Scapa Deep Water Quay
Seal Risk Assessment

September 2025

CONTROL SHEET

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EXECUTIVE SUMMARY

EnviroCentre Limited was commissioned by Orkney Islands Council Harbour Authority to undertake a Seal Risk Assessment to inform an Environmental Impact Assessment and Habitats Regulations Appraisal in relation to the construction and operational phase of the Scapa Deep Water Quay development, approximately 8km south of Kirkwall at Bay of Deepdale, Scapa Flow.

Both harbour seal and grey seal are priority marine features and Annex II species and can be seen all around Scotland, predominantly on many of the offshore islands and along much of the west mainland coast.

Two Special Areas of Conservation (SAC) and three Sites of Special Scientific Interest (SSSI) designated for harbour and grey seals and 60 haul out sites are considered within influence of the development and dredge disposal site. However, due to distance, the development is not considered to directly impact any of these sites.

There is a clear decline in harbour seal populations based on reviews of data over the years. The causes for the decline are not yet been defined, however factors such as prey quality and availability, exposure to toxins/ harmful algae and competition for resources from grey seal, whose population size are considered to be at carrying capacity in Orkney waters, are currently considered to be the most likely critical drivers. Although no evidence for coastal developments or vessel movement have been identified, these can’t be ruled out as also contributing to declines directly or indirectly.

The construction methods of the proposed development do not require marine blasting, piling or drilling. Underwater noise modelling identified dredging activities have short risk ranges for seals, with Permanent Threshold Shift (PTS) of <50m. Temporary Threshold Shift (TTS) risk ranges from 70m – 250m dredging.

General disturbance to seals in water may occur as a result of works. It is expected that seals would be likely to exhibit a behavioural change due to the noise, when in water (fleeing from noise source/ vocalisations/ splashing), with physiological stress likely to also occur. This could impact seals energy and fitness levels through disturbing foraging or causing avoidance of feeding areas for periods of time. A precautionary 5km radius buffer for disturbance has been applied to quantify the number of individuals that may be disturbed as a result of construction works. Quantitative data identified a total of 19 grey seals and 4 harbour seals at sea within the disturbance area of the construction works. These numbers are considered low and the 5km is a ‘worst case’ scenario, therefore the potential for disturbance is considered to be limited.

Disturbance of seals on land or when ‘bottling’, caused by noise associated from terrestrial blasting, was also considered. As a 6m high bund will be created and a 6dB noise reduction is expected as the distance from the source doubles, it is considered unlikely that seals using regular haul out spots (closest being 7km west), or those at sea at the waters surface (bottling) will be negatively impacted to a population level from terrestrial noise associated with blasting.

Due to protocols, controls and mitigation outlined in section 5 required to be implemented during dredging and the nearest seal haul out site being 7km west of SDWQ, it is considered unlikely that seals will be negatively impacted from dredging during construction or vessel movements during the construction or operational phase

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1 INTRODUCTION

1.1 Terms of Reference

EnviroCentre Limited was commissioned by Orkney Islands Council Harbour Authority to undertake a Seal Risk Assessment (SRA) to inform an Environmental Impact Assessment (EIA) and Habitat Regulations Appraisal (HRA) in relation to the construction and operational phase of Scapa Deep Water Quay (SDWQ), approximately 8km south of Kirkwall at Bay of Deepdale, Scapa Flow. Please see Appendix A: Proposed Site Location and Layout.

The SRA is required to identify known populations and records of seals and assess potential risks of causing injury and disturbance as a result of proposed construction and operational activities.

1.2 Project Overview

The main purpose of this facility would be to undertake multiple industrial activities that require both deep-water berthing and large laydown area.

It is envisaged that the main activity will be the construction/assembly and maintenance of offshore wind turbines. This is also a potential location for the development of a storage and supply hub for future marine fuels.

There will also be an access road from the A961 to the site.

1.2.1 SDWQ Design Mitigation and Project Description

There have been various changes to the proposed development since the original Scapa Deep Water Quay (SDWQ) EIAR was produced, and these are detailed below. It should be noted that these changes do not affect the assessments within the existing EIAR.

Based on consultee feedback the project team has taken proactive steps during the design and environmental assessment process to reduce the potential negative impacts of the project, a crucial part of responsible project management (mitigation by design), aiming to prevent or minimise environmental impacts before they arise. It must be noted that the overall development footprint and dredge area remain unchanged from the reference design.

1.2.2 Design

Environmental Impact Assessment (EIA) is generally considered an iterative process, meaning it is not a one-time only assessment undertaken after a project is designed. Rather, it's a continuous process where findings from the EIA inform and influence the design of the project throughout its development. In the case of SDWQ, EIA assessments identified potential impacts on certain habitats and wildlife. Based on these findings, the design has been modified.

The design, manufacture, and construction of both temporary and permanent marine works shall adhere to current good practice and comply with all relevant and up-to-date Eurocodes, British Standards, Codes of Practice, and other applicable international standards and regulations. This includes structural, geotechnical, maritime, corrosion protection, drainage, and other discipline-specific codes necessary to ensure safety, durability, and regulatory compliance.

The design of the marine structures for the SDWQ Project is based on a minimum design life of 60 years, ensuring resilience in a highly aggressive marine environment, with salt spray, seawater immersion, and scour action. The quay structure must be designed for a return period of 570 years, while the revetment has a return period of 200 years, reflecting different failure probabilities for each element (10% for the quay and 20% for the revetment).

Key design parameters include:

- **Dredging Requirements:** The operational depths of -15.0m CD and -20.0m CD must be achieved.
- **Environmental Conditions:** Consideration of climate change and sea-level rise scenarios (A projected sea level rise of 0.9 m by 2100 is considered, based on national climate projections), with tidal lag and wave conditions (1/50-year,1/200-year,1/570-year return periods) integrated into the design.
- **Materials:** Concrete and reinforcement materials must comply with Eurocodes and British Standards, with specifications for exposure classes, cement types, and aggregate properties.
- **Caisson Design:** The caissons are designed with a focus on durability, using concrete that is resistant to corrosion in marine environments. Concrete properties, cement types, and aggregate characteristics have been carefully specified to ensure a long lifespan (Diagram 1-2).
- **Foundations and fill:** Crushed igneous rock is used as the foundation layer, with strict controls on durability and strength. Fill materials inside and behind caissons are selected for high density and internal friction to ensure stability.
- **Scour Protection:** Concrete scour protection mattresses and rock armour is installed to mitigate seabed erosion caused by vessel thrusters and propellers near the quay (Diagram 1-3)
- **Load types considered:** Includes structural dead loads and imposed loads, wave loads, buoyancy effects, hydrostatic pressures, vessel impacts, and backfill pressures
- **Structural Stability**: The strength and stability of the marine works are evaluated for failure modes such as sliding, overturning, bearing capacity, and structural integrity following BS 6349, Eurocode, and PIANC guidelines. Additional considerations include buoyancy, hydrostatic pressure, and surcharge loads.

These criteria form the foundation for the design of a robust, long-lasting marine structure, ensuring safety, stability, and durability under challenging environmental conditions.

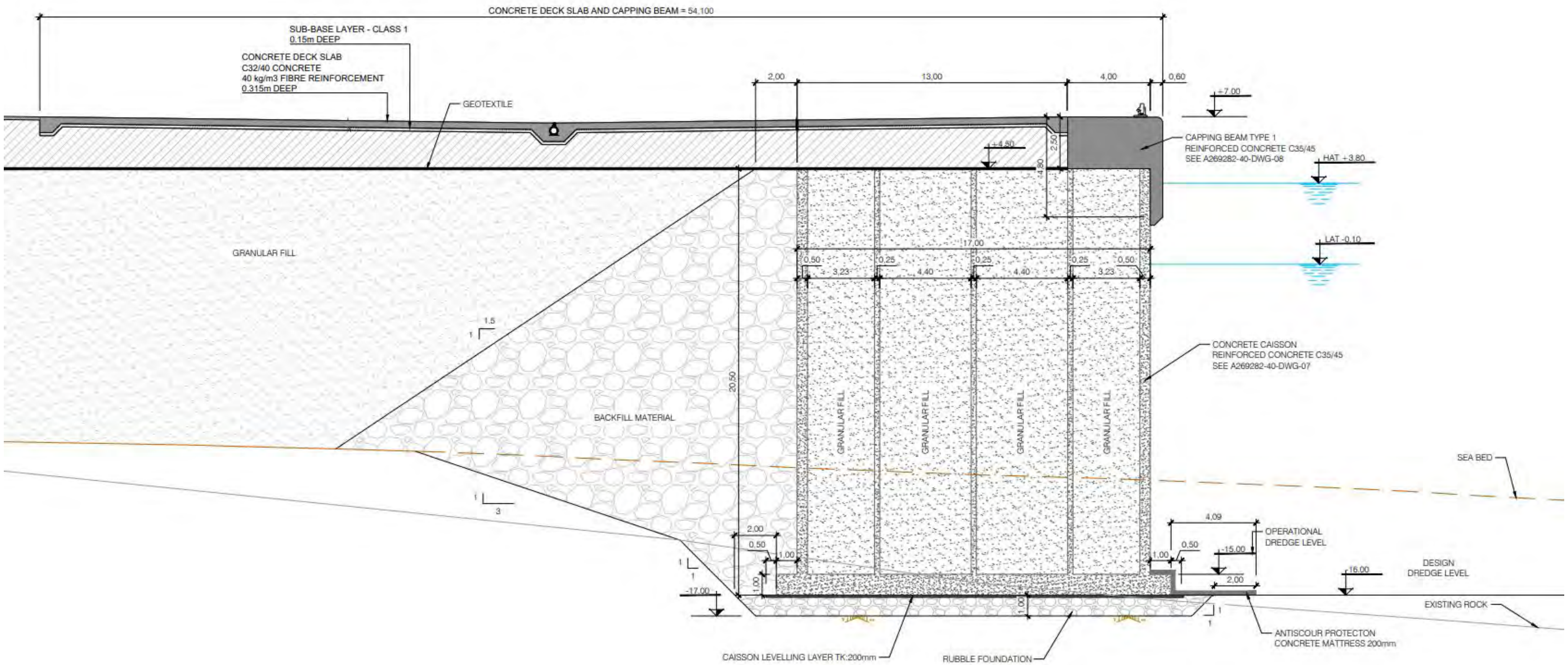

Diagram 1-1: Typical Cross Section

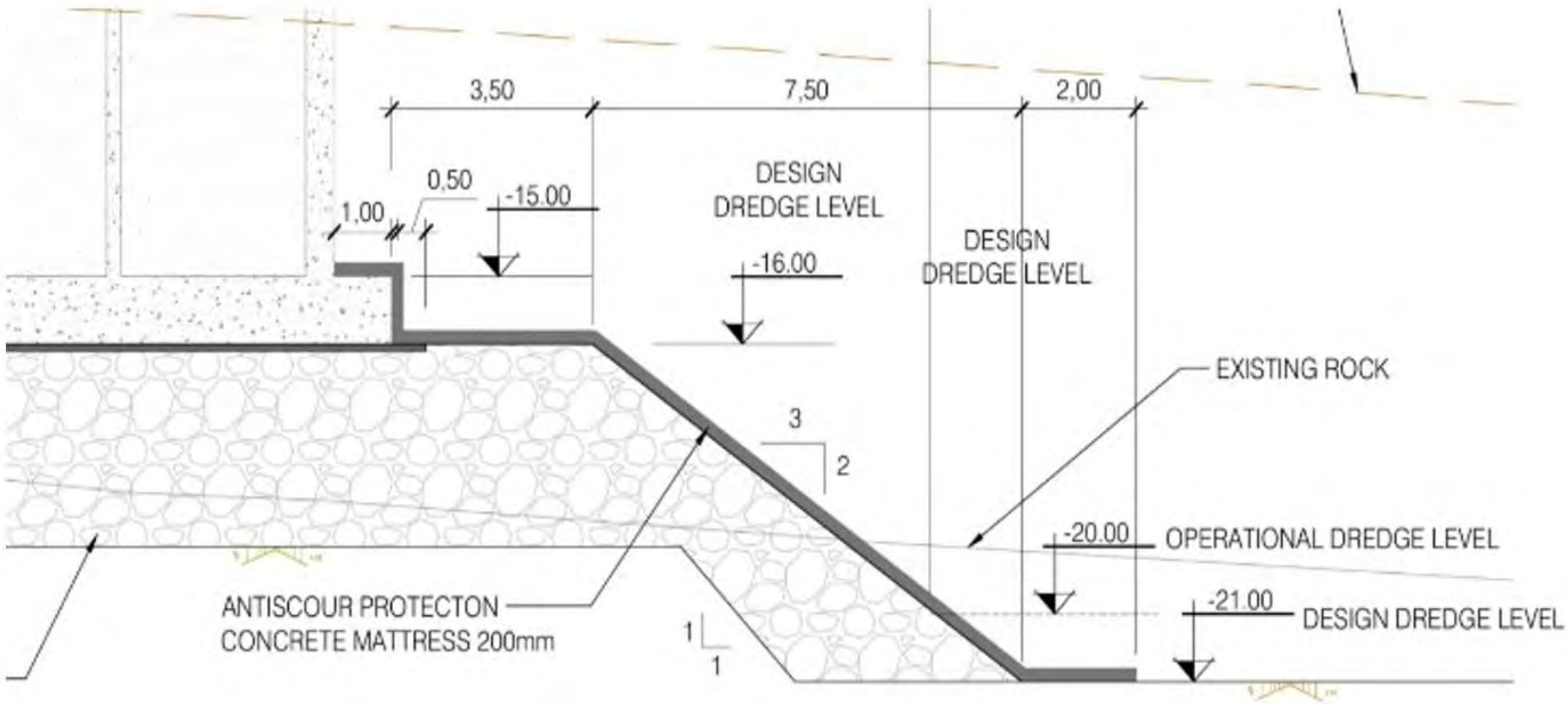

Diagram 1-2: Concrete mattress on rock

1.2.3 Caisson Design Summary

- The main quay is composed of nine large reinforced concrete caissons, with a smaller caisson at the south end that ties into the south revetment.
- Different caisson cross-sections are used along the alignment to adapt to dredging depths and variable geotechnical conditions.
- The quay top level is at +7.00m CD and dredging in front of the quay reaches -15.00m CD, with a 1m over-dredge allowance for design purposes.
- A specific 140m section includes a deeper dredge pocket of -20.00m CD, offset 10m from the quay face. This will be confirmed with the developed design.
- At the north end, the OICHA tug and pilot boat berths are formed by four caissons, and one berth (62m long) uses a blockwork wall due to shallower seabed depth.
- Dredging design considers slopes based on soil type, ensuring foundation levels reach engineering rock.
- Geotechnical stability of caissons is checked against sliding, overturning, bearing capacity, and overall stability, using standard analytical methods and software tools such as SLOPE/W.

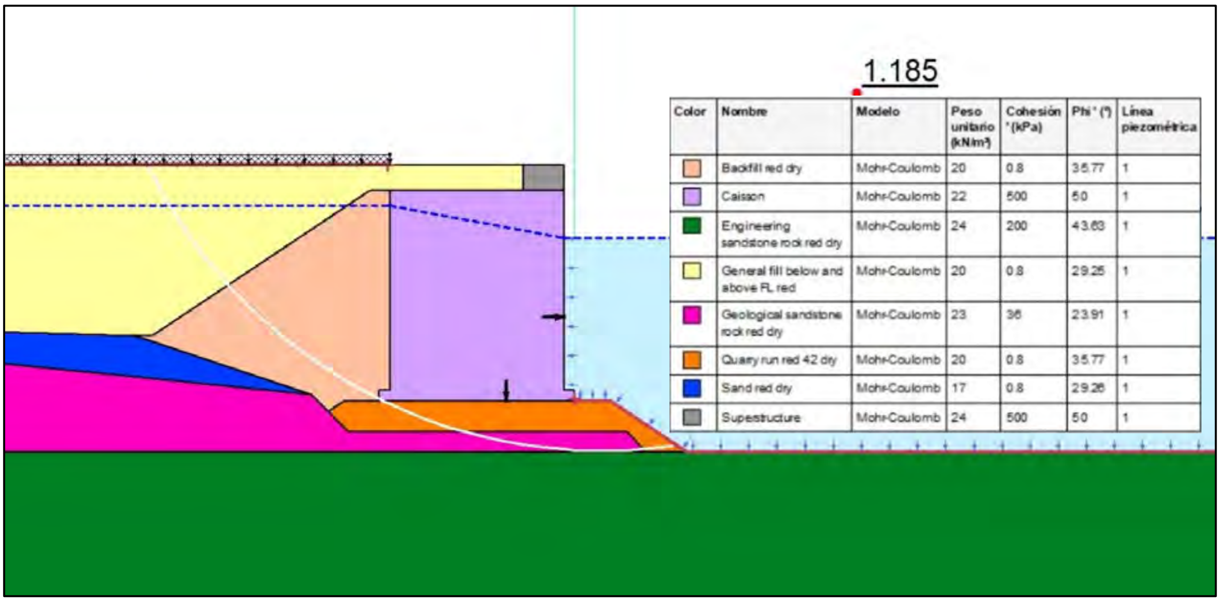

Diagram 1-3: Example of results of the geotechnical stability analysis for bearing capacity and overall stability using SLOPE/W and Plaxis software

Structural analysis is based on a representative caisson (A1) using FEM Reinforcement is currently unified across all caissons but may be optimised later.

- In areas where the foundation is not directly on rock, scour protection is provided with a concrete mattress, adjusted based on the seabed material and vessel propeller forces.
- The geometry of the caissons has been standardized as much as possible, especially in the main quay (all 17 m wide and 20.5 m high for types A1–A3), to simplify construction and allow reuse of formwork. Caissons in the tug and pilot berth areas (types B1–B4) have lower heights, adapted to specific site and operational conditions. Some include multilevel steps for vessel access.
- Buoyancy stability was analysed to ensure safe transport and installation, by adjusting internal ballast water to maintain appropriate draft and stability.
- A range of cross-sections have been developed to match site conditions, particularly for the tug and pilot berths, which include pre-and post-tender bulletin design options. Key design assumptions include:
  - 1m over-dredge applied throughout

- Rock profiles interpolated from borehole data
- Slope angles based on material type (e.g. 3:1 for granular soils)
- Caisson foundations in the main quay resting on engineering rock where feasible

1.2.4 Dredging works

In addition to the dredging required at the berth pockets, the caisson design approach requires additional dredging for the caissons/block wall foundations. The design assumes that the structures will be founded on hard bearing strata, requiring the removal of superficial soils and hard strata from approx. -15m CD down to a maximum depth of -20.5m CD. The dredged area edge slopes depend on the material type ranging from 1:3 in superficial soils to 1:1 in engineering rock, whilst the dredging berth pockets are required to be operative for elevations of -15m CD and -20m CD. The structures have been designed to accommodate an over-dredge of 1m.

Refer to the dredging section below for dredge volumes, particularly disposal to sea. The Best Practicable Environmental Option (BPEO) report has been updated to take account of updated dredge volumes.[1]

1.2.5 Dredging

Dredging will be performed as one of the first construction activities in a single campaign. It is proposed to be executed by a combination of different methodologies that can tackle the scope while minimising impacts on the environment and coordinated with the critical path activities.

For reference, the dredge volumes associated with the **exemplar design** were as follows.

Table 1.1: Dredging Area and Sediment Quantities (Exemplar Design)

Dredging Phases	Area (m^2)	Est. Quantities (m^3)
Phases 1 and 2 - Initial to -15m CD	39,000	86,000
Phase 3 -20m CD berthing pocket	26,000	90,000

Of the 176,000m^3 dredge material noted above, 25,000m^3 was intended to be disposed offshore. Sea disposal was originally calculated using a barge expected to carry material up to 1,000m^3 volume, therefore 25 return trips (50vessel movements in total).

As a result of the modified **caisson design**, additional dredging volume is required compared to the exemplar design to provide the caisson foundations. The revised total dredge volume is detailed in Table 1.2.

Table 1.2: Dredge Material (Caisson Design)

Material type	Total volume dredged (m^3)	Volume reused on site (m^3)	Volume disposed offshore (m^3)
Sand	249,859	49,972	199,887
Clay	53,022	0	53,022
Rock	61,627	61,627	0
TOTAL	**364,508**	**111,599**	**252,909**

Dredging methods: Sand and clay will be dredged either by hydraulic dredging using a trailer suction hopper dredger (TSHD) or mechanically using backhoe or grab dredgers. Rock will be dredged using

[1] Rev 2 (May 2025)

a cutter suction dredger (CSD) or mechanical equipment such as backhoe dredgers equipped with rock rippers.

Dredging Caisson trench: Additional dredging is required to accommodate the caisson section (rock foundation, scour protection and caisson). Different levels have been considered following assumptions of founding the caisson on suitable hard bearing strata along the full length of the quay line. The width of this trench at the lowest level is 24 m from toe to toe.

Disposal at sea: As stated above, the volume of material (predominantly sand with some clay) to be disposed of at sea has increased to a maximum of 252,909m^3 (this figure may be reduced once additional geotechnical information is available). Further information about sea disposal is provided in the updated BPEO. It is assumed that 4,000m^3 capacity barge(s) will be used to transport material to the offshore disposal site. Therefore, the revised estimated dredge disposal vessel movements will increase from 25 round trips (50 vessel movements in total over a two-month period or almost 1 vessel movement each day) to approximately 63 round trips (126 vessel movements in total) over 33 weeks between end of October 2026 and end of May 2027. This equates to approximately 4 vessel movements each week.

It should be noted that dredging vessel routes to the sea disposal site are within existing shipping lanes. Much of the barge movements shall be within harbour limits and therefore speeds shall require to be adhered based on the Ports requirements.

1.2.6 Quay Wall

The quay wall will be formed from reinforced concrete caissons installed on a rock bed foundation, as shown on Diagram 1-5)

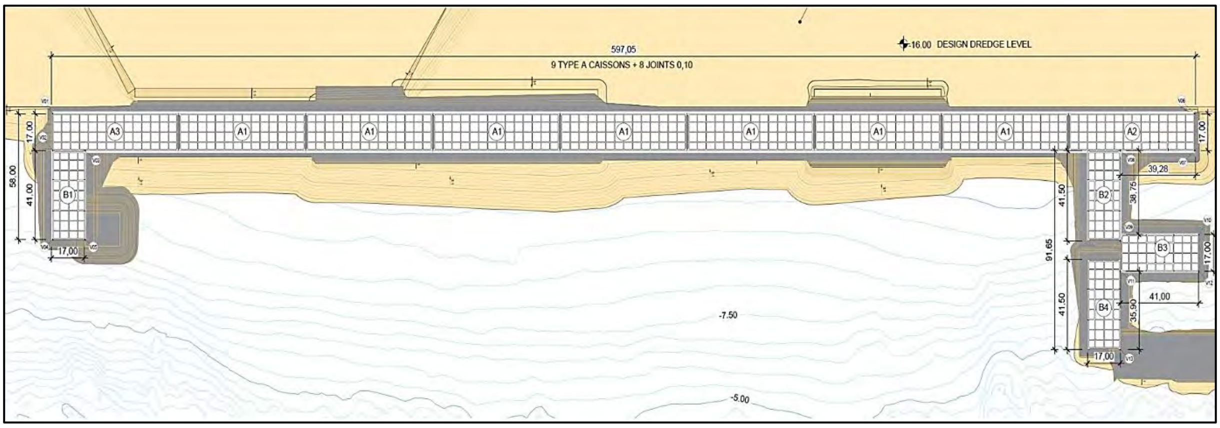

Diagram 1-4: General arrangement

The main quay is composed of nine large reinforced concrete caissons, with a smaller caisson at the south end that ties into the south revetment.

At the north end, the OICHA tug and pilot boat berths are formed by four caissons. At the innermost berths of the tug and pilot boat area, where seabed levels are shallow, concrete block walls are used instead of caissons. Another block wall acts as a retaining structure behind the southern end of the main quay. The block walls are built using large interlocking concrete blocks reinforced with vertical steel bars for added stability.

1.2.7 Caisson Transport and Unloading

Following the fabrication of caissons in a floating dock in Spain, they will be towed to a sheltered area within the port basin. There, they will be stored in a floating condition until the arrival of the semisubmersible vessel, which will transport them to the SDWQ site. It is anticipated that 3 or 4 four trips using a semi-submersible vessel will be required to deliver all caissons to the SDWQ site. The estimated transit time for the transfer of the caissons to SDWQ is 8 days (round-trip). Consecutive trips will be undertaken to transport all caissons.

A Biosecurity Plan will be produced as part of the Detailed Construction Environmental Management Plan (CEMD) which will set out the measures to prevent introduction of invasive non-native species, in accordance with relevant legislation and best practice.

Diagram 1-5: Image of a previous caisson loading operation onto semisubmersible vessel at Langosteira Port.

1.2.8 Caisson Unloading

The unloading operation (Diagram 1-9) at Scapa Flow requires water depths over 27m due to the draft of the vessel and caissons, and favourable metocean conditions (Table 1.3)

Table 1.3: Required metocean conditions for vessel loading/unloading

Limiting weather criteria for loading/discharge operations		
Maximum 10-minute sustained wind speed	15	knots
Maximum significant wave height	0.5	m
Maximum swell	0.3	m
Maximum swell period	7	seconds
Maximum current	1	knots

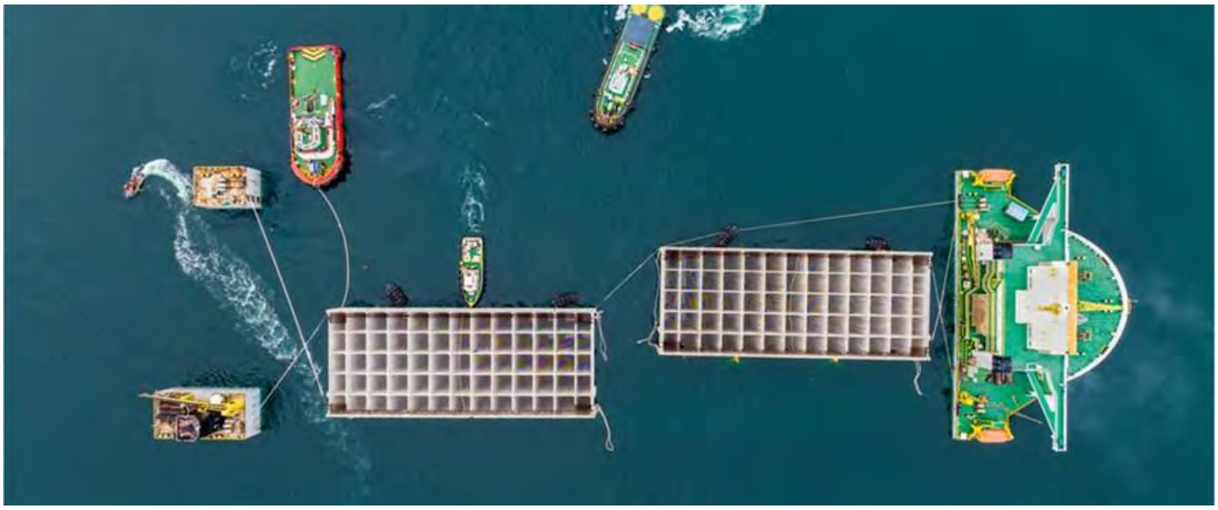

Diagram 1-6; Caisson loading into the semi-submersible vessel

The three/four batches of caisson deliveries will be unloaded using 3 tugboats of at least 4000 Horsepower which will be hired locally, with the operation carried out in one to two good weather days per shipment.

Caissons will be unloaded from the semisubmersible vessel to the quay location and stored within the project area, as shown in Diagram 1-7. They will be prepared with the installation of auxiliary equipment such as winches, mooring ropes and anchors, walking platforms, ballast systems, topographic prisms and fenders. At present, the methods to be used for mooring and anchoring are unknown. Once the weather conditions permit, they will be sunk into their final positions. Alternatively, caissons can be temporarily stored onto the foundation at the quay line and refloated to install within tolerance later. Any temporary storage will be within the project boundary; there will be no anchoring or mooring outwith the project boundary.

Once caissons are unloaded from the semi-submersible vessel, they will be either temporarily tied to each other at the (partially constructed) quayside or temporarily secured to the seabed using anchors. No piling or drilling is required, therefore, there will be negligible underwater noise generated by this activity

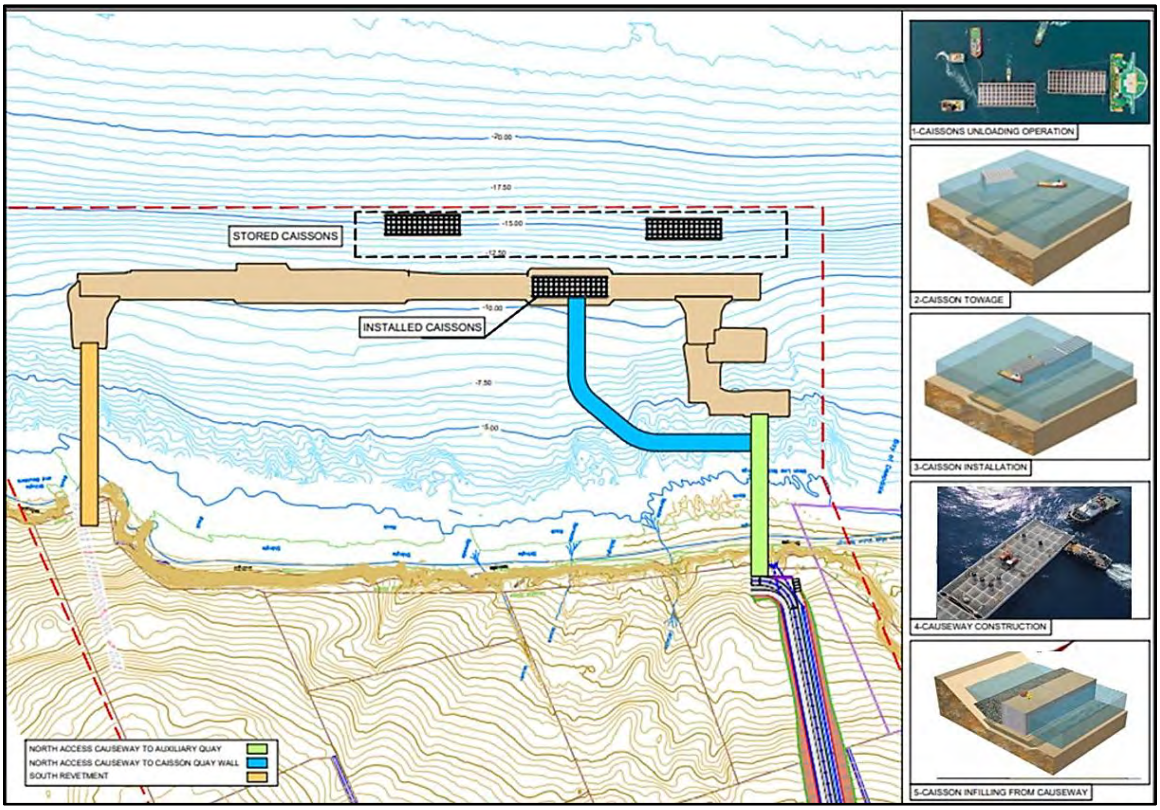

Diagram 1-7: Storage area for caisson within project boundaries.

1.2.9 Caisson Installation

The process to install a caisson is typically performed in around 6-8 hours given suitable metocean conditions. Caissons will be towed individually from their temporary storage location to the quay line. Typically, one tugboat will be sufficient, with the same tug used to assist the installation operation.

Diagram 1-8: Caisson control platform and equipment to position and sink them.

The caisson will be positioned while sinking, using tugs and winches until a final controlled touchdown on the rock foundation. Each caisson has independent and watertight groups of cells. During the operation, each group of cells is filled simultaneously with sea water either using a pump or a valve, with surveyors monitoring the level in each group to ensure that the installation process is performed in a controlled manner.

The caissons arrive dry, and any ballasting uses water introduced locally and not imported. Each caisson is ballasted with seawater until touchdown on the gravel foundation. If the final positioning is within specified tolerances, ballasting continues until the caisson is filled with seawater. Where tolerances are not achieved, the caisson is re-floated by de-ballasting water and repeating the operation, until tolerances are met. It is typical for a single operation to achieve successful installation within tolerance.

Once caissons are unloaded from the semi-submersible vessel, they will be either temporarily tied to each other at the (partially constructed) quayside or temporarily secured to the seabed using anchors. No piling or drilling is required. Negligible underwater noise is generated by this activity.

The installation process requires specific conditions to ensure the operation is safely and accurately completed as shown in Table 1.4.

Table 1.4: Required metocean conditions for installation

Limiting weather criteria for caisson sinking operations		
Maximum 10-minute sustained wind speed	10	m/s
Maximum significant wave height	0.8	m
Maximum swell	0.3	m
Maximum swell period	8	seconds
Maximum current	0.5	m/s

1.2.10 Revetments

Rock-armoured revetments will be constructed to protect the north and south sides of the site from wave action, as shown in Diagram 1-8. Armour layers will consist of 2.5 tonnes (north) and 4.5 tonnes (south) of imported rock with appropriately sized underlayers and geotextiles.

1.2.11 Sea Filling

Once caissons are installed, filled and backfilled, and the revetments are also in place closing the perimeter, general infilling will commence. Reclamation material is comprised of dredged material and land-based excavated material (which will be screened on site to remove fines before placement). Substantial marine area containment will be achieved before land reclamation fill is progressed, thus minimising sediment discharge outside the works. It should be noted that OICHA intend to install turbidity meters to measure any rogue emissions, which will be included within the supporting outline CEMD, and will be detailed in full within the final working version to be prepared by the contractor once commissioned i.e. post-consent.

This element of the project is largely unchanged when considering the exemplar design and the new development proposals (caisson design).

1.2.12 Site Setup and Access Road Construction

The access road design utilises the exemplar design alignment retaining the swale on the northern side and footpath on the southern side. The road surface has been modified to a fully flexible solution to meet the requirements of the proposed design vehicle and loading. To ensure stability of the slope in the fill sections the swale has been designed to incorporate a High-Density Polyethylene (HDPE) liner.

A safety barrier assessment indicates that H1/W2 safety barriers are required at the bend to the compound entrance access road, signage, lighting utility connections and stock fencing have all been reviewed and the design updated as required.

The access road is prioritised as a critical path activity as its completion triggers the commencement of the esplanade cut and fill operations. The contractor will require temporary service connections to the esplanades early in the programme to facilitate blasting, quarrying and earthworks operations.

Access will be formed from the realigned highway. Safe access and egress from the A961 will be achieved with reflective signage, 2-way lights as necessary, and the utilisation of banksmen.

The contractor will carry out the topsoil strip, overburden removal and elements of rock cut for the new access road. The contractor will place the subbase and surcharge it to act as a robust haul road during the construction programme. This will take cognisance of Scottish Environment Protection Agency (SEPA) comments on the need to protect Groundwater Dependent Terrestrial Ecosystems (GWDTE) in Deepdale.

The contractor will install the service trenching, drainage and ducting as the works progress to ensure water is managed effectively, services can be connected to the esplanade and a safe road is completed prior to temporary traffic using it. Upon completion of the project, the contractor will trim the surcharge and carry out the final surfacing.

1.2.13 Excavation Platform

The excavation of soft soils on land will be excavated by mechanical means, and the rock will be excavated by drilling and terrestrial blasting consisting of approximately one blast per week over 35 weeks (no marine blasting is proposed). Initially, the contractor will install pre-earthworks drainage to control surface water run-off. After installing perimeter cut off V ditches and ahead of main land excavation and land blasting, a 6m high bund will be formed at the seaward boundary of the site by retaining the existing land and excavating behind. This will create a natural noise screen and sediment runoff retention barrier. This natural bund will be removed once the remainder of the site is excavated to create the final profile.

1.2.14 Programme

The project contractor will deliver the Project ten months early when compared with the exemplar design duration of 52 months. This will be achieved through an innovative and robust off-site caisson manufacturing methodology, which delivers a de-risked project solution and minimises disruption to the Orkney Islands residents and environment.

A summary of the main programme milestones is included below (Diagram 1-9)

Diagram 1-9: Proposed Programme

The proposed programme is comprehensive, feasible and delivers a low risk and quicker approach to the design and construction of the Project by:

- Progressing the construction of the quay wall using an offsite caisson fabrication solution while the dredging and earthworks progress concurrently on site
- Installing 13 caisson units instead of approximately 1800m of combi-wall/sheet pile wall, significantly reducing the volume of activities on site and the associated exposure to downtime risk from seasonal weather (especially wind and the effect on craneage operations)
- Using the time savings (Diagram 1-10) from the caisson solution and concurrent working approach to: – De-risk the critical path by creating a programme float of ten months.
- Propose 1st of March 2026 as the Start Date to enable continuous works sequencing for summer transport and installation of caissons.

Diagram 1-10: Critical path through programme

1.3 Report Usage

The information and recommendations contained within this report have been prepared in the specific context stated above and should not be utilised in any other context without prior written permission from EnviroCentre Limited.

If this report is to be submitted for regulatory approval more than 12 months following the report date, it is recommended that it is referred to EnviroCentre Limited for review to ensure that any relevant changes in data, best practice, guidance or legislation in the intervening period are integrated into an updated version of the report.

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2 METHODS

2.1 Baseline

In order to anticipate the potential ecological sensitivities in relation to seals at the site, a desk study was conducted. The following sources were checked:

- Marine Directorate National Marine Plan interactive (NMPi) for:
    - Seal haul out sites;
    - Distribution of Priority Marine Features (PMFs)
- Sea Watch Foundation (SWF) website for recent sightings of marine mammals from the Orkney region[2];
- Scottish Marine Animal Stranding Scheme (SMASS) for records of strandings between 2001 and 2024[3];
- MS Updated Seal Usage Maps: The Estimated at-sea Distribution of Grey and Harbour Seals[4], which includes data obtained from the Sea Mammal Research Unit at St Andrews University[5];
- NatureScot Aerial surveys of seals in Scotland during the harbour moult season 2016-2019[6];
- Marine Scotland Regional Differences in the Abundance Trends Amongst Harbour Seal Populations[7];
- Special Committee on seals (SCOS) reports 2015 to 2022[8];
- Fine-scale harbour seal at-sea usage mapping around Orkney and the North coast of Scotland[9];
- Data of Orkney seal haul out counts 2016-2019 provided by SMRU[10];
- Carter et al (2025) Harbour seal and grey seals: distribution maps for Scotland[11]
- Sanday Special Area of Conservation (SAC) Conservation and Management Advice (2024)[12];
- JNCC Sanday SAC[13];
- Faray and Holm of Faray SAC Conservation and management Advice (2024)[14]
- JNCC Faray and Holm of Faray SAC[15];

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[2] Sea Watch Foundation Recent Sightings Orkney available at: https://www.seawatchfoundation.org.uk/recentsightings/ (Accessed 12/12/2023)
[3] Species reported within a 10km (sea route) from 2001-2024 to Scottish Marine Animal Stranding Scheme (SMASS) available at: https://strandings.org/map/ (Accessed 05/03/2025)
[4] Updated Seal Usage Maps: The Estimated at-sea Distribution of Grey and Harbour Seals, Scottish Marine and Freshwater Science, Vol 8 No 25, available at: https://data.marine.gov.scot/sites/default/files//SMFS%200825.pdf (Accessed 07/06/2024)
[5] St Andrews Sea Mammal Research Unit, available at: http://www.smru.st-andrews.ac.uk/ (Accessed 07/06/2024)
[6] NatureScot Aerial Surveys of Seals in Scotland during the Harbour Seal Moult, 2016-2019, available at: https://www.nature.scot/doc/naturescot-research-report-1256-aerial-surveys-seals-scotland-during-harbour-seal-moult-2016-2019 (Accessed 07/06/2024)
[7] Marine Scotland topic Sheet Number 33 (V2), Regional Differences in the Abundance Trends Amongst Harbour Seal Populations, available at: https://www.gov.scot/binaries/content/documents/govscot/publications/factsheet/2019/11/marine-scotland-topic-sheets-marine-mammals/documents/regional-differences-in-the-abundance-trends-amongst-harbour-seal-populations-updated-march-2017/regional-differences-in-the-abundance-trends-amongst-harbour-seal-populations-updated-march-2017/govscot%3Adocument/harbour-seal-populations.pdf (Accessed 27/05/2024)
[8] SCOS Reports | SMRU
[9] Fine-scale harbour seal at-sea usage mapping around Orkney and the North coast of Scotland | Marine Scotland Data Publications (Accessed 26/02/2025)
[10] Excel file detailing the latest SMRU seal data counts (2016-2019) for Orkney provided by John Baxter on 03/03/2025
[11] Carter, M. I. D, Bivins, M., Duck, C. D., Hastie, G. D., Morris, C. D., Moss, S. E. W., Thompson, D., Thompson, P. M., Vincent, C., Russell, D. J. F. (2025) Updated habitat-based distribution maps for harbour and grey seals in Scotland. Report to Scottish Government by Sea Mammal Research Unit, University of St Andrews. Available at: https://www.gov.scot/publications/updated-habitat-based-sea-distribution-maps-harbour-grey-seals-scotland/pages/6/
[12] Sanday - Conservation and Management Advice - Final Version (Accessed 26/02/2025)
[13] Sanday - Special Areas of Conservation (Accessed 26/02/2025)
[14] Faray and Holm of Faray - Conservation and Management Advice - Final (Accessed 26/02/2025)
[15] Faray and Holm of Faray - Special Areas of Conservation (Accessed 26/02/2025)

- NatureScot Eynhallow Site of Special Scientific Interest (SSSI) Citation[16]
- Muckle and Little Green SSSI Site Management Statement[17];
- NatureScot Muckle and Little Green SSSI Citation[18];
- East Sanday Coast SSSI Site Management Statement[19];
- East Sanday Coast SSSI Citation[20].

2.2 Underwater Noise Modelling

Underwater noise modelling was commissioned as part of this assessment assess noise levels generated by common construction methods.

Please refer to Irwin Carr Consulting report: ‘SDWQ, UW Noise Modelling’, Appendix B which details the methods and findings of the underwater noise modelling.

2.3 Disclaimer

It should be noted that the baseline is limited by the reliability of third party information and the geographical availability of biological and/or ecological records and data. The absence of species from biological records cannot be taken to represent actual absence. Species distribution patterns should be interpreted with caution as they may reflect survey/reporting effort rather than actual distribution.

