Inch Cape

OFFSHORE LIMITED

# Inch Cape Offshore Transmission Works

# Cofferdam Screening Request & Supporting Information

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## Acronyms & Abbreviations

| Acronym | Term |
|---|---|
| dBA | A-weighted decibel |
| ALARP | As Low as Reasonably Practicable |
| EIA | Environmental Impact Assessment |
| EIAR | Environmental Impact Assessment Report |
| ELC | East Lothian Council |
| ES | Environmental Statement |
| HRA | Habitats Regulations Appraisal |
| ICOL | Inch Cape Offshore Limited |
| LF | Low Frequency |
| MD-LOT | Marine Directorate Licensing Operations Team |
| MHWS | Mean High Water Springs |
| MLWS | Mean Low Water Springs |
| MS-LOT | Marine Scotland Licensing Operations Team |
| MW | Megawatts |
| MW Regulations | Marine Works Regulations |
| NIS | Non-indigenous Species |
| OD | Ordnance Datum |
| OfTI | Offshore Transmission Infrastructure |
| OfTW | Offshore Transmission Works |
| OnTW | Onshore Transmission Works |
| OSP | Offshore Substation Platform |

| Acronym | Term |
|---|---|
| PAC | Pre-application Consultation |
| PSA | Particle Size Analysis |
| SAC | Special Area of Conservation |
| $SEL_{cum}$ | Cumulative sound exposure level |
| SLVIA | Seascape, Landscape and Visual Impact Assessment |
| SPA | Special Protection Area |
| SSC | Suspended Sediment Concentrations |
| SSSI | Site of Special Scientific Interest |
| te | Tonne |
| TTS | Temporary Threshold Shift |
| VOR | Valued Ornithological Receptor |
| WeBS | Wetland Bird Survey |
| WSI | Written Scheme of Investigation |

# Glossary

| Defined Term | Meaning |
|---|---|
| Additional Landfall Works | Comprising the construction of a temporary access road, diversion of the East Lothian Council (ELC) outfall, movement of part of the rock revetment and temporary removal and reinstatement of sections of the seawall. |
| Cetacean | A marine mammal such as dolphin, porpoise or whale. |
| Cofferdam | A structure used in construction projects to create a dry working environment. The main components of a cofferdam include steel sheet-piles, waling beams, props, and tie-rods. Each element serves a specific function in maintaining the structural form and integrity of the cofferdam. |
| Cofferdam Works | Comprising the construction of a temporary crushed rock platform for piling and erection and removal of the cofferdam. |
| Development | Refers to the wind turbine generators (WTGs), inter-array cables, Offshore Substation Platforms (OSPs) and the Offshore Export Cable and any other associated works. |
| Development Area | The area which includes proposed WTGs, inter-array cables, OSPs and the initial part of the Offshore Export Cable and any other associated works. |
| Eulittoral | A mid-tide zone between the highest and lowest extent of the tides where the water inundates and retreats twice daily. |
| Inch Cape Offshore Transmission Infrastructure (OfTI) | Components of the Development which are permitted by the OfTI Marine Licence (06782/19/0). |
| Inch Cape Offshore Wind Farm (the Wind Farm) | A component of the Development, comprising wind turbines and their foundations and substructures, and inter-array cables. |
| Littoral | The littoral zone is defined as the part of the sea which is close to shore, including the intertidal zone, covering the area from MHWS to MLWS. |
| Littoral fringe | The littoral fringe is the upper most reaches of the littoral zone where marine ecosystems exist. |

