical Society of America |
| BACI | Before-after-control-impact |
| BAP | Biodiversity Action Plan |
| BGL | Below Ground Level |
| CAES | Compressed Air Energy Storage |
| CEFAS | Centre for Environment Fisheries and Aquaculture Science |
| CTD meter | Conductivity |
| DAERA | Department of Agriculture |
| dB | Decibel |
| DDV | Drop Down Videos |
| DPM | Detection Positive Minutes |
| EIA | Environmental Impact Assessment |
| EMP | Environmental Monitoring Programme |
| EQS | Environmental Quality Standards |
| ES | Environmental Statement |
| FEED | Front-End Engineering Design |
| HDD | Horizontal Directional Drilling |
| HDPE | High-density Polyethylene |
| HRA | Habitats Regulation Assessment |
| HSE | Health and Safety Executive |
| IEFs | Important Ecological Features |
| IGSF | Islandmagee Gas Storage Facility |
| IMEL | Islandmagee Energy Limited |
| IWDG | Irish Whale and Dolphin Group |
| MCZs | Marine Conservation Zones |
| MMO | Marine Mammal Observer |
| MoM | Minutes of Meetings |
| N/m2 | Newton per square metre |
| NERC Act 2006 | Natural Environment and Rural Communities Act 2006 |
| NIEA | Northern Ireland Environment Agency |
| NMBAQC | The National Marine Biological Analytical Quality Control Scheme |
| Pa | Pascal |

| | |
|---|---|
| PSU | Practical Salinity Units |
| PTS | Permanent threshold shift |
| RMS | Root Mean Square |
| ROV | Remote Operated Vehicle |
| SAC | Special Area of Conservation |
| SAM | Static Acoustic Monitoring |
| SEL | Sound Exposure Level |
| SMRU | Sea Mammal Research Unit |
| SNIP | The Scotland to Northern Ireland gas transmission Pipeline |
| SPA | Special Protection Area |
| TTS | Temporary Threshold Shift |

# 1 INTRODUCTION

## 1.1 Context

In March 2010, Islandmagee Storage Limited (now called Islandmagee Energy Limited) submitted a planning application to the Northern Ireland Planning Service. The submission was accompanied by an Environmental Statement prepared by RPS. The components of the proposed Islandmagee Natural Gas Storage Facility being applied for under the Planning (NI) Order 1991 were the above ground facilities and associated terrestrial pipelines.

In August 2011, an Addendum to the Environmental Statement (ES) of the Islandmagee Natural Gas Storage Facility was submitted in response to a Planning Service NI request for further information in accordance with Regulation 15 of the Planning (Environmental Impact Assessment) Regulations (Northern Ireland) 1999. The Department of Environment (NI) subsequently granted planning permission for the Natural Gas Storage Facility at Islandmagee in October 2012 (Application No: F/2010/0092/F). This permitted the construction of the terrestrial elements of the Gas Storage facility and associated development at Islandmagee, Co Antrim, subject to certain conditions. The planning consent did not cover any works beyond the high water mark as marine works are subject to a Marine Licence application under the Marine and Coastal Access Act 2009.

On 22nd October 2012 Islandmagee Storage Limited submitted an application for a Marine Licence. The application included details of the associated marine infrastructure to enable seawater abstraction and the subsequent discharge of brine required for the creation of the caverns by solution mining. On the 10th of July 2014, a Draft Marine Licence was issued to the Islandmagee Storage Ltd for discussion, by the Department of the Environment, Marine Division (ML 28_12) with pre-construction conditions.

On 22nd October 2012, Islandmagee Storage Limited also submitted an application to NIEA for abstraction and discharge licences under the Water (NI) Order 1999. Licences for both the abstraction of seawater and discharge of brine were issued by Northern Ireland Environment Agency (NIEA) on 14th November 2014.

In 2018, Islandmagee Energy Limited corresponded with DAERA Marine & Fisheries Division in regards to recommencing the application for a Marine Licence to facilitate the commencement of construction of the seawater intake and outfall. A review of the Environmental Statement (ES) submitted with the original planning application was subsequently undertaken by DAERA Marine & Fisheries Division. DAERA identified that some of the marine data used to inform the Environmental Statement in 2012 may now be considered out-dated and therefore should be supplemented with more recent information. It was agreed that Islandmagee Energy Ltd would proceed with the baseline survey works which would by default cover any information that could be considered out dated.

Consultation with DAERA has clarified that the specific areas requiring update are: Avian and Marine Biodiversity including food web considerations, Underwater Noise, Cumulative Effects and an update to the Brine Dispersion Model to consider the conclusions of the Front-End Engineering Design (FEED).

This Updated Environmental Conditions Report is in response to the further information request from DAERA Marine & Fisheries Division. The primary objective of this report is to supplement the marine elements of the Environmental Statement and Addendum Report submitted as part of the Marine Licence Application with more recent survey information before the marine licence can be fully considered. An update to the previous Habitats Regulation Assessment (HRA) will also be required.

## 1.2 Islandmagee Gas Storage Facility

### 1.2.1 Project History

In 1981 a borehole drilled by the Department of Energy (known as the "Larne-2 borehole") encountered a 113m thick salt sequence of Permian age (approx. 260 million years old) 1,688 metres below the surface. Desktop studies undertaken by Islandmagee Storage Limited in 2006 identified the potential for the Permian salt to extend beneath Larne Lough and subsequently mineral exploration licences were acquired from the Department of Energy, Trade and Investment (DETI) and the Crown Estate in 2007 to explore the Larne Lough area (Figure 1-1).

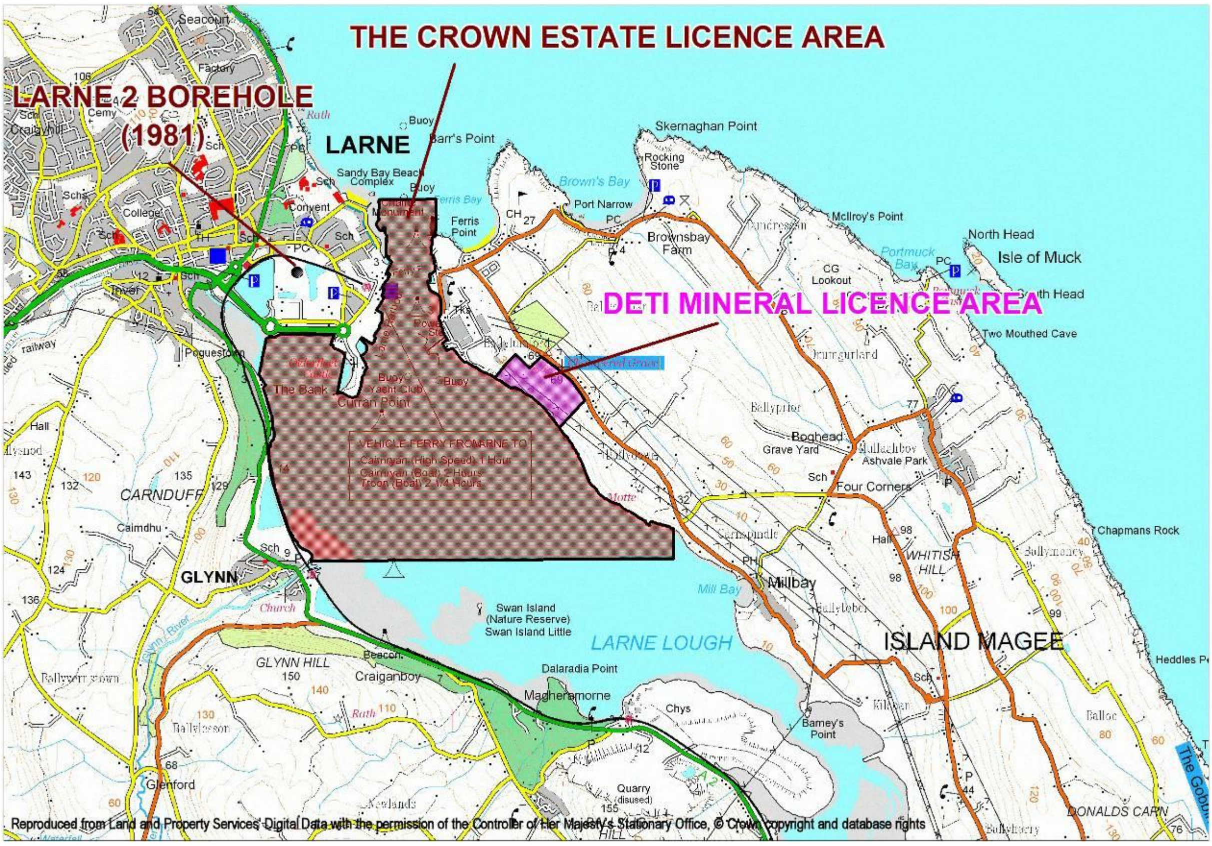


**Figure 1-1 Islandmagee Storage Licensed Exploration Areas**

Rock salt exhibits unique physical properties and mechanical behaviour that make it an ideal host for the development of caverns for the storage of materials that do not themselves react with or dissolve salt (BGS, 2008). Natural gas is one such material and the use of salt strata for underground gas storage is widely employed in northern Europe in the Permian salt of the Zechstein Basin. Several gas storage facilities are also in operation in England within the Permian salt beds in Yorkshire and Teeside and also the Triassic salt beds found in Cheshire.

Tests undertaken at the Larne-2 borehole showed that the Permian salt found at Larne appeared to be low in impurities and was therefore particularly suited to natural gas storage.

In October/November 2007 a seismic survey was undertaken across the licence area identified in Figure 1-1 and part of Islandmagee to determine whether the salt layer was confined to the area around the Larne-2 borehole or whether it extended across the Lough, as was thought to be the case by the Islandmagee Storage Geological team. The survey identified a layer of salt up to 250m thick extending across the Lough, with the most promising area being located near Ballylumford, Islandmagee.

Gas storage facilities require a connection to the national gas network and a considerable power supply for the compression equipment. The Scotland to Northern Ireland gas transmission Pipeline (SNIP) enters Northern Ireland at Islandmagee close to the site of the Islandmagee Gas Storage Facility (Figure 1-2). Ballylumford Power generating station is also located on Islandmagee immediately adjacent to the consented site for the proposed Gas compression facility.

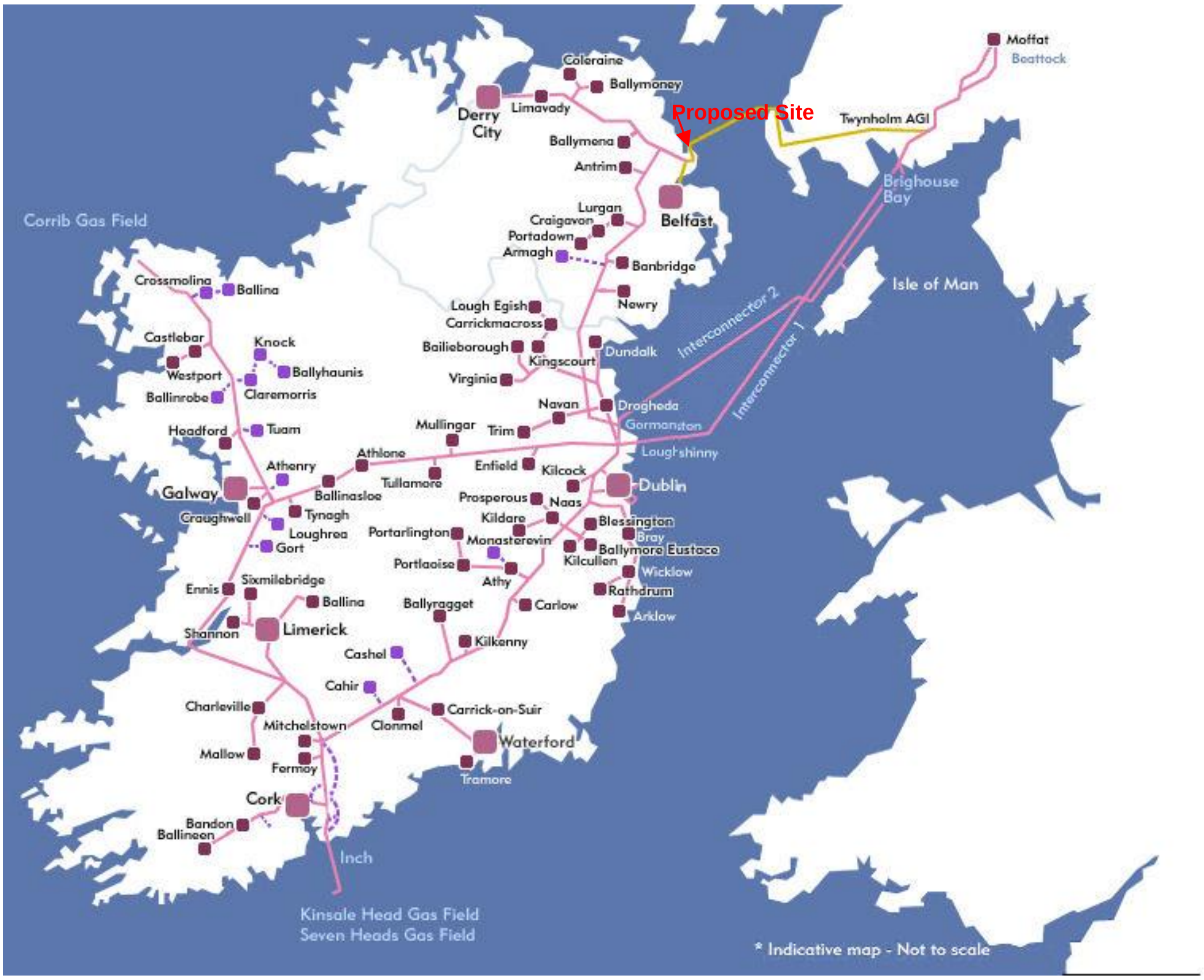


**Figure 1-2 Main Gas Network in Ireland (Eirgrid)**

## 1.2.2 Project Description

The Islandmagee Gas Storage Facility (IGSF) when constructed will create a new high pressure natural gas storage facility beneath Larne Lough. A total working gas storage capacity of circa 500 million standard cubic meters will be created in up to 7 salt caverns, formed at a depth of approximately 1350m below sea level in the Permian Salt Layer (Figure 1-3). The project facilities will be mainly located adjacent to the southern boundary of the existing power station at Ballylumford, located at the northern end of the Islandmagee peninsula.

The seven storage caverns, will be created by a technique called 'leaching' or 'solution mining'. The caverns will be created by directionally drilling underneath Larne Lough from a terrestrial site close to Ballylumford in

Islandmagee and extracting the salt by dissolving it with sea water. The leaching process dissolves the salt, under controlled conditions, and creates a cavity within the salt layer in which gas can be stored. The salt will be dissolved using seawater drawn from an intake point on the eastern shore of Islandmagee. The waste product, a concentrated brine, will be discharged back into the sea on the eastern side of Islandmagee.

The possibility of re-using the salt extracted from the caverns was investigated under the original EIS. It was, however, determined that for this particular project the most appropriate means of dealing with the waste brine was to pump it across Islandmagee and return it to the sea by managed dispersal through an outfall discharging at a point circa 450 metres offshore in a water depth of approximately 27 metres (Chart Datum) where it will rapidly disperse (Figure 1-4).

The location and length of the seawater intake and brine outfall pipelines were carefully designed and modelled to take advantage of the natural dilution and dispersion characteristics of the tidal currents offshore from Islandmagee. The brine will be forced through an outfall diffuser, comprising two ports, at high pressure to maximise mixing and dilution. The rate of brine discharged will vary over the construction period, being relatively low initially before rising to a peak production rate, and then reducing again as cavern construction nears completion.

A gas plant will be constructed to inject gas into the caverns and to dry gas for export to the gas network.

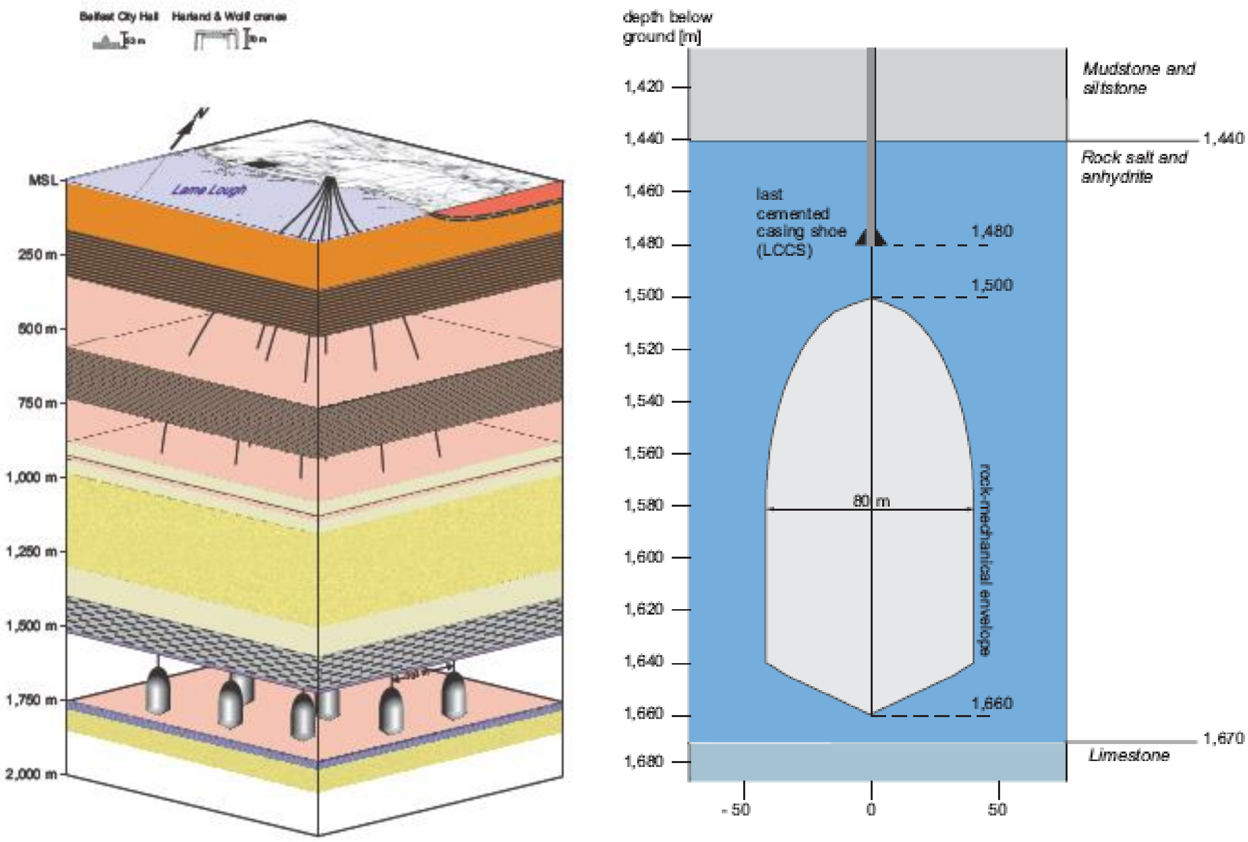


**Figure 1-3 Conceptual Cavern Design Produced by DEEP Underground Engineering Gmbh**


**Figure 1-4 Location of discharge and abstraction points**

The main above ground elements of the gas storage scheme (shown in Figure 1-5) are briefly described below. Construction work on these facilities will be phased, with the wells and leaching infrastructure being built first, followed by construction of the main gas plant facility.

1. **Wellpad** – a flat pad approximately 110m by 45m which initially supports the drilling rig to create the wells and subsequently will contain the well heads in underground cellars (Detailed in Chapter 2 below).
2. **Sea Water and Brine Pumping Facilities (Leaching Plant)** – a building housing the pumping equipment and brine tanks which will pump sea water into the wells and pump the waste brine back to the sea via an outfall during the construction phase.
3. **Main Gas Plant Facility** – the main operational facility which will house compression, heating/cooling, dehydration and metering equipment required for the day to day operation of the gas storage facility.
4. **Sea Water Intake Pumping Station** – an intake sump and pumping equipment located on the eastern shore of Islandmagee, at a site known as Castle Robin Bay or Bell's Port, which will draw in the "fresh" sea water and pump it to the Leaching Plant.

These facilities will be connected by sub-surface **Sea Water Intake** and **Brine Outfall pipelines.** The wellpad and main gas plant facility will also be connected with a sub-surface **Gas Transfer Pipeline**.

The Leaching Plant, Intake Pumping Station and Sea Water and Brine Pipelines are primarily intended for use during the initial construction of the storage caverns, once the caverns are fully constructed the plant will be decommissioned. If future maintenance of the caverns is required during the lifetime of the project the facilities required for this will be subject to new applications.


**Figure 1-5 Islandmagee Gas Storage - Project Layout**

# 2 ONSHORE CONSTRUCTION WORKS

## 2.1 *Phase 1: Wellpad Construction and Confirmation Well Drilling*

### 2.1.1 Well Pad Construction (2013)

Well pad construction was undertaken in August 2013. The well pad construction included the construction of an access road, the well pad and associated site drainage.

The site access road was designed to provide a safe route to and from the wellpad for heavy construction vehicles. It travels from the main road (B90), which is at an elevation of approximately 40m AOD, to the wellpad site, which is at an elevation of 5.75m AOD. The access road crosses the Belfast Transmission Pipeline (gas) which is protected by as concrete protection slab, installed at the pipeline crossing.

The Wellpad site was initially constructed to support the drilling rig required to drill the confirmation well. The Wellpad will now form the basis of the platform to drill the wells for the seven proposed caverns within the salt layer during construction and will accommodate the storage cavern connections in underground cellars beneath the pad.

Prior to construction of the well pad all surface water drains discharging towards the well pad site were diverted away from the excavated face into ditches to avoid erosion (Plate 2-1). Rainwater drainage from the site is contained within a perimeter ditch that was lined with Bentomat. The Bentomat is protected by a combination of concrete lining or stone fill. The ditch discharges to an oil interceptor, and then into Larne Lough. The discharge valve from the site will remain closed during drilling operations to ensure total control of any spillages. The outflow from the balancing pond also has a valve fitted to prevent any pollutants in the pond from being discharged.

**Preconstruction Drainage**

**Plate 2-1 Preconstruction Drainage at Well Pad Site, Islandmagee.**

**Plate 2-2 Perimeter ditch that has been lined with Bentomat**


**Plate 2-3 Well Pad Site Development (June-August 2013)**

## 2.2 Confirmation Well

In May 2015, a data gathering well (Islandmagee-1 / IM-1) was successfully drilled to a total depth of 1,753 metres obtaining wireline data and cores of the 185.8 metre thick Permian salt sequence.

Core samples from the salt sequence were sent to Germany and subjected to laboratory analyses. The test results were incorporated into the preliminary design and the subsurface and surface facility. The cost estimates for the project were also updated.

The overall results from the technical programme of work were positive and confirmed the feasibility of the development of an underground gas storage facility in salt caverns at this location. The thickness and depth of the Permian Salt were both within 10% of pre-drill estimates. The average thickness of the Permian Salt over the area of the proposed caverns is approximately 200 metres at a depth of approximately 1,300 metres sub-sea. The rock mechanical properties of the salt determined from the core data are in line with data for Permian Salt at other locations across Northern Europe where caverns for gas storage have been constructed and successfully operated.

### 2.2.1 Analysis of the salt core / composition of brine

To demonstrate the level of non-salt impurities in the brine to be produced at any stage of the solution-mining process, four rock salt samples from core material of well IM-1 were dissolved in North Channel sea water. The core material was selected from the stratigraphic interval of the salt sequences in which the caverns will be solution-mined. These artificial brines were prepared to have a total salinity close to saturation i.e. to identify the maximum concentrations of pollutants possible. A sample of North Channel water was also analysed for reference. Analytical results are summarised in Table 2-1.

The results for the artificial brine samples only reflect possible pollutant contributions from the natural rock salt, however during the leaching phase igneous intrusions will be disintegrated from the salt rock. The insoluble solid particles such as sand, igneous rock, mud stone etc. may enter the brine although the majority will collect at the cavern bottom in the cavern sump. Any material carried out of the cavern with the brine will settle in the degassing tank. Elution of any mineral constituents can therefore safely be assumed not to occur during leaching.

The brine produced from the salt core material of the IM-1 demonstrates that the chemical components in the brine produced by the project will be within the limits of the NIEA licences previously granted.

**Table 2-1 Results of chemical analysis of four artificial brine samples and one sea water sample for reference**

| Sample | | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | EQS/EAL levels* |
|---|---|---|---|---|---|---|---|
| Sampled from | | Core 12 | Core 14 | Core 18 | Core 20 | Seawater | |
| Top sample interval | m MD | 1,431.52 | 1,444.04 | 1,479.47 | 1,501.19 | n/a | |
| Bottom sample interval | m MD | 1,431.62 | 1,444.145 | 1,479.58 | 1,501.31 | n/a | |
| Chloride | mg/l | 191,000 | 191,000 | 194,000 | 193,000 | 19,300 | |
| Sulphates | mg/l | 3,210 | 3,850 | 3,450 | 3,770 | 2,700 | |
| Boron | mg/l | 3.69 | 3.61 | 3.61 | 3.81 | 4.3 | 7.0000 |
| Sodium | mg/l | 119,000 | 117,000 | 118,000 | 118,000 | 10,600 | |
| Potassium | mg/l | 428 | 416 | 413 | 417 | 389 | |
| Magnesium | mg/l | 1,100 | 1,100 | 1,090 | 1,110 | 1,310 | |
| Calcium | mg/l | 705 | 980 | 782 | 934 | 414 | |
| Arsenic | mg/l | 0.001 | 0.0018 | 0.0009 | 0.001 | 0.001 | 0.0250 |
| Lead | mg/l | 0.0017 | 0.0017 | 0.0022 | 0.0005 | <0.0001 | 0.0250 |
| Cadmium | mg/l | 0.00036 | 0.00007 | 0.00034 | 0.00018 | <0.00005 | 0.0025 |
| Chromium** | mg/l | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 | 0.0150 |
| Copper | mg/l | 0.0017 | 0.0014 | 0.0015 | 0.0008 | 0.0108 | 0.0050 |
| Nickel | mg/l | 0.0011 | 0.0034 | 0.0021 | 0.0016 | 0.0003 | 0.0300 |
| Mercury | mg/l | 0.000024 | 0.00002 | <0.00002 | <0.000020 | <0.00002 | 0.0003 |
| Zinc | mg/l | 0.0026 | 0.0044 | 0.0025 | 0.0011 | 0.0048 | 0.0400 |

*As per Table B2 in Discharge Consent Application for the Islandmagee Gas Storage Facility (RPS, October2012);
**Total

# 3 MARINE FEED DESIGN

## 3.1 Seawater Intake

### 3.1.1 Overview

A seawater intake is required to provide water for the solution mining of the storage caverns. The proposed seawater intake is located on the east side of Islandmagee and will extract water directly from the Irish Sea. The proposed intake head is located in approximately 10m water depth.

The project proposal is for a 450mm HDPE pipeline to be installed from the intake head to the onshore sump by way of a tunnel and shaft. The 450mm pipeline will be installed through the tunnel following tunnel completion. The shaft is to act as a sump and water will be abstracted and pumped across the island from the pump house located at the shaft location.

### 3.1.2 Alternative Solutions

#### 3.1.2.1 Horizontal Directional Drilling

The use of Horizontal Directional Drilling (HDD) was considered as an alternative construction technique. For HDD to be suitable the drilling profile would need to be designed to pass through the sump (shaft) at the required depth to ensure that sufficient water would always be available whilst exiting on the seabed in the correct location for the placement of the intake structure. The portion of the pipeline from the shaft to the drill entry point would then be abandoned following the sinking of the shaft over the pipeline.

Due to the topographical constraints posed by the proposed location of the sump a suitable profile to meet the requirements for HDD could not be determined, hence the HDD alternative was discounted.

#### 3.1.2.2 Pump Station Relocation

Relocation of the pumping station to the top of the slope to the south of the currently consented location was also considered as this would reduce the enabling works associated with construction of the pumping at the consented position.

However the cost of increasing the shaft depth a further 10m (due to the elevated location of all alternative sites) was significantly greater than the cost of the additional enabling works to form a suitable working area at the lower consented position. Additionally there were concerns that any alternative pumping station would be more visible and for these reasons the relocation alternative was dismissed.

### 3.1.3 Design

The Seawater intake structure was sized for the maximum flowrate of 1,000$m^3$/hr, at a maximum velocity of 0.15m/s to maintain the intake structure as 'hydraulically invisible'. A solidity ratio of 20% was taken for the screen structure, with a blockage ratio of 20%. Based on these constraints an intake structure with a maximum head height of 0.75m will require a structure with a minimum diameter of 1.20m.

The foundation for the Intake head structure was sized to resist overturning and sliding caused by the application of the design wave forces. The minimum required size for the foundation was determined as 3.0m x 3.0m x

1.5m to provide on bottom stability with acceptable factors of safety. For detailing purposes, the actual size of the foundation was determined to be 3.0m x 3.0m x 2.0m. To provide protection to the Intake head connection flange and minimise the likelihood of seabed disturbance during storm events, rip-rap protection are proposed for the seabed immediate adjacent to the Intake head extending for up to 2.5m beyond the intake screens.

### 3.1.4 Construction

To achieve the tunnel drive of 144.5m on a downhill tunnel gradient of 1.2° as proposed to reduce the depth of the shaft a 1.5m ID tunnel machine would be required. Ground investigation data currently available indicates the drive will be through basalt bedrock.

It is anticipated that a closed full face slurry machine with a combination of cutting knives and disc cutters will be required to complete the tunnel drive. Full face machines can maintain a positive face pressure irrespective of driving direction, hence no difficulties are anticipated with driving downhill. A soft eye will need to be included in the shaft construction to allow the tunnel machine to be advanced out of the shaft.

To receive and recover the tunnel machine offshore a tunnel reception pit will need to be excavated and backfilled with a coarse grained granular material to allow the tunnel machine to be driven into ground, which can later be removed by dredge pumps, to facilitate recovery of the tunnelling machine in the marine environment.

Once the tunnel drive is complete and the tunnel machine made ready for recovery the granular material will be removed from around the tunnel machine. Divers will be deployed to assist the operation and complete the connection of the lifting frame and buoyancy to the tunnelling machine.

The crane on the support vessel will lift the tunnel machine clear of the excavated pit, supported by additional buoyancy. Once the buoyancy reaches the surface the tunnel machine, complete with buoyancy will be towed to port for recovery.

For the intake head it is assumed that the 3.0 x 3.0 x 2.0m foundation could be precast, with the 16" NB SS pipe integral within it, and loaded directly onto a construction vessel for transportation to the Intake head worksite.

The foundation would be set into a pre-excavated hole within sedimentary seabed deposits such that the top of the foundation would be exposed at existing seabed level. Limited excavation works would also be required to expose the end of the micro-tunnel for the intake. Once the micro-tunnel end is exposed, and the foundation installed in the seabed, the flanged ends of both pipes can be surveyed to establish position, orientation, and arrangement prior to fabricating a tie-in spool. Once the fabricated tie-in spool is diver installed, the Intake head foundation, and tie-in spool can be back-filled, and sandbag protection and anti-scour gabions can be installed (Refer to Appendix A for the Seawater Intake General Arrangement drawing).

## 3.2 Brine Outfall

### 3.2.1 Overview

Brine resulting from solution mining during the formation of the storage caverns will be transferred by pipeline from the wellsite across Islandmagee to the proposed discharge point on the east side of Islandmagee where a 400mm HDPE pipeline is proposed to discharge the brine direct to the Irish Sea.

The topography at the discharge location is such that a trenchless technique is required for the transition from onshore to the offshore discharge location. The trenchless technique most suited to meet the requirements of the project is HDD. HDD has been undertaken on many projects worldwide for the installation of pipelines from land to sea.

### 3.2.2 Alternative Solutions

The only other realistic alternative to HDD for the construction of the outfall at Islandmagee is direct laying of the pipeline on the sea bed. However it was concluded, during concept design, that the environmental impact of this option would be too high for consideration.

### 3.2.3 Design

The Brine outfall diffuser structure was sized to accommodate the maximum flow rate of 1,000m$^3$/hr. The proposed design that emerged from the FEED process comprises of two diffuser ports pointing vertically upwards and fitted with duckbill diffuser valves to maximise the dispersion and mixing of discharged brine.

The original design for the Brine outfall diffuser structure comprised of three discharge ports. The performance of this port arrangement was subjected to dispersion modelling and found to be acceptable. During the FEED Study a more detailed review of the discharge design was possible than in the concept phase of the project and this identified the potential to improve the dispersion during all expected flows and periods of lower discharge flow. A detailed study was carried out to determine discharge performance for a variety of port sizes and port quantities. This study concluded that the increased port velocity associated with a 2 port design utilising 6” diameter ports, had potential to generate improved initial dilution when compared to a 3 port design. The overall impact of the revised arrangement was subjected to dispersion modelling using the appraisal well salt core data, which confirmed that the revised arrangement optimised dispersion and reduced salinity at the first contact with the seabed. These results were confirmed by the subsequent third party assessment carried out by HR Wallingford.

### 3.2.4 Construction

The adoption of HDD for the installation of the brine outfall is considered feasible. The existing ground investigation information indicates up to 8.0m of superficial deposits comprising firm slightly sandy gravelly clay overlaying solid deposits comprising weak basalt to 10m bgl overlying strong to medium strong greenish black dolerite to the base of the exploratory hole at 20.0m depth. Ground conditions of this nature have been successfully drilled using HDD on numerous previous occasions confirming the feasibility of adopting HDD, suitable rock tools will need to be used and detailed information on the ground conditions, including rock strength, fracture index and abrasivity will need to be obtained prior to the completion of detailed design.

For the installation of the 400mm pipeline a minimum bore diameter of 560mm will be required. It is anticipated that to achieve the required bore diameter the following sequence of operations will be required:

- Pilot hole 300mm (12”)
- Pass 1 hole opening 457mm (18”)
- Pass 2 hole opening 560mm (22”)

It is proposed that the initial pilot hole and reaming runs will be completed with a blind hole i.e. the seaward end of the drill will be stopped short of the seabed to facilitate return of drilling muds and cuttings to the entry hole for recovery. Once the majority of the HDD profile has been opened out to the required size the final punch out will occur. For punch out at the seabed and connection of the diffuser assembly a marine support spread will need to be in attendance. When punch out onto the seabed occurs, drilling fluid from the bore will be lost to the seabed. Environmentally friendly, CEFAS approved fluids such as Pure-Bore® are therefore proposed to minimise the environmental impact of drilling fluids escaping to the sea.

The offshore end of the pipeline will be flanged to facilitate the later connection of the diffuser. A 400mm to 355mm conical reducer and 355mm stub flange c/w stainless steel backing ring will need to be connected to the pipeline prior to launch to facilitate the connection to the diffuser assembly. To facilitate the removal of the blank flange offshore and the connection to the diffuser the pipeline will need to be flooded from onshore to offshore to equalise the pressures. Once connected to the diffuser the water level in the pipeline will be allowed to reach natural equilibrium.

The 40m length of Diffuser head will be fitted with ballast weights at regular intervals along its length to sink it and temporarily secure it on the seabed. Once the diffuser head is connected to the exposed end of the outfall pipe, proprietary concrete block mattress protection units will be laid over the pipe for the full on-seabed length. An additional layer of concrete mattress protection will be laid immediately adjacent to the 6” check valve to provide inherent protection against over-trawling/anti snagging (Refer to Appendix A for the Brine Outfall General Arrangement drawing.)

# 4 SCOPING AND CONSULTATION

## 4.1 Consultation

**Table 4-1 Consultation with Statutory Bodies**

| Date | Description | Summary |
|---|---|---|
| 30-Jul-18 | Meeting<br>Location - DAERA Belfast Office.<br>Attendees –<br>- Claire Vincent (DAERA)<br>- Charmaine Beer (DAERA)<br>- Pol Mac Cana (DAERA)<br>- Judith Tweed (IMEL)<br>- Martyn Garbutt (Costain)<br>- Gordon Williams (Costain) | • **Environmental Regulations**<br>DAERA to review applicable EIA regulations (2011 or 2017). DAERA Marine Division provided clarification that the Marine Licence is a draft only and that both the discharge and abstraction licences require the marine licence to be in place.<br>• **Salt Core Analysis**<br>DAERA highlighted requirement for analysis of the salt core and requirement for a robust monitoring strategy.<br>• **Marine Science Group**<br>DAERA advised that it was agreed at the last science group meeting (2014) that the group would be reconvened to review the salt core analysis results once they are available.<br>• **HRA**<br>DAERA advised that a new HRA would be required due to lapse in time, new Natura 2000 sites and the new requirement to assess cumulative impacts. DAERA advised that a single HRA would suffice for the whole project.<br>• **Public Engagement**<br>DAERA stated that Infrastrata have an obligation to engage with the public. |
| 3-Aug-18 | Letter<br>From - Judith Tweed (IMEL)<br>To - Pol Mac Cana (DAERA) | • **EIA regulations**<br>Letter requesting clarification of the applicable version of the Marine and Coastal Access act. |
| 8-Aug-18 | Email<br>From - Pol Mac Cana (DAERA)<br>To - Judith Tweed (IMEL). | • **MoM**<br>Minutes of Meeting from 30-Jul-19 (attached to email)<br>• **EQS**<br>Clarification of changes to EQS's. |
| 20-Aug-18 | Letter<br>From - Pol Mac Cana (DAERA)<br>To - Judith Tweed (IMEL). | • **Current Licence Position**<br>Clarification that the Marine Licence is a draft only and that both the discharge and abstraction licences require the marine licence to be in place.<br>• **Project Alterations**<br>Request from DAERA for all design alterations be presented in comparison to the original design.<br>• **Environmental Impact Assessment**<br>DAERA requested an update of the dispersion modelling and confirmed that the 2011 EIA regulations are applicable to this project.<br>• **HRA**<br>Confirmation that a new HRA would be required.<br>• **Marine Science Group**<br>DAERA confirmed that the group would be reconvened once the salt core analysis and monitoring proposal are available.<br>• **Monitoring and ground truthing of model**<br>DAERA advised that the modelling must be ground-truthed (using the actual salt core data) and the monitoring strategy should be sufficiently detailed to detect deviations from the model predictions. |

| Date | Description | Summary |
|---|---|---|
| | | • **Public Engagement**<br>DAERA requested that they be informed of all public engagements including meetings, website updates and publications. |
| 22-Jan-19 | Letter<br>From – Judith Tweed (IMEL)<br>To - Marine Licencing (DAERA) | • **Salt Core Analysis**<br>Analysis document confirming that non-salt components are within EQS limits. |
| 6-Feb-19 | Letter<br>From - Pol Mac Cana (DAERA)<br>To - Judith Tweed (IMEL) | • **Current Licence Position**<br>Clarification that licence consideration cannot commence until all requested information is received.<br>• **Public Engagement**<br>Statement regarding the requirement for public participation on the new information. |
| 27-Feb-19 | Letter<br>From - John Wood (IMEL)<br>To - Pol Mac Cana (DAERA) | • **Project Changes**<br>Clarification that the number of caverns (7) is unchanged from the original licence application. Clarification that the only design change has been the reduction in the number of dispersion nozzles (from 3 to 2).<br>• **Brine Dispersion Monitoring Report**<br>Reference to updated Brine Dispersion Monitoring Report (Rev D01 attached to letter). |
| 6-Mar-19 | Letter<br>From - John Wood (IMEL)<br>To - Pol Mac Cana (DAERA) | • **Public Engagement**<br>Notification of meeting held with elected representatives and plans for public meetings and a project information booklet.<br>• **HRA**<br>Reference to shadow HRA Report (Rev D02 attached to letter).<br>• **Meeting**<br>Request for meeting with DAERA. |
| 8-Mar-19 | Email<br>From - Claire Vincent (DAERA)<br>To - Martyn Garbutt (Costain) | • **Meeting**<br>Recommendation for meeting prior to public engagement planned for 20-Mar-19. |
| 13-Mar-19 | Email<br>From - Alan Barr (RPS)<br>To - Claire Vincent (DAERA) | • **Environmental Monitoring Programme**<br>Issue of draft Environmental Monitoring Programme (Rev F01 attached to email) for discussion at the upcoming meeting with DAERA. |
| 14-Mar-19 | Meeting<br>Location - DAERA Lisburn Office<br>Attendees –<br>- Claire Vincent (DAERA)<br>- Charmaine Beer (DAERA)<br>- Gareth Patterson (DAERA)<br>- Stephanie Bennett (NIEA)<br>- Richard Coey (NIEA)<br>- Peter Close (NIEA) | • **Environmental Impact Assessment**<br>Clarification by DAERA that up to date Environmental documents need to be submitted.<br>• **Project Progress**<br>Update provided by Infrastrata<br>• **Public Engagement**<br>Update provided by Infrastrata<br>• **Current Licence Position**<br>Clarification by DAERA of the requirement for updated information, the required review of the discharge and |

| Date | Description | Summary |
|---|---|---|
| | - James Moore (NIEA)<br>- John Wood (Infrastrata)<br>- Arun Ramen (Infrastrata)<br>- Judith Tweed (IMEL)<br>- Martyn Garbutt (Costain)<br>- Malcolm Brian (RPS)<br>- Alan Barr (RPS) | abstraction licences and the requirement for third party assessment of the brine modelling. Request by DAERA for a project roadmap document (timeline). Clarification of all documents required by DAERA.<br>• **Environmental Monitoring Programme**<br>Overview of Environmental Management Programme provided by RPS.<br>• **Marine Science Group**<br>Clarification that this will be facilitated by DAERA, |
| 15-Mar-19 | Email<br>From - John Wood (IMEL)<br>To - Claire Vincent (DAERA) | • **Marine Licence Timeline**<br>Draft Timeline indicating activity to date issued to DAERA for review. |
| 16-Apr-19 | Email<br>From - Gareth Patterson (DAERA)<br>To - all meeting attendees | • **MoM**<br>Minutes of Meeting from 14-Mar-19 |
| 13-May-19 | Email<br>From - Martyn Garbutt (Costain)<br>To - Charmaine Beer (DAERA) | • **HRA**<br>Shadow HRA Report (Rev D04 attached to email). Updated based on feedback provided to RPS by DAERA. |
| 7-Jun-19 | Email<br>From - Martyn Garbutt (Costain)<br>To - Claire Vincent (DAERA) | • **Third Party Brine Dispersion Study**<br>• Report (Rev R05 attached to email).<br>• **Brine Dispersion Modelling**<br>Report (Rev D03 attached to email) update to incorporate third party recommendations) |
| 10-Jun-19 | Meeting<br>Location - DAERA Lisburn Office<br>Attendees –<br>- Claire Vincent (DAERA)<br>- Charmaine Beer (DAERA)<br>- Gareth Patterson (DAERA)<br>- Stephanie Bennett (NIEA)<br>- Peter Close (NIEA)<br>- Stephanie Millar (NIEA)<br>- James McKervey (NIEA)<br>- John Wood (Infrastrata)<br>- Alan Barr (RPS) | • **Project Progress**<br>Update provided by Infrastrata<br>• **Public Engagement**<br>Update provided by Infrastrata. DAERA advised that they would endeavour to attend future drop-in sessions.<br>• **Brine Dispersion Modelling**<br>DAERA will provide comments once their review is completed. DAERA stated a need for observed ADCP data at M3 on the neap tide cycle.<br>• **Current Licence Position**<br>DAERA are seeking legal advice regarding the validity of the current application. DAERA requested updates of Environmental information and will provide a full list in due course.<br>• **Environmental Monitoring Programme**<br>RPS to further develop Environmental Management Programme following completion of other document assessments by DAERA. |
| 27-Jun-19 | Public Drop-In Session<br>Location - Islandmagee<br>Attendees –<br>- Claire Vincent (DAERA) | • **Public Engagement**<br>Attendance by DAERA to provide licencing updates to the public. |
| 24-Jul-19 | Email | • **MoM**<br>Minutes of Meeting from 10-Jun-19 |

| Date | Description | Summary |
|---|---|---|
| | From - Charmaine Beer (DAERA)<br>To - John Wood (Infrastrata) | |
| 30-Jul-19 | Public Drop-In Session<br>Location - Islandmagee<br>Attendees –<br>- Charmaine Beer (DAERA)<br>- Gareth Patterson (DAERA)<br>- Stephanie Bennett (NIEA)<br>- Peter Close (NIEA) | • **Public Engagement**<br>Attendance by DAERA to provide licencing updates to the public. |
| 21-Aug-19 | Public Drop-In Session<br>Location – Islandmagee<br>Attendees –<br>- Stephanie Bennett (NIEA)<br>- Peter Close (NIEA) | • **Public Engagement**<br>Attendance by DAERA to provide licencing updates to the public. |
| 25-Sep-19 | Public Drop-In Session<br>Location – Larne<br>Attendees –<br>- Charmaine Beer (DAERA)<br>- Stephanie Bennett (NIEA)<br>- Peter Close (NIEA) | • **Public Engagement**<br>Attendance by DAERA to provide licencing updates to the public. |

**Table 4-2 Public Consultation Events**

| Date | Location | Notes | Attendees |
|---|---|---|---|
| 01-Mar-19 | Ballygalley Castle Hotel | Purpose -<br>To meet with local political representatives and provide them with an understanding of the project so that they can better respond to queries from the public.<br><br>Format -<br>PowerPoint presentation, delivered by John Wood, to inform the representatives of the key project aspects followed by a question and answer session. | - John Wood (Infrastrata)<br>- Graham Lyon (Infrastrata)<br>- Arun Ramen (Infrastrata)<br>- Judith Tweed (IMEL)<br>- Martyn Garbutt (Costain)<br>- Patrick McClughan (IMEL)<br>- Joris Milne (JComms)<br>- Roy Beggs MLA (UUP)<br>- Stewart Dickson MLA (Alliance)<br>- David Hilditch MLA (DUP)<br>- Gordon Lyons MLA (DUP)<br>- John Stewart MLA (UUP)<br>- Geraldine Mulvenna Cllr (Alliance)<br>- Gregg McKeen Cllr (DUP)<br>- Mark McKinty Cllr (UUP)<br>- Andy Wilson Cllr (UUP<br>- Paul Reid Cllr (DUP)<br>- Robert Logan Cllr (Alliance)<br>- Sammy Wilson MP (DUP) |

| Date | Location | Notes | Attendees |
|---|---|---|---|
| 20/21-Mar-19 | The Gobbins Visitors Centre | Purpose -<br>To meet with members of the public, provide information about the project and answer questions.<br><br>Format -<br>Individual 30 minute pre-arranged appointments. | - Members of Public (approx. 12)<br>- John Wood (Infrastrata)<br>- Judith Tweed (IMEL)<br>- Rob Beresford (Costain)<br>- Alan Barr (RPS) p/t<br>- Daniel Hogan (RPS) p/t |
| 30-Apr-19 | Second Islandmagee Presbyterian Church | Purpose -<br>To meet with members of the public, provide information about the project and answer questions.<br><br>Format -<br>Two open drop-in sessions<br>10am to 2pm and 5pm to 7pm | - Members of Public (approx. 56)<br>- Arun Ramen (Infrastrata)<br>- Judith Tweed (IMEL)<br>- Martyn Garbutt (Costain)<br>- Rob Beresford (Costain)<br>- Malcolm Brian (RPS) |
| 22-May-19 | Islandmagee Orange Hall | Purpose -<br>To meet with members of the public, provide information about the project and answer questions.<br><br>Format -<br>Two open drop-in sessions<br>10am to 2pm and 5pm to 9pm<br>Evening session extended to 9pm following feedback from previous open day. Additional presentation materials made available to aid understanding of the project. | - Members of Public (approx. 26)<br>- Arun Ramen (Infrastrata)<br>- Judith Tweed (IMEL)<br>- Martyn Garbutt (Costain)<br>- Rob Beresford (Costain)<br>- Alan Barr (RPS) |
| 27-Jun-19 | Islandmagee Orange Hall | Purpose -<br>To meet with members of the public, provide information about the project and answer questions.<br><br>Format -<br>Two open drop-in sessions<br>10am to 2pm and 5pm to 9pm<br>Evening session attended by DAERA to provide updates on Marine Licence status. | - Members of Public (approx. 29)<br>- Arun Ramen (Infrastrata)<br>- Judith Tweed (IMEL)<br>- Martyn Garbutt (Costain)<br>- Rob Beresford (Costain)<br>- Daniel Hogan (RPS)<br>- Claire Vincent (DAERA) |
| 30-Jul-19 | Islandmagee Orange Hall | Purpose -<br>To meet with members of the public, provide information about the project and answer questions.<br><br>Format -<br>Two open drop-in sessions<br>10am to 2pm and 5pm to 9pm | - Members of Public (approx. 31)<br>- Arun Ramen (Infrastrata)<br>- Judith Tweed (IMEL)<br>- Martyn Garbutt (Costain)<br>- Rob Beresford (Costain)<br>- Malcolm Brian (RPS)<br>- Charmaine Beer (DAERA)<br>- Gareth Patterson (DAERA)<br>- Stephanie Bennett (NIEA)<br>- Peter Close (NIEA) |

| Date | Location | Notes | Attendees |
|---|---|---|---|
| 21-Aug-19 | Islandmagee Orange Hall | Purpose - To meet with members of the public, provide information about the project and answer questions.<br><br>Format - Two open drop-in sessions 10am to 2pm and 5pm to 9pm | - Members of Public (approx. 37)<br>- Arun Ramen (Infrastrata)<br>- Judith Tweed (IMEL)<br>- Martyn Garbutt (Costain)<br>- Malcolm Brian (RPS) p/t<br>- Daniel Hogan (RPS) p/t<br>- Chris Midgley (Newgate Comms)<br>- Stephanie Bennett (NIEA)<br>- Peter Close (NIEA) |
| 25-Sep-19 | Larne Town Hall | Purpose - To meet with members of the public, provide information about the project and answer questions.<br><br>Format - Open drop-in session 4pm to 8pm | - Members of Public (approx. 38)<br>- Arun Ramen (Infrastrata)<br>- Judith Tweed (IMEL)<br>- Martyn Garbutt (Costain)<br>- Malcolm Brian (RPS)<br>- Chris Midgley (Newgate Comms)<br>- Charmaine Beer (DAERA)<br>- Stephanie Bennett (NIEA)<br>- Peter Close (NIEA) |

## 4.2 Scoping

In 2018, Islandmagee Energy Limited corresponded with DAERA Marine & Fisheries Division regarding the steps required to facilitate commencement of construction of the seawater intake and outfall. A subsequent review of the Environmental Statement (ES) submitted with the original planning application undertaken by DAERA Marine & Fisheries Division. DAERA identified that some of the marine data used to inform the Environmental Statement in 2012 may now be considered out-dated and therefore should be supplemented with more recent information and the environmental assessments undertaken updated if necessary based on this updated baseline information before the marine licence can be finalised.