[16] https://www.nature.scot/sites/default/files/site-special-scientific-interest/618/sssi-citation.pdf (Accessed 26/02/2025)
[17] https://www.nature.scot/sites/default/files/site-special-scientific-interest/1205/site-management-statement.pdf (Accessed 26/02/2025)
[18] https://www.nature.scot/sites/default/files/site-special-scientific-interest/1205/sssi-citation.pdf (Accessed 26/02/2025)
[19] https://www.nature.scot/sites/default/files/site-special-scientific-interest/1678/site-management-statement.pdf (Accessed 26/02/2025)
[20] https://www.nature.scot/sites/default/files/site-special-scientific-interest/1678/sssi-citation.pdf (Accessed 26/02/2025)

3 BASELINE

3.1 Desk Study

Both harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*) are PMFs and can be seen all around Scotland, predominantly on many of the offshore islands and along much of the west mainland coast.

3.1.1 Designated Sites: SAC and SSSI

Two SAC and three SSSI sites designated for harbour and grey seals are considered within influence of the development site and include:

- Sanday SAC (Harbour seal)
- Faray and Holm of Faray SAC (Grey seal)
- Eynhallow SSSI (Harbour seal)
- Muckle and Little Green Holm SSSI (Grey seal)
- East Sanday Coast SSSI (Harbour seal)

Sanday SAC

Sanday SAC is located 55km (via sea) north east of the SDWQ development site. The Sanday SAC has been designated to protect harbour seal, as well as intertidal mudflats and sandflats, reefs and subtidal sandbanks. The SAC comprises 10976.97 hectares (ha). Harbour seal feature as 'Unfavourable declining' in condition within the SAC. Based on counts from 1997-2019, there has been a decline of 95% at Sanday SAC, indicating it is one of the local areas hit hardest by the harbour seal declines observed in northern and eastern areas of Scotland. In the last count in 2019, the SAC represented 77 individuals (around 5% of the North Coast and Orkney SMU). Harbour seals from Sanday SAC are noted to forage 20-30km to over 100km from the SAC (however the majority of these will be at the shorter end of the range). The Sanday conservation management advice suggests that research is indicating that off-site factors such as predation, competition for prey, prey quality and availability, and toxin exposure from harmful algae are the most likely potential causes of the decline. For harbour seal at Sanday SAC, the reasons for the unfavourable condition appear to lie out with the SAC.

Faray and Holm of Faray SAC

Faray and Holm of Faray SAC is located 53 km (via sea) north of the SDWQ development site and comprises 781.33 ha. The Faray and Holm of Faray SAC is designated for grey seal, which currently feature as 'Unfavourable declining' in condition within the SAC. The unfavourable condition of grey seal at the SAC corresponds to a 43% decline in pup production in 2019 since the late 1990s with the SAC now accounting for 10% of the SMU production. The decrease in pup production does not reflect the trend of the North Coast and Orkney SMU with both grey seal population and pup production remaining stable. SMU pup production is stable (decline appearing to be due to changes in movement of pup activities to other locations within the SMA), accessibility of the site for pupping has not changed and disturbance is minimal during the breeding season, meaning no direct conservation measures can be taken at a site level to address the causes of the unfavourable condition of grey seal. Therefore, the focus of the Conservation Objectives for grey seal are ensuring that the conditions on site are suitable to support a recovery.

Eynhallow SSSI

Enhallow SSSI is located 59km (via sea) north west of the SDWQ development site and comprises 97.22 ha. The Eynhallow SSSI is designated for harbour seal, which are considered 'Unfavourable declining' condition within the SSSI. The site is one of the two most important breeding and haul out sites for harbour Seals in Orkney, and supports on average more than 10% of Orkney's total harbour Seal population. The most recent count for the Eynhallow SSSI in 2019 was 76 individuals.

Muckle and Little Green Holm SSSI

Muckle and Little Green Holm SSSI is located 45km (via sea) north of the SDWQ development site and comprises 52.26 ha. The Muckle and Little Green Holm SSSI is designated for grey seal which are considered to be of a 'favourable, maintained' condition. The site regularly supports about 2% of the pups born in the UK and is one of the largest sites for breeding grey seals in Orkney and is therefore considered a nationally important colony for breeding grey seals. The pup survey for 2010 estimates that 900 pups were born on the Muckle and Little Green Holms SSSI.

East Sanday Coast SSSI

East Sanday Coast SSSI is located 57km (via sea) north east of the SDWQ development site and comprises 1607.56 ha. The East Sanday Coast SSSI lies within the Sanday SAC and is designated for harbour seal, as well as intertidal marine habitats and birds. Harbour seal currently features as 'Favourable, maintained' in condition within the SSSI. The SSSI site supports the largest colony in Orkney. The most recent count for the East Sanday Coast SSSI in 2019 was 78 individuals.

3.1.2 Designated Haul Out Sites

Section 117 of the Marine (Scotland) Act 2010 provided addition protection to seals. The Protection of Seals (Designation of Haul-out Sites) (Scotland) Act 2014 designates a total of 194 individual seal haul-out sites around Scotland, at which it will be an offence to harass seals. Seal haul-outs are locations on land where seals come ashore to rest, moult or breed.

A number of designated seal haul out sites are associated with Orkney, 60 have been identified as potentially relevant to the SDWQ development, due to being in commuting distances to both seal species and are detailed in Appendix C. Those haul out sites considered to be at most risk from disturbance through underwater noise or during vessel movement associated with the development, due to proximity are detailed in Table 3.1 overleaf.

It should be highlighted that the 'Breeding Colony' column in Table 3-1 below (and in Appendix C) is based on the breeding sites on the NMPi, because they are discrete areas that are primarily used for breeding. No information is provided for harbour seals on the NMPi, because they do not go to specific places to breed, they simply breed at their 'home' haul out sites and as such remain relatively dispersed during the breeding season. Therefore, all harbour seal haul sites are considered potential places where pups are born.

Note that all designated seal haul outs provide protection for both species of seal year round regardless of whether it was identified as a breeding colony.

Table 3.1: Seal Haul Out Sites

Seal Haul Out Name	Distance* and Orientation	Species	No. seals (based on August counts)		NMPi Breeding Colony (Grey seal)
			Harbour seal	Grey seal	
Ve Ness	7km west	Harbour and Grey seal	0	8	No
North West Water Sound	7km south	Harbour seal	63	32	-
Calf of Flotta	9km south west	Grey seals	1	13	Yes
Barrel of Butter	10km west	Harbour seal	18	11	-
North Flotta	10km south east	Grey seal	0	228	Yes
Cava	12km west	Harbour seal	17	20	-
Flotta Oil Terminal	12km south west	Harbour seal	9	0	-
Holm of Houton	13km west	Harbour and Grey seal	21	24	No
North and East Fara	14km south west	Harbour and Grey seal	8	179	No
Switha	15km south west	Harbour and Grey seals	19	27	No
North east Hoy	16km west	Grey seals	0	3	Yes
Bay of Ireland	22km north west	Harbour seals	44	23	No
Selwick	22km west	Harbour and grey seals	17	117	No

*Direct route via sea

3.1.3 Grey Seal

Orkney is a stronghold for breeding grey seals and is part of the North Coast and Orkney Seal Management Unit (SMU). It is estimated that the Orkney colonies produced nearly a third of UK pups in 2019. The overall trend is for an increase in numbers in the UK population but there was a slight reduction in the Orkney population estimate between 2016 and 2019. The latest estimate of the UK grey seal population is 129,100 with the Orkney and North Coast SMU being home to approx. 7% of that (based on most recent population estimates for grey seal from 2019-2021 for the North Coast and Orkney SMU of 8,599).

From research undertaken and presented in SCOS 2021, it is considered that grey seal within the Orkney region are estimated to be close to carrying capacity when undertaking modelling. In addition, population estimates for seal management areas in Scotland suggest that due to sustained growth in the numbers of pups born over the last 30 years, this has resulted in all UK populations either increasing or (apparently) stabilising at the maximum levels ever recorded, which is being assumed to be at or close to their carrying capacities.

In general, grey seals are loyal to pupping sites and frequent those places for a few months during the breeding season when the females give birth and wean their pups before mating again. During that period they do not move very far from the breeding sites. However, after the breeding season grey seals are much more mobile and disperse over very large areas and can travel large distances, frequently over 100km, to exploit various haul out sites and forage, and prefer offshore feeding areas as well as exposed coasts and islands to come ashore, with the outer fringes of Orkney being classed as suitable. The waters surrounding the site offer habitat for various gadoids and flat fish which are grey seal prey species. From research undertaken by St Andrews Sea Mammal Research Unit on seal diets[21], in Orkney sandeels were the greatest prey resources, with gadoids (haddock, cod, whiting) being the second biggest contributor (harbour seal diet is yet to be studied as in depth).

A total of 60 designated haul out sites, including 22 breeding for grey seals (see Appendix C) are present within 100km of the SDWQ development, with 13 in vicinity of the development activities. The nearest seal haul out site from the development site is 7km west (Ve Ness) and the nearest breeding colony is located 9km south west (Calf of Flotta). Two SSSIs (Faray and Holm of Faray SSSI located 57km north and Muckle and Little Green Holm SSSI located 47km north) and two SACs (Sanday SAC 56km north east located and Faray and Holm of Faray SAC located 57km north) designated for grey seals are present within 100km of the site.

Seal haul out data counts for grey seal also show the important association with Orkney, as detailed in Figure 3-1.

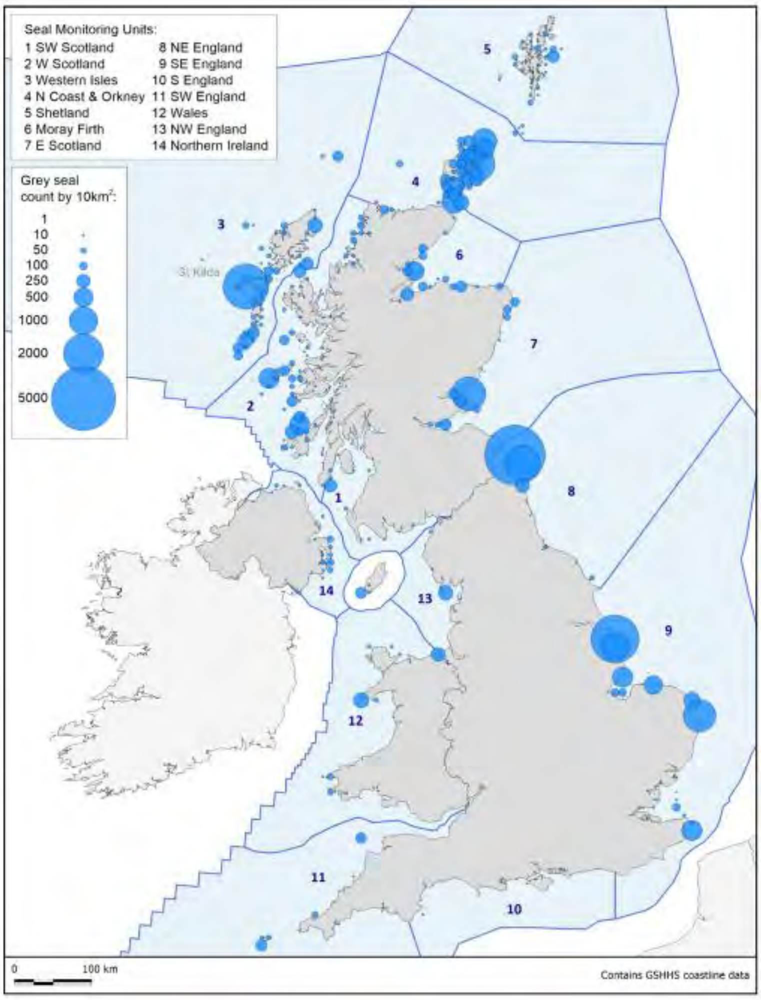


Figure 3-1: August distribution of grey seals around the British Isles by 10km squares based on the most recent available haul out count data collected up until 2021. Map obtained from SCOS 2022.

Records of 285 out of 355 tagged grey seals within UK waters (1988-2018) show a broad-scale distribution, with tagged grey seals utilising both coastal and offshore habitat, with Orkney being a key high-use area, as detailed in Figure 3-2. Grey seal distribution estimates show the mean number of

[21] http://www.smru.st-andrews.ac.uk/documents/scotgov/CSD3-3_Grey_Seal_Diet_Composition_and_Prey_Consumption.pdf (Accessed 07/06/2024)

grey seals estimated to be present in each 5 km by 5 km grid cell at any one time, with that around the development site estimated to be >50 individuals per 5km^2 as detailed in Figure 3-3.

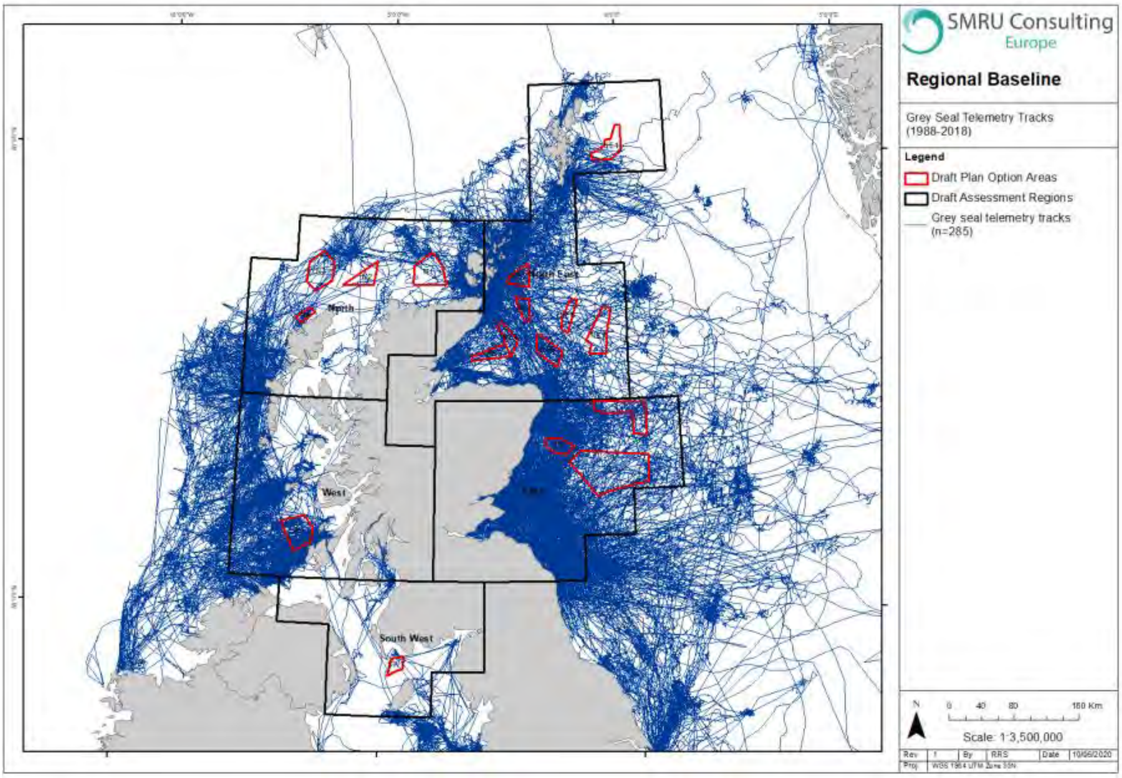


Figure 3-2: Telemetry tracked grey seals (1988-2018)

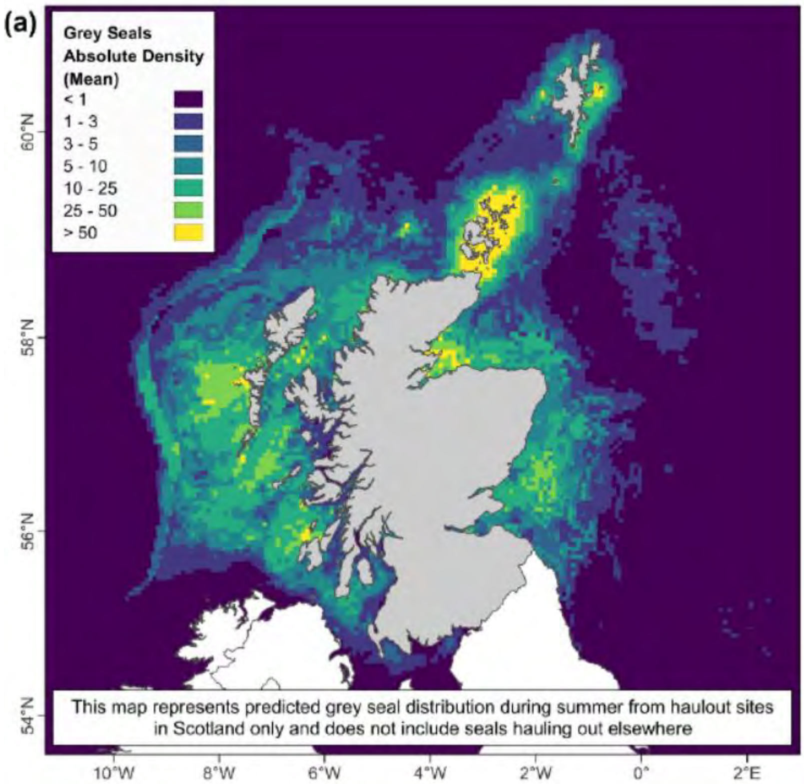


Figure 3-3: Map showing grey seal distribution estimates. The mean number of grey seals estimated to be present in each 5 km by 5 km grid cell at any one time. Image taken from Carter et al (2025).

OW state that grey seals can be observed annually and SMASS have recorded 136 records of stranded grey seals between 1992-2024.

The development site and adjacent coastline is considered suitable (by report authors) for use as a haul out by grey seals due to the relatively low level of disturbance associated with the area and lack of human/ commercial/ vehicular activity. However, the site is near Scapa Pier, where vessels regularly commute to, past the site and the site is not within a designated haul out site for grey seal, as such is not considered that the habitat is suitable for use as a breeding or moulting haul out site. Therefore, grey seals may use the coastal waters within and adjacent to the site for commuting between haul outs (including breeding colonies) and/or foraging.

3.1.4 Harbour Seal

The latest estimate of the UK harbour seal population is 36,600 with the Orkney and North Coast SMU being home to approx. 4% of that (most recent population estimates for harbour seal from 2019-2021 for the North Coast and Orkney SMU of 1405). Whilst the overall trend for harbour seals within the UK is increasing, there has been a dramatic change in distribution. Counts within the Orkney and North Coast SMU have gone from 8,522 in 1997 to 1296 in 2019 (an 85% decline) for counts between 2016 and 2019 (see Figure 3-4 below). Orkney and Shetland were once proportionally the most important regions in Scotland for harbour seals in 1990s, whereas these regions only contribute to one sixth of the Scottish total. Within Scotland there is a general pattern of population increases in the west and losses along the east and north coasts.

The causes of decline for harbour seals in the east and north coasts have not been confirmed yet. Various causes have been speculated, some have been discounted but there is no evidence to support any one of these or indeed a combination of possible causes. SMRU have been working on resolving this problem for the last 15 years and are still no nearer to having a definitive answer[22]. A range of factors such as prey quality and availability, exposure to toxins/ harmful algae and competition for resources from grey seal, whose population size are considered to be at carrying capacity in Orkney waters, are currently considered to be the most likely critical drivers[23]. Although no evidence for coastal developments or vessel movement have been identified, these can't be ruled out as also contributing to declines directly or indirectly to harbour seal decline.

As stated above (Section 3.1.3) as grey seals are considered to be at carrying capacity and although there were limited harbour seal population estimates available before grey seal populations reached/ approached carrying capacity, it has been postulated that if grey seal populations are considered a major driver of harbour seal dynamics it may be that density related effects were already in place before monitoring began in Scotland.

[22] Email correspondence from John Baxter on 03/03/2025.

[23] Marine Scotland topic Sheet Number 33 (V2), Regional Differences in the Abundance Trends Amongst Harbour Seal Populations, available at: https://www.gov.scot/binaries/content/documents/govscot/publications/factsheet/2019/11/marine-scotland-topic-sheets-marine-mammals/documents/regional-differences-in-the-abundance-trends-amongst-harbour-seal-populations-updated-march-2017/regional-differences-in-the-abundance-trends-amongst-harbour-seal-populations-updated-march-2017/govscot%3Adocument/harbour-seal-populations.pdf (Accessed 27/05/2024)

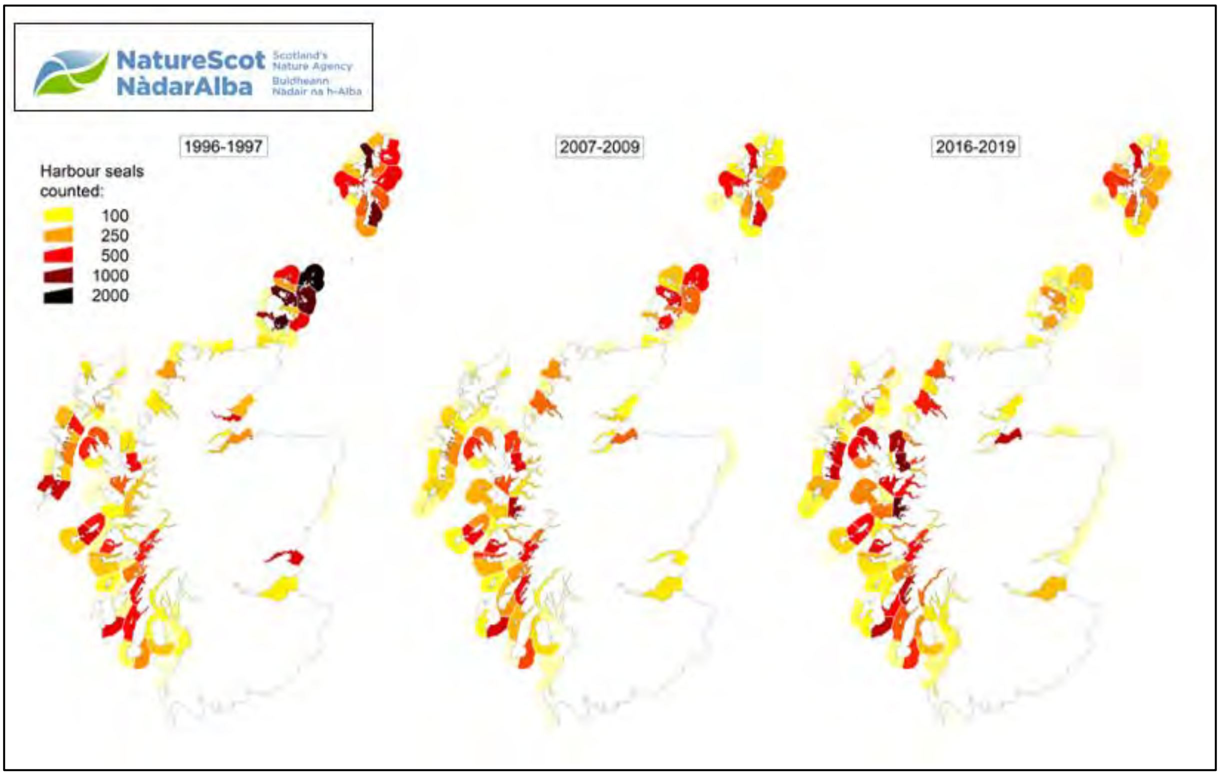


Figure 3-4: Maps showing the number of harbour seals counted during August over three time periods (1996-1997; 2007-2009 and 2016-2019) are detailed in NatureScot Research Report 1256

Harbour seals routinely travel 40-50km from their haul-out sites to forage and prefer more sheltered waters. In general, harbour seals are fairly loyal to a haul out site throughout the year and generally do not forage further than 50km from that site (although there are always exceptions to the rule). The waters within and surrounding the site are known to host fish and other suitable prey items for harbour seals. A total of 23 designated haul out sites for harbour seal (see Appendix C) are present within 50km of the SDWQ development, with 10 in the vicinity of the development activities. The nearest haul out site for harbour seals is 7km west of the site (Ve Ness). A SSSI (East Sanday Coast SSSI located 57km north east) and SAC (Sanday SAC located 56km north east) with harbour seal being a designated feature are located within 60km of the site. Although sat slightly greater distances than what harbour seals routinely travel, some individuals may therefore use the coastal waters within and adjacent to the site for commuting between haul outs and/or foraging.

Records of 420 out of 461 tagged harbour seals within UK waters (2001-2018) show a primarily coastal distribution, with concentrations of tagged seals in Hebrides, the Moray Firth, Orkney and Shetland, as detailed in Figure 3-5. However, telemetry data from 54 tagged harbour seals between 2003-2015 showed a lack of strong connectivity between sites they were tagged at (four from Sanday in 2003 and 12 from Eynhallow 2003-2015) and the SDWQ development site, as detailed in Figure 3-6.

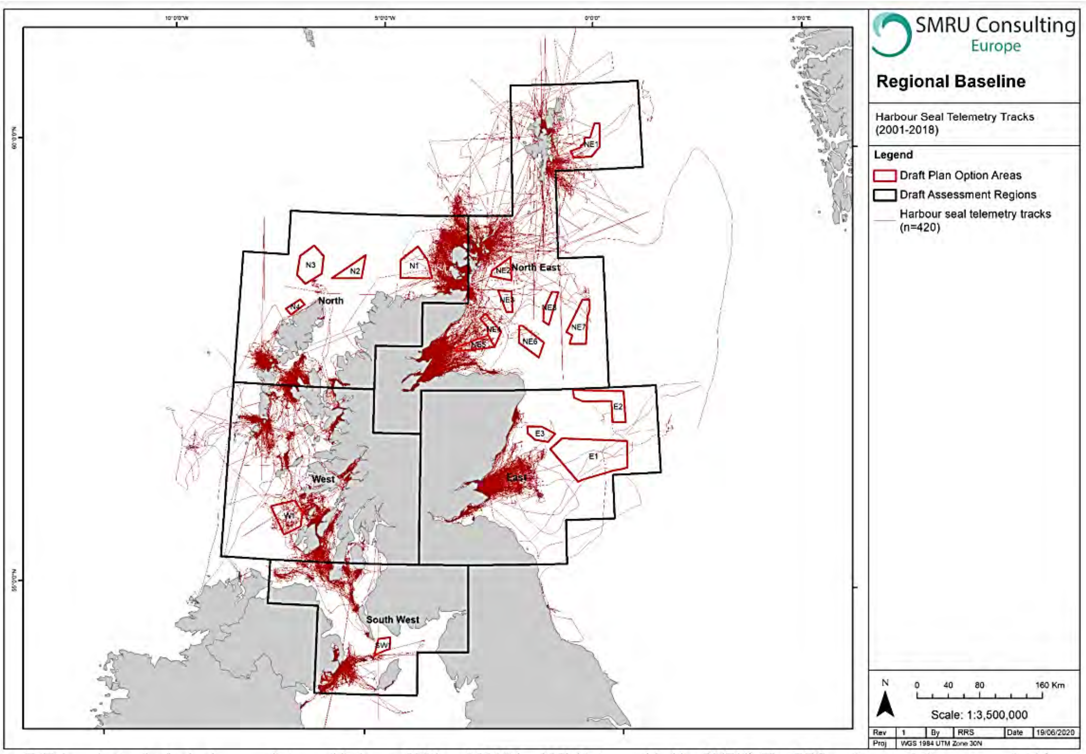


Figure 3-5: Telemetry tracked harbour seals (2001-2018)

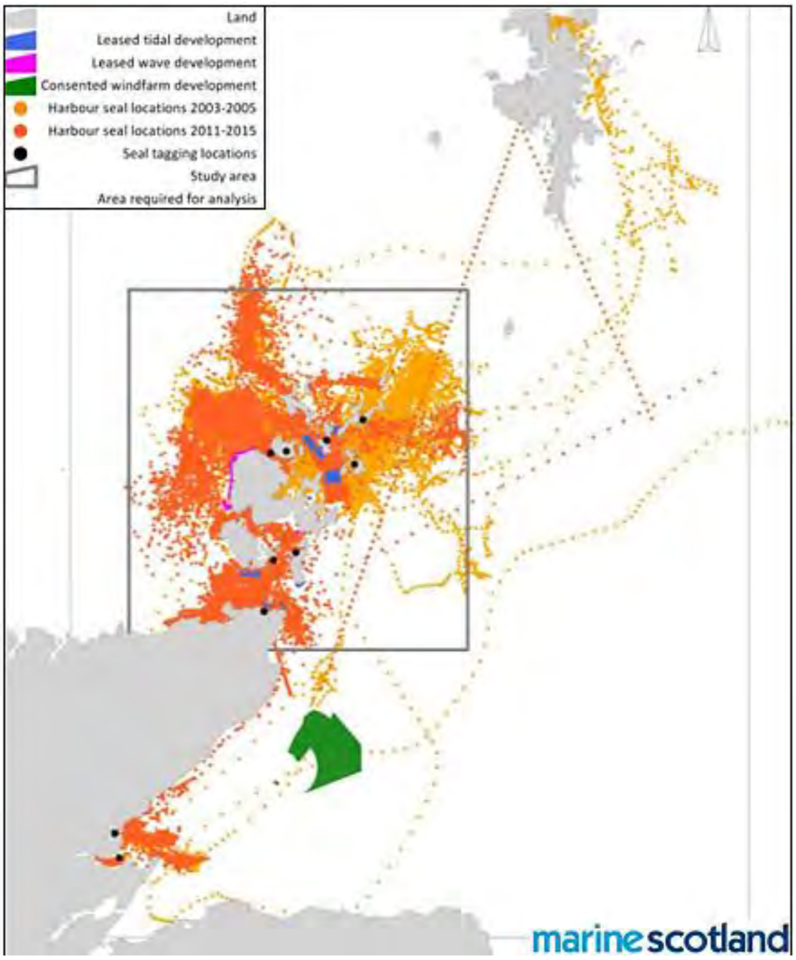


Figure 3-6: Map obtained from Marine Scotland and shows the tracks of 54 harbour seals included in the analysis (orange circles), their tagging locations (black circles)

Harbour seal distribution estimates show the mean number of harbour seals estimated to be present in each 5 km by 5 km grid cell at any one time, with that around the development site estimated to be 10-25 individuals per 5km^2 as detailed in Figure 3-7.

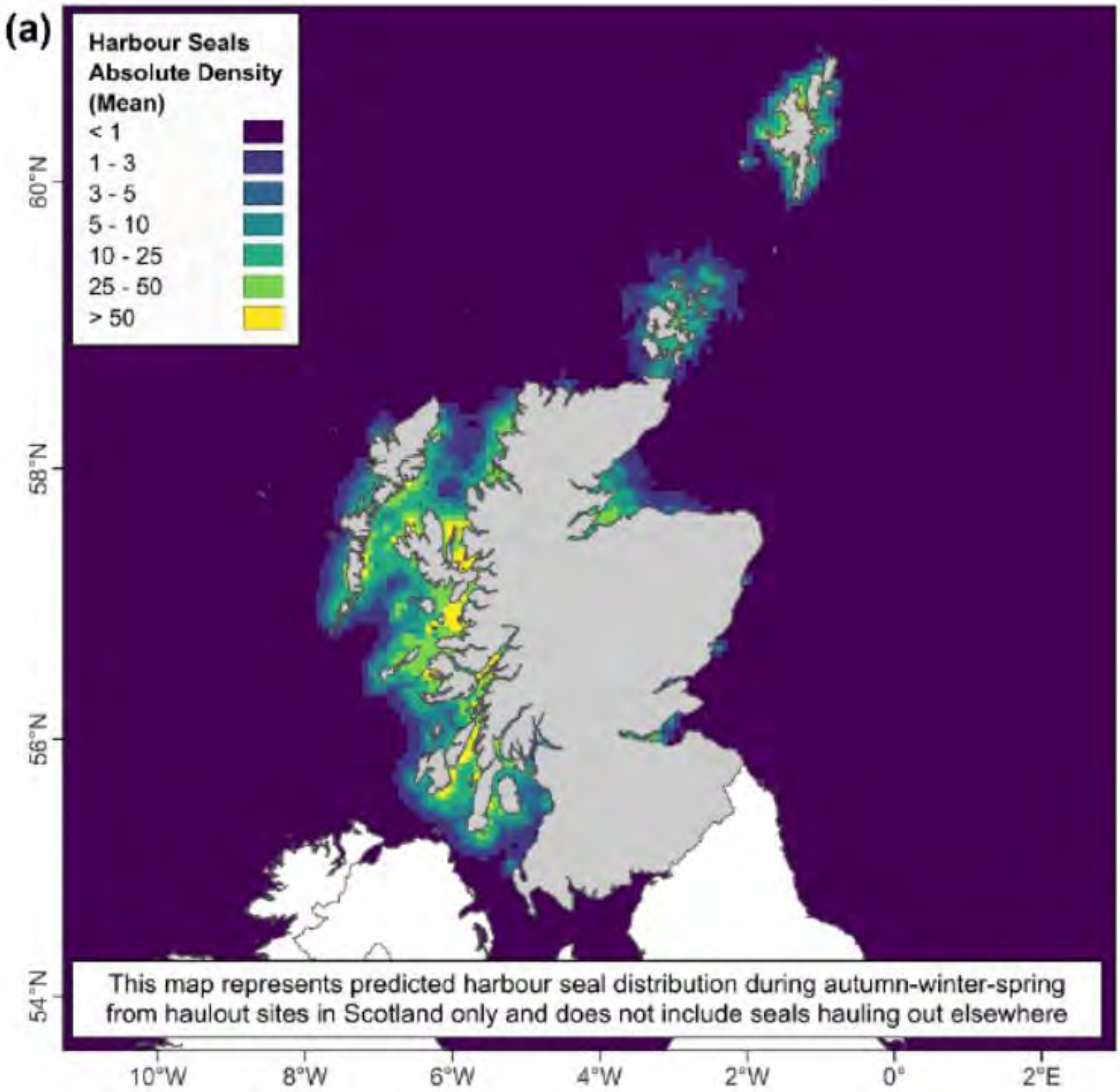


Figure 3-7: Map showing harbour seal distribution estimates. The mean number of harbour seals estimated to be present in each 5 km by 5 km grid cell at any one time. Image taken from Carter et al (2025).

Seal haul out data counts for harbour seal also show the important association with Orkney, as detailed in Figure 3-8.

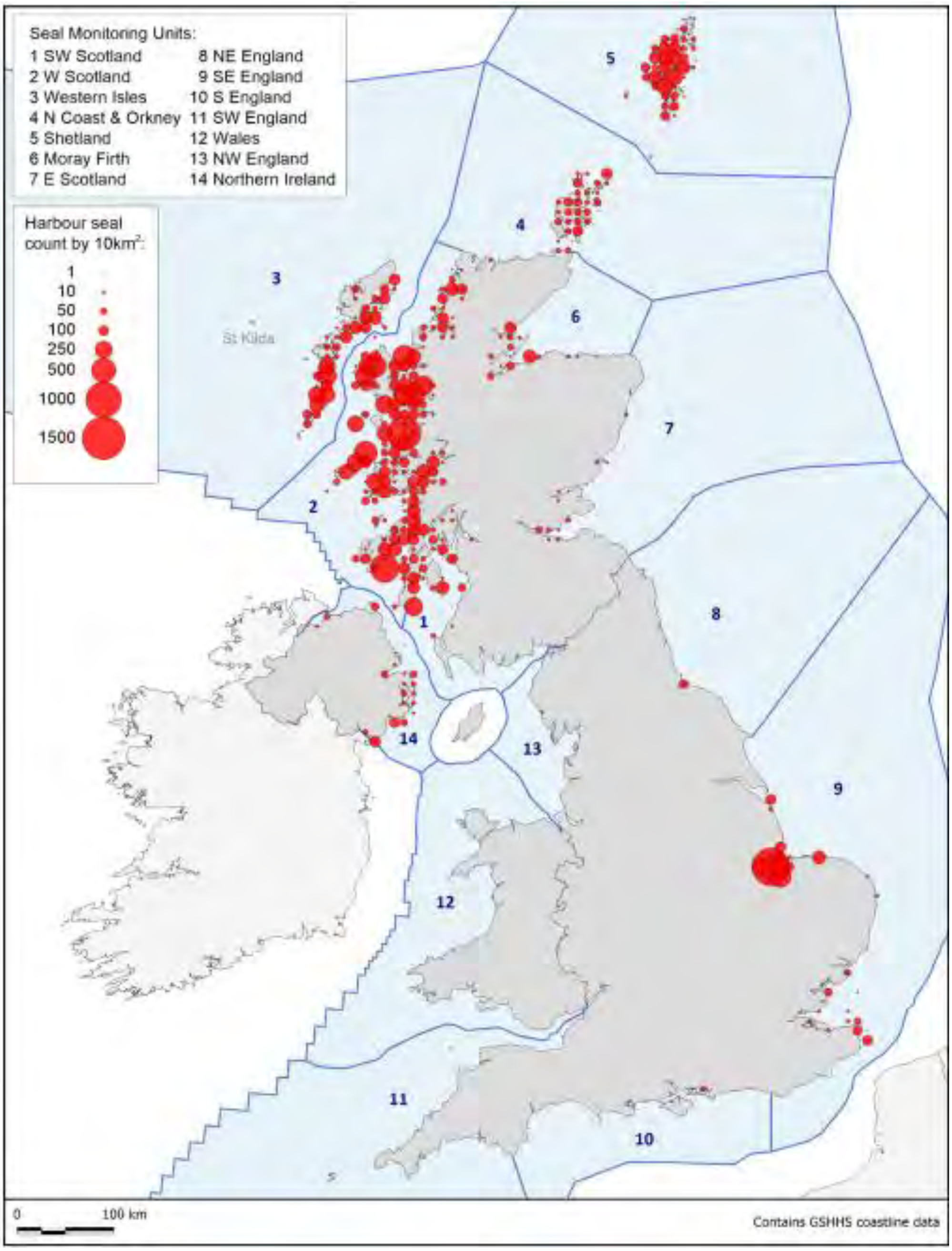


Figure 3-8: August distribution of harbour seals around the British Isles by 10km squares based on the most recent available haul out count data collected up until 2021. Map obtained from SCOS 2022.

SMASS have recorded 25 harbour seal strandings within 10km of the site between 1992-2023.

The site and adjacent coastline is considered suitable (by report authors) for use as a haul out by harbour seals due to the relatively low level of disturbance associated with the area and lack of human/ commercial/ vehicular activity. However, the site is near Scapa Pier, where vessels regularly commute to, past the site and the site is not within a designated site for harbour seal, as such is not considered that the habitat is suitable for use as a breeding or moulting haul out site. It is also considered to be too far from existing haul out sites (>7km) to cause disturbance. However, harbour seals may use the coastal waters within and adjacent to the site for commuting between haul outs and/or foraging, therefore there is a risk of disturbance to a small number from in water development works and vessel movements.

4 SEAL RISK ASSESSMENT

4.1 Activities Affecting Seals

4.1.1 Underwater Noise Producing Activities

The Marine Scotland ‘Guidance for Scottish Inshore Waters: The Protection of Marine European Protected Species from Injury and Disturbance’[24] defines what disturbance means to marine mammals as: ‘Changes in behaviour which may not appear detrimental in the short-term, but may have significant long-term consequences. Additionally the effects may be minor in isolation, but may become more significant in accumulation’. This is also considered applicable to seals. Therefore those disturbances which may be identified that are applicable to seals include the following behaviour:

- Changes in (direction or speed of) swimming or diving behaviour;
- Certain surface behaviours such as increased alertness (head lifting); and
- Moving out of a previously occupied area.

The following negative effects are linked to disturbance:

- Displacement from important feeding areas;
- Disruption of feeding;
- Disruption of social behaviours such as communication, pupping, breeding, nursing, resting and feeding;
- Increased risk of injury or mortality;
- Increased vulnerability of an individual or population to predators or physical stress; and
- Changes to regular migration pathways to avoid human interaction.

At the time of underwater noise modelling being undertaken only exemplar tender designs were completed, with works originally involving dredging, piling and drilling, thus the exact details of the construction methodologies were unknown. However, to caveat for this the data used to inform the noise models was interpolated from equipment used on similar projects. Since the underwater noise modelling was undertaken, piling and drilling works have been removed from the design. Therefore, the only construction activity considered within the underwater noise modelling that will now take place is dredging.

Dredging
Dredging will be undertaken either by hydraulic dredging using a trailer suction hopper dredger (TSHD) or mechanically by means of backhoe or grab dredgers for sand and clay. Cutter suction dredger (CSD) or mechanical equipment such as backhoe dredgers equipped with rock rippers will be used for rock substrate.

The removal of superficial soils and hard strata from approx. -15m CD down to down to a maximum depth of -20.5m CD. Additional dredging is required to accommodate the caisson section (rock foundation, scour protection and caisson). Different levels have been considered following assumptions of founding the caisson on suitable hard bearing strata along the full length of the quay line. Width of this trench at the lowest level is 24 m from toe to toe.

[24] https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2020/07/marine-european-protected-species-protection-from-injury-and-disturbance/documents/marine-european-protected-species-guidance-july-2020/marine-european-protected-species-guidance-july-2020/govscot%3Adocument/EPS%2Bguidance%2BJuly%2B2020.pdf

Further information on dredging is provided in Section 1.2.

4.1.2 Increased vessel movement

Current Vessel Movements

As part of the Navigational Risk Assessment undertaken for this Proposed Development, raw AIS data on vessel movements in Scapa Flow was purchased. The data contains information on vessel movements for a two-week period in August 2023 (14^{th}-28^{th}), representative of a summer period and for a two-week period in February 2024 (12^{th}-26^{th}), representative of the winter period. A range of vessel types (e.g. fishing vessels, dredging vessels, cargo boats, tugboats etc.) were recorded during both the two-week periods in August and February, with a total of 1442 vessel movements per month recorded for August and 1252 vessel movements per month recorded for February.

OICHA have provided information on the current typical monthly vessel movements experienced within the eastern area of Scapa Flow. This is summarised below:

- One Flotta fuel tanker;
- 5 Ship to Ship Operations;
- 3 tugs, each with 11 trips in and out of Scapa Pier;
- Escort duties for 1 tug with 12 trips in and out of Scapa Pier; and
- 22 pilot boat trips: and
- Occasional workboats to the rigs.

This equates to 124 vessel movements each month in the vicinity of the SDWQ site. This is approximately 5% of the total volume of vessel movements within Scapa Flow.