| Defined Term | Meaning |
|---|---|
| Offshore Export Cable | The subsea, buried or protected electricity cables running from the offshore wind farm substation to the landfall and transmitting the electricity generated to the onshore cables for transmission onwards to the onshore substation and the electrical grid connection. |
| Offshore Export Cable Corridor/ Export Cable Corridor | The area within which the Offshore Export Cables will be laid outside of the Development Area and up to Mean High Water Springs. |
| Onshore Transmission Works (OnTW) | Onshore transmission works associated with the Inch Cape Offshore Wind Farm comprising the construction, operation and decommissioning of an onshore substation, electricity cables and associated infrastructure required to export electricity from the Inch Cape Offshore Wind Farm to the National Electricity Transmission System. |
| Pinniped | A carnivorous marine mammal including seals. |
| Props | Diagonal or horizontal compressive elements that support the cofferdam waling beams and transfer the loads to the ground. They act as temporary support, resisting the weight of the water and soil acting on the cofferdam. |
| Ramsar | Wetland site designated to be of international importance under the Ramsar Convention. |
| Strandline | The shifting line of decomposing seaweed and debris typically left behind on sediment beaches at the upper extreme of the high tide. |
| Sublittoral | The zone exposed to air only at its upper limit by the lowest spring tides, although almost continuous wave action on extremely exposed coasts may extend the upper limit high into the intertidal region. |
| Sublittoral fringe | The upper part of the sublittoral zone that is uncovered by the tide i.e. MLWS. |
| The 2010 Act | Marine (Scotland) Act 2010. |
| The 2013 Application | The Environmental Statement, HRA Report and supporting documents submitted by the Company on 1st July 2013 to construct and operate the Inch Cape offshore generating station and transmission works. |
| The 2018 Application | The EIA Report, HRA Report and supporting documents submitted by the Company on 15 August 2018 to construct and operate the Inch Cape offshore generating station and transmission works. |

| Defined Term | Meaning |
| --- | --- |
| Tie Rods | Tension members that run through the cofferdam horizontally, connecting the sheet-piles on opposite sides. Like props, they help hold the sheet-piles in position and prevent them from spreading apart due to the lateral pressure exerted by the water and soil. |
| Steel Sheet-Piles | Long, interlocking, vertical steel elements driven into the ground to form the perimeter of the cofferdam. They act as a barrier, preventing water and soil from flowing into the enclosed area. The sheet-piles are usually installed deep into the ground or toed into rock to provide stability and resist. lateral forces from the surrounding water and soil. |
| Waling Beams | Horizontal beams that connect and support the sheet-piles. They run along the length of the cofferdam and provide additional lateral support. Waling beams help distribute the loads from the sheet-piles and transfer them to the props and tie-rods, enhancing the overall stability of the structure. |

# Executive Summary

Inch Cape Offshore Limited (ICOL) intends to apply for a marine licence (the marine licence application) under Part 4 of the Marine (Scotland) Act 2010, (the 2010 Act). The marine licence is required for a Cofferdam to facilitate the Additional Landfall Works (comprising the construction of a temporary access road, diversion of the East Lothian Council (ELC) outfall, movement of part of the rock revetment, and temporary removal and reinstatement of sections of the seawall), and Export Cable installation for the Inch Cape Offshore Wind Farm.

Marine Scotland - Licensing Operations Team (MS-LOT), (now Marine Directorate - Licensing Operations Team (MD-LOT)) requested that ICOL seek a Screening Opinion under The Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (2017 MW Regulations) to determine if an Environmental Impact Assessment (EIA) is required in support of the marine licence application.

ICOL is of the understanding that the Cofferdam, constitutes a change to an authorised project and therefore may fall under Entry 13 of the Table in Schedule 2 of the 2017 MW Regulations.

Following review of the 2013 Environmental Statement (ES) and 2018 Environmental Impact Assessment Report (EIAR), and further consideration of environmental effects arising from the Cofferdam, no significant impacts were identified to arise, and it is considered that no EIA is therefore required for the marine licence application, pursuant to the applicable thresholds and criteria specified in Schedule 2 of the 2017 MW Regulations.

This document has been prepared by competent experts (Natural Power Consultants), to provide the supporting information to inform the request for a Screening Opinion for the marine licence application.

# 1 Introduction

## 1.1 Background

1 The Inch Cape Offshore Wind Farm (the Wind Farm) and Offshore Transmission Works (OfTW), hereafter referred to as the Development, is being developed by Inch Cape Offshore Limited (ICOL) (see Figure 1.1).