Consultation with DAERA has clarified that the areas requiring update are: Avian and Marine Biodiversity, Underwater Noise, Cumulative Effects and an update to Brine Dispersion Model to consider the conclusions of the FEED. An update to the previous Habitats Regulation Assessment (HRA) will also be required in support of the application.

# 5 MODELLING THE BRINE DISCHARGE

The updated Brine Dispersion Modelling Report (FEED Update) is attached as Appendix B to this report. A summary of the Brine Dispersion Modelling Report is presented below.

The initial dilution and far-field dispersion likely to be achieved by the brine discharge from the proposed Islandmagee Gas Storage Facility (IGSF) under a range of flow condition has been assessed using accepted computational modelling techniques.

The ambient conditions employed in terms of water depths, tidal flows and salinities are identical to those adopted for the earlier work associated with the terrestrial consenting process for the IGSF.

The recently complete Front-End Engineering Design (FEED) stage of the IGSF has confirmed that the salinity of the discharge brine will be a maximum of 260 psu and that the excess temperature of the brine will only be around 2$^{o}$C above the temperature of the intake water.

The initial dilution modelling results show that for the proposed diffuser the salinity of the brine at first contact with the seabed will be between 50.5 psu and 37.6 psu depending on the discharge flow and number of active ports on the diffuser. This will be validated by live real time monitoring as detailed in Section 9.2 of this report.

The medium to far-field dispersion assessment has confirmed that the discharge of up to 1,000m$^3$/hour of saturated brine via the proposed IGSF outfall and diffuser will have minimal impact on salinity levels beyond the immediate vicinity of the outfall. Maximum salinity increases of more than 0.5 psu above background are not anticipated to occur more than a few hundred metres from the diffuser and salinities in excess of 36 psu are not predicted to occur more than 100m from the diffuser. These conclusions apply over the full range of leaching discharges proposed for the Islandmagee Gas Storage Facility, 250m$^3$/hour to 1,000m$^3$/hour, provided the diffuser is operated in the way reported with one port used for discharges of less than 500m$^3$/hour and two active ports for larger discharges.

Cores from the proposed salt sequence at Islandmagee within which the IGSF caverns will be created, were recovered and dissolved in North Channel seawater to produce a saturated brine representative of the brine that will be produced by the cavern creation process at Islandmagee as part of the FEED process. Comparison of the concentration of non-salt compounds in the Islandmagee brine to levels reported from other similar UK sites (Aldborough) and applicable EQS thresholds for marine waters has established that the concentrations in the Islandmagee brine are generally lower than for other similar UK operations and in all cases are lower than the relevant EQS. Thus with the dilution and dispersion that will occur after discharge the non-salt components in the IGSF brine discharge do not pose a threat to marine water quality at Islandmagee beyond a 100m radius of the discharge pipe.

# 6 ASSESSMENT OF UNDERWATER NOISE

## 6.1 Introduction

This section presents an assessment of potential underwater noise impacts arising during the construction and operational phases of the development. The assessment establishes any potential noise impacts on fish and marine mammal species. As outlined in Chapter 3 and shown in Figure 1-5, the marine works and consequently the potential underwater noise element, of the project are associated with the construction of gas storage caverns by dissolving salt formations using seawater. The gas storage caverns will be located over one kilometre below Larne Lough and constructed by dissolution of the surrounding Permian salt layer. Underwater noise will arise principally from the pipeline construction to take in seawater and discharge the brine solution east of Islandmagee.

In this section, the underwater noise impact of the construction and operation of the gas storage facility will be assessed in light of relevant guidelines and international best practice.

During the cavern formation, wells will be drilled from the onshore wellsite at Ballydown and the caverns will be sequentially formed using sea water drawn from the seawater intake at Dundressan. The resulting brine will be discharged into the Irish Sea, also at Dundressan.

The project will also consist of interconnecting pipelines, utilities, off-sites and associated infrastructure to support the operation of the gas storage facility. Figure 6-1 illustrates the location of the elements of the project with potential to generate underwater noise that have been considered in this chapter.

This noise impact assessment considers the construction phase primarily because it will involve the highest underwater noise levels. The assessment will give due consideration to other construction activities and the potential cumulative impact of the existing operation and the construction activities.

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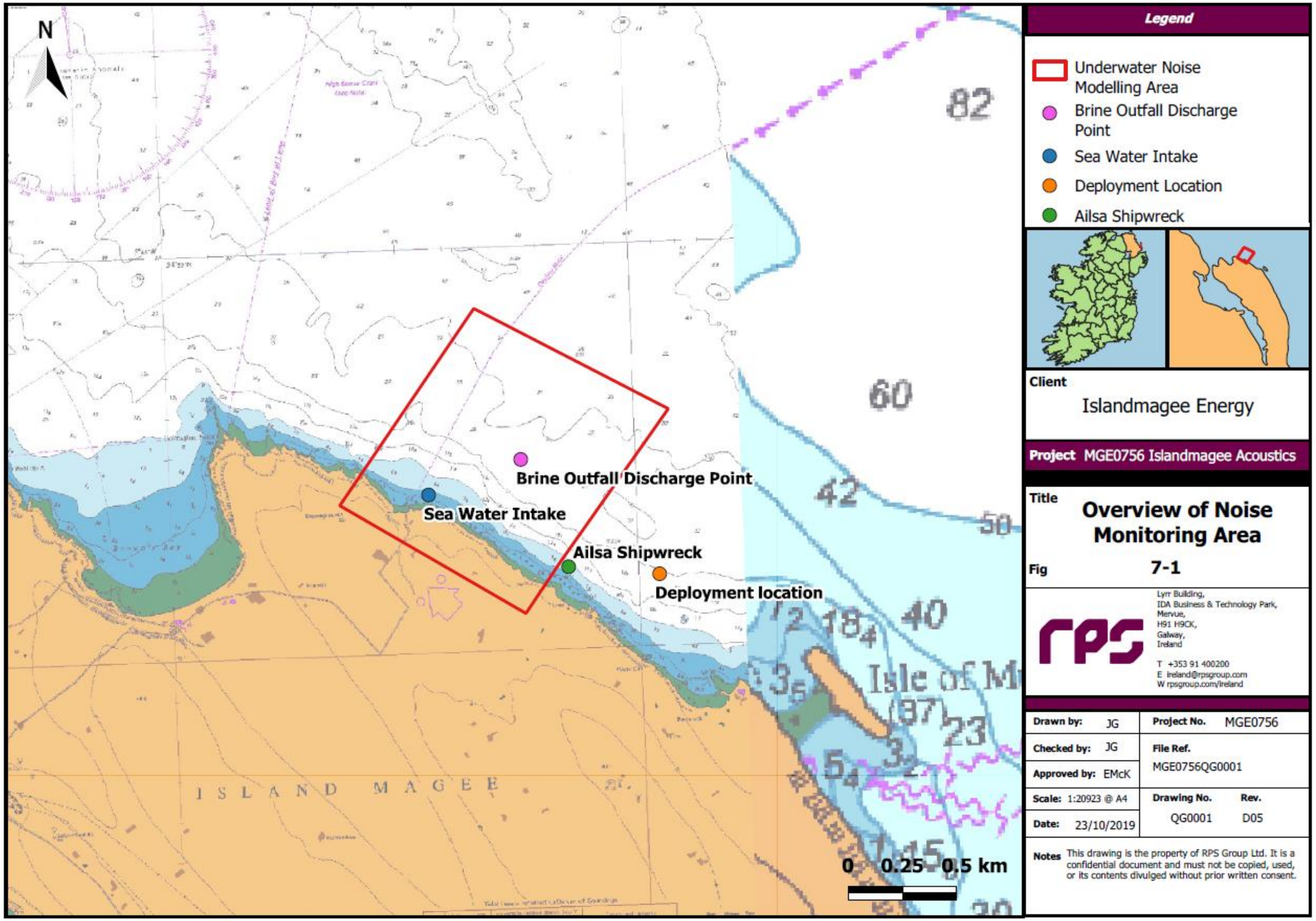


**Figure 6-1: Proposed works and Noise Monitoring Location at Islandmagee**

## 6.2 Assessment Methodology

### 6.2.1 Fundamentals of Underwater Noise

Sound may be defined as the periodic disturbance in pressure from some equilibrium value. Sound pressure is measured in Pascals. The unit of pressure is given in Pascals (Pa) or Newton per square metre ($N/m^2$). In order to avoid dealing with a very large range of numbers, e.g. from 0.00002 Pascals to 20,000 Pascals the logarithmic decibel scale is used. This simplifies the same range of numbers, by setting up a logarithmic scale based on a reference pressure.

For historical and scientific reasons, the reference pressure chosen for airborne noise is not the same as that chosen for underwater noise. The reference pressure for underwater noise is 1 μPa so underwater noise levels are referred to as dB re 1 μPa. The acoustic impedance of water is also greater than that of air. This means that there is no direct relationship between decibels in air and decibels in water.

decibels in air ≠ decibels in water

Quoted (peak) source levels for underwater noise sources are quoted in dB re 1 μPa at 1 metre. This is a 'notional' figure extrapolated from far field measurements as it is not practicable to measure sound levels at 1m from an active source such as a ship or an excavator ripping rock. Measurements are taken in what is known as the far field and extrapolated back to a notional 1 m from the idealised point source. It is usual to take measurements at several hundred metres or kilometres in deep water and extrapolate the measured levels to what has become known as a 1 m source level. This is illustrated in Figure 6-2. The actual propagation of sound in the near (Fresnel) field produces an undulating curve, but the extrapolated dashed line indicates a much higher source level.

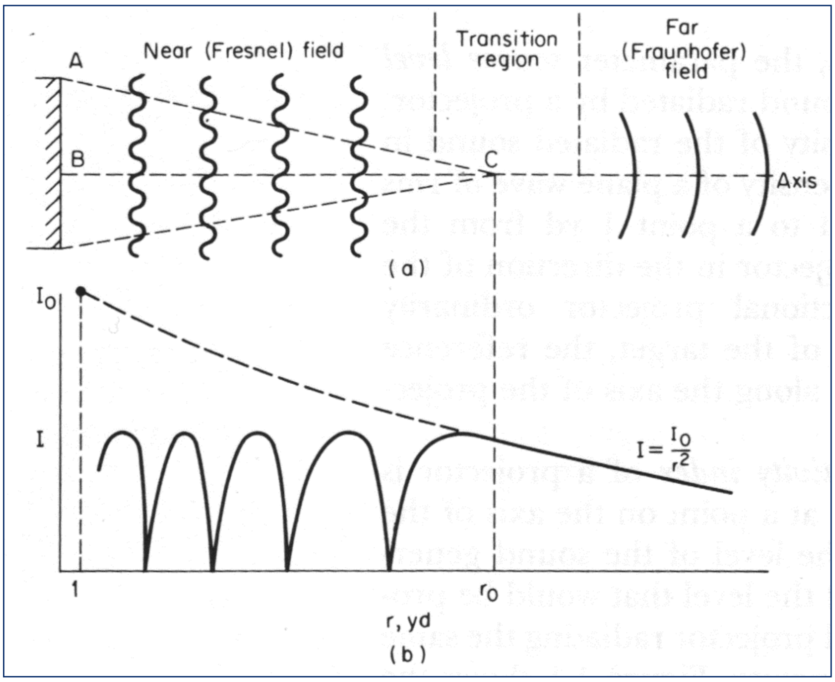


**Figure 6-2: Underwater Noise Source Level Fields (Urich 1983, Fig. 4)**

Typical underwater noise levels is set out below in Table 6-1**.**

**Table 6-1: Typical Underwater Noise Levels - from Richardson et al. (1995)**

| Source | SPL<br>dB re: 1µPa @ 1m | Peak Frequency<br>Hertz | Band Width<br>Hertz |
|---|---|---|---|
| Super Tanker - 337m long @ 18 knots | 185 | 20-30 | 5-100 |
| Trenching - (Suction/Hopper ) | 177 | 80-200 | 20-8,000 |
| Tug vessel - (while towing) | 145-170 | 1,000 | 37-5,000 |
| Fishing vessel - (@ 7 knots) | 151 | 250-1,000 | 250-1,000 |
| 5m RIB - 25 HP outboard | 152 | 6,300 | |

This extrapolation leads to apparently high values for the source level and can lead to erroneous conclusions about the impact on marine mammals and fish for the following reasons:

- Far field source levels do not apply in the near field of the array where the sources do not add coherently; sound levels in the near field are, in fact, lower than would be expected from far field estimates.
- Source level calculations are generally based on theoretical point sources with sound propagating equally in all directions. This is not easily replicated in real world conditions.
- The majority of published data for underwater sources is based on deep water measurements. Sound propagation in shallow water is significantly more complex and, sound does not propagate as efficiently as it would in deep water.

### 6.2.2 Acoustic Metrics

This report utilises the standards and definitions set out by TNO (2011). All times in this report are Coordinated Universal Time.

#### 6.2.2.1 Peak Sound Pressure Level

The peak sound pressure level is the maximum absolute value of the instantaneous sound pressure recorded over a given time interval.

#### 6.2.2.2 Sound Exposure Level (SEL)

The Sound Exposure Level (SEL) is the time integral of the square pressure over a time window long enough to include the entire pressure signal characteristic. SEL values for short duration are calculated in one second intervals or for 90% of the total energy of an impulsive event.

$$\mathrm{SEL} = 10\log_{10}\int_0^T P(t)^2 dt$$

#### 6.2.2.3 Cumulative Sound Exposure Level ($SEL_{cum}$)

The Sound Exposure Level (SEL) is the time integral of the square pressure over a time window long enough to include the entire pressure signal characteristic (an event or a period). $SEL_{cum}$ values are calculated over the full exposure period (normally 24 hours).

$$\mathrm{SEL_{cum}} = 10\log_{10}\int_0^T P(t)^2 dt + 10\log_{10}(\text{Number of events/periods})$$

#### 6.2.2.4 Root Mean Square (RMS)

RMS is the root mean square of the amplitude of a continuous pressure signal in a specified frequency band, for a specified averaging time.

$$\mathrm{P}_{RMS} = \sqrt{\frac{1}{T}\int_0^T P(t)^2 dt}$$

#### 6.2.2.5 Daily Noise Dose ($L_{ep,\,d}$)

The noise dose is the sum of the total weighted noise energy, expressed as a level normalised to an 8-hour period (i.e. an equivalent steady state level for a period of 8 hours).

$$\mathrm{L_{ep,d}} = 10\log_{10}\left[\int_0^{8\,hours} P(t)^2 dt \Big/ 8\,hours\right]$$

#### 6.2.2.6 Description of Effects

In order to characterise the potential effects of construction noise, the magnitude of the effect and the sensitivity of the receptors determines the overall impact. Table 6-2 summarises the sensitivities of marine mammal species with regard to noise thresholds. A permanent threshold shift (PTS) occurs when a permanent auditory injury results in loss of hearing. PTS can result in very significant to profound negative impacts on marine species. A temporary threshold shift (TTS) describes a temporary but recoverable loss of hearing due to exposure to high energy sounds for a short duration or lower energy sounds for a longer duration. The impact of TTS is significant but recoverable. Determining the likelihood of noise sensitive species being exposed to such noise levels will help to categorise the significance of effects on each species.

### 6.2.3 Underwater Noise Thresholds

The underwater noise impacts arising in the construction and operation of the seawater intake and the brine outfall will be associated with seabed and sub-sea construction which generate non-impulsive noise. No blasting or pile driving (activities which give rise to impulsive noise) are proposed. The international guidance on underwater noise threshold levels for marine mammals is published in Southall et al (2019) and provides (inter alia) the following thresholds:

**Table 6-2: TTS- and PTS-onset thresholds for marine mammals exposed to non-impulsive noise:**

| Marine mammal hearing group | TTS onset: SEL (weighted) dB re 1 μPa²s | PTS onset: SEL (weighted) dB re 1 μPa²s |
|---|---|---|
| Low Frequency Cetaceans (baleen whales) | 179 | 199 |
| High Frequency Cetaceans (most dolphin species) | 178 | 198 |
| Very High Frequency Cetaceans (Harbour Porpoise) | 153 | 173 |
| Phocid Carnivores (seal species) | 181 | 201 |
| Other Carnivores (otters) | 199 | 219 |

Harbour Porpoise are the species with the lowest noise threshold and therefore likely to be of most concern. For fish species the thresholds are taken from Popper et al. (2014). There is no direct evidence of mortality or potential mortal injury to fish from ship type continuous noise.

**Table 6-3: TTS- and PTS-onset thresholds for fish exposed to non-impulsive noise:**

| Fish hearing group | Risk of Mortality | Impairment | Risk of Behaviour Response |
|---|---|---|---|
| Fish Eggs and Larvae | Low | Low | Moderate |
| Mortality PTS in adult Fish* | Low | 158 dB rms for 12 hours | Moderate |
| *Impact is dependent upon physiology; the lowest injury threshold is for fish where swim bladders are essential to hearing; this threshold has been used for determining impact distance at 1 x water depth from the source. | | | |

There is no significant underwater noise impact anticipated on human beings as the area close to the proposed intake and outfall is infrequently used as a dive site. The only known wreck in the area is the Ailsa (see Figure 6-1) and due to strong tidal currents dive times in the area are limited. The exposure risk for a diver based on a one-hour period underwater wearing a neoprene suit is derived from HSE (2009) at 179 dB re 1 μPa using the Underwater Weighting.

This threshold level is a worst-case scenario as underwater dives of more than this duration are unusual. Professional divers could be underwater for longer but are likely to wear headgear which further reduces noise exposure. As this threshold will not be exceeded by any of the sources in a diving area, the risk to human divers has been screened out.

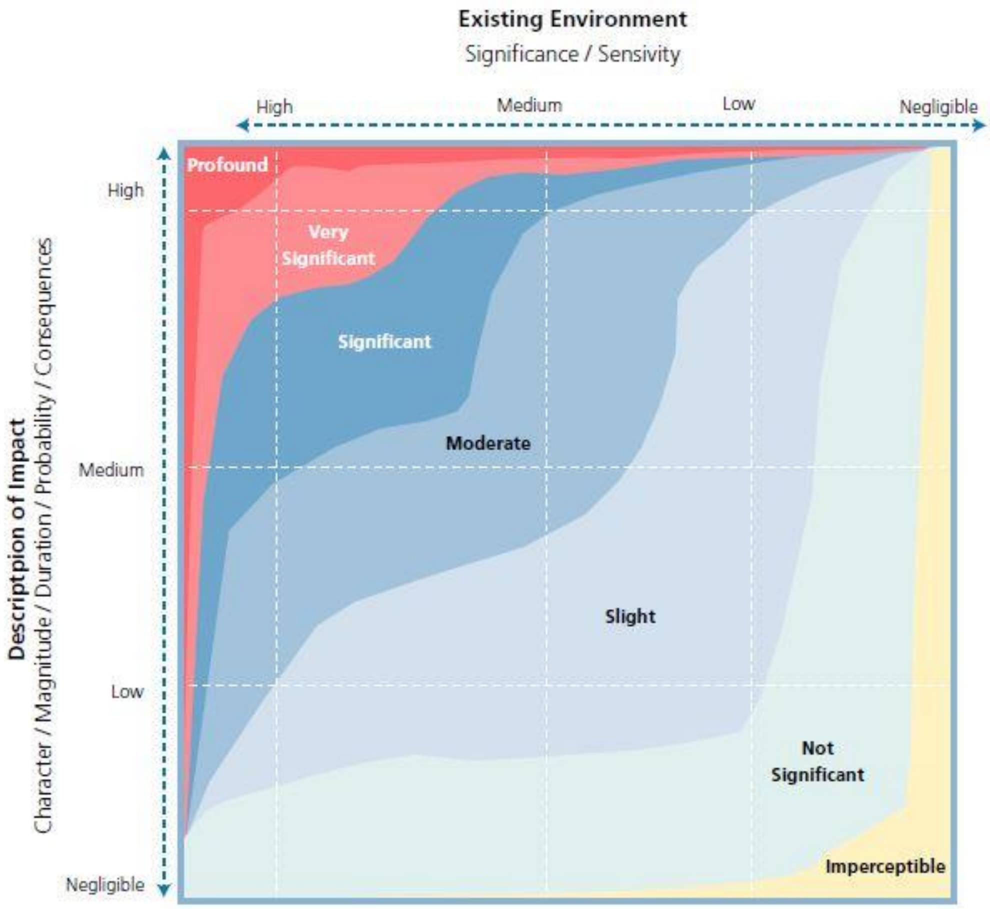


**Figure 6-3: Classifications of the significance of impacts**

Figure 6-3 above is taken from the EPA document 'Guidelines on the Information to be contained in Environmental Impact Assessment Reports'. Table 6-4 can be used as a guide for determining the overall significance of impacts by weighting the considerations required to determine the overall impact.

**Table 6-4: Impact consideration matrix**

| Impact | Effect | Scale | Extent | Duration |
|---|---|---|---|---|
| High | Permanent Injury/Mortality | Population Level | >1000 Metres | Permanent |
| Substantial | Recoverable Injury | Population Level | <1000 metres | Months |
| Medium | Causes Disturbance | Individual Animal | <100 metres | Weeks |
| Low | Above Background Levels | Individual Animal | <20 metres | Days |
| Negligible | No change | Individual Animal | < 5 metres | Hours |

#### 6.2.3.1 Determining Significance

The existing environment, where the seawater intake and brine outfall plant are proposed to be located, has relatively low background noise levels. During underwater noise monitoring undertaken by RPS at the proposed site, background noise levels were steady, with the occasional rise in noise levels as ferries on the Larne-Cairnryan route arrived to and departed from the port at Larne. More detail on baseline noise levels is available in Section 6.3.4.

In order to effectively describe the effects of the noise, a range of criteria have been considered to categorise the effects. As outlined in Section 6.5.4.2, the magnitude and spatial extent of the effects will be confined to the immediate site of the HDD/excavation operations. Any propagation of noise through the adjacent water column is quantified in the results of the underwater noise modelling. Adverse effects to human beings have been scoped out due to the noise source being of low intensity. Noise thresholds for potential hearing injury/loss in non-human species (marine mammals) are presented in Table 6-2. These threshold limits are compared to sound pressure levels generated by the construction activities (Table 6-7). The comparison of noise threshold limits of individual species to estimated noise levels as a result of construction works enables the determining of noise significance. With the use of guidance set out in Figure 6-3. A matrix of noise significance is presented in Table 6-4 as a means of quantifying the effects on the existing environment.

## 6.3 Receiving environment

### 6.3.1 Site Location

The Islandmagee Gas Storage Facility will be located in underground caverns below Larne Lough with the main construction and operation compounds located on the eastern shore of the Lough. The seawater intake and brine outfall will be located to the east of Islandmagee peninsula. The area is located south of the Port of Larne and north of Belfast Port. Regular ferry services operate to Cairnryan in Scotland from both Larne and Belfast. The Larne-Cairnryan route is located approximately 2 km north of the intake and the Belfast-Cairnryan route is located approximately 11 km east of the brine outfall. The area is located in the North Channel of the Irish Sea which is approximately 36 km wide at that point. While there is some local fishing activity, the main fishing ports in the area are Portavogie and Belfast, south of the study area. The area is not heavily trafficked.

### 6.3.2 Baseline Underwater Noise Measurements

In order to quantify the baseline underwater noise levels, measurements were taken from 10:50 on 27th August 2019 to 10:40 on 28th August 2019. The measurements were obtained using an underwater noise recorder (as shown in Figure 6-4) deployed between the brine outfall location and Muck Island as shown in Figure 6-1 .

### 6.3.3 Noise Monitoring

#### 6.3.3.1 Calibration

The underwater noise recorder was calibrated at the National Physical Laboratory in London and checked before and after deployment using a Bruel & Kjaer Type 4229 Hydrophone Calibrator. The difference in calibration level was +0.23 dB which is insignificant. Underwater noise measurements were made at a sampling rate of 48 kHz, recording continuously in 10 min intervals. The hydrophone sensitivities used in the calculation are shown in Table 6-5.

**Table 6-5: Recorder Sensitivity**

| Recorder | Sensitivity |
|---|---|
| R2 Standard Hydrophone | 164.7 dB re 1V/µPa |

This deployment location for the underwater noise recorder was chosen to avoid high levels of tidal flow noise and reduce the risk of drag on the mooring in the strong, tidal environment off Islandmagee. The deployment and recovery were carried out around high water/slack tide for the same reason. Figure 6-4 shows the underwater noise recorder ready for deployment. Note the ferry on the Larne-Cairnryan route in the background. The underwater noise levels are summarised in Table 6-6.


**Figure 6-4: Underwater Noise Recorder ready for deployment**

**Table 6-6: Summary of Baseline Underwater Noise Levels**

| Time | Peak dB re 1 µPa | SEL dB re 1 µPa²s | Description |
|---|---|---|---|
| **10:50** | 135-125 | 115-107 | Deployment vessel departs site |
| **11:30** | 118-125 | 100-105 | Typical daytime baseline |
| **12:00** | 120-145 | 105-130 | Ferry arriving at Larne |
| **13:40** | 115-142 | 95-123 | Ferry departing Larne |
| **20:40** | 118-125 | 98-103 | Shortly after sunset (~baseline) |
| **00:00** | 115-125 | 87-93 | Quiet period |
| **01:30** | 120-145 | 102-125 | Ferry arrives Larne |
| **04:00** | 112-145 | 95-130 | Ferry departs Larne |
| **06:10** | 110-130 | 87-93 | Just before dawn (quiet period) |
| **10:30** | 112-162 | 92-135 | Recovery vessel on site |

### 6.3.4 Significance of the baseline noise levels

As is evident from the table and the plots in Appendix C, baseline noise levels are relatively low and consistent with previous measurements on the Irish Coast carried out by RPS. The arrival and departure of ferries at Larne elevates the baseline noise by up to 25 dB for short periods (minutes) before it returns to the existing level. No significant difference was detected in underwater noise levels at periods of high and periods of low tidal flow

A feature of the noise at the measurement location is the presence of snapping shrimp type noise. No shrimp were captured in the sampling trawls, but the Pistol Shrimp species Alpheus glaber has been recorded in waters surrounding the Isle of Man.

### 6.3.5 Sensitivity of the Receiving Environment

The sea water intake and brine discharge point will be located off the eastern coast of the Islandmagee peninsula. The existing environment, in the context of underwater noise, is characterised by occasional ferry passage due to arrivals and departures at Larne. This traffic elevates the baseline noise levels for a time (see 6.3.4 above) but only for short periods before it returns to existing levels. There are no other significant noise sources in the vicinity of the monitoring location to impact upon underwater noise levels.

The eastern coastline of Islandmagee supports a wide range of fish and marine mammal species. Surveys of the area (refer to chapter 6 of the 2010 EIS) indicate the presence of seals, porpoise and, to a lesser extent, dolphin and small whale species. Benthic and fish surveys were also completed as part of the study for the proposed gas storage facility, details of which are also available in chapter 6 of the 2010 EIS.

## 6.4 Construction Impacts

The formation of the caverns under Larne Lough will take place 1,300 metres below the seabed and will not result in measurable noise emissions. Noise levels during construction will therefore be confined to the construction of the seawater intake and the brine outfall.

The construction phase will generate underwater noise associated with the installation of a seawater intake and a brine outfall diffuser at the locations shown in Figure 6-1. The construction methodology is different for each and the underwater noise impacts are described in the following sections.

### 6.4.1 Seawater Intake

The proposed seawater intake tunnel is approximately 145m long and 1.5m in diameter and is described in more detail in Chapter 3. A vertical tunnel shaft will be constructed on land to commence the tunnelling. There will be no underwater noise impact from the construction of this shaft.

#### 6.4.1.1 Micro-tunnelling

The proposed construction method is to use a 1.5m diameter micro tunnel-boring machine and jack the tunnel lining from a site on land to a pre-excavated and backfilled reception pit offshore. The tunnel boring machine will operate in the rock layers under the seabed until it reaches the tunnel reception pit. When it reaches the reception pit, the pit will be re-excavated and the machine recovered. The pre-fabricated pipe and intake assembly will then be installed.

### 6.4.2 Brine Outfall

The brine outfall diffuser will be located in a depth of 27m, approximately 450m offshore as shown in Figure 6-1. The diffuser arrangement consists of diffuser ports and pipe sections approximately 40m in length.

#### 6.4.2.1 Horizontal Directional Drilling

The topography at the discharge location is such that a trenchless technique is required for the transition from onshore to the offshore discharge location. The trenchless technique most suited to meet the requirements of the project is Horizontal Directional Drilling (HDD). HDD has been undertaken on many projects worldwide for the installation of pipelines from land to sea.

## 6.5 Operational Impacts

### 6.5.1 Seawater intake

There are no projected underwater noise impacts due to the operation of the seawater intake. Any noise from pumps located onshore will be significantly attenuated in the pipeline. It is anticipated that the operational noise from the seawater intake will be close to baseline levels and below those arising from ferry traffic.

### 6.5.2 Brine Outfall

Similarly, there are no projected underwater noise impacts due to the operation of the brine outfall diffuser. Any noise from pumps located onshore will be significantly attenuated in the pipeline and the diffuser. It is anticipated that the operational noise from the brine outfall will be close to baseline levels and below those arising from ferry traffic.

### 6.5.3 Shipping

The operational phase of the project will require occasional physical inspections of the underwater pipelines and water quality sampling, including the servicing of monitoring buoys. Shipping traffic arising from these activities will be limited and will not exceed underwater noise levels arising from fishing activities, e.g. trawling or pot hauling.

### 6.5.4 Underwater Noise Impacts

#### 6.5.4.1 Introduction

During the operational phase the project will not have any significant noise sources located at sea. Therefore, only noise associated with the construction phase of the project was modelled to determine likelihood of impact on receptors.

The main source of noise during the construction phase will come from the construction of the seawater intake and the brine outfall pipes on the seabed. The construction of these assets requires the use of heavy machinery for an extended period. As stated in Section 6.6, noise from tunnelling, excavation and directional drilling will represent worst-case noise events during construction. Any other construction activities will be of short duration and have a lower impact in terms of noise.

#### 6.5.4.2 Primary Noise Sources

The construction of the seawater intake and brine outfall pipes will be undertaken over an estimated 6-month period. The nature of the construction activities (i.e. tunnelling, excavation and directional drilling on/below the seabed) indicates that the type of noise generated will be non-impulsive noise. The noise will be confined to a geographically-small area i.e. the immediate vicinity of the construction activities. The propagation of construction noise in the water was estimated using a noise model (Section 6.6), the results of which were used to estimate the likelihood of significant effects on nearby, sensitive receptors. Drilling and tunnelling are only part of the construction activity associated with the intake and outfall and will operate at full noise output for less than half of this time.

Tunnel boring machines with rotating cutter heads produces low frequency sounds (below 1000 Hz). Maximum energy tends to occur around 10 Hz with diminishing energy at increasing frequencies (Richardson et al., 1995). Underwater noise from the micro tunnel boring machine will be located below the seabed and not contribute significantly to underwater noise levels. RPS has data from a 600mm HDD project which when scaled up to 1.5m indicates a peak level of 130 dB re 1 µPa and 111 dB re 1 µPa2s SEL at the seabed, which is in the range of background noise levels and lower than noise levels from the ferries entering and leaving Larne.

The worst-case underwater noise emission is when the reception pit is being excavated. There are limited data on underwater noise from mechanical (backhoe) operations. Reine et al (2014) provide a source level for rock excavation at 164.2 to 179.4 dB re 1 µPa @ 1m. For the purpose of the seawater intake the higher of these levels was used in the RPS noise model. The excavation of the pit and recovery of the tunnel boring machine are estimated to take 18 days and worst case noise levels will be limited to a fraction of this time.

The proposed location for the brine outfall discharge is approximately 450 metres from the shoreline on the seabed, in a water depth of 27 metres. The outfall to this location will be constructed entirely by horizontal directional drilling beneath the seabed.

RPS has noise measurement data for HDD drilling below the seabed in schist. Schist is a medium/hard rock. Basalt, which is a harder rock, forms the bedrock at this location. Drilling is likely to be slower but not significantly noisier because of this. The data has been extrapolated to a shallow drilling depth to model the worst-case noise level as the drill breaks through the seabed. The rms drilling noise level at this point is estimated to be 120 dB re 1 µPa @ 1m.

## 6.6 Underwater noise model

There are several methods available for modelling the propagation of sound between a source and receiver ranging from very simple models which simply assume spreading according to standard rules such as 10 log(r) or 20 log(r) relationships to computationally intensive acoustic models (e.g. ray-tracing, normal-mode, parabolic equation, wavenumber integration and energy flux models). Semi-empirical models lie somewhere in between and provide a practicable balance for environmental impact assessment modelling.

Sound propagation modelling for this assessment was based on an established, range dependent sound propagation model which utilises the model derived from physics-based considerations by Rogers (1981). The model provides a robust balance between complexity and technical rigour over a wide range of frequencies, has been validated by numerous field studies and has been benchmarked against a range of other models. The following inputs are required for the model:

- Time series source sound level data;
- range (distance from source to receiver);
- water column depth (input as bathymetry data grid);
- sediment type;
- sediment and water sound speed profiles and densities;
- sediment attenuation coefficient; and
- source directivity characteristics.

The absorption coefficient of sea water is calculated based on Ainslie and McColm (1998). Bathymetry, salinity and temperature profile data were taken from standard Marine Institute data. The propagation model also takes into account the depth dependent cut-off frequency for propagation of sound (i.e. the frequency below which sound does not propagate).

It should also be borne in mind that noise predictions are based on a specific dataset and the model predicts a typical worst-case scenario. Injury and disturbance ranges should be viewed as indicative and probabilistic ranges based on the latest scientific advice.

Directionality is considered as a range of azimuth and dip angle source profiles. Each profile is entered as a time series input. The time series propagation is calculated in the frequency domain using the Rogers model. Calculations are carried out for peak-peak, 0-peak, SEL, SELcum and RMS received levels. The propagation is corrected for species sensitivity using the Southall marine mammal weightings and the results are interpolated into a 3D array for visualisation.

### 6.6.1 Underwater Noise Source Levels

The underwater noise impacts will occur in two phases, the construction phase and the operational phase. The main activities required during construction with potential underwater noise impacts are outlined in Table 6-7. There will be no significant underwater noise emissions during the operational phase. For the operational phase the impact will be confined to occasional vessel traffic at the site.

**Table 6-7: Construction Tasks with Potential Underwater Noise Impacts**

| Construction Activity | Extent/Duration | RMS Noise Levels dB re: 1µPa @ 1m (unweighted) |
|---|---|---|
| Construction of gas storage caverns (pumps based on land) | 7 Caverns over period of four years | No significant noise during drilling and solution mining process |
| Construction of seawater intake (Micro-tunnel boring and excavation) | 6 months | 179 (excavator ripping rock) |
| Construction of brine outfall (Horizontal Directional Drilling) | 6 months | 120 (HDD at seabed) |
| Operation phase (small vessel traffic for site inspections and sampling) | Ongoing occasional | 150-155 |

The formation of the caverns under Larne Lough will take place 1,500 metres below the seabed and will not result in measurable noise emissions. Noise levels during construction will therefore be confined to the construction of the seawater intake and the brine outfall.

Noise from tunnelling, excavation and directional drilling will represent the worst-case noise events during construction. These activities occur as relatively stationary events. The assessment of underwater noise impacts will be carried out on the basis of the pipeline construction noise during construction as all other activities will have lower impacts. The cumulative underwater noise impact is addressed in Section 6.6.2.

### 6.6.2 Noise Modelling Results

Noise modelling using the methodology outlined in Section 6.6 was carried out on the worst-case noise level sources at the seawater intake and the brine outfall locations. As can be seen in Table 6-7 the underwater source levels are quite low intensity and barely exceed the injury thresholds set out in Table 6-2 at very close range from the source. This means that the impact radius will be quite small in extent.

**Table 6-8: Underwater Noise Modelling Threshold Zones**

| Species | Criteria | | PTS Impact Zone Surface |
|---|---|---|---|
| | PTS onset (metres) | TTS onset (metres) | Disturbance (metres) |
| Low Frequency Cetaceans (baleen whales) | - | - | 60 |
| High Frequency Cetaceans (most dolphin species) | - | - | 60 |
| Very High Frequency Cetaceans (Harbour Porpoise) | - | 16 | 60 |
| Phocid Carnivores (seal species) | - | - | - |
| Other Carnivores (otters) | - | - | - |
| Fish Eggs and Larvae | - | - | - |
| Mortality PTS in adult Fish | - | - | - |

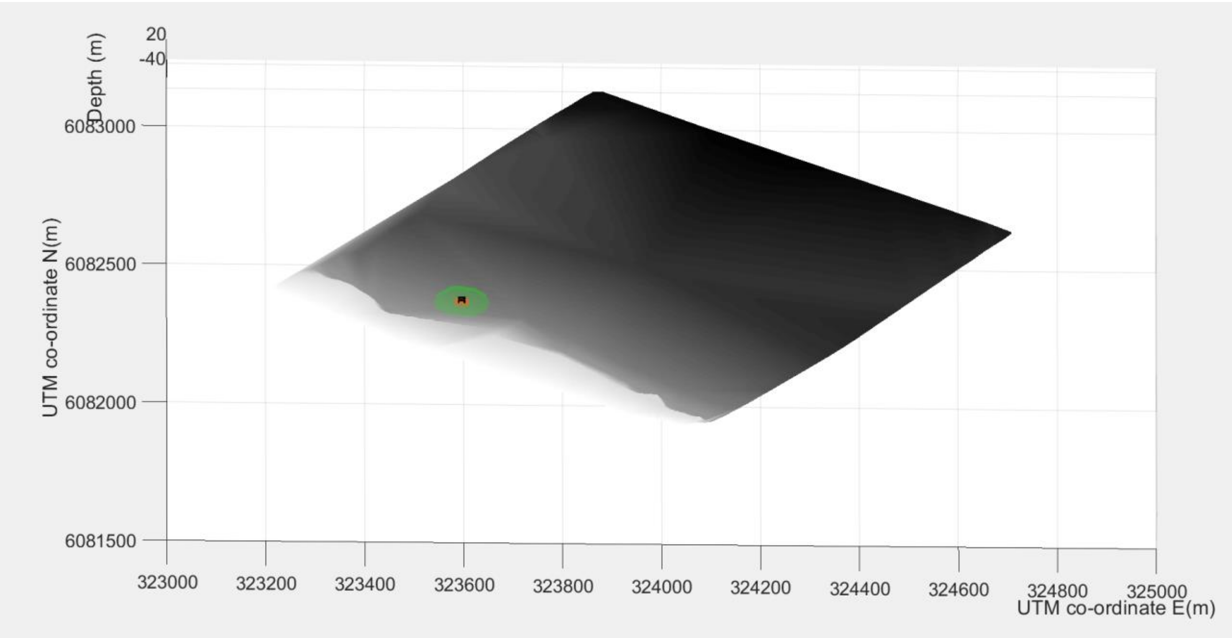


**Figure 6-5 Underwater noise levels – Maximum extent of disturbance during pit excavation**

The modelling results are presented in Table 6-8 and Figure 6-5 which shows the extent of the disturbance (green) and temporary injury (amber) zones for Harbour Porpoise. Harbour Porpoise are the most sensitive species and the impact zone is shown to scale with a 12m x 12m jack up barge at the excavation site. It is clear that the disturbance zone is quite small and will have limited environmental impact. Based on the criteria set out in Table 6-2 the underwater noise impact is classified as Slight Negative. This impact will have a maximum duration of 18 days with lower noise levels (and smaller impact zones) arising for the remainder of the estimated 6 month construction period.

## 6.7 Cumulative Impacts

There are no other significant projects at planning stage in the area. The underwater noise impact of ferry traffic from Larne and local boat traffic have been quantified in the baseline measurements. The cumulative impact of these existing underwater noise sources does not alter the impact of the proposed development.

## 6.8 Remedial and Mitigation Measures

### 6.8.1 Mitigation Requirements

Noise levels arising during the construction phase are classified as *Slight Negative* and will be confined to disturbance level impacts. The most significant impacts will arise during:

- Excavation of the tunnel boring machine pit at the seawater intake;
- The recovery of the tunnel boring machine; and
- The final stages of HDD (breakout to seabed).

### 6.8.2 Mitigation measures

The underwater noise levels arising are classified as *Slight Negative*. Mitigation by having a marine mammal observer present when excavating the tunnel boring pit and at the final stage of HDD breakthrough to the seabed is recommended as a precaution. This observation can be carried out from shore as the two locations are located close enough to be observed.

Exclusion zones for marine traffic or marine mammals may be proposed for different stages of the works and it is recommended that these zones are applied to recreational diving activity.

## 6.9 Residual Impacts

There will be limited vessel traffic to and from the site during operation which will have no significant underwater noise impact.

## 6.10 Monitoring

Underwater noise monitoring should be carried out during the construction phase to verify the modelling assumptions.

## 6.11 Conclusions

This assessment primarily considered the construction phase of the Islandmagee Gas Storage Facility because it will involve the highest underwater noise levels but also gives due consideration to other construction activities and the potential cumulative impact of the existing operation and the construction activities.

The formation of the caverns under Larne Lough will take place 1,500 metres below the seabed and will not result in measurable noise emissions. Noise levels during construction will therefore be confined to the construction of the seawater intake and the brine outfall.

Noise from tunnelling, excavation and directional drilling represent the worst-case noise events during construction. These activities occur as relatively stationary events. Noise modelling was carried out on the worst-case noise level sources at the seawater intake and the brine outfall locations. Noise model results have highlighted that the underwater source levels are quite low intensity and barely exceed the injury threshold levels for fish and marine mammal species at very close range from the source which means that the impact radius will be quite small in extent.

Based on the noise assessment criteria, the underwater noise impact is classified as *Slight Negative*. This impact will have a maximum duration of 18 days with lower noise levels (and smaller impact zones) arising for the remainder of the estimated 6 month construction period. No significant underwater noise levels will arise during the operation of the facility. The underwater noise impact of ferry traffic from Larne and local boat traffic have been quantified in the baseline measurements. The cumulative impact of these existing underwater noise sources does not alter the impact of the proposed development.

# 7 BIODIVERSITY

## 7.1 Introduction

An Environmental Statement (ES) (RPS, 2010) and ES Addendum (RPS, 2011) were submitted as part of the Marine Licence application made (ML 28/12) for the Islandmagee Gas Storage Project (the project) in October 2012. The project was not taken forward for construction and operation at that time. Renewed interest in the project has involved engagement with the Department of Agriculture, Environment and Rural Affairs (DAERA), who, have requested that contemporary baseline characterisation data be collected for the project and that a revised and updated environmental assessment be presented utilising this baseline data.

### 7.1.1 Consultation

DAERA have identified aspects of the original environmental assessment which would now be considered out of date, and require updating. Table 7-1 below presents those aspects and highlights where in this document they have been covered.

**Table 7-1: Consultation with DAERA (letter dated 5 July 2019) and how and where their requirements have been addressed in this document.**

| DAERA Identified | How addressed in this document | Where addressed in this document |
|---|---|---|
| **Baseline Data** | | |
| The latest seabird information provided is from March 2012. Much of the data is considerably older than this. | Seabird surveys conducted between July and September 2019 have informed the update to the Bird baseline which feeds through to the impact assessment | Baseline in section 7.3.7 *et. seq.* |
| Benthic survey work is from 2008-2010. | Benthic surveys conducted in August 2019 have informed the update to the Benthic Ecology baseline which feeds through to the impact assessment | Baseline in section 7.3.4 *et. seq.* |
| The most up-to-date fisheries information presented is 2008. | Fisheries surveys conducted in 1983 - 2018 have informed the update to the Fish and Shellfish Ecology baseline which feeds through to the impact assessment | Baseline in section 7.3.5 *et. seq.* |
| Seals and cetaceans – the most up-to-date information is 2009. | Seal and cetacean sightings data from 1992 - 2019 was obtained to inform the update to the Marine Mammal baseline which feeds through to the impact assessment | Baseline in section 7.3.6 *et. seq.* |
| **Assessment of Impacts** | | |
| There is some consideration of plankton impacts in one of the addendums, but it would be helpful to attempt to quantify the abstraction and discharge to assist the public in understanding the volumes to be abstracted and discharged in comparison to flows in and out of the North Channel. | a) A baseline for plankton has been provided;<br>b) The quantification of abstraction in comparison to flows in and out of the North Channel has been presented; and<br>c) The quantification of discharge in comparison to flows in and out of the North Channel has been presented. | Baseline in section 7.3.3 *et. seq.*<br>Abstraction magnitude in section 7.7.1 *et. seq.*<br>Discharge magnitude in section 7.7.2 *et. seq.* |
| Noise needs to be presented in detail in the Environmental Statement. Currently, there is only a brief mention of this, and it would not be considered adequate in 2019. | The impact of noise as a result of the construction of the project, on marine mammal and fish receptors has been considered in the construction impact assessment, the interdependencies | Construction impacts in section 7.5<br>Interdependencies in section 7.8 |

| DAERA Identified | How addressed in this document | Where addressed in this document |
|---|---|---|
| This will require the updating of information throughout the Environmental Statement for potential impacts on marine mammals. | | |
| **Interdependencies** | | |
| The Marine Strategy Framework Directive requires an ecosystem-based approach to management. It is not enough to assess individual trophic levels and not to consider interdependencies. This is largely the approach of the current Environmental Statement and should now be updated to consider impacts on ecosystems.<br><br>The Environmental Statement must address potential food web and ecosystem impacts on the connectivity between all of the trophic levels, using up-to-date information. | Interdependences between trophic levels have been considered and discussed as part of the impact assessment. | Interdependencies in section 7.8 |
| **Cumulative Effects** | | |
| An assessment of cumulative effects with other projects in the area. | An assessment of cumulative effects has been informed by the updated assessment of impacts presented in this document. | Chapter 8: Cumulative Effects and Updated HRA (under separate cover). |

## 7.2 Assessment Methodology

### 7.2.1 Relevant Guidance

Guidance used in the drafting of this document include:

- The Chartered Institute of Ecology and Environmental Management (CIEEM) guidelines for ecological impact assessment (CIEEM, 2018);
- Biodiversity Strategy for Northern Ireland to 2020 (DAERA, 2015); and
- Environmental Impact Assessment of Projects: Guidance on the preparation of the Environmental Impact Assessment Report (European Union (EU), 2017).

### 7.2.2 Baseline Methodology

#### 7.2.2.1 Desktop study

Information on marine biodiversity receptors within the study area was collected through a detailed desktop review of existing studies and datasets. These are summarised in Table 7-2 below.

**Table 7-2: Summary of key desktop reports.**

| Title | Source | Year | Author |
|---|---|---|---|
| **Plankton** | | | |
| Change in Plankton communities, UK Marine Online Assessment Tool | https://moat.cefas.co.uk/biodiversity-food-webs-and-marine-protected-areas/pelagic-habitats/plankton-communities/ | 2018 | McQuatters-Gollop *et al.* |
| Continuous Plankton Recorder Survey | https://www.cprsurvey.org/ | 1958 - 2014 | The Continuous Plankton Recorder Survey and The |

| Title | Source | Year | Author |
|---|---|---|---|
| | | | Marine Biological Association |
| Phytoplankton Distribution in Relation to Environmental Drivers on the North West European Shelf Sea | https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0164482 | 2016 | Siemering *et al.* |
| Seasonal distribution and succession of dominant phytoplankton groups in the global ocean: A satellite view, Global Biogeochemical Cycles | Global Biogeochemical Cycles | 2008 | Alvain *et al.* |
| SEA area 6 Technical Report – Plankton Ecology of the Irish Sea | https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/197299/SEA6_Plankton_PEML.pdf | 2005 | Kennington and Rowlands, 2005 |
| **Benthic Ecology** | | | |
| A catalogue of seabed habitats from around the British Isles. | https://www.emodnet-seabedhabitats.eu/access-data/launch-map-viewer/ | N/A | EMODnet |
| Synthesis of Information on the Benthos of Area SEA 6 | https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/197283/SEA6_Benthos_SAMS.pdf | 2005 | Wilding *et al.* |
| Marine and coastal ecosystems. In Handbook of Ecological Restoration | Restoration in Practice | 2002 | Hawkins *et al.* |
| **Fish and Shellfish Ecology** | | | |
| Final 2017 landings data by ICES rectangle | International Council for the Exploration of the Sea | 2017 | ICES |
| Fishing Effort and Quantity and Value of Landings by ICES Rectangle. | International Council for the Exploration of the Sea | 2017 | ICES |
| Biodiversity and conservation – Elasmobranchii | http://www.marlin.ac.uk/phylumdetails.php?phylum=2341#elasmobranchii | 2011 | MarLIN |
| Mapping the spawning and nursery grounds of selected fish for spatial planning | CEFAS | 2010 | Ellis *et al.* |
| UK Offshore Energy SEA 2 Environmental Report. | Department Of Energy & Climate Change | 2009 | DECC |
| Vertical movements of Atlantic salmon post smolts relative to measures of salinity and water temperature during the first phase of the marine migration, | Fisheries Management & Ecology, | 2009 | Plantalech *et al*. |
| Strategic Environmental Assessment of the fish and shellfish resources with respect to proposed offshore wind farms in the eastern Irish Sea. | https://tethys.pnnl.gov/sites/default/files/publications/Lockwood-2005.pdf | 2005 | Lockwood |
| Fish and shellfish sensitivity reports | https://www.marlin.ac.uk/activity/pressures_report | n/a | Various |
| NBN Atlas | https://nbnatlas.org/ | n/a | Various |
| **Marine Mammals** | | | |
| Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys | | 2017 | Hammond et al., |
| *Scientific Advice on Matters Related to the Management of Seal Populations* | Special Committee on Seals (SCOS) | 2011, 2012, 2013, 2014, 2015, 2016, 2017 | SCOS |

| Title | Source | Year | Author |
|---|---|---|---|
| *Atlas of Mammals in Ireland 2010 - 2015* | National Biodiversity Data Centre | 2016 | Lysaght, L and F. Marnell |
| Management Units for cetaceans in UK waters | JNCC Report No. 547 | 2015 | IAMMWG. |
| *Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management* | SCANS II | 2006 | Hammond et al. |
| Atlas of cetacean distribution in north-west European waters | JNCC | 2003 | Reid *et al.* |
| UK Cetacean Status Review | Sea Watch Foundation | *2003* | Evans *et al.* |
| *Abundance of Harbour Porpoise and other Cetaceans in the North Sea and Adjacent Waters* | SCANS I | 2002 | Hammond *et al*. |
| **Birds** | | | |
| NIEA Natural Environment Map Viewer | Northern Ireland Environment Agency | 2019 | NIEA |
| SiteLink Protected Areas map viewer | Scottish Natural Heritage | 2019 | SNH |
| *Northern Ireland Seabird Report 2018* | British Trust for Ornithology | 2019 | Booth Jones and Wolsey |

### 7.2.2.2 Site-specific surveys

## Benthic Ecology

To ascertain the sediment physical and chemical properties and characteristic benthic communities of the proposed intake and outfall areas near Islandmagee, Aquatic Services Unit (on behalf of RPS Group) undertook benthic grab, trawl and Drop Down Video (DDV) surveys. Benthic grab surveys were carried out on 14$^{th}$ (Van Veen Grab) and 20$^{th}$ (Hamon Grab) August 2019 to provide a baseline on the infaunal benthos; beam trawl surveys were carried out on 27$^{th}$ August 2019 to look at epibenthos and fisheries; and DDV surveys were carried out on 14$^{th}$ August 2019 to assess the epifaunal benthos.