Dredge Disposal During Construction

It is assumed that 4,000m^3 capacity barge(s) will be used to transport material to the offshore disposal site. Therefore, approximately 63 rounds trips (126 vessel movements in total) over a 33-week period between end of October 2026 and end of May 2027. This equates to approximately 4 vessel movements each week.

Caisson Delivery, Scour Protection and Caisson in Filling During Construction

The new caisson design will see the following vessel movements during construction:

Table 4.1: Number of Predicted Vessel Movements During Construction

Vessel	Predicted Number of Vessel Movements.	Timescales
Caisson delivery	8 (4 deliveries) using semi-submersible vessel	June to August 2027
Caisson offloading (3 tugs for 13 caissons)	39	June to August 2027
Caisson installation (1 tug for 13 caissons)	26	June to August 2027
Scour protection	10 trips (20 movements)	Unknown. Taking precautionary approach, these will be undertaken between October and March.
Caisson infilling	15 trips (30 movements)	July 2027 – March 2028. Equates to 1 movement each week.

Dredging	63 trips (126 movements)	October 2026 – May 2027. Equates to 4 movements each week
Total	**249**	

The 249 (123 above plus 126 for dredge disposal) vessel movements during construction results in a 91% increase of vessel movements from the previous submission using the exemplar design (which incorporated assessed 130 vessel movements).

When the 249 vessel movements are split between seasons (103 during summer and 146 during the period October to May when SPA qualifying species are still present) they would represent an increase in vessel movements of 0.7% over existing baseline for the whole of Scapa Flow and an increase in monthly summer vessel movements within the eastern area of Scapa Flow of 13%. During winter, these additional vessel movements represent a 11% increase over the whole of Scapa Flow and an 13% increase in monthly winter vessel movements within the eastern area of Scapa Flow.

4.1.3 Vessel Movements associated with Operation

There is significant existing vessel activity in the wider area around the proposed SDWQ. The only 'new' vessel route introduced by SDWQ is from the existing shipping channel to the site (hatched orange in Appendix C of the HRA). There are, in fact, existing vessel movements in this area, as shown by the vessel tracks in Appendix C of the HRA, and in more detail in the Navigation Risk Assessment submitted with the Environmental Impact Assessment Report.

During previous iterations of this HRA and dialogue with NatureScot, they have suggested a limit on vessel movements along this 'new' vessel route to SDWQ, to mitigate impacts from disturbance and displacement of SPA qualifying features and in particular Black-throated Diver, stating that 'birds are already habituated to tug and pilot boat traffic at the existing Scapa Pier, therefore a less impactful scenario would see tug and pilot boats remain at Scapa Pier, significantly reducing the vessel traffic along the 'new' route to the 60 vessel movements associated with offshore wind, and baseline traffic at Scapa Pier remaining as it is.'

To address NatureScot's concerns about operational vessel movements, Orkney Islands Council Harbour Authority (OICHA) will not relocate the tug and pilot boats from Scapa Pier to SDWQ in the current consent applications.

In this scenario, the estimated number of vessels calling at SDWQ in the operational phase is 30 per year (60 vessel movements), comprising 18 large vessels and 12 smaller vessel per year. This is the most up-to-date estimate and has not changed since previous iterations of the HRA. Each of the 18 large vessels will have one associated pilot boat (2 vessel movements). In addition, 2 or 3 tugs will assist with berthing the large vessels, although these will be operating in very close proximity to these large vessels, so do not constitute a separate disturbance.

In total, the estimated vessel movements per year is 96. The majority of these vessels (approximately 80 %) are expected to occur during the summer months (April – September), so there will be an average of 12.8 vessel movements per month (3.2 per week) in summer and 3.2 per month (0.8 per week) in winter.

4.1.4 Designated Sites

Harbour Seal from SACs and SSSIs

Harbour seals are not considered to be directly impacted whilst within the SAC and SSSI boundaries, due to the distance from the site. For example, the typical foraging ranges of harbour seals are in the range of 50km and with Sanday SAC, Eynhallow SSSI and East Sanday Coast SSSI all outside of this 50km buffer therefore harbour seal are at a low risk of being in the same vicinity of the impacts of the development. In addition, telemetry studies do not show strong connectivity between designated areas and the area for construction activities. Even where a seal from the SAC/SSSI was present in the vicinity of the development (commuting/ foraging) it would likely not be exposed to injury and therefore disturbance would likely be limited as it is unlikely that the individual would be spending all of its time in that area, if it is returning to SAC/SSSI >50km away.

Grey Seal from SACs and SSSIs

Although grey seals can and do forage considerable distances, the Conservation Objectives for grey seal SACs (and SSSIs) are related to the protection of the breeding colony only. During this sensitive time, grey seals (especially females) do not tend to travel beyond 20km from these sites. Therefore, NatureScot advise screening in grey seal SACs and SSSIs for assessment only where a project site/impact radius is within 20km of the SAC or SSSI. As such, it is considered unlikely that grey seal individuals from the Fary and Holm of Faray SAC and Muckle and Little Green Holm SSSI would be exposed to injury and therefore disturbance would also be unlikely.

4.1.5 Individuals Impacted (Quantitative Data) - Disturbance

In order to try and obtain an indicative numerical value for the number of individual seals that could be impacted when at sea, as a result of the noise related activities, a similar approach was undertaken to that adopted for the Marine Scotland European Protected Species (EPS) licensing applications.

To calculate the number of individuals, likely to be present within the behavioural impact ranges the following process was used:

<u>Step 1 – Obtaining at sea area of maximum buffer distances for disturbance</u>

The Underwater Noise Modelling in Section 7.1 shows received levels on moving animals at levels >120 dB from dredging activities, however does not provide the distances that this model predicted for disturbance ranges. Therefore, values for the maximum distance over which disturbance for seals is predicted for the relevant noise producing activity (dredging) is required. It was considered that a 5km disturbance range suggested by NatureScot would provide a worst-case scenario range, with the understanding that this is likely an overestimation for disturbance, for all noise producing elements.

A buffer of this distance is applied to the application site boundary and only the area (km^2) 'at sea' is taken.

<u>Step 2: Obtain Seal density</u>

Density values of seals present within the 'at sea' disturbance buffer distance were obtained using data from Carter et al 2025)[25] which provides density data in 5km x 5km (25km^2) for at sea usage. As values are provided by 25km2, to calculate the number of individuals per km2, the Carter et al absolute estimates were divided by 25 to obtain the estimated number of individuals impacted per km^2.

[25] Carter et al., 2025

Where the calculated number of individuals is not an exact number, the figure has been rounded up as it would not be possible to cause disturbance to a fraction of an individual.

4.2 Cumulative Impacts

The projects listed in Table 4-2 below were considered for cumulative effect to seals.

In isolation, with mitigation, the Proposed Development will not have an adverse impact on the integrity of the designated sites assessed. From a review of the other projects assessed as part of this process, no significant impacts are predicted. Therefore, it is considered highly unlikely that the majority of Proposed Development would contribute cumulatively to adverse effects on the integrity of these designated sites, however due to the lack of details in relation to vessel movements, cumulative impacts may occur on seals from Sanday SAC.

Table 4.2: Projects considered for In-Combination Effects on Seals

Project (Distance to Proposed Development)	Local Authority and Ref No.	Applicant	Status / Decision	Project Details	Discussion and Conclusion
Hatston Logistics Base	Orkney Islands Council 23/256/NATEIA Supplementary Environmental Information to be re-submitted	Orkney Islands Council Harbour Authority	Pending	Construct a 300-metre pier extension, reclaim land to create a 7.5 hectare laydown area including rock armour, construct a ship lift, linkspan, fuel supply infrastructure, water storage tanks, roads and vehicle parking and associated infrastructure	Details on quantitative assessments on SPA and SAC features are not available at this time. However, with the low numbers of potentially disturbed SPA and SAC features from the SDWQ development it is predicted that there will be no adverse effect on site integrity with regards to Scapa Flow SPA, North Orkney SPA and Sanday SAC. **As such, there will be no in-combination effects.**
Westbister Fish Farm	Orkney Islands Council 15/409/MAR		Consented	Create a salmon farming site, comprising 16 x 100m circumference cages, 2 x 8 in a 60m grid and include a feed barge at Westerbister, Scapa Flow	Consented in 2014 before Scapa Flow SPA designation. HRA undertaken with respect to Sanday SAC. Concluded no adverse effect on site integrity through inclusion of Predator Inclusion Plan. Approved by NatureScot. Vessel movements were not considered a factor with regards to this project. No cumulative effects on seals predicted from SDWQ with respect to Westbister. No ornithological data available in 2014 HRA as SPA not designated. Vessel movements for this site fall under existing baseline which fall under the assessment for the Proposed SDWQ development **As such, there will be no in-combination effects.**
Veantrow Bay, Shapinsay Orkney Fish Farm	Orkney Islands Council 24/423/MARMAJ	Scottish Sea Farms	Awaiting Decision	Create salmon farming site comprising of 12 x 140 metre circumference circular cages in a 100 metre mooring grid, with pole mounted top nets, underwater lighting, and 250 tonne capacity automated feed barge (replacement of existing equipment)	For SDWQ, only 8 vessel movements will occur within the southern approaches, the same area the Shapinsay works will take. This, coupled with the small increase in operational vessel movements within the eastern half of Scapa Flow (2.5% increase), will not give rise to any cumulative effects. **As such, there will be no in-combination effects..**
Bring Head Fish Farm	Orkney Islands Council 21/411/MAR	Scottish Sea Farms	Consented	Create salmon farming site comprising of 12 x 120 metre circumference circular cages arranged in a 2 x 6 formation in a 70	Consented in 2021 when the SPA was still a pSPA. HRA undertaken concluded no adverse effects on site integrity through the implementation of a vessel management plan. Approved by NatureScot. Current

				metre mooring grid, with pole mounted top nets, underwater lighting, and 420 tonne capacity semi-automated feed barge (replacement of existing equipment)	vessel movements for this site fall under existing baseline vessel movements which fall under the assessment for the Proposed SDWQ development. **As such, there will be no in-combination effects.**
Toyness Fish Farm	Orkney Islands Council 21/410/MAR	Scottish Sea Farms	Consented	Create salmon farming site comprising of 12 x 120 metre circumference circular cages arranged in a 2 x 6 formation in an 80 metre mooring grid, with pole mounted top nets, underwater lighting, and 420 tonne capacity semi-automated feed barge (replacement of existing equipment)	Consented in 2021 when the SPA was still a pSPA. HRA undertaken concluded no adverse effects on site integrity Approved by NatureScot. Current vessel movements for this site fall under existing baseline vessel movements which fall under the assessment for the Proposed SDWQ development **As such, there will be no in-combination effects.**
South Cava Fish Farm	Orkney Islands Council 17/134/MAR	Cooke Aquaculture	Consented	Create a salmon farming site, comprising 16 x 120m circumference cages, 2 x 8 in a 70m grid and a 200t feed barge	Consented in 2018 when SPA was still a pSPA. Concluded no adverse effect on site integrity with inclusion of vessel management plan, particularly no vessel movements on the western side of the island during July and August (sensitive period for foraging Red-throated Diver). Vessel movements for this site fall under existing baseline vessel movements. For SDWQ, no construction vessel movements will impact on favoured Red-throated Diver foraging sites during sensitive time periods (July-August). **As such, there will be no in-combination effects.**
Chalmers Hope Fish Farm	Orkney Islands Council 20/231/MAR	Cooke Aquaculture	Consented	Create salmon farming site comprising of 12 x 120 metre circumference circular cages arranged in a 2 x 6 formation with a 70 metre grid, with a 300 tonne capacity semi-automated feed barge (replacement of existing equipment)	Concluded no adverse effects on integrity of Hoy SPA. Approved by NatureScot. SDWQ also concludes no adverse effects on integrity of Hoy SPA. Current vessel movements for this site fall under existing baseline vessel movements. which fall under the assessment for the Proposed SDWQ development **As such, there will be no in-combination effects**
Lyrawa Bay Fish Farm	Orkney Islands Council 18/057/MAR	Cooke Aquaculture	Consented	Increase consented cage size from 8 x 70 meter to 8 x 90 meter circumference cages	Concluded no adverse effects on integrity of Hoy SPA, through avoidance of vessel movements during sensitive foraging period for Red-throated Diver (July and August). SDWQ also concludes no adverse effects on integrity of Hoy SPA. At the time, Scapa Flow SPA was still a pSPA. Concluded no adverse effect on site integrity by NatureScot.Vessel movements for this site

					fall under existing baseline vessel movements. which fall under the assessment for the Proposed SDWQ development **As such, there will be no in-combination effects.**
Pegal Bay Fish Farm	Orkney Islands Council 18/058/MAR	Cooke Aquaculture	Consented	Increase consented cage size from 8 x 70m to 8 x 90m circumference cages	Concluded no adverse effects on integrity of Hoy SPA, through avoidance of vessel movements during sensitive foraging period for Red-throated Diver (July and August). SDWQ also concludes no adverse effects on integrity of Hoy SPA. At the time, Scapa Flow SPA was still a pSPA. Concluded no adverse effect on site integrity by NatureScot. Vessel movements for this site fall under existing baseline vessel movements. which fall under the assessment for the Proposed SDWQ development **As such, there will be no in-combination effects.**
Hunda North Fish Farm	Orkney Islands Council 17/198/MAR	Scottish Sea Farms	Refused April 2017, Consented on appeal Jan 2018	Create a salmon farming site comprising 12 x 100m circumference cages in a 60m grid with a 200 tonne feed barge	At the time, Scapa Flow SPA was still a pSPA. Concluded no adverse effect on site integrity by NatureScot subject to adherence to vessel management plan. Considered no adverse effect on distribution of Slavonian Grebe in isolation but could give rise to cumulative effect. Proposed SDWQ projects may result in displacement of 5 birds but considered (and agreed by NatureScot) that the wider Scapa Flow SPA has the capacity to accommodate these birds. **As such, there will be no in-combination effects.**
Noust Geo Fish Farm	Orkney Islands Council 14/202/MAR	Scottish Sea Farms	Consented	Install 12 x 100m circumference cages with feed barge (to replace existing fish farm cages at Noust Geo (Backaland) and at Kirk Taing)	NatureScot concluded it was unlikely that the proposals will have a significant effect on the seal qualifying interests Sanday SACs, either directly or indirectly. An appropriate assessment is therefore not required. Vessel movements for this site fall under existing baseline vessel movements. which fall under the assessment for the Proposed SDWQ development. **As such, there will be no in-combination effects**
Wyre Fish Farm, Gairsay Sound	Orkney Islands Council 23/183/MARPN	Scottish Sea Farms	Unknown	Replace 12 x 100metre circumference cages with 9 x 120 metre cages, install pole-supported top nets and reposition a feed barge	NatureScot concluded no adverse effect on Sanday SAC. The proposed Predator Exclusion Plan includes the appropriate measures to prevent and reduce any

					risk of entanglement to seals as a result of predation. Measures include appropriate mesh size and strength for the site, and also sufficient tensioning with the use of net weights. Suitable monitoring of the site has been proposed to ensure equipment is maintained and seal interactions are monitored and reported. There was no information on vessel movements associated with these works, but given that the works are for replacement of cages, required vessel movements will be extremely low. This, coupled with the small increase in operational vessel movements within the eastern half of Scapa Flow (2.5% increase), will not give rise to any cumulative effects. **As such, there will be no in-combination effects**
Quanterness Fish Farm	Orkney Islands Council 24/216/MAR		Awaiting Decision	Create salmon farming site comprising of 14 x 120 metre circumference circular cages, with pole mounted top nets, underwater lighting, and 200 tonne capacity feed barge (replacement of existing equipment	No HRA available on planning portal at time of search (May 2025). NatureScot advice was for further information with regards to impacts to North Orkney SPA qualifying features to determine any adverse effect. No mention of connectivity between North Orkney SPA and Scapa Flow SPA NatureScot concluded no adverse effect on the integrity of Sanday SAC. There was no information on vessel movements associated with these works, therefore it is not possible to undertake an assessment of in-combination effects during the operational phase. **As such, although unlikely, it cannot be concluded if there are any in-combinaiton effects.**
Warebeth And Seabed Offshore, Stromness, Orkney	Orkney Islands Council 25/117/WL	RJ MacLeod Ltd	Awaiting Decision	Install horizontal directional drills	NatureScot advised that it is unlikely that the proposal will have a significant effect on any qualifying interests of Scapa Flow SPA either directly or indirectly. An appropriate assessment is therefore not required. Given that an HRA is not required due to no effects, coupled with the predicted no significant impacts from SDWQ, it is considered that in-combination effects are highly unlikely. **As such, there will be no in-combination effects**

4.3 Impacts of Construction Activities on Seals

The way in which noise affects marine mammals is dependent on several factors, including the type of noise generated, the noise level, the species of marine mammal and the distance between the animal and the source of the noise. The National Oceanic and Atmospheric Administration (NOAA) describes how different groups of marine mammals hear and are affected by sounds, which can be found in the *'Guidance for Assesing the Effects of Anthropogenic Sound on Marine Mammal Hearing'*[26]. The effects can be described as either a Permanent Threshold Shift (PTS), where an animal experiences irreversible damage to their hearing which can in turn affect their ability to forage and reproduce and in extreme circumstances result in death; or a Temporary Threshold Shift (TTS) which an animal can recover from but may experience 'masking' which reduces its ability to communicate with other animals and locate prey, resulting in fatigue[27].

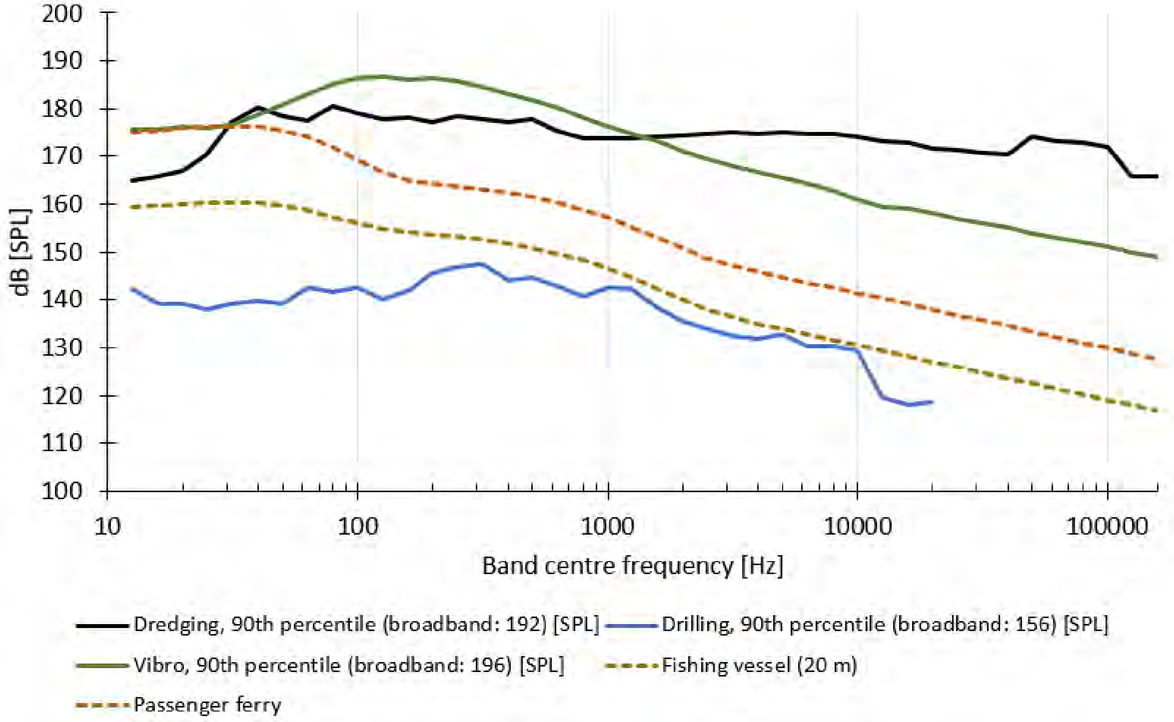
Seals rely on their hearing for foraging, navigation, communication and locating threats. The impact of noise to a population level is difficult to determine, however the expected impact on an individual animal's hearing ability and potential damage that could be caused by noisy activities during construction is assessed by modelling representative scenarios, taking into account environmental variables and the animal's hearing capabilities.

Harbour seals are known to have the highest sensitivity to acoustic exposure of all tested pinniped species. Grey seals are also known to have a high sensitivity to acoustic exposure, however there is no published threshold audio data for grey seals, therefore it is assumed audio data for harbour seals to be the closest approximation for grey seals.

Both harbour and grey seals are vulnerable to increases in acoustic levels when underwater, from dredging. Harbour seals exhibit avoidance behaviour (haul out) when in close proximity to noise above background levels from vessel movement. Grey seals may exhibit avoidance behaviour by hauling out or creating distance from the underwater noise source.

[26] NOAA guidance available at: http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm last accessed 05/03/2025
[27] JNCC UK Marine Noise Registry: Information Document available at: http://jncc.defra.gov.uk/pdf/MNR__Draft_InfoDoc_V1_20160808.pdf last accessed 05/03/2025

Figure 4-1: Underwater noise modelling figure 7.1 showing sound sources considered in the report, alongside a fishing boat and a small ferry for context.



Dredging

The noise from dredging, has short risk ranges for PTS for harbour and grey seal of <50m regardless of longevity (1-8hrs). There is no acute risk of noise related injury related to the dredging, and seals have time to swim away. TTS risk ranges span from 70 m to 250m from 1 to 8 hours dredging, respectively, however, this is only for animals staying close to the activity for extended periods (prolonged exposure). It is considered that any animals would move away from the noise source and so prolonged exposure is considered unlikely. Therefore, it is considered there is no acute risk of noise related injury related to dredging.

<u>Disposal of Dredged Materials</u>

Following identification and screening of available disposal options by EnviroCentre[28], a combination of on land and at sea disposal were considered the most appropriate options. At sea disposal (within the disposal site) would only consist of material considered unsuitable for construction works i.e. material with high silt content. At sea disposal was considered as it would require minimal transportation requirements and low environmental risk. The selected licensed marine disposal site which has been 'open' since 2020, is located 24km from the proposed SDWQ development site (disposal site FI040). It has been agreed that disposal of any dredge arising, to sea, will take place out with the SPA.

The disposal site is < 4.5km from a designated seal haul out site (Selwick) for grey and harbour seals, therefore both seal species associated would likely forage and commute as well as haul out on land in proximity to the disposal site. However, the last counts for the Selwick haul out site recorded only 17 harbour seal and 117 grey seal, with numbers generally considered low. In addition, the disposal site has been active since 2020, and therefore it is likely that seals within the Selwick haul out site would have become relatively used to vessels travelling to and disposing dredge materials over the past five years it has been open.

[28] SDWQ BPEO Report Final - Rev1

Dredge noise levels for the SDWQ project having short risk ranges of PTS (<50m) and TTS (250m), based on the modelling example, it could be assumed that dredging and disposal would have reduced risk ranges of noise output on seals.

Water quality in relation to dredging

As outlined in section 4.7.2.4 in Volume 1 of the EIAR, the marine deposits within the dredge area comprise an approximate stratigraphic order comprising superficial marine deposits (loose to medium dense gravelly silty sands with shell fragments and occasional cobbles) overlying glacial till. A Dredging Best Practicable Environmental Option Report (BPEO) (Technical Appendix 2.2, Volume 3 of the EIAR) has been produced for the proposed development which identifies the dredge budget to consist of approximately 17% gravel, 60% sand, and 23% silt and clay.

Hydrodynamic modelling summarised in Technical Appendix 4.1, Volume 3 of the EIAR show little impact on the surrounding water column and seabed due to the low energy environment in this part of Scapa Flow. The impacts on prey species for harbour seal are expected to be negligible such that their abundance and general distribution remains unchanged from the baseline. In addition, the magnitude or the sediment discharge and dispersion from dredging works will be low within the dredge area and its immediate vicinity, and negligible out with this area. Thus, the supporting habitats for harbour seal beyond the development footprint will be maintained.

Overall, the associated risk of degradation of water quality directly associated with the proposed disposal and thus impacts to seals is considered to be low i.e. unlikely to cause a change in status of the waterbodies in question at both the dredge and disposal sites.

Vessel Movements

Approximately 123 vessel movements are required for the construction activities (caisson delivery, scour protection and caisson installation) and 126 vessel movements are associated with dredge disposal movements for the project. This equates to 249 vessel movements in total, which is considered a relatively low number of vessel movements over the length of the period of works. All vessels will follow designated shipping lanes, with the new/novel route of 2.9km (1.6 nautical miles) leading from the main shipping lane into the SDWQ being the only new route section.

Overall, there will be a low increase in the number of vessels in the SDWQ area, associated with the construction phase of the project, with vessels mainly using existing shipping routes and the works are considered to be temporary in nature, however, more vessels increase the risk of collision with seals, potentially resulting in death or injury to individuals.

General Disturbance

Disturbance to seals may occur as a result of the works occurring. The most likely disturbance to seals as a result of the noise related activities include both physiological (increased stress and cortisol levels, rapid heartbeat, increased breathing rate, coldwater shock (if on land)) and behavioural disturbance (increased vigilance, crash diving, flipper splashing and vocalisation)[29].

The National Marine Fisheries Service (NMFS) predicts that seals (and other marine mammals) are likely to be behaviourally harassed when exposed to underwater noise levels of 120dB during continuous sources such as vibratory piling or drilling, and 160dB for non-explosive, impulsive sources, such as impact pile driving, whilst for underwater explosive sources where multiple detonations occur within a 24 hour period, the behavioural threshold is -5dB from TTS onset [30].

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[29] https://britishcanoeingawarding.org.uk/wp-content/files/Seal_Disturbance_Factsheet.pdf
[30] NMFS Summary of Marine Mammal Acoustic Thresholds

It is expected that both seal species would be likely to exhibit a behavioural change as a result of the noise, when in water, predominantly fleeing away from the noise source, with vocalisations and splashing occurring. In addition, physiological stress is likely to also occur. This could impact seals energy and fitness levels through disturbing foraging or causing avoidance of feeding areas for periods of time.

Seals are considered to be more easily disturbed when on land. However, due to the distance of the nearest seal haul out to the development and dredge disposal site, it is not considered that seals would be disturbed or exhibit behaviours such as tombstoning and stampeding, as the noise levels associated with the works would not extend this far.

4.3.1 Individuals Impacted (Quantitative Data) - Disturbance

Based on an adaptation of the EPS licensing methods, calculations aimed to quantify the number of individuals to be disturbed by the development for noise related activities are detailed below.

<u>Step 1</u>

<u>The maximum buffer distances for the 5km disturbance range equates to seven 5km x 5km grids ‘at sea’ of the Carter et al 2025 data, for both harbour and grey seal.</u>

<u>Step 2</u>

The absolute density estimates of each of the seven grid squares within the disturbance buffer area ‘at sea’ were summed, then as the values are provided by 25km, to calculate the number of individuals per km^2 the value was divided by 25. The results for grey and harbour seal are provided as follows:

Harbour seal

- Density estimate of seven grid squares equates to 101.2 per $25km^2$. 101.2/ 25 = 4 per km^2.
- Total number of harbour seals disturbed within the buffer area is a maximum of **4 individuals**.

Grey seal

- Density estimate of seven grid squares equates to 456.7 per $25km^2$. 456.7/ 25 = 18.27 km^2.
- Total number of grey seals disturbed within the buffer area is a maximum of **19 individuals.**

<u>Conclusion</u>

The quantitative data shows that a maximum of four harbour seals and 19 grey seals could be disturbed from noise related activities, which is considered a relatively low number. However, the 5km disturbance buffer is a worst-case scenario and therefore actual numbers would likely be lower than calculate above and thus the potential for disturbance is limited.

4.4 Effects of Terrestrial Noise from Blasting

Disturbance of seals on land or when ‘bottling’ (head above water at sea) could be caused by noise associated from terrestrial blasting, which could have a negative impact on seals.

Although the majority of energy generated within the atmosphere from any surface mineral blasting will be of a sub-audible nature, there will also be a component that is audible, i.e. at frequencies greater than 20 Hz, and as such can be heard as noise and measured in terms of dB(A).

Routine blasting operations regularly generate air overpressure levels at the closest point to blast area of around 120 dB and the NMFS predicts that harbour seals exposed to $\geq$90 dB (in-air) will be behaviourally harassed, with other species at ≥100 dB. However, the intensity of these noise levels experienced at a distance from the blast site are affected by a range of meteorological conditions (wind speed and direction, temperature, cloud cover and humidity). For example, if a blast is detonated in a motionless atmosphere in which the air temperature is constant, then the air overpressure intensity will decrease purely as a function of distance and will, once outside of the immediate vicinity of the blast, reduce by 6 dB as the distance from source doubles. Although such conditions are very rare, the overall result is that the nominal 6 dB reduction may be greater in some directions from the source and less in others.

A 6m high bund will be formed at the seaward boundary of the site by retaining the existing land and excavating behind, creating a natural noise screen from terrestrial blasting (and other works) and will only be removed once the site is excavated to the final profile. This would reduce the effects on seals of noise on land.

As the distance of the nearest seal haul-out site is 7km west of SDWQ, therefore due to the implementing of a 6m high bund and the 6 dB reduction as the distance from the source doubles, and that when sound waves pass a given position, the pressure of the air rises very rapidly then falls more slowly then returns to the ambient value after a number of oscillations, it is unlikely that seals using regular haul out spots, or those at sea at the water's surface will be negatively impacted to a population level from terrestrial noise associated with blasting.

4.5 Effects of Increased Vessel Movement on Seals

4.5.1 During Construction

Increased vessel movement has the potential to increase collisions with seals.

The development and dredge disposal will require a variety of vessels that differ in size, speed and operating procedure. This can result in seal collision risk levels for different vessels and SDWQ development activities. Although, larger vessels have a greater footprint and therefore may be considered more likely to make encounters with seals, the speed at which smaller vessels travel can be more detrimental to seals.

Presence of vessels can induce a vigilance/alert response in seals, considered to be attributed to similar behavioural responses to predator detection, foraging, observation of conspecifics, kleptoparasitism avoidance, and social cohesion maintenance[31]. Not only does this result in physical disturbance but also other costs (rest, locomotion, not foraging, not mating etc.) to seals.

However, research undertaken by the Sea Mammal Research Unit involving a telemetry-based study of the swimming behaviour of seals was carried out in the Moray Firth to compare seal and vessel movements with the purpose of identifying potential areas with high spatial overlap. The observations of movements of individual seals and vessels did not show any apparent responses, with seals not appearing to react to close passing vessels (not moving towards or away from them)[32].

As well as disturbance, mortality of seals can occur from vessel strikes. Using data of stranded harbour seals in the Salish Sea from 2002–2019, Olson et al identified 27 cases of fatal propeller strikes, with weaned pups being the most frequently affected (64% of cases)[33].

[31] https://www.seawatchfoundation.org.uk/wp-content/uploads/2012/08/Kate-Lewis-thesis.pdf
[32] https://data.marine.gov.scot/sites/default/files/SMFS%20Vol%207%20No%2024.pdf
[33] J.K. Olson; D.M. Lambourn; J.L. Huggins; S. Raverty; A.A. Scott; J.K. Gaydos (2021) Trends in Propeller Strike-Induced Mortality in Harbor Seals (Phoca vitulina) of the Salish Sea. Journal of Wildlife Diseases. Volume 57. Issue 3. Pages 689-693

The likelihood of vessel collisions is dependent upon vessel speed, animal behaviour and vessel manoeuvrability[34]. Vessels travelling at slower speeds in general can allow time for seals and vessel operators to react to avoid collisions.

4.5.2 During Operation

During the operational phase, with the retention of tugs and pilot vessels at Scapa Pier, the estimated number of vessels calling at SDWQ in the operational phase is 30 per year (60 vessel movements), comprising 18 large vessels and 12 smaller vessel per year. Each of the 18 large vessels will have one associated pilot boat (2 vessel movements). In addition, 2 or 3 tugs will assist with berthing the large vessels, although these will be operating in very close proximity to these large vessels, so do not constitute a separate disturbance.

In total, the estimated vessel movements per year is 96. The majority of these vessels (approximately 80 %) are expected to occur during the summer months (April – September), so there will be an average of 12.8 vessel movements per month (3.2 per week) in summer and 3.2 per month (0.8 per week) in winter.

The majority of the routes used by these vessels will be along established routes (ie, the main shipping channel and the shipping lane west towards Stromness). The only new, or seldom used, section of route to be used for vessels will be the 2.6km (or 1.3 nautical miles – 167Ha) branching east off the established route to the SDWQ site. As with the construction phase vessel movements, the effects of the operational phase impacts will be highly localised and unlikely to affect the conservation status of this species. As the majority of the vessel routes will be using existing routes, seals will likely already be habituated to vessels in those areas and/ or avoid the area already. It is likely that due to the seldom used new route that there is a greater likelihood of vessel collision with seals, however over time, seals would likely become habituated to vessels using this route. Again, as above, the likelihood of vessel collisions is dependent upon vessel speed, animal behaviour and vessel manoeuvrability, therefore vessels travelling at slower speeds in general can allow time for seals and vessel operators to react to avoid collisions. The Seal Protection Plan (SPP) details protocols to be implemented to reduce collision risk during operation. This includes limits on vessel speed.

4.6 Conclusion

There is a clear decline in harbour seal populations based on reviews of population data over the years. However, although the cause for the decline has not yet been identified, coastal developments or vessel movements are not considered to be linked.

Some of the activities associated with the SDWQ development (dredging and vessel movement) have the potential to cause disturbance, injury or in extreme circumstances, death to individual seals. For the most part the activities associated with the proposed development will result in temporary avoidance of a small area of habitat available to individuals. It is considered that with mitigation described in the following Seal Mitigation Plan (SMP) the risk of death and injury this will be greatly decreased. It is not possible to rule out some level of disturbance to individuals which might be present within the area.

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[34] SEER U.S. Offshore Wind Synthesis pf Environmental Effects Research: Presence of Vessels: Effects of Vessel Collision on Marine Life (2022): https://tethys.pnnl.gov/sites/default/files/summaries/SEER-Educational-Research-Brief-Effects-of-Vessel-Collision-on-Marine-Life.pdf

Overall, the increase in the number of vessels travelling through to SDWQ, during construction, dredge disposal, and operation would increase the risk of collision with seals, potentially resulting in death or injury to individuals.

It is considered that due to the distance from designated sites and haul out sites, the relatively small area over which individuals are likely to be affected and the temporary nature of the works, there will not be an overall negative effect on the favourable conservation of the local seal population.

5 SEAL MITIGATION PLAN

The seal mitigation will comprise a standard Marine Mammal Observation Protocol (MMOP) as per JNCC guidance will be implemented during dredging operations in sea states less than 4 and during times of optimal visibility

5.1 Seal Observation Protocol

The Seal Observation Protocol (SOP) will be implemented so that the construction and dredging works do not cause injury or unnecessary disturbance to seals. This section has been designed with reference to current JNCC guidance 'Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise' (August 2010) [35] [36].

5.1.1 Marine Mammal Observer

A suitably qualified Marine Mammal Observer (MMO), competent in the identification of seals at sea, will be present during the dredging. The MMO will undertake observation for seals within the mitigation zone before and during the dredging and will be dedicated to that one task for the duration of any watch. The MMO will advise the contractors and crews on the implementation of the procedures set out in the agreed protocol, to ensure compliance with those procedures.

The JNCC guidance provides the following definitions of an MMO:

MMO: Individual responsible for conducting visual watches for seals. It may be requested that observers are trained, dedicated and/or experienced.

Trained MMO: Has been on a JNCC recognised course.

Dedicated MMO: Trained observer whose role on board a vessel is to conduct visual watches for seals.

Experienced MMO: Trained observer with three years of field experience observing for seals, and practical experience of implementing the JNCC guidelines.

The MMO will be, positioned appropriately to cover the full mitigation zone and will be trained. The identity and credentials of the MMO will be agreed with Marine Directorate.

5.1.2 MMO Equipment

The MMO will be equipped with binoculars (10X42 or similar) and/or a spotting scope (20-60 zoom or equivalent), a copy of the agreed protocol and the Marine Mammal Recording Form (MMRF), which is a Microsoft Excel spreadsheet containing embedded worksheets named Cover Page, Operations, Effort and Sightings. A Microsoft Word document named Deck forms is also available, and the MMO may prefer to use this when observing before transferring the details to the Excel spreadsheets. Although these forms were developed for seismic surveys, they can be used for dredging operations,

[35] https://data.jncc.gov.uk/data/31662b6a-19ed-4918-9fab-8fbcff752046/JNCC-CNCB-Piling-protocol-August2010-Web.pdf

[36] It should be noted that these protocols do not document measures to mitigate disturbance effects but have been developed to reduce to negligible levels of risk of injury or death to marine mammals in close proximity to piling operations or explosives.

although many columns will not be applicable. The ability to determine the range of seals is a key skill for MMOs, therefore a hand-held rangefinder will be used to verify the range.

All MMO forms, including a guide to completing the forms; and instructions on how to make a rangefinder are available on the JNCC website: http://jncc.defra.gov.uk/marine/seismic_survey

5.1.3 Communication

The contractor will be responsible for the communication channels between those providing the mitigation service and the crews working on the dredging. A formal chain of communication from the MMO to the contractor, who will start/stop dredging, will be established. In order to confirm the chain of communication and command the MMO will attend any relevant pre-mobilisation meetings.

5.1.4 Mitigation Zone

Following appointment of contractor / Ecological Clerk of Works (ECoW), logistical information will be available/ updated to provide more detailed mitigation zones for the MMO. This may change throughout the construction period due to ground levels changing and depending on the area of works which need to be viewed.

The JNCC guidance defines the mitigation zone as a pre-agreed radius around dredging site prior to any works. This is the area where a MMO keeps watch for seals (and delays the start of activity should any seals be detected). The extent of this zone represents the area in which a seal could be exposed to sound/ disturbance that could cause injury. The MMO should be located on the most appropriate viewing platform to ensure effective coverage of the mitigation zone. The radius of the mitigation zone should 500m for each activity to cover the PTS and TTS ranges of the activities.

5.1.5 Dredging Protocol

Following appointment of contractor / Ecological Clerk of Works (ECoW), logistical information will be available/ updated to provide more detail regarding dredging protocols.

The standard JNCC protocol is outlined below:

1. Dredging will not commence during poor visibility (such as fog) or during periods when the sea state is not conducive to visual mitigation as there is a greater risk of failing to detect the presence of seals. An elevated platform for the MMO to monitor from would be beneficial when the during rougher periods, the dredging works could also be scheduled on a day where the sea is expected to be calmer.

2. The MMO(s) should be situated in a location that provides the best viewing platform and is likely to be closest to the dredging activities. For example, an elevated area of the coast or a vessel's bridge that allows 360 degree cover (depending upon the size of the mitigation zone more than one MMO viewing platform (and therefore more than one vessel) may be required to ensure that the entire mitigation zone can be observed).

3. At least 30 minutes before any dredging, a visual watch, known as the 'pre-works search', should be carried out in the mitigation zone. The pre-works search should continue until the MMO advises that the mitigation zone is clear of seals, and the dredging works can start.

4. The MMO will scan the waters using binoculars or a spotting scope and by making visual observations. Sightings of seals will be appropriately recorded in terms of date, time, position, weather conditions, sea state, species, number, adult/juvenile, behavior, range etc. on the JNCC standard

forms. Communication between the MMO and the contractor and the start/end times of the activities will also be recorded on the forms.

5. Dredging should not be undertaken within 20 minutes of a seal being detected within the mitigation zone.

6. If a seal is observed, within the mitigation zone, it should be monitored and tracked until it moves out of range. The MMO should notify the relevant chain of command of the detection and advise that the operation should be delayed. If the seal is not detected again within 20 minutes, it can be assumed that it has left the area and the works may commence.

7. If an MMO is uncertain whether seals are present within the mitigation zone, they should advise that the activity should be delayed as a precaution until they are certain that no animals are present.

8.The MMO or ECoW should periodically check the silt boom to ensure that no seals have been enclosed or interacted with the boom during works.

5.1.6 Reporting

As per the JNCC guidance, reports detailing the dredging activity and seal mitigation (the MMO reports) will be sent to Marine Directorate at the conclusion of these activities. Reports will include:

- Completed MMRFs;
- Date and location of the dredging activities;
- A record of all occasions when dredging occurred, including details of the duration of the pre-dredging search and soft-start procedures, and any occasions when dredging activity was delayed or stopped due to presence of seals;
- Details of watches made for seals, including details of any sightings, and details of the dredging activity during the watches;
- Details of any problems encountered during the dredging activities including instances of non-compliance with the agreed dredging protocols; and
- Any recommendations for amendment of the protocols.

5.1.7 Terrestrial Noise Considerations - Blasting

Following appointment of a contractor, logistical information will be available/ updated to provide more detail regarding terrestrial blasting protocols and blasting methods will be determined by the contractor once commissioned.

The MMO protocol implemented for dredging will also be undertaken for terrestrial blasting. However, a 10-minute pre-work search would be required rather than a 30-minute pre-works search.

In addition, the following mitigation methods should be considered to be implemented for terrestrial blasting:

During terrestrial blasting, minimising air overpressure at the source, such that, even under unfavourable weather conditions, all such energy is within acceptable criteria at distance, remains the best practicable approach. It is an approach that all surface mineral sites are obliged to follow under the provisions of The Quarries Regulations 1999.

Detonating cord should be used as sparingly as possible, and any exposed lengths covered with as much material as possible. Just a few feet of exposed cord can lead to significant amounts of audible energy and, hence, high air overpressure levels. Stemming release can be controlled by detonation technique, together with an adequate amount of good stemming material. It should be noted however that detonation cord and stemming release have been virtually eliminated with the use of in hole initiation techniques.

If the use of exposed detonating cord is avoided the characteristic noise of a blast is no longer a sharp crack but rather a dull thump. This is partly due to the detonating sequence and partly due to natural energy dissipation and reduction. Whilst some of the noise perceived by a neighbouring resident would be directly from the blast itself, the lower frequency components of the air overpressure might well induce secondary rattling of windows and ornaments within a property which could augment the overall effect.

Thus, in terms of noise control or reduction in the care and attention to blast design and subsequent implementation, including initiation, necessary for the control of air overpressure is equally applicable to noise.

