

Dales Voe – Capital Dredging Seal Risk Assessment



February 2026

CONTROL SHEET

Client: Arch Henderson
 Project Title: Dales Voe
 Report Title: Seal Risk Assessment
 Document number: 15619
 Project number: 679000

Issue Record

Issue	Status	Author	Reviewer	Approver	Issue Date
1	FINAL	JEP	GN	DF	09/10/2025
2	DRAFT V2	JEP	GN	GN	05/11/2025
3	FINAL V3	JEP	GN	IB	16/12/2025
4	FINAL V4	JEP	GN	GN	09/02/2026

EnviroCentre Limited Office Locations:

Glasgow

Edinburgh

Inverness

Banchory

Registered Office: Craighall Business Park 8 Eagle Street Glasgow G4 9XA

Tel 0141 341 5040 info@envirocentre.co.uk www.envirocentre.co.uk

This report has been prepared by EnviroCentre Limited with all reasonable skill and care, within the terms of the Contract with Arch Henderson ("the Client"). EnviroCentre Limited accepts no responsibility of whatever nature to third parties to whom this report may be made known.

No part of this document may be altered without the prior written approval of EnviroCentre Limited.

EnviroCentre Limited is registered in Scotland under no. SC161777.

VAT no. GB 348 6770 57.



EXECUTIVE SUMMARY

EnviroCentre Limited was commissioned by Arch Henderson to undertake a Seal Risk Assessment (SRA) to inform pretreatment drilling and blasting in relation to Dales Voe dredging works. The proposed capital dredging works are driven by an urgent requirement to improve navigational safety through the harbour due to ever increasing vessel size and number being experienced in the port.

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. There is a clear decline in harbour seal populations based on reviews of data over the years. Although no evidence for coastal developments or vessel movement have been identified as factors contributing to the decline, these can't be ruled out as contributing to declines directly or indirectly.

A review of available resources assessing underwater noise impacts of blasting and findings from similar projects was used to inform and assess likely Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) and general disturbance ranges for seals as a result of blasting, dredging and drilling works required for this project. Blasting PTS ranges are considered to be within 1000m for a MIC of <50kg, with dredging PTS ranges likely to be up to 270m and TTS 1840m. Drilling is not considered to result in dB levels causing PTS or TTS. Mitigation via Marine Mammal Observer and Passive Acoustic Monitoring (PAMs) (potential use of Acoustic Deterrent Devices (ADD), where necessary) and implementing an adaptive management trial drilling and blasting programme ahead of works with MMO monitoring zones at 500m and 1000m, will be implemented to reduce risks.

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 6.5km radius buffer for disturbance has been applied, which is identified as an appropriate buffer from Subacoustech calculations, in conjunction with the latest density data for at sea usage, to quantify the number of individuals that may be disturbed as a result of drill and blast works. Quantitative data identified a total of 25 grey seals and 69 harbour seals at sea within the disturbance area of the drill and blast works. The 6.5km is considered a 'worst case' scenario based on MIC of 50kg being used. As telemetry studies show no strong connectivity between the site and the SACs, the potential for disturbance is considered to be limited and no adverse impacts to SAC populations are predicted.

Seals are considered to be more easily disturbed when on land. Although the nearest haul out site is 500m from the disposal area, the works area for dredging, drilling and blasting are located 5km away, thus noise sources at that distance would unlikely transfer from the underwater environment to the terrestrial environment. It is recommended that vessels should stay at least 100m away from seals when on land to avoid disturbance, however vessel movements associated with the dredge disposal site will be 500m from the haul out site providing five times this distance and the Lerwick disposal grounds have been utilised for historic dredge spoil disposal thus seals associated with this haul out site are likely habituated to vessel movements in this area.

Due to protocols, controls and mitigation outlined in section 5 required to be implemented during works, it is considered unlikely that seals will be negatively impacted at a population level from works associated with the Dales Voe project.

Contents

Executive Summary	i
1 Introduction	1
1.1 Terms of Reference	1
1.2 Background	1
1.3 Report Usage	1
1.4 Project Overview.....	2
2 Methods.....	10
2.1 Baseline.....	10
2.2 Calculating Permanent and Temporary Threshold Shift.....	11
2.3 Calculating General Disturbance.....	12
2.4 Effects of Increased Vessel Movement on Seals	13
2.5 In-Combination Effects.....	13
2.6 Disclaimer	13
3 Baseline	14
4 Results and Assessment	25
4.1 Calculating PTS and TTS	25
4.2 Calculating General Disturbance.....	31
4.3 Effects of Increased Vessel Movements on Seals.....	34
4.4 Conclusion.....	35
4.5 In-Combination Effects.....	36
5 Marine Mammal Mitigation Plan.....	40
5.1 Marine Mammal Observation Protocol	40
5.2 Marine Mammal Observer.....	40
5.3 MMO Equipment.....	41
5.4 MMO Protocol.....	42
5.5 Acoustic Deterrent Device Protocol.....	43
5.6 Vessel Movement Mitigation Protocol.....	44
5.7 Additional Good Practice Recommendations	44

Appendices

- A Site Location and Dredge Disposal Site
- B Seal Sightings During Vantage Point Bird Surveys for Dales Voe 2023-2025
- C Seal Haul Out Sites
- D Subacoustech Report

Figures

- Figure 1-1: Example blast pattern previously used at Lerwick Harbour dredge campaign in 2008 and during Holmsgarth Pier Development in 2018 obtained from the drilling and blasting method statement provided by the contractors..... 6
- Figure 1-2: Annual average vessel density based on vessel Automatic Identification System (AIS) data. The basemap showing the location of Dales Voe is shown above, with the vessel density below, and approximate location of works indicated by blue circle. 8
- Figure 3-1: August haul out density of grey seals around the UK by 10km squares based on the most recent available haul out count data collected up until 2023. Map obtained from SCOS 2024. 15
- Figure 3-2: Map from Carter et al 2025, showing tracking data for seals hauling out in Scotland. Data are coloured by habitat preference region. Data shown are raw locations and not at a consistent temporal resolution..... 16
- 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). 17

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..... 19

Figure 3-5: August haul out density of harbour seals around the UK by 10km squares based on the most recent available haul out count data collected up until 2023. Map obtained from SCOS 2024. ... 20

Figure 3-6: Map from NatureScot showing 10km wide buffer areas up to 50km around the two harbour seal Special Areas of Conservation (SACs) associated with Shetland. These buffer areas are based on at-sea distances from intertidal areas within the SAC..... 20

Figure 3-7: Map from Carter et al 2025 showing Tracks of 26 harbour seals tagged in Shetland. Maps show seals tagged in (a) Southeast Shetland (n = 15), and (b) Yell Sound (n = 9). Black dots show haul out locations. 21

Figure 3-8: 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). 22

Figure 3-9: Graph Obtained from NatureScot Research Report 1256, Showing Harbour seal counts in the Mousa SAC and in 10km wide buffer areas extending up to 10, 20, 30, 40 and 50km from the SAC 23

Figure 4-1: Example of drilling noise band levels. Data from various drills, diameter 0.1-1.2 m and various rock types. Figure obtained from Irwin Carr UWNM report for Hatston..... 26

Figure 4-2: Shows the SPL_{peak} measurements against MIC size, normalised to 1000m with seal instantaneous PTS threshold marked (223 dB SPL_{peak}, as per NMFS, 2024 threshold). Figure obtained from Subacoustech report 28

Tables

Table 1-1: Summary of Dredge Volumes and Depths..... 3

Table 3-1: Seal Haul Out Sites..... 24

Table 4-1: Predicted significance of effects from underwater noise from dredging. Information obtained from AHEPES 25

Table 6-2: Assumed swim speeds of species and time to swim 1km 30

Table 4-2: Behavioural thresholds for underwater explosives, NMFS (2025) and predicted impact ranges. Note these use the NMFS (2024)⁶ marine mammal weightings and linked thresholds, dB re 1 µPa²s 32

Table 4-5: Individuals Impacted (General Disturbance)..... 32

Table 4-6: Projects identified with potential for in-combination effects 37

1 INTRODUCTION

1.1 Terms of Reference

EnviroCentre Limited was commissioned by Arch Henderson to undertake a Seal Risk Assessment (SRA) to inform pretreatment drilling and blasting in relation to Dales Voe dredging works. The proposed capital dredging works are driven by an urgent requirement to improve navigational safety through the harbour due to ever increasing vessel size and number being experienced in the port.

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 activities.

1.2 Background

A dredging & sea deposit licence is in place for capital dredging at Dales Voe (Ref MS-00011213) – the permitted volume is 168,000 wet tonnes.

Phase 1 of the dredging was carried out from July – September 2025 to remove all soft material using a trailer suction hopper dredger (TSHD) and backhoe dredging (BHD). Approximately 46,288m³ of material has been removed.

Since the original dredging campaign was planned, the appointed dredging contractor has put forward a method to over-dredge to ensure that the depth required for safe navigation is achieved. The dredge area is unchanged.

The volume remaining to be dredged under Phase 2 is approximately 31,808m³ of rock. This updated SRA supports a request to vary the existing marine licence to include drilling and blasting to remove the remaining rock.

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.

Whilst the Client has a right to use the information as appropriate, EnviroCentre Limited retains ownership of the copyright and intellectual content of this report. Any distribution of this report should be managed to avoid compromising the validity of the information or legal responsibilities held by both the Client and EnviroCentre Limited (including those of third-party copyright). EnviroCentre Limited does not accept liability to any third party for the contents of this report unless written agreement is secured in advance, stating the intended use of the information.

EnviroCentre Limited accepts no liability for use of the report for purposes other than those for which it was originally provided, or where EnviroCentre Limited has confirmed it is appropriate for the new context.

1.4 Project Overview

Since the original dredging campaign was planned, the appointed dredging contractor has put forward a method to over-dredge to ensure that the depth required for safe navigation is achieved. The volume remaining to be dredged under Phase 2 is approximately 31,808m³ plus an over dredge of rock. Revisions include the below and are shown in Appendix A:

1. Pre-treatment of hard rock strata using drilling and blasting over no more than 2.5 weeks, including contingency time for any delays due to weather or marine mammal presence and drilling may be undertaken 24 hours a day, seven days a week.
2. Larger vessels are proposed to reduce return trips to the designated dredge disposal site from 24 / day previously assessed down to 5 per day.
3. Contingency over dredge volume allowance based on contractor's methods that may not all be required (current contingency allowance of 29,000m³ has been calculated).
4. While the dredging duration remains unchanged, dredging may be undertaken partly in winter.

Dredged materials will be disposed of at the nearest existing licensed sea disposal site (FI080) for LPA, which is approximately 350m offshore north of Bressay (centre point approximately OSGR HU 48277 45111), hereafter referred to as the 'disposal site'. The disposal site is located in naturally deep water with ease of access, has a large capacity with a footprint of 145,000m² in 30m of water and is anticipated to be active for the foreseeable future.

It should be noted that the dredging works at Dales Voe will be undertaken under the same contract as the dredging works at North Harbour. The current intention is to undertake the dredges consecutively with North Harbour completed first and then Dales Voe, over a period of 11 weeks.

The works area is noted in Appendix A and is located on the Dales Voe - seawater inlet to the northwest of Lerwick, Shetland. The proposed work area covers approximately 4.91 ha/ 0.0491km².

1.4.1 Construction Methodology

Capital Dredging

The contractor completed Phase 2A Backhoe dredging works in Dales Voe on 8th October 2025 with the pre-survey paid volume above design = 78,097m³, interim survey volume above design = 31,809m³ and total Dales Voe dredge contract complete to date= **59.27%**

The current dredging campaign is now awaiting Marine Directorate / NatureScot assessment of the required final drill and blast (D&B) dredging campaign to complete dredging down to design levels using agreed methods and mitigation.

On completion of the drilling and blasting, dredging will be undertaken using BHD methods to remove blasted material from the seabed. The dredged material will be transferred to a split hopper barge. This material will then be deposited at the disposal site.

A Dredging Best Practicable Environmental Option Report (BPEO)¹ has been produced for the proposed development, informed by sediment sampling at both the Dales Voe dredge site and the disposal site. Samples from Dales Voe were noted to be largely either sand (23% to 92%) or gravel (2% to 37%) sized fractions with limited silt fractions recorded. Silt sized particles ranged from 2% to 12% in samples submitted for analysis. The BPEO included with the original application confirmed volumes in m³ and the table below shows these together with additional volumes from the proposed

¹ EnviroCentre (2024). Dales Voe and Lerwick Harbour North Best Practicable Environmental Option. Document number 14356.

revised dredging, together with a further contingency allowance for any over dredge due to specific dredging techniques:

Table 1-1: Summary of Dredge Volumes and Depths

Dredge Area	Dredge Volume (m³)	Target Dredge Depth (m below Chart Datum)
Dales Voe -12.5 / -14.5m CD	42,044	-14.6
Dales Voe -16.5m CD	34,363	-16.5
Dales Voe Total Volume	76,407	
Additional Material		
Over Dredge (est. 500mm ave.)	29,000	
Dales Voe Total Volume (Revised)	105,407	

Due to the majority of the dredge material being of a coarse nature, plumes generated as a result of the dredging works will be very localised and short term in duration, and any sands and gravels lost to the water column during dredging will fall out of suspension quickly at both the dredge and disposal sites. The disposal site is a sacrificial disposal ground with a large footprint, and as such there is considered to be an allowance for some lateral dispersal of materials within the area of disposal over time due to sites typically being dispersive, rather than retentive.

The BPEO report concluded that one sample contained levels of contaminants above Marine Directorate Revised Action Level (RAL) 1 for Polycyclic Aromatic Hydrocarbons (PAH), but there were no exceedances of RAL2. Despite this, assessment of the key receptors identified from the Water Framework Directive assessment for estuarine and coastal waters concluded there is a low risk of the sediments impacting upon the overall ecological or chemical status classifications. The levels of contaminants encountered are typically within levels accepted for sea deposit of dredged material. Additionally, the contaminant levels recorded in the sediment are not considered likely to have a significant adverse impact once placed within the disposal site.

It is noted that the Lerwick disposal grounds have been utilised for historic dredge spoil disposal and water quality classification for chemical status of the waterbody which accommodates the disposal grounds was classified by SEPA as “good” in 2022². On this basis, the associated risk with degradation of water quality directly associated with the proposed disposal is considered to be very low i.e. unlikely to cause a change in the status of the waterbodies in question at both the dredge and disposal sites.

Drilling and Blasting

Rock that could not be directly dredged during Phase 1 using a backhoe or trailer dredger, either because of rock strength or low fracture rate will require pre-treatment using drill and blast methodologies. The drilling and charging will continue on a 24 hours a day, 7 days a week basis.

Drilling and blasting will occur from a specialist drill platform, ‘Rockmate’ equipped with two marine drill tower units. The ‘Rockmate’ is 41m x 18m and utilises four spud legs (avoiding the requirement for anchor spread).

Drilling

To determine the starting position of the ‘Rockmate’ a drill/blast location will be determined in a less sensitive area to gather information on vibration and underwater noise impact. Drilling will start at the

² <https://map.environment.gov.scot/sewebmap/>

minimum rock layer depth meaning the explosive placed into the hole can be reduced, so the Maximum Instantaneous Charge (MIC) will also be small.

The drill pattern will vary between the areas based on design thickness, rock strength and locality to structures. The space between drill points will vary from 2.0m-5.0m, covering approximately 4m² to 20m² for each drill point. The drill pattern will be adjusted as required. Drilling will extend up to 2m below design to ensure the later dredging can fully remove the rock to the required design level and to reduce the number of pinnacles created during the blasting operation. Drill holes can vary in diameter from 85mm to 165mm. To ensure that the blasting extends over the full dredge area, it will be necessary to drill up to 1-2m beyond the planned extents of the dredge area.

Blasting

Offshore Kemiitti Explosives, a liquid explosive, with packaged boosters and detonators, will be used for the works. These explosives are specifically tailored to be used in underwater rock blasting. In addition, provision for EXEM 100 50mm diameter packaged emulsion provided by Explosives and Pyrotechnic Consultants (EPC) for required controlled works to manage MIC weights and thus controlling vibration as required.

Trial blasting is required to ascertain the site parameters for vibration predictions. Initial trial blasting will be carried out as part of the production, but with charged levels reduced to ensure vibration levels at nearby structures stay below the normal operational safe limits. Several trial blasts over the first days will be used to take these trial measurements.

A warning signal (both aural and visual) will be emitted several minutes before the blast, and the area checked visually for the presence of swimmers, divers, vessels, mammals, etc. in good time.

A typical example of a blast warning procedure is:

- The local VTS and other specified parties will be informed 60 minutes prior to planned blasting.
- Ten minutes before blasting: - Relevant parties will be informed by radio and/or phone.
 - A blasting control vessel equipped with red flag will depart the 'Rockmate' to patrol the designated safety area. An additional fast craft vessel will be available to encourage birds out of the works area, only if/ when the Marine Mammal Observer (MMO) has confirmed an absence of marine mammals within the mitigation zone (as detailed in section 5).
 - Acoustic Deterrent Devices (ADDs) will also be available on site but will only be used if persistent issues arise with marine mammal species converging into or not leaving MMO area just prior to a blast. ADD will only be deployed when the MMO has confirmed here are no marine mammals within the PTS zone for marine mammals (as detailed in section 4 and 5).
 - VTS will be contacted to obtain all clear to blast (vessel traffic, divers etc.)
- The supervisor onboard will make a visual check of the area and obtain confirmation from the blasting control vessel that everything is correct.
- Upon receipt of clearance short sound signals will be given, and the blast will be initiated after the last signal.
- After successful blasting one long sound signal will be given, and the relevant parties will be informed on the radio that blasting is completed.

The use of bubble curtains has currently been discounted as it would be extremely challenging to deploy them effectively in open water and with the presence of the existing heavy vessel traffic, for

individual blasts at different locations. A NatureScot report (2019)³ completed a review of noise abatement systems for offshore wind farm construction noise, and the potential for their application in Scottish waters concluded that 'big bubble curtains' are effective for prolonged piling of large wind turbines, however, the evidence is mixed for blasting⁴. In addition, the report also acknowledges the significant logistical challenges and high costs of deploying them for individual blast locations. Furthermore, during the works at the Aberdeen South Harbour project, where double bubble curtains were implemented as mitigation, the programme was to undertake one blast a day, but only 12 blasts were carried out in 96 days, primarily due to the presence of seals in the mitigation zone for hours at a time, and/ or adverse weather conditions and operational issues preventing the bubble curtain from being operated effectively. As a result, blasting was abandoned, and instead, the rock was able to be removed by backhoe dredging⁵.

The quantity of explosives in each hole will be dependent on the layer of rock and findings from trial blasting, which will start at MIC 20kg and work up in small increment whilst monitoring noise levels at 500m and 1000m (as agreed and identified in trial blasting, see Section 1.5.2 for further details).

Charges will go off at the beginning and end of each day (during daylight). Blasting is expected to occur over a duration of 2.5 weeks at Dales Voe, weather dependent, and may be undertaken partly in winter.

As part of an overall mitigation of blast noise impact intensity then the contractor is proposing to use 25 millisecond blast delays between each charged hole to help minimise the MIC / Qmax value for each overall blast. It estimated that 9-90 holes will be drilled for each field. A sample blast design calculation is detailed in See Figure 1-1. It shows a drill pattern with a typical overall total charge weight of 980Kg over 30 holes, but with blast delays resulting in an MIC/ Qmax value of 70Kg. This individual blast hole charge delay method was previously used at Lerwick Harbour dredge campaign in 2008 and during the Holmsgarth Pier Development in 2018.

³ Verfuss, U.K., Sinclair, R.R. & Sparling, C.E. 2019. A review of noise abatement systems for offshore wind farm construction noise, and the potential for their application in Scottish waters. Scottish Natural Heritage Research Report No. 1070.

⁴ This report refers to blasting from detonating UXOs, rather than blasting in the same respect as this project, so although some differences, the theory is considered relevant.

⁵ It has been demonstrated that the remaining material to be removed at Dales Voe cannot be excavated using a backhoe dredger.

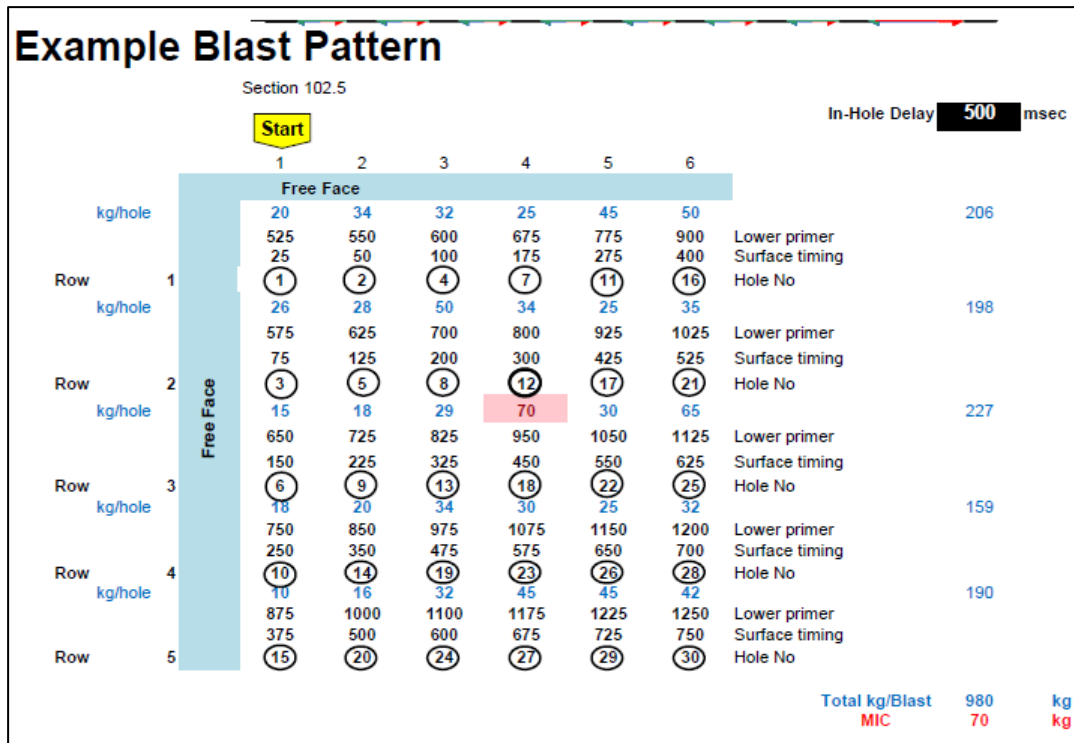


Figure 1-1: Example blast pattern previously used at Lerwick Harbour dredge campaign in 2008 and during Holmsgarth Pier Development in 2018 obtained from the drilling and blasting method statement provided by the contractors

1.4.2 Trial Blasting

Underwater noise monitoring

In order to record impulsive noise in the field and assess relative to the above MMO mitigation zones then the following method is proposed to be undertaken by a specialist underwater acoustic noise contractor during a programme of trial blasts leading onto the main drilling and blasting campaign in order to have confidence that suitable and practical MMO distance is used.