**Benthic grab survey**

Subtidal benthic samples were taken using a 0.1 m$^2$ Hamon Grab (12 stations) as well as a 0.1 m$^2$ Van-Veen Grab (2 stations) (stations identified as soft sediment during the video survey). All sampling positions (see Figure 7-1) were recorded using a Trimble Geo XM differential GPS. At each survey station, three replicate grab samples were collected. A subsample of sediment was collected from one of the replicates and stored for Particle Size Analysis (PSA). A photographic record was taken of each grab. Sampling was undertaken using standardised protocols for quantitative sampling of sublittoral sediment biotopes (Davies *et al.*, 2001).

The National Marine Biological Analytical Quality Control Scheme (NMBAQC) scheme for marine invertebrate identification was implemented, and samples were identified to species level where possible, counted and logged. PSA was carried out on oven dried sediment samples collected from one replicate at each station. Samples were processed as per standard protocols (Holme and McIntyre, 1971). On completion of the sample processing and identification, the data were analysed using a variety of univariate and multivariate analyses to determine community structure. Detailed multivariate analysis was undertaken on the data obtained from the grab samples. Samples were analysed using fourth-root transformation (countable data only) and presence/absence (to include the epifaunal data). Biotopes were assigned based on the Marine Habitat Classification for Britain and Ireland (Connor *et al.*, 2004).

**Trawl survey**

Trawling was undertaken with a 2 m beam trawl towed at approximately 2.7 knots for between 10 and 15 minutes which resulted in trawl tracks ranging from 0.8-1.4 km. Ten trawls were undertaken, all within the main mixed sediment habitat surveyed during the video drop-down survey (see Figure 7-1). The locations of the trawl lines were chosen to comprehensively cover the area where the brine dispersal model indicated there would be salinity levels above background, and beyond. Trawls in shallower water i.e. landward of the outfall point were avoided because of potential hard ground that could have damaged the gear. All fish taken in trawls were identified counted and measured. Invertebrates were identified where possible on site and counted or preserved for later identification in the laboratory.

**Drop Down Video (DDV) survey**

Pre-determined sampling positions were navigated to using the vessel's GPS system (see Figure 7-1). Once on site, the precise location of each sampling station was fixed using a Trimble Geo-XM GPS. A number of the pre-determined sampling positions could not be surveyed as they were considered too shallow for the survey vessel. A total of 38 stations were sampled using an Outlander DDV camera system. Data was recorded as MPEG4 format files, recorded to a hard drive. At each station a single drift was made. The video camera was lowered to above the sediment surface, and video imagery was recorded as the boat drifted at that location. Video assessment was carried out by selecting frames for each location, which were chosen to be representative of the main features along each video drift.

Survey Reports are presented in Appendix D: Benthic Survey Reports.

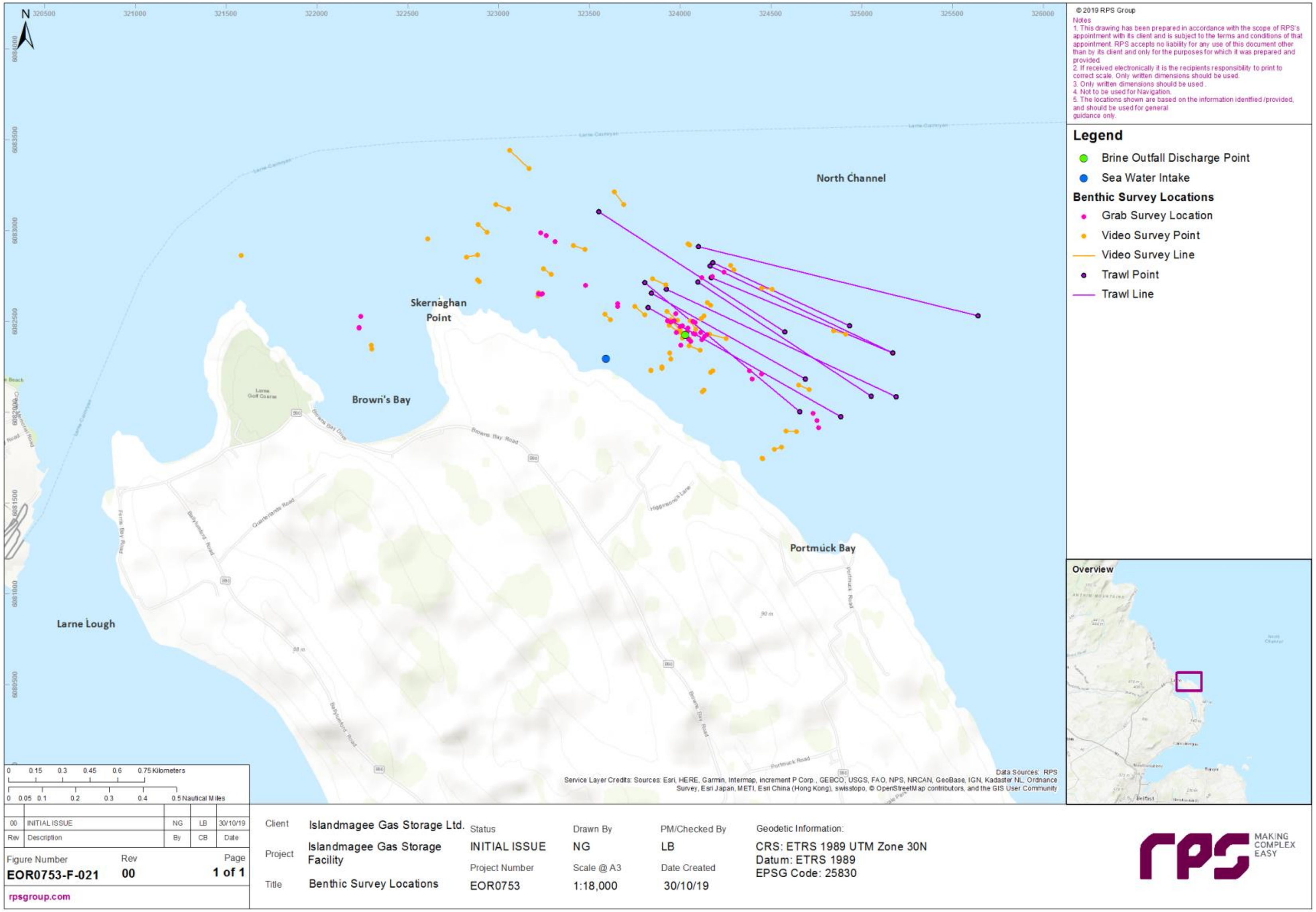


**Figure 7-1: Benthic Survey Location.**

## Birds

**Vantage point survey (open coast)**

Six surveys, totalling 18 hours were conducted between July and September 2019. Surveys were carried out across a range tides and weather conditions (see Appendix E – Ecological Survey for Birds).

**Table 7-3: Conditions during open coast vantage point surveys.**

| Date | Start | End | Cloud | Wind | Visibility | Seastate | Swell | Glare | Tide | Tide time |
|---|---|---|---|---|---|---|---|---|---|---|
| 25-Jul-19 | 13h25 | 16h25 | 4/8 | F4/5 | >25km | SS4 | 1-2 | 0 | Rising | HT: 17h49 |
| 30-Jul-19 | 14h15 | 17h15 | 8/8 | F4/5 | >25km | SS2 | 1-2 | 0 | Low | LT: 16h36 |
| 15-Aug-19 | 13h55 | 16h55 | 4/8 | F4-2 | >25km | SS2-SS1 | 2-<1 | 0 | Falling | LT: 18h34 |
| 21-Aug-19 | 08h50 | 11h50 | 7/8 | F2 | >20km | SS2 | 1 | 30° | Low | LT: 09h22 |
| 05-Sep-19 | 08h30 | 11h30 | 4/8 | F5 | >20km | SS2 | 1 | 20° | Low | LT: 10h14 |
| 13-Sep-19 | 10h00 | 13h00 | 8/8 | F3 | >25km | SS1 | <1 | 0 | High | HT: 11h42 |

Surveys were conducted to gather information on the distribution and behaviour of waterbirds and seabirds within the potential zone of influence of the proposed outfall, particularly of species listed as ornithological features of nearby Special Protection Areas (SPA) and whose potential foraging ranges overlaps with the potential zone of influence of the brine outfall.

The methodology employed broadly followed that set out in Bibby *et al.* (1992) (see Appendix E – Ecological Survey for Birds), where counts were undertaken over a 3-hour period, from a single vantage point located between the proposed horizontal directional drill (HDD) routes of the intake and outfall at Castle Robin Bay.

The survey area was an arc 1,000 m north and south of the vantage point, stretching from waters off Skernaghan Point to the northern edge of Portmuck Bay. For the purposes of recording distribution, the 180° arc was subdivided into eight zones of four c.45° sectors (numbered 1-4 north to south) which were split into two distance bands; 0-500 m (A) and 500-1000 m (B). The survey area and zones are illustrated in Figure 7-2.

During surveys, distance bands were checked periodically by using a hand held rangefinder (Heinemann,1981) and by comparison with the known distances of reference points including Isle of Muck and the Hunter Rock Buoys (South Hunter Rock Buoy and North Hunter Rock Buoy equal to 1.7 km and 2.5 km offshore from Skernaghan Point respectively).

Anything beyond the 1,000 m arc was not included in the survey results.

**Boat-based transect survey**

Two boat-based transect surveys through the survey area were undertaken to supplement data gathered from the vantage point surveys, both conducted on 28th August 2019 (see Table 7-4).

**Table 7-4: Conditions during boat-based transect surveys.**

| Direction of travel | Start | End | Cloud | Wind | Visibility | Seastate | Swell | Starting point | End point | Vessel speed |
|---|---|---|---|---|---|---|---|---|---|---|
| North | 10h46 | 11h05 | 8/8 | F4 | >25km | SS2 | 1.5 | 54 51'067 N 005 43'886 W | 54 51'964 N 005 45'621 W | 3.1 knots |
| South | 11h05 | 11h25 | 8/8 | F4 | >25km | SS2 | 1.5 | 54 51'964 N 005 45'621 W | 54 51'271 N 005 43'800 W | 2.9 knots |

Surveys were conducted as the vessel slowly moved through the survey area (see Figure 7-2) and all seabirds seen were recorded along with their numbers and behaviours, using the "look-see approach" as discussed in Bibby *et al.* (1992). The full survey report can be seen in Appendix E – Ecological Survey for Birds.

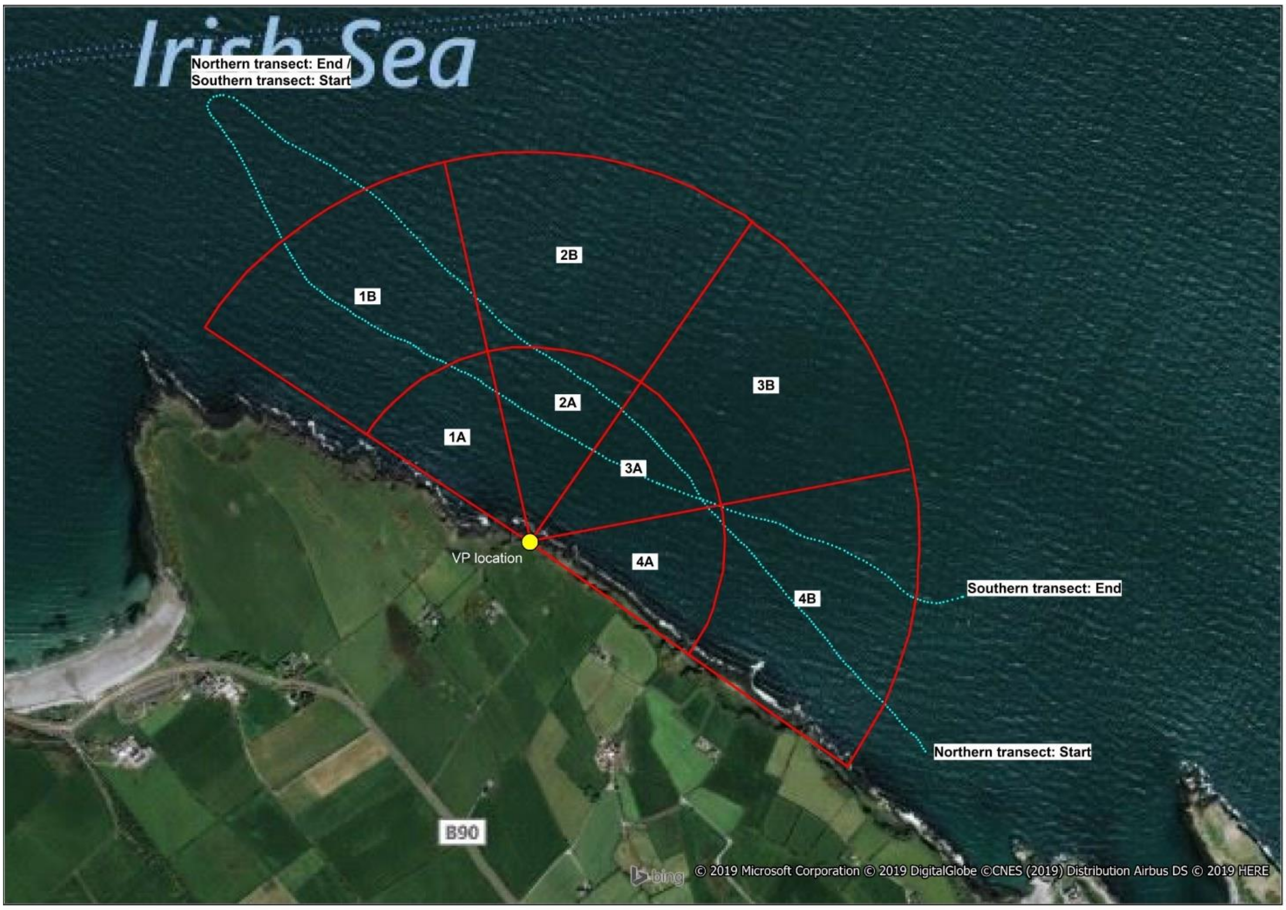


**Figure 7-2: Bird surveys.**

### 7.2.3 Assessment Criteria and Assignment of Significance

The criteria for determining the significance of effects is a two-stage process that involves defining the magnitude of the impacts and sensitivity of the receptors. This section describes the criteria applied in this chapter to assign values to the receptor to assist in defining sensitivity of receptors, and the magnitude of potential impacts.

An assessment of the ecological effects of a proposed development should focus on 'Important Ecological Features (IEFs). These are species and habitats that are valued in some way and could be affected by a proposed development; other IEFs may occur on or in the vicinity of the site of a proposed development but do not need to be considered because there is no potential for them to be affected significantly.

The value of ecological features is dependent upon their biodiversity, social, and economic value within a geographic framework of appropriate reference (CIEEM, 2018). The most straightforward context for assessing ecological value is to identify those species and habitats that have a specific biodiversity importance recognised through international or national legislation or through local, regional or national conservation plans (e.g. Annex I habitats under the Habitats Directive, Annex II species under the Habitats Directive or Birds Directive, OSPAR, Biodiversity Action Plan (BAP) habitats and species, habitats/species of principal importance listed under the NERC Act 2006 and habitats/species listed as features of Marine Conservation Zones (MCZs) / recommended MCZs (rMCZs)). However, only a very small proportion of marine habitats and species are afforded protection under the existing legislative or policy framework and therefore evaluation must also assess value according to the functional role of the habitat or species. For example, some features may not have a specific conservation value in themselves but may be functionally linked to a feature of high conservation value. Table 7-5 shows the criteria applied to determining the ecological value of IEFs. The assigned IEF values are given in paragraphs 7.3.3.2, 7.3.4.4, 7.3.5.8 and 7.3.6.10.

**Table 7-5: Criteria used to inform the valuation of receptors.**

| Value | Definition |
|---|---|
| International | • Internationally designated sites.<br>• Habitats and species protected under international law (i.e. Annex I habitats within a Special Area of Conservation (SAC) boundary; Annex II protected species designated as a feature of a European designated site).<br>• OSPAR List of Threatened and/or Declining Species and Habitats. |
| National | • Nationally designated sites.<br>• Species protected under national law.<br>• Internationally protected species (including European Protected Species (EPS)) that are not qualifying features of a designated European site but are regularly recorded within the regional or marine biodiversity study areas.<br>• Annex I habitats not within an SAC boundary.<br>• UK BAP priority habitats and species, NERC habitats and species of principal importance in Northern Ireland, and Nationally Important Marine Species that have nationally important populations within the study area, particularly in the context of species/habitat that may be rare or threatened in the UK.<br>• Habitats and species that are features of MCZs and rMCZs (i.e. broad-scale habitats and Features of Conservation Importance (FOCI)). |

| Value | Definition |
|---|---|
| Regional | • Internationally protected species that are not qualifying features of a European designated site and are infrequently recorded within the regional study area in very low numbers compared to other regions of the British Isles.<br>• UK BAP priority habitats, NERC habitats and Northern Ireland Priority Species or Nationally Important Marine Species that have regionally important populations within the study area (i.e. are locally widespread and/or abundant).<br>• Habitats or species that provide important prey items for other species of conservation or commercial value. |
| Local | • Habitats and species which are not protected under conservation legislation which form a key component of the marine ecology within the study area. |
| Negligible | • Habitats and species of very local importance only. |

### Receptor Sensitivity

Each IEF sensitivity has been defined by categorising according to the five-point scale presented in Table 7-6. This scale is based on:

- The vulnerability of the receptor to the impact;
- The potential for recovery of the receptor following the impact; and
- The value of the receptor based on the criteria summarised in Table 7-6 below.

**Table 7-6: Definitions of sensitivity.**

| Sensitivity | Definition |
|---|---|
| Very high | International or National IEFs with high vulnerability and no ability for recovery. |
| High | Regional IEF with high vulnerability and no ability for recovery.<br>International or National IEF with high vulnerability and low recoverability. |
| Medium | Local IEF with high vulnerability and no ability for recovery.<br>Regional IEF with medium to high vulnerability and low recoverability.<br>International or National IEFs with medium vulnerability and medium recoverability. |
| Low | Local IEF with medium to high vulnerability and low recoverability.<br>Regional IEF with low vulnerability and medium to high recoverability.<br>International or National IEFs with low vulnerability and high recoverability. |
| Negligible | Receptor is not vulnerable to impacts regardless of value/importance.<br>Local IEF with low vulnerability and medium to high recoverability. |

### Magnitude of Impact

The criteria for defining magnitude in this chapter is outlined in Table 7-7 below.

**Table 7-7: Definitions of magnitude of impact.**

| Magnitude of impact | Typical descriptors |
|---|---|
| High | Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements (Adverse). |
| | Large scale or major improvement of resource quality; extensive restoration or enhancement; major improvement of attribute quality (Beneficial). |
| Medium | Loss of resource, but not adversely affecting the integrity; partial loss of/damage to key characteristics, features or elements (Adverse). |
| | Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality (Beneficial). |
| Low | Some measurable change in attributes, quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features or elements (Adverse). |
| | Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring (Beneficial). |
| Negligible | Very minor loss or detrimental alteration to one or more characteristics, features or elements (Adverse). |
| | Very minor benefit to or positive addition of one or more characteristics, features or elements (Beneficial). |
| No change | No loss or alteration of characteristics, features or elements; no observable impact in either direction. |

### Significance of Effect

The significance of the effect upon marine biodiversity receptors is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The particular method employed for this assessment is presented in Table 7-8. Where a range of significance of effect is presented in Table 7-8, the final assessment for each effect is based upon expert judgement.

For the purposes of this assessment, any effects with a significance level of minor or less have been concluded to be not significant.

**Table 7-8: Significance of Effect assessment matrix.**

| Sensitivity | Magnitude of impact | | | | |
|---|---|---|---|---|---|
| | No Change | Negligible | Low | Medium | High |
| **Negligible** | No change | Negligible | Negligible or Minor | Negligible or Minor | Minor |
| **Low** | No change | Negligible or Minor | Negligible or Minor | Minor | Minor or Moderate |
| **Medium** | No change | Negligible or Minor | Minor | Moderate | Moderate or Major |
| **High** | No change | Minor | Minor or Moderate | Moderate or Major | Major or Substantial |
| **Very high** | No change | Minor | Moderate or Major | Major or Substantial | Substantial |

## 7.3 Receiving Environment

### 7.3.1 Study Area

The study area used for this Environmental Appraisal to guide the review of existing desktop baseline information is based on *The Gobbins Regional Seascape Character Area* and *Larne Lough Regional Seascape Character Area*, as defined in the draft Marine Plan Area for Northern Ireland (DAERA, 2018; see Figure 7-3). Broader areas have been discussed for marine mammals and birds, based on their larger foraging ranges (see sections 7.3.6 and 7.3.7). A broader study area has been discussed for plankton (see section 7.3.3), focusing on the wider Irish Sea to provide context to the project area.

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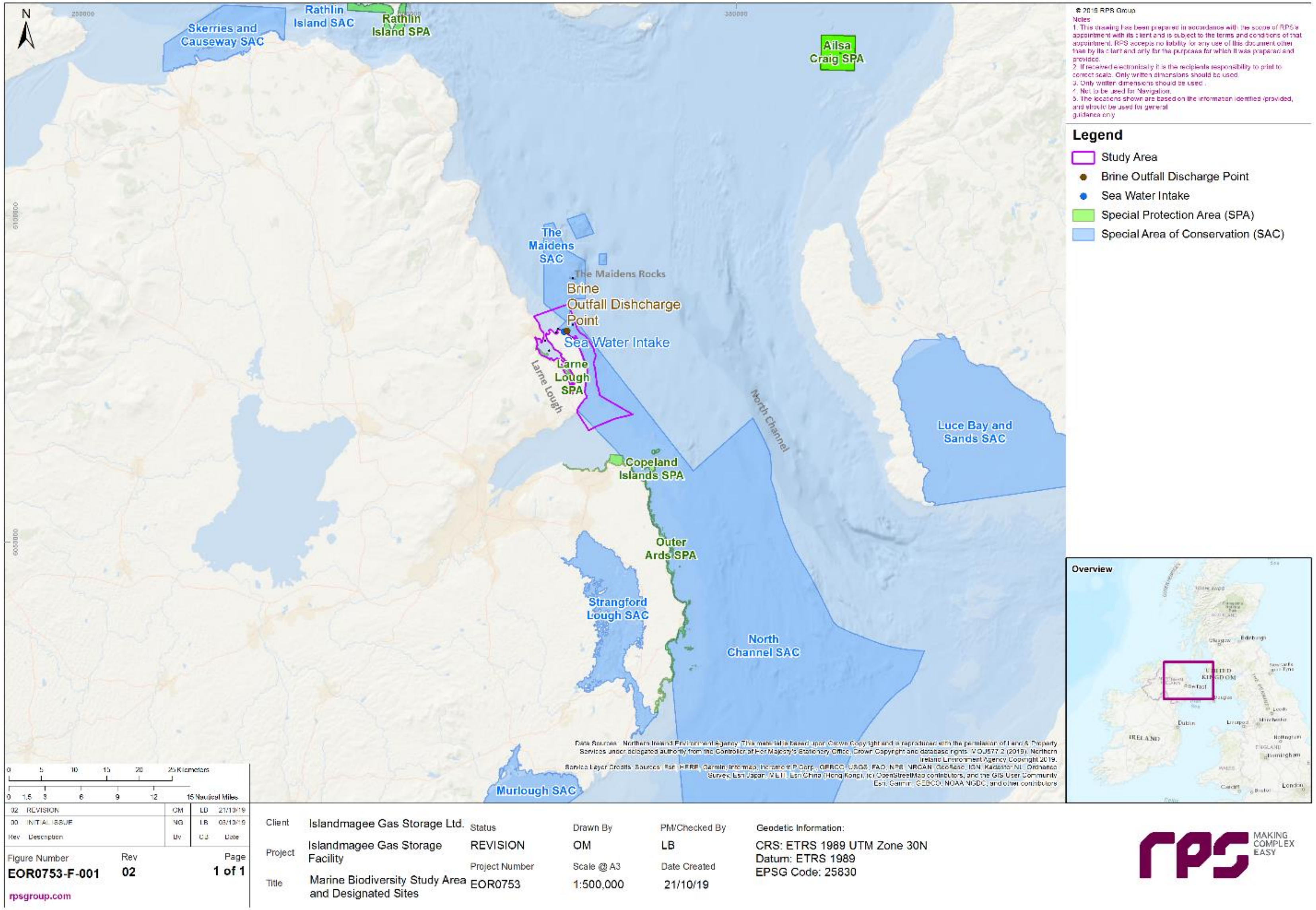


**Figure 7-3: Marine biodiversity study area and designated sites.**

### 7.3.2 Designated Sites

All designated sites with qualifying interest features that could be potentially impacted by the project were identified using the following approach:

- Step 1: All designated sites of international, national and local importance were identified using the MAGIC interactive map[1], the Joint Nature Conservation Committee's (JNCC's) website, the Department of Agriculture, Environment and Rural Affairs' (DAERA) website, and the European Site European Nature Information System (EUNIS) database;
- Step 2: Information was compiled on the relevant qualifying feature for each of these sites by examining JNCC, DAERA and EUNIS databases; and
- Step 3: Using the above information and expert judgement, sites were included in the assessment if:
  - A designated site directly overlaps with the project;
  - Sites and associated features were located within the potential Zone of Impact (ZoI) for impacts associated with the project, based on expert judgement;
  - Qualifying features of a designated site were either recorded as present during recent and historic site-specific surveys within the project area, or identified during the desktop study as having the potential to occur within the project area; and
  - Where a national site falls outside of an international site, but is located within the identified study area, the national site has been taken forward for further assessment for a particular feature.

The project is located within the North Channel Special Area of Conservation (SAC), designated under the Habitats Directive for the Annex II species Harbour porpoise (*Phocoena phocoena*) and less than 1 km from the Maidens SAC, designated under the Habitats Directive for the Annex I habitats 'Sandbanks which are slightly covered by sea water all the time' and 'Reefs'.

The nearest SPA is the Larne Lough SPA, located circa 3.2 km from the proposed Brine Outfall Discharge Point, and 2.8 km from the proposed intake location. Selection features for this SPA include the sandwich tern (*Thalasseus sandvicensis*) breeding population, roseate tern (*Sterna dougallii*) breeding population, common tern (*Sterna hirundo*) breeding population and light-bellied brent goose (*Branta bernicla*) wintering population. In addition, the project is located within a proposed SPA, East Coast (NI) Marine pSPA.

A list of identified international and nationally designated sites, distance from project and qualifying features that have the potential to be impacted by the project is provided in Table 7-9.

[1] http://magic.defra.gov.uk/

**Table 7-9: Designated sites identified for marine biodiversity receptors considered in this assessment.**

| Protected area | Distance and direction from the proposed outfall / intake locations (as the crow flies) | Relevant qualifying features |
|---|---|---|
| North Channel SAC | 0 km / 0 km | *Primary reason*<br>• Harbour porpoise (*Phocoena phocoena*) |
| The Maidens SAC | 1.01 / 1.71 km N | *Primary reason*<br>• Sandbanks which are slightly covered by sea water all the time<br>• Reefs<br>*Qualifying feature*<br>• Grey seal (*Halichoerus grypus*) |
| Larne Lough SPA | 3.16 km SW / 2.76 km SW | *Selection features*<br>• Sandwich tern (*Thalasseus sandvicensis*) breeding population<br>• Roseate tern (*Sterna dougallii*) breeding population<br>• Common tern (*Sterna hirundo*) breeding population<br>• Light-bellied brent goose (*Branta bernicla*) wintering population |
| Outer Ards SPA | 20.90 km S / 21.18 km S | *Selection features*<br>• *Arctic tern* (*Sterna paradisaea*) breeding population<br>• *Golden plover* (*Pluvialis apricaria*) wintering population<br>• Light-bellied brent goose (*Branta bernicla*) wintering population<br>• Ringed plover (*Charadrius hiaticula*) wintering population<br>• Turnstone (*Arenaria interpres*) wintering population |
| Copeland Islands SPA | 22.45 km SE | *Selection features*<br>• *Arctic tern* (*Sterna paradisaea*) breeding population<br>• *Manx Shearwater (Puffinus puffinus)* breeding population<br>*Non-qualifying species of interest*<br>• *Eider (Somateria mollissima)* breeding population<br>*Common Gull (Larus canus)* breeding population |
| Strangford Lough SAC | 31.28 km S | *Primary reason*<br>• Mudflats and sandflats not covered by seawater at low tide<br>• Coastal lagoons<br>• Large shallow inlets and bays<br>• Reefs<br>*Qualifying feature*<br>• Annual vegetation of drift lines<br>• Perennial vegetation of stony banks<br>• Salicornia and other annuals colonizing mud and sand<br>• Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)<br>• Harbour seal (*Phoca vitulina*) |
| Luce Bay and Sands SAC | 50.91 km E | *Primary reason*<br>• Large shallow inlets and bays<br>• Embryonic shifting dunes<br>• "Fixed coastal dunes with herbaceous vegetation (""grey dunes"")"<br>• Atlantic decalcified fixed dunes (*Calluno-Ulicetea*)<br>*Qualifying feature* |

| Protected area | Distance and direction from the proposed outfall / intake locations (as the crow flies) | Relevant qualifying features |
|---|---|---|
| | | • Sandbanks which are slightly covered by sea water all the time<br>• Mudflats and sandflats not covered by seawater at low tide<br>• Reefs |
| Rathlin Island SAC | 51.49 km NW | *Primary reason*<br>• Reefs<br>• Vegetated sea cliffs of the Atlantic and Baltic Coasts<br>• Submerged or partially submerged sea caves<br>*Qualifying feature*<br>• Sandbanks which are slightly covered by sea water all the time<br>• Annual vegetation of drift lines |
| Rathlin Island SPA | 51.49 km NW | *Selection features*<br>• *Peregrine Falcon* (*Falco peregrinus*), breeding population<br>• *Chough* (*Pyrrhocorax pyrrhocorax*), breeding populatio<br>• *Razorbill* (*Alca torda*), breeding population<br>• *Guillemot* (*Uria aalge*), breeding population<br>• *Kittiwake* (*Rissa tridactyla*), breeding population<br>• Seabird assemblage, breeding<br>*Non-qualifying species of interest*<br>• *Fulmar* (*Fulmarus glacialis*), breeding<br>• *Shag* (*Phalacrocorax aristotelis*), breeding population<br>• *Eider* (*Somateria mollissima*), breeding population<br>• *Common Gull* (*Larus canus*), breeding population<br>• *Herring Gull* (*Larus argentatus*), breeding population<br>• *Lesser Black-backed Gull* (*Larus fuscus*), breeding population<br>• *Black Guillemot* (*Cepphus grille*), breeding population<br>*Puffin* (*Fratercula arctica*), breeding population |
| Ailsa Craig SPA | 56.89 km NE | *Selection features*<br>• *Gannet* (*Morus bassanus*), breeding population<br>• *Guillemot* (*Uria aalge*), breeding population<br>• *Herring Gull* (*Larus argentatus*), breeding population<br>• *Kittiwake* (*Rissa tridactyla*), breeding population<br>• *Lesser black-backed gull* (*Larus fuscus*), breeding population<br>Seabird assemblage, breeding |
| Skerries and Causeway SAC | 64.12 km NW | *Primary reason*<br>• Harbour porpoise (*Phocoena phocoena*) |
| Murlough SAC | 67.95 km S | *Primary reason*<br>• "Fixed coastal dunes with herbaceous vegetation (""grey dunes"")"<br>• Atlantic decalcified fixed dunes (*Calluno-Ulicetea*)<br>*Qualifying feature*<br>• Sandbanks which are slightly covered by sea water all the time<br>• Mudflats and sandflats not covered by seawater at low tide<br>• Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) |

| Protected area | Distance and direction from the proposed outfall / intake locations (as the crow flies) | Relevant qualifying features |
|---|---|---|
| | | • Embyonic shifting dunes<br>• "Shifting dunes along the shoreline with Ammophila arenaria (""white dunes"")"<br>• Dunes with Salix repens ssp. argentea (*Salicion arenariae*)<br>• Harbour seal (*Phoca vitulina*) |

### 7.3.3 Plankton

Plankton are drifting organisms that inhabit the water column and include phytoplankton and zooplankton. Phytoplankton are autotrophic prokaryotic or eukaryotic algae that live near the water surface where there is sufficient light to support photosynthesis, including diatoms, cyanobacteria and dinoflagellates. Zooplankton are small protozoans or metazoans that feed on other plankton. Some of the eggs and larvae of larger animals, such as fish, crustaceans, and annelids, are included within the zooplankton.

Plankton abundance and distribution are driven by factors such as light availability, ambient nutrient concentrations, the physical state of the water column, and the abundance of other plankton.

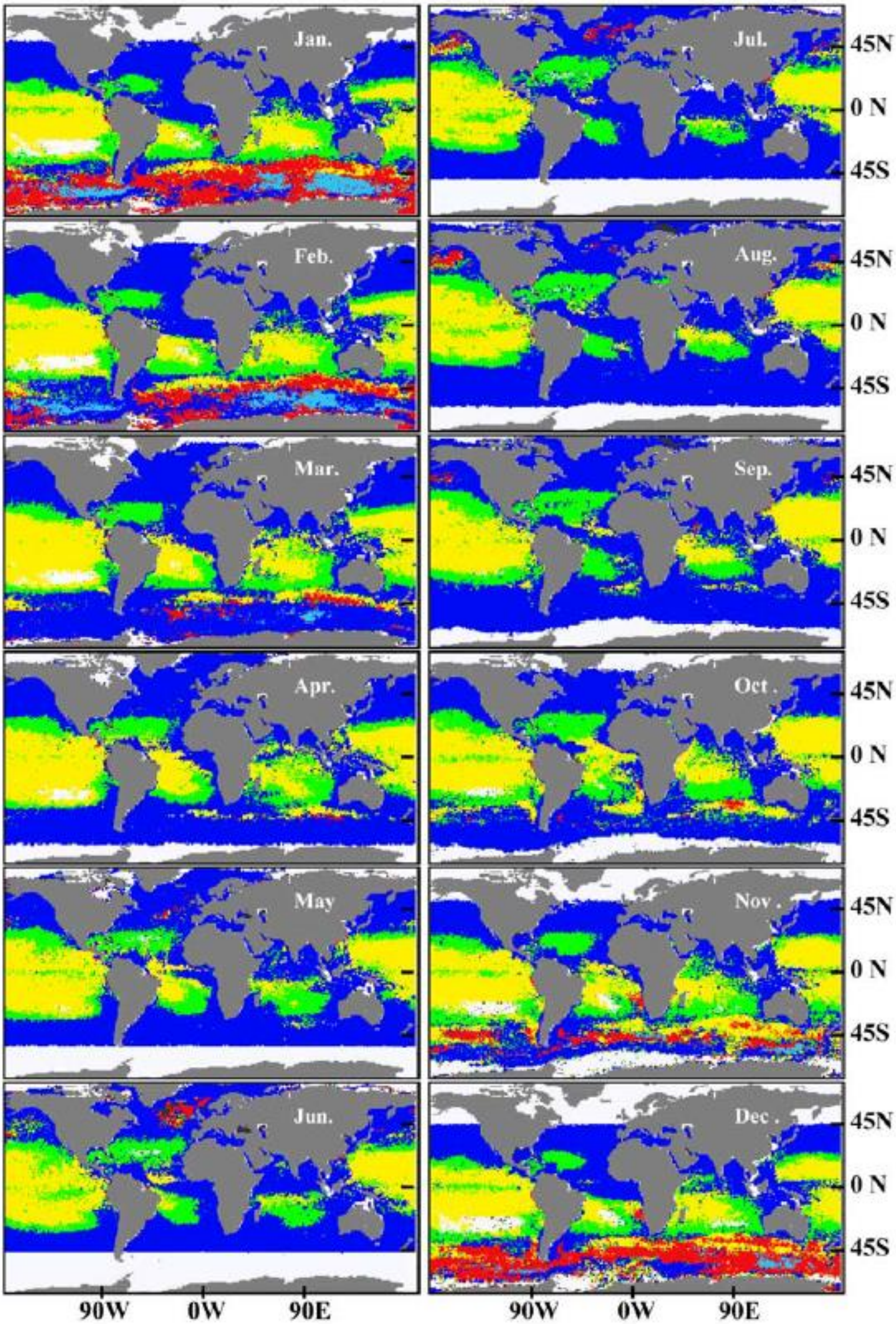


**Figure 7-4: Monthly climatology (1998–2006) of the dominant phytoplankton group (Alvain *et al.,* 2008).**

Local abundance varies horizontally, vertically and seasonally, responding primarily to light and nutrient availability (particularly nitrate, phosphate and silicate) (Kennington and Rowlands, 2005). Diatom blooms occur every year in the North Atlantic and associated seas, in the springtime, with the increase of Chlorophyll-a in February, following the stratification of waters and increase in Sea Surface Temperature (SST) (Alvain *et al.,* 2008). Blooms occur in the south-east of the Atlantic basin in May around 40° North, moving northward up to 60° N in August (see Figure 7-3), however important inter-annual variability has regularly been observed (Alvain *et al.,* 2008).

The Irish Sea exhibits large regional differences in bathymetry, hydrology, nutrient chemistry and ecology. Waters in the western Irish Sea are generally more than 100 m in depth, have high salinity values, shorter residence times and become stratified during the summer months. A gyre with a strong thermocline, shown to retain organisms, develops between the Isle of Man and Ireland during the summer months (Hill *et al.,* 1996; Dickey-Collas *et al.,* 1997; Gowen, *et al.,* 1997 *in* Kennington and Rowlands, 2005), just south of the project area. Waters enter the Irish Sea primarily through St Georges Channel in the south, but there is also exchange with Atlantic water through the North Channel.

In general, the north west (in the region of the project area) and north east of the Irish Sea tend to have higher plankton species abundance and concentration than the rest of the Irish Sea. A seasonal pattern of abundance is shown by all species with lowest numbers over the winter months and maximum abundances observed during spring and summer. Within the Irish Sea, a study (Kennington and Rowlands, 2005) identified five ecohydrodynamic typologies; distinct regions that have similar characteristics, including hydrology, and nutrient chemistry, of which the study area most aligns with type B (Coastal Frontal Zone). Type B waters have salinities between 30 and 33 psu and moderately high winter nutrient concentration. The phytoplankton growth season lasts for five to six months, with diatom abundance showing a distinctive spring peak; the major period of phytoplankton production is taken as the period through spring and summer, with peaks in abundance occurring in the north-west in March/April and a second peak in July/August. Coastal waters tend to be first to respond to the improving temperature, hydrographic and light regimes during the early spring months. Whilst inter-annual variation in seasonality does occur, there appears to have been a downward trend in abundance since the 1970’s in plankton species.

The major period of phytoplankton production occurs in the summer months in the Irish Sea, however variation in depth and tidal mixing influence the timing of the phytoplankton production season in the Irish Sea (Gowen *et al.,* 1995), and coastal waters tend to be first to respond to the increase in SST and light regimes during the early spring months. In the western Irish Sea, the spring bloom develops between March and May (Gowen and Bloomfield, 1996), and by June the phytoplankton populations begin to decline across the region as a whole. Liverpool’s Port Erin Marine Laboratory (PEML) currently have records of over 70 species/species groups of diatoms and 60 species/species groups of dinoflagellates collected from the northern Irish Sea (Kennington and Rowlands, 2005).

The most abundant zooplankton in the Irish Sea are copepods, small holoplanktonic crustaceans ranging in size from 0.5 mm to 6.0 mm, at nearly 70% of all the zooplankton. The abundance of all copepods varies throughout the year in relation to their food; phytoplankton. Of these copepods, it is the smaller species of

*Pseudocalanus elongatus, Temora longicornis* and *Acartia clausi* that dominate the western Irish Sea. This population pattern is reflected in other areas of the Irish Sea such as the North Channel (Gowen *et al.,* 1998). Other crustaceans also form an important constituent of the zooplankton, the majority of which are the larval forms of large benthic crustaceans such as crabs (Kennington and Rowlands, 2005). Fish eggs and larvae are also included (icthyoplankton) (Kennington and Rowlands, 2005). High abundance of other species of nanoplankon (all organisms in the size range of 2-20 µm), microzooplankon (zooplanktonic organisms in the size range of 2-200 µm) and zooplankton (such as decapods, cirripede, cladocerans, and larvaceans) are also observed in the western Irish sea. Only a few species of euphausids, molluscs and echinoderms are found in the Irish Sea, showing relatively low abundances, with numbers lower in the east than the west. There is little information available on the bryozoans, but they are thought to be more abundant in the north-western Irish Sea compared to the north-eastern.

The phytoplankton are the primary producers of the oceans and thus provide the principal source of primary nutrition for organisms such as the zooplankton. Copepods constitute the major prey items for the larvae of many commercial fish species. Not only is their abundance important but also the size range and species present due to the fact that fish larvae at first-feeding eat copepod nauplii, but as they grow, take larger prey items. The presence of copepods for these feeding larvae is essential as the larvae are dependent on these copepods at a critical stage in their lifecycle, where they are prone to high mortalities (Hjort, 1914; Jordaan and Brown, 2003). Therefore, a plentiful food supply is vital in the survival of these larvae and thus the eventual recruitment of these larvae to their respective stocks.

#### 7.3.3.1 Comparison with data presented in the original Environmental Statement

Plankton were not presented as a separate receptor or discussed in baseline sections in the Original ES (RPS, 2010) or ES Addendum (RPS, 2011). Impacts to larval stages and plankton were however discussed in the impact assessment, in terms of likely survival and development following brine disposal at sea (section 6.6.2; 6.6.4; 6.6.5; and 6.7.4 of the Original ES, RPS, 2010). The ES Addendum (RPS, 2011) also presented information on larvae within the section entitled Overview of Osmoregulation in Fish and Impacts on Scallop, Crab, Lobster and Shrimp.

#### 7.3.3.2 Important Ecological Features (IEF)

**Table 7-10: Plankton IEFs in the study area.**

| Important Ecological Features (IEF) | Value within the study area | Justification |
|---|---|---|
| Plankton | Regional | Low intensity spawning grounds |

### 7.3.4 Benthic Ecology

#### 7.3.4.1 Subtidal

The main faunal community identified within the broad survey area, including in the immediate vicinity of the proposed brine discharge point was Flustra foliacea and Hydrallmania falcata on tide-swept circalittoral mixed sediment. This community type is common along the east Antrim coast. A habitat map was generated using the faunal data from the grab sample in combination with information obtained from video and trawl surveys. This is presented in Figure 7-5.

Three distinct faunal groupings were identified, reflecting the biotopes identified across the site, with fine sands in Brown's Bay (SS.SSa and SS.SSa.CmuSa.AalnBuc), and mixed coarse sediments present from Skernaghan Point to Portmuck Bay (SS.SMx.CMx.FluHyd) (see Figure 7-5). Within these mixed sediments are occasional areas of coarse sands.

Group 1 contained all replicates from samples collected in Brown's Bay. This site was noticeably different to the other sites, containing muddy sands and fine sands, with no gravel. Biotopes identified were sublittoral sands and muddy sands and Abra alba and Nucula nitidosa in circalittoral muddy sand or slightly mixed sediment (SS.SSa and SS.SSa.CmuSa.AalnBuc). The species composition included small crustaceans, Ampelisca brevicornis and Harpinia antennaria, molluscs Abra alba, Abra sp., Fabulina fabula, Corbula gibba and Nucula nitidosa were common, in addition to the polychaete worms Euclymene oerstedii. These taxa are typical of sandy environments.

Group 2 contained all replicates from samples collected immediately east of Skernaghan Point in a pocket of gravelly sands as identified from the video survey. The sediment at these sites consists primarily of coarse sands and shell gravel. Biotopes identified were infralittoral mixed sediment and infralittoral coarse sediment (SS.SMx.IMx, SS.SMx.IMx,DE and SS.SCS.ICS). This group contained fauna which was more typical of coarser sediments, compared to Group 1. These include the molluscs Spisula eliptica and Timoclea ovata as well as the polychaete worms Aonides paucibrachata, Syllis spp., Aglaophamus agilis and Laonice bahusiensis.

Group 3 was the largest group present in the survey area, covering all of the sites at and around the outfall location and extending north to Skernaghan Point and south to Portmuck Bay. The seabed in this area consists of coarser gravels and sands, and this was reflected in the fauna identified in the area. Biotopes identified were Flustra foliacea and Hydrallmania falcata on tide-swept circalittoral mixed sediment (SS.SMx.CMx.FluHyd DE and SS.SMx.CMx.FluHyd EP). The area is diverse, in terms of species abundances and numbers of individuals. The dominant fauna present in this group include the barnacle Balanus creanatus which encrusts on pebbles and larger substrate components, polychaetes Sabellaria spinulosa, Lepidonotus squamatus and Lumbrineris aniara agg., the mollusc Modiolula phaseolina, the sipunculid Nephasoma (Nephasoma) minutum, and the tunicates Dendrodoa grossularia and Ascidiacea spp. Also present in the group are the echinoderms Amphipholis squamata.

The main assemblage encountered in the trawl surveys may be likened to an assemblage described by Ellis et al., 2000, entitled 'Echinus-Crossaster'. 83% of the indicator species listed for that assemblage were noted in the current study as compared to 43-66% of the indicator species of the other assemblages. Species that were caught with notably greater catches in this assemblage included Echinus esculentus, Crossaster papposus and Pandulus montagui in particular. Ellis et al. (2000), along with a study by Freeman and Rogers (2003) confirm that the epibenthic assemblage present within the near field mixing zone of the proposed outfall is typified by species that tend to occur on coarser bottom material and exposed to generally greater near-bed velocities.

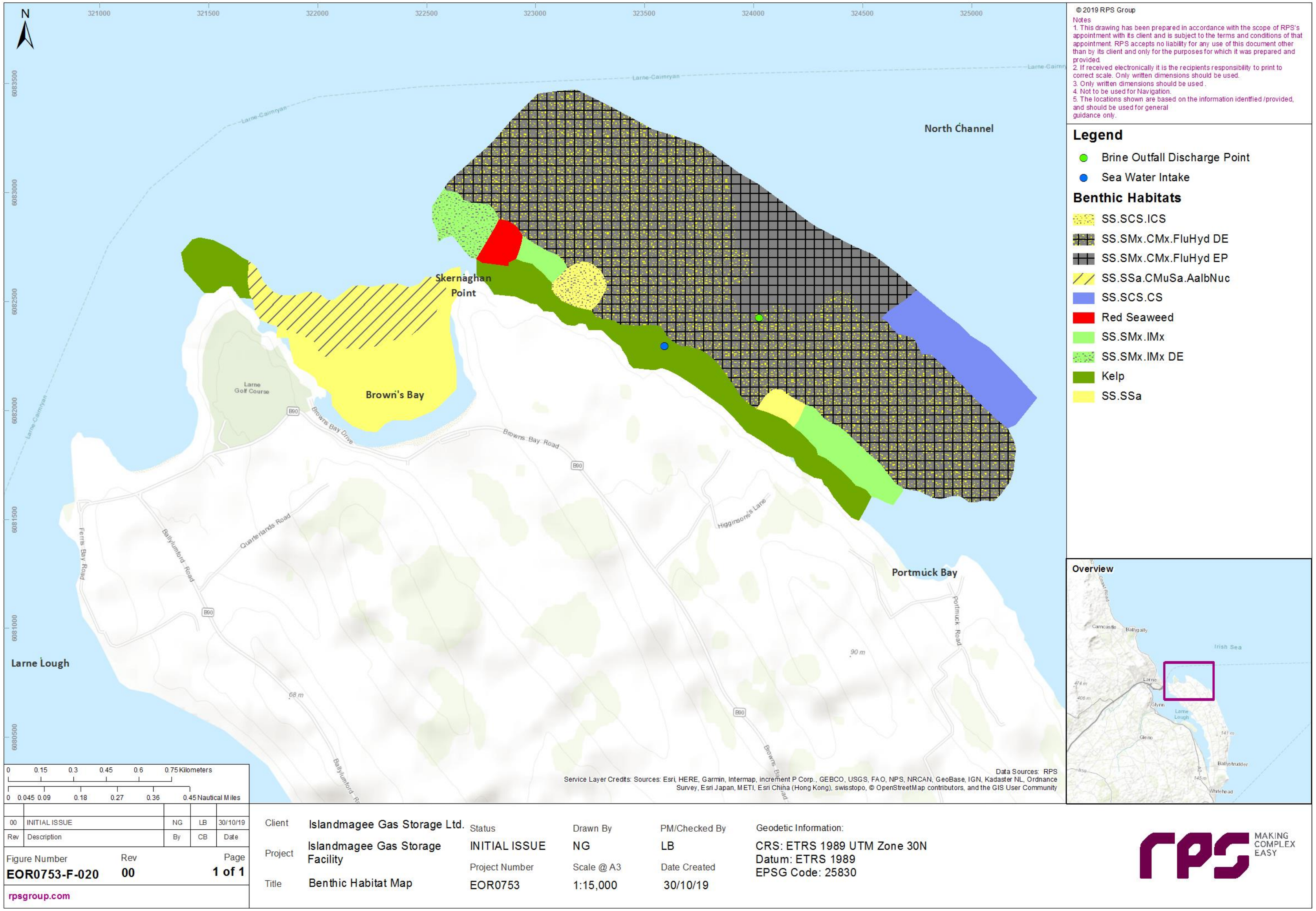


**Figure 7-5: Benthic Habitat Map.**

### 7.3.4.2 Intertidal

In the absence of a site-specific intertidal survey (noting that the project proposes to HDD under the intertidal area, so there is no impact pathway to this receptor, see section 7.7.2.1), a combination of aerial footage and video data taken during DDV surveys (lower intertidal only) has been used to characterise the intertidal zone in the region of the project. The project intake and outfall are located on the north eastern side of Islandmagee where coarse sediment with intermittent rock outcrops extend from Portmuck Bay towards Skernaghan Point. Infralittoral rock with kelp beds and an understory of red seaweeds, were identified in the DDV surveys. It is assumed that this will extend into the lower intertidal zone, with the rest of the intertidal zone characterised by communities typical of this part of Northern Ireland, including fucoid seaweeds and intertidal fauna (e.g. barnacles and mussels).