BS 6472-2:2008 states that "The highest [air overpressure] levels normally measured in the United Kingdom are generally less than 1% of the levels known to cause structural damage." Therefore, by implementation of the best practice measures, effects due to air overpressure generation by the Proposed Development are anticipated to have a negligible effect on seals in terrestrial environments**.**

5.2 Vessel Movement Mitigation Protocol

The Harbour Authority implement speed restrictions on vessels within Orkney waters. Implementation of a Vessel Management Plan including agreed routes, speed limits and incorporation of the Scottish Marine Wildlife Watching Code[37] should be in place ahead of construction works commencing (inclusive of dredging)[38].

Training courses such as those provided by the WiSe scheme[39] could be offered to vessel operators.

5.3 Additional Good Practice Recommendations

If any dead seal is anecdotally observed during construction, it should be reported to the Scottish Marine Animal Stranding Scheme (SMASS) (www.strandings.org) and live seals in distress will be reported to British Divers Marine Live Rescue (www.bdmlr.org.uk). All dead or distressed seals should also be reported to the local NatureScot office.

The MMO should keep a record of all seal sightings, whether in the mitigation zone or not, to be issued to NatureScot. An understanding of the location of species is essential to appropriately assess the impacts of a proposed development and plan and target effective mitigation, therefore this data could be used to inform future projects. Biodiversity data are extremely important as, aside from use in planning and decision making, they are key to delivering state of environment reporting, education, modelling trends in species and habitat distribution, and research and policy making.

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[37] https://www.nature.scot/doc/scottish-marine-wildlife-watching-code-smwwc

[38] Identified in a project team meeting that 4 knots isn't a safe/practical speed for dredging vessels, and isn't considered necessary as vessels will be using established shipping routes to reach the licensed sea deposit site.

[39] Information available at: https://www.wisescheme.org/ (accessed 02/06/2023)

APPENDICES

A PROPOSED SITE LOCATION AND DISPOSAL SITE FI040

Site Location

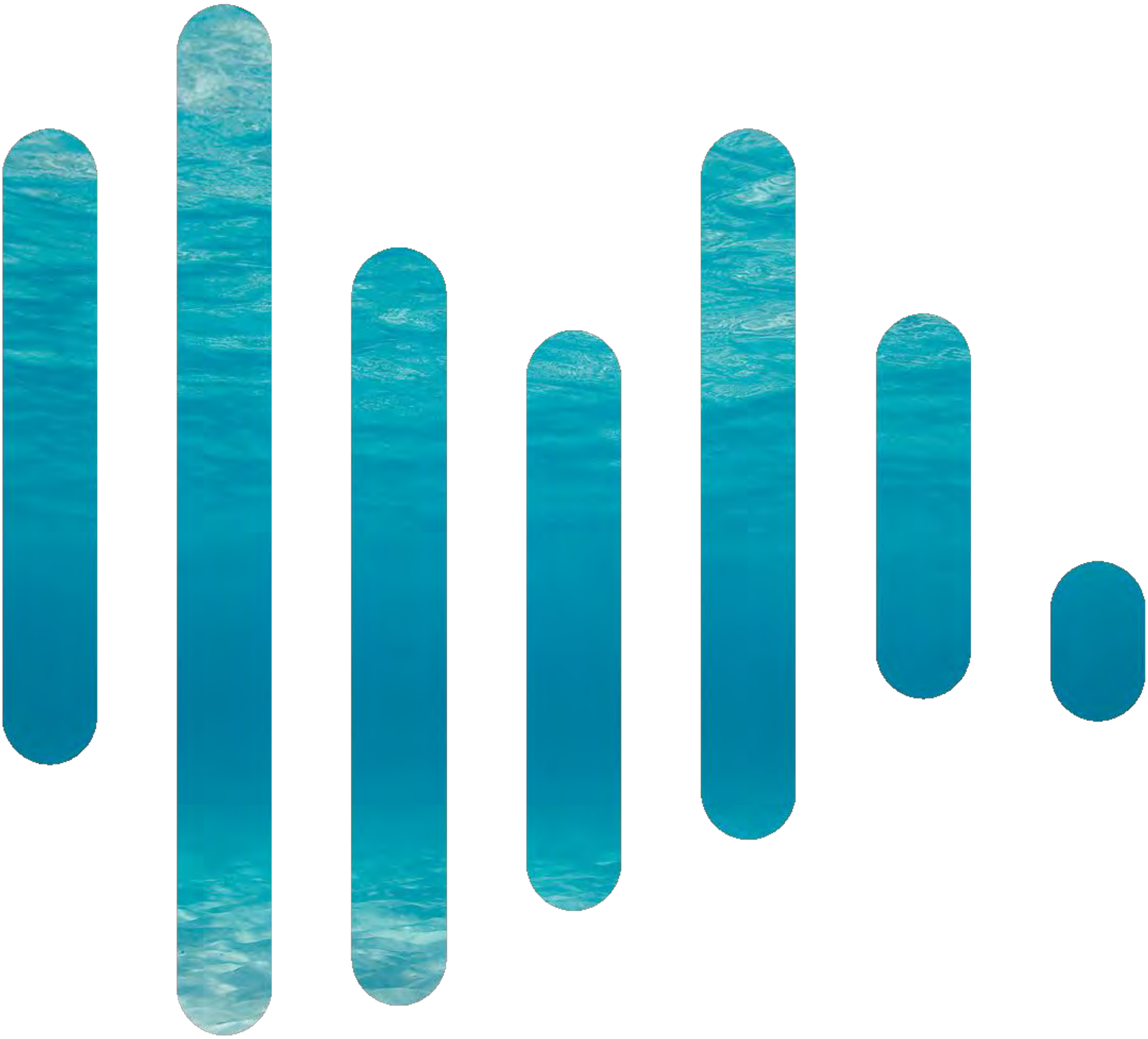
Location of Disposal Site FI040

Source: https://marinescotland.atkinsgeospatial.com/nmpi/default.aspx?layers=712

B UNDERWATER NOISE MODELLING REPORT

Note: piling and associated drilling is no longer required for the caisson design.

IRWIN CARR
CONSULTING



Scapa Deep Water Quay, UW Noise Modelling

Kirkwall, Orkney

RP001 Rv4 2022248 (Scapa DWQ, UW Modelling)

19 May 2025

PROJECT: SCAPA DEEP WATER QUAY, UW NOISE MODELLING

PREPARED FOR: ENVIROCENTRE

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SCOTLAND

ATTENTION: EMMA CORMACK

REPORT NO.: RP001 2022248 (Scapa DWQ, UW Modelling)

Document Control

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				Rasmus Sloth Pedersen	Shane Carr

EXECUTIVE SUMMARY

BRIEF DESCRIPTION OF WORK

In relation to the construction of a deep-water port in Scapa Flow, both dredging, drilling and piling is planned. The noise from these activities can adversely affect local fauna either through direct injury of sensory systems or indirect harm from noise pollution drowning out communication and foraging sounds. Noise modelling has been carried out in respect to the various noise sources and local animals to estimate impact from noise and what mitigation can/needs to be employed to keep impacts below levels of significant harm to the local wildlife.

Source sources (dredging, piling and blasting) are modelled from a combination of empirical models (based on recorded data) and numerical models (calculated source levels from inputs).

CONCLUSION & RESULTS SUMMARY

Dredging

The noise from dredging, while presenting a significant Permanent Threshold Shift (PTS (hearing injury) risk to ranges <210 m for the Very High Frequency (VHF) group (e.g., porpoise), this is only for animals staying close to the activity for extended periods (> 1 hour) and assumes continuous dredging with the dredger level as given by the 90th percentile. For the best estimate (model mean) the PTS risk range is 210m after 8 hours exposure. There is no acute risk of noise related injury related to the dredging, and animals have time to swim away. Further the area ensonified does not “block” access through a channel or strait.

Vibro piling

Prolonged exposure to vibro piling at close range (<50 m) carries some auditory risk for the animals assessed, specifically groups LF, VHF and P- (baleen whales, porpoises and salmon/trout), where the peak pressures in the noise have risk ranges up to 300 m for the VHF group. We therefore suggest surveillance takes place prior to piling to minimise the risk of impact on porpoises. While this is a significant risk for animals close to the activity, we stress that we have used a very conservative approach to estimating the source levels, and the realised emission will likely be significantly lower.

Further, animals will tend to move around, or away from noise, which will limit exposure. In Figure 16, p. 23 and Figure 18, p. 24 we show an example of the effect of using moving receivers (animats, modelled animals) to estimate what might be the effect of movement.

Table of Contents

Abbreviations and Definitions:

PTS	Permanent Threshold Shift
VHF	Very High Frequency
SOFAR	Sound Fixing And Ranging
SSP	Sound Speed Profile
SPL	Sound Pressure Level
Hearing group	Refers to the Southall 2019 hearing groups (Southall, et al., 2019).
"," and "."	Comma "," is used as thousands separator, while dot "." Is used as decimal separator.
TL, PL	Transmission Loss, Propagation Loss. Used interchangeably in this document.
Psu	Practical salinity unit, equivalent to parts per thousand as g/kg, mass of salts per mass of water.
Noise	Sound that causes, or is assumed to cause, annoyance or disadvantage. No automatic significance of impact is associated with this term.
Solver	Mathematical algorithm for calculating sound transmission losses in water.
[]	Square brackets are used throughout to denote units, e.g.: "Pressure [Pa]" means pressure in Pascals.
Degrees	Either angular degrees (0-360) or degrees Celsius
3rd octave, decidecade	Refers to the subdivision of octaves (doublings of frequency) and decades (10x frequency). Using the appropriate base frequency, the two are identical for practical purposes.
Worst case	Used as "reasonable worst case". E.g. use of MHWS instead of historical maximum for max water level. Or 90th percentile as representative of worst-case.
Mean case	The expected case, both median and mean values will inform this.
Signature, Impulse	When in relation to a sound, this refers to the time-pressure signal associated with that sound, normally as a time-series of pressures relative to ambient pressure, in pascals.
Vibro	Vibration pile driving
MSL	Mean Sea Level
β, Log multiplier	Symbol used to denote the factor multiplied by the base ten Log in equations like: "$TL = \beta \times Log_{10}(range)$"
SL, Source level	Apparent monopoint source level as viewed from the acoustic far field

1 INTRODUCTION

In relation to the construction of a deep-water port in Scapa Flow, both dredging, drilling and piling is planned. The noise from these activities can adversely affect local fauna either through direct injury of sensory systems or indirect harm from noise pollution drowning out communication and foraging sounds. Noise modelling has been carried out in respect to the various noise sources and local animals to estimate impact from noise and what mitigation can/needs to be employed to keep impacts below levels of significant harm to the local wildlife.

Source sources (dredging, piling and blasting) are modelled from a combination of empirical models (based on recorded data) and numerical models (calculated source levels from inputs).

1.1 Underwater Acoustics Basics

Underwater acoustics modelling is the application of physical models to characterise the behaviour of sound in environments under the surface of the sea and in the top layers of the seabed. As some familiarity with in-air acoustics is assumed the focus here is on key differences between in-air acoustics and underwater acoustics, making waterborne propagation more efficient than airborne propagation.

This chapter only gives reader a quick overview, please see APPENDIX B – Underwater Acoustics Basics APPENDIX *for more detail.*

1.1.1 SOUND SPEED

Water is much harder to compress than air, and a soundspeed of 1500 m/s is often used as a standard soundspeed in water[1] much as 340 m/s is in air.

The soundspeed changes with depth, “sound speed profile”, this is quite important in sound propagation, as refraction (changes in propagation angle) will occur when sound moves between layers of water with varying sound speed. These effects can lead to profoundly inhomogeneous sound fields and SOFAR (Sound Fixing And Ranging) channels.

The same relationships are valid in the sediment, though sediments commonly have soundspeeds higher than water. Soundspeeds from 1700 m/s (fine sand/silt) to 2500 m/s (gravel) are common for non-solid sediments, with solid sediments (rocks) having much higher soundspeeds 2800 m/s (Calcarenite) to 6000 m/s (some granite).

1.1.2 SPREADING LOSS

Most of the propagation loss (loss in dB from source to receiver, “PL”) that occurs initially is governed by “spreading loss”. It is the simple “thinning out” of acoustic energy as it spreads away from the source, usually in all directions – spherically. This means a reduction in received level of 6 dB per doubling of distance

At longer ranges the medium is no longer unbounded. We reach ranges where the sound has interacted with the surface (near perfect acoustic reflector) or the seabed (lossy acoustic reflector). Here we expect spreading loss to be ~3 dB per doubling of distance.

1.1.3 ABSORPTION

Besides the “thinning out” of the sound energy as described above, the sound is also dissipated into heat by the way the pressure changes interact with water, molecules and particles in its path. This absorption is salinity dependant. Frequencies under 1 kHz experiences almost no absorption, while high frequencies, over 10 kHz, can be attenuated by over 10 dB / km.

Small bubbles, wind or wave induced, will further attenuate especially the high frequencies.

1.1.4 SEDIMENT

Depending on the incident angle of the sound, the frequency and the acoustic properties of the sediment, sound can either mostly penetrate the sediment or mostly be reflected by it.

[1] Varies from 1450 m/s at 0° to 1550 m/s at 30° at salinity of 35 psu.

In shallow areas with soft sediment (acoustically similar to water), it is typical to find that close to the source, at high incidence angles and at low frequencies (<250 Hz) the sound will penetrate into the sediment and dissipate there, leading to very high transmission losses for these frequencies.

1.1.5 SOUND LEVEL UNITS

All references to sound pressure levels (SPL), peak pressure levels (L_p) and sound exposure levels (L_e) refer to a logarithmic ratio between a reported/measured pressure or exposure and a reference pressure or exposure. As an example, a level of 220 L_p (decibel zero-to-peak) is equal to a peak pressure of 100000 Pascals (Pa) over ambient pressure, while 120 L_p is equal to 1 Pa over ambient pressure.

To avoid dealing with these large numbers as pascals (as a linear scale), they are converted to a decibel ratio (Table 1 for definitions). Besides compressing large numbers to a smaller scale this also corresponds better to how animals are thought to perceive sound, namely as relative steps. This means that an increase from 1 to 2 Pa *sounds like* the same increase as from 100 to 200 Pa, even though the first step was only 1 Pa, while the second was 100 Pa. This is better reflected in a logarithmic scale based on ratios, where both steps are equal, here 3 dB.

However, while dBs are practical, they can be hard to compare between studies, due to vague definitions, and so we have adopted the standards set by ISO 18405-2017 (Table 1 below).

For ease of reference please see following overview for unit definition.

Table 1: Definitions.

Unit	Definition	Comments
SPL (dB_{RMS}) ISO 18405- 2017: 3.2.1.1	$SPL = 10 \cdot Log_{10}\left(\frac{\frac{1}{t_2 - t_1} \cdot \int_{t_1}^{t_2} p(t)^2 dt}{1 \cdot 10^{-12} Pa}\right)$	Functionally equivalent to deprecated $20 \cdot Log_{10}\left(\frac{RMS}{1 \cdot 10^{-6} Pa}\right)$
L_p ($dB_{z\text{-}p}$) ISO 18405- 2017: 3.2.2.1	$L_p = 20 \cdot Log_{10}\left(\frac{Pa_{max}}{1 \cdot 10^{-6} Pa}\right)$	This assumes that Pa_{max} is equal or greater than $\sqrt{Pa_{min}{}^2}$
$L_{p\text{-}p}$ ($dB_{p\text{-}p}$)	$L_{p-p} = 20 \cdot Log_{10}\left(\frac{Pa_{max} - Pa_{min}}{1 \cdot 10^{-6} Pa}\right)$	Often[2] equivalent to $L_P + 6.02\ dB$
L_E (dB_{SEL}) ISO 18405- 2017: 3.2.1.5	$L_E = 10 \cdot Log_{10}\left(\frac{\int_{t_1}^{t_2} p(t)^2 dt}{1 \cdot 10^{-12} Pa}\right)$	For continuous sound this is equivalent to $SPL + 10 \cdot Log_{10}(t_2 - t_1)$ "t" is seconds

Unless otherwise stated SPL has an averaging period of 1 second, and L_E for the duration of the specified event, sometimes indicated as $L_{E\text{-"time"}}$ or $L_{E\text{-single blow}}$.

If the averaging period for SPL is equal to the total even duration then SPL is equal to "Leq" the "equivalent constant level".

When source levels are presented, the same units are used, and it is implicit that all source levels are given as if recorded 1 m from an omnidirectional mono-point source, unless otherwise specified.

[2] If maximum pulse rarefaction is below ambient pressure and compression and rarefaction phases are of equal size.

2 SITE AND LOCAL ENVIRONMENT

The site is located in Orkney, Scotland:

- Scapa DWQ at Lat: 58.920345, Lon: -2.965084. Mean water depths 5-30 m.

The site is sheltered from oceanic swell, with little current and with no major outflows from rivers, meaning that the conditions important for sound propagation are quite stable. The sediment is generally a soft upper layer of mud/silt and gravel overlaid a layer of weathered sedimentary rock, before a stronger layer of sedimentary rock (silt-/mud-/sand-/lime-stone).

Figure 1. General location of Scapa DWQ development (in red circle) on Main Island of the Orkney Islands. Hatston site (just north west of Kirkwall, shown for completeness).

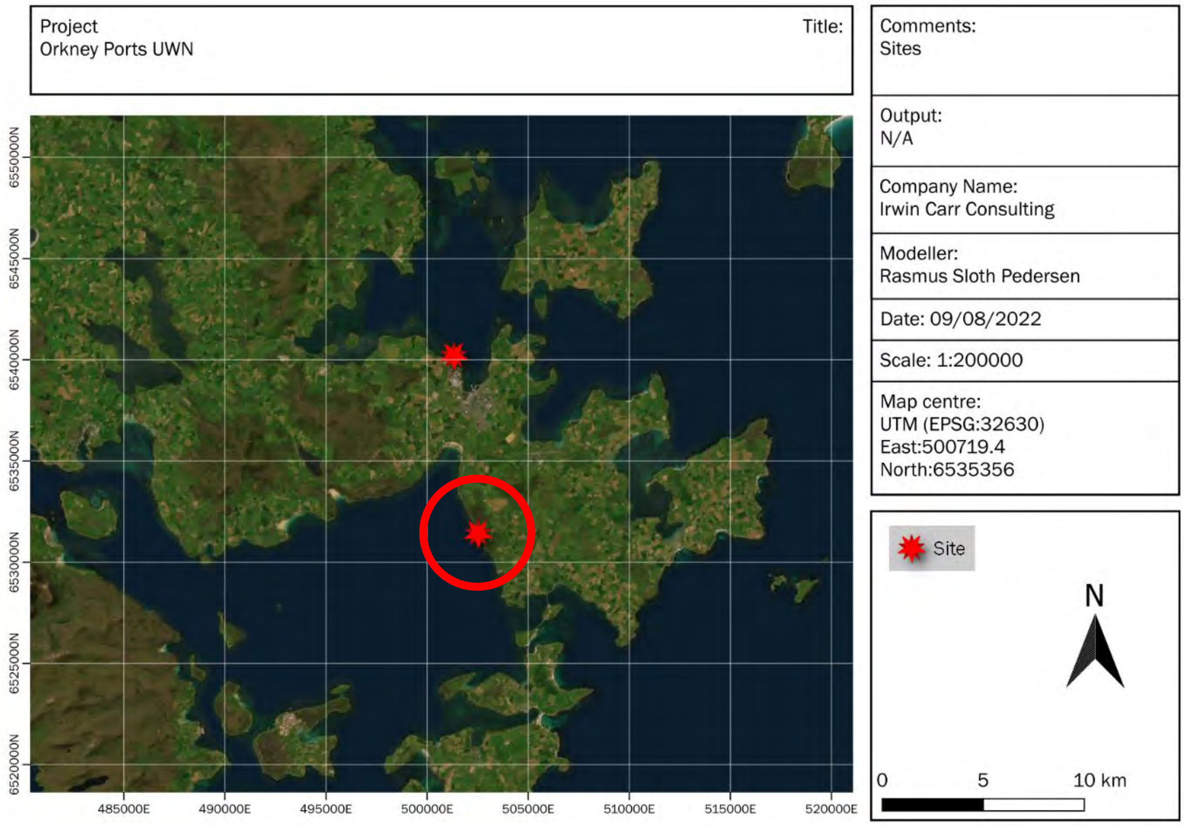
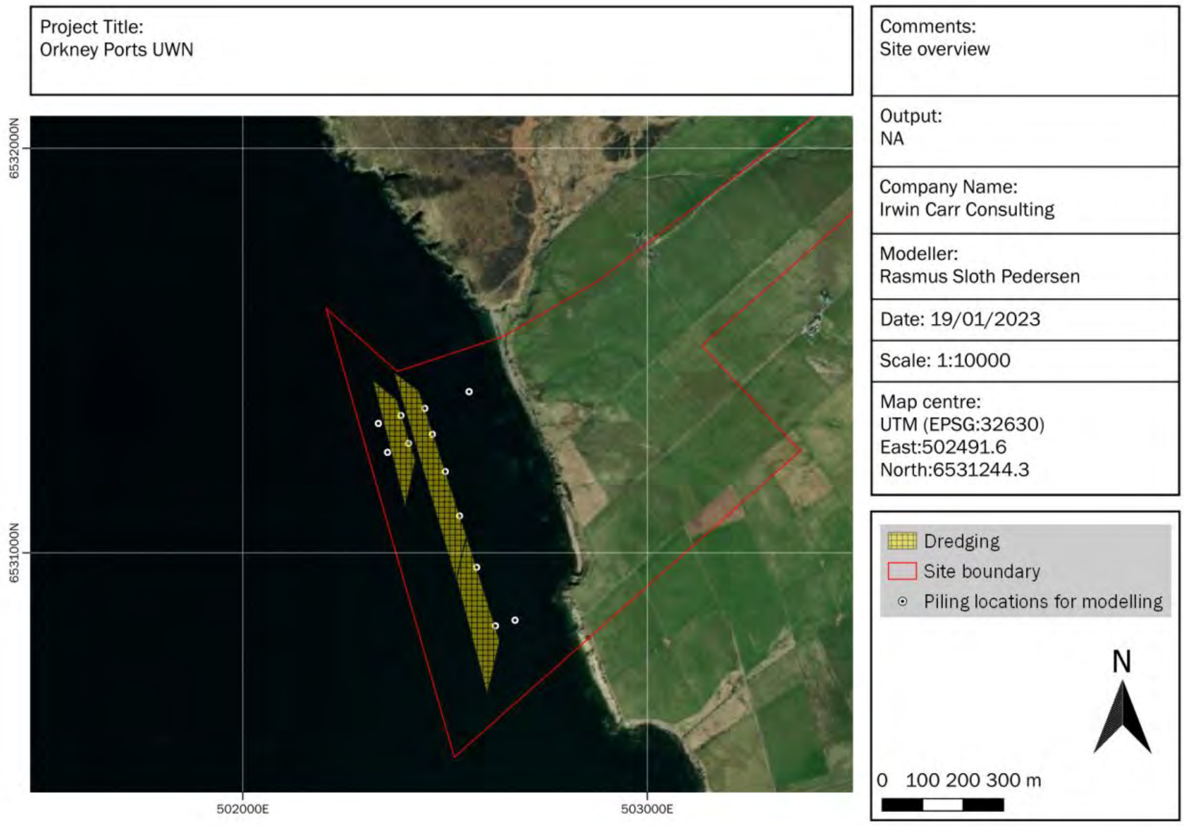


Figure 2. Overview of piling locations for modelling and approximate areas to be dredged.



2.1 Depth, Bathymetry

Depth data for the sites were collected from 3 sources:

- The proponent, detailed data near the site, 4 m resolution.
- EMODNet (European Marine Observation and Data Network, 2019), long range data, ~90 m resolution.
- Nautical charts such as http://fishing-app.gpsnauticalcharts.com, medium range data, variable resolution.

These were corrected to MSL and combined (using a mosaic method) to give the best possible total cover of the area.

For the “worst case” scenario the MHWS (Mean High Water Spring) level is used (deeper water decreases sound transmission loss).

2.2 Water properties

The water properties are important for the sound propagation. Generally the two sites have no major outflows of fresh water so salinity is expected to be near 35 psu (confirmed by (Marine Scotland, 2022)).

2.2.1 TEMPERATURE

The temperature was measured with the inbuilt thermometer of the Soundtrap hydrophone (used for on-site measurements).

Average water temperature at Scapa site during monitoring: 8.9 °C

The water columns are assumed to be well-mixed, given lack of nearby freshwater outflows, windy location, evaporation and generally shallow depths (<30 m).

2.2.2 SOUNDSPEED PROFILE

Given the water properties presented above, we assume the water soundspeed to be constant at all depths, with no significant deviations from the expected values.

The sound speed calculation is based on a widely used model for sound speed in water (Leroy, Robinson, & Goldsmith, 2008), with input of temperature, depth and salinity.

Sound speed in the water is calculated as 1486 m/s

2.3 Sediment properties

Given the project is a construction project there are sediment cores available for sediment characterisation provided by "Causeway Geotech". These give good coverage in the areas close to the Scapa DWQ. For general sediment outside the development area, we have used data from British geological survey (British Geological Survey, 2022).

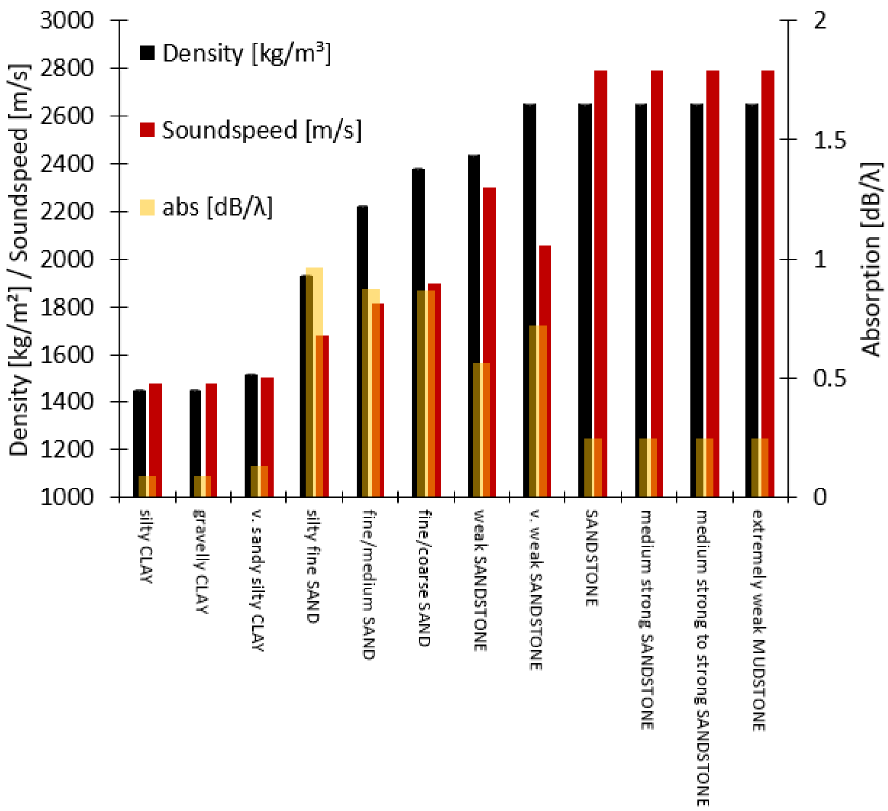
Where samples were taken we mapped the descriptions in the sediment core reports in relation to their Udden-Wentworth or Folk sediment description where these matched the nomenclature well. For other sediment types, e.g. sandstone/mudstone/limestone we have used given values for nominal "sandstone" (Jensen, Kuperman, Porter, & Schmidt, 2011; Boyce, 1981). The cores also contain classifications such as "weak sandstone" this was interpreted as loose, sandy sandstone, and we characterised this with density and soundspeed between that of sandstone and sand. This interpolation was based on an assumption that the scale "very weak-, weak-, medium weak-, sandstone" corresponds to linear interpolation between sand and sandstone (see Table 2 below). We have not changed the properties for categories indicating harder than usual sediments, such as "medium strong", "very strong".

Table 2. Example of interpolation scheme for Sand-sandstone.

Material	Interpolation value	Density [kg/m³]
Sand	0	1931
Very weak sandstone	0.25	2111
Weak sandstone	0.5	2291
Medium weak sandstone	0.75	2470
Sandstone	1	2650

Where we had no direct properties (density, sound speed, absorption) for the sediment we have used a modelling approach to estimate them, following (Ainslie, 2010).

Figure 3. Sediment types. Note that absorption is read on the right vertical axis.



2.4 Background/Ambient Noise

Baseline noise monitoring was carried out on 29-30 November 2022. On both days the weather was very calm (< sea state 1) with no detectable current. The Scapa site was unexpectedly noisy with ~130 dB SPL for all measurements (unaffected by range to our vessel). There were multiple other vessels in the bay, but all far away (> 1km). The most likely source was the small oil platform stationed a few km to the south. This could have some active machinery causing the noise, indicated by the tonal components (seen as horizontal bands in spectrogram in Figure 4).

Note that ambient noise here excludes noise from nearby vessel passes, it is meant as the ambient noise with no identifiable noise sources.

Table 3. Typical background noise levels.

Site	SPL [dB]
Scapa	129.9
Hatston	107.2

Figure 4. Spectrogram of ambient noise at Scapa.

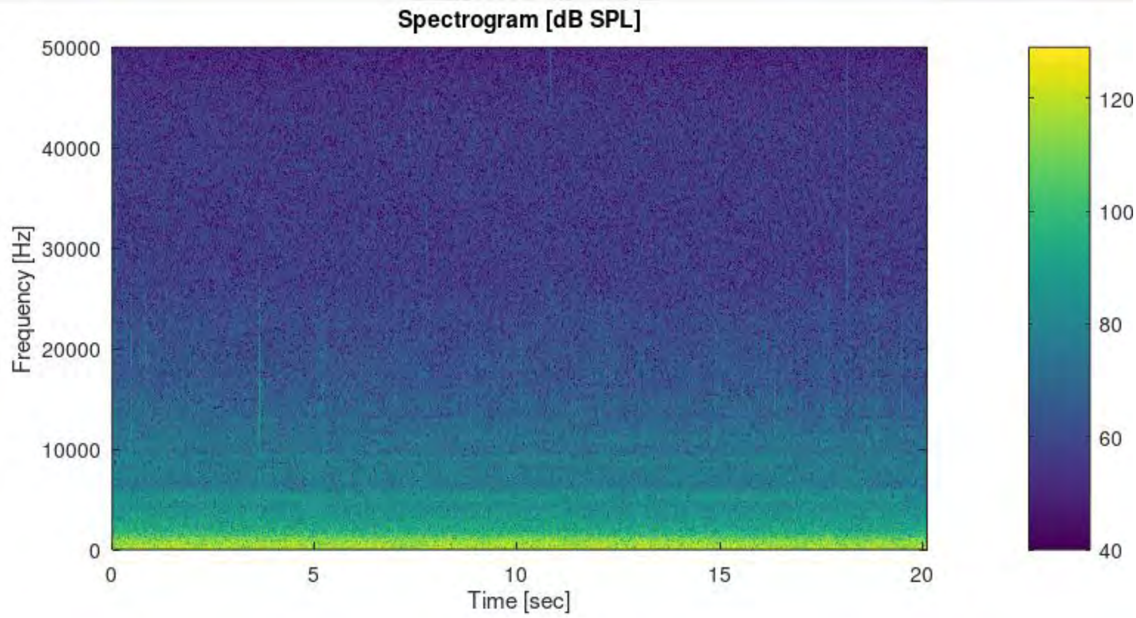


Figure 5. Spectrogram of ambient noise at Hatston.

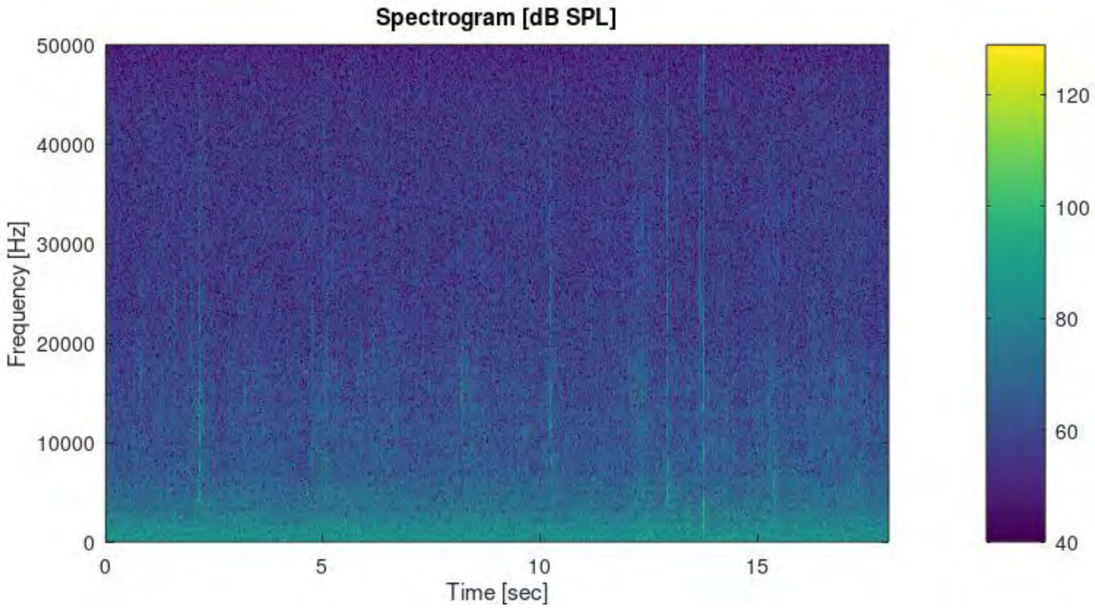
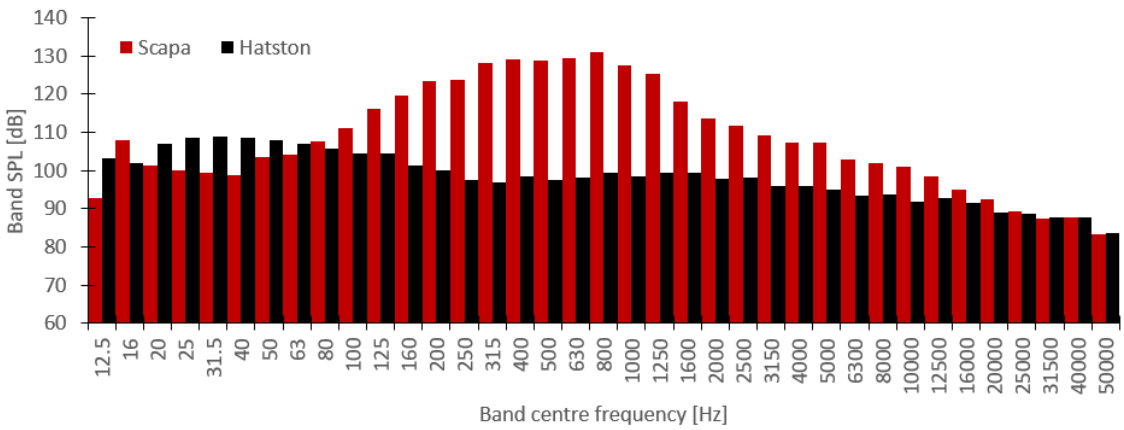


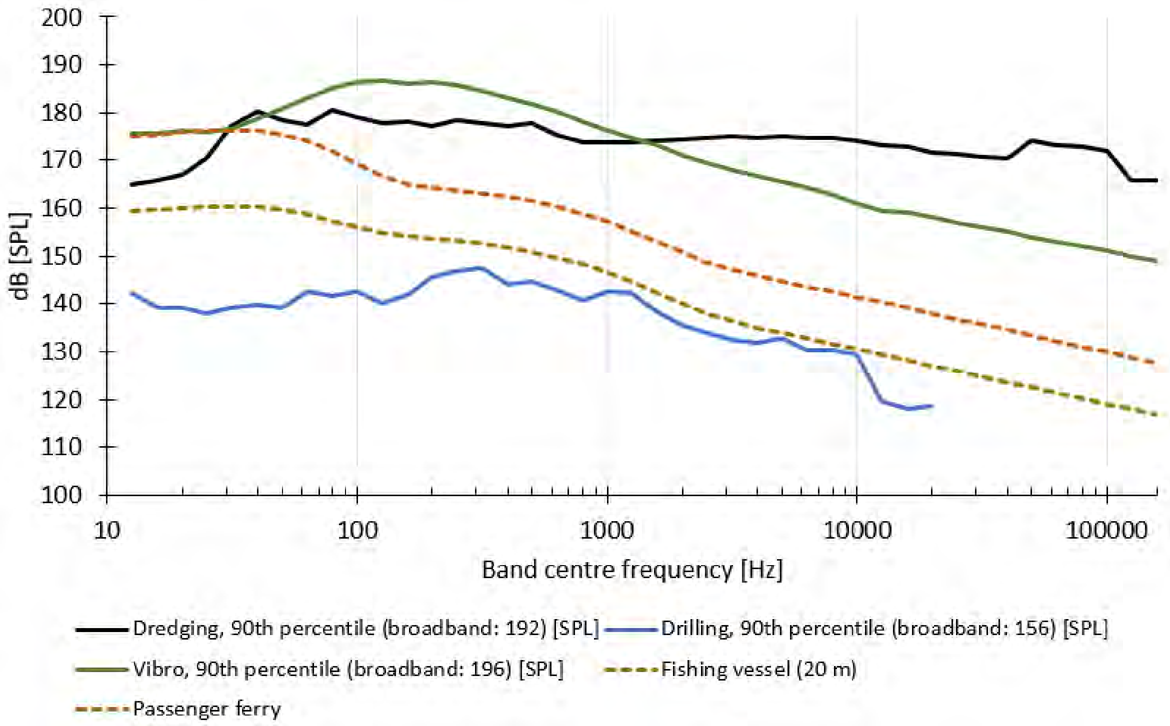
Figure 6. Typical band levels of ambient noise at Scapa and Hatston.



3 SOUND SOURCE MODELLING

We have considered three noise sources for this assessment, but have screened out the drilling as it is not loud enough to meaningfully assess in an environment with many vessels and general human activity (compare with vessel noise in Figure 7, below).

Figure 7. The three sound sources considered in this report. A fishing boat and a small ferry has been added for context.

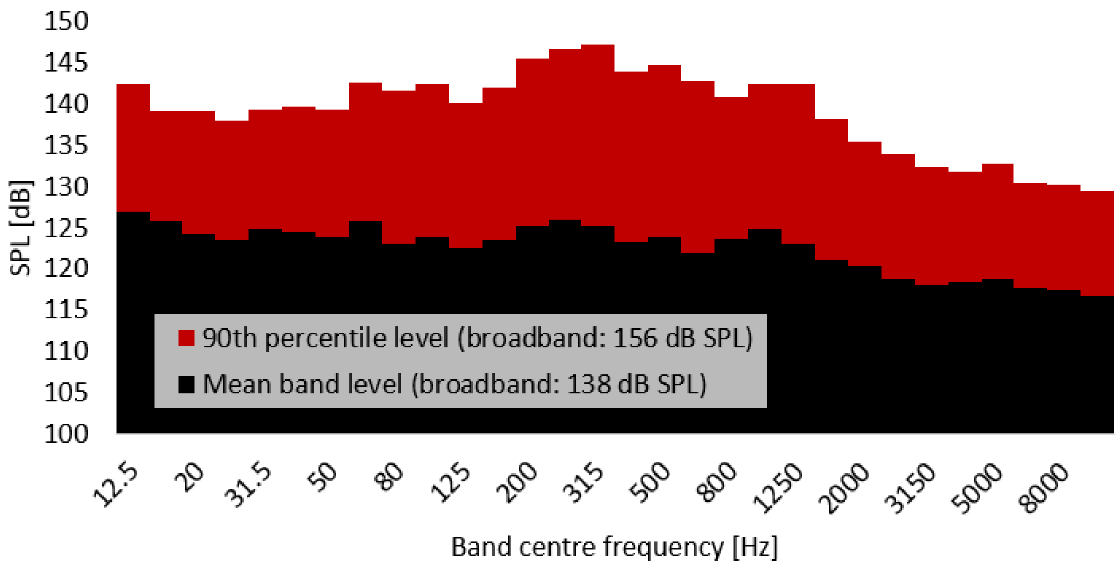


3.1 Drilling

As some hard sediment is expected round piles might be placed in pre-drilled holes, based on the range of noise levels presented in Figure 8, the drilling noise is assumed to be insignificant to the marine life.

The measured levels presented are a summary of 13 different recorded drilling episodes shows noise levels to vary considerably between sites and equipment, and there is no clear connection between drill size, power or sediment type to the emitted noise level. However, given the modest broadband level of even the 90th percentile level (156 dB SPL) this noise source can be ignored.

Figure 8. Example of drilling noise band levels. Data from various drills, diameter 0.1-1.2 m and various rock types.



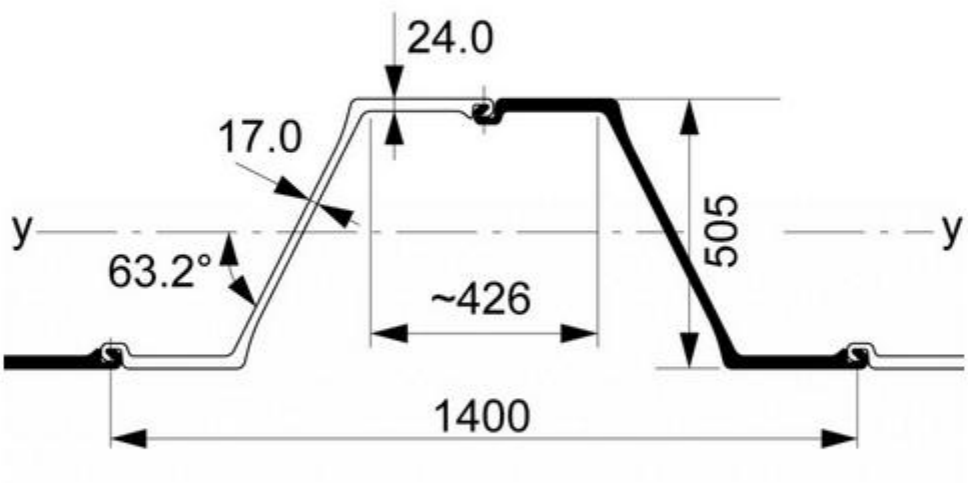
3.2 Vibration Piling Model

Two types of piles are expected to be used:

1. Tubular piles, expected to have a diameter of 2.1 m
2. Sheet piles (Arcelor Mittal AZ52-700[3]).

Both will be vibrated into the sediment or into holes left by the drilling campaign.