During trial blasting, charges will be increased at 2 kg increments until close to the AUD INJ threshold for harbour porpoise (the marine mammal with the most sensitive hearing range considered to be within waters associated with the site location) at 1000m from the blast, or 30kg, whichever comes first. If 30kg is reached, further discussions with NatureScot will be undertaken to agree on the procedure for the remainder of the trial to ensure the AUD INJ threshold isn't exceeded. Until agreement is reached, blasting would continue without increasing MIC.

In order to monitor underwater noise levels during blasting, measurements of blast noise will be recorded simultaneously at locations of 500m and 1000m from the trial blast centre in a direction north of blast. The trial test blast locations will be determined in a less sensitive area to gather information on vibration and underwater noise impact. The objective is to ensure that all recording stations lay along a direct line-of sight transect commencing at the blast field.

Two boats will be used during the drilling and blasting trials with hydrophones capable of detecting marine mammals. The provided vessels must go dead ship (engines and depth sounders switched off) and drift for a short duration for each trial blast to enable high quality data capture from the blast events.

If at any time during the D&B dredging works, there are issues with marine mammals converging inside the agreed MMO distance, then an ADD will be available on site and deployed on the above boats to encourage marine mammals to leave the area ahead of the blast. The ADD is essentially a transducer on the end of a 50m cable connected to a topside unit with only a single switch to turn the device on or off. A back-up spare device will be deployed on each boat.

Blasting will not take place when the weather and sea state affects the efficiency of the MMO and mitigation measures.

Prior to each blasting schedule, a specialist noise survey team will liaise with the Boskalis Westminster Ltd blasting engineers to ensure that two survey vessels are on the 500m and 1000m lines in good time. Noise data, that is collected at each recording station over durations ranging from a few minutes to one hour or more will be recorded to provide general background noise, which can be calibrated and used in the data acquisition system to provide a standardised noise level against which all subsequent measurements would be compared, and the blast noise itself.

In addition to the noise data, the specialist noise survey team will also collate log sheets indicating which blast field was being drilled; the numbers of boreholes prepared, the numbers of charges that were successfully detonated, the state of weather and tide; and any other sources of noise that were present in the area from time to time. All data will then be made available for subsequent data processing and analysis.

Analysis and reporting

The noise data will be supplied as voltage-time series in one or more .WAV files. Subsequently, a calibration adjustment factor related to the ratio of the output signal amplitude to the input signal amplitude will be applied to the blast wave data.

Two boats will be used during the drilling and blasting trials with hydrophones (Passive Acoustic Monitor (PAM)) capable of detecting marine mammals at 500m and 1000m.

The blast data will then be converted into a pressure-time series after taking into account the hydrophone frequency sensitivity; the terminal unit gain settings; and calibration factor. The maximum amplitude of each blast event is then transcribed to give the peak blast level at each station distance. The rms value is then ascertained over each time duration. From the positional data contained within both Boskalis Westminster Field Contractor's Log and the special monitoring contractors log, the distance between the blast site and each recording station is determined.

Summaries of the peak and rms noise levels at each station are then established.

Results will then be shared with MD-LOT and NatureScot with recommendations on final practical MMO distances and impulsive noise limits for marine mammals to avoid temporary and permanent noise-induced threshold shifts; TTS and PTS. Additional mitigation actions will be outlined if PTS are outside the mitigation zones.

Marine mammal detection

The project will provide visual MMOs and the requirement for marine mammal vocalisation detection would also be required via the inclusion of a PAM during trial works and project works.

To comply with Joint Nature Conservation Committee (JNCC) guidelines, the PAM system will be operated by an experienced PAM operator. The PAM operator will be responsible for deploying the vertical PAM system and documenting all PAM actions, including deployment times and detection records.

1.4.3 Vessel Movements

Current Vessel Movement

Given that Dales Voe is already part of an established port, the baseline level of vessel movements is relatively high in and around the proposed works. The annual average vessel density for all vessel types, within the vicinity of the site, shows vessel densities ranging from 0.5->100, as shown within Figure 1-2 with the image taken from the National Marine Plan Interactive (NMPi) map⁶.

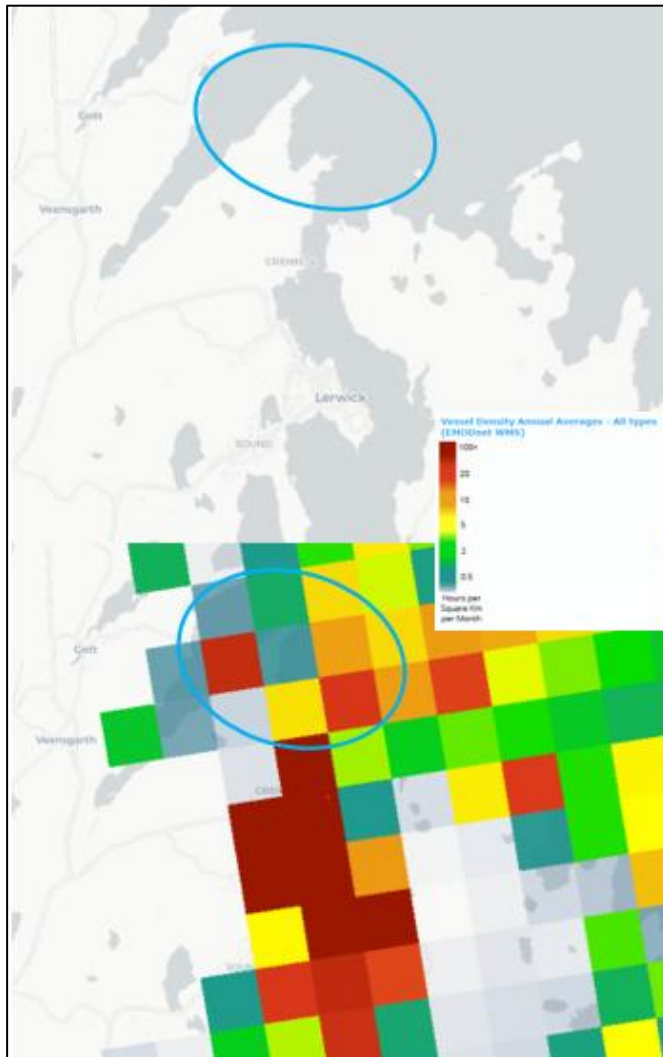


Figure 1-2: Annual average vessel density based on vessel Automatic Identification System (AIS) data. The basemap showing the location of Dales Voe is shown above, with the vessel density below, and approximate location of works indicated by blue circle.

During Works

Dredging

The dredging works will include associated vessel movements with the dredging itself and then barges moving between the dredge site and the disposal site.

⁶ Marine Scotland (2024). Vessel Density Annual Averages - All types (EMODnet WMS) NMPi Map. Available at: <https://marinescotland.atkinsgeospatial.com/nmpi/default.aspx?layers=1972> (Accessed September 2025)

Movements associated with the drill and blast campaign are approximately a maximum of four to five barges per 24 hours throughout the overall final D&B / dredging period. Therefore, total vessel movements in Dales Voe to complete the dredging area is approximately 30 to 45 barge transits over 2.5, weeks depending on final over dredge quantities.

The vessel route is expected to run from the dredge location adjacent to the Dales Voe base, north east out of Dales Voe, before then heading southeast towards the disposal site off the north coast of Bressay. The vessel route is approximately 4.5km long.

Drilling and Blasting

The explosives will be delivered in 75 tonne loads by coaster to Lerwick, taking station at one of the three Dangerous Goods anchorages specified by Lerwick Port Authority. Two vessel movements are proposed to facilitate this.

Once the area requiring pre-treatment has been established, the 'Rockmate' will be towed to the location and positioned using the onboard RTK/ DGPS positioning equipment.

2 METHODS

2.1 Baseline

In order to anticipate the potential marine mammal ecological sensitivities at the site and assess potential impacts of underwater noise, 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 Shetland region⁷;
- Scottish Marine Animal Stranding Scheme (SMASS) for records of strandings between 2022 and 2024⁸;
- Search of the National Biodiversity Network (NBN) Atlas for records of seals within 10km of the site, which are commercially available and within the past 10 years⁹;
- Review of incidental findings from 2023-2024 bird surveys at Dales Voe¹⁰;
- MS Updated Seal Usage Maps: The Estimated at-sea Distribution of Grey and Harbour Seals¹¹, which includes data obtained from the Sea Mammal Research Unit at St Andrews University¹²;
- NatureScot Aerial surveys of seals in Scotland during the harbour moult season 2016-2019¹³;
- Marine Scotland Regional Differences in the Abundance Trends Amongst Harbour Seal Populations¹⁴;
- Special Committee on Seals (SCOS) reports 2015 to 2022¹⁵;
- Fine-scale harbour seal at-sea usage mapping around Orkney and the North coast of Scotland¹⁶;
- Carter et al (2025) Harbour seal and grey seals: distribution maps for Scotland¹⁷;
- Mousa Special Area of Conservation (SAC) Conservation and Management Advice (2025)¹⁸;

⁷ Sea Watch Foundation Recent Sightings Shetland available at: <https://www.seawatchfoundation.org.uk/recent-sightings/> (Accessed September 2025)

⁸ Species reported within a 10km (sea route) from 2022-2024 to Scottish Marine Animal Stranding Scheme (SMASS) available at: <https://strandings.org/map/> (Accessed September 2025)

⁹ NBN Atlas, available at: <https://scotland-records.nbnatlas.org/explore/your-area#60.2009|-1.1694|11|Mammals> (Accessed October 2025)

¹⁰ ECRep 14755 2023-2024 Winter Breeding bird Surveys (2025)

¹¹ 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 September 2025)

¹² St Andrews Sea Mammal Research Unit, available at: <http://www.smru.st-andrews.ac.uk/> (Accessed September 2025)

¹³ 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 September 2025)

¹⁴ 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 September 2025)

¹⁵ SCOS Reports | SMRU (Accessed September 2025)

¹⁶ Fine-scale harbour seal at-sea usage mapping around Orkney and the North coast of Scotland | Marine Scotland Data Publications (Accessed September 2025)

¹⁷ 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/>

¹⁸ Mousa - Conservation and Management Advice - Final Version (Accessed September 2025)

- JNCC Mousa SAC¹⁹;
- Yell Sound Coast SAC Conservation and Management Advice (2024)²⁰;
- JNCC Yell Sound Coast SAC²¹.
- Subacoustech report for underwater noise generated by drill and blast operations to inform blasting and general disturbance for Lerwick Harbour & Dales Voe²²
- Research by Todd, et al. conducted in Shetland on dredging²³
- Aberdeen Harbour Expansion Project Environmental Statement (AHEPES) underwater noise modelling on dredging²⁴
- Underwater noise modelling undertaken for Hatston²⁵ in Orkney by Irwin Carr

2.2 Calculating Permanent and Temporary Threshold Shift

2.2.1 Underwater Noise Producing Activities

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 Assessing 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 fatigue²⁷.

Although this application mainly only concerns the blasting and drilling elements to support the existing dredging campaign, an element of dredging would be required following drilling and blasting, therefore, all three construction methods are considered.

The hearing groups from the National Marine Fisheries Service (NMFS) 2024²⁸ guidance were used to inform the effects of underwater noise producing activities associated with the project (dredging, drilling and blasting). The NMFS guidance is compiled by collating available scientific literature to produce criteria for the onset of TTS and auditory injury (AUD INJ), which includes, but is not limited to, PTS. This document includes a protocol for the formation of marine mammal hearing groups, including phocid (PW) pinnipeds in water, the derivation of marine mammal auditory weighting functions, and the estimation of AUD INJ onset criteria for impulsive (e.g., airguns, impact hammers, explosives) and non-impulsive (e.g., tactical sonar, vibratory hammers, drills) sound sources.

As no underwater noise modelling has been undertaken for the project, instead a review of existing research and projects with modelling considered to include similar parameters (charge weights,

¹⁹ [Mousa - Special Areas of Conservation](#) (Accessed September 2025)

²⁰ [Yell Sound Coast - Conservation and Management Advice - Final Version](#) (Accessed September 2025)

²¹ [Yell Sound Coast - Special Areas of Conservation](#) (Accessed September 2025)

²² [Subacoustech report P438LR0102](#)

²³ Todd, V. L. G., Todd, I. B., Gardiner, J. C., Morrin, E. C. N., MacPherson, N. A., DiMarzio, N. A., and Thomsen, F. A review of impacts of marine dredging activities on marine mammals. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsu187

²⁴ [Microsoft Word - 01 Introduction to the Proposed Development FINAL.docx](#)

²⁵ RP001 Rv3 2022248 (Hatston Pier UW Modelling)

²⁶ NOAA guidance available at: <http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm> (Access September 2025)

²⁷ JNCC UK Marine Noise Registry: Information Document available at: http://jncc.defra.gov.uk/pdf/MNR_Draft_InfoDoc_V1_20160808.pdf (Accessed September 2025)

²⁸ [2024 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing \(Version 3.0\)](#)

number of blasts, dredging methods, etc.) were undertaken to assess impacts in relation to noise associated with the works and PTS and TTS.

2.2.2 Acoustic Deterrent Devices (ADDs)

ADDs may be used to support works during drilling and blasting, where deemed appropriate. However, due to the nature of ADDs, this can have a negative effect on seals, and therefore a review of existing research in relation to the impacts on seals as a result of the works associated with the development is to be undertaken.

2.3 Calculating General 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 Directorate 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:

Step 1 – Obtaining at sea area of buffer distance for disturbance

Subacoustech provided thresholds alongside the calculated result for a selection of charge weights (with embedded charge correction) for seals.

Step 2: Obtain Seal density

Density values of seals present within the 'at sea' disturbance buffer distance were obtained using data from Carter et al 2025²⁹, which provides density data in 5km x 5km (25km²) for at sea usage. The mean density values³⁰ from the number of 25km² squares which fall within the disturbance buffer are added up and divided by the number of squares used (10 in this case). 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 km².

Step 3: Individuals per km²

The estimated number of individuals per km² is then calculated as the seal density calculated in Step 2 multiplied by the area of the 'at sea' disturbance buffer distance.

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.

²⁹ Carter et al., 2025

³⁰ Due to the caveats associated with population scalars to convert relative to absolute abundances, the paper authors suggest using the relative density estimates. However, the absolute densities provide more accurate estimates of seal density in 2023 specifically and are less robust to changes in abundance in subsequent years (that is known to be occurring). Therefore, absolute densities have been utilised as they are likely to be precautionary considering decreasing numbers of harbour seals, particularly associated with Mousa SAC

2.3.1 Designated Sites

Two SACs designated for harbour seals are considered within the influence of the development site and therefore an assessment in relation to the behavioural impacts as a result of the works associated with the development are to be undertaken. The designated sites to be assessed include:

- Mousa SAC, located 20km south of the site
- Yell Sound Coast SAC, located 28km north of the site

Seal Haul Out Sites

Two seal haul out sites are located within 8km of the development, comprising Holm of Beosetter 500m east (harbour seal and grey seal) and E South Shetland located 7.7km south (harbour seal). Therefore, an assessment in relation to the behavioural impacts as a result of the works associated with the development are to be undertaken in relation to these two sites also.

2.4 Effects of Increased Vessel Movement on Seals

As increased vessel movement has the potential to increase collisions with seals, an assessment of the increase in vessels associated with the works has been undertaken, with a review of relevant resources to inform the assessment.

2.5 In-Combination Effects

A review of the Shetland Islands Council Planning Portal³¹, the MD-LOT portal³² and information provided by LPA was undertaken to identify any projects in the vicinity of the site which may have the potential for in combination effects.

2.6 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.

³¹ <https://www.shetland.gov.uk/planning-applications/view-planning-applications>

³² <https://marine.gov.scot/?q=data/marine-scotland-data-portal>

3 BASELINE

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 Grey Seal

The latest estimate of the UK grey seal population is 129,100 with the Shetland SMU being home to approximately 1% of that (based on the most recent population estimates for grey seal from 2019-2021 for the Shetland SMU of 1009). In 2016-2019 August counts, Shetland has been the SMA with the second lowest grey seal count after Southwest Scotland (however, as with most other areas, counts within Subunits can be very variable). In addition, for Shetland, while there is an indication of a decline in pup production, the August count (the latest count in 2019) shows no trend.

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 Shetland 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 diets³³, in Shetland, sandeels were the greatest prey resource, with gadoids (haddock, cod, whiting) being the second biggest contributor and bullrot also being noted as important (harbour seal diet is yet to be studied in depth).

Recent sightings from Seawatch Foundation in the Shetland region between 13/06/2025 – 18/04/2025 report 11 records of grey seal equating to 17 individuals. SMASS have recorded no records of stranded grey seal within 10km of the site, with a total of 25 for the whole of Shetland.

A search of NBN Atlas returned nine records of grey seal, but none within the proposed works area, and the closest record approximately 1.5km north (location OSGR HU 47207 48861) of the anticipated vessel route between the dredge site and disposal site.

In addition, during Vantage Point surveys at Dales Voe for birds conducted monthly since from October 2023 to September 2025 within 2km of the site, a total of 43 seal sightings were confirmed, 18 of which were grey seal. One sighting of a single grey seal was recorded within the site boundary during the 2024/25 survey season. All other sightings were of lone animals in the water. A plan of the location of seals identified during these surveys is provided in Appendix B³⁴.

A total of 27 designated haul out sites, including four breeding for grey seals (see Appendix C), are present within 100km of the site, with three in the vicinity of the work activities. The nearest seal haul out site from the development site is 500m east (Holm of Beosetter) and the nearest breeding colony is located 69.9km north west (Uyea). Seal haul out data counts for grey seal also show the important association with Shetland, as detailed in Figure 3-1.

³³ http://www.smru.st-andrews.ac.uk/documents/scotgov/CSD3-3_Grey_Seal_Diet_Composition_and_Prey_Consumption.pdf (Accessed September 2025)

³⁴ To note, nine sightings were not digitised, due to not having locations for these on the field maps provided and two were beyond 2km so not included on the plan

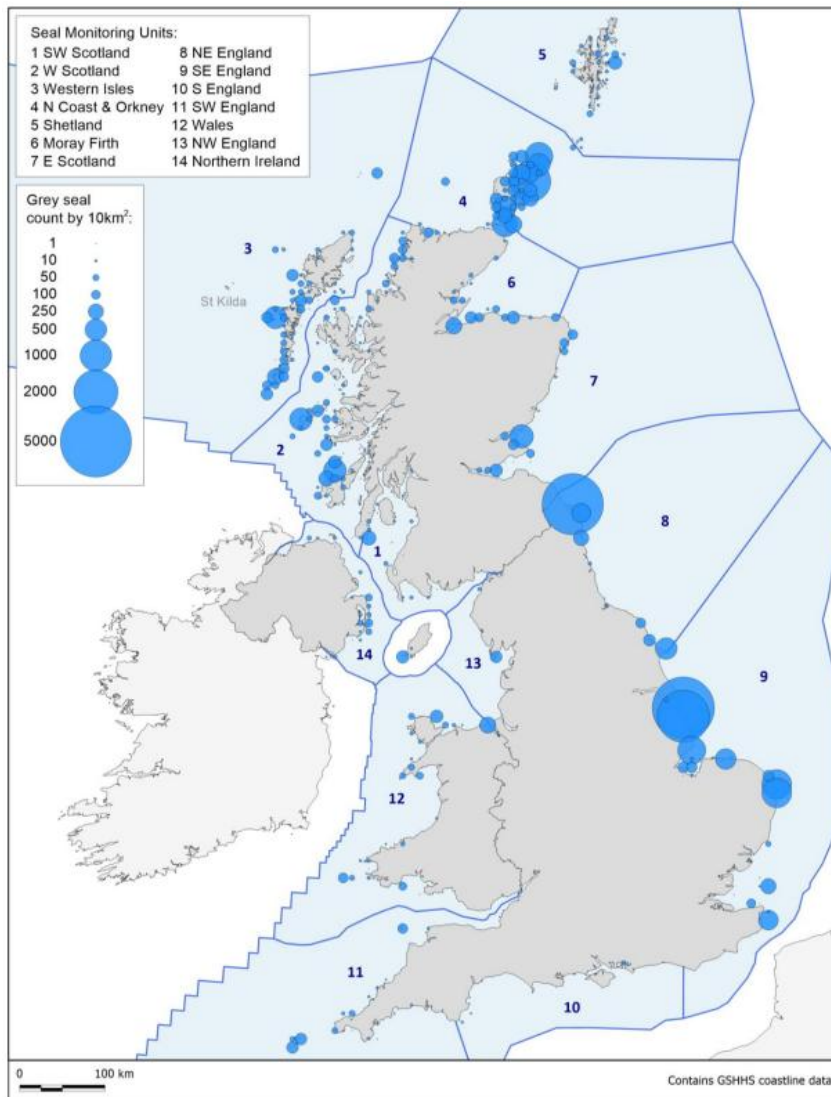


Figure 3-1: August haul out density of grey seals around the UK by 10km squares based on the most recent available haul out count data collected up until 2023. Map obtained from SCOS 2024.

Nine GPS-GSM tags were deployed on grey seals in Shetland in Summer of 2022. Data from the tags deployed on these grey seals in 2022 were combined with existing data from GPS-GSM tags deployed in Scotland and further afield, and models were fitted to discrete habitat preference regions. Habitat preference modelling for grey seals hauling out in Scotland (only trips beginning and ending at haul outs in Scotland shown), shows a lack of grey seals within the site or surrounding waters, as detailed in Figure 3-2.