### 7.3.4.3 Comparison with data presented in the original Environmental Statement

Baseline data identified in the 2019 surveys are similar to those identified in 2009, when a survey was undertaken in the area using a semi-quantitative Anchor Dredge, for the purposes of informing the Original ES (RPS, 2010). Due to the difference in sampling method between the two surveys, direct comparison of the abundances cannot be made. The survey in 2009 identified the presence of a single community in the area of the proposed discharge point. The habitat was assigned to the Polychaete rich deep *Venus* community in offshore mixed sediments (SS.SMx.OMx.PoVen). There is a large degree of overlap between the species present in that community and the biotope assigned in the present survey.

Baseline data presented in the original ES and ES Addendum (RPS, 2010 and RPS, 2011) were informed by DDV surveys and diver surveys. Baseline data for benthic, and fish and shellfish receptors were presented as a single baseline section.

The Original ES identified six groupings of stations based on the nature of habitat and dominant epibenthic communities. The groupings were as follows:

- Group 1 included most of the stations between the 20 and 30 m contours. which included stations dominated by gravel or sandy gravel - broad JNCC classification Circalittoral Sediments, in sub-classifications of Circalittoral Coarse Sediment (SS.SCS.CCS) (EUNIS A5.14) or Circalittoral Mixed Sediment (SS.SMx.CMx) (EUNIS A5.44);
- Group 2 included stations mainly between the 10 and 20 m contour over mixed cobble boulder, pebble, sand and gravel – placed in Moderate energy Circalittoral Rock (CR.MCR) (EUNIS A4.2), within the broad sub-classification Echinoderms and Crustose communities (CR.MCR.EcCr) (EUNIS A4.21);
- Group 3 straddled the 5 m contour and included stations which overlay bedrock, cobble, boulder and pebble with highest densities of kelp – it was suggested in the Original ES that these stations could fit the JNCC classification *Laminaria hyperborean* with dens folios Red seaweeds on exposed infralittoral rock IR.HIR.KFaR.LhypR (EUNIS A3.115) or could have also been classified as sediment-affected or disturbed Kelp and seaweed communities IR.HIR.Ksed (Eunis A3.12) because of the sandy cover noted on rock in some areas;
- Group 3a comprised one station of shallow hard substrate just shoreward of station group 3 – in the Original ES, this habitat was thought to be closest to the JNCC classification: *Laminaria hyperborea* and foliose red

seaweeds on moderately exposed infralittoral rock (IR.MIR.KR.Lhyp) (EUNIS A3.214) but thought also to have similarities to *Laminaria hyperborea* forest with dense foliose Red seaweeds on exposed upper infralittoral rock IR.HIR.KFaR.LhypR.Ft (EUNIS A3.1151) due to the presence of *Sacchoriza polyschides* and *Saccharina latissima*;

- Group 4 comprised two stations at 17.5 m and 25.6 m, both of which showed a dense population of brittle stars as well as a diverse range of bryozoans – broadly classified as SS.SMx.CMx.OphMx (*Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on Sublittoral Mixed sediment) (EUNIS A5.445); and
- Group 5 included two stations on the Larne Lough side of Islandmagee between 5 and 10 m depth – grouped as part of the general JNCC biotope *Laminaria saccharina* and red seaweeds on infralittoral sediments (SS.SMp.KSwSS.LsacR) (EUNIS A5.521). However, it was suggested that the sediment infauna may classify the site differently e.g. Infralittoral sandy Mud (S.SMu.IsaMu) (EUNIS A5.33).

### 7.3.4.4 Important Ecological Features (IEF)

**Table 7-11: Benthic habitat IEFs in the study area.**

| Important Ecological Features (IEF) | Representative species | Value within the study area | Justification |
|---|---|---|---|
| **Subtidal** | | | |
| Subtidal Habitat A: Dominated by fauna typical of the *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment, with high diversity (Group 1[2] assemblage from above) | Small crustaceans, *Ampelisca brevicornis* and *Harpinia antennaria*, molluscs *Abra alba*, *Abra* sp., *Fabulina fabula*, *Corbula gibba* and *Nucula nitidosa*; and polychaete worms *Euclymene oerstedii* | Regional | Subtidal sands and gravels are UKBAP habitats |
| Subtidal Habitat B: Dominated by coarse sands and shell gravels, and circalittoral mixed sediment, with diverse epifauna and infauna. Dominated by the bryozoan *Flustra foliacea* and hydroid *Hydrallmania falcata* (Groups 2 and 3 assemblages from above, based on similar broad sediment type and associated assemblages) | Molluscs *Spisula eliptica Timoclea ovata, and Modiolula phaseolina;* polychaetes *Aonides paucibrachata*, *Syllis* spp., *Aglaophamus agilis, Laonice bahusiensis, Sabellaria spinulosa*, *Lepidonotus squamatus* and *Lumbrineris aniara* agg., barnacle *Balanus creanatus;* the tunicates *Dendrodoa grossularia* and *Ascidiacea* spp.; the sipunculid *Nephasoma* (*Nephasoma*) *minutum; and* the echinoderms *Amphipholis squamata* | Regional | Subtidal sands and gravels are UKBAP habitats |
| Annex I habitat - *Sandbanks which are slightly covered by sea water all the time* in The Maidens SAC | Shallow sandy sediments are typically colonised by a burrowing fauna of worms, crustaceans, bivalve molluscs and echinoderms. Mobile epifauna at the surface of the sandbank may include shrimps, gastropod molluscs, crabs and fish. Where coarse stable material, such as shells, stones or maerl is present on the sediment surface, species of foliose seaweeds, hydroids, bryozoans and ascidians may form distinctive communities | International | Annex I habitat within a Special Area of Conservation (SAC) boundary |

[2] Both the Original ES and this document have referred to benthic 'Groups'. Any reference made to benthic groupings (Group 1, Group 2 and Group 3) from this point onwards is in relation to this Environmental Assessment, 2019.

| Important Ecological Features (IEF) | Representative species | Value within the study area | Justification |
|---|---|---|---|
| Annex I habitat - *Reefs* in The Maidens SAC | *Tubularia indivisa, Tubularia larynx, Alcyonium digitatum, Actinothoe sphyrodeta, Caryophylia smithii, Parazoanthus anguicomus* (Goodwin *et al.,* 2011) | International | Annex I habitat within a Special Area of Conservation (SAC) boundary |
| **Intertidal** | | | |
| Intertidal habitat: Red seaweeds and kelps on mixed coarse sediment and infralittoral cobbles and pebbles | Red seaweeds; kelp; communities typical of this part of Northern Ireland, including fucoid seaweeds and intertidal fauna (e.g. barnacles and mussels). | Regional | Infralittoral rock classified as Annex I reef (outside of an SAC) |

## 7.3.5 Fish and Shellfish Ecology

### 7.3.5.1 Local flatfish assemblage

Data held by CEDaR (See Appendix G) from surveys conducted between 1983 and 2018 show that likely flatfish species in the vicinity of the project include European plaice (*Pleuronectes platessa*), common dab (*Limanda limanda*), European flounder (*Platichthys flesus*), common sole (*Solea solea*), lemon sole (*Microstomus kitt*) and brill (*Scophthalmus rhombus*). European plaice, European flounder and dab were the dominant species throughout, with regular sightings of common sole. Lemon sole and brill were identified on only two and one occasions respectively; lemon sole within this dataset has not been sighted in the study area since 1999, however lemon sole were also noted from the recent site-specific trawl survey (Appendix A: Benthic Survey Reports). A single occurrence of plaice was also noted from this site-specific trawl survey. The majority of the CEDaR sightings occurred within Larne Lough, with some sightings on the north and east of Islandmagee in the North Channel and Irish Sea.

### 7.3.5.2 Local roundfish assemblage

Data held by CEDaR for the period 1983 to 2018 (See Appendix G) show that likely round fish species include species within gadidae, lotidae, clupeidae, along with grey gurnard (*Eutrigla gurnardus*), Atlantic horse mackerel (*Trachurus trachurus*), Atlantic mackerel (*Scomber scombrus*), John Dory (*Zeus faber*), European hake (*Merluccius merluccius*) and angler fish (*Lophius piscatorius*). From the recent site-specific trawl survey (Appendix A: Benthic Survey Reports), the most frequently encountered roundfish were dragonet (*Callionymus lyra*), poor cod (*Trisopetrus minutus*) and sand eel (*Ammodytes* sp.). The greater sand eel (*Hyperoplus lanceolatus*) was also observed.

#### Gadidae

Species encountered within the study area in surveys between 1983 and 2018 include Atlantic cod (*Gadus morhua*), pouting (*Trisopterus luscus*), saithe (*Pollachius virens*), whiting (*Merlangius merlangus*), and poor cod (*Trisopterus minutus*). Saithe was the dominant species, with high numbers of whiting and Atlantic cod, all found within Larne Lough and in the North Channel. Poor cod and pouting have been identified in low numbers in Larne Lough and in the North Channel throughout these survey years. Poor cod were also observed in the site-specific trawl survey undertaken in 2019, as were single specimens of haddock (*Melanogrammus aeglefinus*) and rockling (indet.).

### Lotidae

Ling (*Molva molva*) is the only species within *lotidae* that is likely to be found within the vicinity of the project based on surveys between 1983 and 2018, with four encounters recorded between 1985 and 2017, one of which was inside Larne Lough.

### Clupeidae

Both sprat (*Sprattus sprattus*) and herring (*Clupea harengus*) were encountered in high numbers during surveys between 1983 and 2018 in Larne Lough. A single sighting of a school of over 700 sprat was identified in 1991, and a single sighting of a school of over 600 herring occurred in 1992.

### Other roundfish

Angler fish was encountered in high numbers throughout surveys between 1983 and 2018 in Larne Lough and in the North Channel. grey gurnard (*Eutrigla gurnardus*), Atlantic mackerel (*Scrombus scrombus*) and Atlantic horse mackerel (*Trachurus trachurus*) were encountered in very low numbers in Larne Lough between 1991 and 2013, and two observations of John Dory, one in the North Channel and one in Larne Lough occurred in 2008 and 1996, respectively.

## 7.3.5.3 Migratory fish species

No SAC's designated for migratory species are found within the vicinity of the study area, however migratory fish species which been designated as Features of Interest (FOI) of both the River Boyne and River Blackwater SACs (> 150 km south of the project) and Slaney River Valley SAC (> 300 km south of the project), have the potential to occur in the study area. These migratory fish species, including river lamprey (*Lampetra fluviatilis*), Atlantic salmon (*Salmo salar*), sea lamprey (*Petromyzon marinus*) and twaite shad (*Alosa fallax*) migrate to and from the rivers located along the east coast of the Republic of Ireland and Northern Ireland, which these species use either for spawning habitat and/or as a nursery area for growth and development into the adult stage. Sea trout (*Salmo trutta*) and European eel (*Anguilla anguilla*) are listed as OSPAR threatened/declining species and have been found transiting the east coast of the Republic of Ireland and Northern Ireland, however they are not features of either SAC.

Atlantic salmon are known to run the River Boyne almost every month of the year, with large multi-sea-winter salmon generally arriving in February, with smaller spring salmon in April/May and grilse arriving in July. A later run occurring in late August has also been observed (DAHG, 2014). The Slaney River Valley SAC is primarily known for its spring salmon which spawn within the upper Slaney and tributary headwaters (DAHG, 2015).

Data held by CEDaR for the period 1983 to 2018 (See Appendix G) show that likely migratory species in the vicinity of the project include sea trout and European eel. These sightings were all identified within Lough Larne.

Biodiversity maps indicate that sea trout, European eel, Atlantic salmon and sea lamprey all occur in low numbers in the rivers along the east coast of the Republic of Ireland and along the coast of Northern Ireland, including in the Lagan River, 30 km south west of the project.

Sea trout have a large distribution and remain within nearshore waters rather that undergoing extensive migration offshore (DECC, 2009). Trout spawn in winter from October to January, with the eggs deposited in redds[3], small deviations in the river bed, cut by the female in the river gravel.

The European eel has a complex life history, entering two metamorphizations stages. Spawning occurs in the Sargasso Sea (mid Atlantic Ocean), after which larval eels cross the Atlantic Ocean. Once eels have reached the continental shelf, they will have metamorphized into ‘glass eels’, whereby some remain in the sea and others ascend rivers and move between marine, estuarine and freshwater environments. Little is known about the migratory routes taken by eels. The timing of migration peaks in Irish waters is August to November, with many records of eels waiting for water levels to rise in August (Sandlund *et al.*, 2017). The European eel has been found throughout the water column (up to 300 m deep), depending on the time of day and state of tide.

#### 7.3.5.4 Elasmobranchs

Elasmobranchs are a cartilaginous fish group that comprises sharks, rays and skates. Biodiversity records indicate that shark species expected to be present in the study area include basking shark (*Cetorhinus maximus*), small spotted catshark (*Scyliorhinus canicula*), nursehound (*Scyliorhinus stellaris*) and blackmouth catshark (*Galeus melastomus*). The main species of skate and ray likely to be present include thornback ray (*Raja clavata*), common skate (*Dipturus batis*), and cuckoo skate (*Leucoraja naevus*) (NBN Atlas, 2019).

Data held by CEDaR for the period 1983 to 2018 (See Appendix G) identified elasmobranchs in the vicinity of the project including small spotted catshark, nursehound, blackmouth catshark, school shark (*Galeorhinus galeus*), thornback ray, common skate, cuckoo skate and spotted ray (*Raja montagui*). Common skate and small-spotted catshark were the dominant species identified with spotted ray and thornback ray identified in low numbers. Blackmouth catshark, school shark and nursehound were identified on individual occasions in 2012, 2014 and 2006, respectively. A small spotted catshark was observed in the site-specific trawl survey undertaken in 2019 (Appendix A: Benthic Survey Reports referred to by its other common name of lesser spotted dogfish in this report).

*The basking shark has a circumglobal distribution* and can undertake extensive trans-ocean basin migrations (Witt *et al.,* 2012). *Data (sightings, geotag and survey data) suggest a restricted range for basking sharks around Britain, with the majority of sightings falling between the Hebrides and the north coast of Brittany.* This suggests the western region of the European shelf is a particularly important habitat for basking sharks within the north-east Atlantic (Southall *et al.,* 2005). *High density hotspots (through sightings data) appear to be western Scotland, the Isle of Man and south west England, with lower concentrations off the coast of Pembrokeshire and western Ireland, where* they can be observed surface-feeding on dense zooplankton patches (Miller *et al.,* 2015).

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[3] ‘Nests’ of spawning fish.

### 7.3.5.5 Shellfish

Shellfish are aquatic demersal shelled molluscs and crustaceans. Using commercial landing data as a proxy for species present in the study area, species most caught include[4] the brown crab (*Cancer pagarus)*, European lobster (*Homarus gammarus)*, great Atlantic scallop (*Pecten maximus)* and velvet crab (*Necora puber). Other* species caught in the area include periwinkles (*Littorina* spp.), whelks (*Buccinum undatum),* Dublin Bay prawn (*Nephrops norvegicus)*, blue mussels (*Mytilus edulis)*, razor clams (*Solen spp*.), cockles (*Cerastoderma edule)* and native oysters (*Ostrea edulis)*. Important shellfish fisheries in the western Irish sea include *Nephrops*, scallop, and queen scallop (*Aequipecten opercularis*) (Cefas, 2005).

Data held by CEDaR for the period 1983 to 2018 (See Appendix G) show that likely shellfish species in the study area include the crustaceans brown crab, Dublin Bay prawn, brown shrimp (*Crangon crangon*), pink shrimp (*Pandalus montagui*), European lobster, native oysters, Pacific oyster (*Crassostrea gigas*), blue mussels, razor clams, common otter shell (*Lutraria lutraria*), great Atlantic scallop, and queen scallop.

Brown crab were the dominant species during surveys (between 1983 and 2018) with all other crustaceans encountered in small numbers. Brown crab, brown shrimp and pink shrimp were encountered in both Larne Lough and the North Channel. Dublin Bay prawn and European lobster were only encountered in the North Channel.

### 7.3.5.6 Spawning and Nursery Habitats

Nursery and spawning habitats were categorised by Ellis *et al*. (2012) as either high or low intensity dependant on the level of spawning activity or abundance of juveniles recorded within these habitats. Spawning grounds which overlap with or occur near to the study area include Atlantic cod, whiting, ling and Atlantic mackerel (see Figure 7-6). Nursery grounds which overlap with or occur near to the study area include spurdog (*Squalidae*), common skate, cod, whiting (see Figure 7-7), hake, angler fish and mackerel (Ellis *et al.,* 2012) (see Figure 7-8).

[4] Note: This list includes the top ten shellfish species caught within ICES rectangle 46E6 contributing to over 90% of the average landings value (2013-2017; ICES, 2017).

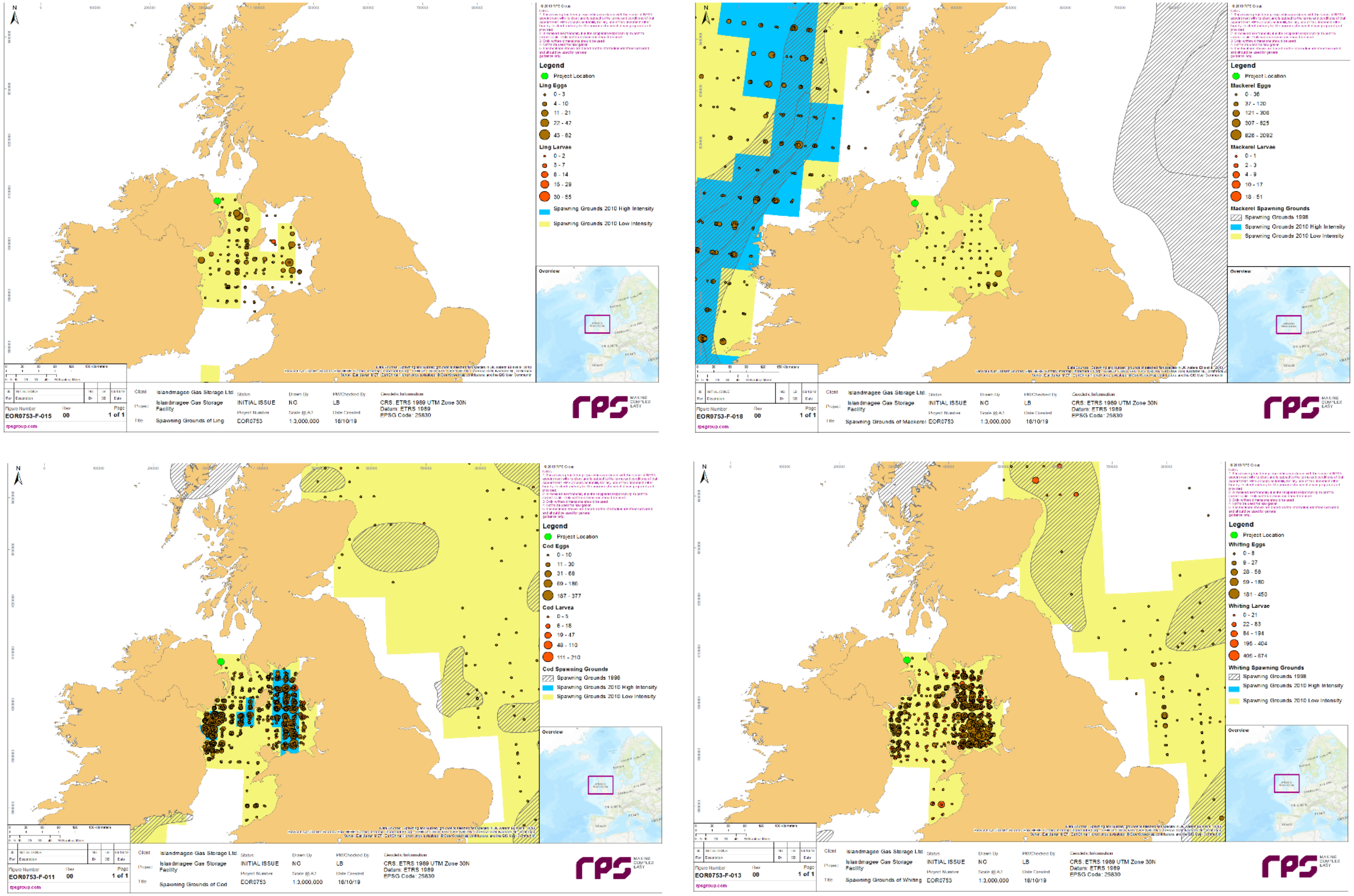


**Figure 7-6: Spawning habitats within the study area (Ellis *et al.*, 2012).**

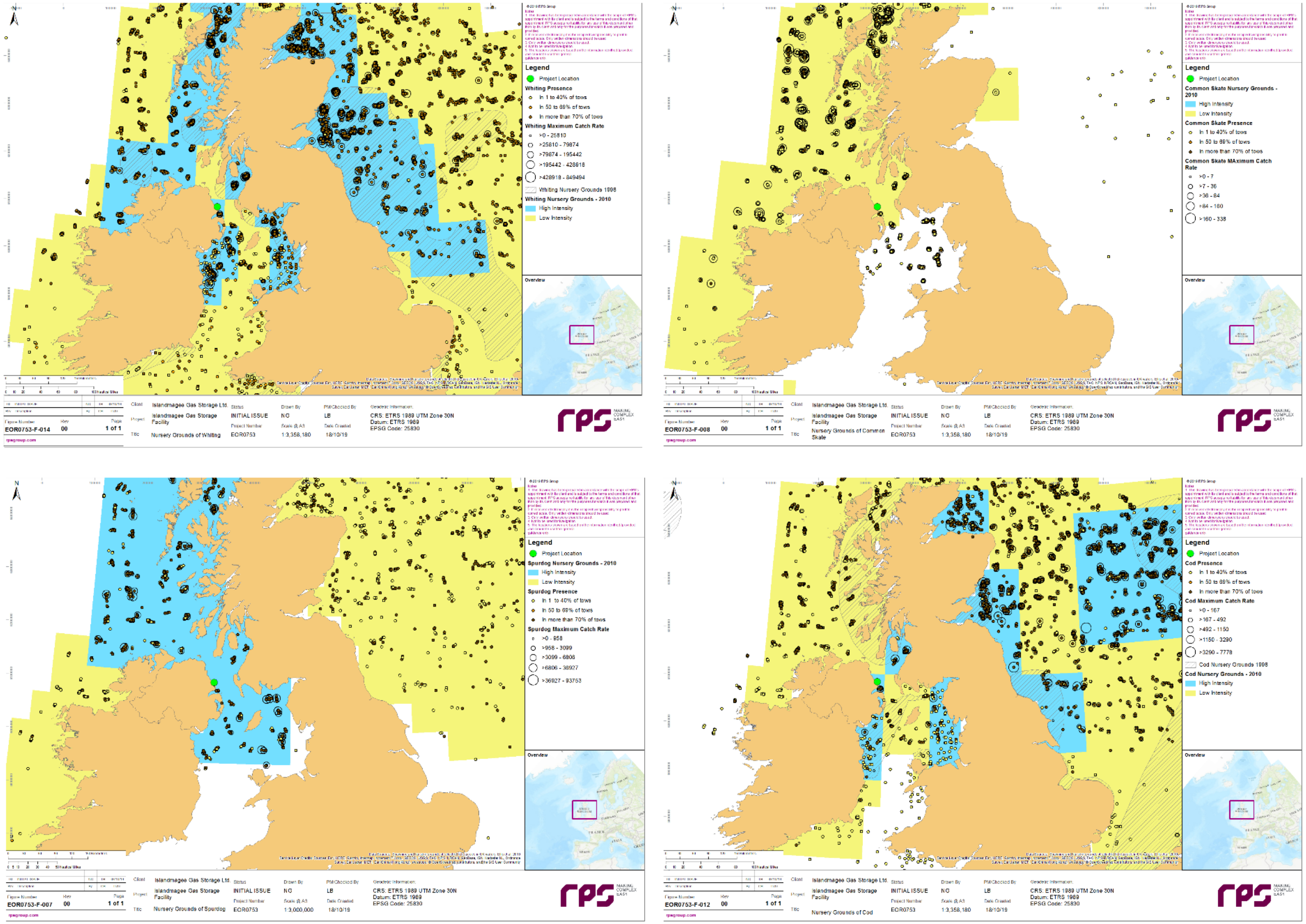


**Figure 7-7: Whiting, common skate, spurdog and cod nursery habitats within the study area (Ellis *et al.*, 2012).**

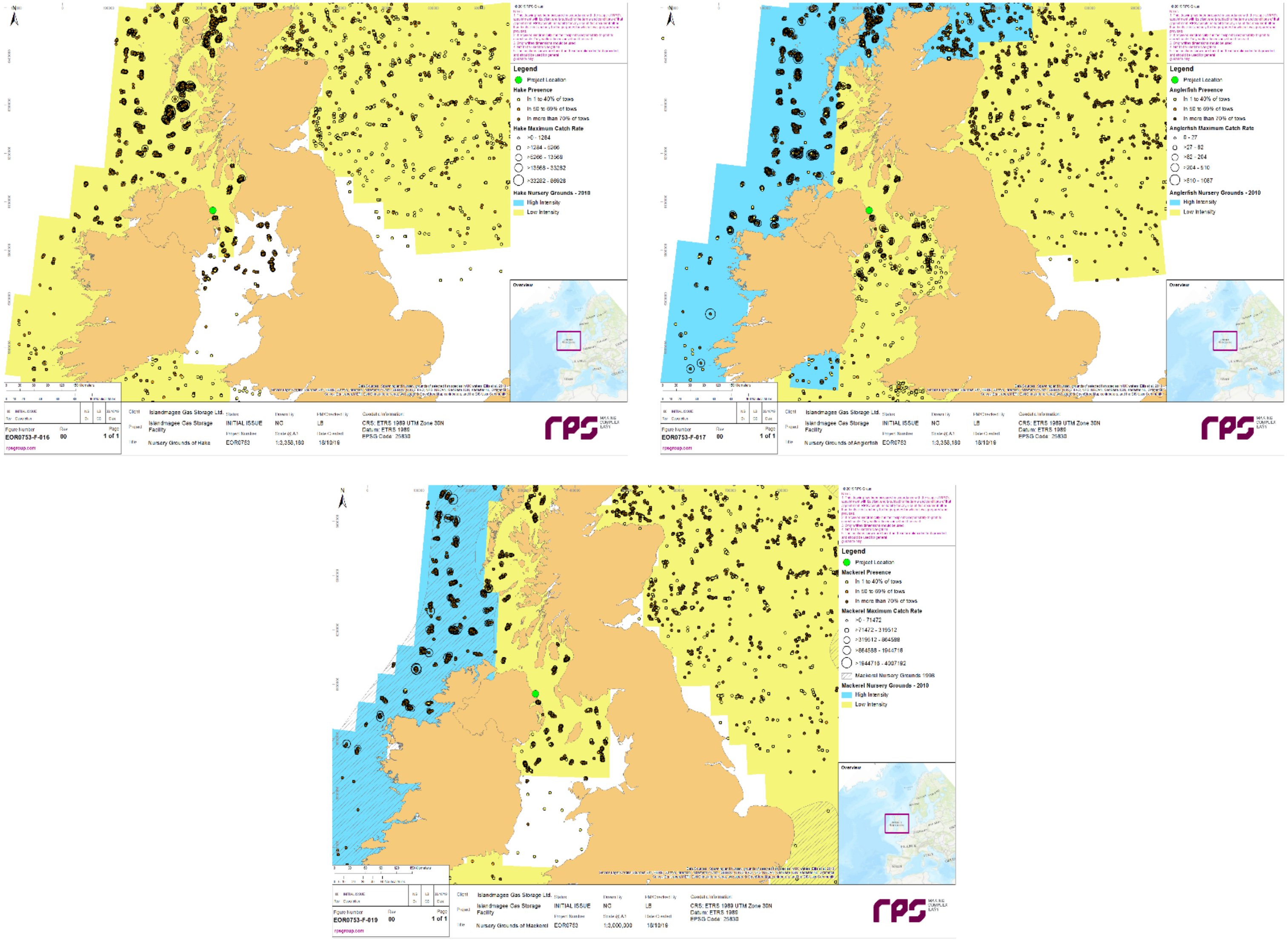


**Figure 7-8: Hake, anglerfish and mackerel nursery habitats within the study area (Ellis *et al.,* 2012).**

### 7.3.5.7 Comparison with data presented in the original Environmental Statement

Baseline data presented in the original ES and ES Addendum were informed by a pot fishery survey within a study area extending from Ballygalley in the north, to Cloghfin in the south and incorporating the Maidens (see Figure 7-3). Baseline data was also informed by drop down video (DDV) surveys and diver surveys. Baseline data for fish and shellfish ecology was presented in the original ES as a 'Fisheries' section and split by the local and commercial fisheries types in the local area. Baseline data (section 7.3.5.1 *et seq.*) in this document has been set out to identify receptor by ecological groupings. Table 7-12 below sets out those fisheries receptors which the original ES (RPS, 2010) identified and the equivalent receptor groups within this document, alongside the baseline location in the original ES.

**Table 7-12: Location of fisheries receptors in the original ES/ES Addendum and their equivalent location and categorisation in this document.**

| Receptor Group in original ES | Location in original ES/ES Addendum | IEF equivalent |
|---|---|---|
| Crustacean fishery | ES in paragraph 6.7.3.1 *et. seq.* | Shellfish |
| Bivalve fishery | ES in paragraph 6.7.3.2 *et. seq.* | Shellfish |
| Shellfish aquaculture | ES in paragraph 6.7.3.3 *et. seq.* | Shellfish |
| Recreational sea angling | ES in paragraph 6.7.3.4 *et. seq.* | • Migratory fish species<br>• Local round fish assemblage<br>• Elasmobranchs |
| Migratory salmonids | ES in paragraph 6.7.3.5 *et. seq.* | Migratory fish species |
| Sandeels | ES Addendum | Local round fish assemblage |

### 7.3.5.8 Important Ecological Features (IEF)

**Table 7-13: Fish and shellfish IEFs in the study area.**

| Important Ecological Features (IEF) | Representative species | Value within the study area | Justification |
|---|---|---|---|
| Local flatfish assemblage | • European plaice<br>• Common dab<br>• European flounder<br>• Common sole<br>• Lemon sole<br>• Brill | Regional | Northern Ireland Priority Species commonly found in the area |
| Local round fish assemblage | • Grey gurnard<br>• Atlantic horse mackerel<br>• Atlantic cod<br>• Pouting<br>• Saithe<br>• Whiting<br>• Haddock<br>• Atlantic mackerel<br>• Angler fish<br>• Ling<br>• Sprat<br>• Herring | Regional | Northern Ireland Priority Species commonly found in the area |

| Important Ecological Features (IEF) | Representative species | Value within the study area | Justification |
|---|---|---|---|
| | • John Dory<br>• European hake | | |
| Migratory fish species | • River lamprey<br>• Sea lamprey<br>• Atlantic salmon<br>• Twaite shad<br>• Sea trout<br>• European eel<br>• Sandeel<br>• Greater sandeel | International | Internationally protected species that are not qualifying features of a candidate or designated European site but are regularly recorded within the study area and/or are OSPAR threatened or declining species |
| Elasmobranchs | • Basking shark<br>• Nursehound<br>• Blackmouth catshark<br>• Small-spotted catshark<br>• Thornback ray<br>• Common skate<br>• Cuckoo skate | National | Internationally protected species that are not qualifying features of a candidate or designated European site but are regularly recorded within the study area and/or are OSPAR threatened or declining species |
| Shellfish | • Brown crab<br>• European lobster<br>• Dublin bay prawn<br>• Brown shrimp<br>• Pink shrimp<br>• Native oyster<br>• Great Atlantic scallop<br>• Queen scallop<br>• Velvet crab<br>• Periwinkle<br>• Whelk<br>• Mussel<br>• Cockle | National | OSPAR threatened or declining species |
| Spawning and nursery habitats | • Atlantic cod<br>• Whiting<br>• Ling<br>• Atlantic mackerel<br>• Spurdog (*Squalidae*)<br>• Skate *spp.*<br>• European hake<br>• Angler fish | National | High intensity spawning, or nursery habitat overlaps the study area |

### 7.3.6 Marine Mammals

Twenty-four species of cetacean and two species of pinniped have been recorded in Irish waters, through incidental sightings, targeted surveys and stranding records (Berrow *et al*., 2010; O'Brien *et al*., 2009). The waters of the north-west of the Irish Sea (see Figure 7-3) regularly support seven species of cetacean, including harbour porpoise (*Phocoena phocoena)*, short-beaked common dolphin (*Delphinus delphis)*, bottlenose dolphin (*Tursiops truncatus)*, killer whale (*Orcinus orca)*, Risso's dolphin (*Grampus griseus*) minke whale (*Balaenoptera acutorostrata)* and humpback whale (*Megaptera novaeangliae)*. Two species of pinniped, the harbour seal (*Phoca vitulina)* and grey seal (*Halichoerus grypus)*, have been recorded in the north-west Irish Sea.

The distribution of these species however varies across the Irish Sea and not all are likely to be present in the wider study area (the study area given in section 7.3.1 plus Block E of SCANS III (see Figure 7-9). Survey Data held by CEDaR for the period 1992 to 2019 (See Appendix G) show that harbour porpoise and harbour seal are the most commonly sighted marine mammals in the study area. During these surveys, other confirmed species sighted were grey seal, bottlenose dolphin, common dolphin, Risso's dolphin, killer whale, minke whale and humpback whale. Based on the maximum water depth in the study area, known species ecology and that in over eighteen years of surveys, humpback and fin whales were only sighted singularly, it is presumed that the study area is unlikely to support larger baleen whales on a regular basis, therefore humpback whale is not considered further in this assessment.

#### 7.3.6.1 Harbour porpoise (Phocoena phocoena)

Harbour porpoise occur in continental shelf waters throughout the North Atlantic from North America to Europe and North-west Africa. In Irish waters, records occur along all coasts, but are thought to be more abundant off the southwest coast (O'Brien, 2016). Harbour porpoise are widely distributed throughout the Irish Sea (Evans *et al*., 2003), and occur in highest densities in the central Irish Sea (O'Brien, 2016). The study area falls within the North Channel SAC, designated for harbour porpoise and identified as an important winter area for this species. The site supports an estimated 1.2% of the UK Celtic and Irish Seas Management Unit (MU) population (DAERA and JNCC, 2017).

Often associated with near-shore headlands and strong tidal currents, porpoise are commonly observed within shallow bays, estuaries and narrow tidal channels (O'Brien, 2016; Pierpoint, 2008; Baines and Earl, 1999). Inshore waters may be important as nursery habitats during summer months. Harbour porpoise need to feed frequently in order to maintain their body temperature and other energy needs. For this reason, porpoise may be highly susceptible to changes in the abundance of prey species or disturbance from foraging areas. Harbour porpoise exhibit diet flexibility, but mainly feed on small shoaling species from demersal or pelagic habitats, including fish, cephalopods and crustaceans (Santos and Pierce, 2003; Aarfjord, 1995).

During marine mammal surveys conducted between 1992 and 2019 (See Appendix G), 584 confirmed sightings of harbour porpoise were recorded within the study area. 101 of those sightings were of individual animals, 156 sightings were of two animals and the remaining groups (416 sightings) ranged from 3 to 70 individuals. The majority of sightings occurred within 4 km of the shore, or around the Maidens rocks area (see Figure 7-3). High concentrations of sightings occurred around Islandmagee, Ballystrudder, Whitehead and the Maidens rocks.

The total harbour porpoise abundance for Block E of the SCANS III abundance estimates covering the study area was calculated as 8,320 (95% Confidence Interval (CI) = 4,643 – 14,354) (Hammond, 2017). The IAMMWG has identified three Management Units (MU) as appropriate for harbour porpoise, of which the study area falls within the Celtic and Irish Seas (CIS) MU which extends from the north west coast of France, to the north west coast of the Republic of Ireland and east from the South west coast of Scotland, including the entirety of Irish waters (see Figure 7-9). The total harbour porpoise abundance for the CIS MU was estimated as 104,695 animals (95% Confidence Interval (CI) = 56,774 to 193,065) (IAMMWG, 2015).

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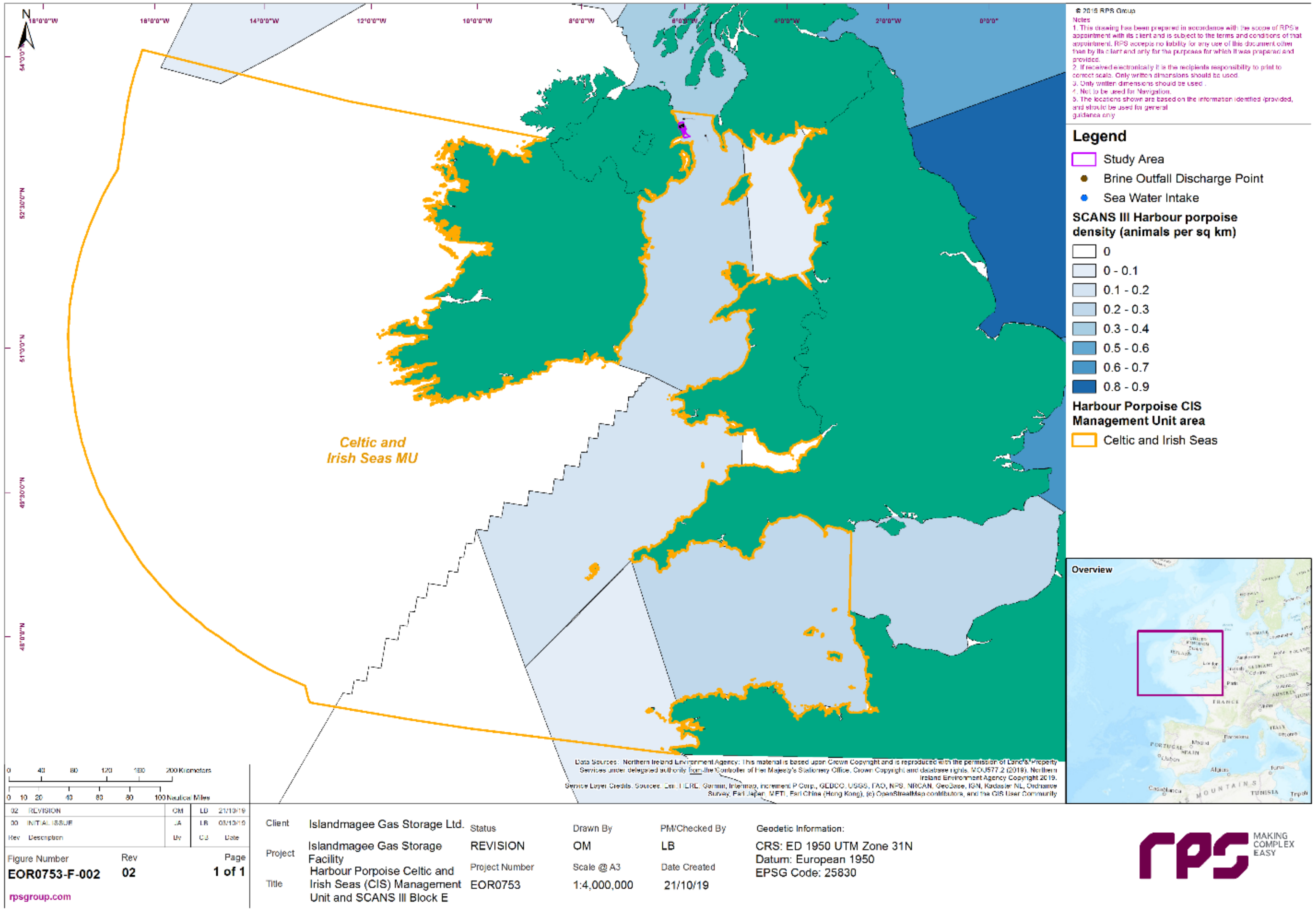


**Figure 7-9: Harbour porpoise management unit and E Block of SCANS III for harbour porpoise.**

### 7.3.6.2 Bottlenose dolphin (*Tursiops truncatus*)

Two large aggregations of bottlenose dolphin, and associated designated areas are found in the UK; one is located in Moray Firth (Moray Firth SAC), and the second is located in Cardigan Bay, Wales (Cardigan Bay SAC) 285 km from the project. Cardigan Bay is an important area for bottlenose dolphin and is occupied by a semi-resident population of approximately 300 individuals which use this area to reproduce, nurture and feed young (NRW, 2018). The number of animals in this region tends to increase throughout the summer and peak in late September/October. Animals from this population are likely to venture throughout the Irish Sea and therefore may occur in the northern Irish Sea and North Channel within which the project is located. There are thought to be at least three distinct populations (determined via genetics, Mirimim *et. al.,* 2011) in Irish waters and each population is thought to associate with distinct habitat types (estuaries, coastal and offshore waters). The coastal population is highly mobile, and individuals have been recorded off all coasts (O'Brien *et al.,* 2009) (estimated at 300-400 individuals throughout its range). This population rarely occurs further than 4 km from the coast. Large groups of over 20 animals have been sighted moving through the North Channel and along the east coast (Berrow, 2016a).

The bottlenose dolphin feeds on a wide range of benthic and pelagic fish species in addition to cephalopods; Typical prey items in UK waters include cod, saithe, whiting, salmon and haddock (Santos *et al*., 2001). Investigations of the feeding habits of bottlenose dolphin in Irish waters reported that this species preys on salmon, garfish *Belone belone*, and eel in estuarine environments, whilst pollock (*Pollachius pollachius*), whiting and saithe have been identified from the stomach contents of stranded animals (O'Brien *et al.,* 2009).

During marine mammal surveys conducted between 1992 and 2019, 81 confirmed sightings of bottlenose dolphin were recorded within the study area. Eight of those sightings were of individual animals, and the remaining groups (73 sightings) ranged from 2 to 100 individuals. The majority of sightings occurred within 3 km of the shore, with 10 sightings occurring outside of this range (furthest sighting 10 km from shore), and sightings were found evenly throughout the coast of the study area.

Data from the SCANS-III surveys estimated a density of 0.008 animals per $km^2$ for this species. Abundance was calculated as 288 (CV=0.57; CI 0-664) animals in Block E, with a mean group size of 1.5 estimated (Hammond *et al.,* 2017). The IAMMWG has identified seven MUs as appropriate for bottlenose dolphin, of which the study area falls within the Irish Sea (IS) MU which occurs to the east of the Republic of Ireland, from south west Scotland to the northern coast of Pembrokeshire (see Figure 7-10). The total bottlenose dolphin abundance for the IS MU was estimated as 397 animals (95% CI = 362 to 414) (IAMMWG, 2015).

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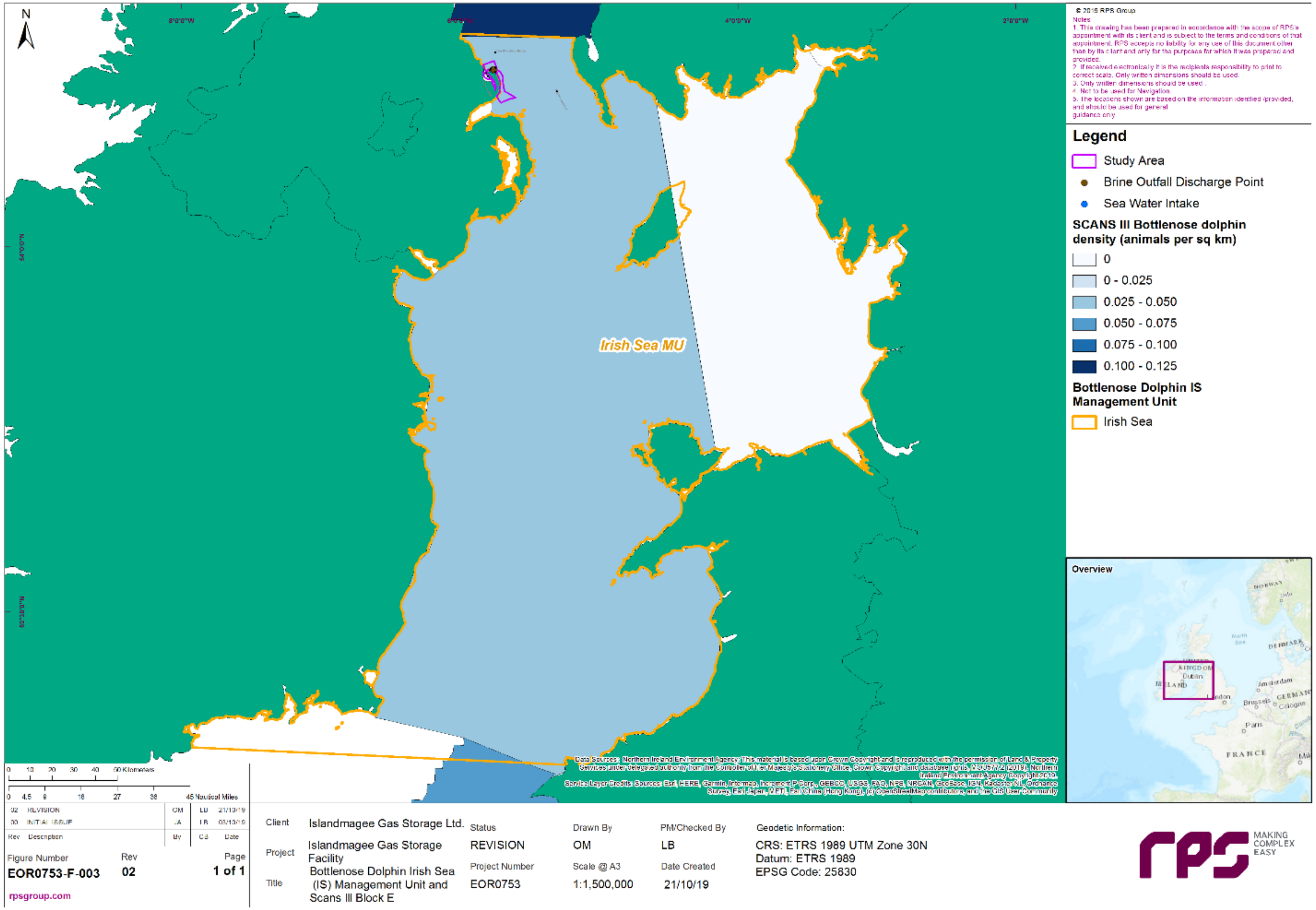


**Figure 7-10: Bottlenose dolphin management unit and E Block of SCANS III for bottlenose dolphin.**

### 7.3.6.3 Common dolphin (*Delphinus delphis*)

Common dolphin are oceanic dolphins, with a pelagic habitat and found throughout the Atlantic seaboard of Europe, in the Western Channel and Irish Sea. This species commonly inhabits continental shelf waters and occurs along the shelf edge and in deep water. The distribution of common dolphin around Irish waters is primarily to the west and south of Ireland, although there are some stranding records from the east coast of Ireland (IDWG, 2010). Common dolphin occasionally visit coastal, shallower waters, presumably in pursuit of prey (Rogan, 2016).

The common dolphin is a small cetacean species found in both neritic and pelagic environments, and exhibits a varied diet which includes mackerel, herring, cod, hake, whiting, sandeel (*Ammodytidae*), and other schooling species (Seawatch Foundation, 2012b).

During marine mammal surveys between 1992 and 2019 there were 11 confirmed sightings of common dolphin (group size range of 1 – 65), with an additional possible 14 sightings (unidentified dolphin) in the study area. Six of the eleven sightings occurred beyond 3 km from shore, with four sightings occurring within 2 km of shore. No obvious seasonality is indicated by these sightings, and no sightings have occurred within the study area since 2014.

There were no sightings of common dolphin recorded in Block E during the SCANS-III surveys (Hammond *et al.,* 2017), or in Block O during the SCANS-II surveys (Hammond *et al.,* 2006). This could be as a result of seasonal changes in distribution; there is likely to be seasonal movements, associated with prey distribution and reproduction (Rogan, 2016). However, occurrence in the study area is likely to be low.

The IAMMWG has identified a single MU as appropriate for short-beaked common dolphin, the Celtic and Greater North Sea (CGNS) MU, which extends from the north of the Shetland Isles, to the west of the Irish landmass, and east to mainland Europe (see Figure 7-11). The project marine mammal study area falls within the CGNS MU. The total common dolphin abundance for the CGNS MU was estimated as 56,556 (CI = 33,014 – 96,920) (IAMMWG, 2015).