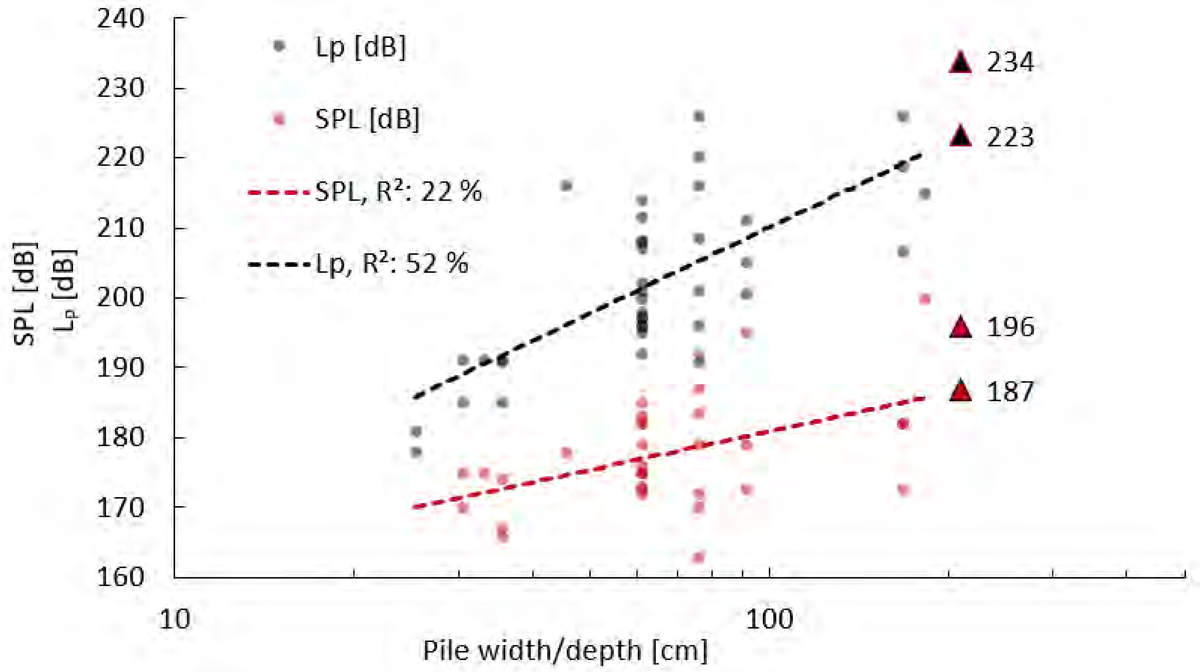
Figure 9. Schematic of the sheet piles.



The diameter of the tubular pile (210 cm) is used a basis for an empirical model based on 50 recorded levels as from CalTrans (CalTrans, 2015).

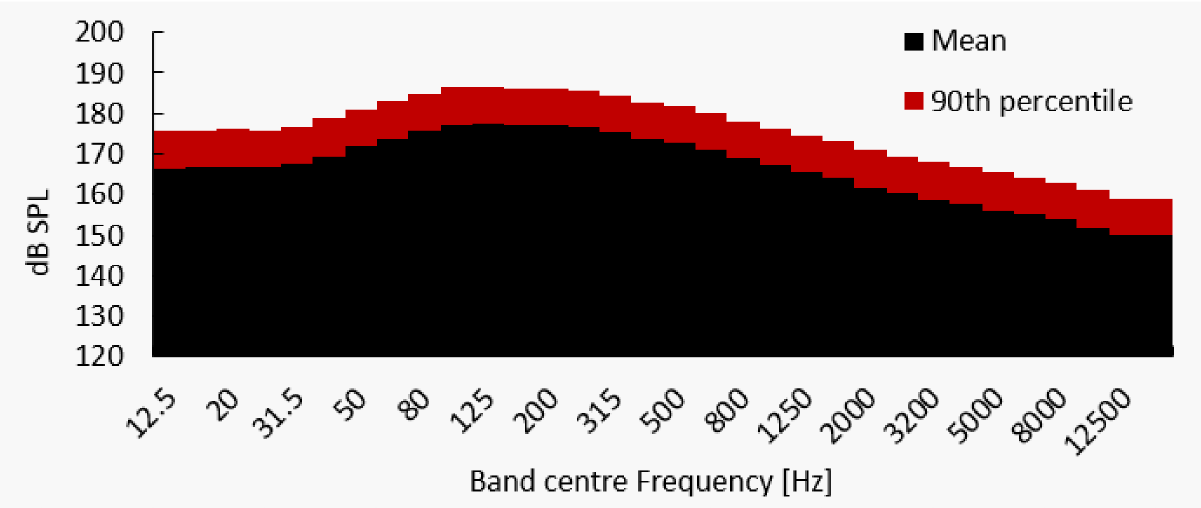
[3] https://sheetpiling.arcelormittal.com/products/az-52-700/

Figure 10. Basis of vibro piling broad band source level as a function of pile size (210 cm diameter).



Given the low confidence we have in this approach (low R^2 values) we use the 90th percentile level as the broadband source level. L_P is estimated to be 234 dB and SPL 196 dB. The frequency content is assumed to be identical to that of the impact piling.

Figure 11. Band levels for vibro-piling.



3.3 Dredging

Dredging is done to chart Datum -15 metres, meaning this will likely be done with a cutter suction dredger (Max reach 15 m) and possible assistance from a backhoe dredger. For the cutter suction dredger a cutter power of 540 kW is assumed, equivalent to the Boskalis "Seine"[4] cutter suction dredger. For cumulative modelling it's assumed that the dredging is potentially active 24 hours per day. The Backhoe dredging is quieter and has been ignored in favour of using the louder method for the assessment.

[4] https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwibnqWF-sH8AhUQg1wKHfYmBVoQFnoECB8QAQ&url=https%3A%2F%2Fboskalis.com%2Fmedia%2Fqbjnfdlv%2Fseine_cutter_suction_dredger.pdf&usg=AOvVaw1bBD75xRPcFc3H0TUXTFkD

Figure 12. Approximate extent of dredging campaign (yellow hatched area).

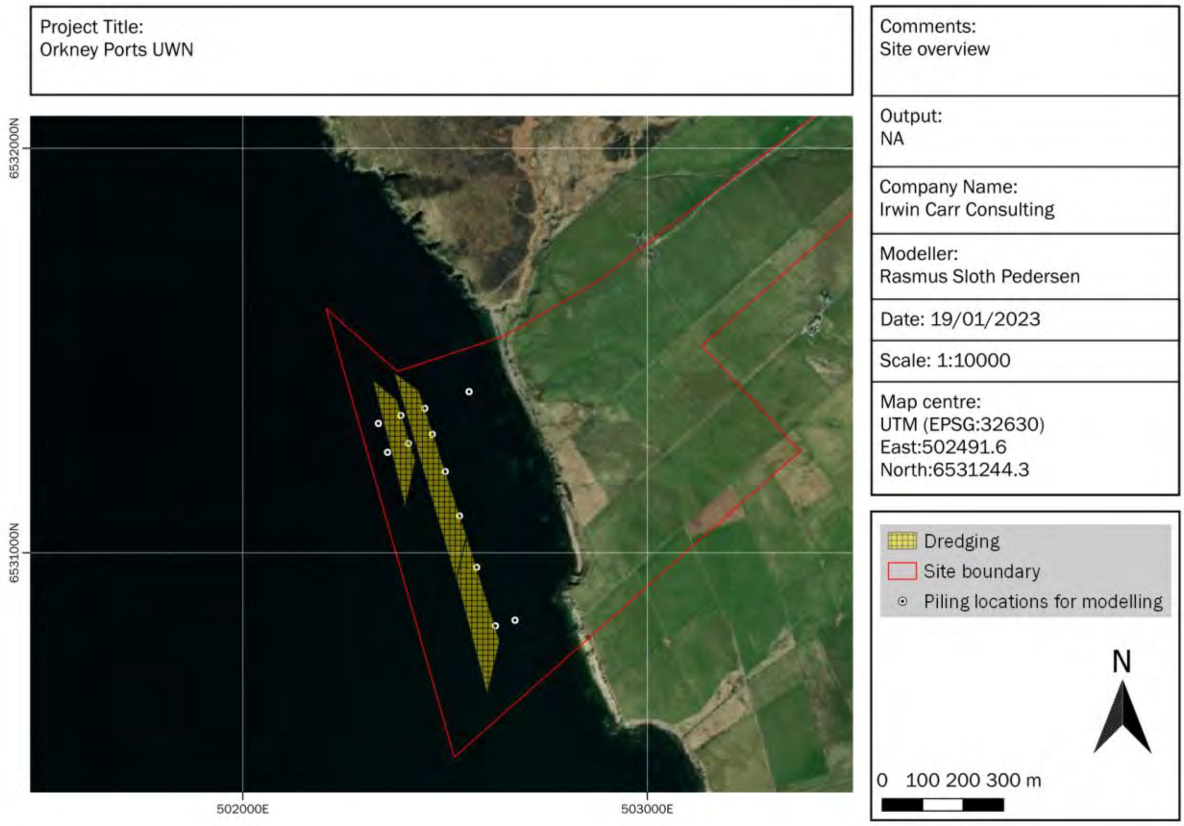
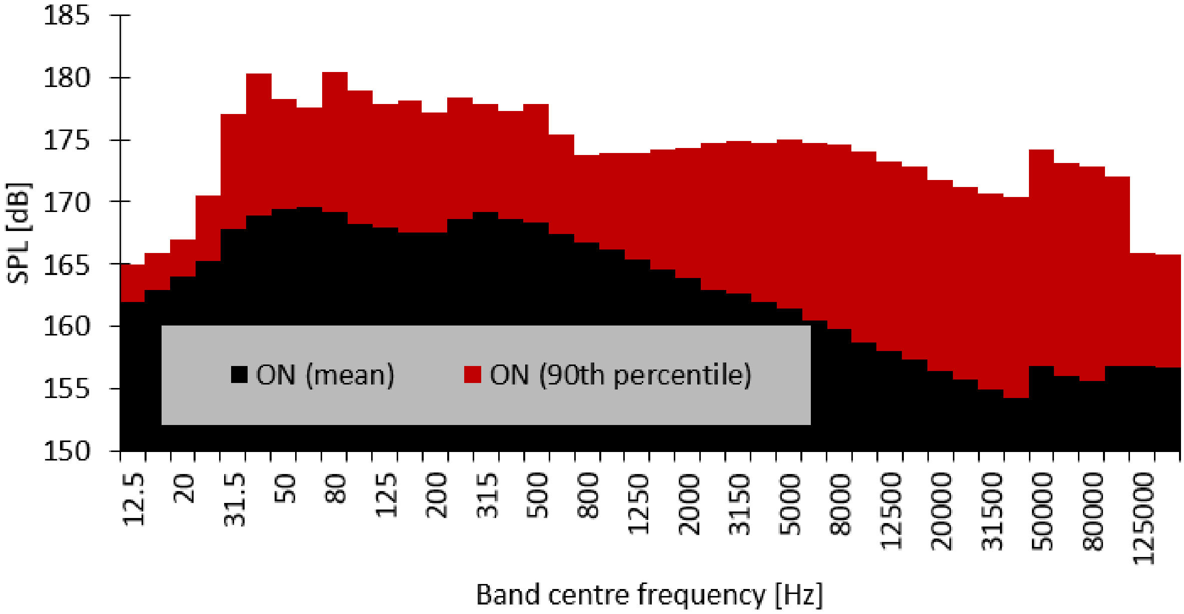


Figure 13. Band levels as modelled for a 540 kW cutter suction dredger with coarse sediment. "ON" refers to active dredging.



4 TRANSMISSION LOSS MODELLING

Transmission loss modelling is done using dBSea underwater noise modelling software.

This software is partially developed by us and can model frequencies from 10 Hz to 168 kHz, normally as 3rd octave bands, but any logarithmic band-spacing can be used. All solvers are range dependent (meaning all conditions can change with range not just depth).

Further details of this modelling software package can be found in APPENDIX A - dBSea.

The sound sources from section 3, Sound Source Modelling, p. 14, was used sources for the model, both as band levels when modelling energy transmission losses (L_E, SPL) and as timeseries/impulse for modelling peak pressure (L_P).

Previous to this assessment measurements of the actual transmission loss for the two sites were measured along two transects for each site. The modelling has been calibrated to match the measurements of these recordings (details in APPENDIX D – MODEL CALIBRATION).

The measurements show a broadband transmission loss consistent with ~12 × Log_{10}(range) at Scapa. However, these are frequency specific, and these losses are not consistent across all frequencies. We have matched the frequency-wise transmission losses to the extend that they are less than 20 × Log_{10}(range) as we find it unlikely that a transmission loss, even for higher frequencies, of > 20 × Log_{10}(range) is sufficiently representative for the site as a whole.

5 ASSESSMENT CRITERIA

5.1 Reporting units

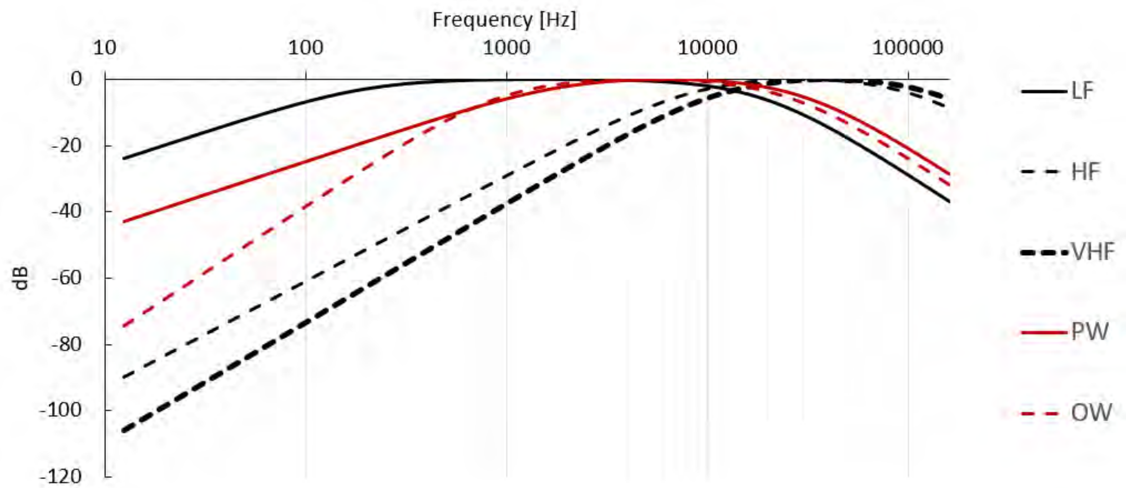
See 1.1.5, p. 8 for definitions.

5.2 Weighting of Noise Levels

When not reporting L_p or $L_{p\text{-}p}$ levels, the noise levels are often weighted according to a generalised hearing sensitivity profile for up to ten different hearing groups. This is done to better reflect the actual impact on the species in question, much like dB(C) level unit for humans.

See Table 4, for full group names and limits.

Figure 14. Weightings for various hearing groups. For L_E levels, the weightings are applied to the noise level to give the weighted noise level (similar to dB(A) or dB(C)-weighted noise for humans).



5.2.1 MARINE MAMMAL WEIGHTINGS

For the marine/aquatic mammals present we will adhere to the thresholds described in “Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing” (National Marine Fisheries Service, 2018), which determines impact from an assessment of area wherein the noise will induce either

"Temporary Threshold Shift" (TTS) or "Permanent Threshold Shift" (PTS)[5] as judged by the weighted SEL level ($L_{E\text{-}24}$) over a typical 24-hour period or by L_P levels, for the different hearing groups.

Please note that the Southall 2019 thresholds and weightings are identical to the NMFS 2018 criteria, only the nomenclature has changed (Southall, et al., 2019; National Marine Fisheries Service, 2018).

Thresholds for behavioural disruption are set by NOAA fisheries[6]. These are 120 dB RMS[7] for continuous noise and 160 dB SPL[8] for impulsive noise.

The hearing groups from the Southall 2019 and the NMFS 2018 guidance were specified by collating available information on marine mammal hearing and generalising their hearing sensitivity into representative groups. This grouping represents a significant research effort and are reviewed by the leading experts (academic, industrial and conservation) on the topic. Because of the large amount of work this represents and the widespread acceptance of the method, the thresholds and the methodology associated, have become de-facto standards for assessing noise impact on marine mammals and represents best available knowledge and practise.

Along with weighting curves, similar in function to the human dB(C) curves, a set of thresholds for hearing impact and injury is associated with the framework and allows for conversion of threshold exceedance into ranges with risk of impact. E.g. we might see that the PW group (true seals) has a risk of PTS at ranges shorter than 50 meters, and a risk of TTS at ranges shorter than 200 meters.

All marine mammal species are covered by the hearing groups and a full list of species in the different groups can be found in the "Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects" (Southall, et al., 2019), but in general the groups cover the following species:

Table 4. Summary of Southall 2019 thresholds and groups with species examples. For full species list see source (National Marine Fisheries Service, 2018; Southall, et al., 2019)

Hearing group	Species examples	Non-impulsive TTS/PTS threshold [$L_{E\text{-}24\ hours}$]	Impulsive TTS/PTS threshold [$L_{E\text{-}24\ hours}$]	Impulsive TTS/PTS threshold [L_p]
PW	Harbour seal, Grey seal	181/201	170/185	212/218
OW	Otters	199/219	188/203	226/232
LF	Minke whale, Humpback whale	179/199	168/183	213/219
HF	Sperm whale, Common dolphin, Bottlenose dolphin, Killer whale, Risso's dolphin, Pilot whales	178/198	170/185	224/230
VHF	Porpoise	153/173	140/155	196/202

It's important to note that the assessment is thus based on the received level of receptors with the above-described auditory sensitivity and not based on the sensitivity of the individual species.

[5] TTS/PTS. A temporary/permanent change in hearing sensitivity caused by acoustic stimuli.

[6] Available from: https://archive.fisheries.noaa.gov/wcr/protected_species/marine_mammals/threshold_guidance.html

[7] Here taken as meaning "SPL"

[8] Assumed to be SPL of 90 % of energy in one impulse or SPL of total duration (L_{EQ}).

5.3 Fishes etc.

Impacts of noise on fishes is less well established than for marine mammals, but a review from 2014 (Popper, et al., 2014) provides guidelines on exposure limits for fish and turtles. The report does not directly use the PTS nomenclature (as above for mammals) as many fish have the capacity to repair structural damage to their ear, and even structural damage then cannot be said to be "permanent".

We use "PTS" here to cover the categories "Mortality and potential mortal injury" and "Recoverable injury".

Note that we use the impulsive limits from piling for all impulsive sources as the information for explosions is rather less well documented (and limits are significantly higher).

TTS is directly used in the report, and we use it in the same way here.

As there are no TTS/PTS limits for non-impulsive noise, we apply the limits for cumulative impulsive noise.

Table 5. Overview of Impact piling thresholds from (Popper, et al., 2014) (Table 7.3). We use these for all impulsive noise, even though explosions have separate thresholds (Table 7.2 in report)).

Hearing group	Species examples	Impulsive TTS/PTS threshold [$L_{E\text{-}24\ hours}$]	Impulsive TTS/PTS threshold [L_p]
P* (Fish with no swim bladder)	Sharks, Rays	186/216	TTS not specified/213
P- (Fish with swim-bladder, but not involved in hearing)	Salmon, Trout, Cod, Herring	186/203	TTS not specified/207
P+ (swim-bladder used in hearing)	Carp, Catfish	186/203	TTS not specified/207

5.4 Threshold Interpretation

5.4.1 THRESHOLD TYPES

The three threshold types refer to different ways that sound can affect the hearing of an animal and are ***important to keep in mind*** when evaluating the results of this report:

5.4.1.1 Non-impulsive, $L_{E\text{-}24\ hours}$

The threshold, over which an effect (TTS/PTS) occurs, taking into account ***continuous***[9] sound received by the animal over a typical 24-hour period as sound exposure, L_E.

When presented as a zone on a map, this refers to the area, within which, an animal would suffer the effect, if it stayed there for 24 hours (or the full duration of the activity or as otherwise specified). We thus identify areas given by this limit as areas of TTS-**risk** or PTS-**risk** respectively, i.e., an animal within the area has a risk of suffering from either TTS or PTS within the zone. Alternatively this can be thought of as the total sound-dose limit over 24 hours.

Weightings are applied for non-impulsive L_E (for mammals only[10]).

5.4.1.2 Impulsive, $L_{E\text{-}24\ hours}$

The threshold, over which an effect (TTS/PTS) occurs, taking into account ***impulsive*** sound received by the animal over a typical 24-hour period as sound exposure, L_E.

[9] Please see (National Marine Fisheries Service, 2018) for definitions of "non-impulsive" and "impulsive". For quick reference, if a sound is shorter than 1 second and is clearly intermittent in nature, it is impulsive – otherwise, it's continuous.

[10] When assessing for fish groups levels are not weighted.

When presented as a zone on a map, this refers to the area, within which, an animal would suffer the effect, if it stayed there for 24 hours (or the full duration of the activity or as otherwise specified). We thus identify areas given by this limit as areas of TTS-**risk** or PTS-**risk** respectively, i.e., an animal within the area has a risk of suffering from either TTS or PTS within this zone.
Alternatively this can be thought of as the total sound-dose limit over 24 hours.

5.4.1.2.1 Impulsive $L_{E\ \text{single impulse}}$ / $L_{E\ \#\ \text{impulses}}$

It is sometimes useful to assess the impact of a single/a number of impulse(s). When we do this, we will refer to it as "LE single impulse / LE # impulses".
Like for the Lp, when single-impulse LE is presented as an impact zone, this refers to the area, within which, an animal would suffer the effect acutely/instantly.

Weightings are applied for Impulsive L_E (for mammals only).

5.4.1.3 Impulsive, L_p

The threshold over which an effect (TTS/PTS) occurs, taking into account ***impulsive*** sound received by the animal at any instant as maximal peak pressure.
When presented as a zone on a map, this refers to the area, within which, an animal would suffer the effect acutely/instantly and from just one exposure.
Weightings are ***not*** applied for Impulsive L_P.

5.4.2 MASKING

Levels that are not over threshold can still cause significant impact, if that noise makes foraging, navigation or communication harder due to masking or where biologically relevant sounds are "drowned out" by the anthropogenic noise. Continuous noise is more likely than impulsive noise to cause this form of impact.

5.4.3 DISPERSAL

Many animals can recognise sounds and might be dispersed from an area at noise levels well below TTS limits. Quantifying a level of dispersal from desk-spaced studies is very challenging and not done here.

6 CONCLUSION & RESULTS SUMMARY

Dredging

The noise from dredging, while presenting a significant PTS risk to ranges >500 m for the VHF group, this is only for animals staying close to the activity for extended periods (> 1 hour) and assumes continuous dredging with the dredger level as given by the 90th percentile. For the best estimate (model mean) the PTS risk range is 450 m after 8 hours exposure. There is no acute risk of noise related injury related to the dredging, and animals have time to swim away. Further the area ensonified does not "block" access through a channel or strait.

There is no issue identified for species outside the VHF range.

Vibro piling

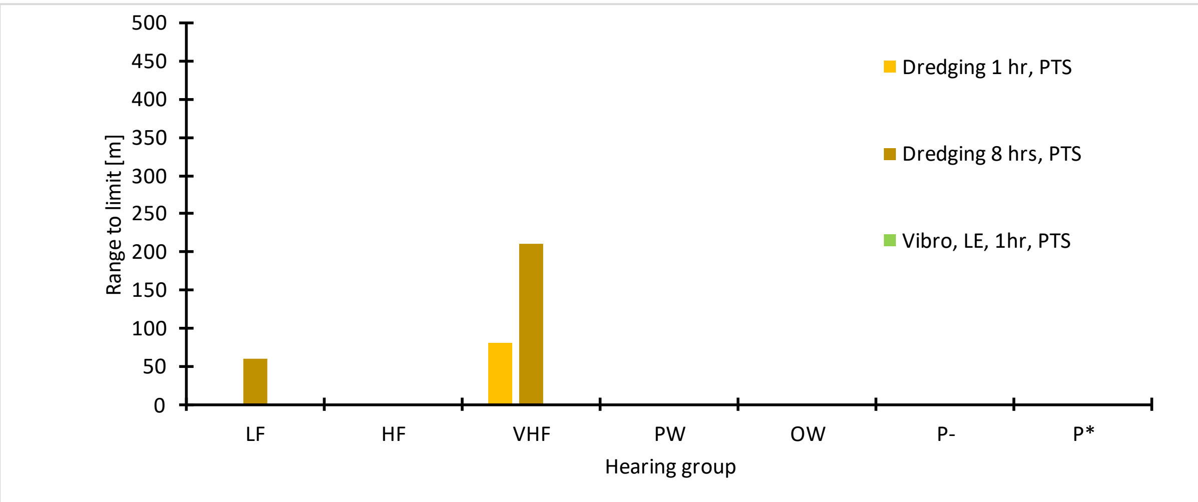
Prolonged exposure to vibro piling at close range (<100 m) carries some auditory risk for the animals assessed, specifically groups LF, VHF and P- (baleen whales, porpoises and salmon/trout), where the peak pressures in the noise have risk ranges up to 300 m for the VHF group. We therefore suggest surveillance takes place prior to piling to minimise the risk of impact on porpoises. While this is a significant risk for animals close to the activity, we stress that we have used a very conservative approach to estimating the source levels, and the realised emission will likely be significantly lower.

Further, animals will tend to move around, or away from noise, which will limit exposure. In Figure 16 and Figure 18 we show an example of the effect of using moving receivers (animats, modelled animals) to estimate what might be the effect of movement.

Table 6. Overview of maximal ranges to limits [m].

Activity	Dredging				Vibro piling			
Dose	1 hr L_E		8 hrs L_E		1 hr L_E		Peak pressure L_P	
Hearing group	TTS	PTS	TTS	PTS	TTS	PTS	TTS	PTS
LF	230	<50	1250	60	760	<50	<50	<50
HF	60	<50	160	<50	<50	<50	<50	<50
VHF	620	80	1350	210	180	<50	550	300
PW	70	<50	250	<50	100	<50	100	<50
OW	<50	<50	<50	<50	<50	<50	<50	<50
P-	120	<50	600	<50	390	<50	<50	125
P*	120	<50	600	<50	390	<50	<50	<50

Figure 15. Overview of PTS risk ranges



7 RESULTS

The noise maps for each activity and hearing group are presented in APPENDIX E – Results.

7.1 Dredging

While exposure to 8 hours of dredging has significant PTS risk ranges (< 210 m) for 2 hearing groups: LF (baleen whales) and VHF (porpoises), but only after prolonged exposure (> 1 hour). The relatively low (compared to limits) source level of the dredging means that there is not acute risk from noise and animals have time to swim away.

Using a model approach to have moving receivers (animats, see Figure 18, p. 24) we can estimate the impact on moving animals. The animats in the model move 0.5-4 m/s depending on the received level and evade levels >120 dB.

Figure 16. Summary of total exposure (L_E) of 225 animats of the VHF group in the soundfield of the dredging. 44 exceeded TTS limit (20 %), none exceeded the PTS limit.

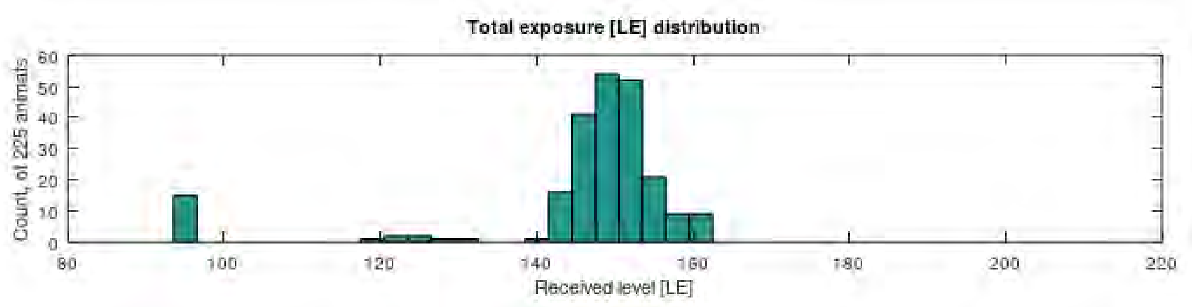


Figure 17. TTS and PTS risk ranges for all groups.

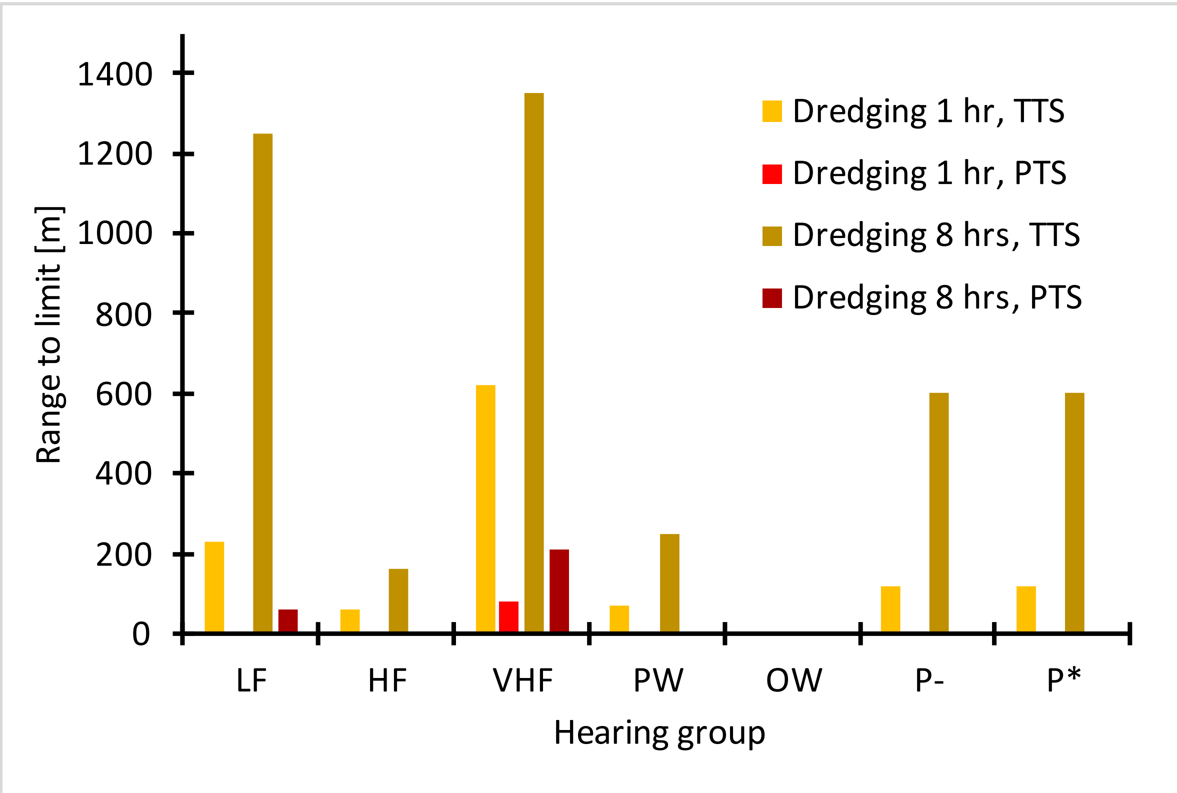
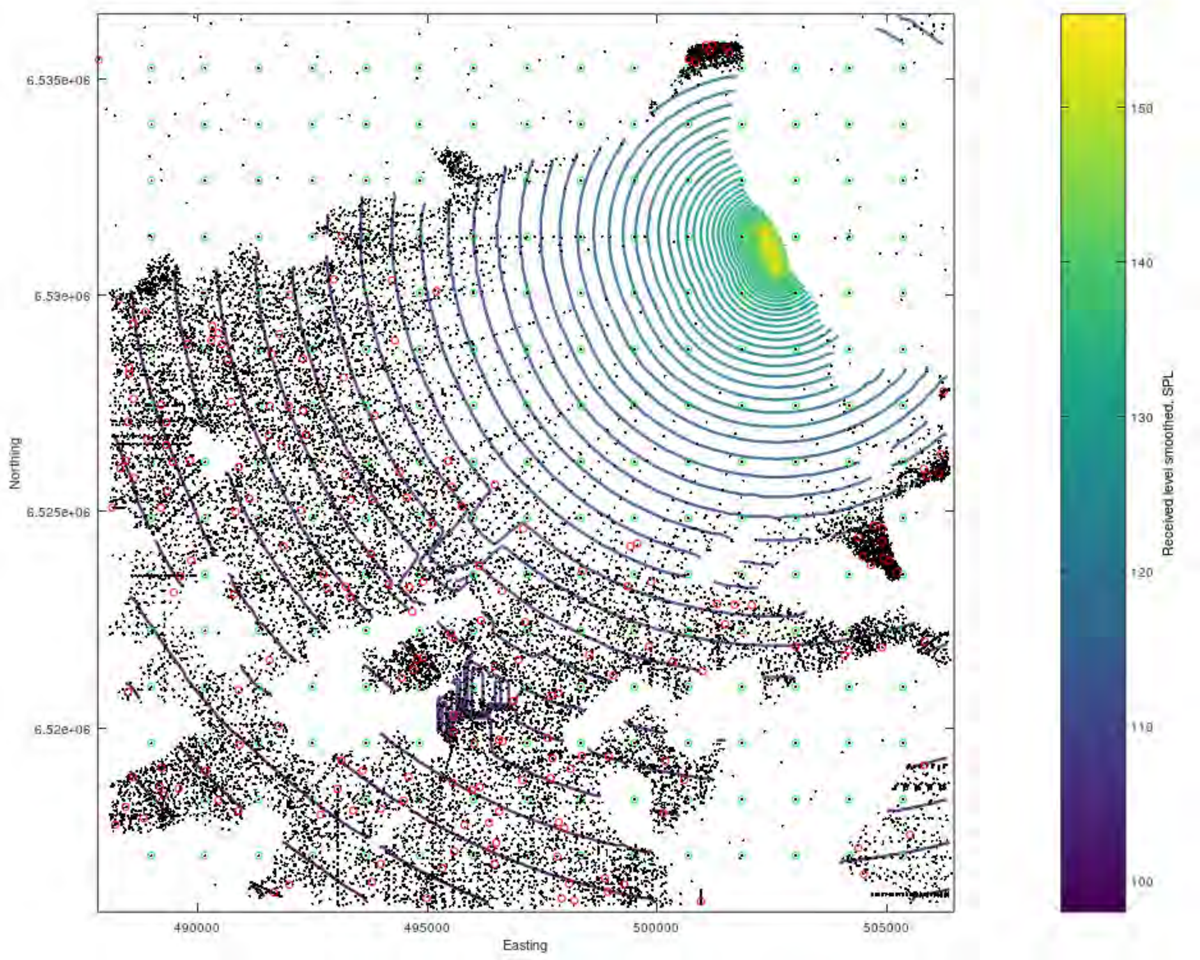


Figure 18. 225 “animats” in the dredger soundfield for 8 hours. Green spots are starting points, and red spots end points. Area covers Scapa Flow.a



7.2 Vibro piling

Longer exposures (> 1 hour) lead to significant PTS risk zones within 50 for all groups, but the proposed duration of vibro piling on this site is less than 1-hour per day.

The peak pressures in the vibro piling have a PTS risk zone max range of 50m. While the risk for the LF and P- groups is only for prolonged exposure, the risk to the VHF group is acute, i.e. the animal has no chance to swim away to avoid the risk.

Figure 19. TTS and PTS risk ranges for all groups.

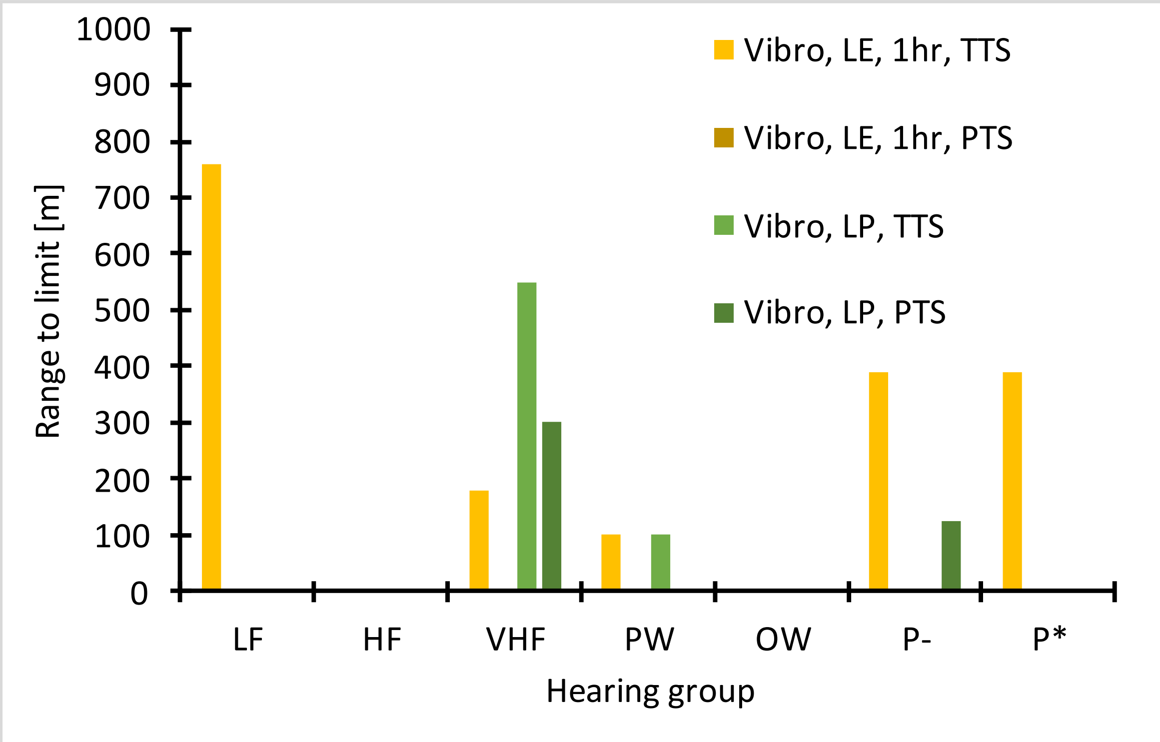
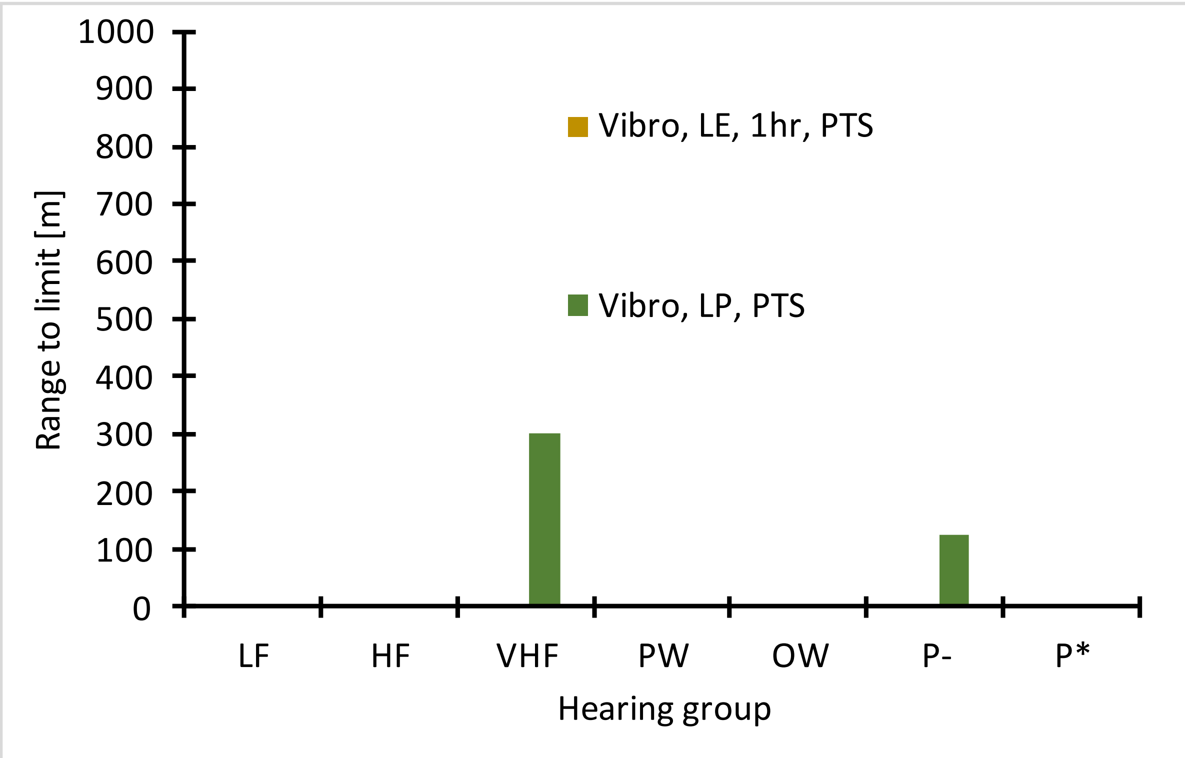


Figure 20. PTS risk ranges for all hearing groups.



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

APPENDIX A - DBSEA

A summary of dBSea's models in standard scenarios can be found in the document (online):
http://www.dbsea.co.uk/media/30782/dBSea-Benchmark-Testing.pdf
(also see Figure 23, p. 29 for one example).