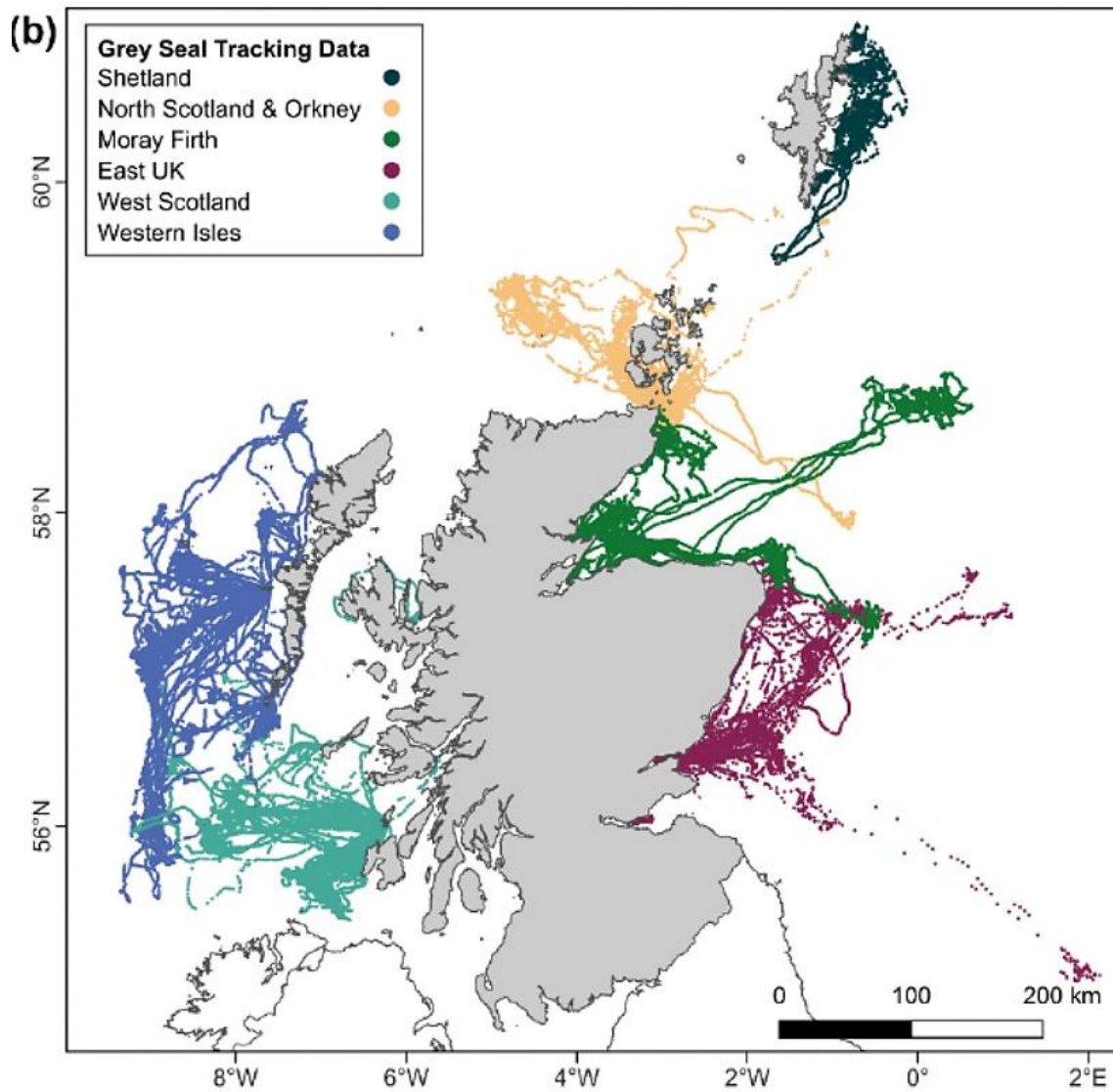


Figure 3-2: Map from Carter et al 2025, showing tracking data for seals hauling out in Scotland. Data are coloured by habitat preference region. Data shown are raw locations and not at a consistent temporal resolution.

Grey seal distribution estimates show the mean number of 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 10-25 individuals per 5km² as detailed in Figure 3-3.

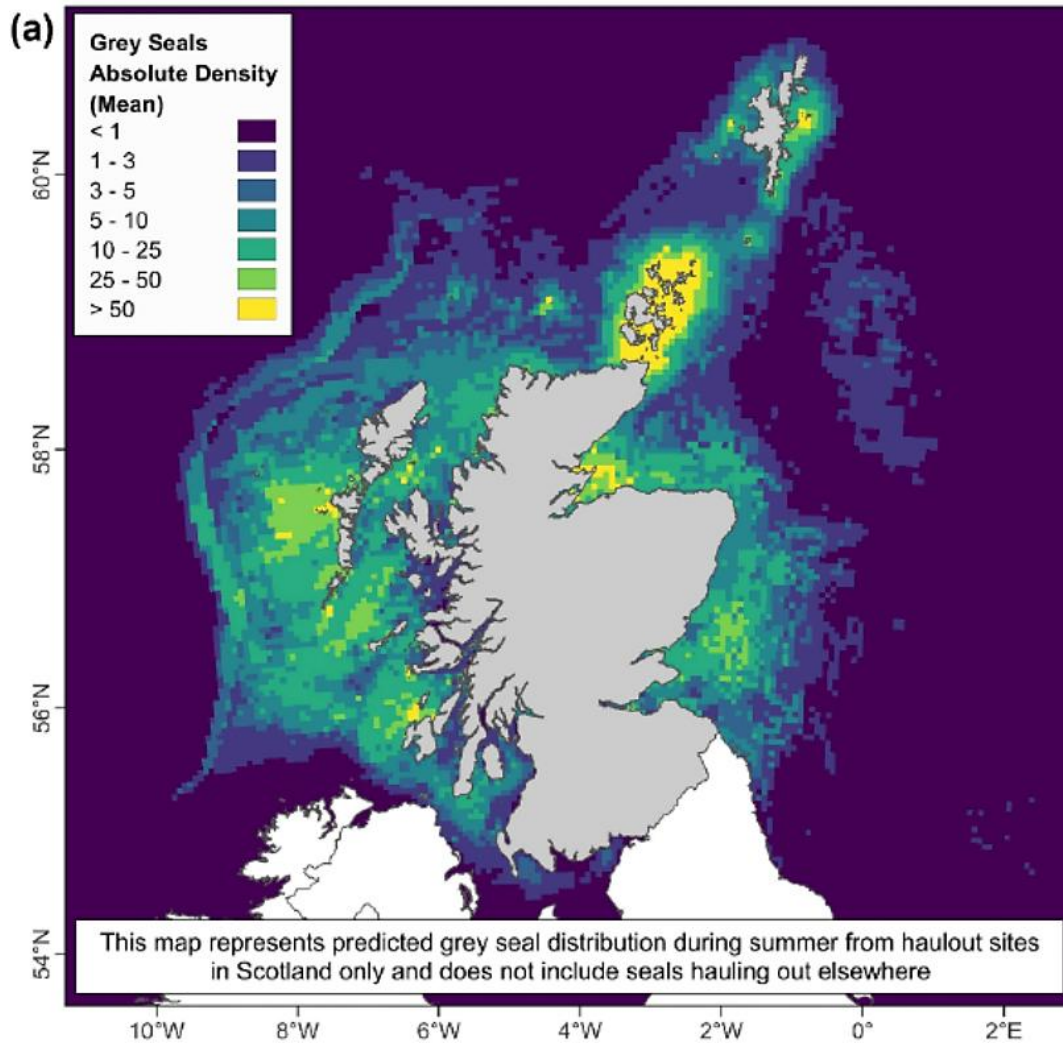


Figure 3-3: Map showing grey seal distribution estimates. The mean number of grey seals estimated to be present in each 5 km by 5 km grid cell at any one time³⁵. Image taken from Carter et al (2025).

The site is not within a designated site for grey seal, and due to activities associated with the existing port, piers and industrial area, it is not considered that the habitat is suitable for use as a breeding or moulting haul out site. However, grey seals may use the coastal waters within and adjacent to the site for commuting between haul outs (including breeding colonies) and/or foraging, however, tracking data suggests this would be limited.

³⁵ The conversion process from relative to absolute density involves use of population scalars derived from telemetry data (see Carter et al. (2022)), and uncertainty in these scalars is not propagated through to the confidence intervals around the mean. Confidence intervals therefore only reflect uncertainty in the modelled habitat preference relationships. Another consideration is that density estimates are scaled using the most recent available count data. While relative density estimates are somewhat robust to changes in abundance (provided the distribution of the population remains the same proportionally among haul outs), the absolute density estimates are not. As such, absolute density estimates provided here reflect an approximation of seal distribution in 2023. Maps of absolute density are shown for ease of interpretation but GIS layers for both absolute and relative density are available.

3.1.2 Harbour Seal

The latest estimate of the UK harbour seal population is 40,525 based on surveys between 2016 and 2023 with the Shetland SMU being home to approximately 8% of that (the most recent population estimates for harbour seal are from 2019-2021 for the Shetland SMU of 3180). Whilst the overall trend for harbour seals within the UK is increasing, there has been a dramatic change in distribution. Shetland is the region that has seen the second largest drop in harbour seal numbers after Orkney. Counts within the Shetland SMU have gone from 5994 in 1997 to 3180 for counts between 2016 and 2019 (a 47% decline), however, are considered to have remained stable over the last ten years, with counts sitting around 3000 each year from 2000 onwards (see Figure 3-4 below), except for numbers of harbour seal associated with SAC Mousa, which have continued to drop.

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 is still no nearer to having a definitive answer³⁶. A range of factors, such as prey quality and availability, exposure to toxins/ harmful algae, climate change, competition for resources and predation from grey seal and killer whale (*Orcinus orca*)³⁷, are currently considered to be the most likely critical drivers³⁸. Although no evidence for coastal developments or vessel movement have been identified, these can't be ruled out as also contributing directly or indirectly to harbour seal decline.

³⁶ Email correspondence from John Baxter on 03/03/2025.

³⁷ Two PhD theses have been submitted that focused on different potential drivers of the decline: 1) grey seal competition and predation and 2) killer whale predation. These analyses suggest that both killer whale predation and grey seal interactions (competition and predation) could be significant contributory factors in the harbour seal decline and/or in the failure of populations to recover in some regions. The outcomes of this research are currently being prepared for publication and further details will be available for SCOS 2025

³⁸ 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 September 2025)

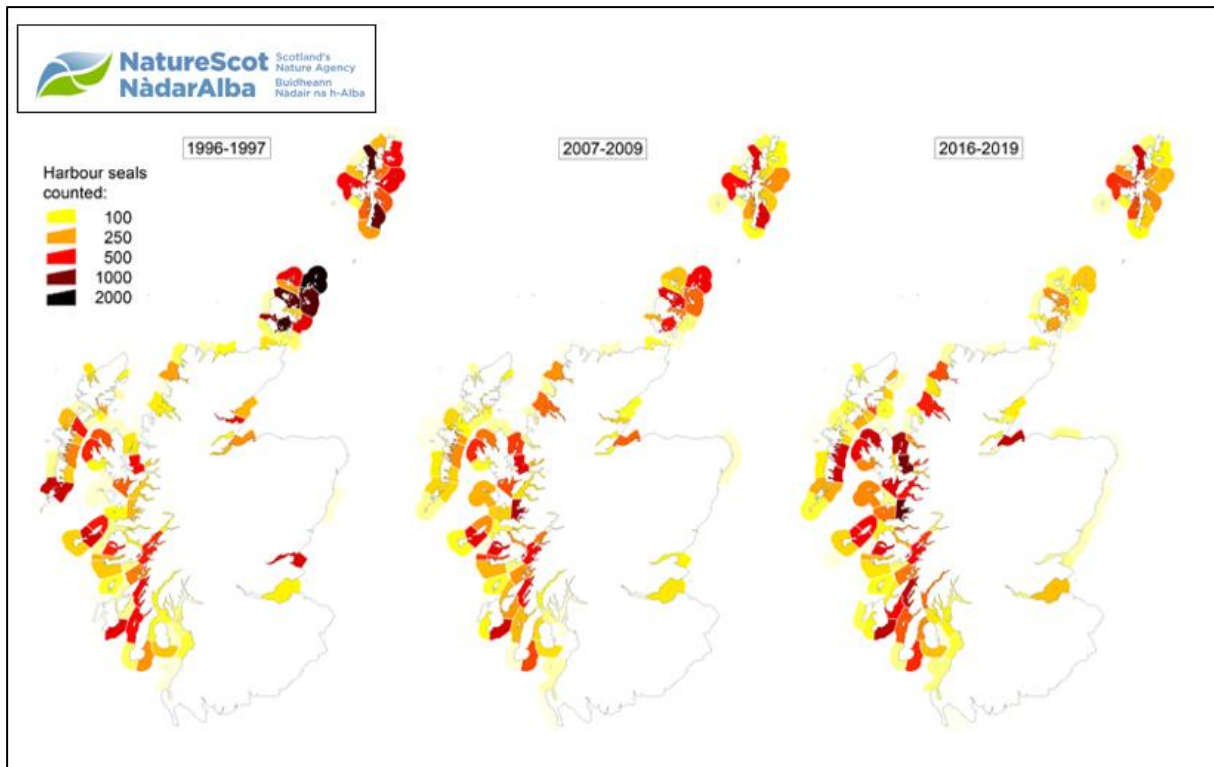


Figure 3-4: Maps showing the number of harbour seals counted during August over three time periods (1996-1997; 2007-2009 and 2016-2019) are detailed in NatureScot Research Report 1256

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. Female harbour seal give birth in June or July, often returning to the haul-out sites where they were born themselves. Harbour seal moult between July and September. These are considered particularly sensitive times for this species.

Recent sightings from Seawatch Foundation in the Shetland region between 13/06/2025 – 18/04/2025 report two records of harbour seal equating to five individuals. SMASS have recorded no records of stranded harbour seal within 10km of the site, with a total of three for the whole of Shetland.

A search of NBN Atlas returned eight records of harbour seal, but none within the proposed works area, and the closest record approximately 245m west (location HU 47100 43840) of the Bressay Sound works area.

In addition, during Vantage Point surveys at Dales Voe for birds conducted over two survey periods (2023/24 and 2024/25) within 2km of the site, a total of 43 seal sightings were confirmed, 17 of which were harbour seal (see Appendix B for locations). One sighting of a single harbour seal was recorded within the site boundary during the 2024/25 survey season. Three of the harbour seal sightings were of two animals together, including hauled out at Califf on the opposite side of the Voe from the site on 21st April 2025. All other sightings were of lone animals in the water. Sightings were spread throughout the year.

A total of 26 designated haul out sites for harbour seal (see Appendix C) are present within 60km of the site, with four in the vicinity of the development activities. The nearest haul-out site for harbour seals is 500m east of the site (Holm of Beosetter). Seal haul out data counts for harbour seal also show

the important association with Shetland, as detailed in Figure 3-5. Two SACs (Mousa SAC located 20km south and Yell Sound Coast SAC located 28km north) with harbour seal being a designated feature are located within 60km of the site. Some individuals may therefore use the coastal waters within and adjacent to the site for commuting between haul-outs and/or foraging. Figure 3-6 shows the swimming distances from SAC haul outs.

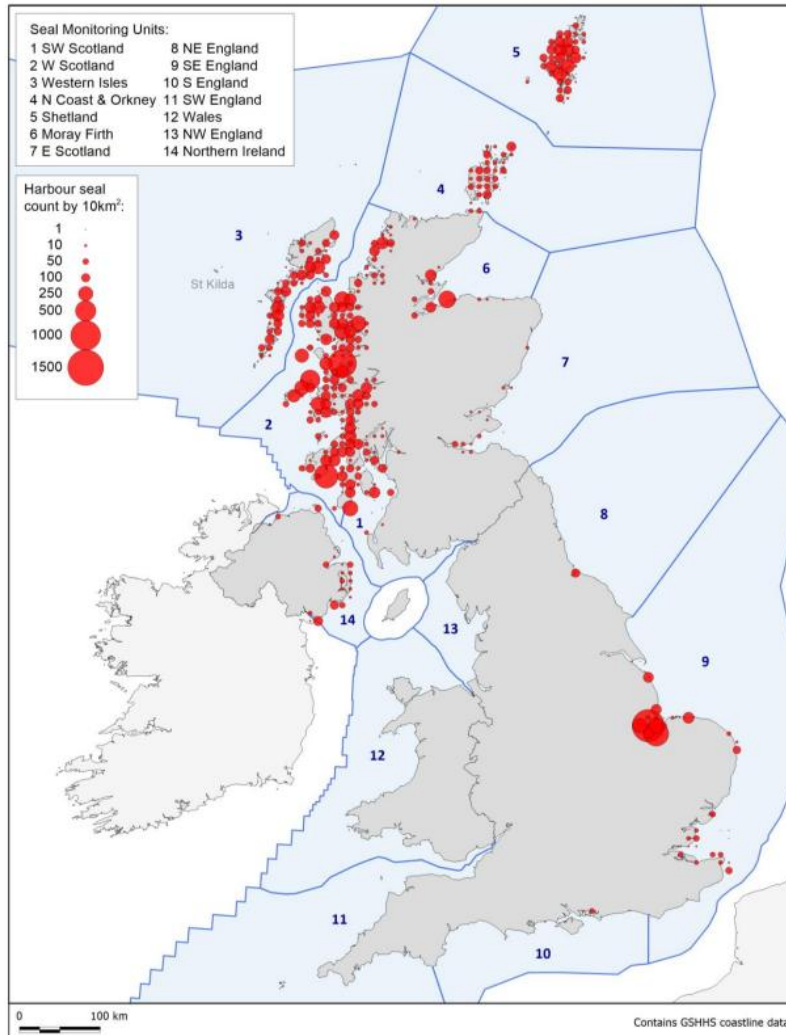


Figure 3-5: August haul out density of harbour seals around the UK by 10km squares based on the most recent available haul out count data collected up until 2023. Map obtained from SCOS 2024.



Figure 3-6: Map from NatureScot showing 10km wide buffer areas up to 50km around the two harbour seal Special Areas of Conservation (SACs) associated with Shetland. These buffer areas are based on at-sea distances from intertidal areas within the SAC.

Records of 26 harbour seals tagged in Shetland (2022) show that seals utilise both coastal and offshore habitats. Tags were deployed in two key areas of interest – Southeast Shetland and Yell Sound – representing the two harbour seal SACs. Given that very few harbour seals are now present in the Mousa SAC, tagging was focused more generally in the surrounding area of Southeast Shetland. The distribution estimates for harbour seals in Shetland reflect a tight coastal distribution, potentially due to a landscape of fear effect attributable to the presence of killer whales, with killer whales observed preying on seals year-round in Shetland. It is notable that limited harbour seals were recorded within the site or the waters surrounding the site, as detailed in Figure 3-7

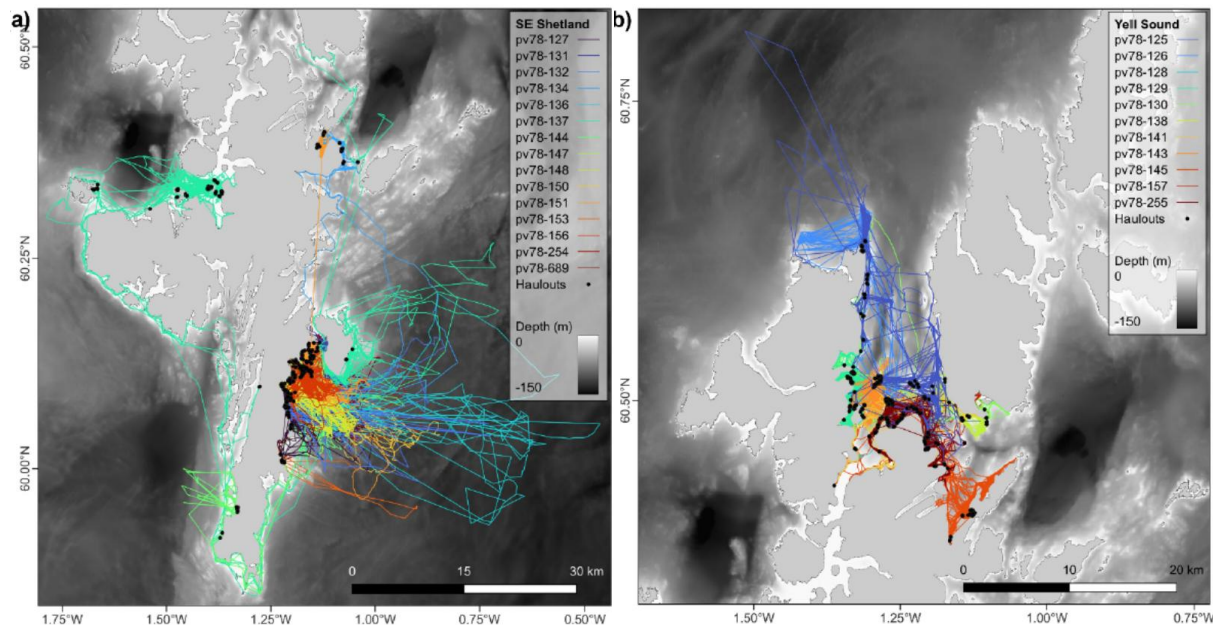


Figure 3-7: Map from Carter et al 2025 showing Tracks of 26 harbour seals tagged in Shetland. Maps show seals tagged in (a) Southeast Shetland (n = 15), and (b) Yell Sound (n = 9). Black dots show haul out locations.

Harbour seal distribution estimates show the mean number of harbour seals estimated to be present in each 5km by 5km grid cell at any one time, with that around the site estimated to be 25-50 individuals per 5km² as detailed in Figure 3-8.

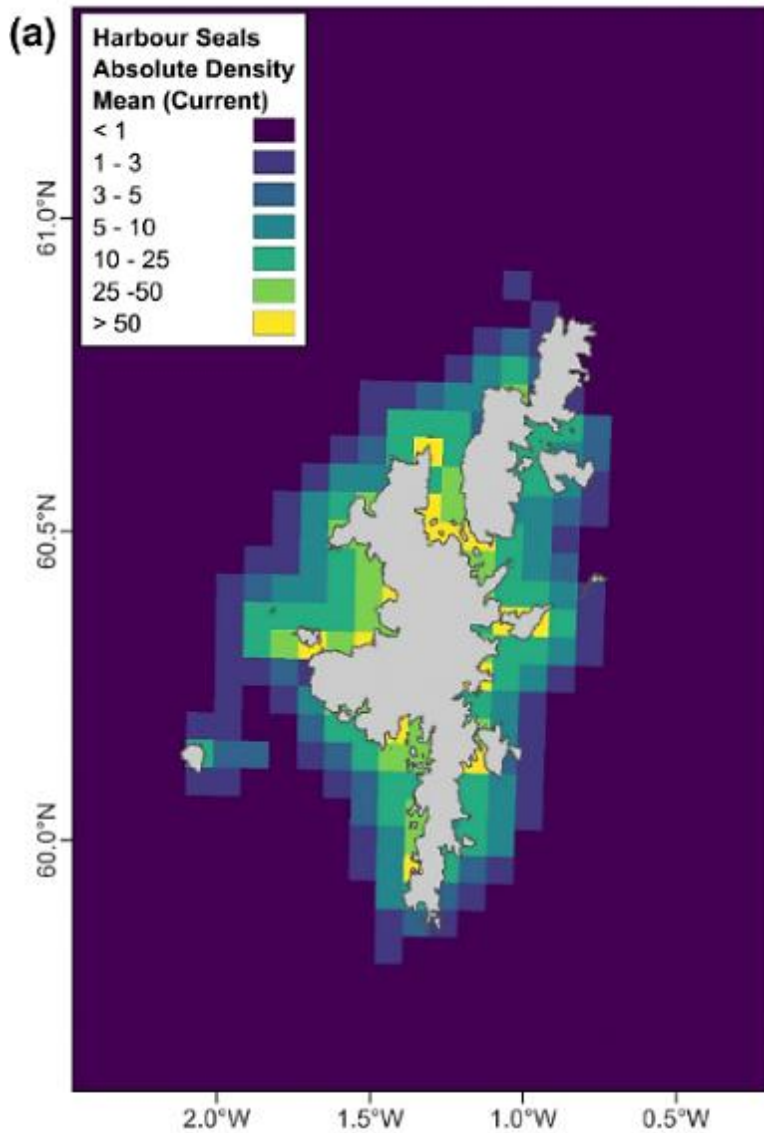


Figure 3-8: Map showing harbour seal distribution estimates. The mean number of harbour seals estimated to be present in each 5 km by 5 km grid cell at any one time. Image taken from Carter et al (2025).