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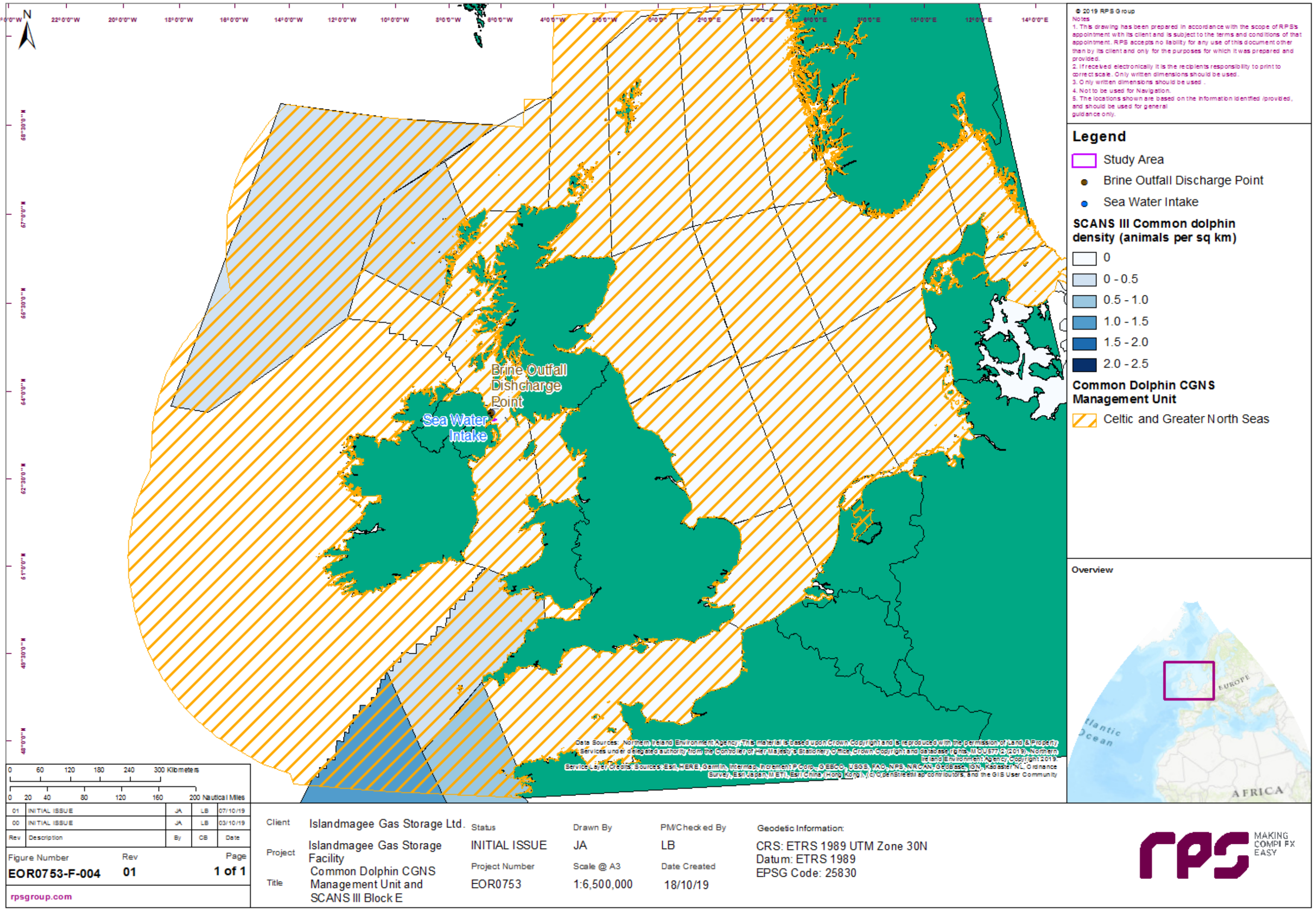


**Figure 7-11: Celtic and Greater North Seas (CGNS) management unit and E Block of SCANS III for common dolphin.**

### 7.3.6.4 Minke whale (Balaenoptera acutorostrata)

The minke whale is the most frequently recorded baleen whale (or mysticete) in British shelf waters (Evans, 2008), including the north Irish Sea. Minke whale have a temporal distribution and are mainly sighted in summer months (peak sightings occurring between June and August (Weir *et al*., 2001, Evans *et al*., 2003); as most minke whale are thought to move out of British waters during the winter in a seasonal migration to offshore or more southerly waters (Hammond *et al.,* 2003; Anderwald and Evans, 2008). Mostly inhabiting continental shelf waters, this species occurs in depths of less than 200 m and can often be seen close to land. Minke whale often forage in areas of upwelling or strong currents around headlands and small islands (Evans *et al*., 2010) and in the eastern North Atlantic, feed on a wide variety of prey species including herring, cod, capelin (*Mallotus villosus*), haddock, saithe and sandeel (Haug *et al.,*1995).

In Irish waters, the minke whale is widely distributed but is most commonly seen along the south coast, with localised patches in the central Irish Sea (Reid *et al.,* 2013; Rogan *et al.*, 2018). There is a distinct seasonal distribution of minke whale with animals moving inshore during the summer months and offshore during winter months.

During marine mammal surveys between 1992 and 2019 there were 21 confirmed sightings of minke whale in the study area. Fourteen of these sightings were of individual animals, with the remaining groups ranging from 2 to 5 individuals. The nearest sighting to shore was less than 1 km and the furthest from shore was 14 km. Sightings were relatively spread out within the study area. The majority of sightings occurred in the months of June and July, with a singular sighting in May and a singular sighting in October, corroborating the idea that minke whale move out of British waters in winter months.

In SCANS-III Block E (see Figure 7-12), the density estimate was similar to that estimated using the OBSERVE aerial data, with 0.017 animals per $km^2$ calculated for this block. The total abundance for Block E was estimated as 603 animals (CV=0.62; 95% CI: 134-1753).

The IAMMWG has identified a single MU as appropriate for minke whale, the CGNS MU, which extends from the north of the Shetland Isles, to the west of the Irish landmass, and east to mainland Europe (see Figure 7-12). The project marine mammal study area falls within the CGNS MU. The total minke whale abundance for the CGNS MU was estimated as 23,528 animals (95% CI = 13,989 to 39,572) (IAMMWG, 2015).

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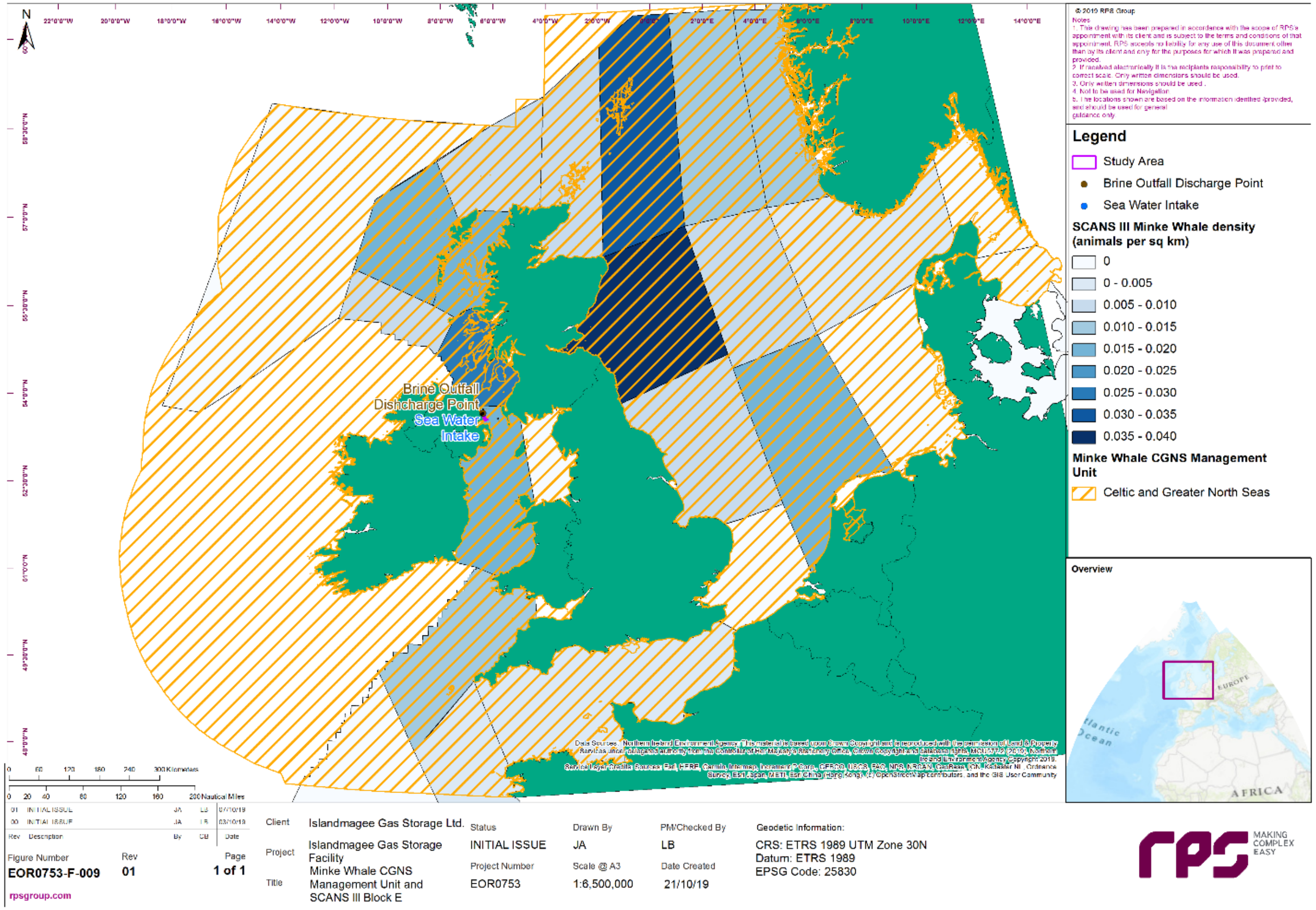


**Figure 7-12: Celtic and Greater North Seas (CGNS) management unit and E Block of SCANS III for minke whale.**

### 7.3.6.5 Risso's dolphin (*Grampus griseus*)

Risso's dolphin has a worldwide distribution in temperate and tropical oceans with a preference for steep shelf-edge habitat. Risso's dolphin are recorded in low numbers in Irish waters in all seasons, and in a variety of habitats. Around the coast of Ireland, sightings of this species are recorded in inshore waters, but most are recorded in deeper waters over the continental shelf and slope (Rogan *et al*., 2018). Highest abundance appears to be off the south-west and south-east coasts (Berrow, 2016b; Reid *et al*., 2003).

Calves are often recorded closer to the coast suggesting that calving occurs within the warmer inshore waters. In addition, repeated sightings of the same individuals suggest some degree of site fidelity may occur. For example, photoidentification studies of Risso's dolphin from the eastern Irish sea showed indications of residency of identified individuals to a particular region (Felce, 2012). Diet comprises octopus (*Octopus vulgaris*), cuttlefish (Sepiida) and small bottom-dwelling squid (Loliginidae) (Reid *et al*., 2003).

Marine mammal surveys between 1992 and 2019 identified nine sightings of Risso's dolphin within the study area (group size range = 1 to 15; mean group size = 4), with the majority of sightings occurring in winter months, and two sightings occurring in summer months. All but one sighting occurred within 3 km of shore, with the remaining sighting occurring 4 km from shore, to the south of the Maidens. The most recent sightings occurred in July 2019.

The total abundance of Risso's dolphin in the entire European shelf survey area was calculated as 27,025.5, based on the SCANS III abundance estimate of 11,069 (95% CI = 2,794 – 24,412) and season four of the Irish OBSERVE program abundance estimate of 738.5 (95% CI = 349.3 – 1561.2) (based on corrected design-based estimates (Rogan *et. al.,* 2018).

The IAMMWG has identified a single MU as appropriate for Risso's dolphin, the CGNS MU, which extends from the north of the Shetland Isles, to the west of the Irish landmass, and east to mainland Europe (see Figure 7-13).

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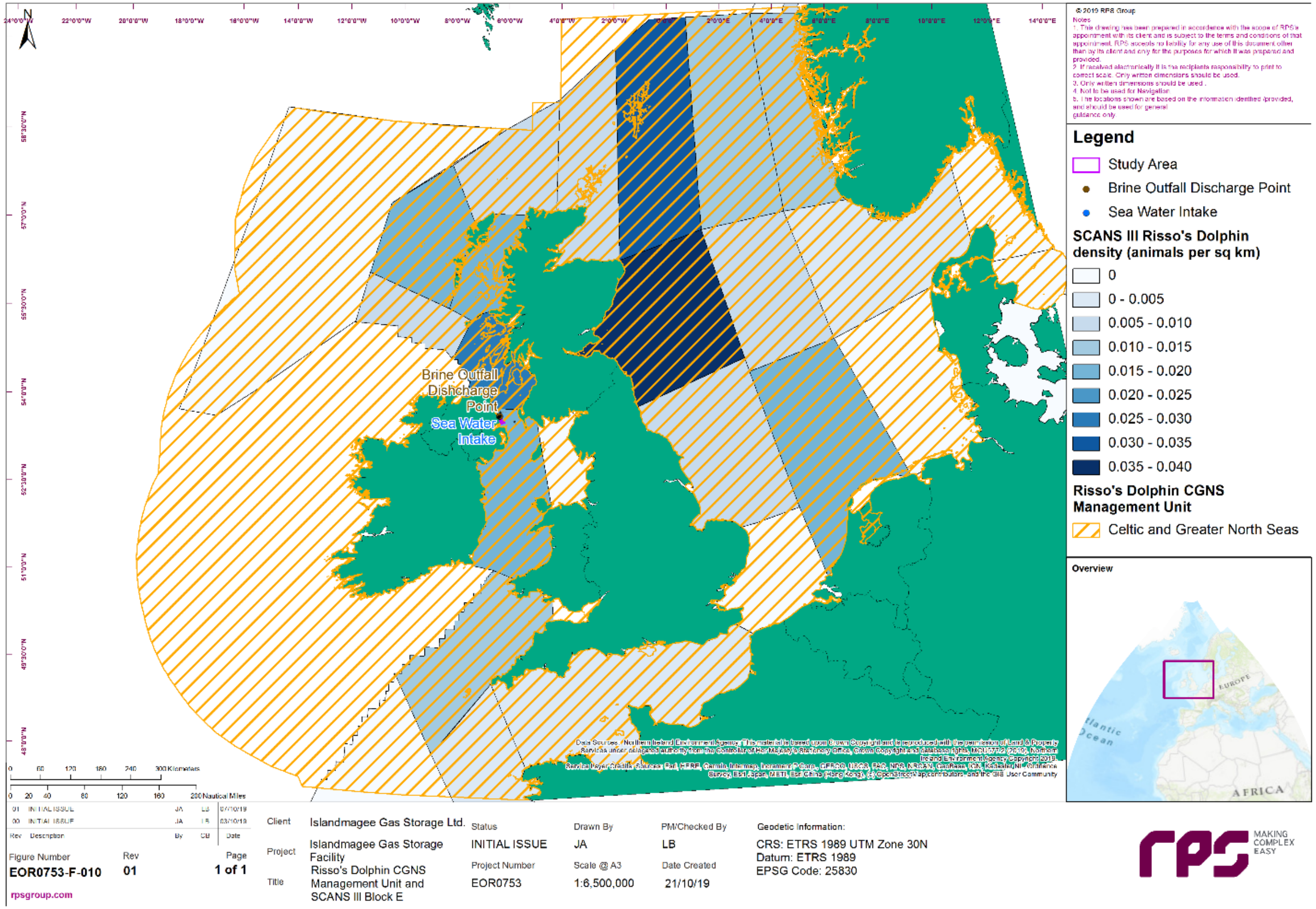


**Figure 7-13: Celtic and Greater North Seas (CGNS) management unit and E Block of SCANS III for Risso's dolphin.**

### 7.3.6.6 Killer whale (*Orcinus orca*)

In UK and Irish waters, killer whale are most commonly found in northern and western Scotland. At least two populations are thought to occur in Irish waters, one of which has a range which is likely connected to those animals frequenting western Scotland, and its range includes the waters around Ireland and the southwest coast of Wales. This population is known to feed on marine mammals, particularly harbour porpoise, which may influence its occurrence in near-shore waters. Killer whale are not permanent residents in Irish waters and therefore sightings are considered rare; the species is therefore difficult to census (Pinfield and Foote, 2016).

Marine mammal surveys between 1992 and 2019 identified eight sightings of killer whale within the study area (group size range = 2 to 10; mean group size = 4), with no obvious patterns of seasonality. Three of the sightings occurred within the same week in 2002, and no sightings within the study area have occurred since 2015.

### 7.3.6.7 Grey seal (Halichoerus grypus)

The coast of the UK supports 38% of the World's grey seal (SCOS, 2017). While grey seals are known to travel up to 2,100 km on foraging trips, most foraging trips remain within 145 km from haul-out sites (SCOS, 2015). Seals are highly mobile and feed mainly at the benthos in shelf seas (Thompson, 2012; Chen *et al.,* 2016). Compared with other times of the year, grey seal in the UK spend longer hauled out during their annual moult (between December and April) and during their breeding season (between August and December) (SCOS, 2017).

They are generalist feeders, foraging mainly on the sea bed at depths of up to 100m although they are probably capable of feeding at all the depths found across the UK continental shelf. They take a wide variety of prey including sandeels, gadoids (cod, whiting, haddock, ling), and flatfish (plaice, sole, flounder, dab). Amongst these, sandeels are typically the predominant prey species. Diet varies seasonally and from region to region. Food requirements depend on the size of the seal and fat content (oiliness) of the prey, but an average consumption estimate of an adult is 4 to 7 kg per seal per day depending on the prey species.

During surveys conducted between 2000 and 2018, 50 sightings of grey seal were identified within the study area. All sightings within the study area occurred during July and August, where grey seal were sighted at the Maidens rocks (8 km from the project). No sightings occurred during winter and spring months when grey seals would likely be hauled out during moulting and breeding seasons. This data implies that the study area is not an important breeding area for grey seals.

Aerial surveys carried out by DAERA/SMRU in August of 2018 (Morris and Duck, 2019) (and previously in 2011 and 2002) confirm that the Maidens Rocks and the southern end of Larne Lough (9 km from the project) are used by grey seals for hauling out (see Figure 7-14).

### 7.3.6.8 Harbour seal (*Phoca vitulina*)

Areas of particular importance for harbour seal in Irish waters are the south and west of Ireland (particularly Galway Bay) and the northwest coast of Ireland (Cronin *et al.,* 2003). Information on harbour seal distribution is provided in the SMRU harbour seal at-sea usage maps published by Marine Scotland[5]. These maps are based on seals tagged in UK waters and therefore may under represent the seals in Ireland, however they indicate that harbour seal are most likely to occur in the northwest Irish Sea, with smaller colonies in north county Dublin and off the southeast coast (County Wexford)

Harbour seal breed in small groups scattered along the coastline. Pups are born in June and July having moulted their white coats prior to birth. This allows harbour seal pups to swim within a few hours of birth (Burns, 2002). During lactation, females spend much of their time in the water with their pups, and although they will forage during this period, distances travelled at this time are more restricted than during other periods (Thompson *et al.,* 1994). Following the spring/summer breeding and nursing season, the annual moult of harbour seal in Ireland occurs from late July through August.

Harbour seal are generalist feeders and their diet varies both seasonally, and from region to region (Hammond *et al.,* 2001). Analyses of seal scat in Ireland has demonstrated that a wide variety of prey items are exploited by harbour seal (Wilson *et al.,* 2002). These includes species from the surface, mid-water and benthic habitats including sandeels; whitefish; herring; sprat; common octopus; and squid (SCOS, 2010). Gadoid fish (whiting, pollack and haddock) are key prey species of harbour seal with pouting contributing to the largest proportion of diet by weight (Kavanagh *et al.,* 2010). Harbour seal foraging distance from haul-out sites is much smaller than that of grey seal; feeding normally within 40-50 km from haul out sites (Thompson *et al.,* 1996).

During surveys conducted between 2000 and 2018, 67 sightings of harbour seal were identified within the study area. Sightings within the study area occurred during all months of the year, with the majority of seals being sighted at the Maidens. All but one of the sightings within Larne Lough (see Figure 7-3) occurred during August and September, during which time most harbour seal pups are born. This implies that Larne Lough acts as a breeding site for harbour seal. The nearest designated site for harbour seal is Strangford Lough, located 65 km from the project site (swimming distance).

Aerial surveys carried out by DAERA/SMRU in August of 2018 (Morris and Duck, 2019) (and previously in 2011 and 2002) confirm that the Maidens Rocks and the southern end of Larne Lough (9 km from the project) are used by harbour seals for hauling out (see Figure 7-15), however the Maidens Rocks appear to be utilised less frequently than for grey seals.

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[5] http://marine.gov.scot/information/seal-usage-maps

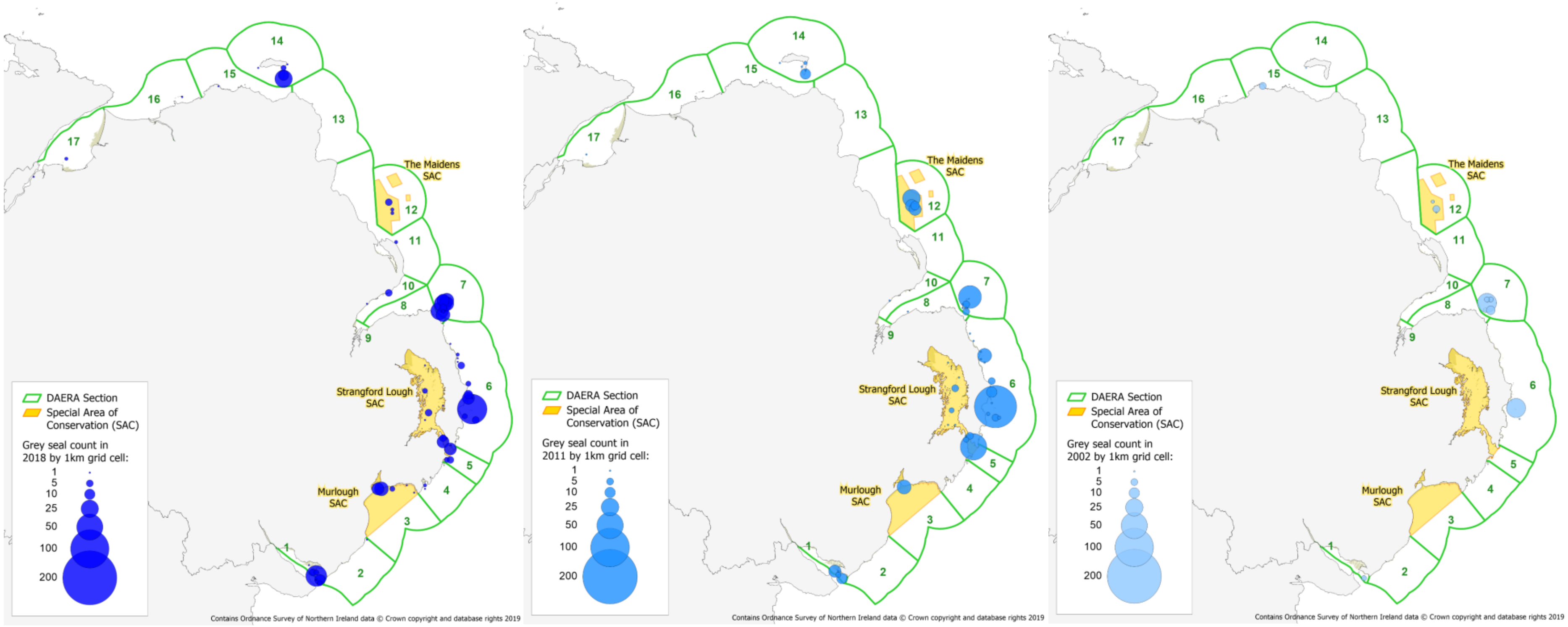


**Figure 7-14: Distribution of grey seal, by 1 km squares in Northern Ireland in (A) 2018, (B) 2011 and (C) 2002 (Morris and Duck, 2019).**

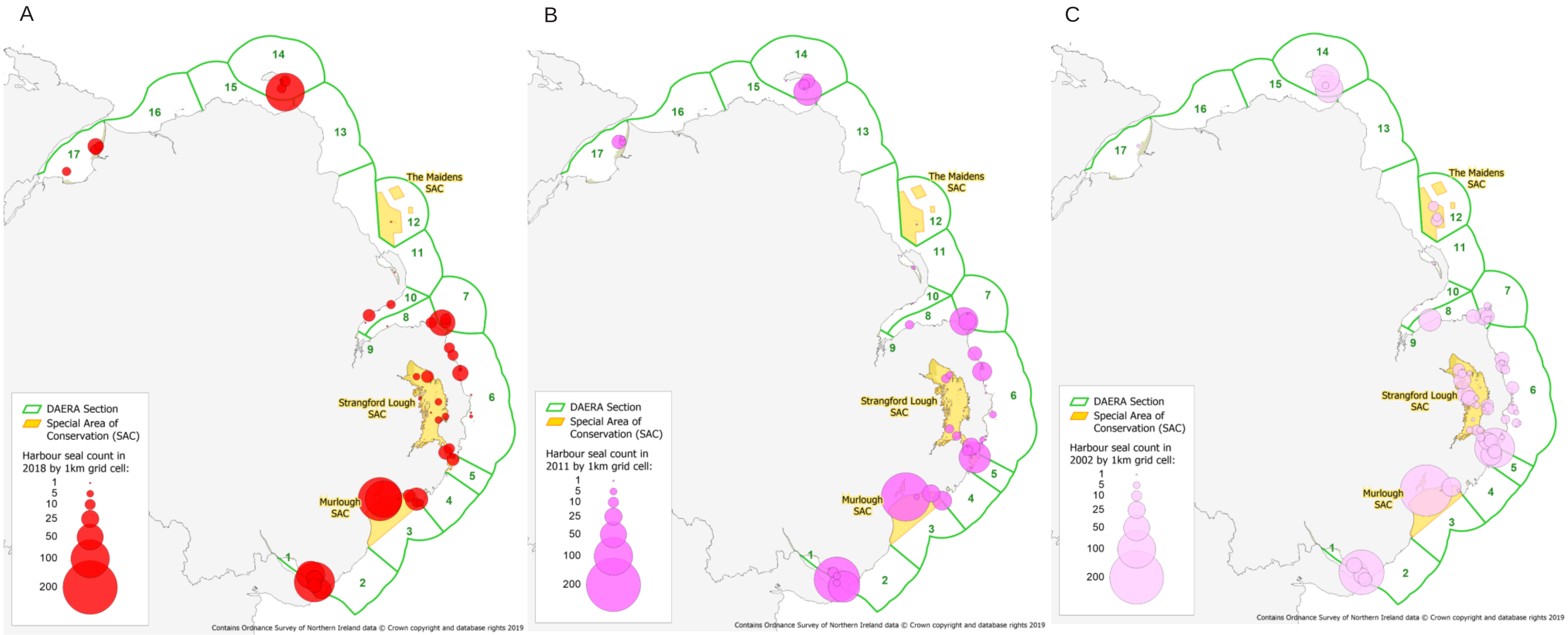


**Figure 7-15: Distribution of harbour seal, by 1 km squares in Northern Ireland in (A) 2018, (B) 2011 and (C) 2002 (Morris and Duck, 2019)**

### 7.3.6.9 Comparison with data presented in the original Environmental Statement

Baseline data presented in the original ES (RPS, 2010) and ES Addendum (RPS, 2011) were informed by five marine mammal survey days in a dedicated survey vessel, in addition to incidental sightings data from the IWDG website (2000 - 2009).

The surveys carried out in 2009 used a targeted approach, based on likely locations of harbour porpoise, as opposed to a line transect method. No other cetacean species were located during these surveys, likely as a result of the harbour porpoise/seal-biased survey method. A single sei or minke whale was observed incidentally in July 2009, from the same survey boat. The sightings data provided by IWDG identified harbour porpoise as the most commonly sighted cetacean. Other species identified included common dolphin and bottlenose dolphin.

However, IWDG sightings data available between 1992 – 2019 (See Appendix G) show that within a similar study area Risso's dolphin, killer whale and minke whale have also been sighted (some of these sightings occurred prior to 2009, but were not identified in the original ES). As such, based on desktop studies, this document assesses these additional species as likely occurring within the wider study area.

The original ES identified that harbour porpoise are likely to be present year-round in the study area, with concentrations in the tidal race areas around the Maidens and to the seawards side of the Isle of Muck. Data available corroborates this. That all other species were likely to be transients to the area is corroborated by current knowledge and up to data sightings data.

The original ES identified the Maidens and Larne Lough as being important haul-out areas for both grey and harbour seals, which is corroborated by aerial surveys conducted in 2011 and 2018 by SMRU. The original ES also identified that no coastal SACs sites had been designated for harbour porpoise and recommended that the area around the Maidens/Islandmagee should be considered; since then the Maidens SAC (designated for grey seal) and the North Channel SAC (designated for harbour porpoise) have been implemented.

### 7.3.6.10 Important Ecological Features (IEF)

**Table 7-14: Marine mammal IEFs in the study area.**

| Important Ecological Features (IEF) | Value within the study area | Justification |
|---|---|---|
| Harbour porpoise | International | Annex II species protected under international legislation and designated feature of North Channel SAC, Skerries and Causeway SAC |
| Bottlenose dolphin | International | Annex II species protected under international legislation and designated feature of Cardigan Bay SAC |
| Common dolphin | National | Internationally protected species regularly sighted in the wider study area |
| Minke whale | National | Internationally protected species regularly sighted in the wider study area |
| Risso's dolphin | Regional | Internationally protected species occasionally sighted in the wider study area |
| Killer whale | Regional | Internationally protected species occasionally sighted in the wider study area |

| Important Ecological Features (IEF) | Value within the study area | Justification |
|---|---|---|
| Grey seal | International | Annex II species protected under international legislation and designated feature of The Maidens SAC |
| Harbour seal | International | *Annex II species protected under international legislation and designated feature of* Strangford Lough SAC (Qualifying) and Murlough SAC (Qualifying) |

### 7.3.7 Birds

There are 185 regularly occurring bird species in Ireland (Colhoun and Cummins, 2013), twenty of which are seabirds known to regularly breed in Northern Ireland (Booth Jones and Wolsey, 2019). Additional species which breed outside Northern Ireland are recorded during foraging trips, overwintering or on migration. Only species listed as feature species from designated sites (see Table 7-9 above), which have potential foraging ranges which overlap with the zone of influence are discussed here.

#### 7.3.7.1 Manx Shearwater (Copeland Island SPA)

A highly oceanic species, manx shearwater (*Puffinus puffinus*) spend most of the year at sea, only coming ashore during the breeding season under the cover of darkness to avoid predators such as large gulls. Nesting in burrows, pairs lay a single egg which takes approximately seven weeks to incubate.

More than 90% of the Irish manx shearwater population breed at fewer than 10 sites, and as such the species is an amber listed bird of conservation concern. It is also a Schedule 1 species on the Wildlife (NI) Order, meaning there are special penalties in place for disturbing them during the breeding season.

Manx shearwater diet consists of small fish, plankton, molluscs, crustaceans, cephalopods and offal taken near the surface.

The population on the Copeland Islands stood at 4,850 pairs in 2007, the only confirmed extant colony in Northern Ireland. Tracking studies from the Copeland Island population has shown that birds typically foraged within 100-120 km of the colony, with foraging hotspots between the east coast of Isle of Man and the Scottish coast, as well as the Firth of Clyde, around the Isle of Arran (Leonard and Wolsey, 2014).

#### 7.3.7.2 (Northern) Gannet (Ailsa Craig SPA)

An oceanic species, northern gannet (Morus bassanus) spend most of the year at sea, only coming ashore during the breeding season. Breeding in colonies on offshore islands, the UK population is concentrated in northern Scotland, with the largest colony at St. Kilda in the Outer Hebrides. Within the Irish Sea, colonies are to be found at Ailsa Craig, off Girvan in Scotland and Ireland's Eye, off Howth in Co. Dublin.

Gannet feed by plunge-diving into the sea from heights of between 10-40 m either singly or in groups. The maximum recorded foraging depth is 34 m, and the mean foraging depth is 8.8 m. They are effective scavengers for discards and can outcompete smaller species. They regurgitate food for their chicks. They eat mid-sized schooling fish and squid (generally 2 – 30 cm in length) as well as fish discarded by fishing boats. Gannet feed in inshore and offshore continental shelf waters, with the foraging range varying between colonies and with the season. They can travel long distances on foraging trips. The mean foraging range is 140 km, with a maximum foraging distance of 600 km recorded (Natural England, 2012a).

#### 7.3.7.3 (Black-legged) Kittiwake (Rathlin Island SPA & Ailsa Craig SPA)

An oceanic gull, the black legged kittiwake (*Rissa tridactyla*) is primarily a summer visitor to our shores, spending the winter months in the north Atlantic. The preferred nest site are ledges on steep sea cliffs, where a nest of mud, grass and seaweed is constructed.

The largest colony in Northern Ireland is found on Rathlin Island, with smaller colonies on Isle of Muck and The Gobbins. An amber listed bird of conservation concern in Ireland, due to its localised breeding population.

Kittiwake feed by dipping from the surface, chiefly on marine fish and invertebrates, although they are also known to scavenge on waste from fishing vessels.

#### 7.3.7.4 Mediterranean Gull (Larne Lough SPA)

After first breeding in Northern Ireland in 1995, the breeding population of Mediterranean gull (Larus melanocephalus) in Northern Ireland is still relatively low, with 14 apparently occupied nest (AON) recorded in 2018 (Booth Jones and Wolsey, 2019). Five of these were recorded at Larne Lough. Due to the low Irish breeding population, which is confined to a small number of sites, the species is amber-listed in Birds of Conservation Concern in Ireland. Similar to black-headed gull, the species breed in colonies and are opportunistic feeders with a varied diet.

#### 7.3.7.5 Herring Gull (Ailsa Craig SPA)

The population of herring gull (Larus argentatus) on Ailsa Craig, approximately 60 km north-east of the site, stood at 2,250 pairs at the time of designation in 2009. In Northern Ireland, the largest colonies are found on the Copeland Islands (418 AON in 2018) and Strangford Lough (1,061 AON in 2018). There are smaller breeding populations at Rathlin Island, Burial Island, Isle of Muck and The Skerries (Booth Jones and Wolsey, 2019).

Tracking studies conducted on the Copeland Islands populations show that during the breeding season, birds tend to forage to the west and south (Leonard and Wolsey, 2016) and therefore the survey area is not an important feeding area for herring gull from the Copeland Islands.

#### 7.3.7.6 Lesser Black-backed Gull (Ailsa Craig SPA)

Primarily a summer visitor to Northern Ireland, the lesser black-backed gull (Larus fuscus) is a widespread breeding species. Mainly confined to large colonies at Strangford Lough, Copeland Islands, Lower Lough Erne and Lough Neagh, smaller numbers can be found at Rathlin Island, The Skerries and Muck Island. Urban roof nesting is widespread in Belfast and there is also a colony in Antrim town (Booth Jones and Wolsey, 2019). The population on Ailsa Craig, approximately 60 km north-east of the site, was 1,800 pairs at time of designation in 2009.

Studies have shown that lesser black-backed gull can routinely fly 40–80 km from breeding colonies to find food (Camphuysen et al., 2010) and can travel over 150 km in a single foraging trip (Thaxter et al., 2011).

### 7.3.7.7 Sandwich Tern (Larne Lough SPA)

Sandwich tern (Thalasseus sandvicensis) are colonial, ground-nesting birds, often found alongside black-headed gull. Colonies are present in Larne Lough and at Cockle Island, Belfast Lough.

They are an amber listed bird of conservation concern in Ireland and Schedule 1 species on the Wildlife (NI) Order, meaning there are special penalties in place for disturbing them during the breeding season.

Sandwich tern feed mainly on small fry which are caught by diving, usually from a greater height than other tern species. Tracking studies have shown that sandwich tern mainly feed close to their breeding colonies, however, they can range over >40 km when foraging for food (Leonard and Wolsey, 2015) with a mean maximum foraging range of 49 km (Natural England, 2012f).

Previous surveys and tracking data showed that tern species tended to avoid the area identified as the potential zone of influence of the brine outfall for feeding (Wilson et al, 2014).

### 7.3.7.8 Roseate Tern (Larne Lough SPA)

As with other tern species found in Northern Ireland, roseate tern (Sterna dougallii) are long-distance migrants, wintering off west Africa. The only known breeding pair in Northern Ireland are to be found at Larne Lough (Booth Jones and Wolsey, 2019).

They specialise in small shoaling fish, particularly sandeels, with a less varied diet than other tern species. They very occasionally feed on small crustaceans. Roseate tern tend to forage over sandy substrates, utilising shallow waters and areas of upwelling, including tidal rips and shoals. The mean of all the maximum foraging ranges recorded by different studies is c.16.5 km (Natural England, 2012g).

### 7.3.7.9 Common Tern (Larne Lough SPA)

The common tern (*Sterna hirundo)* nests in colonies on the ground and regularly breeds at inland, freshwater sites as well as coastal, marine habitats. They are amber listed in Birds of Conservation Concern in Ireland and are a Schedule 1 species on the Wildlife (NI) Order, meaning there are special penalties in place for disturbing them during the breeding season. The most widespread breeding tern species in Northern Ireland with coastal and inland populations. Significant numbers breed at several sites on Lough Neagh, with their main coastal sites at Strangford Lough, Larne Lough, Belfast Lough and Carlingford Lough.

Common tern feed mainly on small fish caught by plunge diving which are swallowed immediately upon resurfacing, unless intended for mate or young.

Previous surveys and tracking data showed that tern species tended to avoid the area identified as the potential zone of influence of the brine outfall for feeding (Wilson et al, 2014).

### 7.3.7.10 Arctic Tern (Larne Lough SPA and Outer Ards SPA)

Arctic tern (Sterna paradisaea) are the commonest tern breeding in the UK. In Northern Ireland the species is concentrated into just a few colonies including the Copeland Islands, Strangford Lough, Belfast Harbour, Bird Island, Green Island and Cockle Island.

### 7.3.7.11 (Common) Guillemot (Rathlin Island SPA and Ailsa Craig SPA)

One of the most abundant seabirds in Britain and Ireland, common guillemot (*Uria aalge*) are highly gregarious with colonies tens of thousands strong. Nesting on ledges on steep sea-cliffs, a single egg is laid directly onto the rock.

Amber listed in Birds of Conservation Concern in Ireland, as the majority of the population breed at less than ten sites. Rathlin is considered to be the largest colony in Britain and Ireland with 130,445 individuals recorded in 2011. At the time of SPA designation, the number was 41,887.

As with razorbill (*Alca torda;* see section 7.3.7.12 below), their diet is almost entirely fish, with some invertebrates, caught mainly by surface-diving although they are also known to "crash-land" on shoals of fish near the surface. Unlike razorbill, they are often seen feeding by swimming in lines and occasionally surrounding shoals of fish.

After breeding, adult guillemot go into moult and become flightless for approximately 45-60 days (Birkhead and Taylor, 2008). The male will accompany fledged juveniles, which are also unable to fly, feeding the chick at sea.

Guillemot was the most commonly recorded species with 553 individuals observed during the site specific survey. This is not surprising given the proximity to breeding colonies on Isle of Muck and The Gobbins where, during 2018, the populations stood at 2,478 and 2,284 individuals respectively (Booth Jones and Wolsey, 2019). The vast majority (i.e. 91%) of observations (n. 503) were of loafing birds. Only 46 (8.3%) of birds were observed foraging within the survey area. The mean foraging range for Guillemot is 24 km from the colony (Natural England, 2012b).

### 7.3.7.12 Razorbill (Rathlin Island SPA & Ailsa Craig SPA)

A highly marine species, razorbill are only seen onshore during the breeding season. Nesting in colonies on steep sea-cliffs, a single egg is laid directly onto the rock. A burrow is sometimes used.

Amber listed in Birds of Conservation Concern in Ireland as the majority of the population breed at less than ten sites. Rathlin is considered to be the largest colony in Britain and Ireland with 22,975 individuals recorded in 2011. At the time of SPA designation, the number was 8,922.

Their diet is almost entirely fish, with some invertebrates, caught mainly by surface-diving although they are also known to "crash-land" on shoals of fish near the surface. They have a more restricted foraging range than guillemot, with a mean foraging range of 10 km (Natural England, 2012c).

As with guillemot, they become flightless during post-breeding moult (Natural England, 2012b) and the proximity of the survey area to the breeding colonies at Isle of Muck and The Gobbins is reflective in the fact that 90.7% (n. 108) of observations were of loafing birds.

The 2018 population at Isle of Muck (736 individuals) and number of birds recorded at The Gobbins (882 individuals) was a 57.5% increase on 2017 (Booth Jones and Wolsey, 2019).

### 7.3.7.13 Important Ecological Features (IEF)

**Table 7-15: Bird IEFs in the study area.**

| Important Ecological Features (IEFs) | Value within the study area | Justification |
|---|---|---|
| Manx shearwater | National | Schedule 1 species protected under national legislation and features species of Copeland Islands SPA |
| Gannet | International | Feature species of Ailsa Craig SPA |
| Kittiwake | International | Feature species of Ailsa Craig SPA and Rathlin Island SPA |
| Mediterranean gull | International | Annex II species protected under international legislation and feature species of Larne Lough SPA |
| Herring gull | International | UK BAP species and feature species of Ailsa Craig SPA |
| Lesser black-backed gull | International | Feature species of Ailsa Craig SPA |
| Sandwich tern | International | Annex II species protected under international legislation and feature species of Larne Lough SPA |
| Roseate tern | International | Annex II species protected under international legislation and feature species of Larne Lough SPA |
| Common tern | International | Annex II species protected under international legislation and feature species of Larne Lough SPA |
| Arctic tern | International | Annex II species protected under international legislation and feature species of Copeland Islands SPA and Outer Ards SPA |
| Guillemot | International | Feature species of Ailsa Craig SPA and Rathlin Island SPA |
| Razorbill | International | Feature species of Rathlin Island SPA |

## 7.4 Scoping

Table 7-16 below provides a summary of the impacts scoped out for further assessment for each receptor topic, including a brief justification.

**Table 7-16: Summary of receptor impacts scoped out for further assessmen addressing the three impacts discussed and agreed with DAERA (letter dated 5 July 2019).**

| Impact | Receptor | Justification |
|---|---|---|
| Underwater noise emissions from construction of intake and outfall | Plankton (excluding fish larvae) | No impact-receptor pathway and therefore scoped out for further assessment. |
| | Benthic communities | No impact-receptor pathway and therefore scoped out for further assessment. |
| | Shellfish | No impact-receptor pathway and therefore scoped out for further assessment. |
| | Fish (including larvae) | Impact-receptor pathway therefore scoped in for further assessment. |
| | Marine mammals | Impact-receptor pathway therefore scoped in for further assessment. |

| Impact | Receptor | Justification |
|---|---|---|
| | Birds | No impact-receptor pathway and therefore scoped out for further assessment. |
| Effects on marine ecology receptors associated with the discharge of during operation of the outfall | Plankton | Plankton receptors could be located within the boundary of the potential impact therefore scoped in for further assessment. |
| | Benthic communities:<br>• Annex I habitat - *Sandbanks which are slightly covered by sea water all the time* in The Maidens SAC;<br>• Annex I habitat - *Reefs* in The Maidens SAC;<br>• Benthic subtidal habitat A;<br>• Benthic intertidal | These communities / habitats are located > 100 m from the outfall. Potential impacts are highly localised (< 100 m from outfall) therefore scoped out for further assessment. |
| | Benthic communities:<br>• Benthic subtidal habitat B | This habitat is located within 100 m of the outfall, within the boundary of potential impact therefore scoped in for further assessment. |
| | Fish and shellfish | Fish and shellfish receptors could be located within the boundary of the potential impact therefore scoped in for further assessment. |
| | Marine mammals | Highly localised impact (< 100 m from outfall) therefore scoped out for further assessment. |
| | Birds | No impact-receptor pathway and therefore scoped out for further assessment. |
| Effects on marine ecology receptors from entrainment and impingement associated with the operation of the intake | Plankton | Free-moving receptors which could be found within range of the potential impact therefore scoped in for further assessment. |
| | Benthic communities | Sessile communities therefore no impact-receptor pathway for further assessment. |
| | Fish and shellfish | Free-moving receptors which could be found within range of the potential impact therefore scoped in for further assessment. |
| | Marine mammals | The diameter of the outfall pipe is 450 mm and the flow of water is calculated to be < 0.1 m/s (equal to the lowest expected tidal velocity) therefore marine mammals are too large to be entrained and too agile to be impinged therefore scoped out for further assessment. |
| | Birds | No impact-receptor pathway and therefore scoped out for further assessment. |

## 7.5 Remedial and Mitigation Measures

A grill, with a mesh diameter of 12 mm, across the intake will be installed to prevent, in particular, European eel and salmonid smolts from being entrained. This mitigation has been guided by the Environment Agency Eel Manual, Screening at intakes and outfalls: measures to protect eels (Sheridan et al., 2011). Whilst this is not a required commitment, given that the project is not located within or near to an estuary, this would represent good practice; as a grill following these guidelines is likely to not only to prevent entrainment of eels but other fish of a similar size such as salmonids.

As highlighted in Chapter 3, the outfall pipe will comprise of two diffuser ports pointing vertically upwards and fitted with duckbill diffuser valves to maximise the dispersion and mixing of discharged brine.

## 7.6 Construction Impacts

### 7.6.1 Effects on marine ecology receptors associated with underwater noise emissions from construction of intake and outfall infrastructure

#### 7.6.1.1 Fish Ecology and Plankton

Noise produced as a result of tunnelling, excavation and drilling for the intake and outfall has the potential to generate underwater noise, which may result in effects on fish and plankton receptors found within the study area.

**Magnitude**

The main source of noise during the construction phase will come from the construction of the intake and outfall pipes on the seabed. The construction of these assets requires the use of heavy machinery. Noise from tunnelling, excavation and directional drilling will represent worst-case noise events during construction. Any other construction activities will be of short duration and have a lower impact in terms of noise. The construction of the intake and outfall pipes will be undertaken over an estimated 6-month period. The nature of the construction activities (i.e. tunnelling, excavation and directional drilling on/below the seabed) indicates that the type of noise generated will be non-impulsive noise. The noise will be confined to a geographically-small area i.e. the immediate vicinity of the construction activities. Drilling and tunnelling are intermittent activities and will operate at full noise output for less than half of the overall construction time (3 months).

The worst-case underwater noise emission is when the reception pit is being excavated . There are limited data on underwater noise from mechanical (backhoe) operations. Reine *et al* (2014) provide a source level for rock excavation at 164.2 to 179.4 decibels (dB) re 1 micropascal (µPa) @ 1 m. The excavation of the pit and recovery of the tunnel boring machine are estimated to take 18 days and worst-case noise levels will be limited to a fraction of this time. For drilling, the worst-case noise level will be as the drill breaks through the seabed. The root mean square (rms) drilling noise level at this point is estimated to be 120 dB re 1 µPa @ 1 m. Table 7-17 shows the extent, duration and noise levels of construction activities.

**Table 7-17: Estimated maximum noise levels and durations associated with key construction activities.**

| Construction Activity | Extent/Duration | RMS Noise Levels<br>dB re: 1μPa @ 1m (unweighted) |
|---|---|---|
| Construction of gas storage caverns (pumps based on land) | 22 months per cavern | No significant noise |
| Construction of intake (Micro-tunnel boring and excavation) | 6 months | 179<br>(excavator ripping rock) |
| Construction of outfall (Horizontal Directional Drilling) | 6 months | 120<br>(HDD at seabed) |
| Operation phase (small vessel traffic for site inspections and sampling) | Ongoing occasional | 150-155 |

The impact is therefore expected to be of short-term duration and intermittent, reversible and localised. The magnitude of the impact is therefore considered to be low.

### Sensitivity

Mortality and impairment

Sound plays an important role in fish, allowing them to communicate with one another, detect predators and prey, navigate their environment, and avoid hazards.

Recent peer reviewed guidelines have been published by the Acoustical Society of America (ASA) and provide directions and recommendations for setting criteria (including injury and behavioural criteria) for fish. Tunnelling, excavation and drilling are considered continuous noises, and according to Popper (2014) (see Table 7-18) are unlikely to cause mortality in any hearing groups of fish, eggs and larvae. Recoverable injury is considered low risk for all groups, other than those fish with swim bladders which are involved in hearing, where recoverable injury is considered possible at 170 dB root mean square (rms) for 48 hours (see Table 7-18). This however is based on a fish of this group being exposed to drilling noise continuously over a period of 48 hours. Temporary Threshold Shift (TTS) is shown to have a moderate risk to all fish groups within the near vicinity of the sound source, and low risk from an intermediate distance. Similarly, those fish with swim bladders which are involved in hearing are at risk of TTS when continuously exposed to a sound source of 158 dB rms for 12 hours. Finally, most fish groups are at high risk of masking when in the near or intermediate vicinity of the sound source and eggs and larvae are at a moderate risk of masking when in the intermediate vicinity of the sound source. Masking is reduced for all fish groups when far from the sound source (Popper *et al.,* 2014).

**Table 7-18: Continuous sounds (Popper *et al.,* 2014).**

| Type of Animal | Mortality and potential mortal injury | Impairment | | | Behaviour |
|---|---|---|---|---|---|
| | | Recoverable Injury | TTS | Masking | |
| GROUP 1: Fish: no swim bladder (particle motion detection) | (N) Low<br>(I) Low<br>(F) Low | N) Low<br>(I) Low<br>(F) Low | N) Moderate<br>(I) Low<br>(F) Low | (N) High<br>(I) High<br>(F) Moderate | (N) Moderate<br>(I) Moderate<br>(F) Low |
| GROUP 2: Fish: swim bladder is not involved in hearing (particle motion | N) Low<br>(I) Low<br>(F) Low | N) Low<br>(I) Low<br>(F) Low | N) Moderate<br>(I) Low<br>(F) Low | (N) High<br>(I) High<br>(F) Moderate | (N) Moderate<br>(I) Moderate<br>(F) Low |

| Type of Animal | Mortality and potential mortal injury | Impairment | | | Behaviour |
|---|---|---|---|---|---|
| | | Recoverable Injury | TTS | Masking | |
| detection) | | | | | |
| GROUP 3: Fish: swim bladder involved in hearing (primarily pressure detection) | N) Low<br>(I) Low<br>(F) Low | 170 dB rms for 48 h | 158 dB rms for 12 h | (N) High<br>(I) High<br>(F) High | (N) High<br>(I) Moderate<br>(F) Low |
| GROUP 4: Eggs and larvae | N) Low<br>(I) Low<br>(F) Low | N) Low<br>(I) Low<br>(F) Low | N) Low<br>(I) Low<br>(F) Low | (N) High<br>(I) Moderate<br>(F) Low | (N) Moderate<br>(I) Moderate<br>(F) Low |
| Notes: rms sound pressure levels dB re 1 μPa. All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist. Relative risk (high, moderate, low) is given for animals at three distances from the source defi ned in relative terms as near (N), intermediate (I), and far (F). | | | | | |

For the purposes of this assessment, these Sound Exposure Guidelines for Fishes and Sea Turtles (Popper *et. al.,* 2014) were considered to be most relevant for impacts of underwater noise on fish species. The Popper *et al.* (2014) guidelines broadly group fish into the following categories according to the presence or absence of a swim bladder and on the potential for that swim bladder to improve the hearing sensitivity and range of hearing (Popper *et al*., 2014):

- Group 1: Fish with no swim bladder or other gas chamber (e.g., flatfish, skates and rays). These species are less susceptible to barotrauma and only detect particle motion, not sound pressure. However, some barotrauma may result from exposure to sound pressure;
- Group 2: Fish with swim bladders in which hearing does not involve the swim bladder or other gas volume (e.g., salmonids). These species are susceptible to barotrauma although hearing only involves particle motion, not sound pressure;
- Group 3: Fish in which hearing involves a swim bladder or other gas volume (e.g., Atlantic cod, saithe, herring, sprat). These species are susceptible to barotrauma and detect sound pressure as well as particle motion; and
- Group 4: Fish eggs and larvae (and therefore plankton stages of fish species).