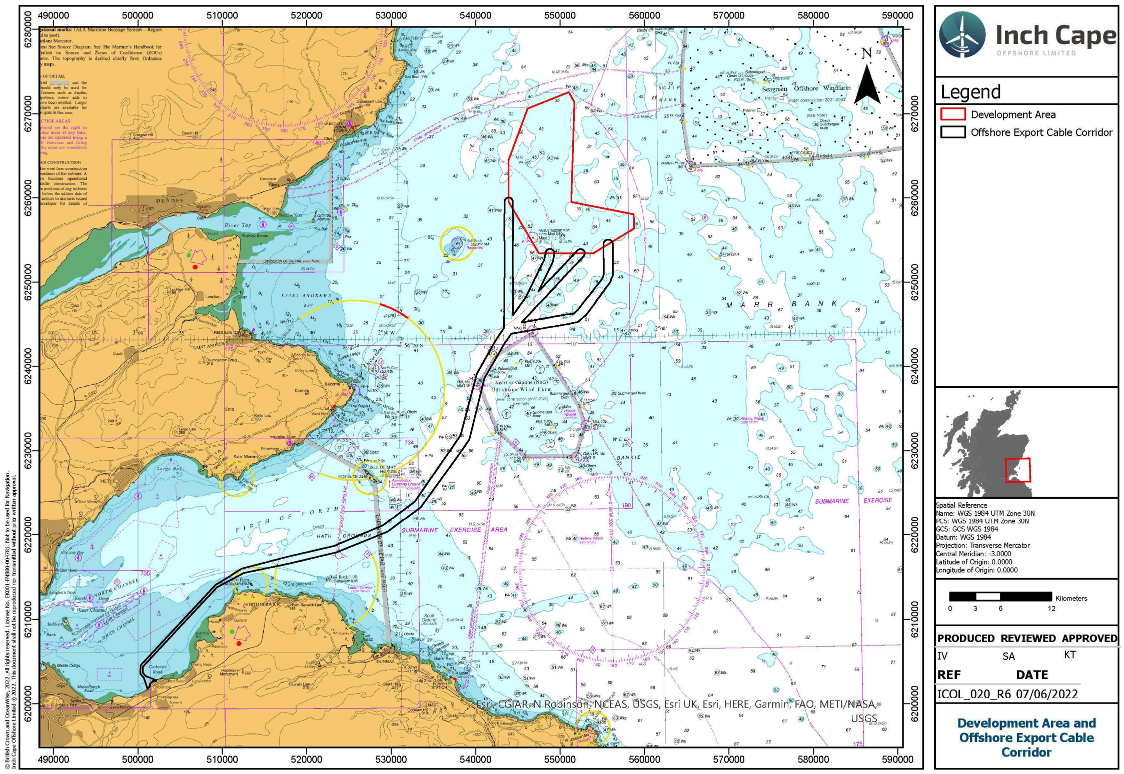


**Figure 1.1: Inch Cape Offshore Development Area and Offshore Export Cable Corridor**

2 In 2014, the Scottish Ministers granted ICOL Section 36 and marine licence consents, pursuant to the 2013 Application, for the construction and operation of an offshore wind farm and a marine licence for the construction and operation of offshore transmission works[1]. The licences granted to ICOL in 2014 (along with those for other Forth and Tay projects, Seagreen Alpha and Bravo and Neart na Gaoithe) were subject to a petition for judicial review in early 2015. A decision was made by the UK Supreme Court in November 2017 to uphold the Scottish Ministers' decisions to grant the offshore consents.

3 ICOL subsequently submitted the 2018 Application with a revised design that would allow the development of a project that could utilise progressions in technology since the 2014 consent.

[1] In 2014, the Scottish Ministers granted ICOL Section 36 and Marine Licence consents for the construction and operation of an offshore wind farm and a marine licence for the construction and operation of offshore transmission works (for up to six export cables). In 2018, ICOL submitted a new application with a revised Wind Farm design, with the revised offshore transmission licence still providing an option of four export corridors from the wind farm boundary, but only allowing for up to two export cables.

Section 36[2] and Marine Licence Consents for the revised design were granted by Scottish Ministers in 2019.