The site and adjacent coastline are not considered suitable for use as a haul out site by harbour seals due to the relatively high level of disturbance associated with the existing port, piers and industrial area. However, harbour seals may use the coastal waters within and adjacent to the site for commuting between haul outs and/or foraging, and two haul out sites are within 8km of the development site, therefore, there is a risk of disturbance to a small number from in water development works and vessel movements.

3.1.3 Designated Sites: SAC

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

- Mousa SAC
- Yell Sound Coast SAC

Mousa SAC

Mousa SAC is located 20km south of the site via sea. The Mousa SAC has been designated to protect harbour seal, as well as reefs and sea caves. The SAC comprises 529.74 hectares (ha). Harbour seal feature as ‘Unfavourable declining’ in condition within the SAC. The unfavourable condition of harbour seal at Mousa SAC corresponds to about a 98% decline in the SAC population since the 1990s. However, the Shetland population has remained relatively stable since 2006 and does not reflect the trend of the Shetland Management Area, with a 40% decline between 2001 and 2005. This can be seen in Figure 3-9 below, where NatureScot notes that over the last 10 years, numbers within the SAC and up to around 20km from the SAC have continued to decline. The Mousa conservation management advice states that the reasons for the unfavourable condition are unclear and that ongoing research is investigating whether wider factors such as predation, competition for prey, prey quality and availability, and toxin exposure from harmful algae are contributing to the regional decline in harbour seals. Therefore, for harbour seal at Mousa SAC, the reasons for the unfavourable condition appear to lie out with the SAC.

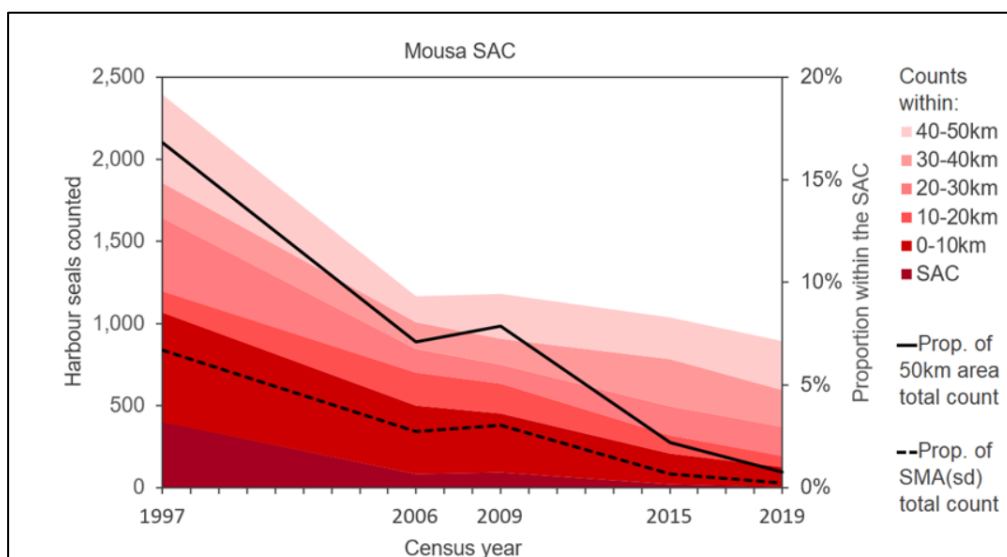


Figure 3-9: Graph Obtained from NatureScot Research Report 1256, Showing Harbour seal counts in the Mousa SAC and in 10km wide buffer areas extending up to 10, 20, 30, 40 and 50km from the SAC

Yell Sound Coast SAC

Yell Sound Coats SAC is located 28km north (via sea) of the site and comprises 1544.44 ha. The Yell Sound Coast SAC is designated for harbour seal as well as otter (*Lutra lutra*). Harbour seal features as ‘Unfavourable no change’ in condition within the SAC. The unfavourable condition of harbour seal corresponds to about a 40% decline in the population of the Shetland Management Area between 2001 and 2005. Since 2006, the Shetland population has been stable but at a lower level than in the late 1990s. The Yell Sound Coast conservation management advice suggests that research indicates 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 the Yell Sound Coast SAC, the reasons for the unfavourable condition appear to lie out with the SAC.

3.1.4 Designated Haul Out Sites

Section 117 of the Marine (Scotland) Act 2010 provided additional 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 (46) of designated seal haul out sites are associated with Shetland, 39 of which have been identified as potentially relevant to the 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 protect 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	NMPI Breeding Colony (Grey seal)
Holm of Beosetter	500m east	Harbour seal and Grey seal	No
Eswick Holm	6.7km north	Harbour seal	-
Hoo Stack	7.2km north	Harbour seal and Grey seal	No
E South Shetland	7.7km south	Harbour seal	-

*Direct route via sea

4 RESULTS AND ASSESSMENT

4.1 Calculating PTS and TTS

Seals rely on their hearing for foraging, navigation, communication and locating threats. The impact of noise on 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 that audio data for harbour seals is the closest approximation for grey seals.

Both harbour and grey seals are vulnerable to increases in acoustic levels when underwater, from dredging, drilling, blasting and piling. 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.

4.1.1 Dredging

Research³⁹ conducted in Shetland recorded backhoe dredger source level noise within 1m as 163dB re 1µPa rms. NMFS (2024) reports that for continuous (non-impulsive) noise, the TTS and PTS thresholds for seals are 217 and 195dB re 1 µPa²s, respectively. As such, the noise emitted by backhoe (BH) dredgers is under both the PTS and TTS threshold for seals. It should also be noted that the continuous thresholds detailed above are based on animals staying in close proximity to the sound source for 24 hours, and the source level noise for the dredger is experienced within 1m. It is likely that once dredging commences, any individuals within the area will move away from the sound source fairly quickly. Therefore, the likelihood of dredging resulting in physical trauma or death to individuals is considered to be low.

In addition, from a review of other relevant projects, Aberdeen Harbour Expansion Project Environmental Statement⁴⁰ (AHEPES) the underwater noise from TSHD and BHD activities were modelled and identified the following for both grey and harbour seals in relation to Cumulative TTS (TTS onset not considered worst-case scenario) and Cumulative PTS (PTS as auditory injury onset and Level A-Auditory Injury were not considered the worst-case scenario) (m) as seen in Table 4-1.

Table 4-1: Predicted significance of effects from underwater noise from dredging. Information obtained from AHEPES

Species	Effect	Range of Effect	Criterion
Grey Seal	Cumulative PTS	270m	203 dB re 1 µPa ² s
	Cumulative TTS	1840m	183 dB re 1 µPa ² s
Harbour Seal	Cumulative PTS	270m	203 dB re 1 µPa ² s
	Cumulative TTS	1840m	183 dB re 1 µPa ² s

³⁹ Todd, V. L. G., Todd, I. B., Gardiner, J. C., Morrin, E. C. N., MacPherson, N. A., DiMarzio, N. A., and Thomsen, F. A review of impacts of marine dredging activities on marine mammals. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsu187

⁴⁰ Microsoft Word - 01 Introduction to the Proposed Development FINAL.docx

For both grey and harbour seal above, it was considered that individuals are expected to be able to avoid adverse noise arising from the dredging by simply moving out of these areas before the onset of significant injury or mortality and in relation to TTS, it would likely result in avoidance and temporary displacement of seals from these areas for the duration of dredging activities. These effects are temporary and not a permanent loss of hearing. Individuals would be expected to forage in adjacent waters for these periods. Although TTS and PTS threshold levels in relation to dB for seals differ within this report to updated findings from NMFS, the assessment is not considered to change. This would be considered the same outcome for Dales Voe.

4.1.2 Drilling

Drilling through hard sediment can be significantly noisy, and given that drilling will be part of the wider blasting activity and will occur up to 24 hours a day and a 7 day a week basis, the noise from drilling will not be dominated by the acoustic impact of the blasting. Drilling will be undertaken for up to approximately 90 holes per field, during which there would likely be a noise increase in the water environment over 2.5 weeks, weather depending, and may be undertaken partly in winter.

The noise that drilling generates is considered to vary mainly depending on the bed substrate type being drilled, with some drilling noise levels for underwater being found to range up to approximately 190dB re 1µPa rms⁴¹, whilst a detailed analysis of underwater noise during offshore exploratory drilling found noise levels to be 155.9dB re 1µPa rms⁴².

In addition, in underwater noise modelling undertaken for Hatston⁴³ in Orkney (a recent harbour extension site) by Irwin Carr, which is expected to have 10 holes drilled per day included a summary of 13 different recorded drilling episodes showing 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 (as seen in Figure 4-1).

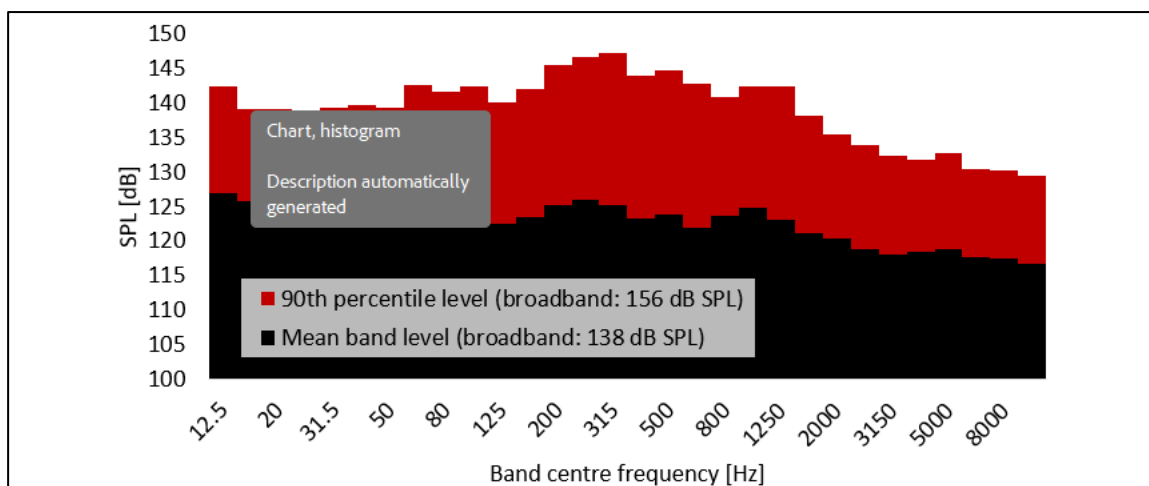


Figure 4-1: Example of drilling noise band levels. Data from various drills, diameter 0.1-1.2 m and various rock types. Figure obtained from Irwin Carr UWNM report for Hatston

Drilling has a broadband level of 156 dB SPL at the 90th percentile, which will mean that its impact on the marine environment is minimal, and therefore it is considered that drilling would be unlikely to have

⁴¹ OSPRA Commission, Assessment of environmental impact of underwater noise (2009)

⁴² Huang L-F, Xu X-M, Yang L-L, Huang S-Q, Zhang X-H and Zhou Y-L (2023) Underwater noise characteristics of offshore exploratory drilling and its impact on marine mammals. *Front. Mar. Sci.* 10:1097701. doi: 10.3389/fmars.2023.1097701

⁴³ RP001 Rv3 2022248 (Hatston Pier UW Modelling)

major auditory impacts, however, drilling may still have impacts on seals in relation to general disturbance (behavioural changes). Although the implementation of a MMO, use of PAM and a soft-start for drilling ahead of works will reduce general noise disturbance from drilling to seals.

4.1.3 Blasting

The charge per holes at Dales Voe will commence at 20kg MIC⁴⁴ and be undertaken within the parameters identified in the trial blasting, described in section 1.4.1. It is also estimated that 9-90 holes will be drilled in for each field. Charges will go off at the beginning and end of each day (daylight). This would occur over a 2.5 week period. As part of an overall mitigation of blast noise impact intensity then the contractor is proposing to use 25 millisecond blast delays⁴⁵ between each charged hole to help minimise the MIC / Qmax value for each overall blast. This means that the number of charges detonated alone does not necessarily relate to the overall blast noise level. It is also worth noting that the noise (peak sound pressure) of each blast will only be as high as that of the largest (loudest) detonation in each blast sequence. Subsequent detonations in the sequence, which are of equal or lesser noise level, will not add to the overall noise of the blast, although the time component of the blast event will increase.

The Subacoustech report (see Appendix D) assessed MIC values up to 130kg and total charge weights up to 700kg based on predictions using Soloway and Dahl (2014)⁴⁶ calculations and was then compared to a real-world project at Singapore Harbour 2024⁴⁷.

Following the prediction in Soloway and Dahl (2014), (which includes a correction for explosives in rock noted in MTD 96/101⁴⁸), a noise level of 191.6 dB SPL_{peak} at 1000m from a blast with a MIC up to 130kg is predicted, which is substantially below the threshold of instantaneous PTS onset for seals of 223 dB SPL_{peak}. The estimated distance at which 223 dB SPL_{peak} is predicted for seals to occur is approximately 45m from the blast location using this methodology. A total charge weight of 700kg⁴⁹ (including the 30% correction for embedded charges) leads to a noise level of 183 dB SEL (PCW weighted, as per Southall *et al.*, 2019⁵⁰) at 1000m, marginally below the 185 dB SEL limit for PTS onset in seals⁵¹

⁴⁴ The total charge mass of explosives firing at one instant during a blast, a key measure in managing blasting vibration.

⁴⁵ Colin Fergusson who is advisor to contractors who completed the drilling and blasting method statement advised that 25 millisecond delays between charges are regarded as individual blasts and therefore minimise the MIC/ Qmax overall.

⁴⁶ Soloway and Dahl (2014) sets out calculations for the prediction of noise from detonations of explosives underwater, with a specific focus on UXO (i.e. unconstrained detonation in the water column)

⁴⁷ Mason T and Morgan I (2024) *Underwater noise monitoring, drilling and blasting in Temasek Fairway, Singapore*. Subacoustech report ref. P398R0102

⁴⁸ MTD 96/101 also states that the explosive peak pressure of explosions in rock reduces to approximately 5% of the value for freely suspended charges, or 30% for total exposure

⁴⁹ This value is based on the greatest for both Shetland sites, with Dales Voe expected to be 400kg

⁵⁰ Southall B L, Finneran J J, Reichmuth C, Nachtigall P E, Ketten D R, Bowles A E, Ellison W T, Nowacek D P, Tyack P L (2019). *Marine mammal noise exposure criteria: Updated scientific recommendations for residual hearing effects*. *Aquatic Mammals* 2019, 45 (20, 125-232) DOI 10.1578/AM.45.2.2019.125.

⁵¹ Note that criteria for PTS onset based on the instantaneous SPL_{peak} threshold use the NMFS (2024) guidance, whereas the SEL criteria use the older Southall *et al.* (2019) guidance. This is because the SPL_{peak} thresholds are straightforward to update, whereas the species-weighted SEL thresholds would require considerable reanalysis of the Singapore data to update and enable a direct comparison. Subacoustech's analysis previously of the difference between seal criteria in Southall *et al.* (2019) and NMFS (2024) indicate that the overall difference between the two criteria is relatively small.

However, when the theoretical calculation is compared to real-world measurements for a project at Singapore Harbour 2024⁵², it suggests that charge weights with a MIC of >50 kg will result in AUD INJ threshold distances outside the mitigatable 1000m range for seals (see Figure 4-2⁵³).

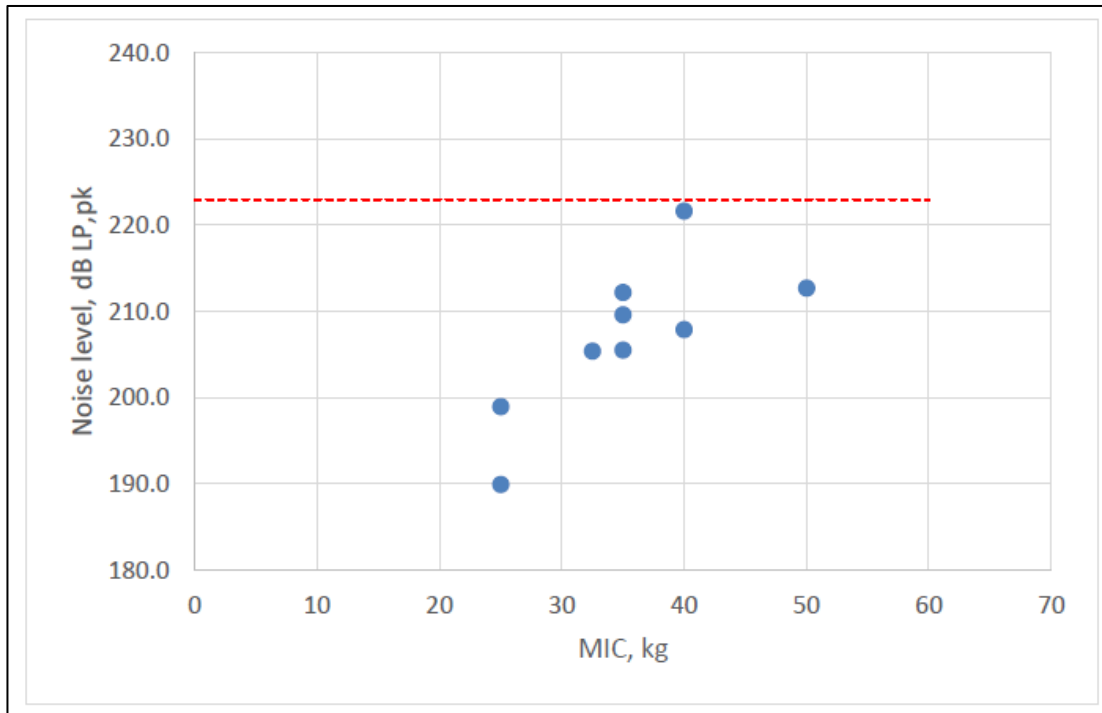


Figure 4-2: Shows the SPL_{peak} measurements against MIC size, normalised to 1000m with seal instantaneous PTS threshold marked (223 dB SPL_{peak} , as per NMFS, 2024 threshold). Figure obtained from Subacoustech report

The theoretical models suggest noise levels at 1000m are safely below the point where seals would suffer permanent hearing damage, though close to the limit when considering total exposure. However, real-world measurements from Singapore Harbour indicate that there could be a risk of exceeding this limit above 50kg MIC. Overall, predictions based on total exposure still indicate levels just under the threshold.

Due to similarities in parameters, findings from Singapore Harbour may closely mirror the required works at Dales Voe. Therefore, it is considered possible that PTS could be <1000m at ≤ 50 kg. However, the noise produced from blasting is based on a worst-case scenario, and other factors, such as local geological conditions, hole drill depth, hole geometry, water depth and water stratification can also influence noise levels propagating from each blast⁵⁴. Such variables further limit the consideration of the effect of charge numbers on blast noise levels alone.

As the blasting has no slow build-up of noise or soft-start and leaves no time for seals to vacate the area, mitigation will be put in place to ensure seals are clear of the area prior to blasting. Working within the charge and mitigation buffers identified in the trial blasting and implementing MMOs, use of PAMs and, if required, ADD to ensure seals are clear of the area prior to blasting would reduce the likelihood of auditory impacts occurring to seals. In addition, as drilling will occur continuously between

⁵² Mason T and Morgan I (2024) *Underwater noise monitoring, drilling and blasting in Temasek Fairway, Singapore*. Subacoustech report ref. P398R0102

⁵³ The results shown in the figures were obtained from the measurements at Singapore Harbour. A range of distances were sampled, between 580m and 2000m (most at 800m to 1000m), and the measurements were normalised using a simple acoustic principle ($15 \cdot \log[r]$), as if all measurements were sampled at 1000m and the only variable was the charge weight.

blasts, there will be a constant noise source occurring within the vicinity of the blasting area, and this will likely discourage seals from using the area of works ahead of blasting occurring. Additionally, the findings from trial blasting will better confirm these parameters for the Dales Voe site.

4.1.4 ADD

ADDs are devices consisting of a control unit and a transducer (sound head). The control unit contains a pulse generator and an amplifier and transmits random bursts of audio frequency signals to the transducer, where they are converted into sound. ADDs were originally developed for the aquaculture industry to deter marine mammals, largely seals, from fish farms. Therefore, seals display avoidance reactions to these sounds. However, ADDs have been widely applied to reduce the risk of injury to marine mammals during pile-driving at offshore wind farms or for UXO clearance activities.

A JNCC Report⁵⁵ which acts to provide a collated reference for Statutory Nature Conservation Bodies (SNCBs), including NatureScot, Natural Resources Wales and Natural England, to inform advice in relation to marine industries on the use of ADDs to deter marine mammals from areas where there is a risk of injury or death for a range of ADDs.

For example, Ace Aquatec: Midfrequency Acoustic Startle Response Device (US3) (formerly Universal Scrammer) is reported⁵⁶ to have deterrence ranges of between 200m and 1.4km⁵⁷, with an evidence score of 3 – High Confidence⁵⁸, whilst Fauna Guard⁵⁹ is reported to have ddeterrence range estimated from noise modelling at 100 – 500 m and an evidence score of 3 – High Confidence. Therefore, it is essential to determine the appropriate ADD to be used to ensure seals are deterred from entering PTS risk ranges during works.