### Important Ecological Features

Shellfish IEFs have been scoped out of this impact due to their very low to negligible sensitivity to noise. Most shellfish hear in a different way to vertebrates, e.g. arrays of sensory hairs on lobsters, crabs etc. or statocyst organs. They are able to sense vibrations and movements associated with sound production, but the absence of gas-filled cavities indicates a lesser potential for injury and mortality.

Whilst those species in Group 3, such as cod, are more sensitive to noise, there is unlikely to be a risk of mortality or recoverable injury to fish or plankton. Group 3 species are at a higher risk of recoverable injury and TTS; however, this would require exposure to a sound source over a number of hours. Although worst-case scenario noise levels could exceed the threshold for injury, the likelihood of injury occurring is extremely low.

All fish and plankton IEFs are therefore considered to be of low vulnerability, medium to high recoverability and local to national value. The sensitivity of all receptors is therefore considered to be low.

Behavioural effects

According to Popper *et al.* (2014) there is moderate risk of behavioural impacts to fish receptors of all groups in the near vicinity of the sound source (see Table 7-18). Group 3 species have a greater sensitivity to sound and have a high risk of experiencing behavioural effects as a result of drilling at the project. For all species, the risk of behavioural impacts decrease with increasing distance from the sound source.

Drilling noise can cause potential behavioural disturbance to fish receptors. For example, research looking at biases of vessel noise on the spatial distribution of fish showed that pelagic schooling fish respond by vertical or lateral avoidance of approaching vessels (Mitson and Knudsen, 2003).

Behavioural effects in response to construction related underwater noise include a wide variety of responses including startle responses (also known as C-turn responses), strong avoidance behaviour, changes in swimming or schooling behaviour or changes of position in the water column. Depending on the strength of the response and the duration of the impact, there is potential for some of these responses to lead to significant effects at an individual level (e.g. reduced fitness, increased susceptibility to predation) or at a population level (e.g. avoidance or delayed migration to key spawning grounds), although these may also result in short term, intermittent changes in behaviour that have no wider effect, particularly once acclimatisation to the noise source is taken into account.

Effects of avoidance will also depend on the species in question and the life stage affected but may include reduced access to spawning and feeding grounds or barriers to migration, which may have negative consequences for breeding success and stock recruitment. While behavioural effects have been demonstrated in numerous fish species in response to underwater noise, it has also been demonstrated that such effects are temporary with normal behavioural patterns returning soon after the noise source ceases. For example, in studies on the effects of seismic survey noise on various caged fish species, McCauley *et al.* (2000) showed a return to normal fish behaviour patterns 14 to 30 minutes after the cessation of seismic airgun operations.

Demersal fish and elasmobranch species are expected to have a low sensitivity to sound, detecting a narrow band of frequencies (Popper and Hawkins, 2019). Species in Group 3 such as cod and European eel may be classed as having high auditory sensitivity. Species in Group 2, such as sea trout and Atlantic salmon are moderately sensitive to underwater noise as they have a gas-filled swim bladder, which is vulnerable to sharp changes in pressure but lack the connection between the swim bladder and the internal ear which is present in more sensitive species (Gill and Barlett, 2010).

**Local demersal fish assemblage IEF**

The local demersal fish assemblage includes flatfish, round fish and elasmobranchs. Those species in groups one and two, such as flatfish, skates and rays are at a relatively moderate risk of exhibiting behavioural effects within near and intermediate distances from the sound source, with a low risk of exhibiting behavioural effects at a relatively far distance from the sound source (Popper *et al.,* 2014). Those species in group 3, such as saithe and Atlantic cod are at a relatively high risk of exhibiting behavioural effects within near distances from the sound source, with moderate risk at an intermediate distance, and low risk at a far distance (Popper *et al.,* 2014). Fish however have the ability to move away from the sound source. Whilst this may temporarily displace individuals, and potentially alter recruitment at the larval stage, displacement will only be temporary and is likely to be extremely localised.

The local demersal fish assemblage IEF is deemed to be of low vulnerability, high recoverability and regional value and therefore the sensitivity of the receptor is considered to be low.

**Spawning and nursery habitats IEF**

Behavioural effects could include the displacement of adult fish which spawn within the vicinity of the study area, however as stated above, all spawning and nursery grounds extend over large areas relative to the small area over which individuals are likely to be displaced, thus displacement is expected to be highly localised. In addition, any effect will occur over a temporary period only and as such is not expected to affect recruitment to spawning and nursery grounds.

The spawning and nursery habitat IEF is deemed to be of medium vulnerability, high recoverability and national value and therefore the sensitivity of the receptor is considered to be low.

**Migratory fish species IEF**

Species in group 2, such as Atlantic salmon are at a relatively moderate risk of exhibiting behavioural effects within near and intermediate distances from the sound source, with a low risk of exhibiting behavioural effects at a relatively far distance from the sound source (Popper *et al.,* 2014). Those species in group 3, such as European eel are at a relatively high risk of exhibiting behavioural effects within near distances from the sound source, with moderate risk at an intermediate distance, and low risk at a far distance (Popper *et al.,* 2014). Fish however have the ability to move away from the sound source. Whilst this may temporarily displace individuals which are moving along the coast, this is unlikely to cause a barrier to migration, given the distance of the project from the nearest designated SAC for migratory fish species (more than 100 km away). There are no spawning or nursery grounds for migratory fish species which overlap with the project area, therefore there will be no effect on recruitment of these species. In addition, any displacement will only be temporary and likely to occur over a highly localised area.

The migratory fish species IEF is deemed to be of low vulnerability, high recoverability and international value and therefore the sensitivity of the receptor is considered to be low.

**Plankton IEF**

As stated above, there is less concern for plankton in consideration of hearing-related effects than pressure-related injuries, therefore behavioural effects are likely to be minimal in this IEF. As stated above, behavioural effects have the potential to occur within a highly localised area, and whilst displacement will not occur, similarly to those species in Groups 1 and 2, plankton are at a relatively moderate risk of exhibiting behavioural effects within near and intermediate distances from the sound source, with a low risk of exhibiting behavioural effects at a relatively far distance from the sound source (Popper *et al.,* 2014). However, unlike adults, plankton are unable to take evasive action to noise impacts and are therefore more vulnerable to drilling activities. The plankton IEF is deemed to be of high vulnerability, high recoverability and regional value and therefore the sensitivity of the receptor is considered to be low.

### Significance of Effect

Mortality and impairment

The magnitude of the impact is deemed to be low and the sensitivity of all receptors is considered to be low. The effect will therefore be of *minor (adverse)* significance.

Behavioural effects

The magnitude of the impact is deemed to be low and the sensitivity of all receptors is considered to be low. The effect will therefore be of *minor (adverse)* significance.

#### 7.6.1.2 Marine mammals

Tunnelling, excavation and drilling activities involved in the construction of the intake and outfall has the potential to generate underwater noise within the project area, which may result in effects on marine mammal receptors found within the study area.

**Magnitude**

The magnitude of the drilling activities is discussed in section 7.6.1.1 and is therefore not reiterated here. The impact is expected to be of short-term duration, reversible and localised. The magnitude of the impact is therefore considered to be low.

**Sensitivity**

Auditory Injury

Tunnelling, excavation and drilling are considered continuous, non-impulsive noise sources and according to NMFS (2018) the onset of auditory injury in marine mammals, defined as a Permanent Threshold Shift (PTS) occurs at different received noise levels, dependent on the hearing ability of the marine mammals, and is given in Table 7-19. Temporary Threshold Shift (TTS) is discussed under disturbance.

**Table 7-19: Summary of PTS and TTS onset thresholds for non-impulsive continuous noise.**

| Hearing group | Species | PTS onset: SEL (weighted) dB re 1 μPa$^2$s | TTS onset: SEL (weighted) dB re 1 μPa$^2$s |
|---|---|---|---|
| Low-frequency (LF) cetaceans | Minke whale | 199 | 179 |
| Mid-frequency (MF) cetaceans | • Bottlenose dolphin<br>• Common dolphin<br>• Risso's dolphin<br>• Killer whale | 198 | 178 |
| High-frequency (HF) cetaceans | • Harbour porpoise | 173 | 153 |
| Phocid pinnipeds (PW) (underwater) | • Grey seal<br>• Harbour seal | 219 | 181 |

Given that noise produced during the construction phase is not predicted to exceed thresholds for PTS onset (see Table 7-20), the sensitivity of all IEF receptors is considered to be negligible.

**Table 7-20: Underwater noise modelling threshold zones.**

| Hearing group | Criteria | | |
|---|---|---|---|
| | PTS onset (m) | TTS onset (m) | Disturbance |
| Low Frequency Cetaceans (baleen whales) | - | | 60 |
| High Frequency Cetaceans (most dolphin species) | - | | 60 |
| Very High Frequency Cetaceans (Harbour Porpoise) | - | 16 | 60 |
| Phocid Carnivores (seal species) | - | - | |

Disturbance

Unlike for thresholds of auditory injury, there are currently no established regulatory guidance documents and few published scientific articles providing clear advice on the appropriate thresholds for behavioural response to continuous non-impulsive noise. Behavioural responses to noise are highly variable and are dependent on a variety of animal dependent and environmental factors. Animal dependent factors include past experience, individual hearing sensitivity, activity patterns, motivational and behavioural state at the time of exposure. Demographic factors such as age, sex and presence of dependent offspring can also have an influence. Environmental factors include the habitat characteristics, presence of food, predators, proximity to shoreline or other features. Influenced by these factors, responses can be highly variable, from small changes in behaviour such as longer intervals between surfacing (Richardson, 1995a) or a cessation in vocalisation (Watkins, 1986) to more dramatic escape responses (Götz and Janik, 2016). This variability makes it extremely difficult to predict the likelihood of responses to underwater noise from drilling. Even where empirical data exist on responses of animals in one particular environment, the context related variability makes it difficult to extrapolate from one study to a new situation. It is important to note that all any impact assessment can do, is predict the potential for behavioural responses, as definitive predictions of likelihood or magnitude are particularly difficult.

Marine mammals, particularly cetaceans, are capable of detecting and generating sound (Au *et al., 1974;* Bailey *et al.,* 2010) and are dependent on sound for many aspects of their lives, i.e. prey-identification; predator avoidance; communication and navigation. Increases in anthropogenic noise may consequently pose a risk within the marine environment (Parsons *et al.,* 2008; Bailey *et al.,* 2010).

It is now recognised that some of the more ubiquitous noise sources, such as ships, can either individually or cumulatively mask communication signals of, and pose a threat to marine mammals (Clark *et al.,* 2009; Ellison *et al.,* 2011; Chen *et al.,* 2017; Simpson *et al.,* 2016, Rolland *et al.,* 2012). The overall increase in oceanic background noise can alter acoustic habitats over large regions in ways which may be detrimental to marine animals that rely on sound for basic life functions (Ellison *et al.,* 2011). It is also now emerging that non-injurious effects can accumulate at the population level (Williams *et al.,* 2015).

Little information is available on likely responses of marine mammals to drilling noise. More information however is available on responses to vessel noise, which may be used as a proxy. The likely behavioural response of marine mammals to continuous non-impulsive noise is avoidance, however some species are known to be attracted to vessel noise (as likely however to be in response to vessel movement as well as noise output).

Harbour porpoise are particularly sensitive to high frequency noise and are more likely to avoid vessels (Heinanen and Skov, 2015). Other behavioural responses to continuous noise include increased swimming speed, avoidance, increased group cohesion and longer dive duration (Miller *et al.,* 2008). Sensitivity to vessel noise is most likely related to the marine mammal activity at the time of disturbance (ICW, 2006, Senior *et al*., 2008). For example, resting dolphins are likely to avoid vessels, foraging dolphins will ignore them and socialising dolphins may approach vessels (Richardson *et al*., 1995). Unlike cetaceans, seals store energy in a thick layer of blubber, which means that they are more tolerant of periods of fasting when hauled out and resting between foraging trips, and when hauled out during the breeding and moulting periods. Therefore, they are unlikely to be particularly sensitive to any short-term displacement from foraging grounds during periods of noise production. Juvenile seals may be more sensitive to displacement from foraging grounds due to a smaller body size and higher energetic needs.

Noise modelling results show that underwater source levels are low intensity and barely exceed the thresholds set out in Table 7-19. Disturbance is only expected to occur out to 60 m from the noise source for cetaceans and is not expected to occur at any distance for pinnipeds. Thresholds for TTS are only expected to be exceeded within 16 m of the noise source for very high frequency cetaceans (harbour porpoise). The impact radii are therefore very low.

**Cetacean IEFs**

Harbour porpoise are small cetaceans which makes them vulnerable to heat loss and requires them to maintain a relatively high metabolic rate. This makes them potentially vulnerable to disturbance if they are unable to obtain sufficient levels of prey intake. For mid-frequency cetaceans, while there remains the potential for disturbance and displacement to affect individual behaviour, individuals do have some capability to adapt their behaviour and tolerate certain levels of disturbance. Minke whale have been shown to change their diving patterns and behavioural state in response to disturbance from whale watching vessels; and it was suggested that a reduction in foraging activity at feeding grounds could result in reduced reproductive success in this species given its capital breeding pattern (i.e. that it relies on stored energy to provide resources for future breeding attempts) (Christiansen *et al.,* 2013). However, noise produced as part of the construction phase is expected to occur over a short period of time, therefore any disturbance is likely to be temporary and intermittent, and all relevant species have wide ranges and alternative foraging habitat available to them.

The cetacean IEF is deemed to be of low vulnerability, high recoverability and international or national value. The sensitivity of the receptor is therefore, considered to be low.

**Pinniped IEFs**

As stated above, noise modelling results show that disturbance is not expected to occur at any distance from the noise source. Therefore, the sensitivity of all pinniped IEFs is considered to be negligible.

### Significance of Effect

<u>Auditory Injury</u>

The magnitude of the impact is deemed to be low and the sensitivity of all receptors is considered to be negligible. The effect will therefore be of negligible significance.

Disturbance

The magnitude of the impact is deemed to be low and the sensitivity of all receptors is considered to be negligible to low. The effect will therefore be of negligible to minor (adverse) significance.

## 7.7 Operational Impacts

### 7.7.1 Effects on marine ecology receptors from entrapment and impingement associated with the operation of the intake structure

During the cavern formation, wells will be drilled from an onshore wellsite and the caverns will be sequentially formed using sea water drawn from seawater intake. During seawater intake, small marine fauna are vulnerable to both entrainment (direct intake via the intake head of fauna which are small enough to pass through the intake screen mesh, into the salt caverns and then discharged with the brine) and impingement (when animals which are sufficiently large to avoid going through the intake screen are trapped against them by the force of the flowing water).

#### 7.7.1.1 Plankton

**Magnitude**

Tidal velocity was calculated for spring and neap tides at the outfall pipe, giving a range of < 0.1 m/s (turning tide) to 0.6 m/s (typical spring tidal velocity). It is presumed that the tidal velocity range will not be significantly different at the intake pipe. The maximum velocity through the intake was calculated based on a pipe diameter of 450 mm and a maximum flow rate of 1,000 m3/h. The maximum velocity was therefore calculated as being 0.15 m/s, which is almost equivalent to the lowest expected tidal velocity. The magnitude of the effect of entrainment on plankton is therefore considered to be low.

The maximum diameter of the intake screen mesh holes will be 12 mm, which is significantly larger than the majority of plankton (< 200 µm). Impingement of plankton on the intake screen is therefore unlikely and the magnitude is considered to be negligible.

**Sensitivity**

Increased water flow could have an impact on marine fauna, particularly at the intake pipe, as an increase in velocity could lead to entrainment of small mobile species. Plankton, being largely smaller than the diameter of the proposed screen, could be entrained into the pipe as a result of intake of water. Plankton are fully passive, lacking the ability to avoid intake flow regardless of velocity (EPA, 2014). The numbers of entrained plankton however will likely be low as plankton would need to be within the immediate vicinity of the intake to be entratined. Those plankton which do become entrained will experience mechanical, thermal and hypersaline stresses, which will result in high levels of mortality. The low numbers of plankton which are expected to be entrained, however, mean that there is unlikely to be a significant impact on the abundance of plankton in the water column or at the population level of the constituent species.

Plankton are deemed to be of medium vulnerability, high recoverability and regional value. The sensitivity of the receptor is therefore, considered to be low.

### Significance of Effect

Overall, the sensitivity of the IEF is considered to be low and the magnitude is deemed to be low. The effect will, therefore, be of *minor (adverse)* significance.

## 7.7.1.2 Fish and shellfish ecology

### Magnitude

The parameters of the intake are given in section 7.7.1.1 and are not reiterated here. Dependent on the size of the fish, both entrapment and impingement is possible. The magnitude of the impact of both entrapment and impingement is considered to be low.

### Sensitivity

The intake pipe will be fitted with a 12 mm mess screen to reduce the entrainment of marine biota and therefore adult and larger and/or more actively moving juvenile fish will be prevented from entrainment but would be potentially susceptible to impingement (EPA, 2014). However, studies have shown that because entrance velocities in passive screen intakes are generally low (for this project as above, a maximum velocity of 0.15 m/s), impingement is also likely to be quite minor (EPRI, 2006). The swimming abilities of juvenile estuarine fish have been assessed, and studies have shown that they have the ability to avoid being impinged (or entrained); whilst species and size of the juvenile would impact their critical swimming ability, the smallest individuals studied (length = 20 mm) had a critical swimming speed of 20 cm/s (or 0.2 cm/s) which is greater than the velocity of the intake (Kimball *et al.,* 2018).

Entrainment of organisms which are small enough to fit through the screen is likely to be more common (Zeitoun *et al.,* 1981; Weisberg *et al.,* 1987). Entrainable organisms include those which are smaller than the mesh aperture and/or with limited to no swimming ability (Missimer and Maliva, 2018). Although mortality effects are likely to occur for those fish which do become entrained (e.g. Environmental regulatory agencies in the state of California in the United States assume that there is a 100% mortality of any marine organism entering an intake (Missimer and Maliva, 2018)), the level of fish entrainment is expected to be low. The velocity of the intake, as stated above, is the equivalent speed of the lowest tidal velocity, and therefore it is expected that the majority of small and/or juvenile fish below the mesh size will have the ability to swim against, or away from this force (Missimer and Maliva, 2018). Fish and shellfish larvae as part of the plankton environment would be entrained. However, as stated above, the numbers of individuals likely to be affected will not be high at the population level. Species which have spawning and nursery grounds that overlap the vicinity of the project are described in Section 7.3.5.6. Of those species, none are listed as being of international value within the study area. Species which could be of particular concern are migratory fish species, including European eel and salmonids. However, there are no estuaries within the vicinity of the project, and therefore any juvenile migratory fish which occur in the vicinity of the project, will do so in very low numbers.

Fish receptors are therefore deemed to be of low vulnerability, high recoverability and regional to national value. The sensitivity of the receptor is therefore, considered to be low.

### Significance of Effect

The sensitivity of the receptors is considered to be low and the magnitude is also deemed to be low. The effect will, therefore, be of *minor (adverse)* significance.

## 7.7.2 Effects on marine ecology receptors associated with the discharge of brine during operation of the outfall

The rate of brine discharge will increase in stages as the number of caverns under construction increases with time and will range from 250m$^3$/hour at initial start-up, to potentially 1,000m$^3$/hour at the maximum possible cavern construction rate. The design of the leaching facilities is such that this will be achieved in a stepped process by uprating and commissioning additional pumps such that there will in effect be three potential discharge scenarios, 250m$^3$/hour, 500m$^3$/hour and 1,000m$^3$/hour (see Appendix B – Brine Dispersion Modelling Report). The baseline salinity data obtained from AFBI and NIEA at the initial project development stage indicated that background salinities in this part of the North Channel off Islandmagee can range between circa 30.5 Practical Salinity Units (PSU) and 34.8 PSU. The background salinity of the study area was taken as 34.2 PSU for the purposes of the brine dispersion modelling.

The initial dilution modelling results show that for a diffuser with 6” ports the salinity of the brine at first contact with the seabed will be between 50.5 PSU and 37.6 PSU depending on the discharge flow and number of active ports on the diffuser. The medium to far-field dispersion assessment confirmed that the discharge of up to 1,000m$^3$/hour of saturated brine via the proposed outfall will have minimal impact on salinity levels beyond the immediate vicinity of the outfall. Maximum salinity increases (during neap tides) of more than 0.5 PSU are not anticipated to occur more than a few hundred metres from the diffuser and salinities in excess of 36 PSU are not predicted to occur more than 100 m from the diffuser under normal operations. Salinity levels in excess of 40 PSU are only predicted to extend for approximately 10-15 m from the diffuser location (see Figure 7-16 for Maximum Brine Plume Envelope, which also included a period of very small neap tides with tidal ranges approaching 1 m). It is unlikely however that maximum flow will coincide with maximum salinity increase as conservatively assumed for this study. In addition, concentration of non-salt compounds in the Islandmagee brine are lower than the relevant Environmental Quality Standards (EQS). Thus with the dilution and dispersion that will occur after discharge the non-salt components in the IGSF brine discharge do not pose a significant threat to marine water quality at Islandmagee (see Appendix B – Brine Dispersion Modelling Report).

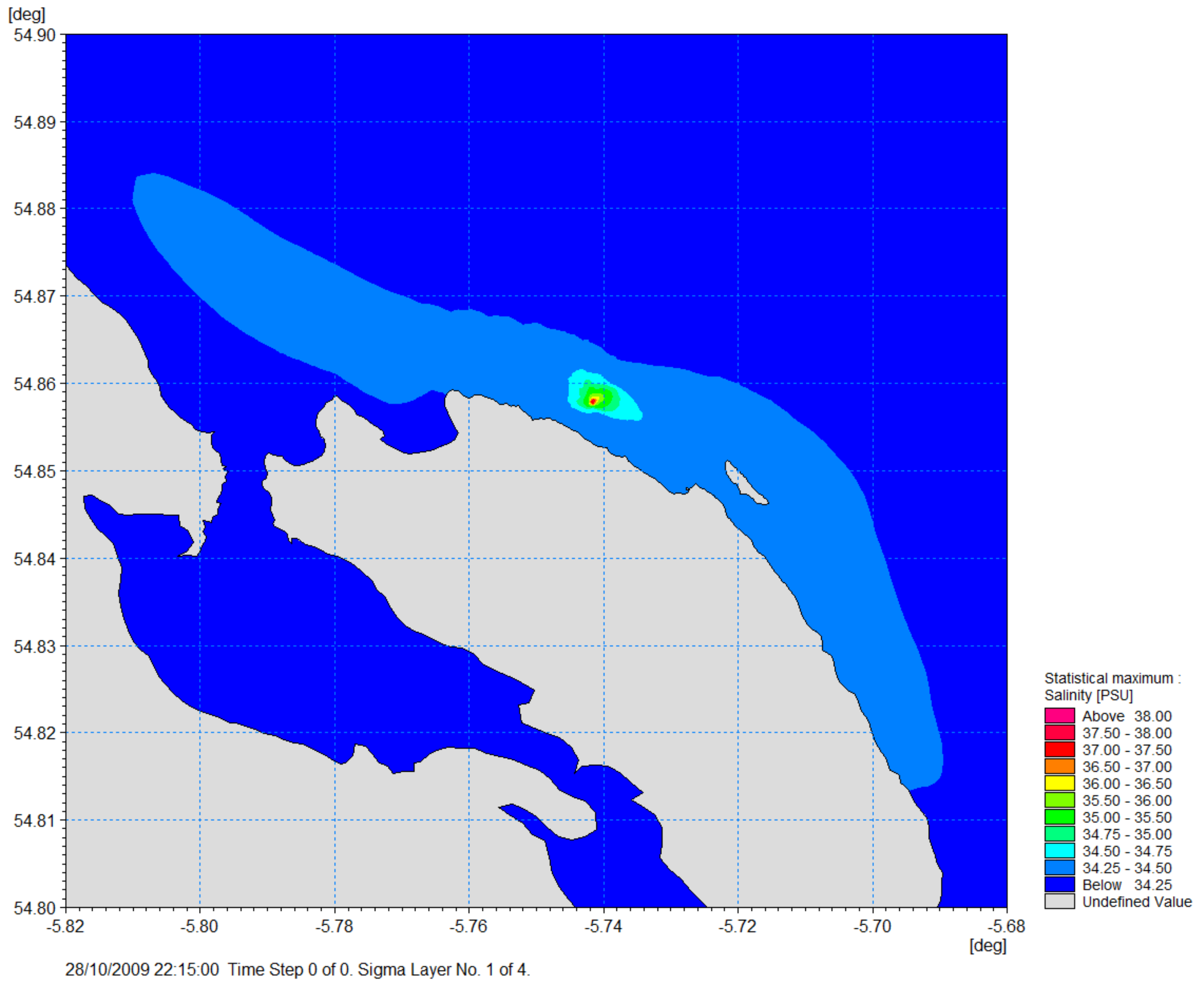


**Figure 7-16: Maximum Salinity during a Spring-Neap Tidal Cycle (1,000m3/hour Discharge) (RPS, 2019).**

## 7.7.2.1 Benthic ecology

### Magnitude

As stated in Section 7.7.2, the salinity of the brine at first contact is expected to be between 50.5 PSU and 37.6 PSU and salinity levels in excess of 40 PSU (5.8 PSU above the background salinity levels) are only expected to extend approximately 10-15 m from the outfall location. In terms of far field brine dispersion during neap tides for 1,000 m$^3$/hour discharges, any salinity increase in excess of the range normally experienced in seasonal variations (34.8 PSU) is expected to be restricted to an area of less than 300 m from the outfall. The maximum brine plume envelope (as shown in Figure 7-16 and Figure 7-17) presents elevated salinity levels of ~34.25 PSU to extend slightly further , which would occur if a period of very small neap tides coincided with the operation of the brine discharge at maximum capacity. However, even under these conditions, any elevation in salinity levels by more than 0.5 PSU is still restricted to the immediate vicinity of the discharge and are flushed with the subsequent spring tides. In addition, the non-salt components are expected to be below EQS levels. Once discharge of saline waters ceases, the salinity of the surrounding waters is expected to return to background levels within a few tidal cycles. Therefore, the magnitude of the impact on the Benthic Subtidal Habitat B IEF is considered to be low.

## Sensitivity

Brine discharge is expected to remain in the lower part of the water column because of its high density and therefore has the potential to have an effect on marine benthic communities. Marine organisms live in an osmotic balance with their environment and an increase in salt concentration may result in the dehydration of cells, a decrease of the turgor pressure and, ultimately, death of mainly larvae and young individuals (Einav *et al.,* 2002). At the community level, increased salinity may cause a decrease in abundance, richness and diversity. Effects are expected to be higher at shallower depths, with communities being more stable at greater depths. Most marine species are able to tolerate short-term fluctuations in salinity of 20 to 30% (Walker and McComb, 1990). The main impact on marine communities is caused by the discharge of an effluent of very high salinity (70 - 90 PSU) (Höpner and Widdelberg, 1996). Whilst studies at desalination plants have observed these changes, Raventos *et al.* (2006) found no significant variations attributable to the brine discharges from a small desalination plant, likely due to the smaller size of the plant facilitating more rapid dilution of the brine.

**Benthic Subtidal Habitat B IEF**

The salinity in which this receptor, or habitat type exists is between 30 and 35 parts per thousand (ppt) (JNCC, 2019). The MarLIN sensitivity review states that this biotope (MarLIN, 2019b), whilst having a low resistance to changes in salinity (decreases, as no evidence available for increases) is considered to have medium resilience and medium sensitivity to salinity change of one Marine Nature Conservation Review (MNCR) salinity category. The biotope in general is considered to have a high recovery potential. A change at the pressure benchmark therefore refers to a change to full salinity i.e. changes above this have not been considered within MarLIN assessment as no directly relevant evidence was found to assess this pressure.  For salinity increases above full salinity (hypersaline conditions) an alteration in the structure of the biological assemblages, reducing species richness and abundance would be expected (Riera *et al.,* 2012).

The Benthic Subtidal Habitat B IEF, beyond the immediate vicinity of the outfall however is deemed to be of low vulnerability, high recoverability and regional value. The sensitivity of the receptor is therefore, considered to be low.

## Significance of Effect

The magnitude of the Benthic Subtidal Habitat B IEF is considered to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of *minor (adverse)* significance, with changes in the structure of the biological assemblages only anticipated within the immediate area (10-15 m) of the brine discharge.

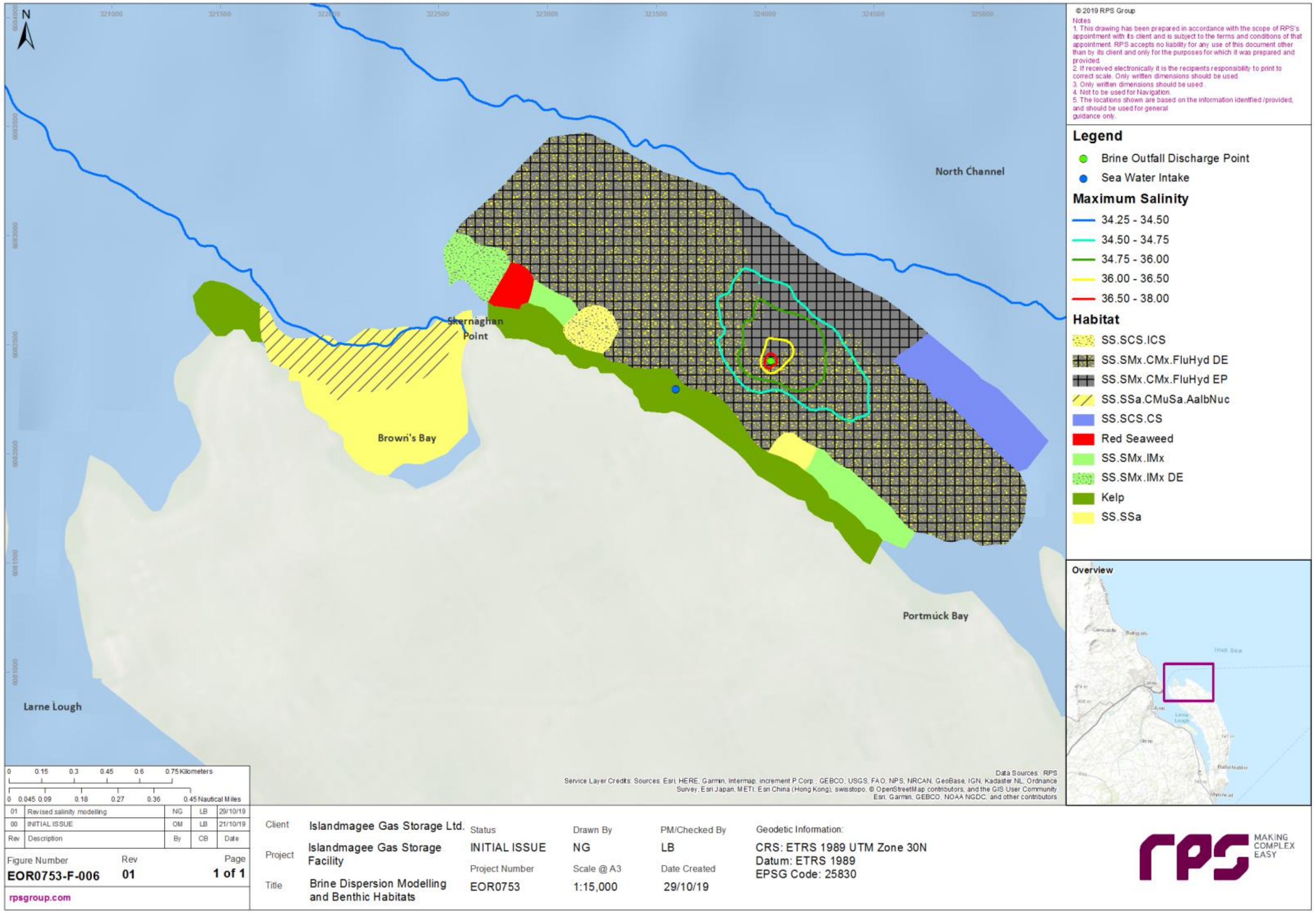


**Figure 7-17: Brine dispersion model (Maximum Salinity during a Spring-Neap Tidal Cycle (1,000m3/hour Discharge) (RPS, 2019) and identified benthic habitats.**

### 7.7.2.2 Fish and shellfish ecology and Plankton

#### Magnitude

The parameters of the impact are discussed in section 7.7.2.1 and are therefore not discussed further. The magnitude of the impact for all fish and shellfish receptors is considered to be low.

#### Sensitivity

Aquatic organisms that obtain their oxygen from the water (e.g. fish, shellfish) rather than the air are adapted to the normal salinity of their environment, taking saline into their bodies to obtain oxygen. Therefore, any change to ambient salinity has the potential to affect the organism's ability to achieve vital biological processes (Aziz *et al,* 2002). In addition, salinity is a major driver in the control of reproduction, larval disbursement and recruitment, and therefore has the ability to affect larval stages and plankton (Anger 1991; Anger 1996; Spivak and Cuesta 2009). Studies on the effects of changes in the salinity of sea water on marine organisms have shown that initial changes will occur in mobile species such as plankton and fish, and that the reaction will be highest in those organisms with a plankton stage in their life history (*Hiscock et al*, 2004). Salinity alteration plays a significant role on the marine species size, population and behaviour; however, these impacts differ between different organisms. There is also likely a direct negative correlation between the number of marine species and the salinity increment of the seawater (*Gunter*, 1961). In addition to the considerations given in section 8.6.2.1, it is thought that adult stages of all fish species have the ability to tolerate a vast range of salinity alteration and have the ability to move away from high saline conditions. In the case of sessile and sedentary organisms, burrowing or closing shell valves acts as a short term defence mechanism (Smyth, 2011). Shellfish in general have variable saline preferences with general preference for saline conditions of between 30 and 40PSU and high recoverability following increases in saline conditions (e.g. MarLIN, 2019b, 2019c, 2019d and 2019e). The MarLIN information Network identifies only the razor clam as having intermediate intolerance to increased saline conditions, however recoverability is still considered to be high, and sensitivity low (although information is lacking for some species) (MarLIN, 2019f).

Experiments on salinity levels and the resulting effects in plankton have shown that even relatively small increases in salinity levels (> 1.2PSU) can drive the depletion of biodiversity and abundance, altering ecosystem functioning (Schallenberg *et al.,* 2003). In addition, given that plankton are fully passive, unlike adult fish and mobile shellfish species, they are unable to re-locate in order to avoid higher saline concentrations. Spawning and nursery habitats in the vicinity of the project could be affected initially by the temporary displacement of adult stages, and therefore the delay or absence of spawning. Aziz in 2002 noted that environmental stress resulted in the shifting of spawning seasons and a reduction in spawning stock size of prawns (Aziz *et al.,* 2002). Additionally, an increase in salinity, could lead to physiological changes (Martínez-Álvarez *et al.,* 2002), the depletion of biodiversity and abundance (Schallenberg *et al.,* 2003; Sosa-López *et al.,* 2007), or the delay of organism development (Moreira *et al.,* 2018; Smyth, 2011).

**Fish and shellfish IEFs**

The Fish and Shellfish IEFs are deemed to be of low to medium vulnerability, high recoverability and regional to international value. The sensitivity of the receptor is therefore, considered to be low.

**Plankton IEF**

The Plankton IEF is deemed to be of high vulnerability, high recoverability and regional value. The sensitivity of the receptor is therefore, considered to be low.

#### Significance of Effect

Whilst fish, shellfish and plankton receptors in the project area are vulnerable to brine discharge from the outfall, the impact will be temporary in nature, reversible and is only likely to affect the immediate vicinity around the outfall (see Figure 7-17) and therefore at the population level, recoverability from effects of the brine discharge is expected to be high.

Overall, the sensitivity of all IEFs is considered to be low and the magnitude is deemed to be low. The effect will, therefore, be of *minor (adverse)* significance.

## 7.8 Interdependencies

Any disruption to one element in a food web could have a causal effect, being detrimental to other organisms (Kennington and Rowlands, 2005). Therefore, recruitment to larval stage of fish species as a result of construction impacts has the potential to reduce feeding opportunities for adult fish and subsequently to marine mammals and birds. The study area hosts spawning and nursery grounds for fish such as cod, whiting, ling, mackerel, hake and skate. The impact assessment has shown that whilst temporary displacement from construction and operational impacts of adult stages of fish species could result in changes to spawning and nursery habitats, all spawning and nursery grounds are extensive, relative to the study area, therefore effects are unlikely to be significant. In addition, those higher trophic levels which rely on fish for prey have wide ranges and alternative feeding habitats, therefore localised changes to the food chain are unlikely to have significant impacts on interdependencies within the wider study area.

Surveys to assess the use of the wider area around the potential zone of influence by foraging seabirds conducted in 2008-2009; 2011-2012; 2015 and 2019 have shown that this area is not an important area for feeding. Tracking studies of terns between 2009-2011 supported the finding that the area is not widely utilised by foraging birds (Wilson *et al*, 2014). In addition, seabirds are known to have extensive foraging areas which can range from tens to hundreds of kilometres and therefore localised changes to the levels of prey in the local area are unlikely to have significant impacts on the wider seabird populations.

## 7.9 Conclusions

Table 7-21 summarises the assessment of impact on marine biodiversity receptors associated with the construction and operational phases of the project.

**Table 7-21: Summary of potential effects and mitigation measures at the project.**

| Impact | Measures adopted as part of the project | Receptor | Magnitude | Sensitivity | Significance of Effect | Proposed mitigation |
|---|---|---|---|---|---|---|
| **Construction Impacts** | | | | | | |
| Effects on marine ecology receptors associated with underwater noise emissions from construction of intake and outfall infrastructure (Mortality and impairment) | N/A | All fish and plankton IEFs | Low | Low | Minor (adverse) | N/A |
| Effects on marine ecology receptors associated with underwater noise emissions from construction of intake and outfall infrastructure (disturbance) | N/A | All fish and plankton IEFs | Low | Low | Minor (adverse) | N/A |
| Effects on marine ecology receptors associated with underwater noise emissions from construction of intake and outfall infrastructure (Auditory injury) | N/A | All marine mammal IEFs | Low | Negligible | Negligible | N/A |
| Effects on marine ecology receptors associated with underwater noise emissions from construction of intake and outfall infrastructure (Disturbance) | N/A | Cetacean IEFs | Low | Low | Minor (adverse) | N/A |
| | N/A | Pinniped IEFs | Low | Negligible | Negligible | N/A |
| **Operational impacts** | | | | | | |
| Effects on marine ecology receptors from entrainment and impingement associated with the operation of the intake structure | Grill (of mesh diameter 12 mm) to be installed over intake | Plankton IEF | Low | Low | Minor (adverse) | N/A |
| | Grill (of mesh diameter 12 mm) to be installed over intake | All fish IEFs | Low | Low | Minor (adverse) | N/A |
| Effects on marine ecology receptors associated with the discharge of brine during operation of the outfall | High pressure dispersal nozzles | Plankton IEF | Low | Low | Minor (adverse) | N/A |
| | High pressure dispersal nozzles | Benthic subtidal habitat B IEF | Low | Low | Minor (adverse) | N/A |
| | High pressure dispersal nozzles | Fish and shellfish IEFs | Low | Low | Minor (adverse) | N/A |

# 8 CUMULATIVE EFFECTS

This section summarises the potential for cumulative effects arising from the Islandmagee Gas Storage Facility (IGSF) project in association with other developments. Cumulative effects consider the long-term changes that may result from the construction and operation of the proposed development and the combined effect of this development with other developments in the area.

Cumulative assessment is undertaken to ensure that the combined effects of the proposed development and other influences are assessed together, and not as individual aspects of the environmental assessment.

Cumulative effects are defined as changes to the environment that are caused by an action in combination with other actions, arising from:

- the interaction between all of the different (existing and/or approved) projects in the same area; as required by Annex IV, point 5 (e) of the EIA Directive;
- the interaction between the various impacts within a single project.

The EU Guidance on the preparation of the Environmental Impact Assessment Reports states that it is important to consider effects, not in isolation, but cumulatively, as this may show that individually analysed impacts can become significant when they are added together, or with, other effects.

The coexistence of impacts may increase or decrease their combined impact. Impacts that are considered to be insignificant, when assessed individually, may become significant when combined with other impacts.

Cumulative effects can occur at different temporal and spatial scales. The spatial scale can be local, regional or global, while the frequency or temporal scale includes past, present and future impacts on a specific environment or region.

The methodology for selecting the relevant projects is presented in Section 8.1.1. The experts leading each of the technical assessments (as presented in Chapters 6 and 7), have defined significance thresholds and criteria for the cumulative effects assessment. These are based on professional judgement and consideration of the relevant standards and guidelines via a collaborative approach, involving all the interested parties in the process of data collection and analysis, to determine whether in-combination effects gives rise to additional levels of significance.

The overall summary of the assessment of the likely cumulative effects, and interactions, between the Islandmagee Gas Storage Facility and other projects in the vicinity of Larne Lough and the North Channel is presented in Section 8.1.2, along with appropriate mitigation measures to address any identified cumulative effects (if applicable).

### 8.1.1 Methodology

The following guidelines and publications were considered when determining the other projects to be considered for their potential to generate cumulative effects with the Islandmagee Gas Storage Facility.

- European Commission (EC) Guidelines for the Assessment of Indirect and Cumulative Impacts (1999);

- European Commission (EC) Guidance on the preparation of the Environmental Impact Assessment Report (2017); and
- UK Planning Inspectorate (PINS) Advice Note 17: Cumulative effects assessment relevant to national significant infrastructure projects. Version 1, 2015.

The different developments considered as part of this cumulative assessment were identified through a desk study that identified developments in close proximity to the Islandmagee Gas Storage Facility and with the potential to interact with it.

The resulting selected developments comprise of:

- projects on or in close proximity to Islandmagee that are listed on the local planning authority website.
- ongoing projects with a Marine Licence or in the process of applying for a Marine Licence under the Marine and Coastal Access Act 2009.
- planned future projects that client and project staff are aware off;

The period up to the end of October 2019 was considered for the purposes of identifying existing and/or approved projects (A full list of submissions are listed in Appendix F – Cumulative Assessment (Stage 1 & 2).

#### 8.1.1.1 Stage 1 - Identification of "Existing and/or Approved Projects"

The first stage in determining cumulative effects entailed the identification of a long list of projects in the locality that exist, have been approved, or for which approval had been sought . The potential for these projects to have an impact in combination with the Islandmagee Gas Storage Facility was assessed based on available information. This stage involved a desktop study to review all existing, approved or pending projects that are located in close proximity to the Islandmagee Gas Storage Faciltiy and, those that fall outside of the immediate area but still have the potential to interact.

This review was carried out using the NI Planning web portal and the DAERA Marine Licence Database to identify other projects that have the potential to interact with the Islandmagee Gas Storage Facility.

Once the long list was established, a "Tier 1 or 2" rating was assigned to each project to indicate the level of certainty associated with its implementation. Table 8-1 shows the classification of Tier 1 and Tier 2 projects. This table was derived from the Planning Inspectorate Advice Note 17 (2015).

**Table 8-1 Tier 1 and Tier 2 Classification for Existing and/or Approved Projects**

| Tier | Planning Stage | Decreasing level of detail likely to be available |
|---|---|---|
| 1 | Currently under construction or construction complete. | ↓ |
| | Planning Permission Granted but permitted application(s) not yet implemented | |
| | Planning Application(s) submitted but not yet determined by planning authority | |
| 2 | Application for Marine Licence under the Marine and Coastal Access Act 2009. | |
| | Identified in relevant Development Plan (and emerging Development Plans – with appropriate weight being given as they move close to adoption) recognising that much information on any relevant proposals will be limited | |
| | Identified in other plans and programmes (as appropriate) which set the framework for future development consents/approvals, where such development is reasonably likely to come forward. | |

The long list was then scrutinised to identify which of the projects fell within the Project zone of influence, which, for the purposes of this assessment, were those projects within the Islandmagee and Larne Area.

The spatial location of each planning application was assessed in relation to the Islandmagee Gas Storage Facility using GIS Analysis. This analysis determined whether the different projects fell within or outside the Islandmagee Gas Storage Facility zone of influence. This determination was used to screen out projects where there was no spatial overlap with the Islandmagee Gas Storage Facility or where no source-pathway-receptor linkage was considered likely. This derived a “short list” of potentially applicable projects for further assessment during Stage 2 of the process.

#### 8.1.1.2 Stage 2 – Shortlisting

Stage 2 of this assessment involved applying inclusion or exclusion criteria to the list of existing, approved or pending projects to determine whether they had any potential to give rise to cumulative effects with respect to the following criteria:

- Temporal Scope – is there any temporal overlap or potential for interaction between the IGS Project due to the relative construction operation and decommissioning programmes of other projects?
- Scale and Nature of the other projects - Due to the scale and nature of the other projects, are they likely to interact with the IGSF Project to result in a cumulative effect? Statutory definitions of major development and EIA screening thresholds were considered in determining issues of scale.
- Other Factors - such as the nature and/or capacity of the receiving environment, that would make significant cumulative effects with ‘other developments’ more or less likely. A source-pathway-receptor conceptual modal was used to inform the assessment of other factors.

The identification and short list process is documented in Appendix F . Professional judgement and consultation with chapter authors was used in applying theses thresholds. The reasons for excluding any development from further consideration is recorded. If the potential for any existing, approved or pending project to give rise to significant cumulative effects was identified, those were taken forward to Stage 3 of the process.

#### 8.1.1.3 Stage 3 – Information Gathering and Assessment of Cumulative Effects

For the shortlisted developments, all available information was compiled to inform the assessment of cumulative effects. The relevant data was sourced from websites of the relevant planning authorities and included information such as:

- The design and location of the existing, approved or pending project;
- The proposed programme of construction, operation and decommissioning (if applicable);
- Compilation and review of relevant environmental assessments and planner reports that set out baseline data and effects arising from the other developments and;
- A review of the mitigation measures that will be applied to the Islandmagee Gas Storage Facility to ensure they are sufficient to remove any cumulative effects when considered in combination with the other developments.

Where information was limited, these gaps were acknowledged within the assessment and the associated uncertainly documented.

When determining the significance of the cumulative effects of the IGSF Project and other projects, consideration was given to the following factors:

- The Spatial and Temporal interactions between the IGSF Project and other projects;
- Identification of potential of cumulative effects by environmental topics and establishing if a potential linkage exists using the source-pathway-receptor conceptual model;
- The  type and duration of the impact - will it be temporary or permanent;
- The value and resilience if the receptor affected; and
- Mitigation measures that will be employed and the likelihood of their success.

### 8.1.2 Assessment of Cumulative Effects

#### 8.1.2.1 Stage 1 & 2 Identification and shortlisting of other projects

The identification and short list process is documented in Appendix F. This process included a review of all planning applications within in the area surrounding Islandmagee between January 2017 and October 2019. A review of the Marine Licence Public Register for all applications submitted to DAERA under the Marine and Coastal Access Act 2009 was also undertaken.

Planning application data since January 2017 was downloaded from the Department For Infrastructure website (https://applications.infrastructure-ni.gov.uk/DFI/PSepicdataextract/) in the form of two excel datasets; New Applications Received and Recent Planning Decisions. Due to limitiations of the website, only Planning Applications and Decisions data for the last two year could be extracted for analysis.  It is likely that construction for all successful applications prior to January 2017 will have already been completed or be close to completion and therefore unlikely to have a cumulative effect when considered in combination with the construction of the Islandmagee Gas Storage Faciltiy Infrastructure.

Since January 2017, there was approximatly 24,000 planning applications in Northern Ireland. Figure 8-1 below illustrates the number of planning applications in the areas surrounding Larne and Belfast Lough.