All solvers in dBSea are based on Jensen et al. 2011 (Jensen, Kuperman, Porter, & Schmidt, 2011)

dBSea has four primary models of calculation:

- **Range dependent Parabolic Equation model - dBSeaPE**
  dBSeaPE uses a split-step, wide angle parabolic equation method. It uses either Greene's approximation or several Padé terms (as set by user) to get very wide propagation with low phase error.

  dBSeaPE is best suited to deeper scenarios (>50 m) or where sediment interaction is not dominant relative to sound speed profile. The model is very efficient for low frequencies and only suffers a small efficiency penalty for higher frequencies.

  dBSeaPE will generally be used for deeper/long range scenarios in the frequency interval 10-1000 Hz.
- **Range dependent Normal Modes model - dBSeaModes**
  dBSeaModes is especially suited to shallower and sediment dependent scenarios and will typically be used where water is shallower than 50 m and depth changes are a large proportion of the total depth, or where sediment effects are thought to play a significant role. dBSeaModes incurs a significant efficiency-penalty at high frequencies and will normally be used in the frequency range 10-1000 Hz.
- **Ray tracing**
  dBSea uses a Gaussian raytracing method, dBSeaRay, to calculate transmission losses for higher frequencies (scenario dependent, but normally from 500 Hz). dBSeaRay compares favourably with the opensource BELLHOP model, in that it is accurate to lower frequencies and agrees well with PE and NM models.
- **Full waveform propagation**
  dBSeaRay also supports full waveform propagation in the frequency range 10 Hz to 168 kHz (limited by the waveform sample rate). Used in this way dBSeaRay takes into account all scenario range dependence (as models above) as well as the arrival time, phase information and transmission loss of all significant paths to any number of receivers in the scenario (the results grid).

General notes:

- dBSea is an "Nx2D" solver, meaning it models transmission losses in "N" number of vertical radial slices from the source (Figure 22, p. 28). There is no backwards propagation towards the source, and no sideways reflection/refraction (We're testing dBSea with full 3D solvers currently).

- dBSea models the sediment propagation only for compressional waves, not for shear waves. This generally means that the transmission loss will be slightly underestimated as no energy is transferred into shear waves, and also means that dBSeaRay does not propagate into the sediment, but relies on a complex reflection coefficient (calculated from the sediment layers) to calculate the reflection/refraction properties of the sediment. Given that dBSeaRay is generally only used for higher frequencies, this has very little practical effect, as higher frequencies will only interact weakly with deeper layers of the sediment.

- The individual sources in a scenario are modelled radially (radial coordinates) from the source at several depths. In post-processing levels are transferred to a cartesian "results grid". This results grid stores levels from all sources so that the cumulative level at any point in the scenario can be investigated immediately.

- Levels can be, and are often post-processed to apply a conservative margin and smooth results (Figure 21, p. 28). Radial smoothing (triangular kernel of variable width) is carried out to mitigate modelling artefacts arising from low environment sampling density or chance occurrences. Levels are often made to decrease monotonically from the source to make general trends more visible and decrease the risk of misinterpreting impact ranges.

- When refereeing to a level at a certain range, this usually refers to the greatest level at any depth at that range (unless specifically mentioned otherwise).

Figure 21. Post-processing to eliminate artefacts and ease interpretation. Level are radially smoothed by default, and are made to be monotonically decreasing with increasing range from the source.

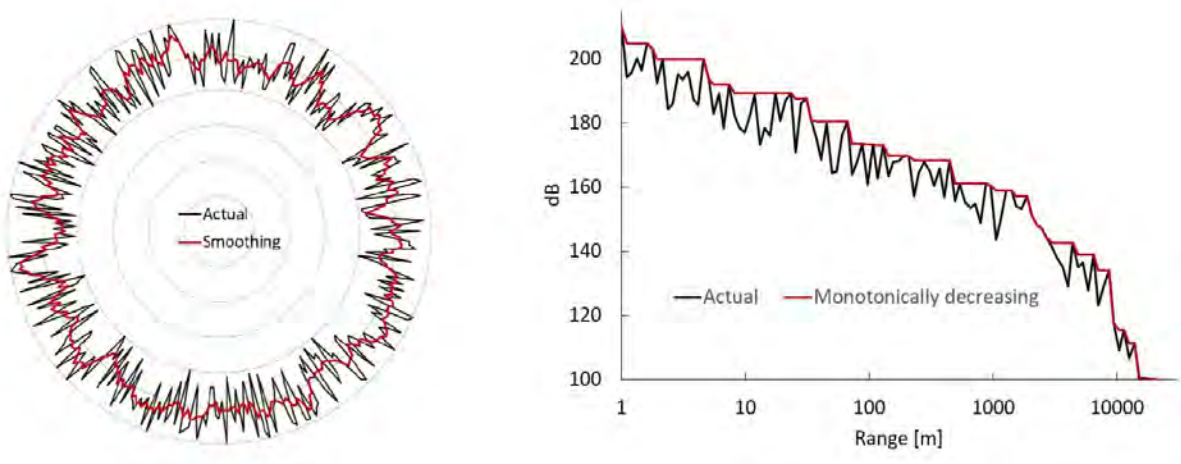


Figure 22. Low resolution schematic of the dBSea modelling space. Source transmission loss is modelled radially from the sources at a number of depths. Results are extracted from a "square" 3D grid that hold cumulative levels from all sources in the scenario.

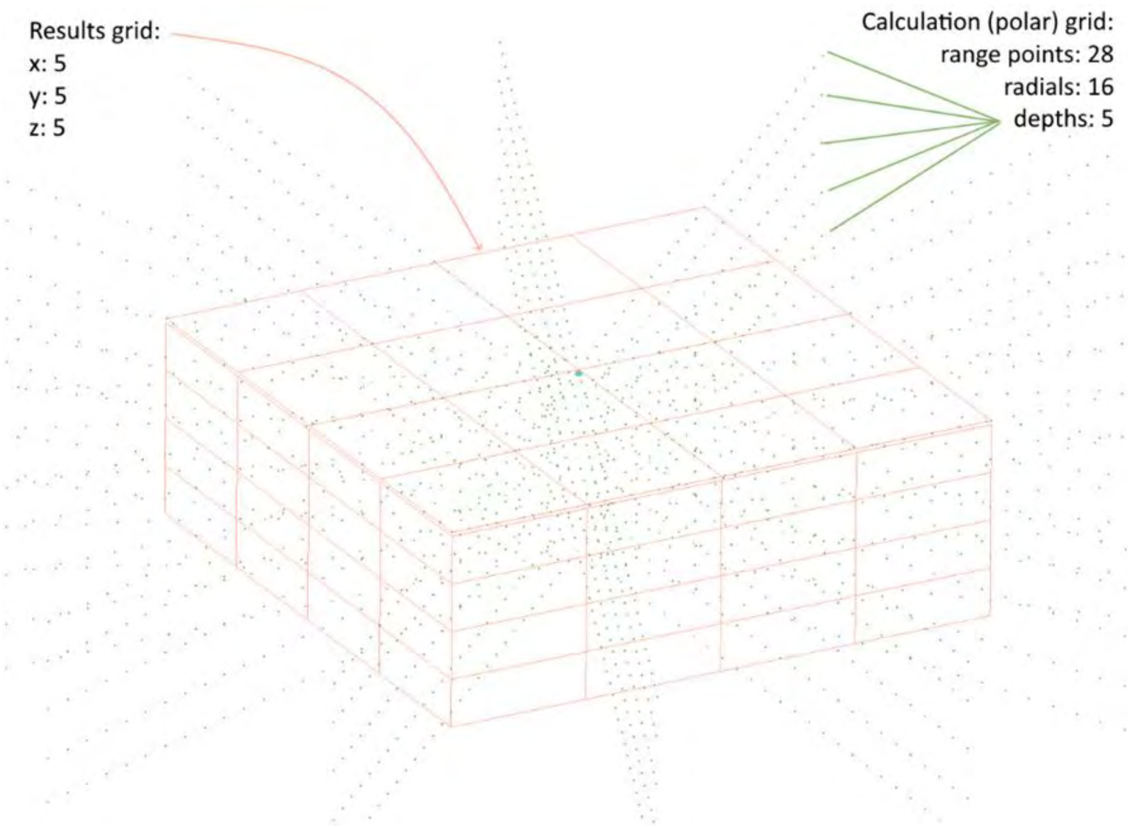
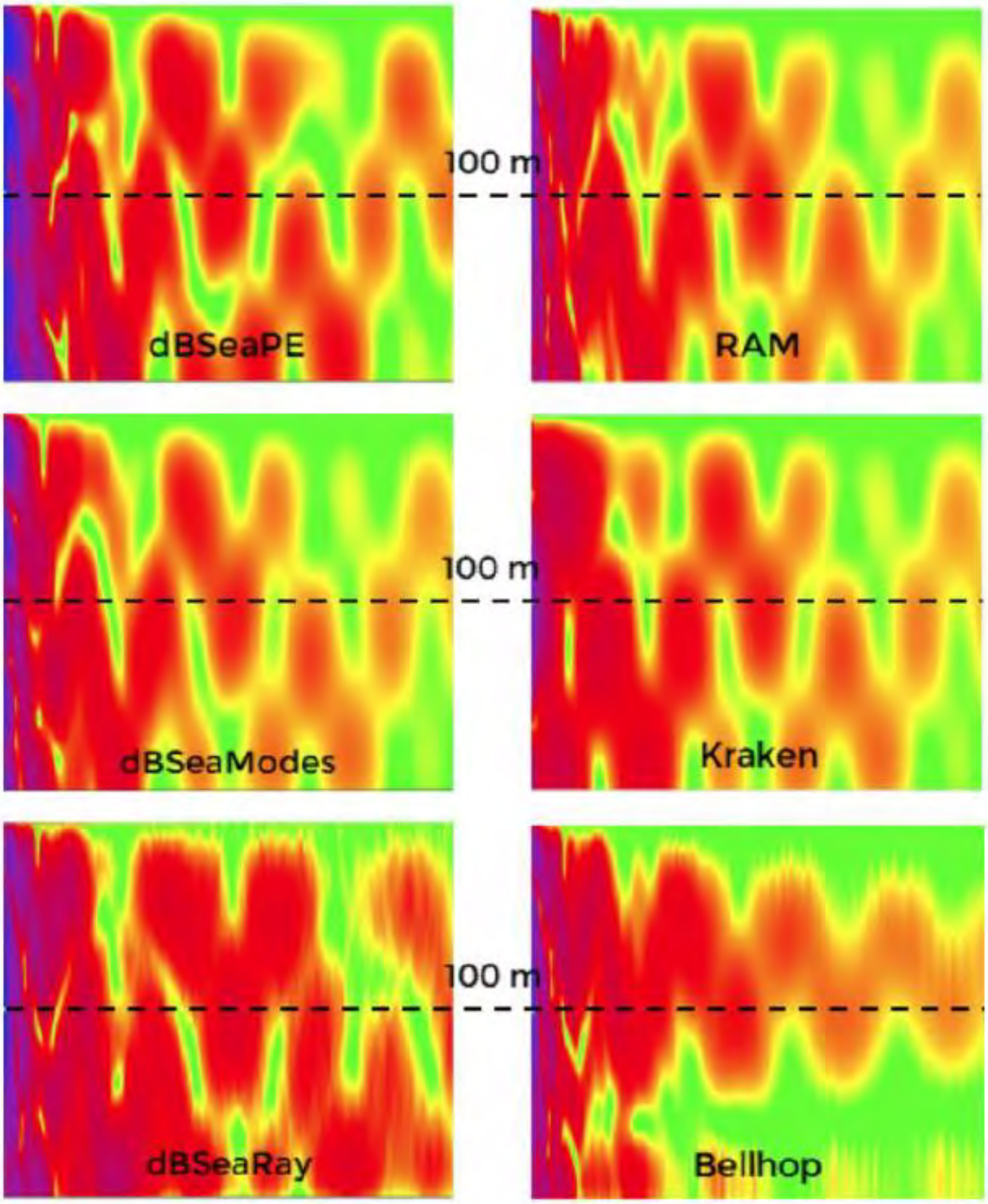


Figure 23. the “Pekeris” standard problem, a low frequency problem. Note that due to sediment effects, neither dBSeaRay nor Bellhop should be relied upon for low frequency problems, and are only include for completeness.



APPENDIX B – UNDERWATER ACOUSTICS BASICS

Sound Speed

Water is much harder to compress than air, and a soundspeed of 1500 m/s is often used as a standard soundspeed in water[11] much as 340 m/s is in air. Soundspeed is given by the following equation:

$$c = \frac{Z}{\rho}$$

$$Soundspeed\ [m/s] = \frac{Acoustic\ impedance\ \left[\frac{kg}{m^2 \cdot s}\right]}{Specific\ density\ [kg/m^3]}$$

Because changes to pressure, salinity and temperature occur with changes in depth, the specific density and acoustic impedance of water changes with depth, and thus the soundspeed changes as well.

The soundspeed profile is quite important in sound propagation, as refraction (changes in propagation angle) will occur when sound moves between layers of water with varying sound speed. This change is quantified in “Snell’s Law” and results in sound being “bent” towards the depth of minimal soundspeed. These effects can lead to profoundly inhomogeneous sound fields and SOFAR channels.

The same relationships are valid in the sediment, though sediments commonly have soundspeeds higher than water. Soundspeeds from 1700 m/s (fine sand/silt) to 2500 m/s (gravel) are common for non-solid sediments, with solid sediments (rocks) having much higher soundspeeds 2800 m/s (Calcarenite) to 6000 m/s (some granite).

Spreading loss

Most of the propagation loss (loss in dB from source to receiver, “PL”) that occurs initially is governed by “spreading loss”. It is the simple “thinning out” of acoustic energy as it spreads away from the source, usually in all directions – spherically.

For a sound source in an unbound medium the initial PL will be dominated by spherical PL:

$$Received\ level = Source\ level_{at\ reference\ range} - 20 \cdot \log_{10}\left(\frac{range}{reference\ range}\right)$$

This means a reduction in received level of 6 dB per doubling of distance and explains the rapid reduction in received levels often seen close to the source, e.g.: with a reference range of 1 m, at 16 meters range, there has been 4 doublings of distance, and thus 24 dB loss (4×6 dB).

At longer ranges the medium is no longer unbounded. We reach ranges where the sound has interacted with the surface (near perfect acoustic reflector) or the seabed (lossy acoustic reflector). Also, at greater ranges a doubling of distance is no longer trivial as the PL from spherical spreading loss from 500 m to 1000 m is also just 6 dB.

Sound Channels and Wave guides

In bounded mediums where the sound energy is confined to cylindrical spreading, the PL (ignoring absorption) is often well-characterised by:

$$Received\ level = Source\ level_{at\ reference\ range} - 10 \cdot \log_{10}\left(\frac{range}{reference\ range}\right)$$

This means a reduction of received level of 3 dB per doubling of distance. Depending on the sediment this kind of “waveguide” can sustain efficient transmission of sound over long ranges, provided the sediment is acoustically hard and there is low absorption (such as is the case for low frequencies or in low salinity).

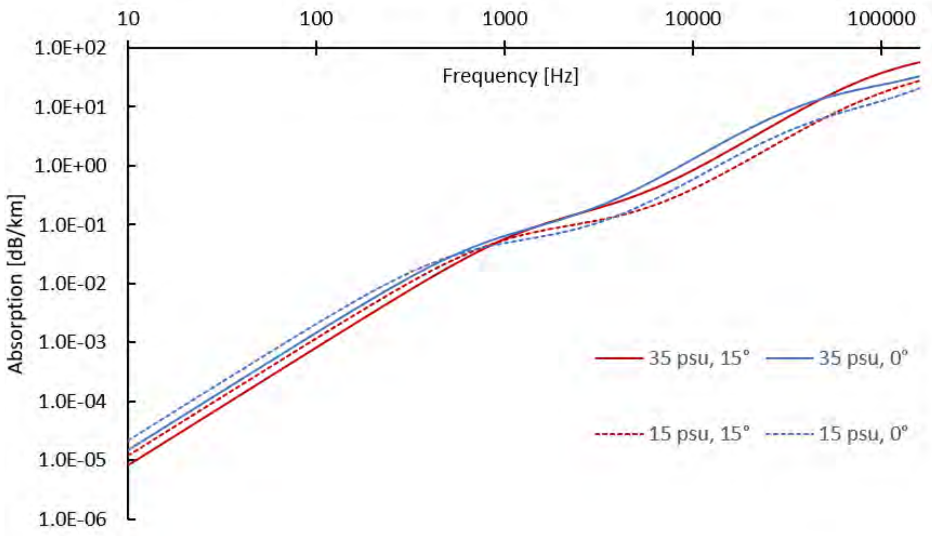
In absence of a bounding from the surface or the seabed, a soundspeed profile with a clear low-speed region, surrounded by higher soundspeeds can act a sound channel, by focusing the sound towards a single depth (with lower soundspeed), limiting the PL from spherical to cylindrical (a SOFAR channel is formed).

[11] Varies from 1450 m/s at 0° to 1550 m/s at 30° at salinity of 35 psu.

Absorption

Besides the "thinning out" of the sound energy as described above, the sound is also dissipated into heat by the way the pressure changes interact with water, molecules and particles in its path. This absorption is mostly governed by the concentration of boric acid and magnesium sulphate and is very dependent on the frequency, with lower frequencies, <1 kHz, experiencing almost no absorption, while high frequencies, > 10 kHz, can be attenuated by over 10 dB / km.

Figure 24. Absorption comparison at salinities of 35 psu & 15 psu and temperatures of 0° and 15°. Both scales are logarithmic. Note how increased salinity increases high-frequency absorption (solid v dashed lines), while a decrease in temperature increases absorption at lower frequencies (red v blue lines).



Small bubbles, wind or wave induced, will further attenuate especially the high frequencies, but as modelling is often done to estimate a worst-reasonable case, or for weather sensitive activities, fair weather with little wind and waves are assumed, thus ignoring this attenuation effect.

Sediment

Depending on the incident angle of the sound, the frequency and the acoustic properties of the sediment, sound can either mostly penetrate the sediment or mostly be reflected by it.

In shallow areas with soft sediment (acoustically similar to water), it is typical to find that close to the source, at high incidence angles and at low frequencies (<250 Hz) the sound will penetrate into the sediment and dissipate there, leading to very high transmission losses for these frequencies. This effect coupled with the high absorption at high frequencies often leads to the soundscape being dominated by frequencies from a few hundred hertz to a few thousand hertz. In deeper water, or with an upward refracting soundspeed profile, low frequencies will tend to dominate the soundscape away from sound sources, as there is no efficient mechanism for attenuating them.

A "cut-off[12]" frequency, below which, there will be high sediment-associated attenuation can be approximated by:

$$f_{cut-off} = \frac{c_{water}}{4 \cdot D \cdot \sqrt{1 - \left(\frac{c_{water}}{c_{sediment}}\right)^2}}$$

With "C_{water}" and "$C_{sediment}$" being the soundspeed in the water and the sediment respectively, and "D" the local depth (Jensen, Kuperman, Porter, & Schmidt, 2011).

[12] The cut-off is not an immediate loss of energy in frequencies under this frequency, but rather something like a high pass, 1st-order, Butterworth filter (Audoly, 2020).

In water with lower salinity and less absorption, the soundscape will tend to have a relatively higher content of high frequencies as these are absorbed much less efficiently when the salinity is lower.

Sound transmission Across Interfaces

Sound waves are reflected and refracted (Snell's law) as they travel through interfaces. Also, depending on acoustic impedance and interface angles only a proportion of the incident acoustic energy is transmitted through that interface (the rest is reflected).

In the following: W: Watt; Pa: Pascal; s: second; m: metre; N: Newton; J: Joule; θ: angle; v: soundspeed; Z: acoustic impedance; p: pressure from ambient;

Snell's law:

$$\frac{\sin\theta_{in}}{\sin\theta_{out}} = \frac{v_{in}}{v_{out}}$$

- rearranged to give transmission angle from incidence angle and soundspeeds:

$$\sin^{-1}\left(\frac{\sin\theta_{in}}{\frac{v_{in}}{v_{out}}}\right) = \theta_{out}$$

Transmission fraction of sound pressure for plane waves (part of the Fresnel equations):

$$\frac{p_{out}}{p_{in}} = \frac{2 \cdot Z_{out} \cdot \cos\theta_{in}}{Z_{out} \cdot \cos\theta_{in} + Z_{in} \cdot \cos\theta_{out}}$$

Reflection fraction of sound pressure for plane waves (part of the Fresnel equations):

$$\frac{p_{out}}{p_{in}} = \frac{Z_{out} \cdot \cos\theta_{in} - Z_{in} \cdot \cos\theta_{out}}{Z_{out} \cdot \cos\theta_{in} + Z_{in} \cdot \cos\theta_{out}}$$

It follows from these relations that for transmission from an acoustically relatively slow medium like water to an acoustically faster medium here exists an incident angle above which there is total reflection, and thus no transmission of acoustic energy through the interface (real interfaces are rugged and lumpy, and perfect reflection is not realistic).

For the water/sediment interface presented here (sediment is sand with a soundspeed of 2000 m/s) this occurs at 0.84 radians (~48.5 degrees) from normal incidence.

The fraction of pressure transmission from water (soundspeed 1500 m/s) to sediment (2000 m/s) is around 146 % at normal incidence and drops as the incidence angle increases away from normal, much faster for water-to-sediment than for sediment-to-water.

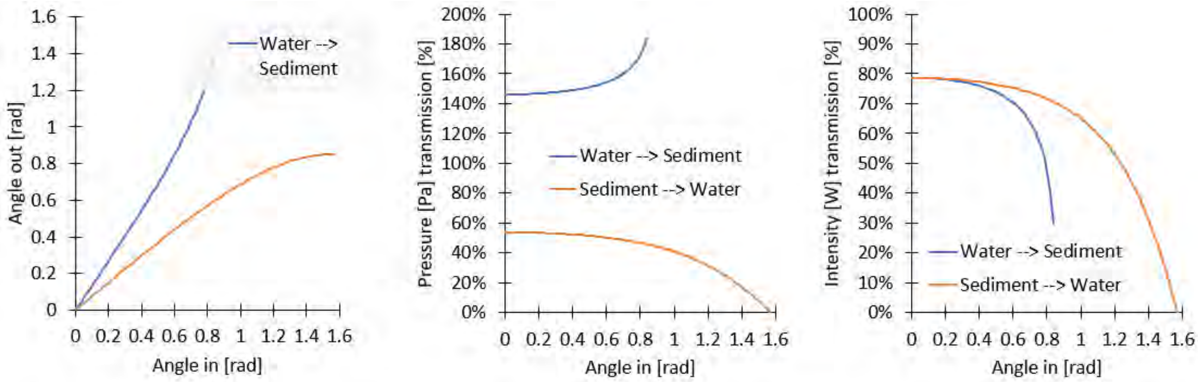
While it may seem counter-intuitive that pressure can increase after transmission over an interface, remember that the energy in the sound is a function of pressure *and* acoustic impedance:

$$I = \frac{p^2}{Z}$$

$$With\ units: [W] = \frac{[Pa]^2}{\left[\frac{Pa \cdot s}{m^3}\right]} = \frac{\frac{N^2}{m^4}}{\frac{\frac{N}{m^2} \cdot s}{m^3}} = \frac{N^2 \cdot m^3}{m^4 \cdot \frac{N}{m^2} \cdot s} = \frac{N}{m \cdot m^{-2} \cdot s} = \frac{J \cdot m}{m^{-1} \cdot s} = \frac{J}{s} = W$$

Thus, if the transmitted intensity fraction is 80 % then the reflected intensity is 20 %; there is energy conservation.

Figure 25. Transmission angles [radians] and fractions as function of incident angle between water and sediment (sand). Note that total reflection from water to sediment occurs around incident angle of 0.84 [rad] (48.5 degrees), meaning there is no transmission of sound at greater incidence angles.



Simplified Propagation Loss Model

Taking all the above into account we can construct a simplified model, that will give a good indication of the expected propagation loss (PL) in scenarios of constant depth:

$$PL = \begin{Bmatrix} r < D \ : & -20 \cdot \log_{10}\left(\frac{r}{r_0}\right) \\ r > D \ : & -20 \cdot \log_{10}\left(\frac{D}{r_0}\right) - 10 \cdot \log_{10}\left(\frac{D}{r_0}\right) \end{Bmatrix} - \alpha(f) \cdot r - l(f) \cdot r$$

Where:

- "r" is horizontal range from source.
- "D" depth at source.
- "r_0" the reference range of the source (often 1 m).
- "f" the frequency,
- "l" the frequency specific leakage loss to the sediment.
- "α" the frequency specific absorption.

Sound Level Units

All references to sound pressure levels, peak pressure levels and sound exposure levels refer to a logarithmic ratio between a reported/measured pressure or exposure and a reference pressure or exposure. As an example, a level of 220 L_p (decibel zero-to-peak) is equal to a peak pressure of 100000 Pascals (Pa) over ambient pressure, while 120 L_p is equal to 1 Pa over ambient pressure.

To avoid dealing with these large numbers as pascals (as a linear scale), they are converted to a decibel ratio (Table 1 for definitions). Besides compressing large numbers to a smaller scale this also corresponds better to how animals are thought to perceive sound, namely as relative steps. This means that an increase from 1 to 2 Pa *sounds like* the same increase as from 100 to 200 Pa, even though the first step was only 1 Pa, while the second was 100 Pa. This is better reflected in a logarithmic scale based on ratios, where both steps are equal, here 3 dB.

However, while dBs are practical, they can be hard to compare between studies, due to vague definitions, and so we have adopted the standards set by ISO 18405-2017 (Table 1 below).

For ease of reference please see following overview for unit definition.

Table 7: Definitions.

Unit	Definition	Comments
SPL (dB_{RMS}) ISO 18405- 2017: 3.2.1.1	$SPL = 10 \cdot Log_{10}\left(\frac{\frac{1}{t_2 - t_1} \cdot \int_{t_1}^{t_2} p(t)^2 dt}{1 \cdot 10^{-12} Pa}\right)$	Functionally equivalent to deprecated $20 \cdot Log_{10}\left(\frac{RMS}{1 \cdot 10^{-6} Pa}\right)$
L_p ($dB_{z\text{-}p}$) ISO 18405- 2017: 3.2.2.1	$L_p = 20 \cdot Log_{10}\left(\frac{Pa_{max}}{1 \cdot 10^{-6} Pa}\right)$	This assumes that Pa_{max} is equal or greater than $\sqrt{Pa_{min}^2}$
$L_{p\text{-}p}$ ($dB_{p\text{-}p}$)	$L_{p-p} = 20 \cdot Log_{10}\left(\frac{Pa_{max} - Pa_{min}}{1 \cdot 10^{-6} Pa}\right)$	Often[13] equivalent to $L_P + 6.02\ dB$
L_E (dB_{SEL}) ISO 18405- 2017: 3.2.1.5	$L_E = 10 \cdot Log_{10}\left(\frac{\int_{t_1}^{t_2} p(t)^2 dt}{1 \cdot 10^{-12} Pa}\right)$	For continuous sound this is equivalent to $SPL + 10 \cdot Log_{10}(t_2 - t_1)$ "t" is seconds

Unless otherwise stated SPL has an averaging period of 1 second, and L_E for the duration of the specified event, sometimes indicated as $L_{E\text{-"time"}}$ or $L_{E\text{-single blow}}$.

If the averaging period for SPL is equal to the total even duration, then SPL is equal to "Leq" the "equivalent constant level".

When source levels are presented, the same units are used, and it is implicit that all source levels are given as if recorded 1 m from an omnidirectional mono-point source, unless otherwise specified.

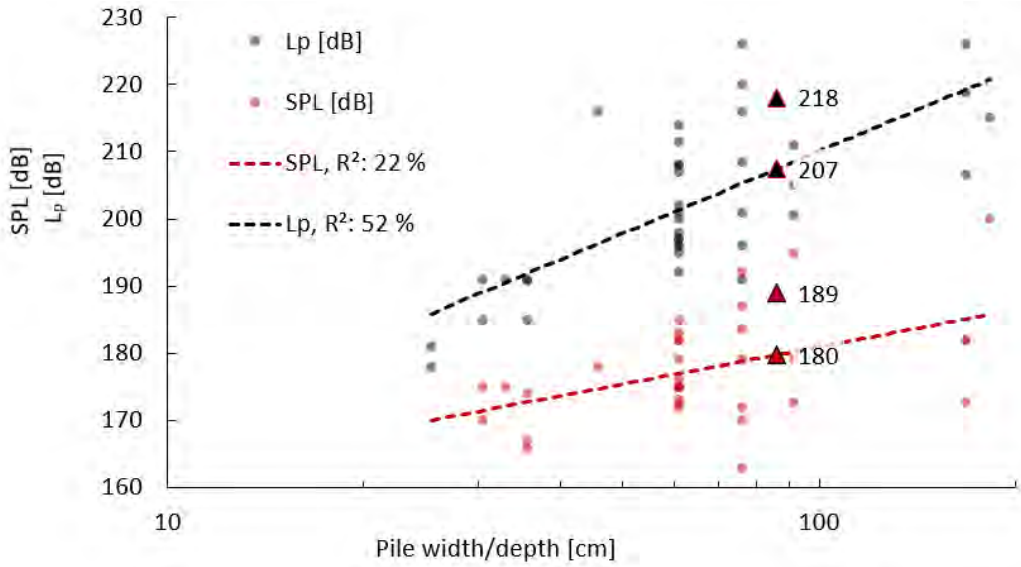
13 If maximum pulse rarefaction is below ambient pressure and compression and rarefaction phases are of equal size.

APPENDIX C – SOURCE MODELS

Vibration piling model

We only have a few recordings (50) from vibration piling and have no dedicated source model for this type of piling. Instead, we rely on published recorded levels as from CalTrans (CalTrans, 2015).

Figure 26. Basis of vibro piling broad band source level as a function of pile size.



Given the low confidence we have in this approach (low R^2 values) we use the 90th percentile level as the broadband source level. L_P is estimated to be 218 dB and SPL 189 dB. The frequency content is assumed to be identical to that of the impact piling.

Table 8. Sources decidecade band levels.

Band centre frequency [Hz]	Dredging, Mean (broadband: 182) [SPL]	Dredging, 90th percentile (broadband: 192) [SPL]	Drilling, Mean (broadband: 138) [SPL]	Drilling, 90th percentile (broadband: 156) [SPL]	Vibro, Mean (broadband: 187) [SPL]	Vibro, 90th percentile (broadband: 196) [SPL]
12.5	162	165	127	142	166	176
16	163	166	126	139	167	176
20	164	167	124	139	167	176
25	165	170	123	138	167	176
31.5	168	177	125	139	168	177
40	169	180	124	140	169	179
50	169	178	124	139	172	181
63	170	178	126	143	174	183
80	169	180	123	142	176	185
100	168	179	124	142	177	186
125	168	178	123	140	178	187
160	168	178	123	142	177	186
200	168	177	125	146	177	186
250	169	178	126	147	177	186
315	169	178	125	147	175	184
400	169	177	123	144	174	183
500	168	178	124	145	173	182
630	167	175	122	143	171	180

800	167	174	124	141	169	178
1000	166	174	125	142	167	176
1250	165	174	123	142	165	175
1600	165	174	121	138	164	173
2000	164	174	120	135	162	171
2500	163	175	119	134	160	169
3150	163	175	118	132	159	168
4000	162	175	118	132	158	167
5000	162	175	119	133	156	165
6300	161	175	118	130	155	164
8000	160	175	117	130	154	163
10000	159	174	117	129	152	161
12500	158	173	110	120	150	159
16000	157	173	109	118	150	159
20000	156	172	109	119	149	158
25000	156	171			148	157
31500	155	171			147	156
40000	154	170			146	155
50000	157	174			145	154
63000	156	173			144	153
80000	156	173			143	152
100000	157	172			142	151
125000	157	166			141	150
160000	157	166			140	149

APPENDIX D – MODEL CALIBRATION

Recorded Transmission losses

Scapa

Broadband transmission losses for exposure levels (L_E) show good consistency between measurements and a transmission loss consistent with -14.7 × Log_{10}(range), suggesting a sediment with some ability to reflect sound back into the water column and form a waveguide.

Transmission loss for peak pressure levels (L_P) were near spherical spreading loss which is consistent with a poorly reflecting bottom resulting in little overlap in arrival times for the source impulse.

There was a clear pattern in the transmission losses versus frequency, with higher frequencies experiencing much higher losses, likely due to interaction with a rough sediment resulting in a lot of scattering.

*Note that for the bands 50 – 1250 Hz the ambient noise at Scapa was above the source level, while we have tried to compensate for this, those values are still subject to considerable uncertainty (*Figure 28*).*

Figure 27. Broadband transmission losses at Scapa. L_P losses follow a near spherical loss pattern while L_E shows a tendency to follow a waveguide with some absorption losses. Thick lines are best fit of logarithmic loss, while thin lines are for loss accounting for the depth at the source. Error bars are expected 95 % of measurements.

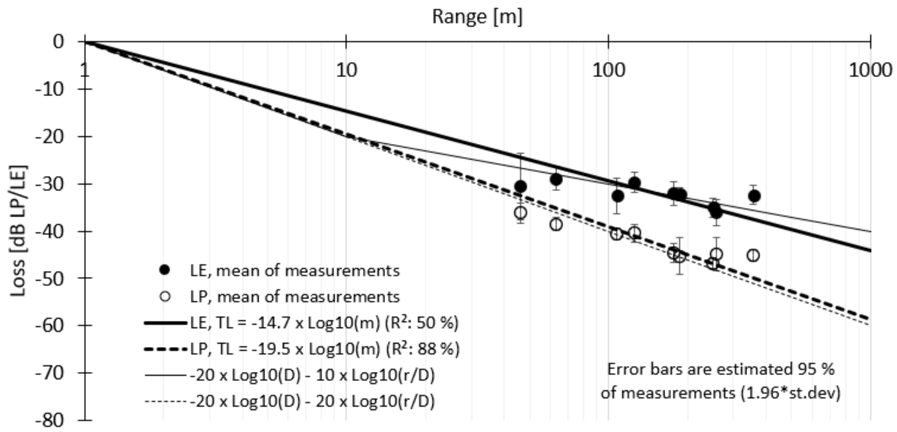
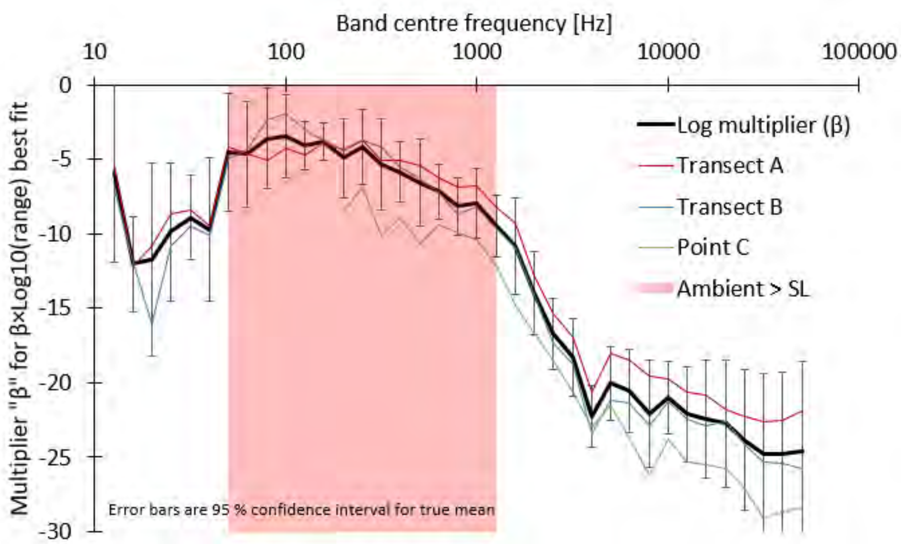


Figure 28. Transmission losses per band shown as the best fit multiplier "β" for a simple logarithmic transmission loss. Error bars are 95 % confidence interval for the true mean. While Transects A & B have some difference, this was not significant at a 10 % level in a t-test. Bands 50 – 1250 Hz have been corrected for contributing ambient noise as ambient noise was near or above recorded levels (red band).



APPENDIX E – RESULTS

Maps are presented with impact for different hearing groups as summarised here

Note that some maps have areas marked as "model artefacts", these are areas where the levels are assumed to not be realistic, but rather an example of a digitisation problem with the bathymetry.

Group	Description	Example species
LF	Low frequency, baleen whales	Mike whale, Fin whale, Blue whale
HF	High frequency, most dolphins	Common dolphin, Risso's dolphin, beaked whales, Bottlenose dolphin, Sperm whale, Killer whale
VHF	Very high frequency, few dolphins and porpoises	Harbour porpoise, Hourglass dolphin
PW	Phocid water, True seals	Harbour seal, Grey seal
OW	Otariid + other water, Fur seals, walruses and aquatic mammals	Walrus, Otter, Polar bear
P-	Fish with swim bladder, not coupled to inner ear	Salmon, Trout, Cod, Herring
P*	Fish with no swim bladder	Sharks and rays

Dredging L_E

Maps are provided for 90th percentile source levels for 1 hours and 8 hours.