As ADDs emit noise levels that deter the target species from a certain area, there are concerns that some of the louder ADD devices may have the potential to result in PTS onset, particularly from accumulated exposure to the sound. JNCC developed a simple empirical model in the original 2022 report (Version 4) (McGarry et al. 2022) to estimate the received cumulative Sound Exposure Level (SELcum) that marine mammals swimming away from a single active ADD could be exposed to⁶⁰, to investigate the potential for auditory injury due to ADD. Sound exposure calculations were based on a set of simplistic assumptions, and that real-world sound propagation is more complex, thus, the modelling is required to be treated as an indicative, risk-based approach rather than a definitive statement or assessment as to whether there is potential for any ADD in any situation to cause injury. The modelling found the NOAA (2018) PTS onset threshold (i.e. hearing frequency weighted SELcum) for all mammals was not exceeded beyond a range of 100m (theoretically possible that PTS could occur in VHF cetaceans (e.g. harbour porpoise) at a range of up to 130m) for any of the modelled devices, except one - SaveWave Orcasaver (which is no longer commercially available and also not a recommended ADD for use during the project). To support these results, a comprehensive review of peer-reviewed literature was undertaken, which found ADDs do have the potential to induce auditory

⁵⁵ Phillips, B, Roberts, A., Buckland, L., Canning, S., Goulding, A., Mendes, S., Prior, A., De Silva, R., Stephenson, S., & McGarry, T. (2025) Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation (Version 5). JNCC Report 615. JNCC, Peterborough. ISSN 0963-8091. <https://hub.jncc.gov.uk/assets/e2d08d7a-998b-4814-a0ae-4edf5d887a02>

⁵⁶ Deterrence ranges reported in the literature and/or manufacturer's information are likely to be influenced by factors such as local propagation characteristics, as well as animal's motivation, previous exposures to device and background noise levels

⁵⁷ Noise modelling showed that device was likely to deter harbour seal at ranges between 0.2 km and 1.4 km (Kastelein et al. 2010).

⁵⁸ Evidence Score is not a measure of the effectiveness of an ADD but is an assessment of confidence in the evidence for an ADD's effectiveness. Evidence score 3 requires to be backed up by at least one peer reviewed study

⁵⁹ <https://www.vanoord.com/en/sustainability/cases/faunaguard-minimising-potential-impact-generated-under-water-sound/>

⁶⁰ The modelling undertaken as part of the original 2022 report (Version 4) assumed a generalised swim speed of 2.5 m s⁻¹ (a single swim speed was applied to cover a range of assumptions and species) and utilised the source noise data, frequency and pulse rate specific to each ADD available at the time of modelling. The modelling assumed 30 minutes of activation and is based on a simplistic 15 log R propagation assumption.

injury in marine mammals⁶¹, and that injury in marine mammals may be avoided by the judicious and proportionate use of ADDs.

In addition, to avoid the risk of excessive disturbance on marine mammals or habituation and to ensure enough time has been allowed for animals to leave the mitigation zone, the duration of ADD requires clarification. Assumed swim speeds can be taken from examples used in UK offshore EIAs submitted to Marine Directorate^{62,63}. The time taken to swim 1km (mitigation zone) was calculated using a simple distance–speed relationship (time = distance ÷ speed). This provides an indicative estimate of how long it would take an animal travelling at the assumed constant swim speed to move beyond a 1km radius. The time take for seals and other relevant marine mammals is detailed in Table 4-2.

Table 4-2: Assumed swim speeds of species and time to swim 1km

Species	Assumed swim speed (m/s)	Time to swim 1 km (minutes)	Notes
Seals (harbour and grey)	1.8	~9.3	Species-specific value used in UK EIAs
Harbour porpoise (<i>Phocoena phocoena</i>)	1.5	~11.1	Value used in multiple UK EIAs submitted to Marine Directorate
Minke whale (<i>Balaenoptera acutorostrata</i>)	2.3	~7.3	Species-specific value used in recent UK EIAs

Seals are therefore anticipated to take approximately 10 minutes to evacuate the 1km mitigation zone. However, harbour porpoise has the slowest assumed swim speed of the species listed above (1.5 m/s), with all other species taking slightly less time to evacuate the 1km mitigation zone due to faster swim speeds (e.g. seals 9.3 minutes and minke whale 7.2 minutes). Therefore, ADD should be used for a minimum of 12 minutes to ensure all marine mammals are safely out of the mitigation zone, and a maximum of 15 minutes to ensure they do not excessively disturb marine mammals. Use of ADD would only commence upon confirmation no marine mammals were within 130m of the ADD device.

As such, it is considered that although there are some risks of ADDs effecting seals negatively, the risk of PTS occurring can be avoided/ and the risk of physical injury or death (due to blasting) greatly reduced by utilising ADDs proportionately to ensure seals are not present within 130m of the noise source to avoid PTS. The mitigation section identifies appropriate systems and protocols for ADD use.

⁶¹ The focus of these studies is on the continuous activation of devices (SELcum) over 24 hours, rather than in the context of SPLs.

⁶² Seagreen Alpha and Bravo Windfarms EIA submitted to Marine Scotland- available on <https://marine.gov.scot/?q=data/eia-report-technical-chapters-seagreen-alpha-and-bravo-wind-farms>

⁶³ Array (Ossian) EIA submitted to Marine Scotland (2024). Available on https://marine.gov.scot/sites/default/files/chapter_10_marine_mammals.pdf

4.2 Calculating General Disturbance

The Marine Scotland 'Guidance for Scottish Inshore Waters: The Protection of Marine European Protected Species from Injury and Disturbance'⁶⁴ 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 apply 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.

Disturbance to seals may occur as a result of the works occurring (drilling, dredging, blasting and vessel movement). The most likely disturbance to seals as a result of the noise related activities includes 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, vocalisation or avoidance)⁶⁵.

The 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.

Overall, 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.

4.2.1 Individuals Impacted (Quantitative Data) – Disturbance

Although the NMFS predicts 160 dB SPL_{rms} for impulsive noises, crucially, this threshold is not intended for explosive noise. However, in their Summary of Acoustic Thresholds (2025)⁶⁶, NMFS provides a series of weighted SEL behavioural thresholds for explosions considering multiple detonations for relevant

⁶⁴ <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/EP%2Bguidance%2BJuly%2B2020.pdf>

⁶⁵ https://britishcanoeingawarding.org.uk/wp-content/files/Seal_Disturbance_Factsheet.pdf

⁶⁶ <https://www.fisheries.noaa.gov/s3/2025-09/MM-Acoustic-Thresholds-508-secure-SEPT-2025-OPR1.pdf>

species groups. As such, Subacoustech detailed these thresholds alongside the calculated result for a selection of charge weights (with embedded charge correction)⁶⁷.

Table 4-3: Behavioural thresholds for underwater explosives, NMFS (2025) and predicted impact ranges. Note these use the NMFS (2024)⁶ marine mammal weightings and linked thresholds, dB re 1 $\mu\text{Pa}^2\text{s}$

Hearing Group	Example species	Threshold, weighted	20 kg	30 kg	50 kg	700 kg
Phocid pinnipeds	Seal	163 dB SEL	4.2 km	5.1 km	6.5 km	20 km

As the PTS for seals at 1000m may be exceeded with a MIC >50kg, therefore a 6.5km buffer for disturbance would be most suitable and would cover noise related behavioural responses. A buffer of this distance is applied to the application site boundary, and only the area (km^2) 'at sea' is taken.

Based on the methods in Section 2.3.1 the estimated number of individuals that could be disturbed for grey and harbour seals are presented in Table 4-4.

Table 4-4: Individuals Impacted (General Disturbance)

Species	Step 1: Maximum Disturbance Buffer and No. grid Squares	Step 2: Density Estimates per km^2	Step 3: Individuals within 6.5km
Harbour seal	6.5km (10 grid squares)	Mean Absolute Density estimates of 10 grid squares equate to 285.96 per 25 km^2 . $285.96 / 10 \text{ (grid squares)} / 25 \text{ (km}^2) = 1.14 \text{ per km}^2$	At sea area covered by a 6.5km buffer equates to 60.11 km^2 . $1.14 \text{ per km}^2 \times 60.11\text{km}^2 \text{ buffer area} = 68.76 \text{ (69 individuals)}$
Grey seal	6.5km (10 grid squares)	Mean Absolute Density estimates of 10 grid squares equate to 100.51 per 25 km^2 . $100.51 / 10 \text{ (grid squares)} / 25 \text{ (km}^2) = 0.40 \text{ per km}^2$	At sea area covered by a 6.5km buffer equates to 60.11 km^2 . $0.40 \text{ per km}^2 \times 60.11\text{km}^2 \text{ buffer area} = 24.17 \text{ (25 individuals)}$

4.2.2 Designated Sites

Harbour Seal from SACs

Based on the distance of predicted behavioural ranges, harbour seals are not considered to be directly impacted whilst within the SACs from auditory related impacts and behavioural impacts associated with noise. However, the typical foraging ranges of harbour seals are in the range of 50km and with Mousa SAC and Yell Sound Coast SAC within this 50km buffer, harbour seal are at risk of being in the same vicinity of the impacts of the development. Although telemetry studies do not show a strong connectivity between designated areas and the area for construction activities (see Figure 3-7 above), likely due to the highly active nature of the site currently.

⁶⁷ "Level B" criteria are normally 160 dB for impulsive noise and 120 dB for non-impulsive noise – but the 160 dB threshold has an exclusion for explosive noise. There are separate thresholds for these (and all are lower than what 160 dB would be)

Based on the estimated number of individual harbour seals that could be disturbed from a 50kg MIC blast, equates to 69, in relation to the Mousa SAC⁶⁸, where 7 individuals were present during 2019 August counts, this would result in >100% of the population if all of those seals were to come from the Mousa SAC. Although it is considered unlikely that seals associated with Mousa would travel within the area of works, as telemetry studies have shown no strong connectivity. In relation to the Yell Sound Coast SAC, where 209 individuals were present during 2019 August counts, this would result in 33.5% of the population if all those 69 seals were to come from the Yell Sound Coast SAC. This is also considered unlikely that seals associated with Yell Sound Coast SAC would travel within the area of works based on telemetry studies showing no strong connectivity and therefore not likely to impact the population level of this SAC. Although the percentage of the population for Mousa and Yell Sound potentially affected is quite high, this data is based on a precautionary calculation, and in practice, blasts would be limited to the most sensitive marine mammal hearing range (harbour porpoise initially assessed as reaching PTS at 1000m for a 30kg MIC). In addition, the results calculated to inform general disturbance buffers are likely to be a significant over-estimation of the real risk, due to the relatively shallow water at the site, which will likely attenuate the noise more quickly than the calculation assumes.

As harbour seals are known to travel up to 50km between haul-outs and feeding areas, and there are four designated haul-out sites within 8km of works, it is possible seals from the SACs population could be present within waters surrounding the proposed works for foraging or utilising the haul-out sites nearby. Disturbance to seals from the SACs using the haul-out site at Holm of Beosetter is feasible given the proximity of the disposal site, particularly on the south to west aspects of the island. However, this location would support only a very small proportion of the SAC population, and there are alternative haul out locations between the SACs and the proposed works (particularly E South Shetland) which are more likely to be used by the SACs population. Additionally, works are not planned to occur within the sensitive breeding (June – July) and moulting (July – mid September) periods for harbour seal, when they spend more time hauled out than usual.

Even where a seal from the SACs was present in the vicinity of the development (commuting/ foraging), it would likely not be exposed to injury (due to the mitigation measure to be implemented in Section 5). However, some behaviour changes may occur (vigilance or avoidance) out to 6.5km. Although disturbance could occur out to these ranges, it is unlikely that individual seals from the SACs would be spending all of their time in the development area (or disturbance range area), if it is returning to SACs up to 50km away and the works to be undertaken are short term and temporary in nature, as such disturbance is likely to be limited.

In addition, harbour seals are known to habituate to some levels of disturbance over time (for example, the same boat passing by a haul-out every day). As such, the likelihood of disturbance is small, and any disturbance to a small number of individuals at this location is unlikely to result in effects at the SACs population level.

Designated Seal Haul-outs

Disturbance to the haul-out site at Holm of Beosetter is feasible given the proximity of the disposal site, particularly on the south to west aspects of the island. The distance at which seals display signs of disturbance will differ depending on location, the time of year (mothers with pups will be distinctly wary), how they are approached and how accustomed they already are to vessels/ noise associated within the locale. Works are not planned to occur within the sensitive breeding (June – July) and moulting (July – mid September) periods for harbour seal, when they spend more time hauled out than

⁶⁸ August counts of harbour seals in the Seal Management Area 'Shetland' 2019 by Subunits. Mousa features in subunit 6

usual. However, winter pupping does occur on Holm of Beosetter, and works are to be undertaken during this time.

Seals are considered to be more easily disturbed when on land. Although the nearest haul out site is 500m from disposal area, the works area for dredging, drilling and blasting is located 5km away, as such noise sources at that distance being unlikely to transfer from the underwater environment to the terrestrial environment, it is not considered that seals would be disturbed or exhibit behaviours such as tombstoning and stampeding, from the noise levels associated with the works.

Vessel movements associated with the works and specifically the disposal site have a higher likelihood of causing disturbance to hauled out seals, due to the distance of the nearest seal haul out to the dredge disposal area being 500m. However, it is noted that the Lerwick disposal grounds have been utilised for historic dredge spoil disposal and therefore seal associated with this haul out site are likely habituated to vessel movements in this area. In addition, it is recommended that vessels should stay at least 100m away from seals when on land to avoid disturbance, therefore, with the disposal area being 500m from the haul out, a greater distance will be provided between seals on land and the vessels, as such, the likelihood of disturbance is small, even when pupping occurs.

4.3 Effects of Increased Vessel Movements on Seals

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

The works will include associated vessel movements with dredging itself, blasting and drilling and then barges moving between the dredge site and the disposal site.

Movements associated with the final drill and blast campaign are four to five barges per 24 hours over 2.5 weeks, equating to approximately 87 total vessel movements. Vessel activity related to explosive delivery will only involve two trips. However, although there will be an increase in dredging vessel activity, no port activity will take place, and therefore, there will be an offset with a reduction in normal harbour vessel activity.

The works will require a number of vessels that will be of consistent size, speed and operating procedure. However, this can still result in seal collision risk associated with the Dales Voe Capital dredge campaign activities.

The 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 maintenance⁶⁹. Not only does this result in physical disturbance, but it also incurs 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 nor away from them)⁷⁰.

⁶⁹ <https://www.seawatchfoundation.org.uk/wp-content/uploads/2012/08/Kate-Lewis-thesis.pdf>

⁷⁰ <https://data.marine.gov.scot/sites/default/files/SMFS%20Vol%207%20No%2024.pdf>

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)⁷¹.

The likelihood of vessel collisions is therefore dependent upon vessel speed, animal behaviour and vessel manoeuvrability⁷². Vessels travelling at slower speeds in general can allow time for seals and vessel operators to react to avoid collisions.

However, the Dales Voe harbour is already part of an established port and the site is within a highly trafficked area for vessels, and the area within the proposed works is not estimated to be an area with a particularly high usage by harbour seal for foraging. As such, it is considered that seals utilising the waters within this area would likely avoid or be accustomed to the regular movements of vessels and thus the likelihood of vessel strike may be lower.

Although vessel strike is considered highly unlikely during the construction phase, measures to reduce disturbance related impacts will be devised for the project.

4.4 Conclusion

Some of the activities associated with the works (dredging, blasting and drilling) 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 works will result in the temporary avoidance of a small area of habitat available to individuals. PTS ranges are considered to lie within 1000m, which can be mitigated through the use of the MMO, PAM and ADD, where required, to ensure seals are clear of the area prior to works occurring.

The increase in the number of vessels travelling through to Dales Voe Harbour during dredging could increase the risk of collision with seals, potentially resulting in death or injury to individuals. However, Dales Voe is already part of an established port, and due to the high number of vessels utilising the area already, the likelihood is reduced.

It is considered unlikely that disturbance of seals using haul outs and designated sites (SACs) would occur due to the distance from the works, although it is possible that seals from the haul outs and designated sites may be present within the waters around the development and thus could be disturbed during in water works. However, the quantitative data show that 69 harbour seals and 25 grey seals could be disturbed by noise related activities. These numbers are considered a 'worst case' scenario due to the range associated with MIC >50kg (6.5km) being used to determine the buffer distance. Therefore, the actual numbers would likely be lower. In addition, telemetry studies show seals are unlikely to transit near Dales Voe during movements from the SACs. It is considered that the favourable conservation status of seals associated with the SACs will not be adversely impacted by the works.

Overall, the project may result in seals avoiding the works area during works, and behavioural changes may occur out to 6.5km. However, the implementing of adaptive management through trial drilling and blasting pre works, with a starting MIC of 20kg, and charges being capped at the 1000m PTS range for the marine mammal with the most sensitive hearing range, it is considered that the risk of death and

⁷¹ 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

⁷² SEER U.S. Offshore Wind Synthesis of 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>

injury from noise can be more accurately quantified, and the disturbance duffers, which are currently conservative, have opportunity to be significantly decreased.

4.5 In-Combination Effects

The projects listed in Table 4-5 below were considered for In-combination effects on seals.

Table 4-5: Projects identified with potential for in-combination effects

Proposal Details	Local Authority and Ref No.	Applicant	Status / Decision	Conclusion
Dales Voe - Extension to open storage area	Shetland Islands Council - 2023/289/PPF	Captain Calum Grains	Pending Consideration	No in combination effects. A consultation response from NatureScot concluded that <i>“on the basis of the information provided, if the proposal is carried out strictly in accordance with the following mitigation, our conclusion is that the proposal will not adversely affect the integrity of the site: Surface water drainage management must be detailed so that Shetland Islands Council is satisfied that significant release of sediment and other pollutants into Dales Voe will be avoided, including during extreme rainfall events.”</i>
The Proposed Development replaces two previously consented wind turbines at Luggies Knowe, Gremista and will comprise the construction and operation of one wind turbine with a ground to blade tip height of up to 149.9 m, battery energy storage system units, site access tracks and associated infrastructure	Shetland Islands Council - 2024/006/PPF	Mr Brendan Hall	Pending Consideration	No in combination effects. A consultation response from NatureScot concluded that although <i>“There are natural heritage interests of international importance on the site... our advice is that these will not be adversely affected by the proposal”</i>
Peatland Restoration	Shetland Islands Council - 2023/189/PN	Mr Eric Graham	Prior Approval Not Required	No in combination effects. A consultation response from NatureScot concluded that they <i>“do not intend to offer formal comment on this proposal as it does not meet our criteria for consultation, as outlined in our document, How and when to consult NatureScot”</i>
New Shellfish Farm - Muckle Ayre, Dales Voe, Shetland	MD-LOT - 06865	Blueshell Mussels Ltd	Marine Licence Granted – start 2019-	No in combination effects.

Proposal Details	Local Authority and Ref No.	Applicant	Status / Decision	Conclusion
			04-25 and end 2025-04-24	There is no information available on the MD-LOT planning portal to advise whether this development was likely to have LSEs on the qualifying interests of any designated sites.
Arlanda Quay Development and Reclamation - The requirement for reclamation arises from the need for more shoreline land for development use. The scheme will use material for land reclamation from an LPA owned source.	MD-LOT – N/A	Lerwick Port Authority	Pre-application	No in combination effects. The Arlanda Quay will not be undertaken simultaneously with the capital dredge at North Harbour and/or Dales Voe.
Capital Dredge North Harbour - The proposed dredging works are driven by an urgent requirement to improve navigational safety through the harbour due to ever increasing vessel size and number being experienced in the port. It is anticipated that the dredge volume will be 301,150m ³ , to a maximum depth of -10.5 m below Chart Datum. The proposed works are anticipated to be undertaken in summer 2025 for 11 weeks, subject to the time taken to obtain the relevant permits and suitable weather conditions for dredging and associated vessel movements. It should be noted that the dredging works at North Harbour will be undertaken under the same contract as the dredging works at Dales Voe, but it has not been identified how long the dredges at each site will take. Please see Section 1.4 for more information on the proposed works (which will follow the same method as the dredge at Dales Voe).	MD-LOT – N/A	Lerwick Port Authority	Pre-application	No in combination effects. The current intention is to undertake the dredges consecutively, with North Harbour completed first and then Dales Voe. The two dredges will not be undertaken simultaneously.

Proposal Details	Local Authority and Ref No.	Applicant	Status / Decision	Conclusion
<p>Dales Voe Ultra-Deep Water Quay (UDWQ) – The proposed works include the construction of temporary bunds, excavation, capital dredging, controlled blasting, land reclamation, construction of quay and laydown area and construction of a potential industrial site.</p>	<p>MD-LOT – N/A</p>	<p>Lerwick Port Authority</p>	<p>Pre-application</p>	<p>No in combination effects. It is expected that works at Dales Voe UDWQ will commence a number of years after the capital dredge at Dales Voe is undertaken.</p>

5 MARINE MAMMAL MITIGATION PLAN

The Marine Mammal Mitigation Plan (MMMP) comprises a standard MMO protocol as per JNCC guidance (and therefore takes into account all cetaceans and not just seals) to be implemented during the trial drilling and blasting, and during operations in optimal sea states less than 4 and during times of optimal visibility.

5.1 Marine Mammal Observation Protocol

The Marine Mammal Observation Protocol (MMOP) will be implemented so that the blasting, drilling and dredging works do not cause injury or unnecessary disturbance to marine mammals. This section has been designed with reference to the current JNCC guidance 'Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise' (August 2010)⁷³ and 'Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from explosives' (January 2025)^{74 75}.

5.2 Marine Mammal Observer

A minimum of two suitably qualified MMOs (as per guidance), competent in the identification of marine mammals (inclusive of seals) at sea, will be present during the dredging, drilling and blasting works. The MMOs will undertake observation for marine mammals within the mitigation zone before and will be dedicated to that one task for the duration of any watch. The MMOs 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 MMOs:

MMOs: An individual responsible for conducting visual watches for marine mammals. It may be requested that observers are trained, dedicated and/or experienced.

Trained MMOs: Has been on a JNCC recognised course.

Dedicated MMOs: Trained observer whose role on board a vessel is to conduct visual watches for marine mammals.

Experienced MMOs: Trained observer with three years of field experience observing for marine mammals, and practical experience in implementing the JNCC guidelines.

The MMOs will be trained. The identity and credentials of the MMOs will be agreed with the Marine Directorate.

⁷³ <https://data.jncc.gov.uk/data/31662b6a-19ed-4918-9fab-8fbcff752046/JNCC-CNCB-Piling-protocol-August2010-Web.pdf>

⁷⁴ <https://data.jncc.gov.uk/data/24cc180d-4030-49dd-8977-a04ebe0d7aca/jncc-guidelines-marine-mammals-and-explosive-use.pdf>

⁷⁵ 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.