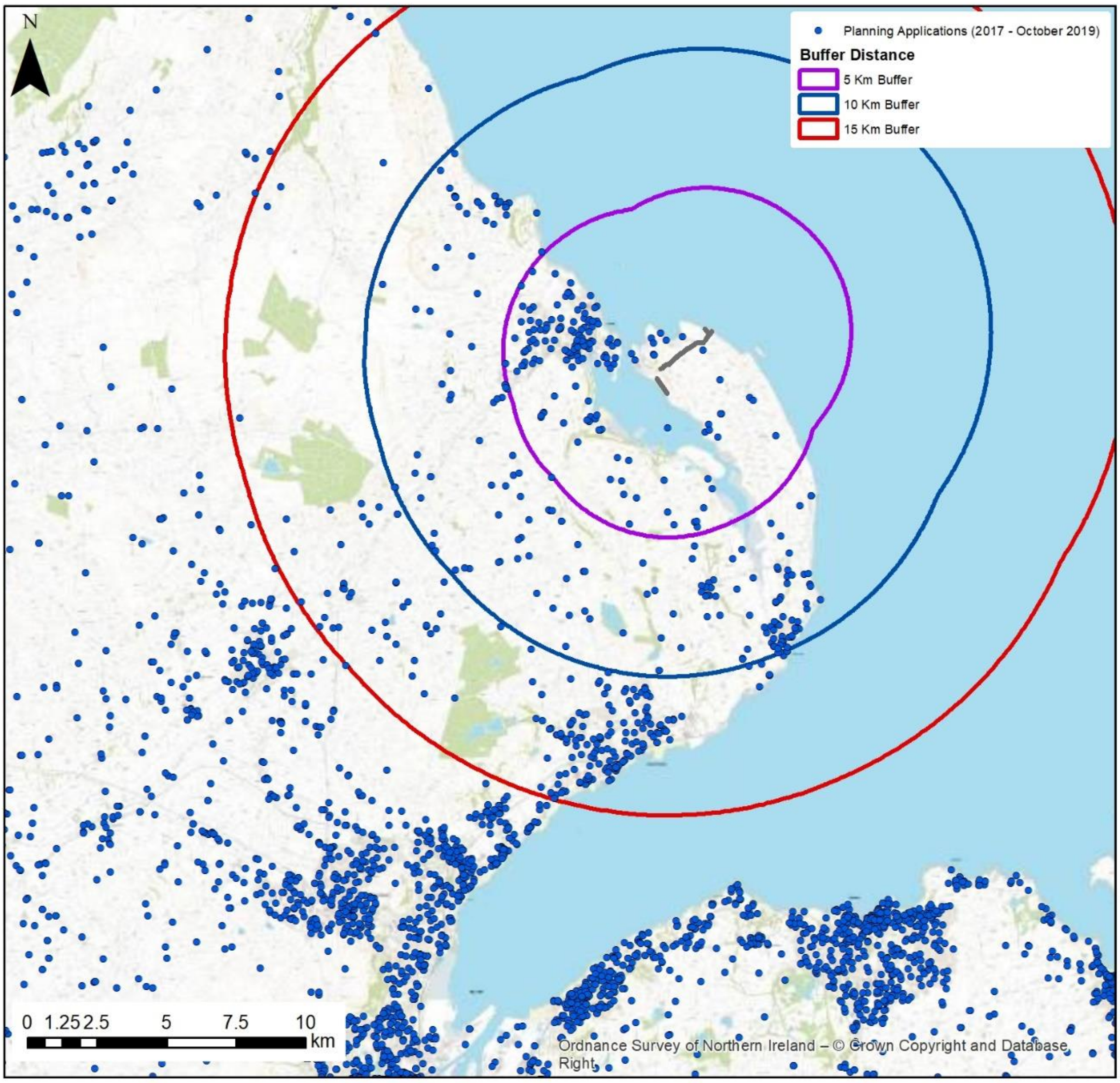


**Figure 8-1 Planning Applications Submitted since January 2017**

Of the 24,000 applications, there were 615 applications within 15km of the Islandmagee Gas Storage Facility in that same period. Summary of the planning applications shown in Table 8-2 below

**Table 8-2 Summary of Planning Applications within 15Km of Islandmagee Gas Storage Facility**

| Application Status | Number of Applications |
|---|---|
| Granted | 464 |
| Pending | 114 |
| Refused / Withdrawn | 37 |

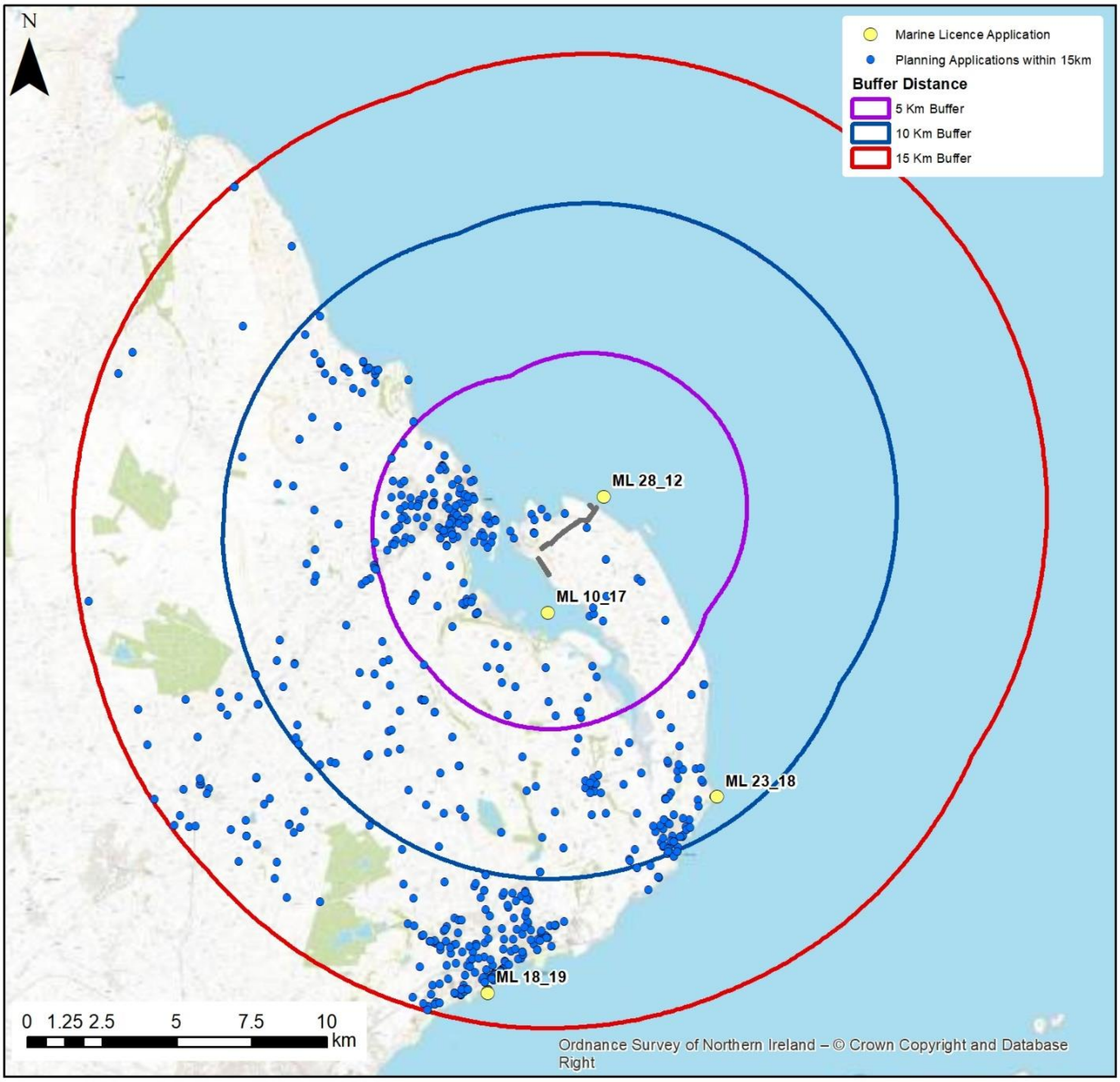


**Figure 8-2 Planning Applications/Active Marine Licence within 15km of Islandmagee Gas Storage Facility.**

A review of the Marine Licence Public Register was also undertaken. All licences that were withdrawn, expired or not located within the vicinity of Larne Lough were discounted. Of the 100 plus marine licence applications only four have been identified for further assessment (Table 8-3). For the purposes of this cumulative assessment all active marine licences were linked to their planning reference No. to avoid duplication.

**NOTE:** The Gaelectric Energy Storage Project (ML 49_13) has been withdrawn from the Planning Portal and Marine Licence Register and is therefore no longer relevant in terms of cumulative assessment.

**Table 8-3 DAERA Marine Licence Register**

| Marine Licence No (Planning Ref.) | Applicant name | Application description | Application address | Status |
|---|---|---|---|---|
| ML 28_12 | Islandmagee Storage Ltd. | Gas Storage Project | Islandmagee, Co. Antrim | Ongoing |
| ML 10_17 *(LA02/2017/1125/F)* | Doran Consulting | Remedial Sea Defences Works | Blue Circle Island, Larne Lough, Co Antrim. | Ongoing |
| ML 23_18 *LA02/2018/0787/F* | AECOM | Remedial Works & Borehole Testing | Blackhead Coastal Path, Whitehead | Ongoing |
| ML 18_19 *(LA02/2017/0357/F)* | O'Sullivan Macfarlane Consulting | Slipway widening | Carrickfergus Sailing Club | Ongoing |
| ML 49_13 *(LA02/2016/0006/F)* | Gaelectric Energy Storage (CAES) | Intake/Outlet pipe | Islandmagee, Co. Antrim | Plannning Submission and Marine Licence Withdrawn |

The long list was comprised of all planning applications within the 5km buffer zone (Figure 8-2).All Planning submissions that fell outside of the 5Km Buffer Zone were discounted from the long list using a source-pathway-receptor conceptual modal. The assessment highlighted that no source-pathway-receptor linkage exists between the planning applications outside the 5km Buffer zone and the construction and operation of the Islandmagee Gas Storage Facility solution mining infrastructure. Therefore no cumulative effects are considered likely.

Appendix F contains the long-list of planning applications within 5Km of the Islandmagee Gas Storage Facility considered and details of each planning proposal. The reasons for excluding any existing or approved projects from further consideration is also documented. Figure 8-3 illustrates all the planning submissions on the Islandmagee and Larne areas and highlights the four shortlisted developments that have been brought forward to Stage 3 for further assessment.

Table 8-4 provides a brief description of each planning proposal, information on the potential effect on the recieving receptor when considered in combination with the Islandmagee Gas Storage Facility and highlights the mitigation measures that have been proposed to reduce any significant cumulative effects (if any).

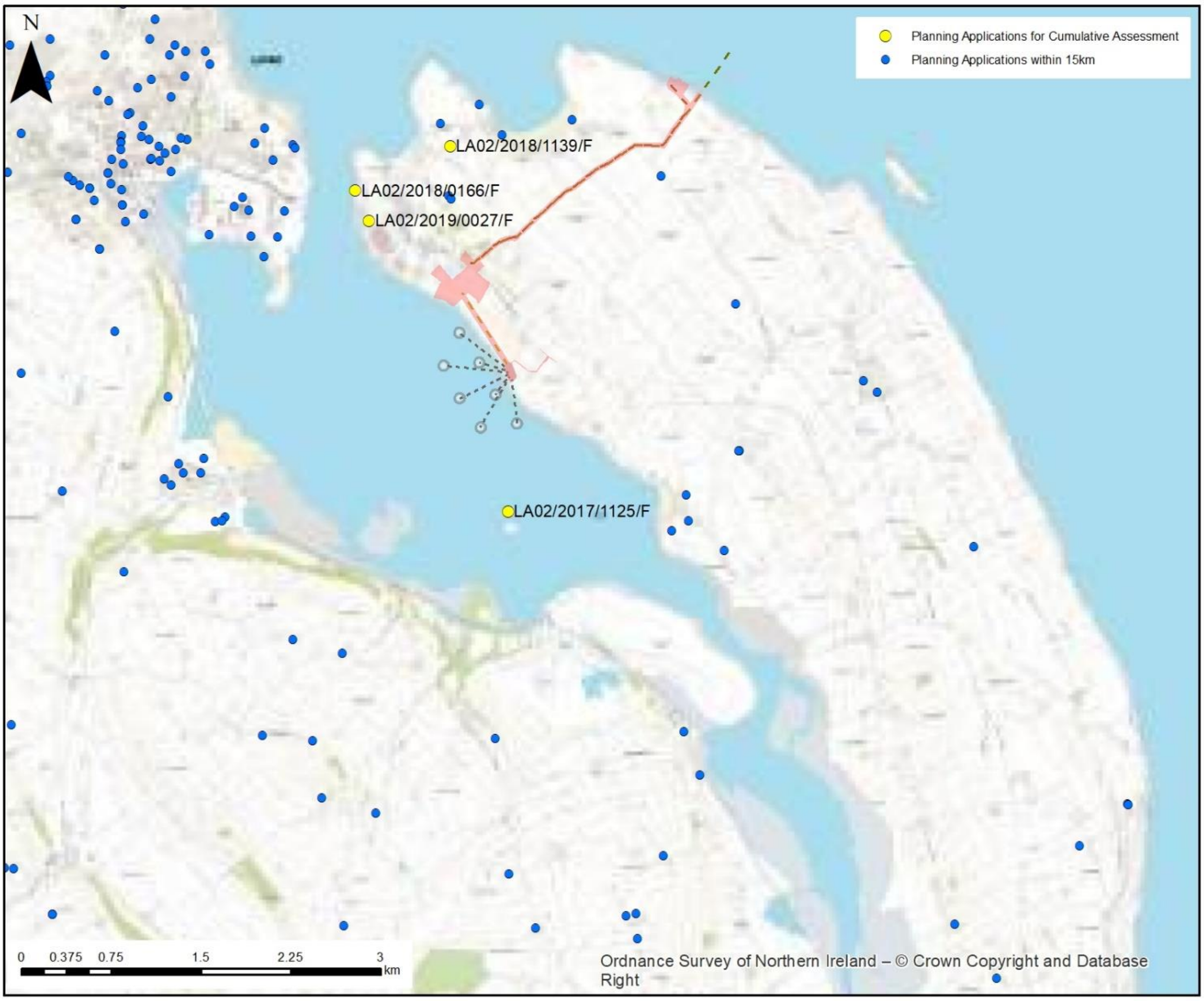


**Figure 8-3 Planning Applications and Marine Licence Applications for Further Assessment**

**Table 8-4 Description of potential cumulative effect between the Islandmagee Gas Storage Facility and existing and/or approved projects**

| Project / Applicant | Cumulative Interaction |
|---|---|
| **Ballylumford Harbour Remedial Works**<br><br>(LA02/2018/0166/F)<br><br>Mid & East Antrim Council | <u>Project Description</u><br><br>Planning permission was sought for Ballylumford Harbour Remedial Works at Ballylumford Harbour Ferris Bay Road Islandmagee. Permission for the development was Granted by the Mid and East Antrim Council on the 06 Dec 2018.<br><br>The application is located on the Islandmagee peninsula at 341974/402328.This application lies within 1Km of the Islandmagee Gas Storage Facility.<br><br>**<u>Potential Cumulative Effects</u>** |

| Project / Applicant | Cumulative Interaction |
| --- | --- |
| | Potential cumulative effects associated with the Islandmagee Gas Storage Project in combination with the Ballylumford Harbour Remedial Works at Ballylumford Harbour are:<br><br>• Cumulative effects on Biodiversity (Natura 2000 Site)<br><br><u>Cumulative effects on Biodiversity (Natura 2000 Site):</u><br><br>The Planner's Report was reviewed, and no effects upon any European site were identified by the planning authority. The Planners report included a number of planning conditions to ensure there are no impacts on the site integrity of any European Designated site.<br><br>A Habitats Regulation Assessment (HRA) submitted with this application on the 23rd of August 2018 was reviewed. The HRA referenced the CAES Larne scheme which has since been withdrawn but did not consider the effects of this development in combination with the Islandmagee Gas Storage Facility. Nevertheless, the HRA concluded that the provided the mitigation measures were employed the proposed development (Ballylumford Harbour Redevelopment) would have no adverse effects on the integrate of any European sites, either alone or in combination with other plans or projects.<br><br>When both projects are considered together, there will be no cumulative effects. |
| **Ferris Bay Waste Water Treatment Works**<br><br>(LA02/2018/1139/F)<br><br>Northern Ireland Water | **<u>Project Description</u>**<br><br>Planning permission was sought for Replacement wastewater treatment plant, new electricity kiosk, security fencing and associated works will be constructed within the existing site boundary owned by NI Water to meet NIW & NIEA's current and future requirements. No new buildings/access are planned and no structure will exceed 5m in height at the Ferris Waste Water Treatment Works 25m N E of 45 Ferris Bay Road BT40 3RT Islandmagee. N Permission for the development was Granted by the Mid and East Antrim Council on the 03 Jul 2019.<br><br>The application is located on the Islandmagee peninsula at 342763/402700.This application lies within 1Km of the Islandmagee Gas Storage Facility.<br><br>**<u>Potential Cumulative Effects</u>**<br><br>Potential cumulative effects associated with the Islandmagee Gas Storage Project in combination with the works at Ferris Bay WWTP are:<br><br>• Cumulative effects on Biodiversity (Natura 2000 Site) |

| Project / Applicant | Cumulative Interaction |
|---|---|
| | Cumulative effects on Biodiversity:<br><br>The Planner's Report was reviewed, and no effects upon any European site were identified by the planning authority. The Planners report included the following condition to protect water quality within the adjacent water course and to protect the site features and habitats within designated sites downstream: A suitable buffer of at least 10 metres must be maintained between the location of refuelling, storage of oil/fuel, concrete mixing and washing areas, storage of machinery/material/spoil etc. and the adjacent watercourse.<br><br>A Habitats Regulation Assessment (HRA) submitted with this application on the 7th of March 2019 was reviewed. The report did not predict any likely water quality, habitat deterioration or habitat loss effects; and it did not predict any underwater, aerial or visual disturbance effects.<br><br>The HRA assessment considered the in combination effects of the Islandmagee Gas Storage Facility and also the CAES Larne Project which has since been withdrawn. The HRA noted that the brine discharge of 2 projects in the Larne Lough area involving excavations of chambers in deep (>1km) salt beds are still to be completed. It acknowledged that the brine discharge would be close to the Ferris Bay area but that the nature of the discharge was different to that of the current project (Ferris Bay Waste Water Treatment Works) and no in-combination impacts were anticipated.<br><br>When both projects are considered together, there will be no cumulative effects. |
| **Ballylumford Waste Water Treatment Works**<br><br>(LA02/2019/0027/F)<br><br>Northern Ireland Water | **Project Description**<br><br>Planning permission was sought for Replacement Rotating Biological Contactor (RBC) plant and associated ancillary works at Ballylumford Wastewater Treatments Works Loughview Bungalows Larne. 27m south of 24 Loughview Bungalows. Permission for the development was Granted by the Mid and East Antrim Council on the 27 Aug 2019.<br><br>The application is located on the Islandmagee peninsula at 342084/402079.This application lies within 1Km of the Islandmagee Gas Storage Facility.<br><br>**Potential Cumulative Effects**<br><br>Potential cumulative effects associated with the Islandmagee Gas Storage Project in combination with the works at Ballylumford WWTP are: |

| Project / Applicant | Cumulative Interaction |
|---|---|
| | • Cumulative effects on Biodiversity (Natura 2000 Site)<br><br>Cumulative effects on Biodiversity:<br><br>The Planner's Report was reviewed, and no adverse effects upon the natural environment were identified by the planning authority.<br><br>A Habitats Regulation Assessment (HRA) submitted with this application on the 4th of June 2019 was reviewed. The report did not predict any likely water quality, habitat deterioration or habitat loss effects; and it did not predict any underwater, aerial or visual disturbance effects.<br><br>The HRA assessment considered the in combination effects of the Islandmagee Gas Storage Facility and also the CAES Larne Project which has since been withdrawn.<br><br>The HRA noted that the brine discharge of 2 projects in the Larne Lough area involving excavations of chambers in deep (>1km) salt beds are still to be completed. It acknowledged that the brine discharge would be close to the Ballylumford area but that the nature of the discharge is different to that of the current project (Ballylumford Waste Water Treatment Works) and no in-combination impacts were anticipated.<br><br>When both projects are considered together, there will be no cumulative effects. |

| Project / Applicant | Cumulative Interaction |
|---|---|
| **Coastal Erosion Defences at Blue Circle Island**<br><br>LA02/2017/1125/F)<br><br>RSPB | **Project Description**<br>Planning permission was sought for Reconstruction and maintenance works to coastal erosion defences reinstatement of eroded land and erection of moveable bird hide at Blue Circle Island, Larne Lough, and Larne. Permission for the development was Granted by the Mid and East Antrim Council on the 08 May 2018.<br><br>The application is located within Larne Lough at 343248/399650.This application lies within 2Km of the Islandmagee Gas Storage Facility.<br><br>**Potential Cumulative Effects**<br><br>Potential cumulative effects associated with the Islandmagee Gas Storage Project in combination with the works at Blue Circle Island are:<br><br>• Cumulative effects on Biodiversity (Natura 2000 Site)<br><br>Cumulative effects on Biodiversity:<br><br>The Planner's Report was reviewed, and no effects upon any European site were identified by the planning authority. A HRA submitted with this application on the 27th of October 2017 was reviewed. The report did not predict any likely water quality, habitat deterioration or habitat loss effects; and it did not predict any underwater, aerial or visual disturbance effects.<br><br>The HRA assessment did not consider the in combination effects of any other projects on the basis that no plans or programmes (requested or approved planning applications) had been identified within the Larne Area Plan (2010) that could contribute to an in-combination effect with the proposed works (Coastal Erosion Defences at Blue Circle Island).<br><br>When both projects are considered together, there will be no cumulative effects. |

The potential for cumulative effects to arise with consented and pending schemes near the Islandmagee Gas Storage Project was assessed. Relevant projects were selected and the Project team defined significance thresholds and criteria for assessment based on professional judgement, alongside relevant standards and guidelines, to determine whether in-combination effects gives rise to additional levels of significance.

The cumulative assessment process included a review of all planning applications within in the area surrounding Islandmagee between January 2017 and October 2019. During that period there was approximately 24,000 planning applications in Northern Ireland and 615 within 15km of the Islandmagee Gas Storage Facility. A review of the Marine Licence Public Register for all applications submitted to DAERA under the Marine and Coastal Access Act 2009 was also undertaken. All short-listed projects were assessed for likely cumulative effects in combination with the construction and operation with the Islandmagee water abstraction and brine outfall.

The most significant nearby project initially identified was the Gaelectric Energy Storage Scheme (CAES), however the planning application (LA02/2016/0006/F) and Marine Licence Application (ML49_13) for this project was withdrawn on the 23rd of July 2019. As the project has been withdrawn there are is no longer any potential for any cumulative effects to arise in combination with the Islandmagee Gas Storage Facility.

Other nearby projects included the Ballylumford Harbour Remedial Works, Ferries Bay Waste Water Treatment Works, Ballylumford Waste Water Treatment Works and the Coastal Erosion Defences at Blue Circle Island. The cumulative assessment concluded that due to the nature of these projects, these projects will not result in cumulative effects when considered in combination with the Islandmagee Gas Storage Facility.

# 9 ENVIRONMENTAL MONITORING PROGRAMME

This chapter presents proposals for a comprehensive Environmental Monitoring Programme (EMP) to ensure that the computational modelling predictions, together with the environmental appraisals presented within the Project Environmental Statement (ES) and associated documents are an accurate reflection of the actual environmental impact of the brine discharge. The EMP offers additional safeguards by setting trigger levels above which construction works may be temporarily halted to ensure the environmental impact of the brine discharge remains within acceptable limits. This Environment Monitoring Programme is subject to agreement with DAERA following discussions with the Science and Technical Advisory Group.

## 9.1 Monitoring the Brine Discharge

The design of the brine monitoring programme is based on the known characteristics of the brine and how it is expected to disperse within the marine environment based on the results of the models presented in Appendix B of this report.

A pragmatic approach has been adopted whereby it is proposed that the results of the monitoring programme will be reviewed with the Licensing Authority on an annual basis and the programme adjusted accordingly.

## 9.2 Continuous Monitoring Buoys

It is proposed to deploy three real-time monitoring buoys for the duration of the brine discharge. Two buoys will be located northwest and southeast of the marine outfall, the position of these buoys will enable brine monitoring 100m from the discharge point along the axis of the main tidal flow (as shown in Figure 9-1).The third buoy will act as a control site and will be sited following discussions with DAERA.

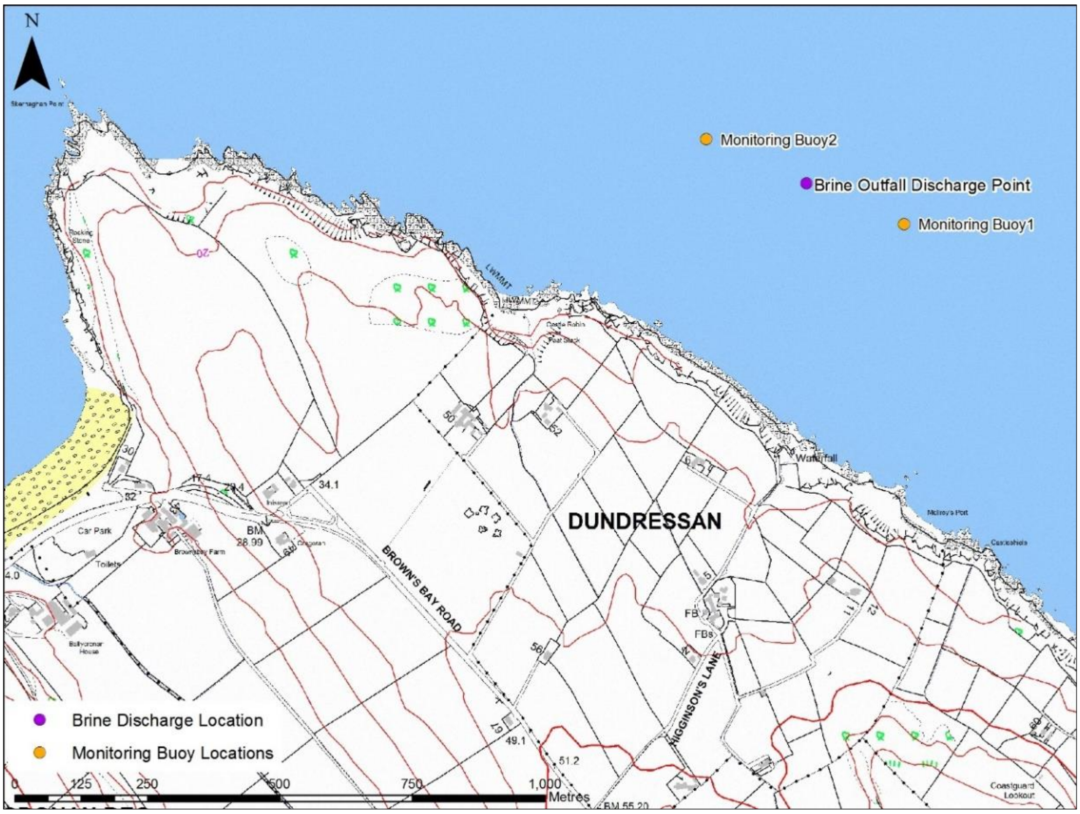


**Figure 9-1 Proposed location of real-time monitoring buoys**

The buoys and their moorings will be designed for the sea conditions expected at the deployment sites and the power requirements of the monitoring equipment installed on the buoys.

The sea conditions likely to be experienced at the site during storm conditions are expected to be extremely harsh. The trend is of increasing extreme storm wave heights within the Irish Sea as presented in Figure 9-2, and it is anticipated that the wave climate in the North Channel has undergone a similar change.

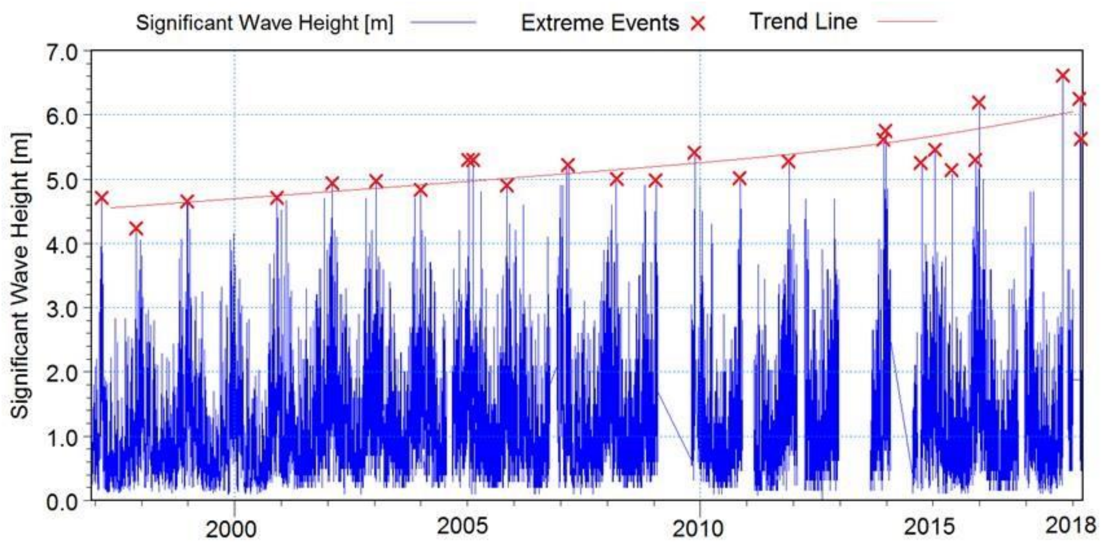


**Figure 9-2 Extreme significant wave heights experienced in the Irish Sea 1997 – 2017**

Through monitoring work that RPS is overseeing in Dublin Bay we know that storm waves recorded at the entrance to Dublin Bay during Storm Emma (the beast from the east) on 2nd March 2018 reached significant wave heights of 5.08m (maximum wave height of 7.86m) presented in Figure 9-3. These waves had relatively short wave periods of between 8.5 – 10.5 seconds which placed considerable strain on the moorings leading to damage.

Given that it is anticipated that the waters off Islandmagee are experiencing a similar trend in wave climate, it is also expected that during such extreme conditions, considerable strain will be put on the moorings which must be designed according, using the lessons learned from the Dublin Bay work and elsewhere.

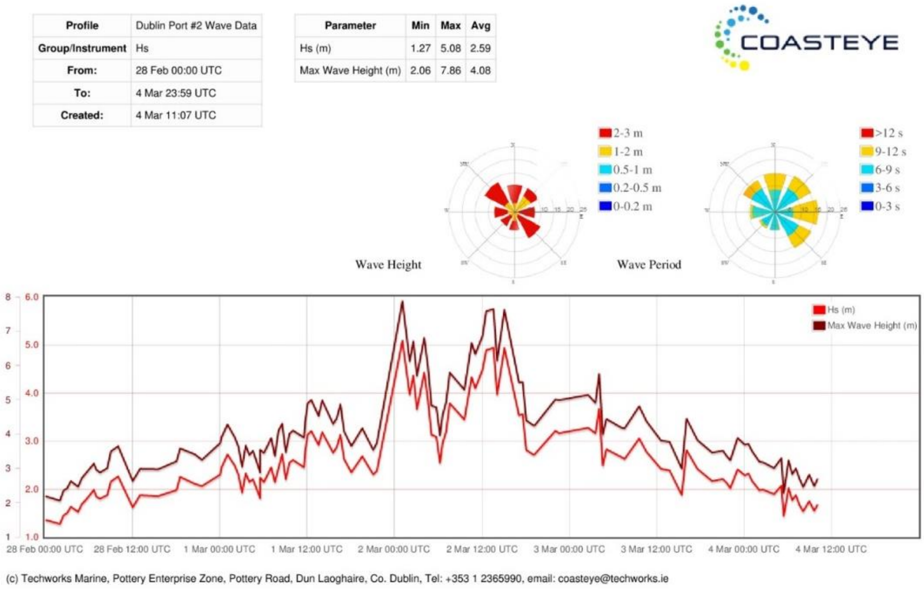


**Figure 9-3 Wave conditions recorded during Storm Emma at entrance to Dublin Bay**

The typical buoy and mooring design as presented in Figure 9-4 is therefore anticipated, although this is subject to detailed design by the specialist contractor employed to undertake the works. The example arrangement shown in Figure 9-4 comprises a buoy with a 1.9m diameter hull constructed from multiple-section polyethylene floats bolted around the central structure, with through-hull access for underwater instrumentation and cabling.

A double mooring arrangement is used to allow a data cable to hang vertically within the water column to enable monitoring sensors to record data close to the seabed. The data cable will also provide support to other monitoring equipment such as Static Acoustic Monitoring (SAM) devices, known as CPODs.

A single point mooring option is not considered suitable for the Islandmagee application because the swinging movement of the mooring and data cable would lead to entanglement and potential damage.

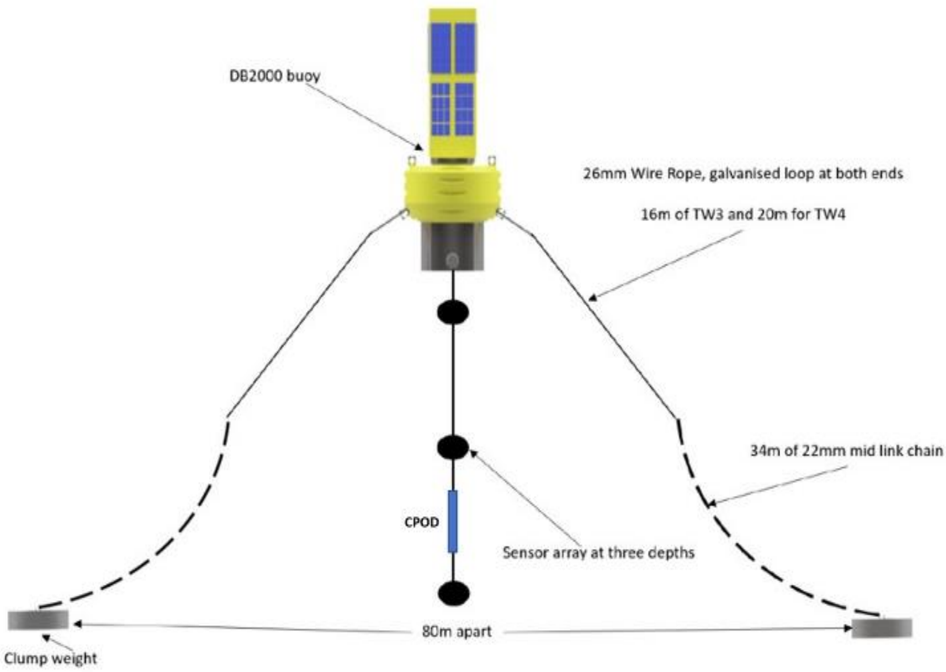


**Figure 9-4 Typical buoy and mooring arrangement expected to be deployed**

The monitoring buoys would support a number of solar panels to meet the power requirements of the monitoring sensors and the transmission system required to remotely interrogate the data being recorded.

The buoys will be fitted with AIS (Automatic Identification Systems) to ensure navigational safety. The Hydrographic Office will be notified of their presence.

## 9.3 Water Quality Monitoring System Specification

The proposed monitoring system specification is based on the use of state of the art 24/7 real time monitoring equipment. Water quality monitoring sensors, giving high resolution data with respect to the parameters presented in Table 9-1 will be used at each of the monitoring locations.

**Table 9-1 Water Quality Monitoring Parameters**

| Parameter | Meter Type | Accuracy |
|---|---|---|
| Salinity | Conductivity | ± 1 % of reading or 0.1 psu, whichever is greater (after post-calibration) |
| Dissolved Oxygen | Optical | ± 1 % of reading |
| Temperature | Optical | ± 1 % of reading |

The buoy and mooring arrangement described in Section 9.2 above will allow for monitoring at three depths within the water column, typically one metre from the surface, mid-depth, and one metre from the seabed.

A calibration and servicing programme will form an integral part of the water quality monitoring system specification comprising:

- Regular calibration of the sensors
- Regular maintenance of the sensors (including cleaning)
- Maintaining Data Quality Control
- Provision of replacements if required

A data acquisition and transfer system will be specified to enable the transmission of high resolution data at 15 minute intervals. Alarms triggers will however be based on 5 minute resolution data.

It is intended to use a web-based data interrogation system through which multiple users can gain access to the recorded data in virtual real-time. One such system is the 'Coasteye' system illustrated in Figure 9-3.

## 9.4 Water Quality Monitoring Alarm Values

The real-time water quality monitoring system will be designed to automatically send text messages to the mobile phones of the Environmental Clerk of Works, Contractor and the Resident Engineer to alert them if a pre-determined alarm level has been breached. This early warning system will enable the responsible parties to quickly investigate the cause of the breach and to take appropriate action.

In the event that salinity levels breach the predetermined threshold level for a period of 5 minutes or more, a process of discharge termination will be initiated and the discharge stopped within one hour in accordance with

Condition 20 of the Draft Marine Construction Licence, including the temporary cessation of the works where appropriate.

The proposed alarm levels set to safeguard the marine environment in the vicinity of the brine outfall and are presented in Table 9-2. Subject to agreement by the relevant Authorities, these trigger settings will be implemented via the proposed monitoring system.

**Table 9-2 Water Quality Monitoring Alarm Levels**

| Parameter | Alarm Level |
|---|---|
| Salinity | > 36 psu for 5 minutes |
| Dissolved Oxygen | < 6 mg/l for 5 minutes |

Note: Temperature is a supporting parameter used in the calculation of dissolved oxygen percentage saturation

## 9.5 Additional brine tracking surveys

The deployment of the monitoring buoys will provide real time water quality data at strategically located positions throughout the duration of the leaching process and brine discharge. This will be complemented by additional field surveys to confirm the overall footprint of the brine plume.

The brine tracking survey will comprise the lowering of a CTD meter (Conductivity, Temperature, Dissolved Oxygen) from a vessel at a series of pre-determined locations and recording the Conductivity, Temperature, Dissolved Oxygen profile with depth.

The results of each brine tracking survey will be used to tailor the locations of subsequent surveys in order to accurately depict the dispersal characteristics of the brine discharge.

It is proposed to undertake six brine tracking surveys during the first year of operation of the brine outfall. At this time, the merits of undertaking further brine tracking surveys will be reviewed with the Licensing Authority.

## 9.6 Marine Mammals

Construction of the intake and outfall pipelines and the operation of the brine outfall have the potential to cause significant impacts on sensitive habitats and species, including marine mammals.

The potential for significant impacts on sensitive marine and coastal habitats will be minimised by employing the use of horizontal directional drilling and tunnelling techniques within the construction methodology. The construction techniques will effectively tunnel the intake and outfall pipelines beneath the seabed, only causing a small area of disturbance where they break through the surface of the seabed at the intake/ outfall points.

## 9.7 Establishing a Baseline for marine mammals using Static Acoustic Monitoring

It is proposed to use Static Acoustic Monitoring (SAM) in advance of the works to establish a baseline for cetaceans.

SAM is based on the use of C-PODS, a fully automated, static, passive acoustic monitoring system which can detect porpoises, dolphins and other toothed whales by recognising the trains of echolocation clicks these species make in order to detect their prey, orientate themselves and interact with one another. C-POD units are designed and manufactured by Chelonia Ltd. and are the only commercially available instruments accompanied by click train recognition software which produce fully automated, accurate data on the behaviour and identification of cetacean species.

A single C-POD can monitor both porpoise and dolphins simultaneously through identifying characteristic click parameters of each species. C-PODs operate in a passive mode and detect tonal clicks within a frequency range of 20kHz to 160kHz. When detected, the time of occurrence, centre frequency, intensity, duration, bandwidth and frequency of the click is logged to an on-board Secure Digital (SD) flash card. Dedicated software, CPOD.exe, is used to download and process the data according to user specified parameters. The C-POD does not record actual sound files. It only records information about the tonal clicks it detects.

SAM is a robust system capable of collecting continuous quality data, independent of weather conditions over the deployment interval. However, the spatial coverage of individual C-POD units is relatively small. Detection range trials carried out in Galway Bay suggest a maximum detection distance of around 400m for harbour porpoises, and results from trials in the Shannon Estuary suggest a range of 800m for bottlenose dolphins (O'Brien et al. 2013).

Consequently it is proposed that three C-PODs will be deployed, two coinciding with the locations of the water quality monitoring buoys near the discharge and a third further away, acting as a control site.

Calibration of equipment is important in order to enable the comparison of results between C-PODs. All C-POD units are factory calibrated prior to dispatch in a laboratory under controlled conditions. The manufacturers strongly recommend that further calibration is carried out in the field prior to deployment in monitoring programmes. Field calibrations aim to assess differences in sensitivity between units, and also facilitate comparisons between datasets collected in different areas using multiple loggers (O'Brien et al. 2013). This is especially important where several units are employed to compare detections at a number of sites since varying sensitivities will result in different detection rates.

Field trials are carried out in areas with high cetacean density in order to determine individual C-POD detection function (O'Brien et al. 2013). All field calibrations use a dedicated reference C-POD for comparisons. It is proposed that calibration of C-PODS for use in this monitoring programme will be carried out in the Shannon Estuary where there is a resident population of bottle nosed dolphins.

The C-PODs will be deployed on moorings and recovered for downloading of data approximately four times per year. This data will be analysed as detection positive minutes (DPM) to generate an acoustic index of activity to serve as a baseline.

## 9.8 Use of Static Acoustic Monitoring during construction and operational phases of the marine works

The use of the C-PODs will continue for the duration of both the construction works and brine discharge. The monitoring will also continue post-development for a period of two years in line with international best practice.

During the operational stage, there will be an opportunity to 'piggy-back' the C-PODs onto the water quality monitoring buoy moorings as shown previously in Figure 9-4.

The use of the C-PODs will provide large datasets to enable changes in activity to be identified at high resolution and will help to determine whether any displacement of cetaceans may have occurred during the construction phase or during the operational phase of the brine discharge. Comparison of data across the sites using a 'before-after-control-impact' (BACI) type design to evaluate any impacts (Carstensen et al. 2006) will provide opportunities for adaptive project management through regular feedback to environmental managers and contractors.

## 9.9 Use of Marine Mammal Observers (MMOs)

Marine Mammal Observers (MMOs) will be employed during the construction phase of the seawater intake and brine outfall when there is potential to generate underwater noise.

The MMOs will ensure that noise generating construction activity does not commence whilst a marine mammal (cetacean or seal) is in close vicinity to the works. The extent of an appropriate exclusion zone will be agreed with the Licensing Authority in advance of the construction works.

The contractor will only be allowed to commence works after the MMO has undertaken a 30 minute pre-watch, during daylight hours and suitable sea state, and has confirmed the absence of marine mammals from the exclusion zone.

## 9.10 Seal Surveys

The use of Static Acoustic Monitoring (SAM) is not a reliable method for the detecting the presence of seals as they do not use echolocation techniques to locate prey or to communicate.

It is therefore proposed to undertake monthly seal surveys at a selection of known haul out sites along the Islandmagee coastline to determine natural behavioural variations prior to construction and thereafter to determine whether the construction works and brine discharge give rise to changes in behaviour, such as avoidance of the site. The survey results will provide opportunities for adaptive project management through regular feedback to environmental managers and contractors.

## 9.11 Benthic Ecology & Fisheries

Construction of the intake and outfall pipelines and the operation of the brine outfall have the potential to cause significant direct impacts on sensitive marine habitats and species. The potential for significant impacts on areas of sensitive marine and coastal habitats will be minimised by employing the use of horizontal directional drilling and tunnelling techniques within the construction methodology. The construction techniques will tunnel the intake and outfall pipelines beneath the seabed, only causing a small area of disturbance where they break through the surface of the seabed at the intake/ outfall points.

## 9.12 Benthic Grab and Video Surveys

It is proposed to collect up to 41 drop down video samples at the locations presented in Figure 9-5. Information gathered from this survey will be used to select infaunal sediment stations, and will be used to provide a snapshot of the seabed prior to construction of the seawater intake and brine discharge, as well as monitor recovery at the site following cessation of the brine discharge.

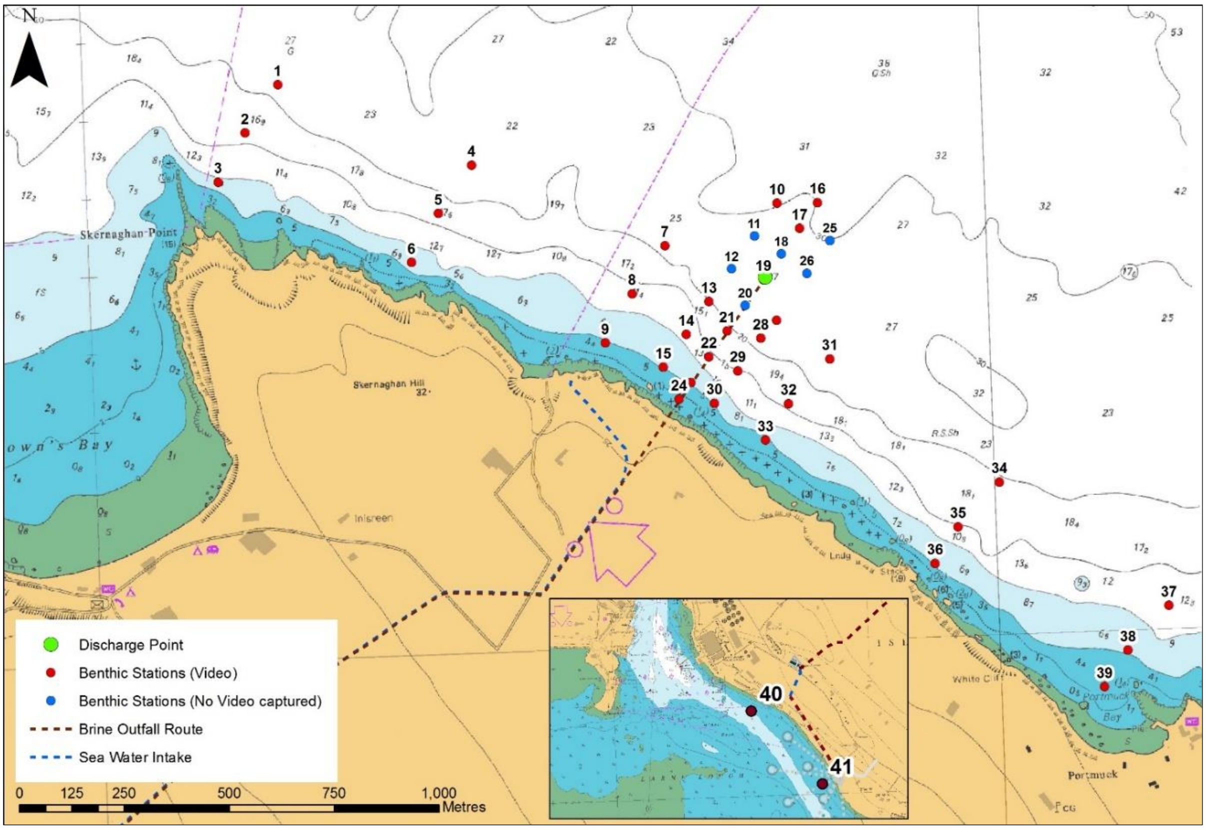


**Figure 9-5 Location of proposed drop down video surveys**

In addition, it is proposed to collect subtidal infaunal sediment grab samples at 20 locations as presented in Figure 9-6. The final locations may be varied subject to the findings of the drop down video surveys. Beam trawl surveys will also be undertaken between the benthic sampling locations, described later in Section 9-11.

This will allow for a detailed assessment to be made on the communities present in the area (replicates showing large degree of variability are often indicators of stress) whilst maximising the spatial spread in areas of potential impact to the north and south of the discharge point. Each biological grab sample will be taken in the same location as a video drop sample. This will allow for a more detailed assessment to be made on potential impacts from the brine disposal activities. In addition, blotted wet weight biomass will be measured at each site for each of the major phyla identified.

Environmental data for granulometry and organic matter (Loss on Ignition) will also be measured at each site.

Results from these surveys will then be used to assess the community structure in the area using a combination of univariate indices (such as evenness and diversity indices) and multivariate analysis.

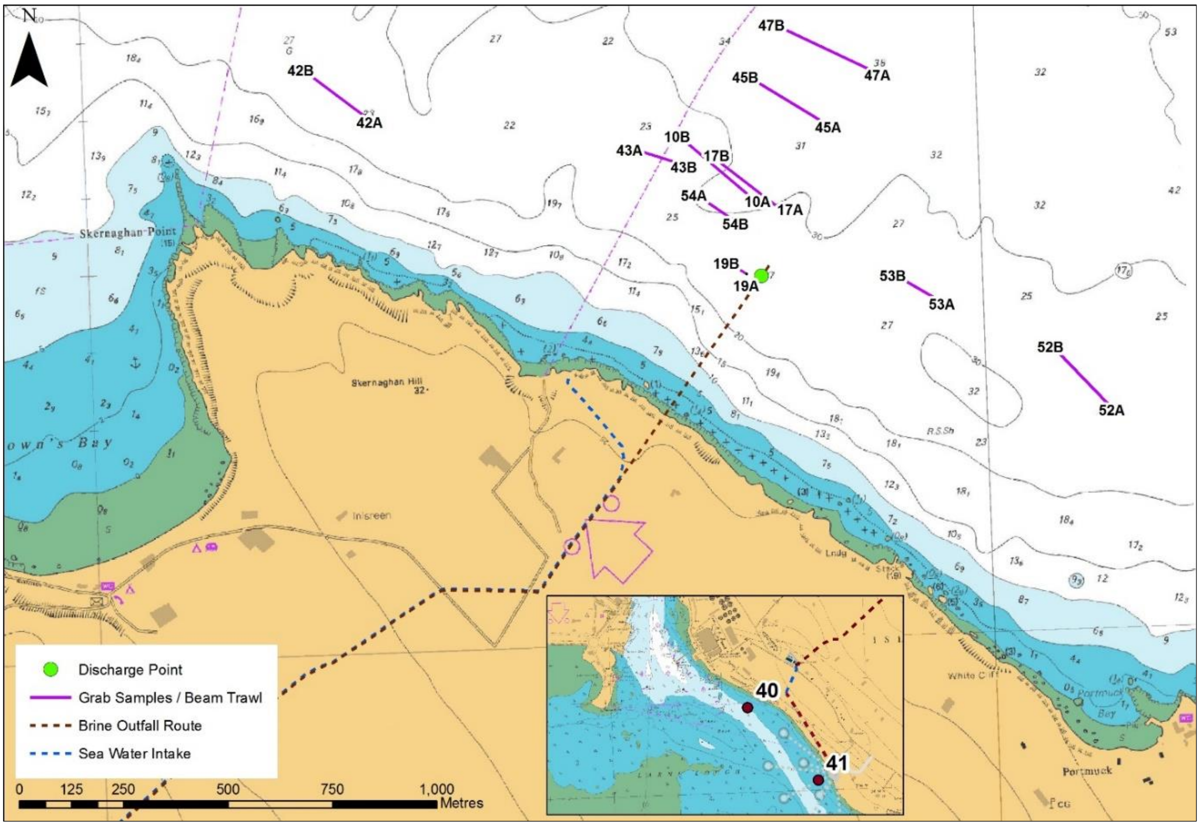


**Figure 9-6 Location of proposed subtidal infaunal sediment grab samples (and 2m beam trawl surveys)**

It is proposed to repeat this survey as follows:

- Pre-construction works
- Annually during the brine discharge
- Annually for 2 years post the brine discharge

Comparisons will be made between the pre- and post-disposal results, and assessments made on community level impacts at the sites, and the spatial distribution of impacts. To complement the above surveys, it is further proposed to undertake a series of benthic survey transacts and spot surveys using divers or a ROV (Remote Operated Vehicle) as presented in Figure 9-7.