4 The revised Marine Licence (06782/19/0)[3] (dated 17th June 2019) was granted for the offshore transmission infrastructure connecting the landfall location near Cockenzie, East Lothian, and the Inch Cape Offshore Wind Farm which is located approximately 15 - 22 km off the Angus coastline, to the east of the Firth of Tay (the OfTW).

## 1.2 Intention to Apply for a New Marine Licence

5 Following further site investigations and detailed engineering design for the installation of the Offshore Export Cables, a Cofferdam is anticipated to be required at Cockenzie (which is described in detail in Section 2). ICOL is therefore applying for a marine licence to cover this work.

6 As agreed with the Marine Directorate, in addition to this Cofferdam Screening Request, ICOL is applying separately for a marine licence for 'Additional Landfall Works', comprising the construction of a temporary access road, diversion of the East Lothian Council (ELC) outfall, movement of part of the rock revetment, and temporary removal and reinstatement of sections of the seawall, required as part of the landfall cable installation enabling works. The proposed Cofferdam will allow these Additional Landfall Works to progress safely in the intertidal area.

7 The Cofferdam will also be installed within the Additional Landfall Works Area (Figures 1.2 and 1.3, and Table 1.1) and will form a separate application to the Additional Landfall Works. A separate Screening Request has been prepared and submitted in relation to the Additional Landfall Works and a Screening Opinion received, confirming that the Works do not require an EIA. The Additional Landfall Works are not therefore considered as part of the screening assessment below.

**Table 1.1: Cofferdam Coordinates**

| Latitude (Degrees, minutes, decimal minutes) | Longitude (Degrees, minutes, decimal minutes) | UTM30N X (Meters) | UTM30N Y (Meters) |
|---|---|---|---|
| 55°58.091301'N | 2°58.479291'W | 6202539 | 501582 |
| 55°58.075464'N | 2°58.504847'W | 6202510 | 501555.4 |
| 55°58.101906'N | 2°58.501667'W | 6202559 | 501558.7 |
| 55°58.086077'N | 2°58.526262'W | 6202530 | 501533.2 |

[2] Since the consent for the revised design was received, ICOL has successfully sought two variations to the Inch Cape Offshore Wind Farm Section 36 Consent and Marine Licence 06781/19/0. A separate variation application for these consents, to optimise wind farm efficiency and enable utilisation of the best available technological solution, was submitted to Marine Scotland Licensing and Operations Team (MS-LOT) and was granted consent in June 2023.

[3] ICOL has requested a variation to capture changes to temporary and permanent deposit quantities and revision of the Offshore Export Cable Corridor Coordinates to include the intended Offshore Substation Platform (OSP) location.