5.3 MMO Equipment

The MMOs 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 MMOs may prefer to use this when observing before transferring the details to the Excel spreadsheets. The ability to determine the range of marine mammals 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: <https://data.jncc.gov.uk/data/31662b6a-19ed-4918-9fab-8fbcff752046/Marine-mammal-recordingforms-guide-piling-rev05.pdf> and <https://hub.jncc.gov.uk/assets/24cc180d-4030-49dd-8977-a04ebe0d7aca>

5.3.1 Communication

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

5.3.2 Mitigation Zone

As part of the drilling and blasting trial, MMOs will monitor the area at both 500m and 1000m with the support for PAMs and noise monitoring equipment analysing the data to determine TTS and PTS associated with the blasting. JNCC guidance recommends a 1,000 m exclusion zone for underwater blasting, however, this distance may be impractical in the context of the site due to spatial and operational constraints and is considered precautionary. The suitability of this will be determined by evaluation of the trial blast underwater noise monitoring as detailed within the drilling and blasting method statement^{76 77}. Depending on the outcome of this, it is considered that there may be potential for the mitigation zone to be reduced, in discussion with the MMOs. If the size of the mitigation zone is adjusted for any reason, this will be stipulated within the works consent or licence conditions and must be agreed with statutory bodies before being implemented.

During the works, the MMOs will therefore monitor the agreed mitigation zone and advise if any seals are within it.

5.3.3 Passive Acoustic Monitoring (PAM)

In addition to MMOs, PAMs should also be used throughout the operation to supplement visual checks.

PAM are software systems that utilise hydrophones to detect the vocalisations of marine mammals. This will help aid in the detection of species which are less easily detected at the surface via MMOs or during unfavourable conditions.

⁷⁶ Lerwick Port Authority – Lerwick Harbour & Dales Voe Dredging, Drill & Blast Dredging Trial Blast – Proposed Underwater Acoustic Monitoring Method Statement (2025).pdf

⁷⁷ Subacoustech Environmental Outline Proposal (2025).pdf

Visual observation is an ineffective mitigation measure during periods of darkness or poor visibility (such as fog), or during periods when the sea state is not conducive to visual mitigation, as marine mammals in the vicinity of blasting will not be detected. JNCC views PAM as the only available mitigation technique that can be used under these conditions, and that it can also be used to enhance the detection of certain marine mammal species⁷⁸.

Specialist PAM operatives are needed to set up and deploy the equipment and interpret the detected sounds. The PAM hydrophones should be situated as close as possible to the site of blasting, and sacrificial hydrophones may therefore be required.

Hydrophones deployed from standby vessels can be used for acoustic monitoring, but a disadvantage of these systems is that they will move away from the site of blasting when the vessel moves and may then be too far away to detect any marine mammal vocalisations within the mitigation zone. Remotely operated static PAM systems, which can be left at the initial blasting site, may be an option, but they may not always be commercially available or best suited for operations in shallow coastal environments.

PAM can provide a useful supplement to visual observations undertaken by MMOs. However, in many cases, it is not as accurate as visual observation for determining range, and this will mean that the mitigation zone will reflect the range accuracy of the system. Some PAM systems do not have a reliable range determination facility or can only calculate the range for some species. In such cases, the detection of a confirmed cetacean vocalisation should still be used to initiate postponement of the drilling soft-start or blasting works, if the PAM operator can make a judgement about the range of the marine mammal (dependent on species) from the works, because of experience gained in differentiating between distant and close vocalisations. In the absence of PAM systems capable of range determination, this expert judgement will constitute the basis for deciding whether an area is free from marine mammals prior to the drilling soft-start or blasting.

PAM operators will submit a method statement and details of the equipment to be used to MD-LOT for approval before the equipment is deployed.

5.4 MMO Protocol

1. A standard MMO protocol as per JNCC guidance is to be implemented during operations in sea states less than 4 and during times of optimal visibility.
2. Visual monitoring will not commence during poor visibility (such as fog) or during periods when the sea state is not conducive to visual mitigation (above sea state 4 is considered not conducive⁷⁹), as there is a greater risk of failing to detect the presence of marine mammals. An elevated platform for the MMOs to monitor from would be beneficial.
3. The MMOs will likely be onboard the works vessel, or a land-based platform, that provides the best viewing platform, that allows 360 degree visual cover, and is likely to be closest to the works activities.
4. The mitigation zone will be monitored visually by the MMOs for an agreed period prior to the commencement of any works. This will be a minimum of 60 minutes for blasting.
5. The MMOs will scan the waters using binoculars or a spotting scope and by making visual observations. Sightings of marine mammals will be appropriately recorded in terms of date, time,

⁷⁸ JNCC guidelines for minimising the risk of injury to marine mammals from explosive use in the marine environment 2025), available at: <https://data.jncc.gov.uk/data/24cc180d-4030-49dd-8977-a04ebe0d7aca/jncc-guidelines-marine-mammals-and-explosive-use.pdf> (Accessed 22/08/2025)

⁷⁹ Detection of marine mammals, particularly porpoises, decreases as sea state increases.

position, weather conditions, sea state, species, number, adult/juvenile, behaviour, range, etc., on the JNCC standard forms. Communication between the MMOs and the contractor, and the start/end times of the activities, will also be recorded on the forms.

6. Dredging, drilling and Blasting activities should not be undertaken within 20 minutes of a marine mammal being detected within the mitigation zone.

7. Where an additional fast craft vessel is used to encourage birds out of the works area, only if/ when the MMO has confirmed an absence of marine mammals within the mitigation zone this may be used.

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

9. If an MMO is uncertain whether marine mammals 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.

10. A soft-start will be employed for dredging and drilling, with the gradual ramping up of works (where possible). The soft-start duration will be a period of not less than 20 minutes. This will allow for marine mammals to move away from the noise source.

11. If a marine mammal enters the mitigation zone during the soft-start, then, whenever possible, the works will cease until the marine mammal exits the mitigation zone and there is no further detection for 20 minutes.

5.4.1 Reporting

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

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

5.5 Acoustic Deterrent Device Protocol

JNCC states that using devices which have the potential to exclude animals from the mitigation zone should be considered. However, ADDs should only be implemented in conjunction with visual and/or acoustic monitoring (PAM) and for as short a period as necessary to minimise the introduction of additional noise.

The following protocol has been designed for use when ADD is considered necessary:

- ADDs will only be used if persistent issues arise with marine mammal species converging into or not leaving MMO area just prior to a blast.
- ADDs should be positioned in the water in close proximity to the explosive source installed.
- MMOs should ensure marine mammals are not present within 130m PTS zone of the ADD ahead of switching on, to avoid PTS (this can be done with the assistance of PAM and MMO pre-works searches).
- If a marine mammal is identified prior to ADD being switched on, ensuring that the animal is given appropriate time to leave the 130m PTS zone is required (again, this can be supported by PAM and MMO searches). If the marine mammal is not detected again within 20 minutes, it can be assumed that it has left the area and ADD use may commence.
- ADD should be used for a minimum of 12 minutes to ensure all marine mammals are safely out of the mitigation zone, and a maximum of 15 minutes to ensure they do not excessively disturb marine mammals.
- The MMOs should maintain a post-works search within the mitigation zone for at least 15 minutes after the works have commenced/ last detonation, to look for any evidence of injury to marine life, including fish kills. Any unusual observations should be noted in the report.
- Clear communication channels should exist between MMOs / PAM operators and personnel undertaking works/ detonating the explosives. It is recommended that communication channels should be established and in place before the activity commences, with these matters discussed and agreed at a pre-mobilisation meeting.

Based on JNCC [Report 615. Acoustic Deterrent Device Selection Database \(last updated February 2025\)](#), a range of ADDs are available for seals and should be considered depending on the project. The following ADDs offer ranges out to >1000m for seals and include:

- Aquatec Group Aquamark 848 (>1000m for LF, HF and VHF cetaceans and pinnipeds)
- Terecos Ltd DSMS-4 – Programme 1 (Sequence 1) (also >1000m for VHF cetaceans, HF cetaceans such as Risso's dolphin and LF cetaceans such as minke whale)
- Terecos Ltd DSMS-4 – Programme 2 (also >1000m for VHF cetaceans, HF cetaceans such as Risso's dolphin and LF cetaceans such as minke whale)
- Terecos Ltd DSMS-4 – Programme 2 (Sequence 2) (also >1000m for VHF cetaceans, HF cetaceans such as Risso's dolphin and LF cetaceans such as minke whale)

5.6 Vessel Movement Mitigation Protocol

The Lerwick Port Authority implements speed restrictions on vessels within Shetland waters. Vessel captains should adhere to agreed routes, speed limits, and consideration of the Scottish Marine Wildlife Watching Code⁸⁰ should be in place ahead of construction works commencing (inclusive of dredging)⁸¹.

Training courses such as those provided by the WiSe scheme⁸² could be offered to vessel operators.

5.7 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

⁸⁰ <https://www.nature.scot/doc/scottish-marine-wildlife-watching-code-smwwc>

⁸¹ 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.

⁸² Information available at: <https://www.wisescheme.org/> (Accessed October 2025)

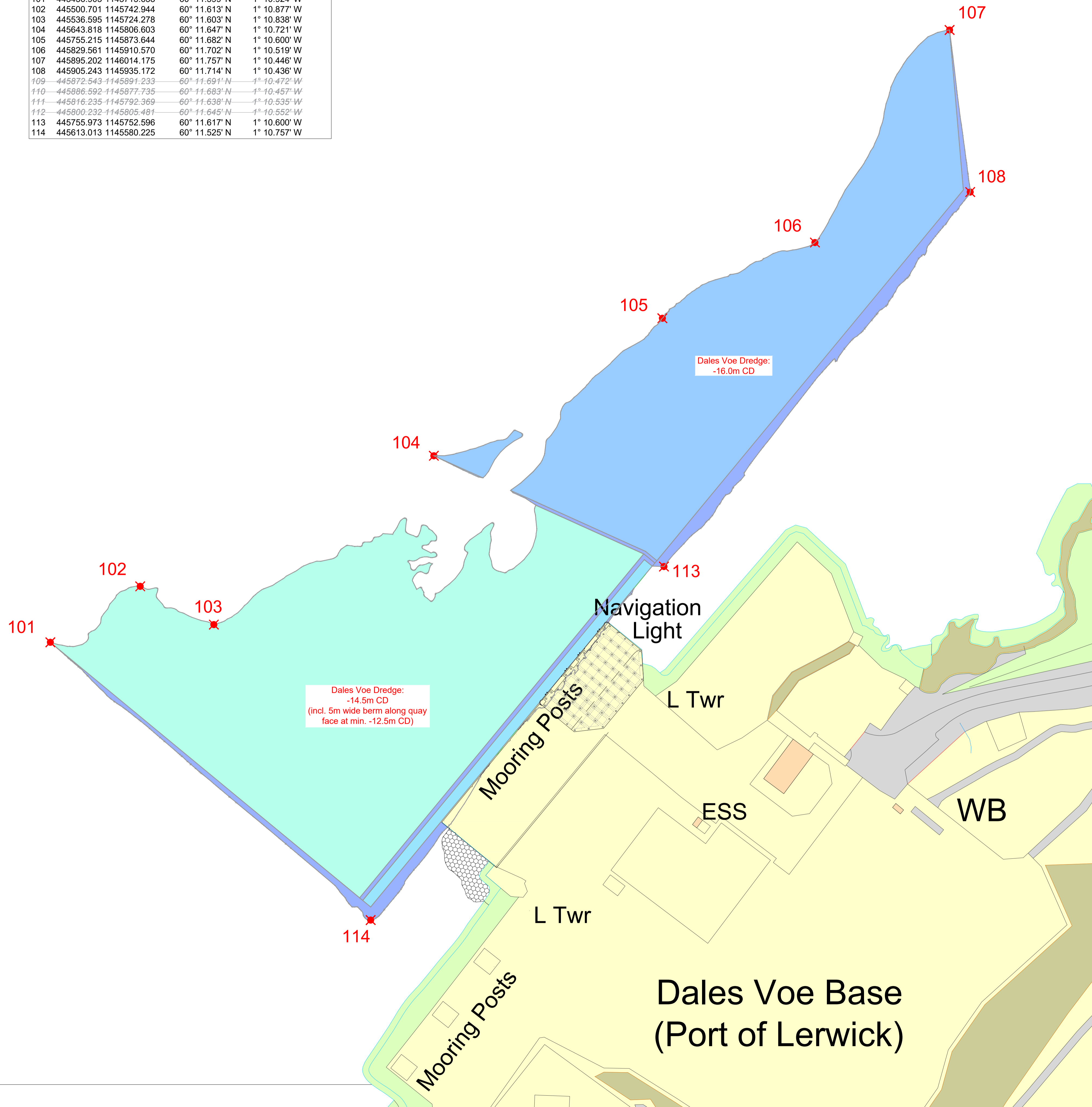
reported to British Divers Marine Life Rescue (www.bdmlr.org.uk). All dead or distressed seals should also be reported to the local NatureScot office.

The MMOs 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.

APPENDICES

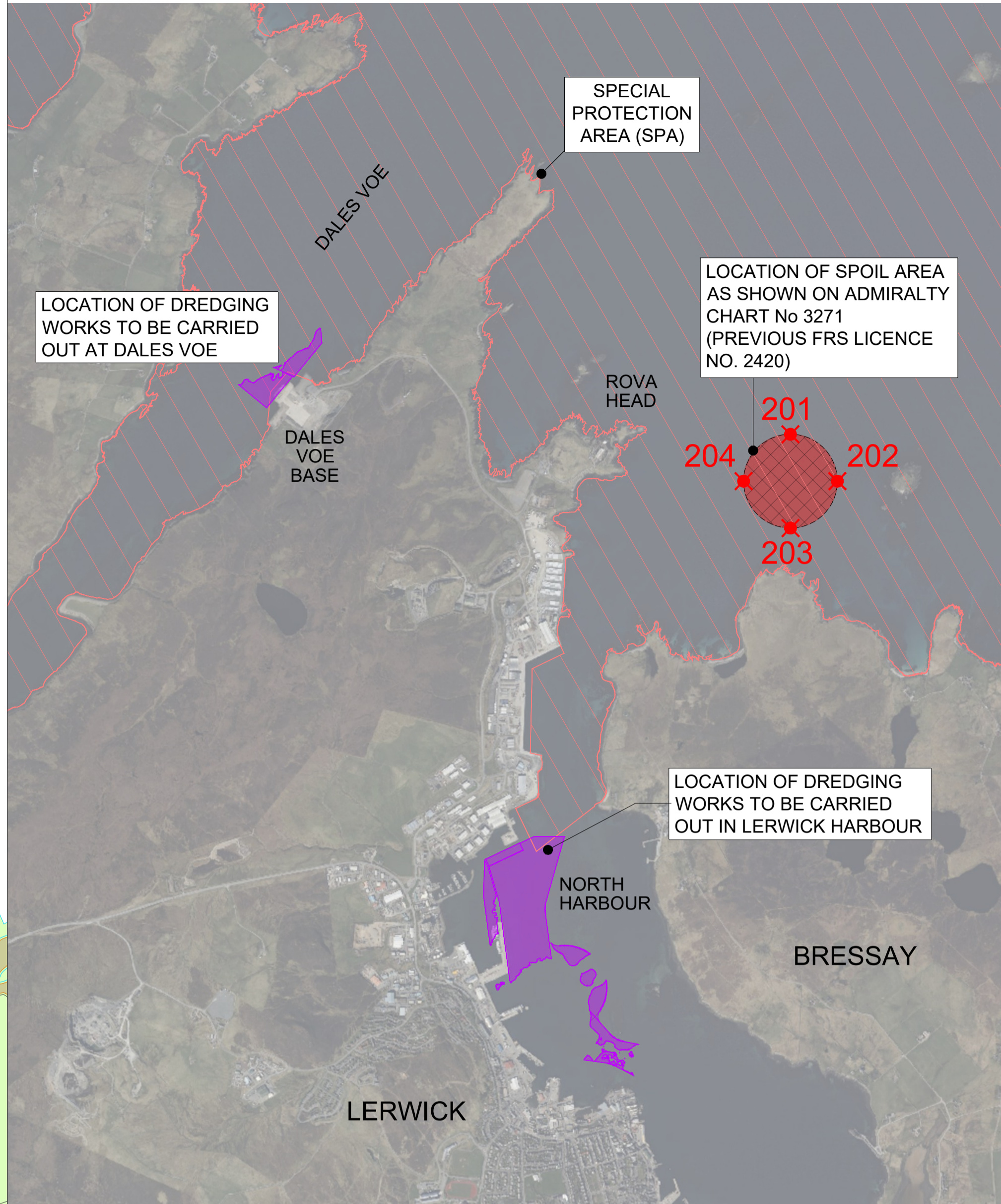
A SITE LOCATION AND DREDGE DISPOSAL SITE

Point	OSGB36 Easting	OSGB36 Northing	WGS84 Lat	WGS84 Long
101	445456.903	1145715.658	60° 11.599' N	1° 10.924' W
102	445500.701	1145742.944	60° 11.613' N	1° 10.877' W
103	445536.595	1145724.278	60° 11.603' N	1° 10.838' W
104	445643.818	1145806.603	60° 11.647' N	1° 10.721' W
105	445755.215	1145873.644	60° 11.682' N	1° 10.600' W
106	445829.561	1145910.570	60° 11.702' N	1° 10.519' W
107	445895.202	1146014.175	60° 11.757' N	1° 10.446' W
108	445905.243	1145935.172	60° 11.714' N	1° 10.436' W
109	445872.543	1145891.233	60° 11.691' N	1° 10.472' W
110	445886.592	1145877.735	60° 11.683' N	1° 10.457' W
111	445816.235	1145792.369	60° 11.638' N	1° 10.535' W
112	445800.232	1145805.481	60° 11.645' N	1° 10.552' W
113	445755.973	1145752.596	60° 11.617' N	1° 10.600' W
114	445613.013	1145580.225	60° 11.525' N	1° 10.757' W

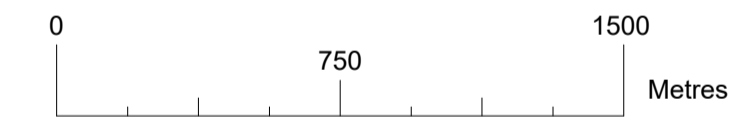


 DENOTES SPECIAL PROTECTION AREA (SPA)

 Reproduced by permission of Ordnance Survey® on behalf of The Controller of Her Majesty's Stationery Office.
 © Crown copyright 2018. All rights reserved.
 Licence number: 100021621



LOCATION PLAN
 Scale 1: 20,000



REV	DATE	REVISION	DRN	CHK
A	12.05.2025	ITT -16.0mCD dredge pocket removed	PRN	SSJ
-	16.12.2024	Invitation to Tender	PRN	APS

THIS DRAWING IS COPYRIGHT . DO NOT SCALE FROM THIS DRAWING.

Arch Henderson 1919
 Civil Engineers
 Structural Engineers
 Architects
 CDM Co-ordinators
 Geotechnical services
 Environmental services
 Stewart Building, Lerwick, Shetland, ZE1 0LL.
 Tel : 01595 695512
 www.arch-henderson.co.uk - email : lerwick@arch-henderson.co.uk
 Aberdeen, Dundee, Glasgow, Lerwick, Inverness, Thurso, Stromness, Southampton, Falkland Islands

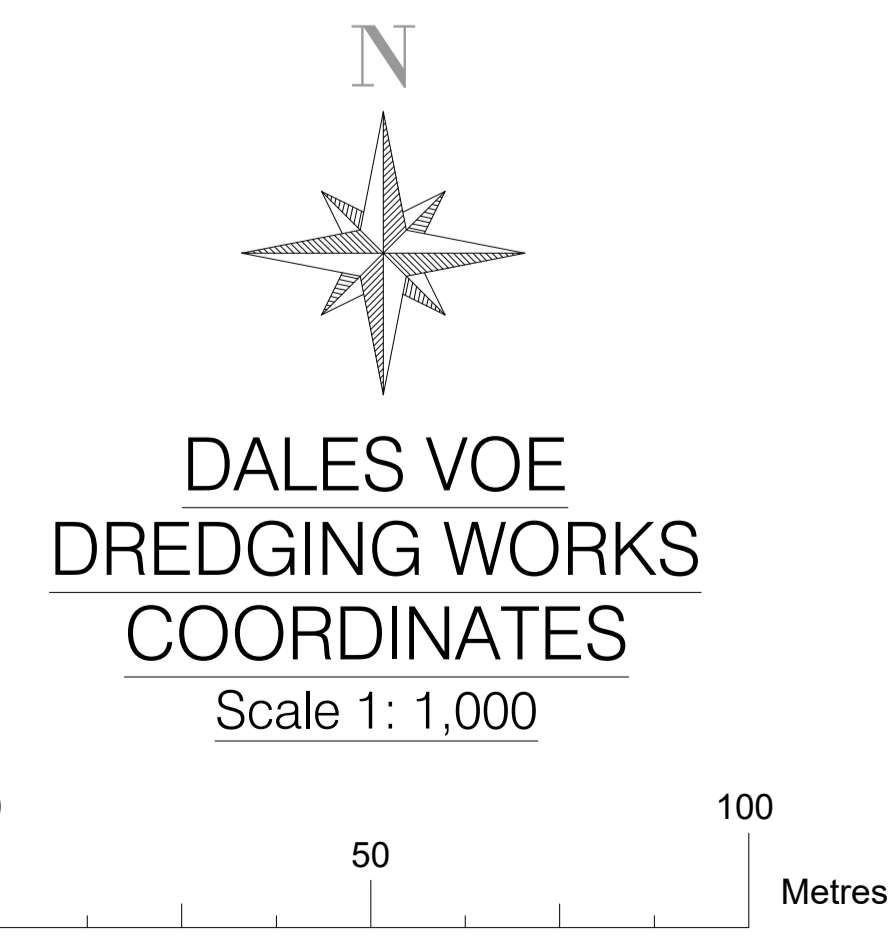
PROJECT :
 Lerwick Port Authority
 Lerwick Harbour Dredging

TITLE :
 ITT
 Dales Voe Dredging Coordinates

DRAWN :	DATE :	CHECKED :	APPROVED :
PRN	Dec 2024	APS	SSJ

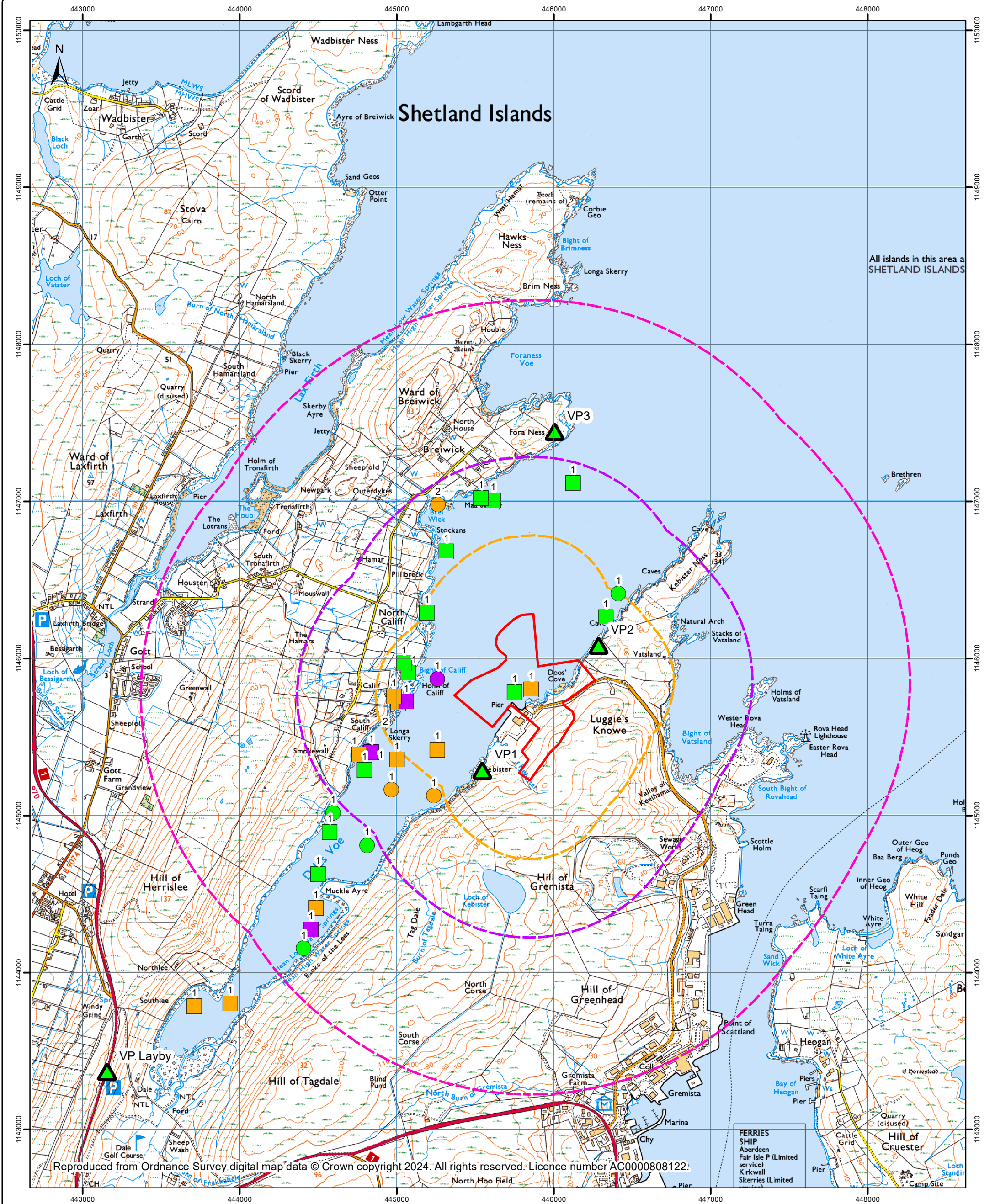
SCALE : (A1)	DRAWING STATUS :
1:2,500	ITT

DRAWING No : 232029-ITT-204 REV : A



DALES VOE DREDGING WORKS COORDINATES
 Scale 1: 1,000

B SEAL SIGHTINGS DURING VANTAGE POINT BIRD SURVEYS FOR DALES VOE 2023-2025



Reproduced from Ordnance Survey digital map data © Crown copyright 2024. All rights reserved. Licence number AC0000808122.