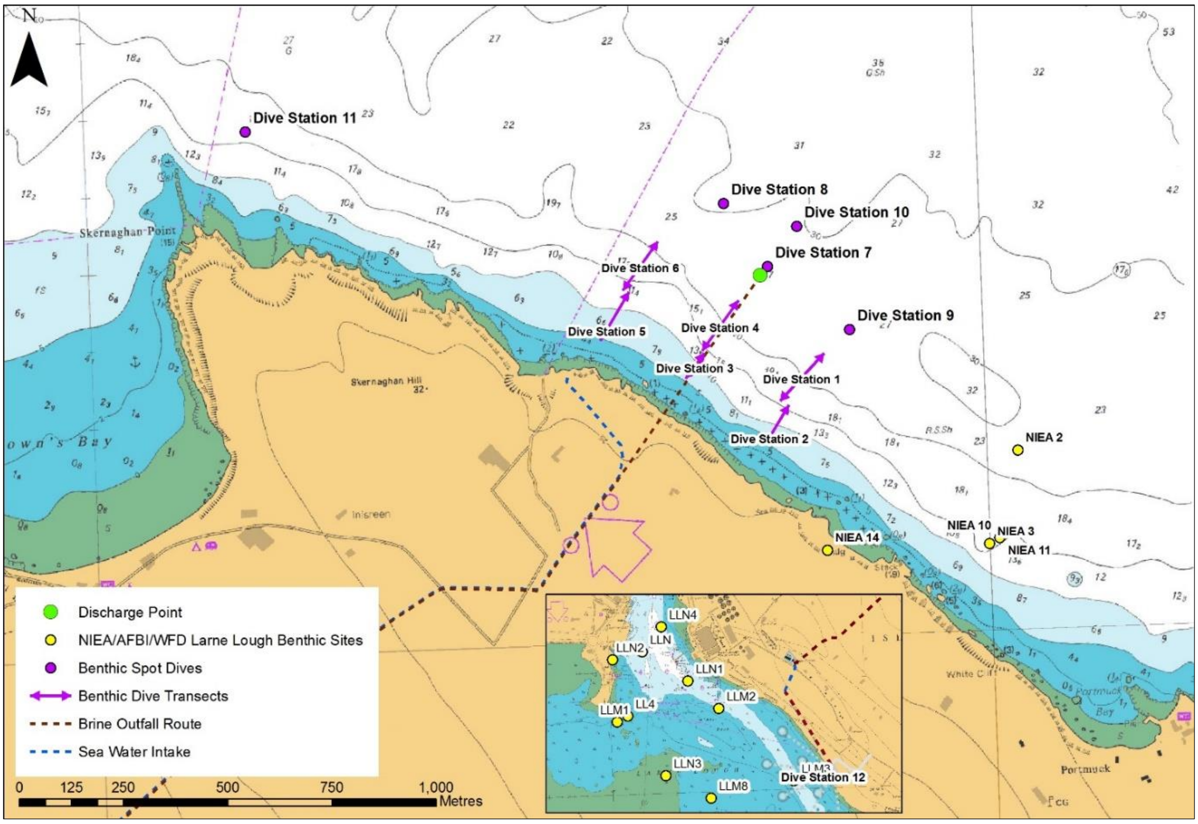


**Figure 9-7 Location of proposed diver or ROV surveys**

## 9.13 Fisheries Management

*Beam Trawl Survey*

A series of beam trawl surveys have been designed to confirm that the fish community in the vicinity of the proposed construction works and brine discharge from year to year remains largely the same, i.e. dominated by the same range of species, across the same general size ranges and broadly the same rank i.e. relative frequency of occurrence. It is proposed that replicate 2m beam trawls would be taken at 9 locations as presented previously in Figure 9-7.A typical 2m wide beam trawl is presented in Plate 9-1.

**Plate 9-1 Typical 2m wide beam trawl**

It is proposed to repeat this survey as follows

- Pre-construction works
- Annually during the brine discharge
- Annually for 2 years post the brine discharge

*Commercial Pot Fishery and By-Catch Survey*

Monitoring of core pot fishery locations (as previously used during the baseline phase of the original EIA study) will be re-established to determine any changes in the nature of the fishery, in terms of target species health and by-catch, since the monitoring for the Project ES was undertaken. The by-catch survey will be used to complement the benthic grab and video surveys described in Section 9.12..

These surveys will be undertaken in co-operation with local pot fishermen within the zones presented in Figure 9-8.

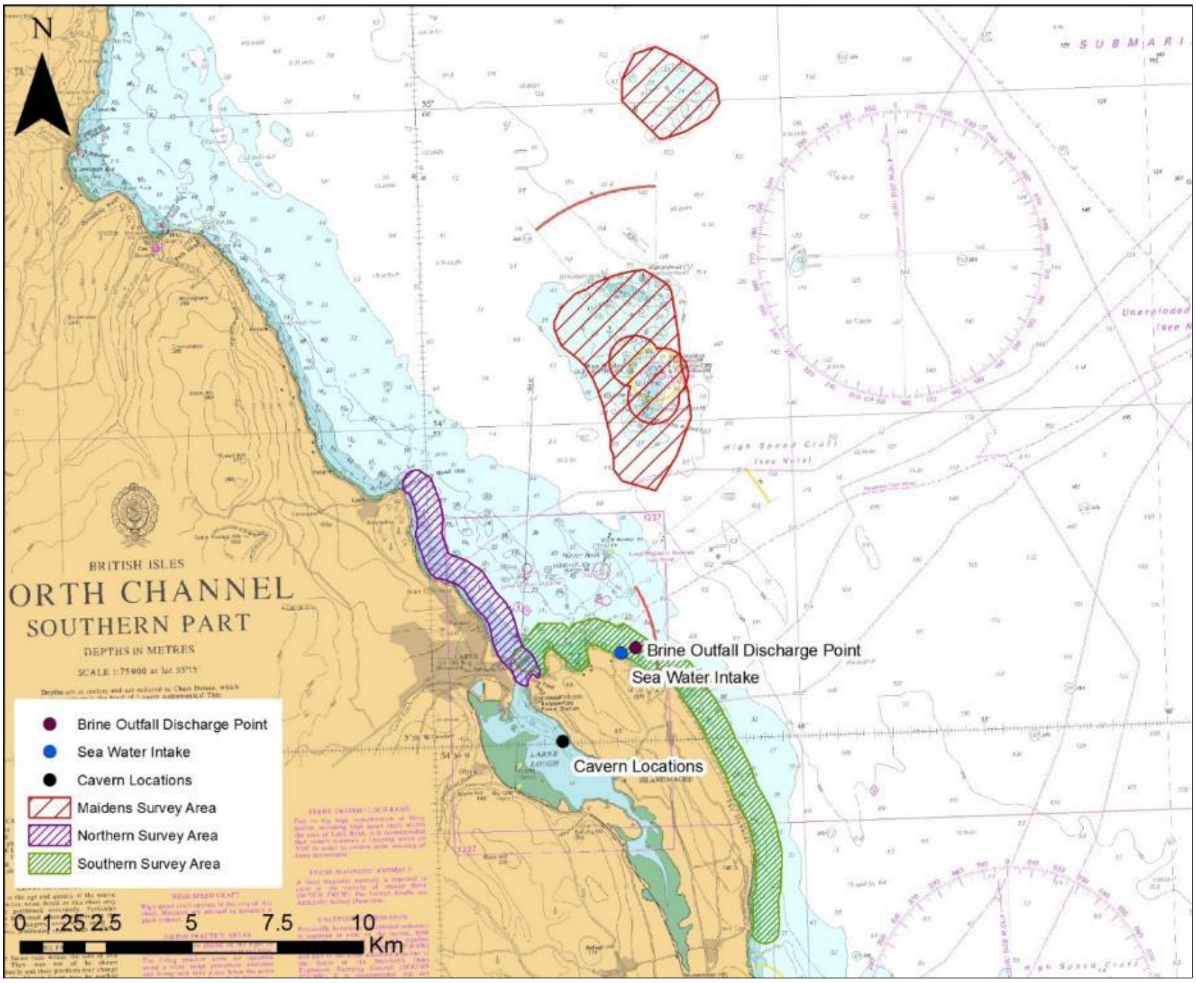


**Figure 9-8 Location of proposed commercial pot surveys, including by-catch**

It is proposed to repeat this survey as follows

- Pre-construction works
- Annually during the brine discharge
- Annually for 2 years post the brine discharge

## 9.14 Birds

Construction of the intake and outfall pipelines have the potential to cause significant impacts on nesting and feeding birds, without mitigation as described in the Project ES.

The operation of the brine outfall is not expected to impact on feeding seabirds because the brine being of higher density compared to natural seawater, will tend to stay close to the seabed when discharged back to sea via the brine outfall.

An ornithological monitoring programme will however be implemented to identify the effectiveness of the mitigation measures identified within the Project ES and associated documents. The data collected during the Environmental Impact Assessment and presented in the ES and ES Addendum and this Environmental Update will form the baseline against which this monitoring will take place (see Figure 9-9). Monitoring will seek to replicate the methods used to collect the baseline data to allow a direct comparison.

In line with the recommendations of the ES, ornithological monitoring in the form of Vantage Point Seabird Counts and a breeding Black Guillemot Survey will be undertaken during the marine construction phase of the proposed works

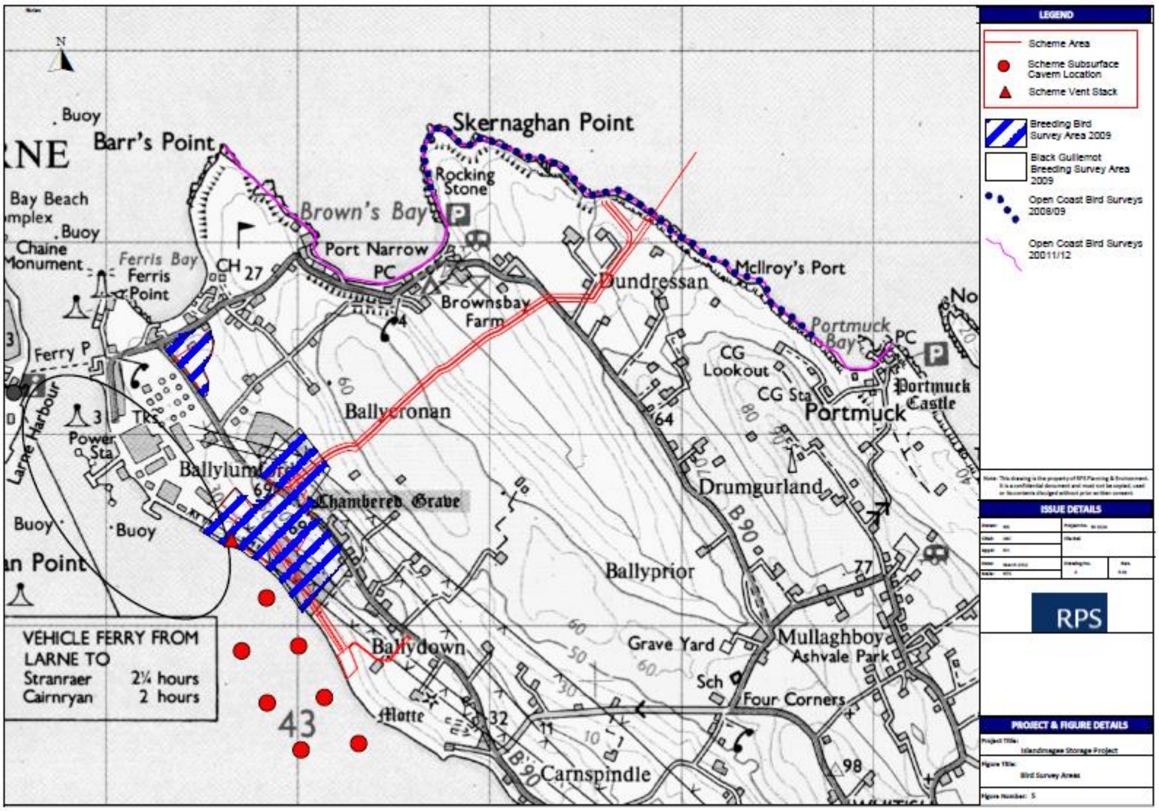


**Figure 9-9 Location of proposed ornithological surveys**

## 9.15 Reporting

All monitoring data will be collected and relayed to the Licensing Authority in accordance with the specifications of the Marine Construction Licence.

# 10 MITIGATION MEASURES & CONCLUSIONS

## 10.1 Mitigation Measures

Islandmagee Energy Ltd seeks to achieve the highest possible standards of environmental management during both the construction and operational phases of the Islandmagee Gas Storage Facility.

Chapter 14 of the Environmental Statement (2010) provides a summary of the potential impacts and mitigation measures that will be employed during construction and operation to reduce or eliminate these impacts. This section of the report only contains a summary of additional mitigation measures and monitoring requirements that have been proposed within this Marine Environmental Conditions Update Report.

### 10.1.1 Construction Phase Mitigation Measures

| Potential Impact | Summary of Proposed Mitigation |
|---|---|
| **Chapter 6 Assessment of Underwater Noise** | |
| Precautionary measures will be implemented to minimise the risk of injury or disturbance to marine mammals during tunnel boring, while excavating the tunnel boring pit and at the final stage of HDD (breakthrough to the seabed) | – A trained and experienced Marine Mammal Observer (MMO) will be put in place during the tunnel boring and tunnel boring pit and at the final stage of the HDD drilling as a pre-caution. This observation can be carried out from shore as the two locations are located close enough to be observed.<br>– Exclusion zones for marine traffic or marine mammals may be proposed for different stages of the works and it is recommended that these zones are applied to recreational diving activity. e extent of an appropriate exclusion zone will be agreed with the Licensing Authority in advance of the construction works.<br>– The contractor will only be allowed to commence works after the MMO has undertaken a 30 minute pre-watch, during daylight hours |

### 10.1.2 Operation Phase Mitigation Measures

#### 10.1.2.1 Mitigation by Design

A grill, with a mesh diameter of 12 mm, across the intake will be installed to prevent, in particular, European eel and salmonid smolts from being entrained.

The outfall pipe will comprise of two diffuser ports pointing vertically upwards and fitted with duckbill diffuser valves to maximise the dispersion and mixing of discharged brine and to prevent entrainment during any periods of shut down.

#### 10.1.2.2 Environmental Monitoring Programme

Chapter 9 of this report sets out a comprehensive Environmental Monitoring Programme (EMP) that will be implemented to ensure that the computational modelling predictions, together with the environmental appraisals presented within the Project Environmental Statement (ES) and associated documents are an accurate reflection of the actual environmental impact of the brine discharge. The design of the environmental monitoring programme is based on the known characteristics of the brine and how it is expected to disperse within the marine environment based on the results of the models presented in Appendix B of this report.

Listed below are the key elements the will be implemented during the operation phase of the marine outfall.

#### 10.1.2.2.1 Monitoring Buoys / Brine Tracking Surveys

It is proposed to deploy three real-time monitoring buoys for the duration of the brine discharge. Two buoys will be located northwest and southeast of the marine outfall, the position of these buoys will enable brine monitoring 100m from the discharge point along the axis of the main tidal flow. The third buoy will act as a control site and will be sited following discussions with DAERA.

Trigger Levels

The EMP offers additional safeguards by setting salinity trigger levels above which construction works may be temporarily halted to ensure the environmental impact of the brine discharge remains within acceptable limits.

The real-time water quality monitoring system will be designed to automatically send text messages to the mobile phones of the Environmental Clerk of Works, Contractor and the Resident Engineer to alert them if a pre-determined alarm level has been breached. This early warning system will enable the responsible parties to quickly investigate the cause of the breach and to take appropriate action.

In the event that salinity levels breach the predetermined threshold level for a period of 5 minutes or more, the process of discharge termination will be initiated and the discharge stopped within one hour in accordance with Condition 20 of the Draft Marine Construction Licence, including the temporary cessation of the works where appropriate.

The proposed alarm levels set to safeguard the marine environment in the vicinity of the brine outfall are presented below (Subject to agreement by the relevant Authorities, these trigger settings will be implemented via the proposed monitoring system).

| Parameter | Alarm Level |
|---|---|
| Salinity | > 36 psu for 5 minutes |
| Dissolved Oxygen | < 6 mg/l for 5 minutes |

Note: Temperature is a supporting parameter used in the calculation of dissolved oxygen percentage saturation

Brine tracking surveys

It is proposed to undertake six brine tracking surveys during the first year of operation of the brine outfall. After this time, the merits of undertaking further brine tracking surveys will be reviewed with the Licensing Authority. The brine tracking survey will comprise the lowering of a CTD meter (Conductivity, Temperature, Dissolved Oxygen) from a vessel at a series of pre-determined locations and recording the Conductivity, Temperature, Dissolved Oxygen profile with depth. The results of each brine tracking survey will be used to tailor the locations of subsequent surveys in order to accurately depict the dispersal characteristics of the brine discharge.

#### 10.1.2.2.2 Environmental Monitoring and Reporting

Marine Mammal Monitoring Programme

C-PODs will be deployed for the duration of both the construction works and brine discharge. The monitoring will also continue post-development for a period of two years in line with international best practice. The use of the C-PODs will provide large datasets to enable changes in activity to be identified at high resolutions and will help to determine whether any displacement of cetaceans may have occurred during the construction phase or during the operational phase of the brine discharge. Comparison of data across the sites using a 'before-after-control-impact' (BACI) type design to evaluate any impacts will provide opportunities for adaptive project management through regular feedback to environmental managers and contractors.

The use of Static Acoustic Monitoring (SAM) is not a reliable method for the detecting the presence of seals as they do not use echolocation techniques to locate prey or to communicate. It is therefore proposed to undertake monthly seal surveys at a selection of known haul out sites along the Islandmagee coastline to determine natural behavioural variations prior to construction and thereafter to determine whether the construction works and brine discharge give rise to changes in behaviour, such as avoidance of the site. The survey results will provide opportunities for adaptive project management through regular feedback to environmental managers and contractors.

Benthic Ecology Monitoring Programme

It is proposed to undertake drop down video sampling at the locations presented in Figure 9-5. Information gathered from this survey will be used to select infaunal sediment stations, and will be used to provide a snapshot of the seabed prior to construction of the seawater intake and brine discharge, as well as monitor recovery at the site following cessation of the brine discharge.

It is proposed to collect subtidal infaunal sediment grab samples to allow for a detailed assessment to be made on the communities present in the area (replicates showing large degree of variability are often indicators of stress) whilst maximising the spatial spread in areas of potential impact to the north and south of the discharge point. Each biological grab sample will be taken in the same location as a video drop sample. This will allow for a more detailed assessment to be made on potential impacts from the brine disposal activities. In addition, blotted wet weight biomass will be measured at each site for each of the major phyla identified. Environmental data for granulometry and organic matter (Loss on Ignition) will also be measured at each site. Results from these surveys will then be used to assess the community structure in the area using a combination of univariate indices (such as evenness and diversity indices) and multivariate analysis.

Fisheries Monitoring Programme

A series of beam trawl surveys have been designed to confirm that the fish community in the vicinity of the proposed construction works and brine discharge from year to year remains largely the same, i.e. dominated by the same range of species, across the same general size ranges and broadly the same rank i.e. relative frequency of occurrence. It is proposed that replicate 2m beam trawls would be taken annually during the brine discharge and annually for 2 years post the brine discharge

Monitoring of core pot fishery locations will be re-established to determine any changes in the nature of the fishery, in terms of target species health and by-catch, since the monitoring for the Project ES was undertaken. These surveys will be undertaken in co-operation with local pot fishermen.

Ornithological Monitoring Programme

An ornithological monitoring programme will be implemented to identify whether potential impacts identified within the Project ES and associated documents are being mitigated effectively. The data collected during the Environmental Impact Assessment and presented in the ES and ES Addendum and this Environmental Update will form the baseline against which this monitoring will take place. Monitoring will seek to replicate the methods used to collect the baseline data to allow a direct comparison.

In line with the recommendations of the ES, ornithological monitoring in the form of Vantage Point Seabird Counts and a breeding Black Guillemot Survey will be undertaken during the marine construction phase of the proposed works

Reporting

All monitoring data will be collected and relayed to the Licensing Authority at intervals specified in the Marine Construction Licence.

## 10.2 Conclusions

This report has been prepared by RPS on behalf of Islandmagee Energy Ltd for the Islandmagee Energy Gas Storage Project.

The primary objective of this report is to supplement the marine elements of the Environmental Statement and Addendum Report submitted as part of the Marine Licence Application with more recent survey information before the marine licence can be fully considered.

The key conclusions of the this Environmental Conditions Update are set out below:

### 10.2.1 Modelling of Brine Discharge

The initial dilution and far-field dispersion likely to be achieved by the proposed Islandmagee Gas Storage Facility (IGSF) two port diffuser under a range of flow condition has been assessed using accepted computational modelling techniques.

The ambient conditions employed in terms of water depths, tidal flows and salinities are identical to those adopted for the earlier work associated with the original consenting process for the IGSF. Similarly the salinity of the brine has also been assumed to be unchanged from those adopted for the earlier work.

However the FEED stage assessment identified that the excess temperature of the brine will be lower than was originally assumed at only around 2$^{o}$C above the temperature of the intake water, consequently this lower brine temperature has been used for all model simulations presented in this study. The sensitivity of the model results to the excess temperature of the brine was assessed using the initial dilution model and the results indicated that the difference in initial dilution achieves between a brine discharge at 2$^{o}$C above ambient and the same discharge at 10$^{o}$C above ambient was minimal, amounting to less than one additional dilution i.e. a dilution of

12:1 at 2ºC above ambient might be increased to 13:1 if the brine was at 10ºC. Thus it was concluded that using the lower excess temperature for all analysis would yield a conservative estimate of salinity levels.

The initial dilution modelling results show that for a diffuser with 6" ports the salinity of the brine at first contact with the seabed will be between 50.5 psu and 37.6 psu depending on the discharge flow and number of active ports on the diffuser. This can be compared to the 49.4 psu to 38.5 psu range of salinities predicted for first contact with the seabed in the original assessment of the concept design.

The medium to far-field dispersion assessment completed using the latest version of the MIKE3 FM software that incorporates a representation of initial dilution not available at the time that the original assessment was undertaken, has confirmed that the discharge of up to 1,000m$^3$/hour of saturated brine via the proposed IGSF outfall will have minimal impact on salinity levels beyond the immediate vicinity of the outfall. Maximum salinity increases of more than 0.5 psu are not anticipated to occur more than a few hundred metres from the diffuser and salinities of in excess of 36 psu are not predicted to occur more than 100m from the diffuser under normal operations. It should be noted that while the modelling assumed the maximum salinity and discharge rate would occur concurrently this is highly unlikely in practice and thus the salinity levels identified should be considered conservative. These conclusions apply over the range of discharges considered in this study, 250m$^3$/hour to 1,000m$^3$/hour provided the diffuser is operated in the way reported with one port used for discharges of less than 500m$^3$/hour and two port for the larger discharges.

Cores from the proposed salt sequences at Islandmagee within which the IGSF caverns will be created have been recovered and dissolved in North Channel seawater to produce a saturated brine representative of the brine that will be produced by the cavern creation process at Islandmagee. Comparison of the concentration of non-salt compounds in the Islandmagee brine to levels of the same compounds in the Aldborough brine and applicable EQS levels for marine waters has established that the concentrations in the Islandmagee brine are generally lower than was recorded at Aldborough and in all cases are lower than the relevant EQS. Thus with the dilution and dispersion that will occur after discharge the non-salt components in the IGSF brine discharge do not pose a significant threat to marine water quality at Islandmagee.

### 10.2.2 Assessment of Underwater Noise

This assessment primarily considered the construction phase of the Islandmagee Gas Storage Facility as it will involve the highest underwater noise levels but also gives due consideration to other construction activities and the potential cumulative impact of the existing operation and the construction activities.

The formation of the caverns under Larne Lough will take place 1,300 metres below the seabed and will not result in measurable noise emissions. Noise levels during construction will therefore be confined to the construction of the seawater intake and the brine outfall.

Noise from tunnelling, excavation and directional drilling represent the worst-case noise events during construction. These activities occur as relatively stationary events. Noise modelling was carried out on the worst-case noise level sources at the seawater intake and the brine outfall locations. Noise model results have highlighted that the underwater source levels are of quite low intensity and barely exceed the injury threshold levels for fish and marine mammal species at very close range from the source which means that the impact radius will be quite small in extent.

Based on the noise assessment criteria, the underwater noise impact is classified as *Slight Negative*. This impact will have a maximum duration of 18 days with lower noise levels (and smaller impact zones) arising for the remainder of the estimated 6 month construction period. No significant underwater noise levels will arise during the operation of the facility. The underwater noise impact of ferry traffic from Larne and local boat traffic have been quantified in the baseline measurements. The cumulative impact of these existing underwater noise sources does not alter the impact of the proposed development.

### 10.2.3 Biodiversity

The assessment of Biodiversity identifies, describes and assesses in an appropriate manner, the direct and indirect effects of the Islandmagee Gas Storage Facility (IGSF) on biodiversity. It contains a description of the marine and avian biodiversity features and their interdependencies within and surrounding the site of the IGSF, followed by an assessment of the potential and likely significant effects of the development.

The summary of the significant impacts during the construction and operation of the intake and outfall are:

- The effects of underwater noise emissions on fish and plankton IEFs (mortality, impairment and disturbance) has been assessed. The magnitude of the potential impacts arising during the construction of the water intake and outfall are considered to be *low*. The significance of the environmental impact is therefore *Minor Adverse* based on the *low* sensitivity of the receiving receptors.

- The effect of underwater noise emissions on Marine Mammals (auditory injury) has been assessed. The magnitude of the potential impacts arising during the construction of the water intake and outfall are considered to be *low*. The significance of the environmental impact is therefore *Negligible* based on the *low* sensitivity of the receiving receptors.

- The effect of underwater noise emissions on Cetacean IEFs and Pinniped IEFs (disturbance) has been assessed. The magnitude of the potential impacts arising during the construction of the water intake and outfall are considered to be *Low*. The significance of the environmental impact for Cetaceans is *Minor Adverse* based on the *low* sensitivity of the receiving receptors. The significance of the environmental impact for Pinnipeds IEFs is *Negligible* based on the *Negligible* sensitivity of the receiving receptors.

- The effects of entrainment and impingement on fish and plankton have been assessed. The magnitude of the potential impacts arising during the operation of the water intake are considered to be *Low*. The significance of the environmental impact is therefore *Minor Adverse* based on the *Low* sensitivity of the receiving receptors.

- The effects the brine discharge on Plankton IEF, Benthic subtidal habitats IEF and Fish and shellfish IEFs have been assessed. The magnitude of the potential impacts arising during the operation of the brine outfall are considered to be *Low*. The significance of the environmental impact is therefore *Minor Adverse* based on the *Low* sensitivity of the receiving receptors.

### 10.2.4 Cumulative Effects

The potential cumulative effects of consented and pending schemes near the Islandmagee Gas Storage Project were assessed. Relevant projects were selected and the Project team defined significance thresholds and criteria for assessment based on professional judgement, alongside relevant standards and guidelines, to determine whether in-combination effects gives rise to additional levels of significance.

The cumulative assessment process included a review of all planning applications within in the area surrounding Islandmagee between January 2017 and October 2019 and a review of the Marine Licence Public Register for all applications submitted to DAERA under the Marine and Coastal Access Act 2009. All project were assessed for likely cumulative effects in combination with the construction and operation with the Islandmagee water abstraction and brine outfall.

The most significant potential project identified was the Gaelectric Energy Storage Scheme (CAES), however the Planning Application (LA02/2016/0006/F) and Marine Licence Application (ML49_13) for this project were withdrawn on the 23rd of July 2019. As the consent applications for this project have been withdrawn there are is no longer potential for any cumulative effects when considered in combination with the Islandmagee Gas Storage Facility.

Other nearby projects included the Ballylumford Harbour Remedial Works, Ferries Bay Waste Water Treatment Works, Ballylumford Waste Water Treatment Works and the Coastal Erosion Defences at Blue Circle Island. The cumulative assessment concluded that due to the nature of these projects, these projects will not result in cumulative effects when considered in combination with the Islandmagee Gas Storage Facility.

# 11 REFERENCES

## 11.1 Introduction

BGS (British Geological Survey) (2008) “Mineral Planning Factsheet : Underground Storage” Department for Communities and Local Government

## 11.2 Assessment of Underwater Noise

Ainslie, M., (2010), Principles of Sonar Performance Modelling, Springer-Verlag, Berlin.

Ainslie, M., and McColm, J., (1998) "A simplified model for viscous and chemical absorption in sea water", J. Acoust. Soc. Am., 103(3), pp. 1671-1672.

EPA (Environmental Protection Agency), (2017 draft), Guidelines on the Information to be Contained in Environmental Impact Assessment Reports. Environmental Protection Agency.

HSE (2009), Health and Safety Executive, Review of diver noise exposure, Prepared by QinetiQ.

Popper, A., Hawkins, A., Fay, R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W., Gentry, R., Halvorsen, M., Løkkeborg, S., Rogers, P., Southall, B., Zeddies, D., Tavolga, W., (2014), Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI, ASA S3/SC1.4 TR-2014.

Reine, K, Clarke, D., Dickerson, C., (2014), Characterization of underwater sounds produced by hydraulic and mechanical dredging operations, J. Acoust. Soc. Am. 135(6).

Richardson, J., Greene, C., Malme, C., Thomson, D., (1995), Marine Mammals and noise, Academic Press, San Diego.

Southall, B., Finneran, J., Reichmuth, C., Nachtigall, P., Ketten, D., Bowles, A., Ellison, W., Nowacek, D., Tyack, P., (2019), Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for residual hearing effects, Aquatic Mammals, 45(2), 125-232.

Rogers, P., (1981) Onboard Prediction of Propagation Loss in Shallow Water, Naval Research Laboratory Report 8500.

Thornley-Taylor, R., (2016), Underground Acoustics, Proceedings of the Institute of Acoustics, Vol. 38. Pt. 1.

TNO, (2011), TNO-DV 2011 C235, Ainslie, M., (ed), Standard for measurement and monitoring of underwater noise, Part I: physical quantities and their units,

## 11.3 Biodiversity

Alvain, S., Moulin, C, Dandonneau, Y and H. Loisel (2008) Seasonal distribution and succession of dominant phytoplankton groups in the global ocean: A satellite view, Global Biogeochemical Cycles, 22, *pp.* 15.

Anger, K. (1991) Effects of temperature and salinity on the larval development of the Chinese mitten crab *Eriochier sinensis* (Decapoda: Grapsidae). *Marine Ecology Progress Series*, 72: 103-110.

Anger, K. (1996) Salinity tolerance of the larvae and first juveniles of a semiterrestrial grapsid crab, *Armases miersii* (Rathbun). *Journal of Experimental Marine Biology and Ecology*, 202: 205-223.

Azis, P. K. A., Al-Tisan, I. A., Daili, M.A., Green, T .N., Dalvi, A. G. I. and M. A. Javeed (2003) Chlorophyll and plankton of the gulf coastal waters of Saudi Arabia bordering a desalination plant, *Desalination* 154: 291-302.

Bassett, H. (1909, unpublished), The flow of water through the Irish Sea. Lancashire Sea Fisheries Laboratory. Report 18: 148-157.

Berrow, S. (2016)a Bottlenose dolphin (*Tursiops truncatus*) Pp 156-157. In Lysaght, L. and Marnell, F. (Eds) (2016) *Atlas of Mammals in Ireland* 2010-2015, National Biodiversity Data Centre, Waterford.

Cefas (2005) Fisheries and marine ecology of the Irish Sea. Poster Accessed https://www.cefas.co.uk/publications/posters/32036web.pdf [30th September 2019].

Connor, D.W., Allen, J.H., Golding, N., Howell, K.L., Lieberknecht, L.M., Northen, K.O. & Reker, J.B. (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05 ISBN 1 861 07561 8. In: JNCC (2015) The Marine Habitat Classification for Britain and Ireland Version 15.03. [30/09/2019]. Available from: https://mhc.jncc.gov.uk/ .

Birkhead, T. R. & Taylor, A. M. (2008). Moult of the Guillemot *Uria aalge*. *Ibis*. **119**: 80–85.

Booth Jones, K. & Wolsey, S. (eds.) (2019) Northern Ireland Seabird Report 2018. BTO & NIEA.

Camphuysen, C. J., de Boer, P., Bouten, W., Gronert, A. & Shamoun-Baranes, J. 2010. Mammalian prey in Laridae: increased predation pressure on mammal populations expected. *Lutra* 53: 5–20.

Chen, F., Shapiro, G. I., Bennett, K. A., Ingram, S. N., Thompson, D., Vincent, C., Russell, D., and Embling, C. B. (2017) Shipping noise in a dynamic sea: a case study of grey seals in the Celtic Sea. Marine Pollution Bulletin, 114 (1), 372-383.

CIEEM (2018). Guidelines for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater and Coastal. Chartered Institute of Ecology and Environmental Management. Third Edition. January 2018.

Colhoun, K. and Cummins, S. (2013) Birds of Conservation Concern in Ireland 2014-2019. Irish Birds, 9, pp 523-544.

DAERA (2018) Draft Marine Plan for Northern Ireland: Public Consultation. ISBN: 978-1-84807-852-9.

DAERA and JNCC (2017) SAC Selection Assessment: North Channel. January, 2017. Joint Nature Conservation Committee, UK. Available from: http://jncc.defra.gov.uk/page-7242

DAHG (2015). Slaney River Valley SAC. Site Synopsis (Site Code: 000781). Department of Arts, Heritage and the Gaeltacht. Available online: https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY000781.pdf

DAHG (2014). River Boyne and River Blackwater SAC. Site Synopsis (Site Code: 002299). Department of Arts, Heritage and the Gaeltacht. Available online: https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY002299.pdf [Accessed 6th October 2019].

Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. & Vincent, M., (2001) Marine Monitoring Handbook, 405 pp, ISBN 1 85716 550 0.

DECC (2009). UK Offshore Energy SEA 2 Environmental Report.

Dickey-Collas, M., Brown, J., Fernand, L., Hill, A.E., Horsburgh, K.J. and Garvine, R.W. (1997), Does the western Irish Sea gyre influence the distribution of pelagic juvenile fish? J. Fish Biol. 51(Supplement A): 209-229.

Electric Power Research Institute (EPRI) (2006) Field Evaluation of Wedgewire Screens for Protecting Early Life Stages at Cooling Water Intake Structures: Chesapeake Bay Studies, Palo Alto, CA. EPRI 1012542

Ellis, J.R., Milligan, S.P., Readdy, L., Taylor, N. and Brown, M.J. (2012) Spawning and nursery grounds of selected fish species in UK waters. Sci. Ser. Tech. Rep., Cefas Lowestoft, 147: 56 pp.

Ellis J.R., Rogers, S.I. and S.M. Freeman (2000) Demersal assemblages in the Irish Sea, St George's Channel and Bristol Channel. *Estuarine Coastal and Shelf Science* 51: 299-315.

EPA (United States Environmental Protection Agency) (2014) National pollutant discharge elimination system – Final regulations to establish requirements for cooling water intake structures at existing facilities and amend requirements at phase I facilities; final rule, Federal Register, 79 (158) 2014 Aug. 15, 2014.

Freeman, S.M. and S.I. Rogers (2003) A new analytical approach to the characterisation of macro-epibenthic habitats: linking species to the environment. *Estuarine Coastal and Shelf Science* 56: 749-764.

Goodwin, C., Picton, B., Breen, J. & Edwards H. (2011) The Maidens — Report from the Sublittoral Survey Northern Ireland project. Northern Ireland Environment Agency Research and Development Series No. 11/02

Gowen, R.J., McCullough, G.M., Dickey-Collas, M. and Kleppel, G.S. (1998), Copepod abundance in the western Irish Sea: relationship to physical regime, phytoplankton production and standing stock. J. Plank. Res. 20: 315-330.

Gowen, R.J., Dickey-Collas, M. and McCullough, G.M. (1997), The occurrence of *Calanus finmarchicus* (*Gunnerus*) and *Calanus helgolandicus* (Claus) in the western Irish Sea. J. Plank. Res. 19: 1175-1182.

Gowen, R.J., Stewart, B.M., Mills, D.K. and Elliot, P. (1995), Regional differences in stratification in the western Irish Sea during 1992 and 1993. J. Plank. Res. 17: 753769.

Hill, A.E., Brown, J. and Fernand, L. (1996), The western Irish Sea gyre: a retention system for Norway Lobster (Nephrops norvegicus)? Oceanologica Acta. 19: 357368.

Hjort, J. (1914), Fluctuations in the great fisheries of northern Europe viewed in the light of biological research. Rapp. P.-v. Reun. Cons. Perm. int. Explor. Mer. 20: 1-228.

Holme, N. A., & A. D. McIntyre [EDS.] (1971) Methods of the study of marine benthos. IBP Handbook No, 16. Blackwell Sci. Publ., Oxford and Edinburgh.

Jordaan, A. and Brown, J.A. (2003), The risk of running on empty: the influence of age on starvation and gut fullness in larval Atlantic cod (Gadus morhua). Can. J. Fish. Aquat. Sci. 60: 1289-1298.

JNCC (2019) Marine Habitat Classification: SS.SMx.CMx.FluHyd, *Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment. Available at https://mhc.jncc.gov.uk/biotopes/jnccmncr00000460 [Accessed 16 October 2019].

Kasahara, S., Uye, S. and Onbé, T. (1974) Calanoid copepod eggs in sea-bottom muds. Mar. Biol. 26: 167-171.

Kennington, K. and W. Rowlands (2005) SEA area 6 Technical Report – Plankton Ecology of the Irish Sea, The University of Liverpool https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/197299/SEA6_Plankton_PEML.pdf [Accessed 19th September 2019].

Kimball, M. E., Boswell, K. M., Rozas, L. P., Berwaldt.E. K. and A. R. Richards (2018) Swimming abilities of juvenile estuarine fishes: implications for passage at water control structures, *Wetlands Ecological Management,* (26)3: 383-390.

Leonard, K. & Wolsey, S. (eds.) (2014) Northern Ireland Seabird Report 2013. BTO & NIEA.

Leonard, K. & Wolsey, S. (eds.) (2015) Northern Ireland Seabird Report 2014. BTO & NIEA.

Lindley, J.A. (1990), Distribution of overwintering calanoid copepod eggs in sea-bed sediments around southern Britain. Mar. Biol. 104: 209-217.

MarLIN (2019a) *Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment, Available at https://www.marlin.ac.uk/habitats/detail/74/flustra_foliacea_and_hydrallmania_falcata_on_tide-swept_circalittoral_mixed_sediment [Accessed 16 October 2019].

MarLIN (2019b) *Cancer pagarus*. Available at https://www.marlin.ac.uk/species/detail/1179 [Accessed 16 October 2019].

MarLIN (2019c) *Pecten maximus.* Available at https://www.marlin.ac.uk/species/detail/1398 [Accessed 16 October 2019].

MarLIN (2019d) ***Nephrops norvegicus.*** Available at https://www.marlin.ac.uk/species/detail/1672 [Accessed 16 October 2019].

MarLIN (2019e) *Mytilus edulis.* Available at https://www.marlin.ac.uk/species/detail/1672 [Accessed 16 October 2019].

MarLIN (2019f) *Ensis ensis.* Available at https://www.marlin.ac.uk/species/detail/1419 [Accessed 16 October 2019].

Marret, F. and Scourse, J. (2002), Control of modern dinoflagellate cyst distribution in the Irish and Celtic Seas by seasonal stratification dynamics. Mar. Micropaleont. 47: 101-116.

Martínez-Álvarez, R. M., Hidalgo, M. C., Domezain, A., Morales, A. E., García-Gallego, M. and A. Sanz (2002) Physiological changes of sturgeon *Acipenser naccarii* caused by increasing environmental salinity, *The Journal of Experimental Biology,* 205: 3699–3706.

McQuatters-Gollop, A., Atkinson, A., Aubert, A., Bedford, J., Best, M., Bresnan, E., Cook, K., Devlin, M., Gowen, R., Johns, D. G., Machairopoulou, M., McKinney, A., Mellor, A., Ostle, C., Scherer, C., and P. Tett (2018) Change in Plankton Communities. UK Marine Online Assessment Tool, available at: https://moat.cefas.co.uk/biodiversity-food-webs-and-marine-protected-areas/pelagic-habitats/plankton-communities/ [Accessed 10th October 2019].

Miller, O. I., Scales,K. L., Ingram, S., Southall, E. J., and D. W. Sims (2015) Basking sharks and oceanographic fronts: quantifying associations in the north-east Atlantic, *Functional Ecology,* 29 (8) 1099-1109.

Mirimim, L., Miller, R., Dillane, E., Berrow, S. D., Ingram, S., Cross, T.F. and Rogan, E.(2011) Fine-scale populations genetic structuring of bottlenose dolphins using Irish coastal waters. *Animal Conservation, 14 (4),* 342-353.

Missimer, T. M. and R. G. Maliva (2018) Environmental issues in seawater reverse osmosis desalination: Intakes and outfalls, *Desalination,* 434: 198-215.

Moreira, A., Figueira, E., Libralato, G., Soares, M. V. M., Guida, M. and R. Freitas (2018) Comparative sensitivity of *Crassostrea angulata* and *Crassostrea gigas* embryo-larval development to As under varying salinity and temperature, *Marine Environmental Research,* 140: 135 – 144.

Morris, C.D. & Duck, C.D. (2019) Aerial thermal Imaging survey of seals in Ireland, 2017 - 2018. Report (unpublished) for the National Parks and Wildlife Service of the Department of Culture, Heritage and the Gaeltacht, Dublin.

Natural England (2012a) *TIN122 Northern gannet: species information for marine Special Protection Area consultations.* http://publications.naturalengland.org.uk/publication/1482686

Natural England (2012b) *TIN123 Common guillemot: species information for marine Special Protection Area consultations.* http://publications.naturalengland.org.uk/publication/1473930

Natural England (2012c) *TIN124 Razorbill: species information for marine Special Protection Area consultations.* http://publications.naturalengland.org.uk/file/1514153

Natural England (2012d) *TIN126 Fulmar: species information for marine Special Protection Area consultations.* http://publications.naturalengland.org.uk/publication/1500441

Natural England (2012e) *TIN128 Black-ledgged kittiwake: species information for marine Special Protection Area consultations. http://publications.naturalengland.org.uk/file/2781616*

Natural England (2012f) *TIN135 Sandwich tern: species information for marine Special Protection Area consultations.* http://publications.naturalengland.org.uk/file/3878686

Natural England (2012g) *TIN136 Roseate tern: species information for marine Special Protection Area consultations.* http://publications.naturalengland.org.uk/file/3898182

Natural Environment and Rural Communities Act 2006, 2006, http://www.legislation.gov.uk/ukpga/2006/16/contents [Accessed 19th September 2019].

O'Brien, J. (2016) Harbour porpoise (*Phocoena phocoena*). Pp 154-155. In Lysaght, L. and Marnell, F. (Eds) (2016) *Atlas of Mammals in Ireland* 2010-2015, National Biodiversity Data Centre, Waterford.

O'Brien , J.M., Berrow. S. D., Ryan, C., McGrath, D., O Connor, I., Pesante, P., Burrows, G., Massett, N., Klotzer, V. and Whooley, P. (2009) A note on long-distance matches of bottlenose dolphins (*Tursiops truncatus*) around the Irish coast using photo-identification. *Journal of Cetacean Research and Management* 11(1) 71-76.

Pinfield, R. and A. Foote (2016) Killer whale (*Orcinus orca*) Pp 171-172. In Lysaght, L. and Marnell, F. (Eds) (2016) *Atlas of Mammals in Ireland* 2010-2015, National Biodiversity Data Centre, Waterford.

Popper, A. N., Hawkins, A. D., Fay, R. R., Mann, D. A., Bartol, S. Carlson, T. J., Coombs, S., Ellison, W. T., Gentry, R. L., Halvorsen, M. B., Løkkeborg, S., Rogers, P. H., Southall, B. L., Zeddies, D. J. and W. N. Tavolga (2014) Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by

ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. ASA S3/SC1.4 TR-2014.

Raventos, N., Macpherson, E., & García-Rubiés, A. (2006). Effect of brine discharge from a desalination plant on macrobenthic communities in the NW Mediterranean. *Marine Environmental Research*, 62, 1-14.

Reid, P.C. (1975), A regional sub-division of dinoflagellate cysts around the British Isles. New Phytol. 75: 589-603.

Reine, K, Clarke, D., Dickerson, C., (2014), Characterization of underwater sounds produced by hydraulic and mechanical dredging operations, J. Acoust. Soc. Am. 135(6).

Richardson, W.J., Greene, C.R. Jr., Malme, C.I., and Thomson, D.H. (1995). Marine Mammals and Noise. Academic Press, San Diego, CA, USA. 576p.

Riera, R., Tuya, F., Ramos, E., Rodríguez, M. & Monterroso, Ó. (2012) Variability of macrofaunal assemblages on the surroundings of a brine disposal. *Desalination*, 291, 94-100.

Rogan, E. (2016) Common dolphin (*Delphinus delphis*) Pp 159-160. In Lysaght, L. and Marnell, F. (Eds) (2016) *Atlas of Mammals in Ireland* 2010-2015, National Biodiversity Data Centre, Waterford.

RPS (2010) Islandmagee Storage Project Environmental Impact Statement. Chapter 6: Intertidal and Benthic Flora and Fauna, Fisheries and Marine Mammals. IBE0096/EIS01/March '10, pp. 146.

RPS (2011) Islandmagee Storage Project Environmental Impact Statement Addendum. Appendix C: Marine Flora and Fauna. IBE0096/ES02/November 11, pp. 12.

RPS (2019) IGSF Brine Dispersion Modelling: FEED Update. IBE1547 Pp. 51

Sandlund, O. T., Diserud, O. H., Poole, R., Bergesen, K., Dillane, M., Rogan, G., ... & Vøllestad, L. A. (2017). Timing and pattern of annual silver eel migration in two European watersheds are determined by similar cues. Ecology and evolution, 7(15), 5956-5966.

Schallenberg, M., Hall, C. J. and C. W. Burns (2003) Consequences of climate-induced salinity increases on zooplankton abundance and diversity in coastal lakes, *Marine Ecology progress Series,* 251, 181-189.

Sheridan, S., Turnpenny, A., Horsfield, X, Solomon D., Bamford, D., Bayliss D., Coates, S., Dolben, I., Frear, P., Hazard, E., Tavner I., Trudgill, N., Wright, R., & M. Aprahamian (2011) Screening at intakes and outfalls: measures to protect eel (*Anguilla anguilla*), International Fish Screening Techniques, 17 – 30.

Simpson, S.S. and Bruintjes, R. (2016). Part 1 Audiometry, using Auditory Evoked Potentials (AEP) to Determine Hearing Thresholds of a Number of Cohorts of Salmon. Scotish Natural Heritage.

Smyth, K. L. (2011) Effects of hypersalinity on the behaviour, physiology and survival of commercially important North Sea crustaceans (Doctoral dissertation, the University of Hull).

Sosa-López, A., Mouillot, D., Ramos-Miranda, J., Flores-Hernandez, D. and T. Do Chi (2007) Fish species richness decreases with salinity in tropical coastal lagoons, *Journal of Biogeography*, 34: 52–61.

Southall, E. J., Sims, D. W., Metcalfe, J. D., Doyle, J. I., Fanshawe, S., Lacey, C., Shrimpton, J., Solandt, J.-L. and C. D. Speedie (2005) Spatial distribution patterns of basking sharks on the European shelf: preliminary comparison of satellite-tag geolocation, survey and public sightings data, *Journal of the Marine Biological Association of the UK*, 85, 1083-1088.

Spivak, E. D. and J. A. Cuesta (2009) The effect of salinity on larval development of *Uca tangeri* (Eydoux, 1835) (Brachyura: Ocypodidae) and new findings of the zoeal morphology. Sci Mar, 73: 297-305.

Thaxter, C. B., Ross-Smith,V. H., Clark, N. A., Conway. G. J., Rehfisch, M. M., Bouten, W. & Burton, N. H. K. 2011. *Measuring the interaction between marine features of Special Protection Areas with offshore wind farm development zones through telemetry: first breeding season report*. BTO Research Report No. 590. Thetford, Norfolk.

Thomas A. Wilding, Lois A. Nickell, Steven Gontarek and Martin D.J. Sayer (2005) Report for the Department of Trade and Industry: *Synthesis of Information on the Benthos of Area SEA 6,* Final Report, available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/197283/SEA6_Benthos_SAMS.pdf [Accessed 11th October 2019].

Wilson L. J., Black J., Brewer, M. J., Potts, J. M., Kuepfer, A., Win I., Kober K., Bingham C., Mavor R. & Webb A. 2014. Quantifying usage of the marine environment by terns Sterna sp. around their breeding colony SPAs. JNCC Report No. 500.

Weisberg, S.B., Burton, W.H. and F. Jacobs (1987) Reductions in ichthyoplankton entrainment with fine mesh, wedgewire screens, N. Am. J. Fish Manag., 7: 386–393.

Witt, M. J., Hardy, T., Johnson, L., McClellan, C. M., Pikesley, S. K., Ranger, S., Richardson, P. B., Solandt, J.-L., Speedies, C., Williams, R. and B. J. Godley (2012) Basking sharks in the northeast Atlantic: spatio-temporal trends from sightings in UK waters. *Marine Ecology Progress Series,* 459, 121-134.

Zeitoun, I.H., Gulvas, J.A. and D.B. Rorabaugh (1981) Effectiveness of fine mesh wedge-wire screens in reducing entrainment of Lake Michigan ichthyoplankton, Can. J. Fish. Aquat. Sci., 38: 120–125.

## 11.4 Cumulative Assessment

European Commission (EC) Guidelines for the Assessment of Indirect and Cumulative Impacts (1999);

European Commission (EC) Guidance on the preparation of the Environmental Impact Assessment Report (2017);

UK Planning Inspectorate (PINS) Advice Note 17: Cumulative effects assessment relevant to national significant infrastructure projects. Version 1, 2015.

# Appendix A – General Arrangement Drawings

# Appendix B - Brine Dispersion Modelling Report

# Appendix C – Underwater Noise

# Appendix D – Benthic Survey Reports (Aquatic Services Unit - 2019)

# Appendix E – Ecological Survey for Birds (2019)

# Appendix F – Cumulative Assessment (Stage 1 & 2)

# Appendix G – Biodiversity Data obtained from CEDaR (Excel)