Figure 29. Dredging, L_E, 1hr, LF group

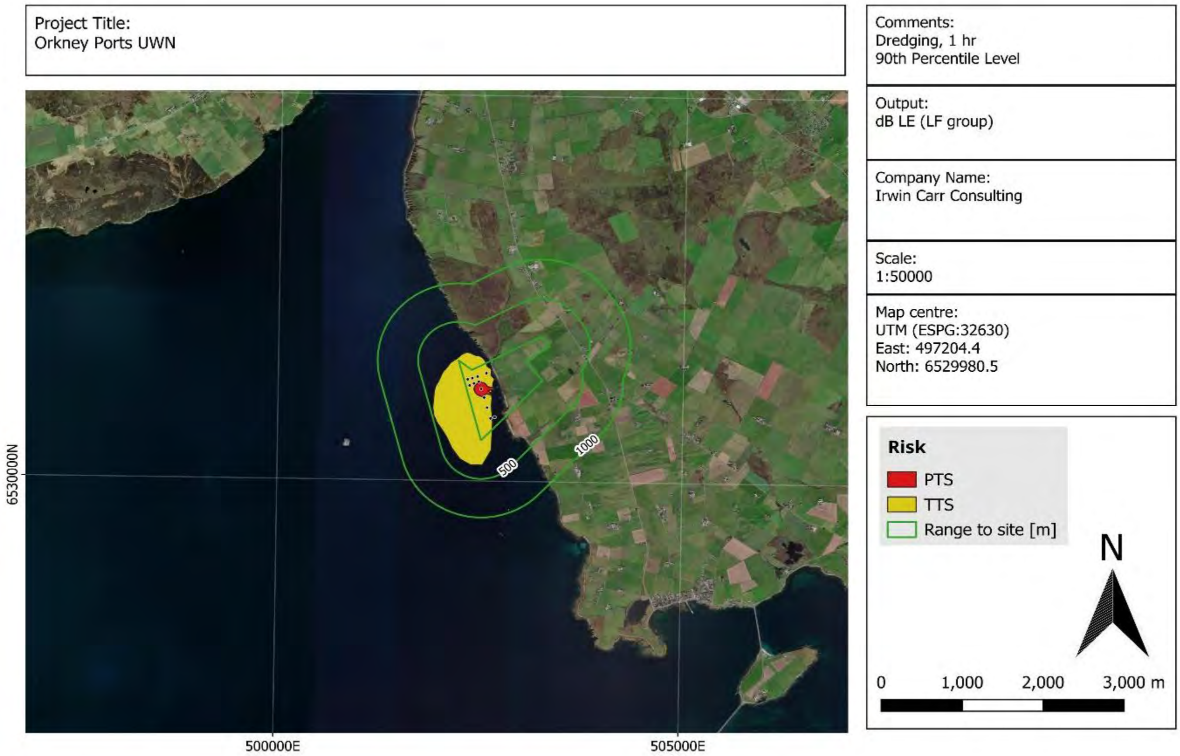


Figure 30. Dredging, L_E, 8hr, LF group

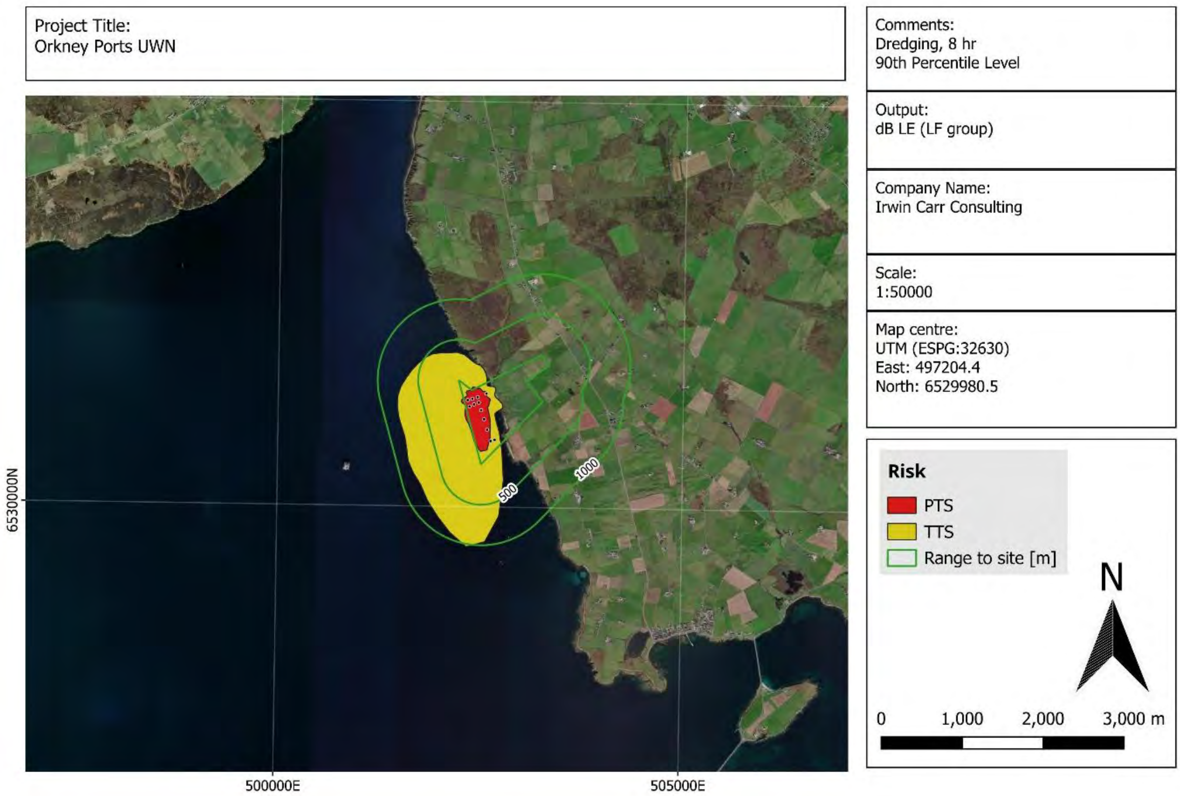


Figure 31. Dredging, L_E, 1hr, HF group

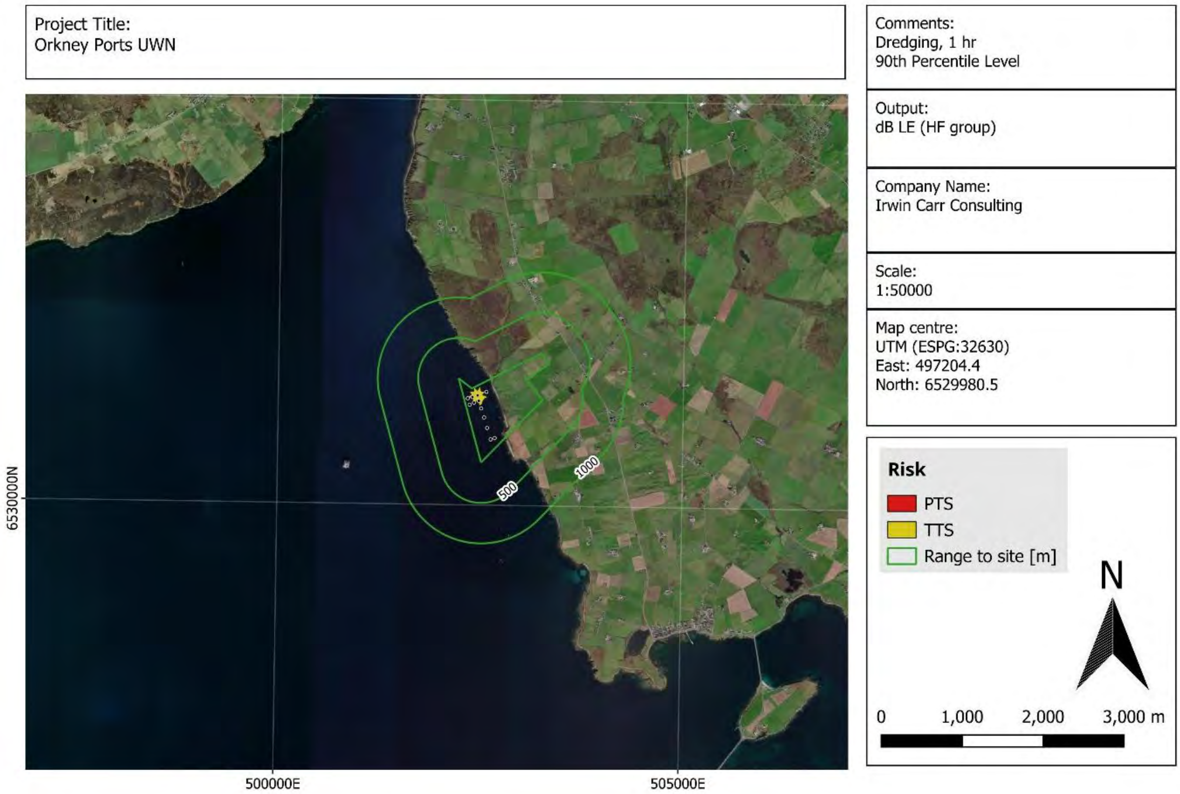


Figure 32. Dredging, L_E, 8hrs, HF group

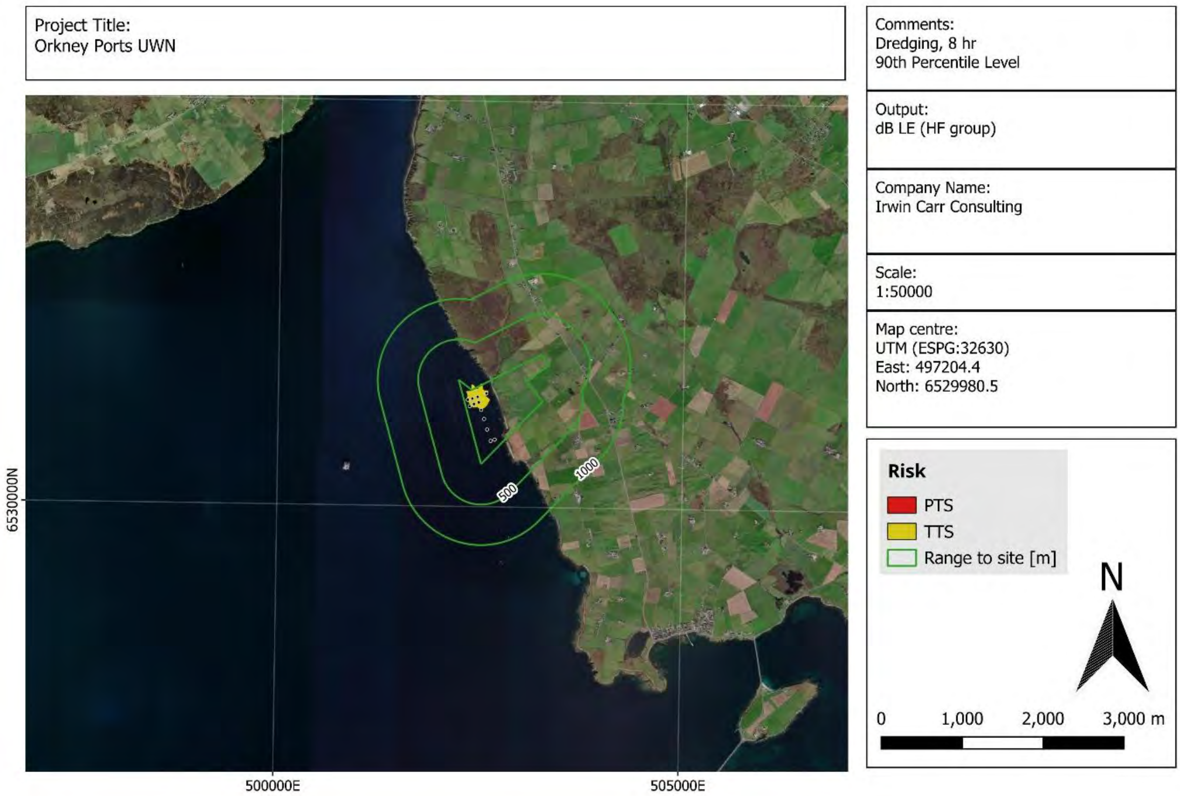


Figure 33. Dredging, L_E, 1hr, VHF group

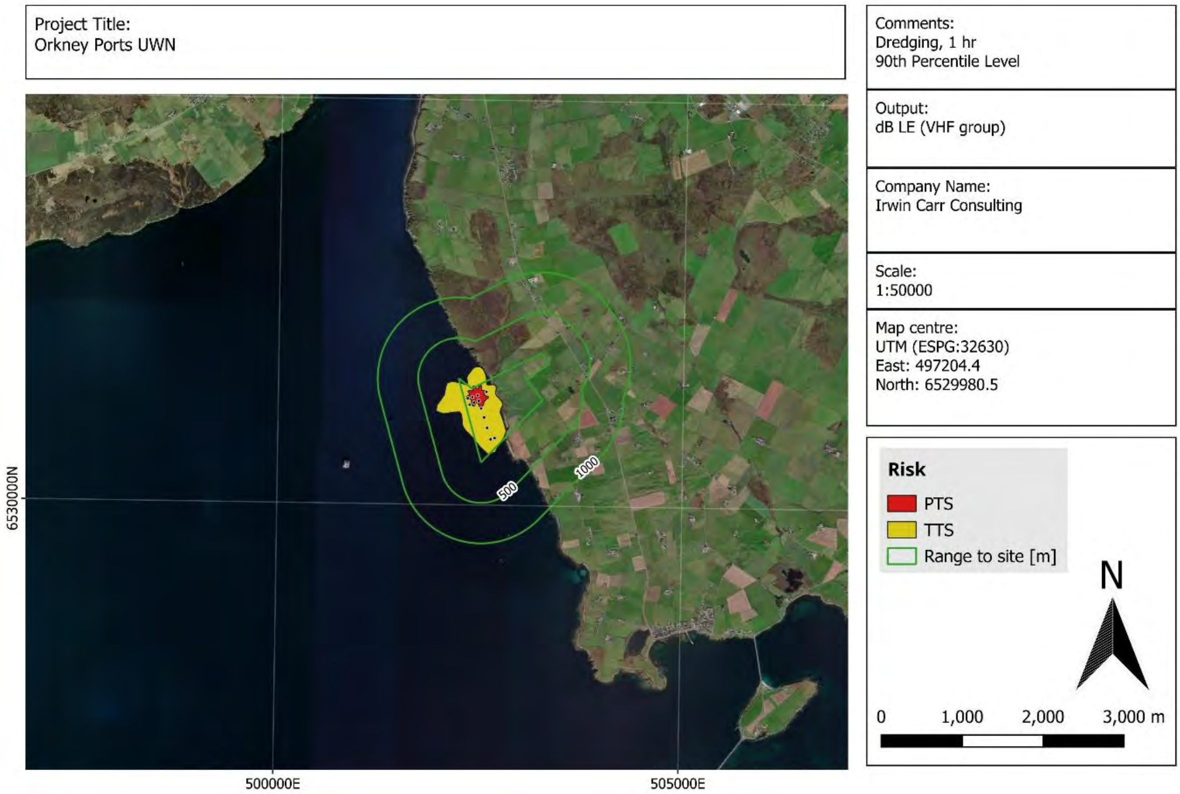


Figure 34. Dredging, L_E, 8hrs, VHF group

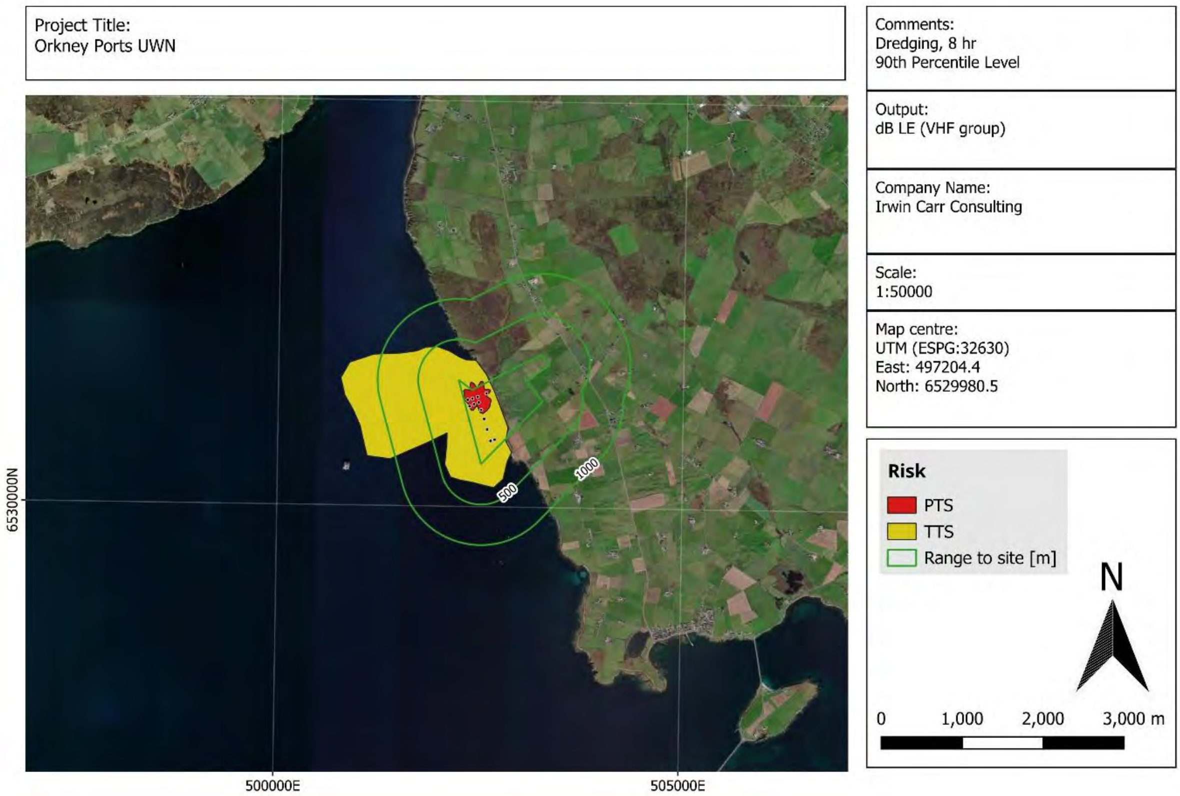


Figure 35. Dredging, L_E, 1hr, PW group

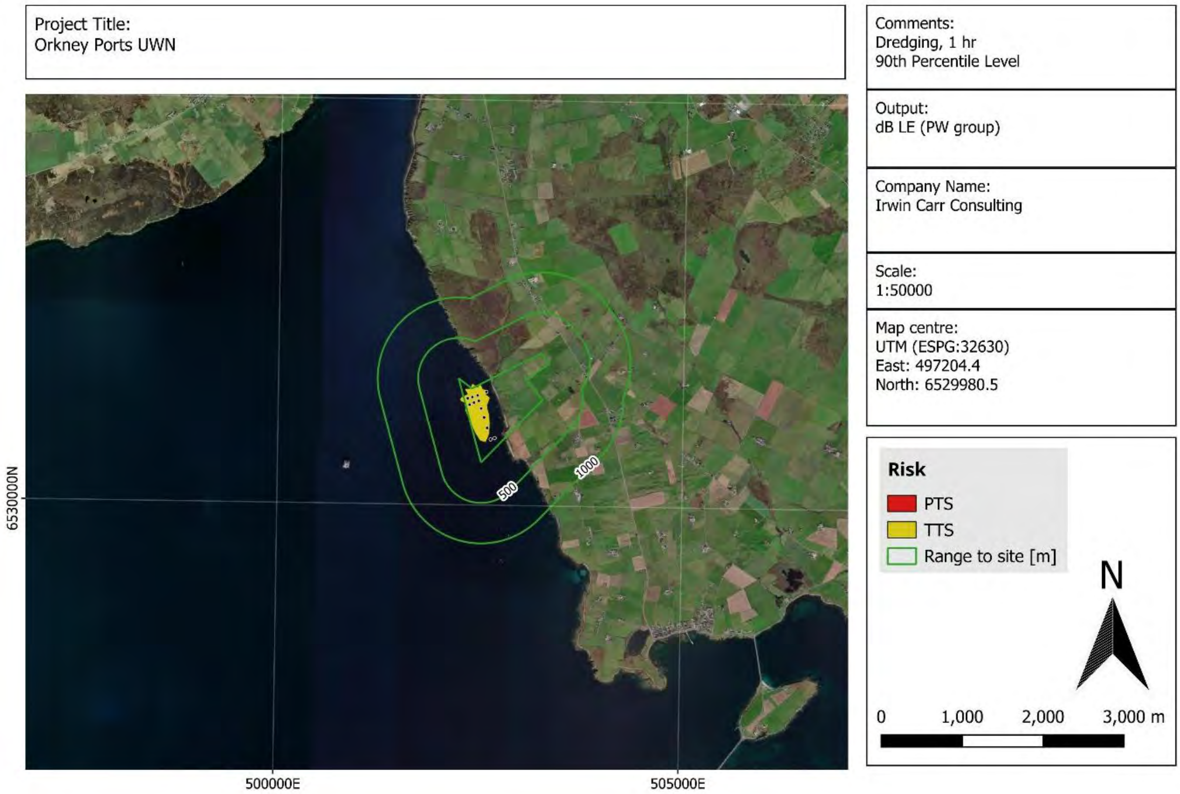


Figure 36. Dredging, L_E, 8hrs, PW group

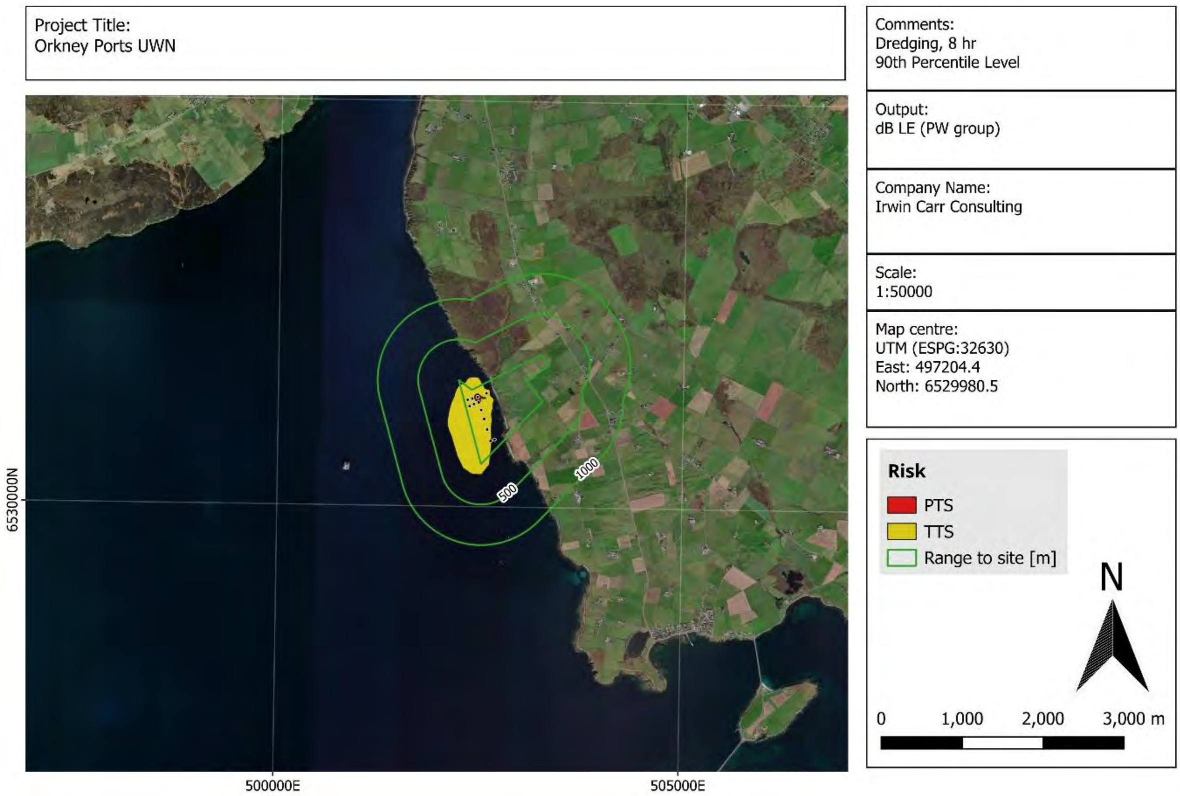


Figure 37. Dredging, L_E, 1hr, OW group

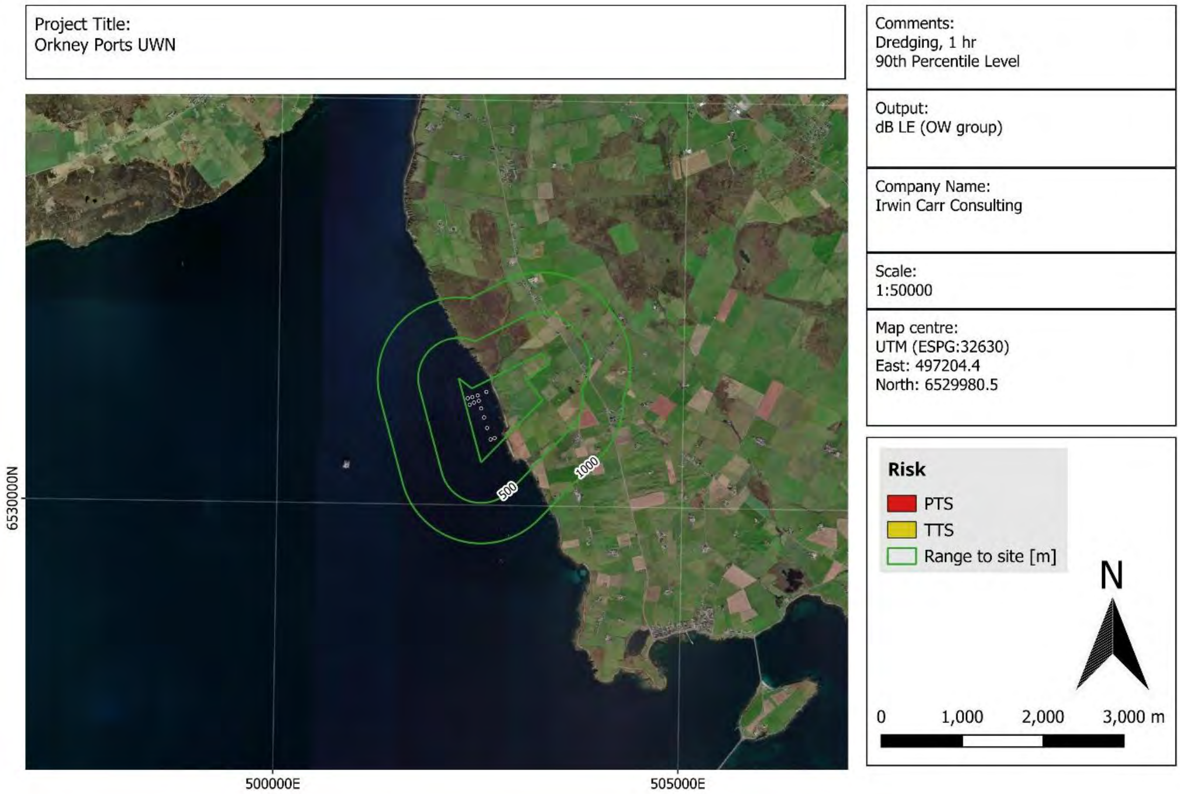


Figure 38. Dredging, L_E, 8hrs, OW group

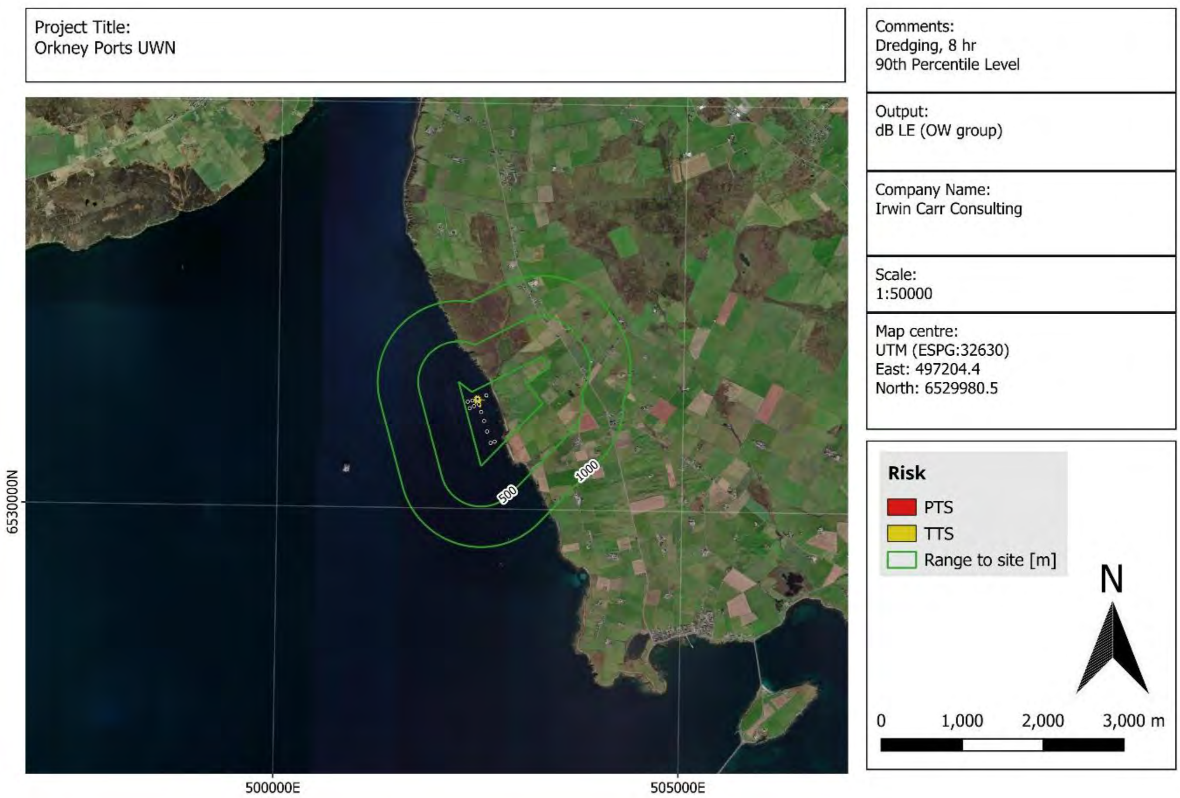


Figure 39. Dredging, L_E, 1hr, P- group

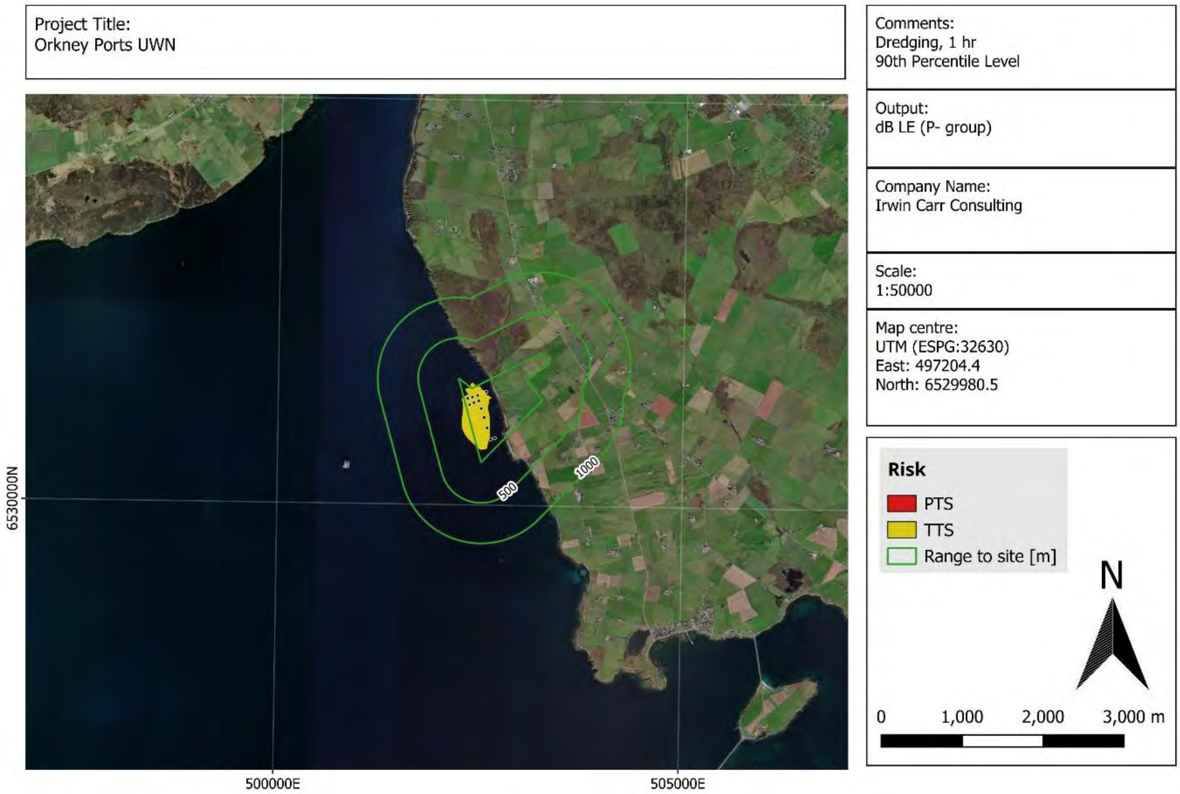


Figure 40. Dredging, L_E, 8hrs, P- group

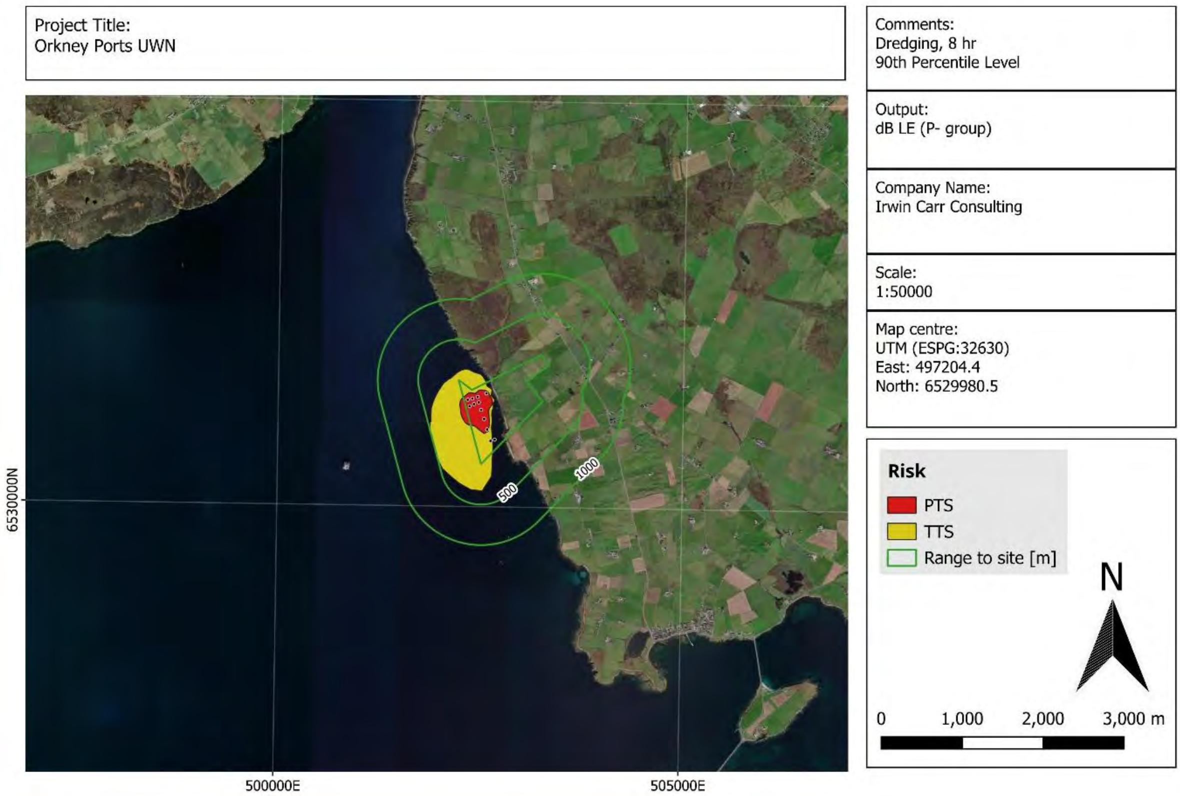


Figure 41. Dredging, L_E, 1hr, P* group

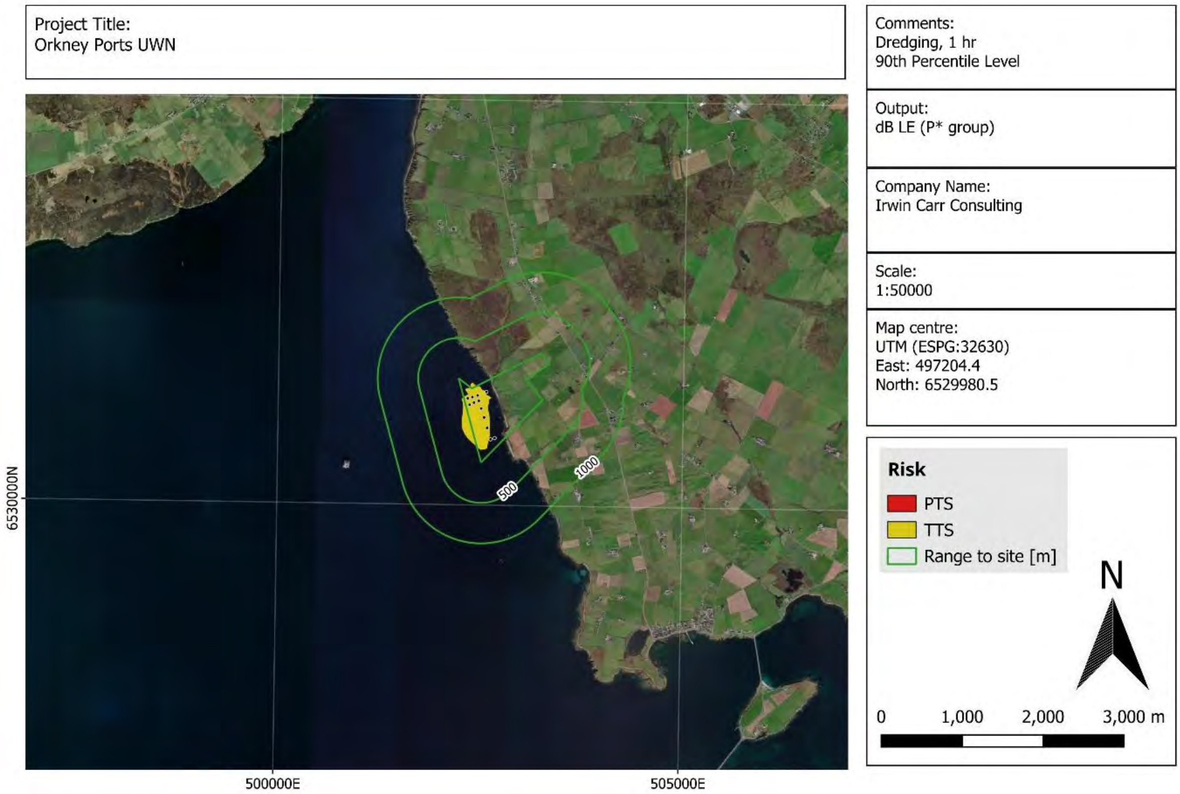
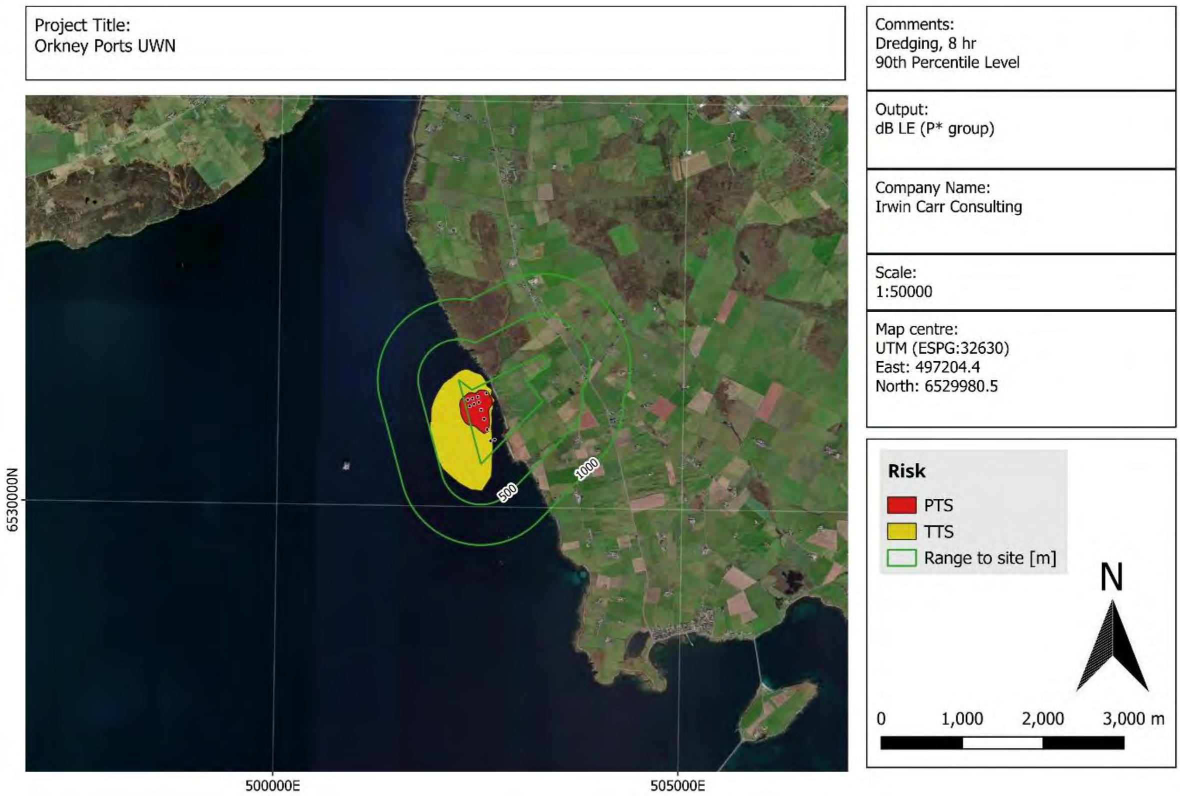