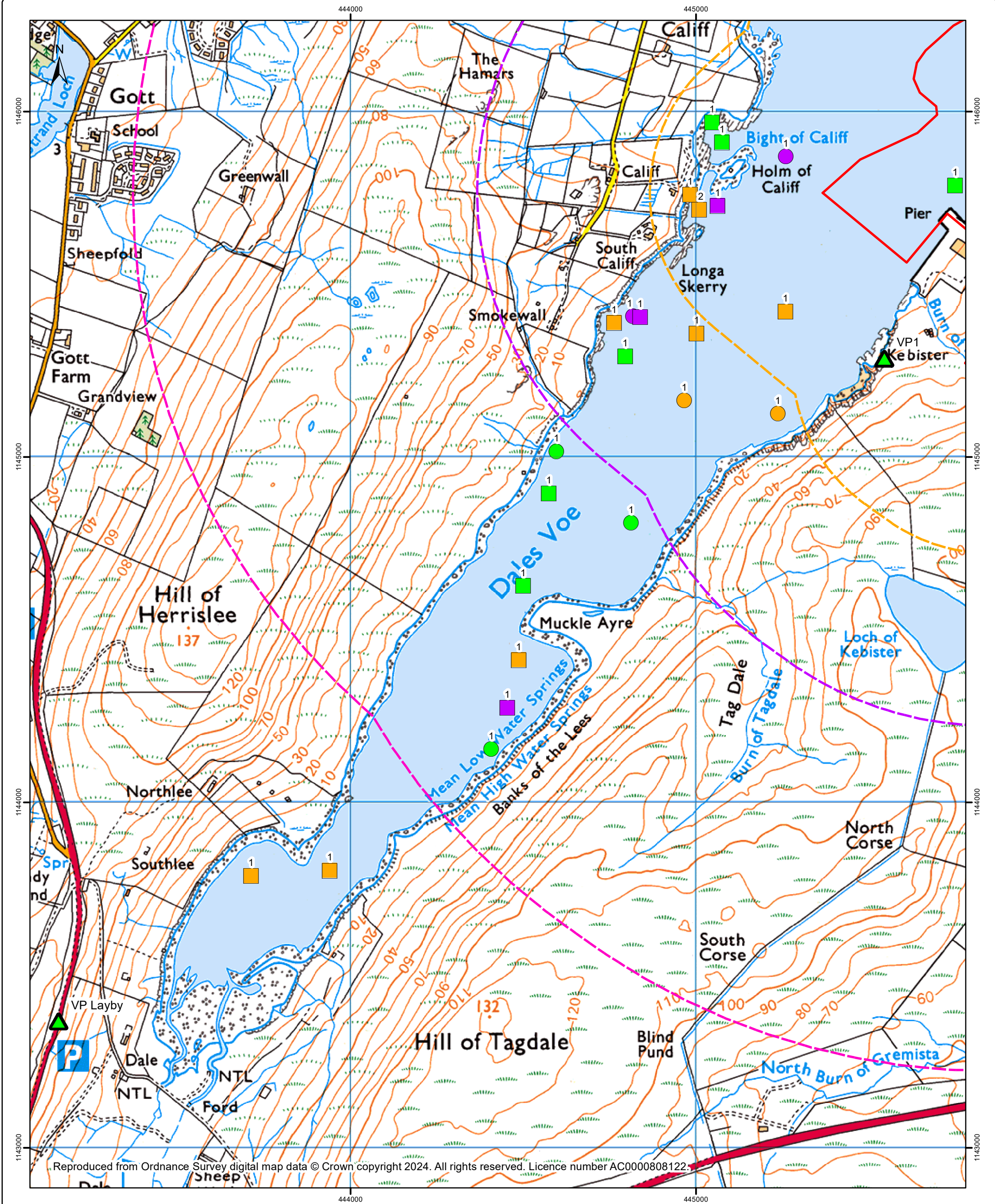
FERRIES SHIP
Aberdeen
Fair Isle P (Limited
service)
Kirkwall
Skerries (Limited

Legend					
	UDWQ Project Boundary		Common Seal, 2023/24		Boundary Buffer (500m)
	Vantage Points		Common Seal, 2024/25		Boundary Buffer (1km)
			Grey Seal, 2023/24		Boundary Buffer (2km)
			Grey Seal, 2024/25		
			Unidentified Seal, 2023/24		
			Unidentified Seal, 2024/25		

Client Arch Henderson LLP
Project Dales Voe
Title Seal Sightings during Oct 2023 and Sept 2025 Surveys Dales Voe Full View
Scale 1:22,000 @A3

Status FINAL		
Drawing No. 681966-GIS014	Revision -	Date 30 Oct 2025
Drawn MMF	Checked HA	Approved GN
Rev	Date	Amendment
		Initials
 8 Eagle Street, Craighall Business Park, Glasgow, G4 9XA. T: 0141 341 5040 E: info@envirocentre.co.uk W: www.envirocentre.co.uk		

Do not scale this map



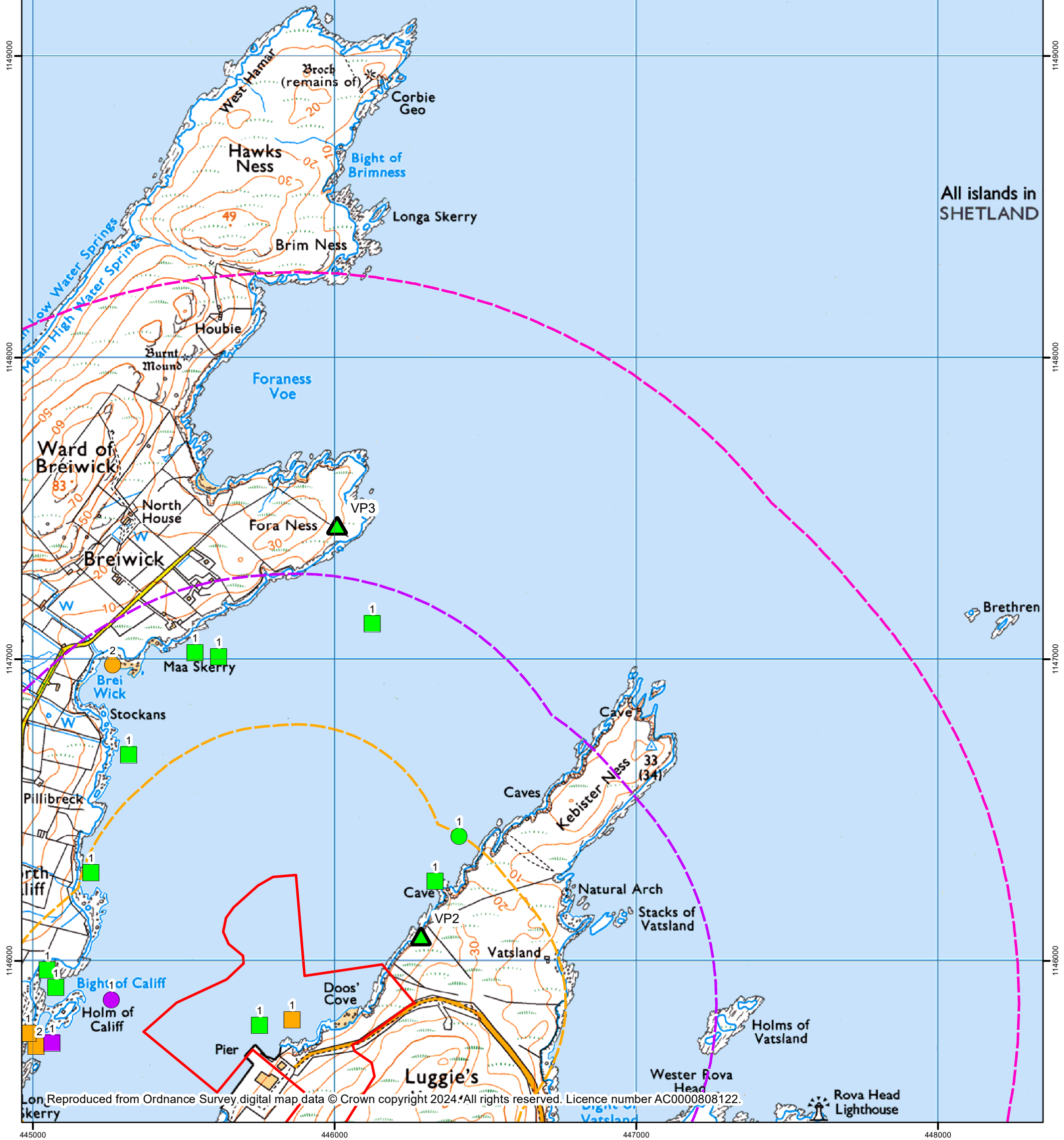
Legend					
	UDWQ Project Boundary		Common Seal, 2023/24		Boundary Buffer (500m)
	Vantage Points		Common Seal, 2024/25		Boundary Buffer (1km)
			Grey Seal, 2023/24		Boundary Buffer (2km)
			Grey Seal, 2024/25		
			Unidentified Seal, 2023/24		
			Unidentified Seal, 2024/25		

Client Arch Henderson LLP
Project Dales Voe
Title Seal Sightings during Oct 2023 and Sept 2025 Surveys Dales Voe Inner
Scale 1:10,000 @A3

Status FINAL			
Drawing No. 681966-GIS014	Revision -	Date 30 Oct 2025	
Drawn MMF	Checked HA	Approved GN	
Rev	Date	Amendment	Initials
-	-	-	-
 8 Eagle Street, Craighall Business Park, Glasgow, G4 9XA. T: 0141 341 5040 E: info@envirocentre.co.uk W: www.envirocentre.co.uk			

Do not scale this map

Shetland Islands



All islands in SHETLAND

Reproduced from Ordnance Survey digital map data © Crown copyright 2024. All rights reserved. Licence number AC0000808122.

Legend					
	UDWQ Project Boundary		Common Seal, 2023/24		Boundary Buffer (500m)
	Vantage Points		Common Seal, 2024/25		Boundary Buffer (1km)
			Grey Seal, 2023/24		Boundary Buffer (2km)
			Grey Seal, 2024/25		
			Unidentified Seal, 2023/24		
			Unidentified Seal, 2024/25		

Client Arch Henderson LLP
Project Dales Voe
Title Seal Sightings during Oct 2023 and Sept 2025 Surveys Outer
Scale 1:12,500 @A3

Status FINAL			
Drawing No. 681966-GIS014	Revision -	Date 30 Oct 2025	
Drawn MMF	Checked HA	Approved GN	
Rev	Date	Amendment	Initials
-	-	-	-
 8 Eagle Street, Craighall Business Park, Glasgow, G4 9XA. T: 0141 341 5040 E: info@envirocentre.co.uk W: www.envirocentre.co.uk			

Do not scale this map

C SEAL HAUL OUT SITES

Seal Haul Out Name	Distance* and Orientation	Species	NMPi Breeding Colony (Grey seal)
Holm of Beosetter	500m east	Harbour seal and Grey seal	No
Eswick Holm	6.7km north	Harbour seal	-
E South Shetland	7.7km south	Harbour seal	-
Hoo Stack	7.2km north	Harbour seal and Grey seal	No
Scudills Wick	12.6km north	Harbour seal	-
West Linga and Lunning Sound Holms	19km north	Harbour seal	-
Rumble, East Linga, Grif Skerry	20.4km north east	Harbour seal and Grey seal	No
The Guens, Filla and The Benelips	29km north east	Harbour seal and Grey seal	No
Channer Wick and Hos Wick	29.2 km south	Harbour seal	-
Tros Wick	30.7km south	Harbour seal	-
Muckle Skerry (Out Skerries)	31.9km north east	Harbour seal and Grey seal	No
Skerries of Neapaback	39.3km north	Harbour seal and Grey seal	No
Horse Island	41.6km south	Grey seal	No
Toab and Scatness	42.2km south	Harbour seal and Grey seal	No
Lady's Holm	43.4km south	Harbour seal and Grey seal	No
Siggarr Ness	46.5km south west	Grey seal	No
Sligga Skerry & North End of Bigga	47.4km north	Harbour seal and Grey seal	No
Tinga Skerry	48.9km north	Harbour seal and Grey seal	No
Little Roe	49.9km north	Harbour seal	-
Ungam	50.5km north	Harbour seal	-
Lamba	51.7km north	Harbour seal	-
Fetlar NW Islands	51.8km north	Harbour seal and Grey seal	No
Colsay and Bay of Scousburgh	54.5km south west	Harbour seal and Grey seal	No
Little Holm	54.7km north	Harbour seal and Grey seal	No
Skea Skerries (Yell Sound)	55.3km north	Harbour seal	-
Head of Calsta	56.8km north	Harbour seal	-
Point of Bugarth	58.5km north	Harbour seal and Grey seal	No
Westling	59.8km north	Harbour seal	-
Maywick	62km south west	Harbour seal and Grey seal	No
Uyea	69.9km north west	Grey seal	Yes
Aa Skerry	77.9km west	Harbour seal and Grey seal	No
Ronas Voe	82km north west	Grey seal	Yes
Gruting Voe NW Head	87km north west	Harbour seal and Grey seal	No

Seal Haul Out Name	Distance* and Orientation	Species	NMPi Breeding Colony (Grey seal)
Isle of Stenness	90km north west	Harbour seal and Grey seal	No
Dale	90km north west	Grey seal	Yes
Da Smell Geo	92.9km south west	Harbour seal and Grey seal	No
Foula West	95.8km west	Grey seal	No
Papa Stour	98km north west	Grey seal	Yes
Swarta Skerry and Mo Geo	98.5km north west	Harbour seal and Grey seal	No

D SUBACOUSTECH REPORT

Andy Sandison

Arch Henderson

Stewart Building,

Lerwick,

Shetland,

ZE1 0LL

11th December 2025

Re: Lerwick Port Authority – Lerwick Harbour & Dales Voe Dredging. Underwater noise generated by drill and blast operations. Subacoustech Report Ref. P438LR0103

Please note that this report issue is a revision to Subacoustech's previous report ref. P438LR0101, to include results for harbour porpoise. Additions to the text are highlighted in blue.

Additional revisions are included in this report issue, updating the previous P438LR0102 regarding whales, dolphins, and the inclusion of NOAA Level B impulsive thresholds for disturbance, with additions highlighted in green.

Introduction and basic environmental underwater noise concepts

Works under Marine Licences MS-00011195 and MS-00011213 for dredging Lerwick Harbour and Dales Voe with the Magnor back-hoe dredger **are now complete**. Although the dredger was able to extract much of the substrate at each site, there is some hard rock that it is unable to remove, and for this, blasting is proposed to loosen the rock to enable its removal. This is currently proposed over five weeks at Lerwick Harbour and 2.5 weeks at Dales Voe. The use of the explosives in drilled boreholes will necessarily generate underwater noise, which has the potential to adversely affect marine species in the vicinity.

It is well understood that there is limited data publicly (and privately) available for the underwater noise caused by borehole blasting, making a confident assessment of this noise and its effect on the environment challenging. This letter report will consider the most suitable underwater noise data available to Subacoustech Environmental to provide the best estimate for the potential impacts in the two locations. During initial test blasting activities, underwater noise monitoring will be undertaken which will confirm the amount of noise generated at each site and contribute to the overall knowledge base.

The following letter report will primarily consider the situation at Dales Voe and Lerwick Harbour in the context of recent measurements Subacoustech took of drill and blast activities at Singapore Harbour in 2024, also undertaken for the removal of hard rock sections of a waterway during channel deepening works. Results from this exercise will also be compared with predictions using Soloway and Dahl (2014)¹.

¹ Soloway, A. G., & Dahl, P. H. (2014). Peak sound pressure and sound exposure level from underwater explosions in shallow water. The Journal of the Acoustical Society of America, 136(3), EL219-EL223. <http://dx.doi.org/10.1121/1.4892668>

The following basic concepts should be understood. Borehole blasting for the clearance of rock 'overburden' (the top layer of rock in a sea or riverbed) requires a grid of boreholes of various lengths and diameters to be drilled, into which are placed an explosive 'pack' which are detonated in sequence, with a delay of a few milliseconds between each. The amount of explosive in each hole will have a 'charge weight' in kilograms, each is likely to be different, but from a noise perspective, this leads to a series of individual 'peaks' of noise in the blast sequence. The greatest individual noise 'peak' will tend to be associated with the largest charge, known as the Maximum Instantaneous Charge, or MIC. The total charge weight detonated in a sequence will contribute to an overall noise exposure. Both of these elements are relevant in the assessment of noise impact.

It is estimated that the MIC required at Dales Voe will be no more than 110 kg in any location, with an average of 34-64 kg; at Lerwick Harbour, the estimated MIC is up to 130 kg, with an average of 33-60 kg. An indicative upper total charge weight in all holes in a sequence is suggested to be around 700 kg, based on an upper extent of the estimated 400 kg-1250 kg over two sequences provided in the "Trial Blast – Proposed Underwater Acoustic Monitoring Method Statement" (Arch Henderson doc. No. 232029-MD-LOT-D&B).

All species have different hearing capabilities and sensitivities, but **although the greatest concern in both locations is potential for harm to the harbour seal, the following assessment will consider all marine mammal species categories.** Harbour porpoise are noted as being the most sensitive species to noise, and there is a small risk that individuals could be present, although it is noted in the Marine Mammal Risk Assessment (Envirocentre doc. no. 15428) that between 2023 and 2025 the nearest animals were sighted approximately 14 km from the Dales Voe site. No individuals were seen in the proposed development site. In order to mitigate the risk, Marine Mammal Observers will be used to ensure no marine mammals are present within 1 km of the blast location. The assessment will be made such that there should be no risk of Permanent Threshold Shift (PTS)², or damage to the hearing ability of a seal, outside of this 1 km range. There must be consideration of the maximum instantaneous (peak sound pressure level, SPL_{peak}³) noise level, controlled by the MIC, and the total noise exposure (sound exposure level, SEL⁴), controlled by the total charge weight detonated in the sequence. Guidance considers these 'dual criteria' where both are relevant, and the 'impact range' should be whichever represents the worst case.

Predictions using Soloway and Dahl (2014)

Soloway and Dahl (2014) sets out calculations for the prediction of noise from detonations of explosives underwater, with a specific focus on UXO (i.e. unconstrained detonation in the water column). MTD 96/101 also states that the explosive peak pressure of explosions in rock reduces to approximately 5% of the value for freely suspended charges, or 30% for total exposure. Following the prediction in Soloway and Dahl (2014), which itself follows Arons (1954)⁵, and including the correction for explosives in rock noted in MTD 96/101, predicts a noise level of 191.6 dB SPL_{peak} at 1000 m from a blast with MIC of 130 kg, which is substantially below the threshold of instantaneous PTS onset for seals of 223 dB SPL_{peak}. **It is also well below the 202 dB**

² Note that in NMFS (2024), PTS is considered under the wider category of Auditory Injury.

³ SPL_{peak} metric is commonly referred to using $L_{P,pk}$ in contemporary underwater noise reporting but SPL_{peak} has been used in the document for the purposes of familiarity with readers.

⁴ SEL metric is commonly referred to using $L_{E,p}$ in contemporary underwater noise reporting, but SEL has been used in this report for the purposes of familiarity with readers.