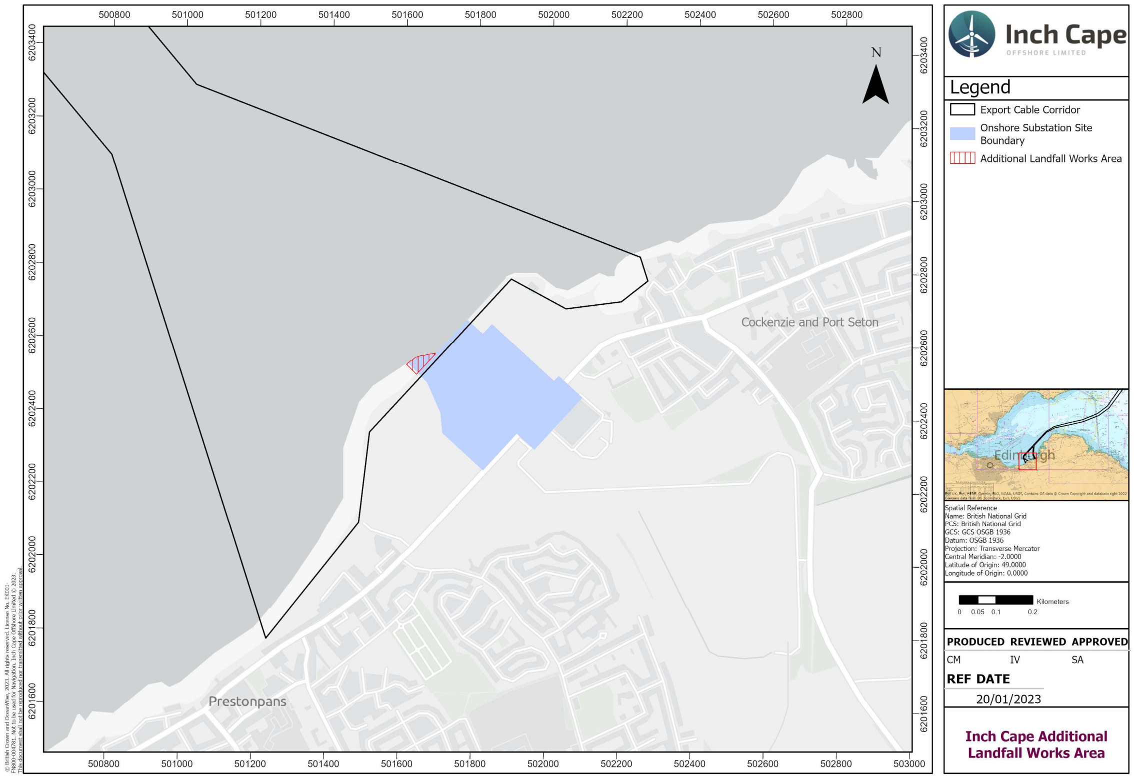


Figure 1.2: Inch Cape Offshore Wind Farm Additional Landfall Works Area


Figure 1.3: Inch Cape Offshore Wind Farm Indicative Cofferdam Location

8 Under the 2010 Act, a marine licence is required if a person or organisation intends to carry out marine construction works in the Scottish marine area, seaward of Mean High-Water Springs (MHWS). Therefore, ICOL intends to apply for a new marine licence under Part 4 of the 2010 Act to cover the Cofferdam. In addition, MD-LOT has requested that ICOL seek a Screening Opinion under The Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (2017 EIA Regulations) to determine if an Environmental Impact Assessment (EIA) is required in support of the marine licence application.

9 The Cofferdam requires Pre-Application Consultation (PAC) under The Marine Licensing (Pre-Application Consultation) (Scotland) Regulations 2013 (the PAC Regulations). ICOL has consulted with all required parties in line with the PAC Regulations and a PAC Schedule and supporting information report will accompany the marine licence application.

## 1.3 EIA Screening

10 ICOL considers that the Cofferdam should be screened out for the purposes of EIA, in terms of the 2017 EIA Regulations.

11 Under the 2017 EIA Regulations, the works will be considered EIA development if it either:

1. Constitutes Schedule 1 Development; or
2. Constitutes Schedule 2 Development and is likely to have significant effects on the environment having regard to the factors set out in Schedule 3[4].

12 ICOL is of the understanding that the Cofferdam constitutes a change to an authorised project and therefore can fall under Entry 13 of the Table in Schedule 2 of the 2017 EIA Regulations which applies to '*Any change to or extension of development of a description listed in Schedule 1 (other than a change or extension falling within paragraph 24 of that Schedule) where that development is already authorised, executed or in the process of being executed*'.

13 Following review of the Inch Cape Offshore Wind Farm and OfTW 2013 Environmental Statement (ES) and 2018 Environmental Impact Assessment Report (EIAR), alongside further consideration of environmental effects arising from the Cofferdam (as detailed in Section 3 and 4 below), no significant impacts are identified as being likely to arise, and it is considered that no EIA is required, pursuant to the applicable thresholds and criteria specified in Schedule 2 of the 2017 Regulations.

14 ICOL is requesting an EIA Screening Opinion under Regulation 10 (1) of the 2017 EIA Regulations.

15 ICOL proposes to include a concise summary of the environmental effects with the Marine Licence application. These are considered not to be significant but will be included to inform stakeholders.