Figure 42. Dredging, L_E, 8hrs, P* group



Vibro Piling L_E

Figure 43. Vibro piling, L_E, 1 hour, LF group

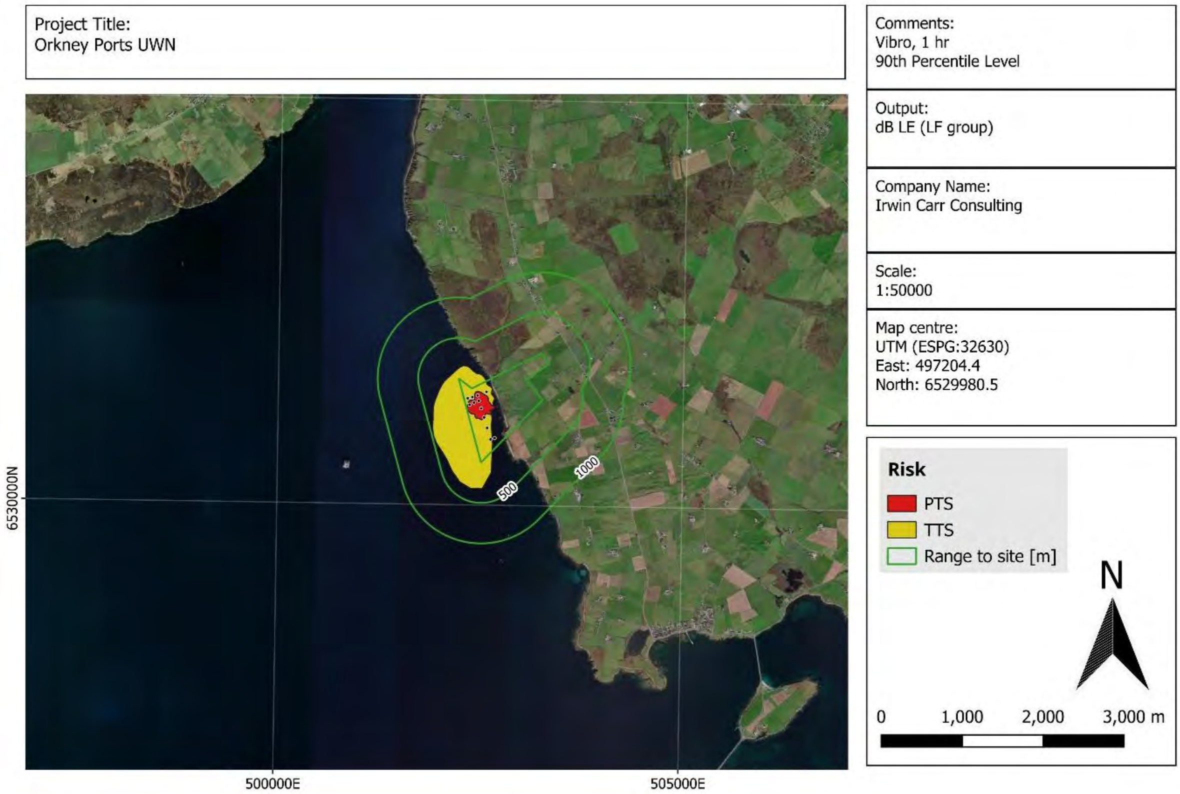


Figure 44. Vibro piling, L_E, 1 hour, HF group

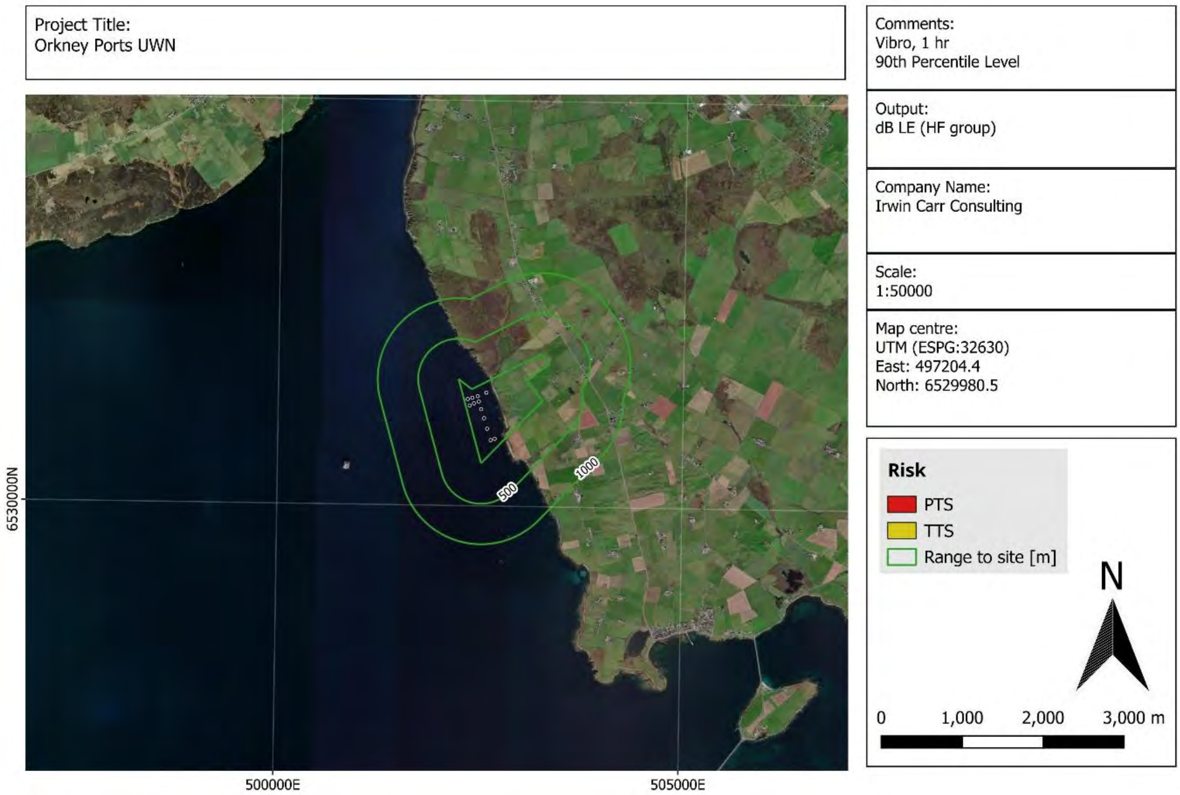


Figure 45. Vibro piling, L_E, 1 hour, VHF group

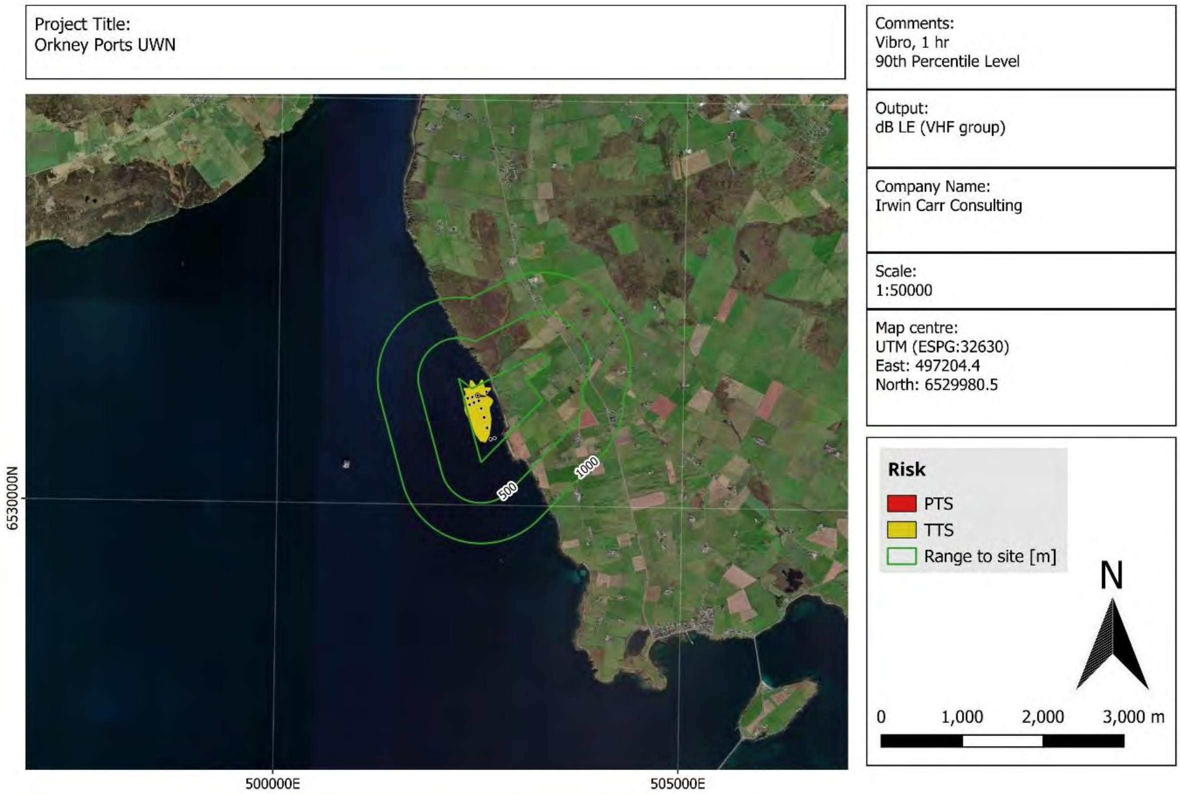


Figure 46. Vibro piling, L_E, 1 hour, PW group

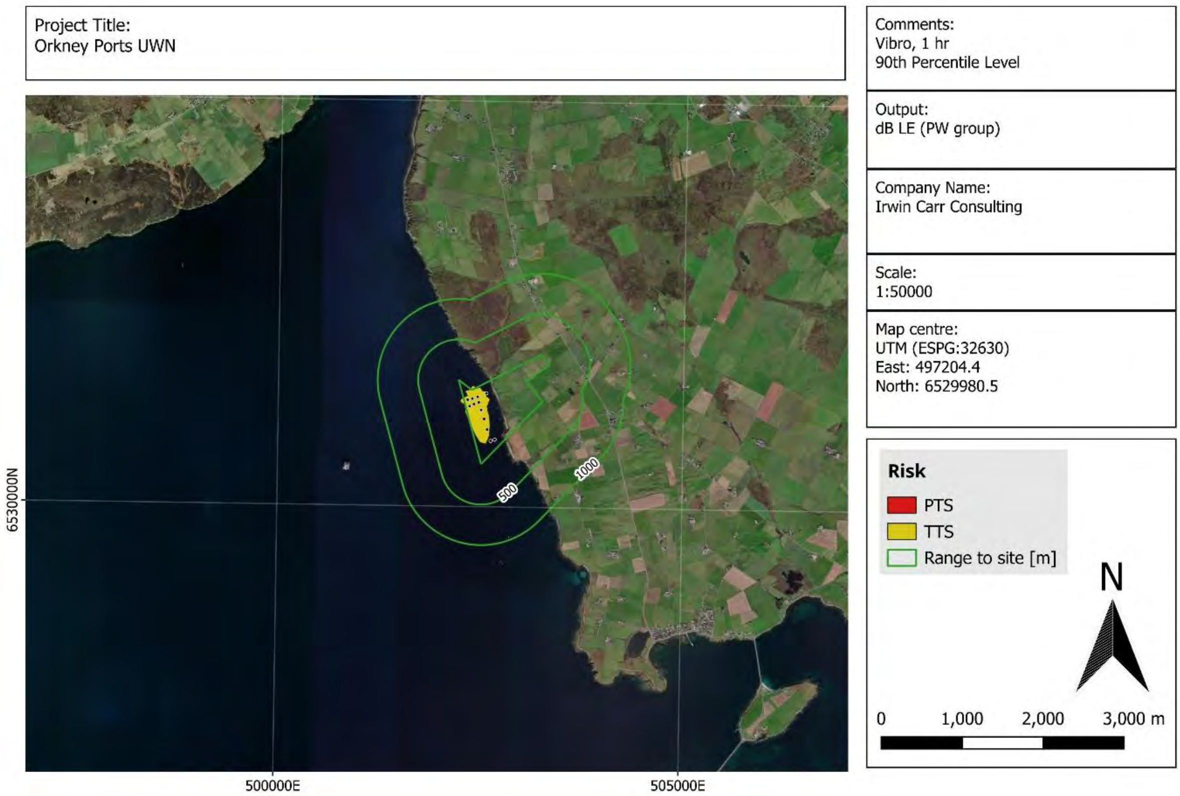


Figure 47. Vibro piling, L_E, 1 hour, OW group

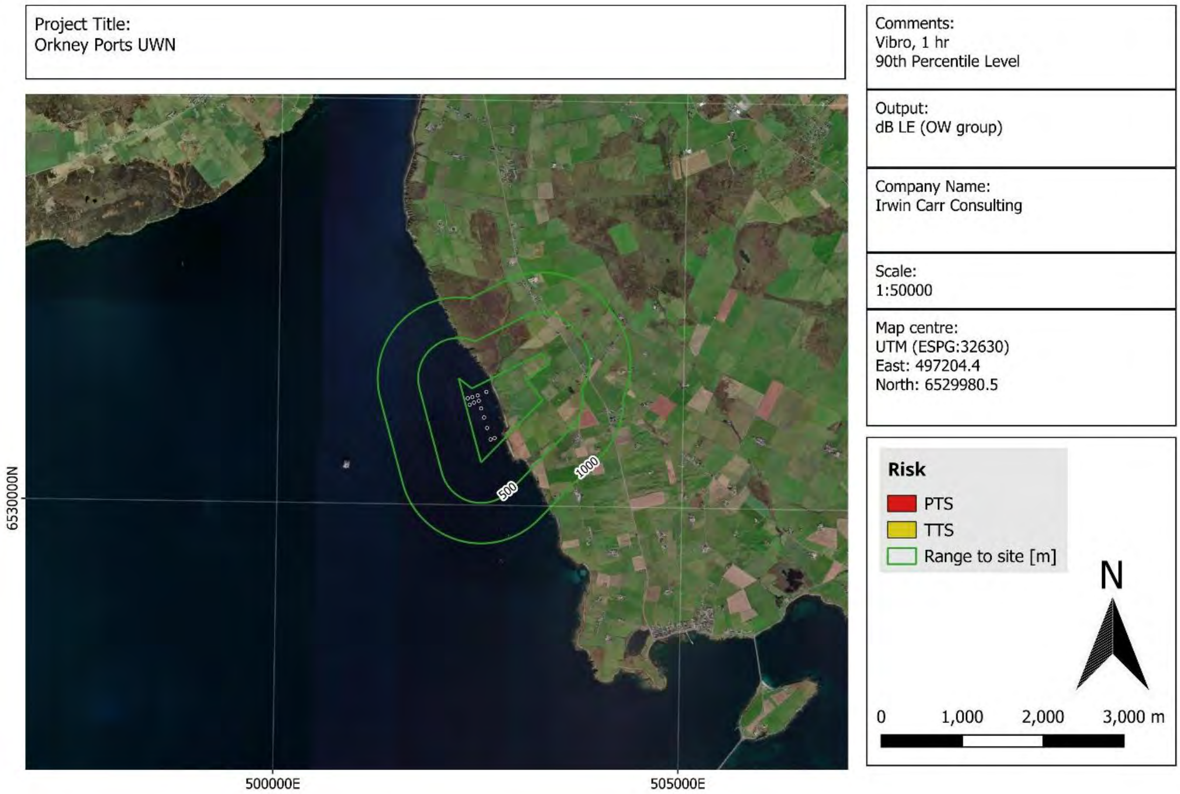


Figure 48. Vibro piling, L_E, 1 hour, P- group

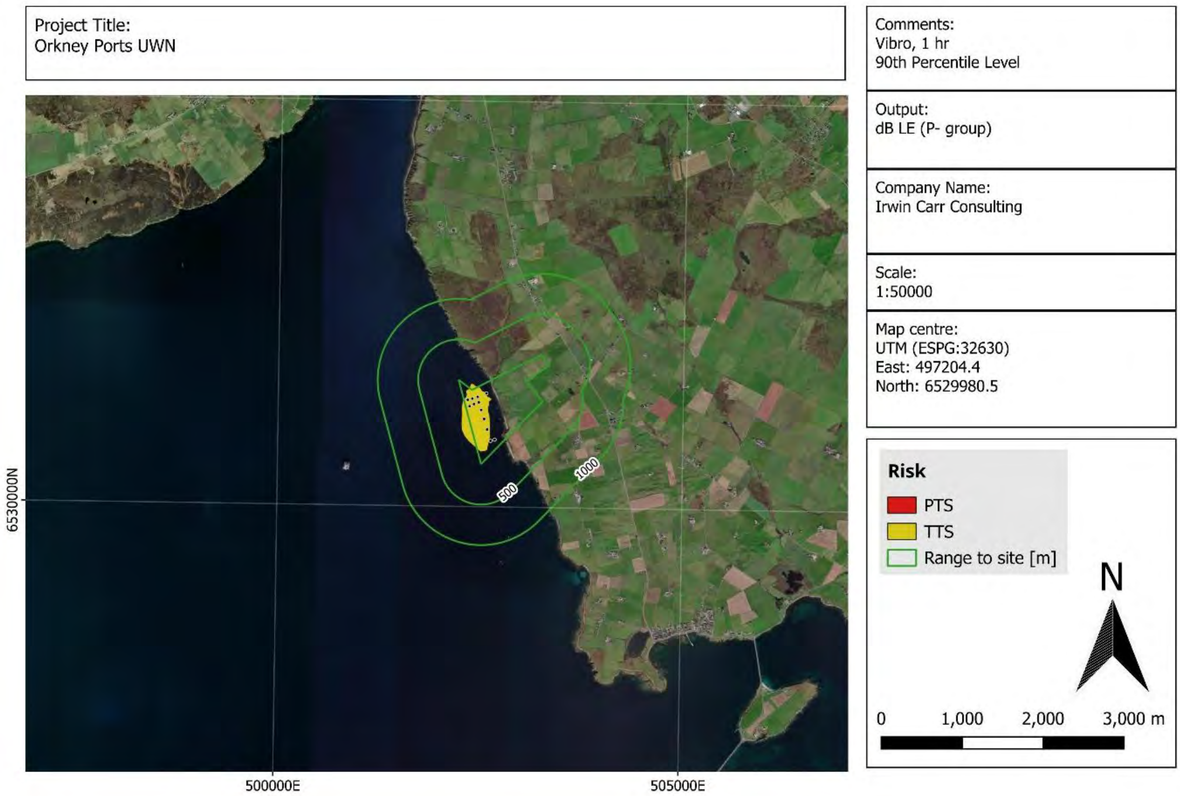
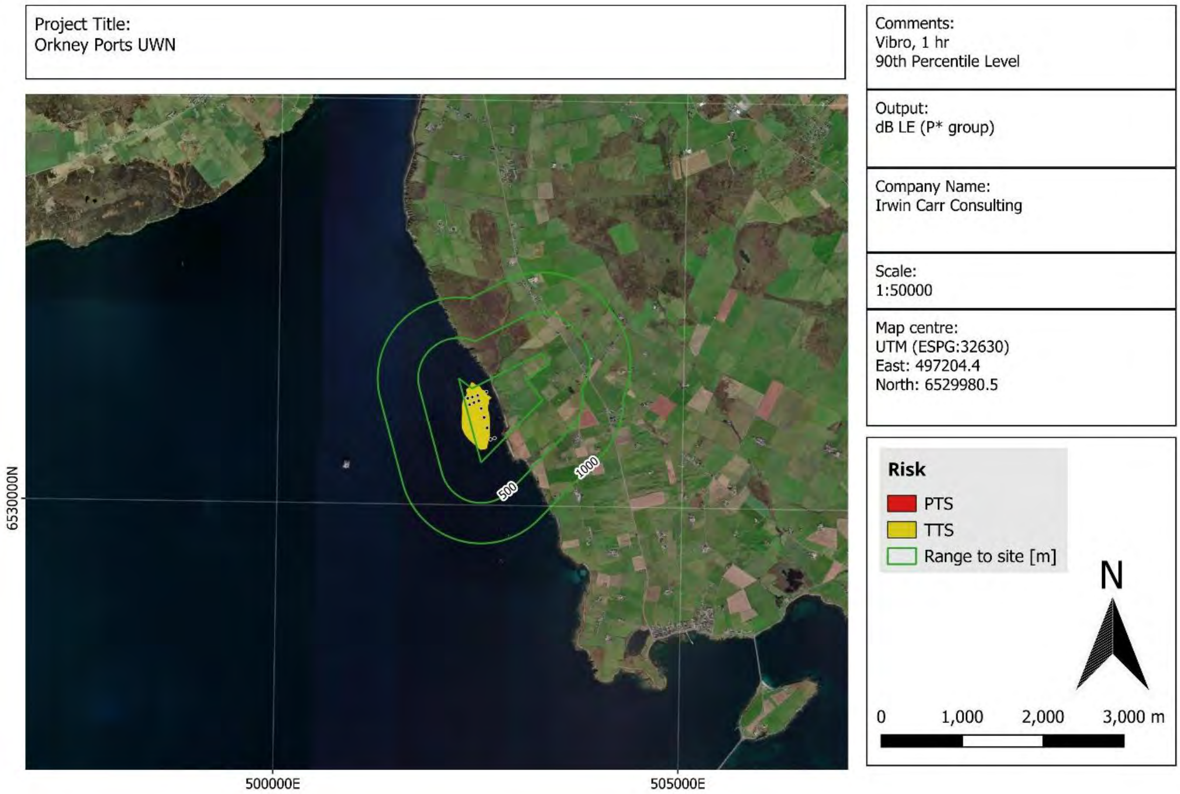


Figure 49. Vibro piling, L_E, 1 hour, P* group



Vibro piling L_P

Figure 50. Vibro piling, L_P, LF group

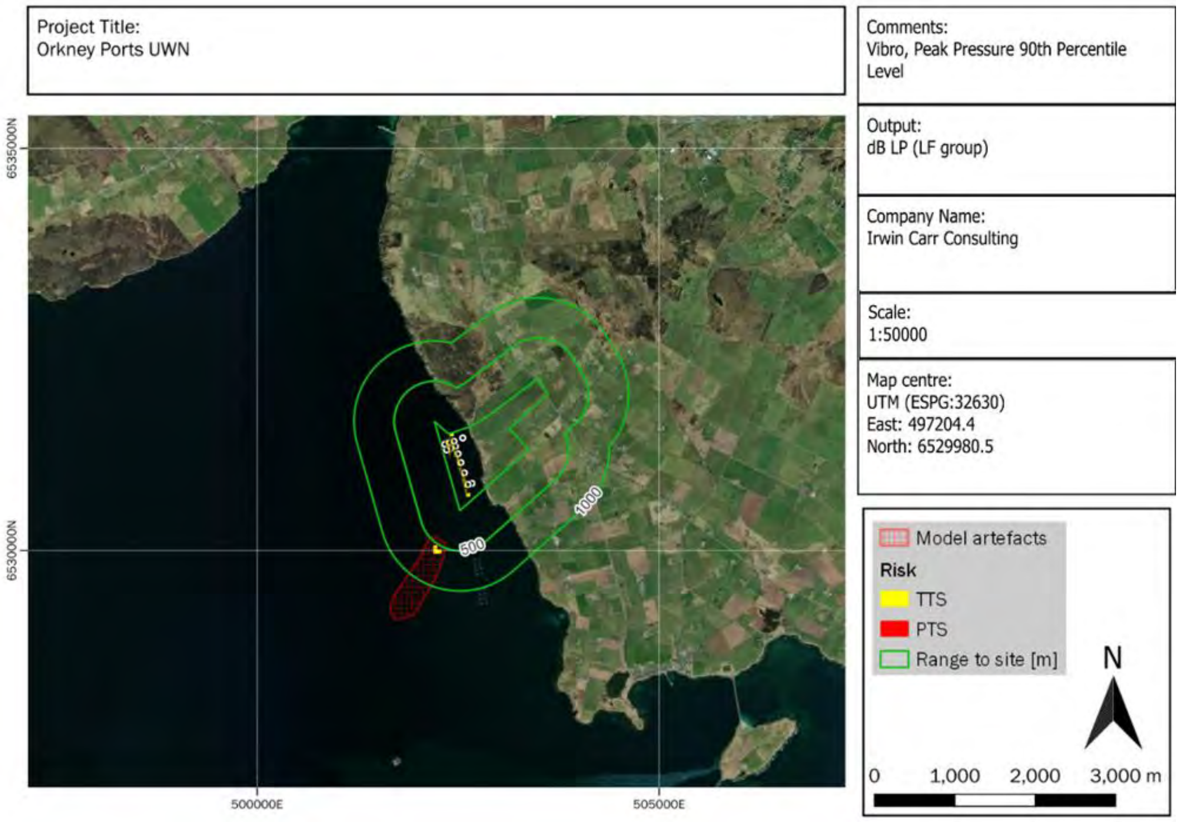


Figure 51. Vibro piling, L_P, HF group

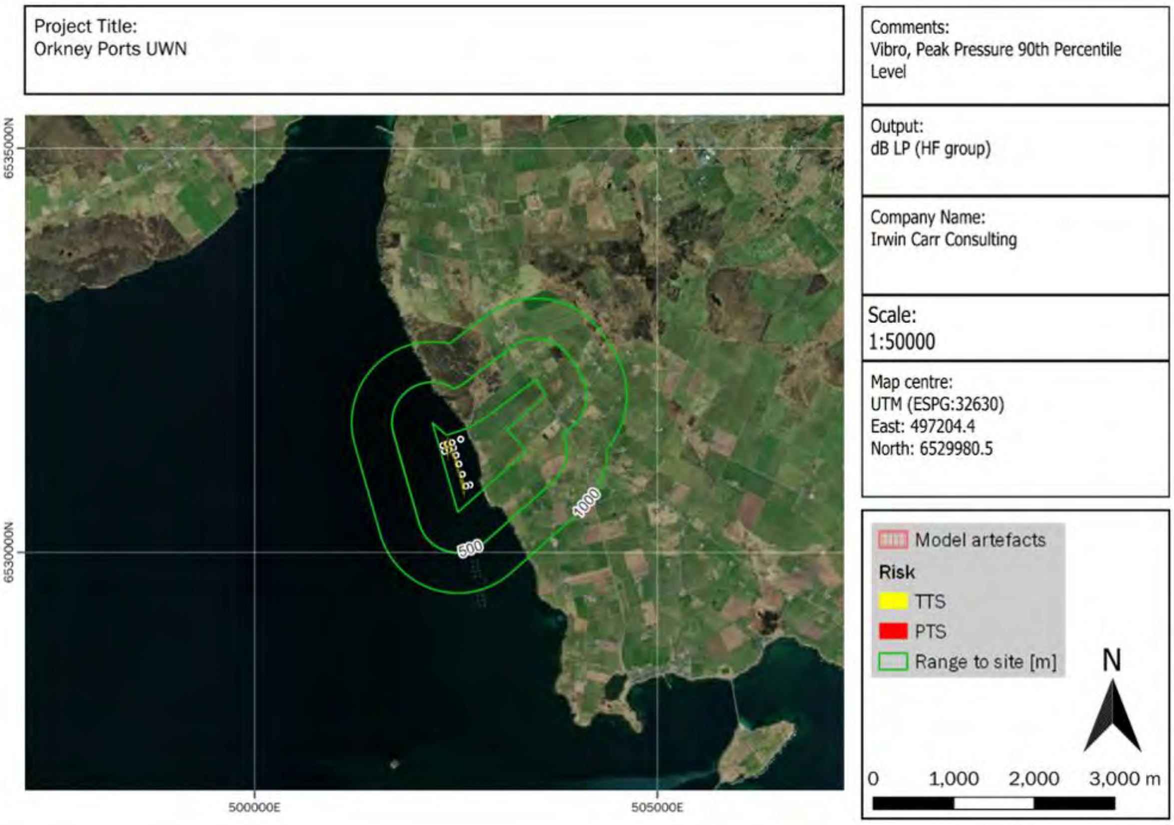


Figure 52. Vibro piling, L_P, VHF group

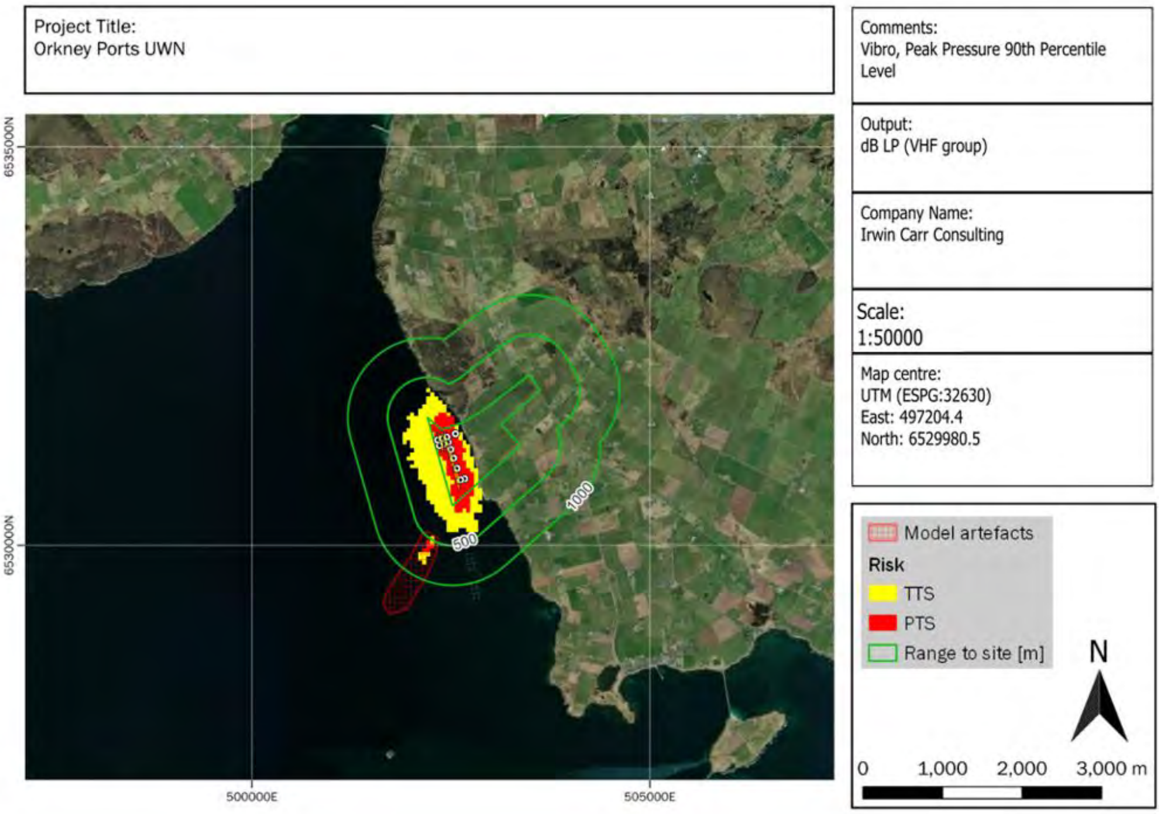


Figure 53. Vibro piling, L_P, PW group

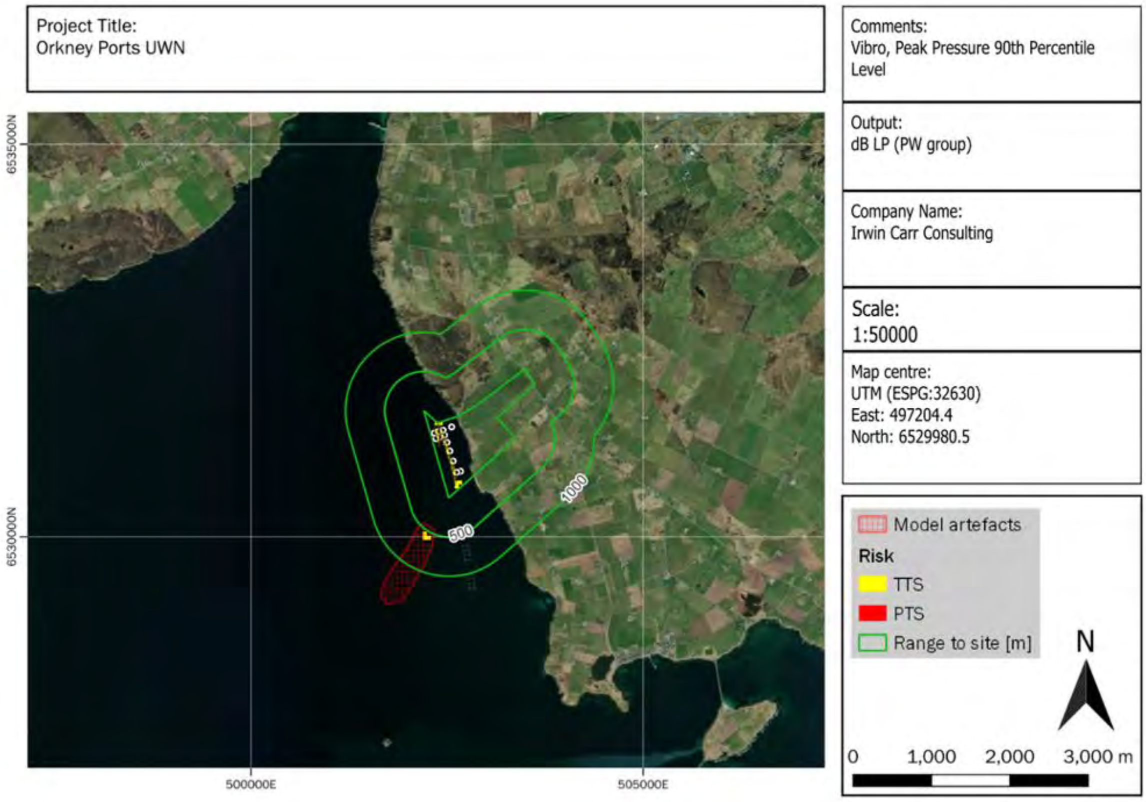


Figure 54. Vibro piling, L_P, OW group

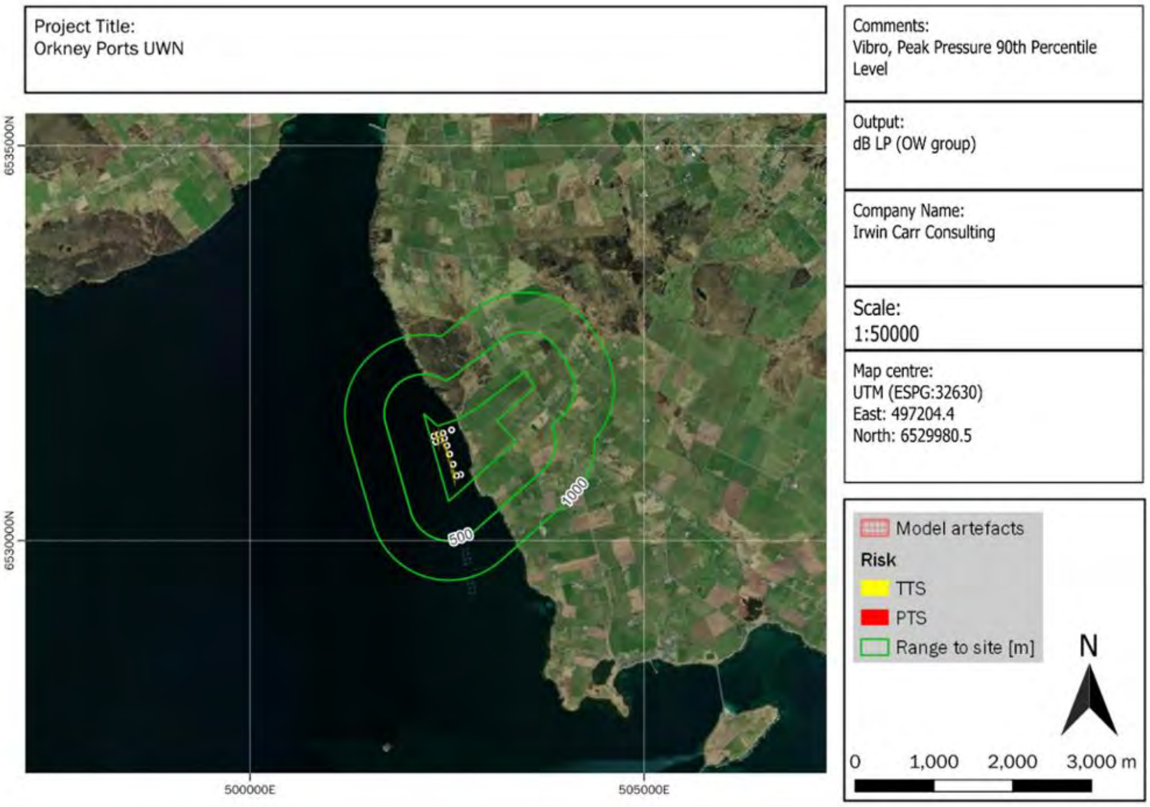


Figure 55. Vibro piling, L_P, P- group

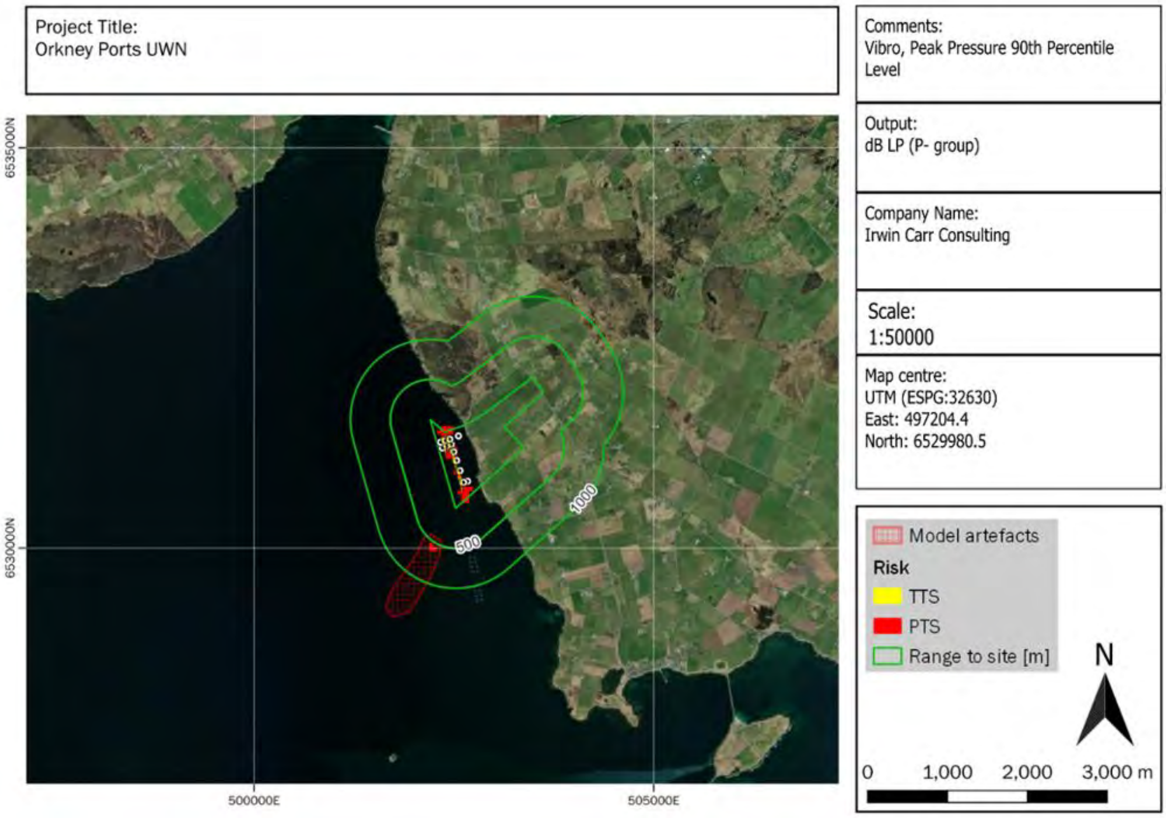
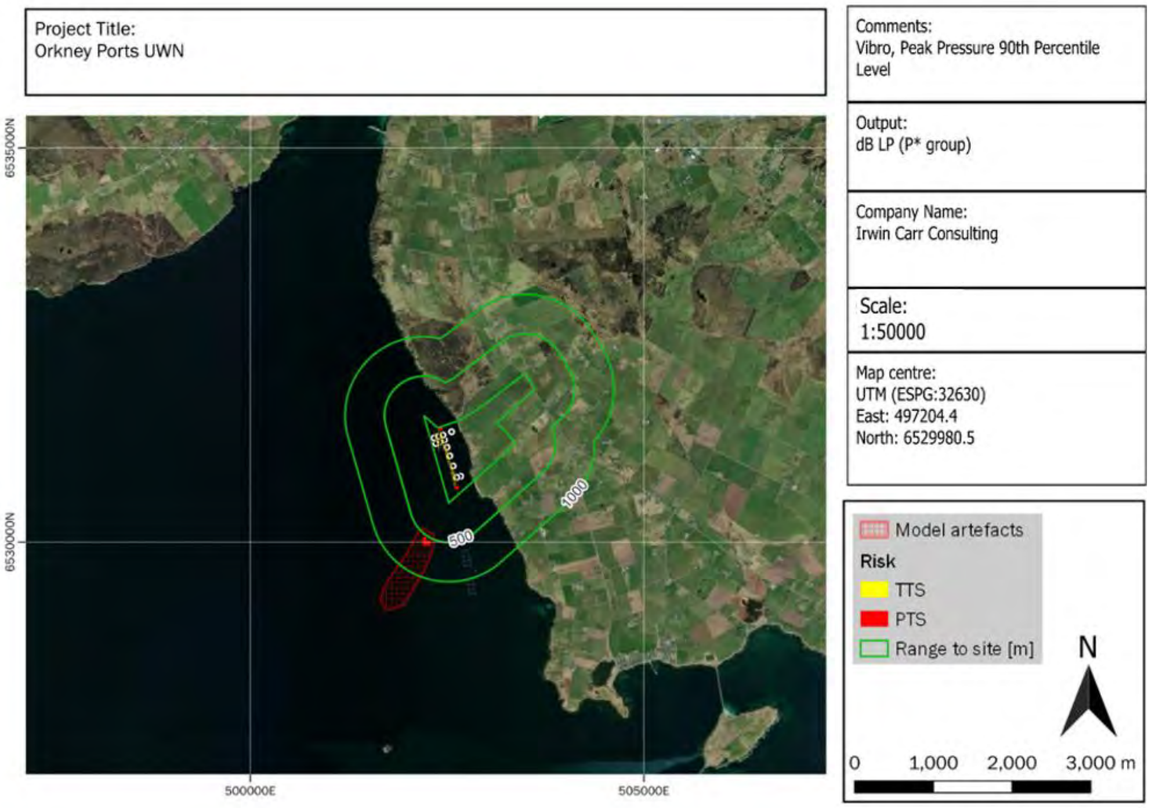


Figure 56. Vibro piling, L_P, P* group



C SEAL HAUL OUT SITES

Seal Haul Out Name	Distance* and Orientation	Species	No. seals (based on August counts)		NMPi Breeding Colony (Grey seal)
			Harbour seal	Grey seal	
Ve Ness	7km west	Harbour and Grey seal	0	8	No
North West Water Sound	7km south	Harbour seal	63	32	-
Calf of Flotta	9km south west	Grey seals	1	13	Yes
Barrel of Butter	10km west	Harbour seal	18	11	-
North Flotta	10km south east	Grey seal	0	228	Yes
Cava	12km west	Harbour seal	17	20	-
Flotta Oil Terminal	12km south west	Harbour seal	9	0	-
Holm of Houton	13km west	Harbour and Grey seal	21	24	No
North and East Fara	14km south west	Harbour and Grey seal	8	179	No
Switha	15km south west	Harbour and Grey seals	19	27	No
North east Hoy	16km west	Grey seals	0	3	Yes
Copinsay	18km east	Grey seals	0	311	No
South Ronaldsay East	19km south	Grey seals	0	0	Yes
Swona	19km south	Grey seals	0	238	Yes
South Ronaldsay West	20km south	Grey seals	0	0	Yes
Bay of Ireland	22km north west	Harbour seals	44	23	No
Selwick	22km west	Harbour and grey seals	17	117	No
Stroma	25km south	Harbour and Grey seals	0	570	No
Pentland Skerries	28km south	Grey seals	0	343	No
Deer Sound	31km east	Harbour and Grey seals	39	79	No
Gills Bay	31km south	Harbour and Grey seals	41	29	No
Duncansby Head	31km south	Grey seals	0	0	Yes
Auskerry	34km north east	Grey seals	0	77	Yes
Greenli Ness	37km north east	Grey seals	0	309	No
Bay of Holland East and Tor Ness	38km north east	Harbour and grey seals	11	607	No
Bay of Houseby	40km north east	Harbour and Grey seals	6	213	No

Seal Haul Out Name	Distance* and Orientation	Species	No. seals (based on August counts)		NMPi Breeding Colony (Grey seal)
			Harbour seal	Grey seal	
Helliar Holm North and Elwick	40km north	Harbour seal	21	13	No
Linga Holm	43km north east	Grey seals	1	347	Yes
Little Green Holm	43km north east	Grey seals	8	20	Yes
Muckle Green Holm	44km north east	Grey seals	0	5	Yes
Taing Skerry and Grass Holm	44.8km north	Harbour and grey seals	6	87	No
Odness	46km north east	Harbour and Grey seals	25	95	No
Little Linga	46km north east	Grey seals	3	27	Yes
Sty Taing	46km north east	Grey seals	0	0	Yes
Gairsay	46km north	Grey seals	0	0	Yes
Holm of Rendall	47km north	Harbour and Grey seals	28	6	No
Damsay and Holm of Grimbister	47km north west	Harbour and Grey seals	63	28	No
Sweyn Holm	48km north	Harbour and Grey seals	4	0	No
Holms of Spurness	48km north east	Grey seals	0	100	Yes
Holm of Huip	48km north east	Grey seals	0	214	Yes
Seal Skerry (Eday)	48km north east	Harbour and Grey seal	0	612	No
North end Mill Bay	49km north east	Harbour and Grey seal	10	44	No
South East Egilsay	51km north	Harbour and Grey seal	2	19	No
Rusk Holm	53km north east	Grey seal	0	0	Yes
Calf of Eday	54km north east	Grey seal	0	55	Yes
Egilsay North	56km north	Harbour and Grey seal	4	61	No
Holm of Scockness	56km north	Harbour Seal	20	22	-
Costa and Burgar	57km north west	Harbour and Grey seal	20	3	No
Eynhallow and Westside	58km north west	Harbour and Grey seal	77	88	No
South Westray	58km north east	Grey seal	0	0	Yes
Skerry of Wastbist	60km north east	Harbour and Grey seal	52	47	No
Spo Ness to Ness of Brough	67km north	Harbour and Grey seal	6	3	No

Seal Haul Out Name	Distance* and Orientation	Species	No. seals (based on August counts)		NMPi Breeding Colony (Grey seal)
			Harbour seal	Grey seal	
Holm of Papa Westray and North Wick	70km north	Harbour and Grey seal	22	206	No
Dunbeath-Wick	75km south	Grey seal	0	0	Yes
South North Ronaldsay	73km north east	Harbour and Grey seal	121	202	No
Narr Ness	77km north	Harbour and Grey seal	14	0	No
Seal Skerry (North Ronaldsay)	79km north east	Grey seal	0	612	No
Dunbeath-Helmsdale	90km south	Grey seal	-	-	Yes
Eilean nan Ron (Tongue)	93km south west	Grey seal	-	-	Yes
Kyle of Tongue Sandbanks	100km south west	Harbour and Grey seal	-	-	No

*Data not provided for those sites with ‘No. seals’ equating to ‘–‘