⁵ Arons A. B. (1954). Underwater explosion shock wave parameters at large distances from the charge. J. Acoust. Soc. Am. 26, 343–346

SPL_{peak} threshold for harbour porpoise, as per NMFS (2024)⁶. The estimated distance at which 223 dB SPL_{peak} (harbour seal) is predicted to occur is approximately 45 m from the blast location using this methodology; 202 dB (harbour porpoise, VHF weighted as per Southall *et al.*, 2019⁷) would occur at 350 m. The total charge weight of 700 kg (including the 30% correction for embedded charges) leads to a noise level of 183 dB SEL (PCW weighted, as per Southall *et al.*, 2019⁷) at 1000 m, marginally below the 185 dB SEL limit for PTS onset in seals⁸. For harbour porpoise, the total charge weight (with the correction) leads to a noise level of 165 dB SEL at 1000 m, which is somewhat in excess of the 155 dB SEL PTS threshold for this species (155 dB SEL is estimated at 2.4 km).

Note that calculations are based on a charge weight of TNT and charge weights of relevant explosive should be converted using TNTeq (TNT equivalent). Based on Simoens *et al.* (2011)⁹, the emulsion explosives proposed at the Shetlands sites (and also used in Singapore, below), have a TNTeq conversion factor of 1 for peak pressure and 0.7 for exposure. For reasons of precaution (and simplicity) a TNTeq with a 1:1 ratio has been used in the calculations.

Comparison with measurements at Singapore Harbour, 2024

The most recent and comprehensive dataset for underwater noise measurements taken during drill and blast operations was taken in June 2024 in Singapore Harbour¹⁰ by Subacoustech, where nine charge sequences were sampled successfully. The charges measured at the Singapore Harbour site are similar to those proposed here (although at some locations the MIC could be higher in Shetland sites). This location had a similar depth to the Shetland sites, up to 20 m, although much of the Shetland sites are shallower, which is beneficial for restricting sound transmission with distance.

The MICs deployed for the project in Singapore were smaller than those proposed at the Shetland sites, with a highest value of 50 kg compared to 110 kg to 130 kg, although 50 kg is representative of a typical MIC charge weight rather than the absolute maximum.

The results shown in Figure 1 and Figure 2 were obtained from the measurements at Singapore Harbour. A range of distances were sampled, between 580 m and 2000 m (most at 800 m to 1000 m), and the measurements were normalised using a simple acoustic principle ($15 \cdot \log[r]$), as if all measurements were sampled at 1000 m and the only variable was the charge weight.

⁶ National Marine Fisheries Service (NMFS) (2024). *2024 update to: Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (version 3.0): Underwater and in-air criteria for onset of auditory injury and temporary threshold shifts*. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-71.

⁷ Southall B L, Finneran J J, Reichmuth C, Nachtigall P E, Ketten D R, Bowles A E, Ellison W T, Nowacek D P, Tyack P L (2019). *Marine mammal noise exposure criteria: Updated scientific recommendations for residual hearing effects*. Aquatic Mammals 2019, 45 (20, 125-232) DOI 10.1578/AM.45.2.2019.125.

⁸ Note that criteria for PTS onset based on the instantaneous SPL_{peak} threshold use the NMFS (2024) guidance, whereas the SEL criteria use the older Southall *et al.* (2019) guidance. This is because the SPL_{peak} thresholds are straightforward to update, whereas the species-weighted SEL thresholds would require considerable reanalysis of the Singapore data to update and enable a direct comparison. Subacoustech's analysis previously of the difference between seal criteria in Southall *et al.* (2019) and NMFS (2024) indicate that the overall difference between the two criteria is relatively small.

⁹ Simoens B, Lefebvre M H, Minami F (2011) *Influence of Different Parameters on the TNT-Equivalent of an Explosion*. Central European Journal of Energetic Materials, 2011, 8(1), 53-67

¹⁰ Mason T and Morgan I (2024) *Underwater noise monitoring, drilling and blasting in Temasek Fairway, Singapore*. Subacoustech report ref. P398R0102

This analysis suggests that all charges sampled at Singapore Harbour were lower than the instantaneous PTS onset threshold, although noting again that the MIC for the Singapore campaign was limited to 50 kg and the trend is indicative of an increase above the instantaneous limit at higher MICs.

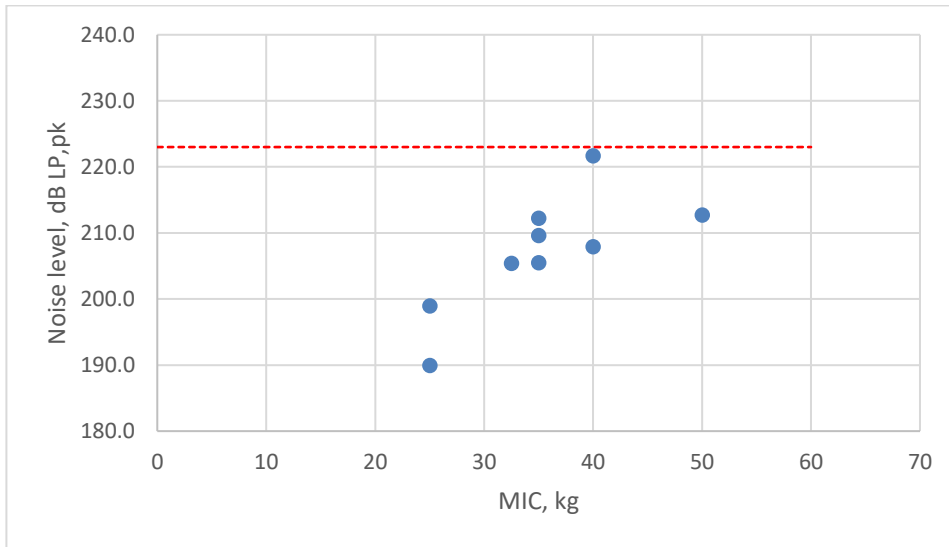


Figure 1 – SPL_{peak} measurements against MIC size, normalised to 1000 m, with seal instantaneous PTS threshold marked (223 dB SPL_{peak} , as per NMFS, 2024 threshold).

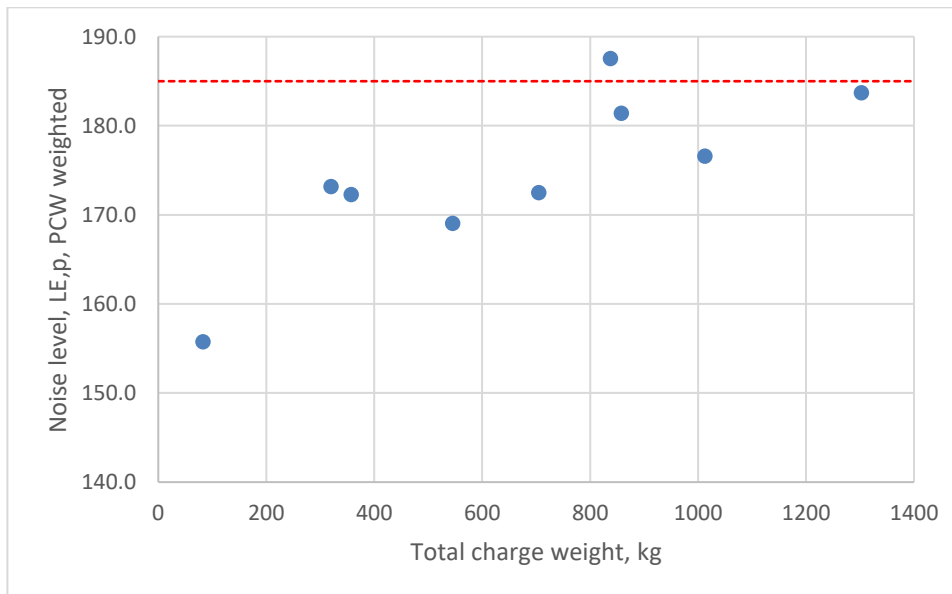


Figure 2 – SEL measurements against total charge weight, normalised to 1000 m, with seal PTS exposure threshold marked (185 dB SEL, as per Southall et al., 2019 threshold).

Here, the 700 kg estimated total charge weight in a detonation sequence is within the boundaries of the measurements sampled and is expected to be likely just below the PTS onset threshold. However, due to the

variability of the measurements, indeed explosive measurements generally, there is still a risk of exceedance at the highest total combined charge weights.

The equivalent charts have been extracted for harbour porpoise, again showing the measurements of blast noise normalised to 1000 m using the SPL_{peak} and SEL metrics.

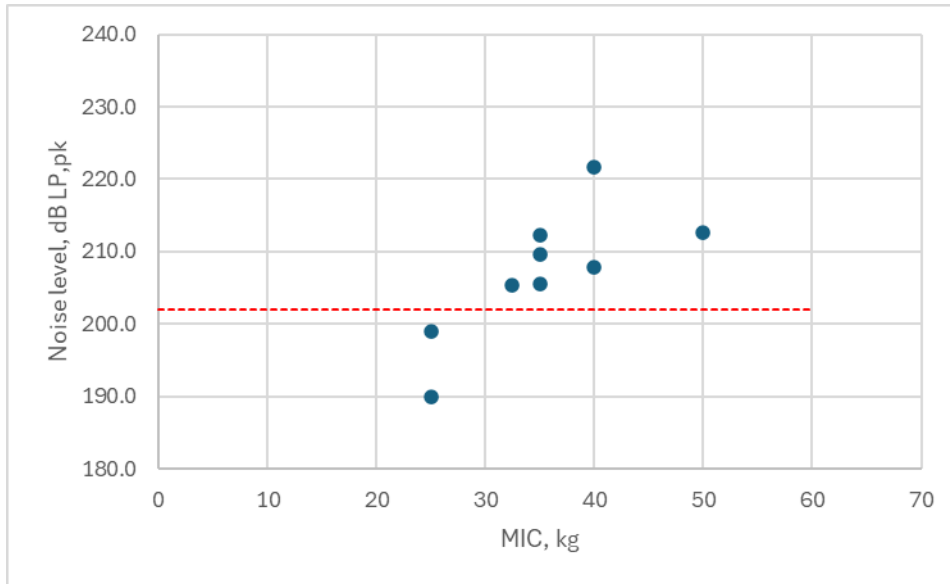


Figure 3 – SPL_{peak} measurements against MIC size, normalised to 1000 m, with harbour porpoise instantaneous PTS threshold marked (2 dB SPL_{peak} , as per NMFS, 2024 threshold).

It is clear here that at an MIC in excess of approximately 30 kg, the measurements exceed the harbour porpoise SPL_{peak} PTS threshold (202 dB SPL_{peak}) at 1000 m. Thresholds for all other species hearing groups are 222 dB SPL_{peak} or greater¹¹, and so are not exceeded.

¹¹ Summary of NMFS, 2024 auditory injury SPL_{peak} thresholds: 222 dB (LF cetacean, e.g. minke whale), 230 dB (HF cetacean, e.g. Risso's dolphin), 202 dB (VHF cetacean, e.g. harbour porpoise), 223 dB (PCW, pinnipeds in water, e.g. harbour seal)

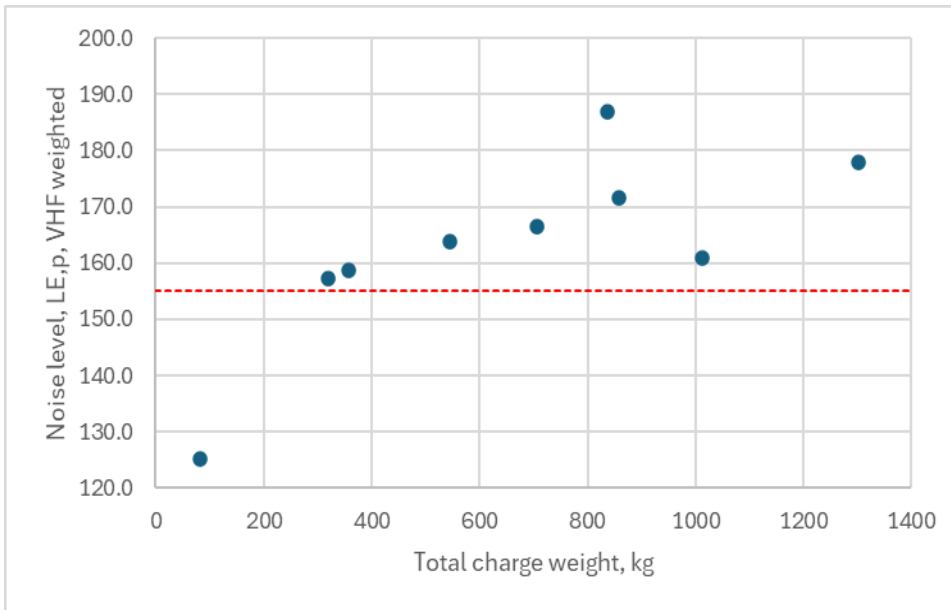


Figure 4 – SEL measurements against total charge weight, normalised to 1000 m, with harbour porpoise PTS exposure threshold marked (155 dB SEL, as per Southall et al., 2019 threshold).

Again here we can see that using the total charge weights measured, most larger explosive quantities exceed the Southall et al. (2019) harbour porpoise SEL threshold at 1000 m.

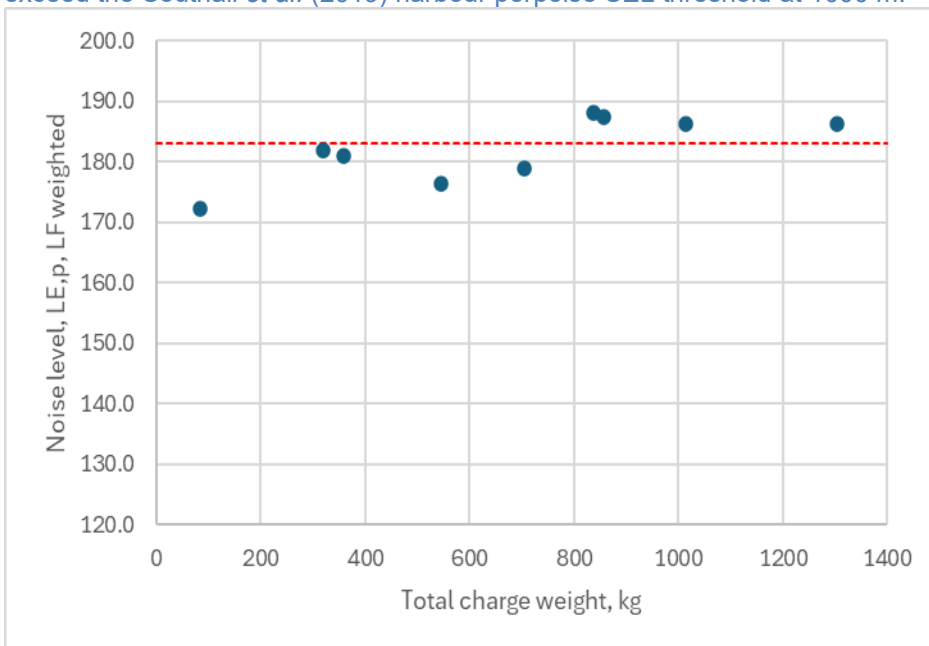


Figure 5 – SEL measurements against total charge weight, normalised to 1000 m, with low frequency cetacean (i.e. minke whale) PTS exposure threshold marked (183 dB SEL, as per Southall et al., 2019 threshold).

All detonations at or below 700 kg total charge weight were less than the criterion.

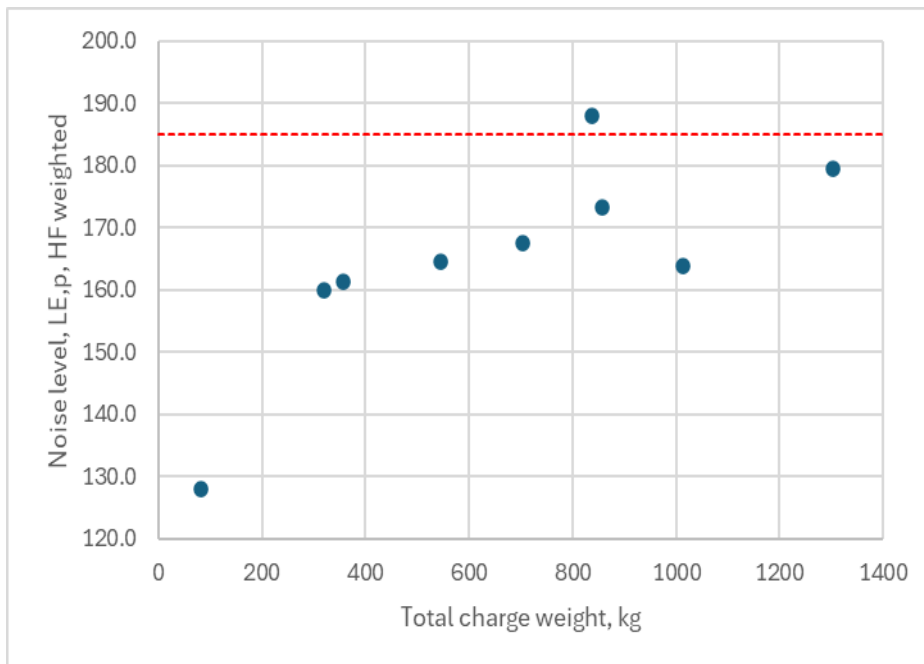


Figure 6 – SEL measurements against total charge weight, normalised to 1000 m, with high frequency cetacean (i.e. Risso's dolphin) PTS exposure threshold marked (183 dB SEL, as per Southall et al., 2019 threshold).

The measured noise levels at or normalised to 1000 m for all detonations (aside from one outlier) were below the PTS noise criterion.

Estimation of disturbance

The National Marine Fisheries Service (NMFS) in the United States has used a concept of Level B Harassment to identify a noise level at which disturbance could occur in marine mammals. For impulsive noises this is often quoted as 160 dB SPL_{rms} but crucially this threshold is not intended for explosive noise. However, in their Summary of Acoustic Thresholds (2025)¹², NMFS provides a series of weighted SEL behavioural thresholds for explosions considering multiple detonations for relevant species groups. These thresholds are provided alongside the calculated result for a selection of charge weights (with embedded charge correction).

Table 1 – Behavioural thresholds for underwater explosives, NMFS (2025) and predicted impact ranges. Note these use the NMFS (2024)⁶ marine mammal weightings and linked thresholds, dB re 1 $\mu\text{Pa}^2\text{s}$

Hearing Group	Example species	Threshold, weighted	20 kg	30 kg	50 kg	700 kg
LF Cetaceans	Minke whale	163 dB SEL	20 km	24 km	30 km	93 km
HF Cetaceans	Risso's dolphin	173 dB SEL	110 m	140 m	170 m	520 m
VHF Cetaceans	Porpoise	139 dB SEL	3.4 km	3.6 km	3.9 km	5.4 km
Phocid pinnipeds	Seal	163 dB SEL	4.2 km	5.1 km	6.5 km	20 km

¹² <https://www.fisheries.noaa.gov/s3/2025-09/MM-Acoustic-Thresholds-508-secure-SEPT-2025-OPR1.pdf>

The long-range results calculated for LF cetaceans is likely to be a significant over-estimation of the real risk, due to the relatively shallow water at the sites which will likely attenuate the noise more quickly than the calculation assumes. It is worth also being mindful of the context: a widespread clearance of an area would be much more likely where high noise levels are present for an extended period. For a single detonation (effectively also a single collection of detonations) lasting less than a second, with many hours between the explosive events, it is hard to localise the sound and so this is thought most likely to lead to a startle reaction in individuals rather than causing a displacement of marine mammals.

Discussion

There is clearly a divergence in the theoretical and empirical results. While the theoretical calculations for the instantaneous SPL_{peak} indicate that there is significant headroom before reaching the seal PTS onset threshold at 1 km, they are very close to (but still beneath) the threshold based on SEL exposure. Despite this, the measurements in Singapore Harbour indicate a risk of exceedance at the maximum MIC proposed at the Shetland sites for the instantaneous PTS SPL_{peak} thresholds at 1 km. Using the total exposure (rather than instantaneous) threshold, the predicted noise appears to be just beneath the threshold, in line with the theory. Considering harbour porpoise however, their greater sensitivity to noise shows that at the larger MICs and total exposures, their PTS thresholds would be exceeded at 1 km using both theoretical and empirical measures for all except theoretical instantaneous calculation.

In some ways divergence between theoretical and empirical measures is not surprising; every detonation is different. This is especially true where the explosives are drilled into rock, and the depth and structure of the particular rock type will affect the noise ultimately transmitted into the water. However on the basis of the measurements available, no exceedance was found at 1 km for MICs up to 50 kg for seals, although an exceedance for harbour porpoise is more likely. All other species group had a lower sensitivity and a lower risk of PTS. In terms of noise transmission over 1 km, the slightly shallower depths around the Lerwick sites are likely to lead to slightly lower noise levels, although its real effect is more complicated to predict and beyond the scope of this report. There is a potential for behavioural disturbance in seals of 6.5 km with a charge weight of 50 kg or up to 20 km for a total charge weight of 700 kg, but due to the single event nature of explosive detonations, it is thought likely that this would lead to a short-term startle reaction rather than individuals leaving the area.

It should be borne in mind that the instantaneous SPL_{peak} PTS calculations use the maximum MIC proposed at the Shetland sites, and so the risk from the majority of the detonations is anticipated to be lower for most of the sites and times. The real risk to harbour porpoise should not be overestimated either, due to the small population in the area and the low likelihood of an individual being present near to the blast sites, especially due to the elevated noise levels from drilling prior to blasting.

It is understood that a major part of the mitigation proposed for the drill and blast works at the sites will be the use of marine mammal observers and underwater noise monitoring at the sites. Measurements will start with lower MICs and incrementally increase until or in case there is a clear exceedance of the impact thresholds. It is suggested that, as the worst case theoretical calculations and empirical measurements indicate that the seal PTS is expected to remain below the threshold for SEL (total charge weights), then there is some comfort that available data show that the threshold using this metric is unlikely to be exceeded at the Shetland sites. However, there remains greater uncertainty based on the SPL_{peak} thresholds, and the ultimate impact is likely to be dependent on the specific conditions at the Shetland sites; indeed a comparison between the noise levels produced at the two sites and the existing data will be useful. The underwater noise monitoring exercise will



be important to confirm the particular characteristics from blasting at various charge weights at the two sites and provide confidence in the underwater noise levels in comparison with the theoretical data and those acquired at a different location.

Subacoustech Environmental Limited
Unit 2 Muira Industrial Estate, William Street
Southampton, Hampshire
SO14 5QH, United Kingdom

Telephone: +44 (0) 2380 236 330
Email: info@subacoustech.com
Website: www.subacoustech.com

VAT No: 935 5701 16
Company registration Number: 6606268
Registered office: Unit A Greengates Way,
Hoveton, Norwich, Norfolk, NR12 8ED, UK