## 1.4 Scope of this Document

16 This document has been produced to provide the supporting information to inform the request for a

[4] Namely, having regard to the characteristics of the works (e.g., the size and design of the works, cumulation with other existing works and/or approved works, the use of natural resources, in particular land, soil, water and biodiversity, etc.), the location of the works and characteristics of the potential impact (e.g., the magnitude and spatial extent of the impact, the nature of the impact, etc.).

Screening Opinion for the marine licence application, and contains the following:

- Description of the Cofferdam Works (Section 2);
- Screening for potential for significant effect (Section 3);
- Further consideration of potential effects (Section 4); and
- Summary and Conclusions (Section 5).

17 The assessment within this document considers whether the Cofferdam Works could result in significant effects on physical, biological, and human receptors.

# 2 Description of the Cofferdam

18 To facilitate the Additional Landfall Works plus installation of the Export Cables, a Cofferdam in the intertidal zone will be required. The Cofferdam is necessary to enable the intertidal elements of the work to be completed to as low as reasonably practicable (ALARP) standards, to provide protection for the works, and ensuring that there is a safe working area.

## 2.1 Outline Programme

19 The sequencing of the work in relation to other associated activities is set out in Table 2.1 below. The Cofferdam is likely to be in place until both Export Cables are installed, and all backfilling works complete, anticipated to be up to 18 months. The commencement date will be no earlier than January 2025 and completion no later than December 2028 with the current indicative programme of works spanning May 2025 to November 2026. Please note that this programme is indicative, and both the programme and sequencing are subject to change.

**Table 2.1: Sequencing of Operations**

| Sequence | Activity | Relevant Consent |
|---|---|---|
| 1 | Installation of temporary access | Additional Landfall Works marine licence. |
| 2 | Diversion of ELC outfall[5] and clearance of the foreshore | Additional Landfall Works marine licence. |
| 3 | Temporary removal of rock revetment | Additional Landfall Works marine licence. |
| **4** | **Installation of temporary crushed rock piling platform** | **This Screening Request, and subsequent marine licence application.** |
| **5** | **Excavation of narrow trench to facilitate piling operations** | **This Screening Request, and subsequent marine licence application.** |
| **6** | **Installation of steel piles using vibro-piling** | **This Screening Request, and subsequent marine licence application.** |
| **7** | **Grouting/concrete sealing of toes of sheet piles and sides of cofferdam to seawall** | **This Screening Request, and subsequent marine licence application.** |
| 8 | Installation of temporary flood defence wall on the landward side behind the sea wall, if considered necessary by the contractor. | Onshore planning consent. |
| 9 | Creation of seawall openings. | Additional Landfall Works marine licence. |
| 10 | Cable pull-in and installation. | OfTW Marine Licence Variation 06782. |

[5] The Cofferdam is not required for this activity.

| Sequence | Activity | Relevant Consent |
|---|---|---|
| 11 | Seawall reinstatement and cable containment completion | Additional Landfall Works marine licence and OfTW Marine Licence Variation 06782. |
| **12** | **Cofferdam removal.** | **This Screening Request, and subsequent marine licence application.** |
| 13 | Temporary access removal. | Additional Landfall Works marine licence. |
| **14** | **Crushed rock piling platform removal.** | **This Screening Request, and subsequent marine licence application.** |
| 15 | Reinstatement of original beach profiles using stored rock armour. | Additional Landfall Works marine licence. |

## 2.2 Outline Method Statement

20 The Cofferdam is envisaged as a traditional box structure (up to 40 m x 40 m) formed from a perimeter of steel sheet-piles toed into the seabed and supported by horizontal waling beams, props, and tie-rods for stability. Installation of the Cofferdam is estimated to take 10 to 12 weeks, undertaken during low tide events, following clearance of the foreshore and upon completion of the ELC outfall diversion, prior to breaking through the seawall. Figures 2.1 and 2.2 illustrate the Cofferdam layout with the yellow areas within the cofferdam on Figure 2.1 representing the two export cables and parts of the seawall required to be removed, and the third yellow area outside the cofferdam representing the ELC outfall pipe. Key parameters are outlined in Table 2.2 and described in more detail in the remainder of this section.

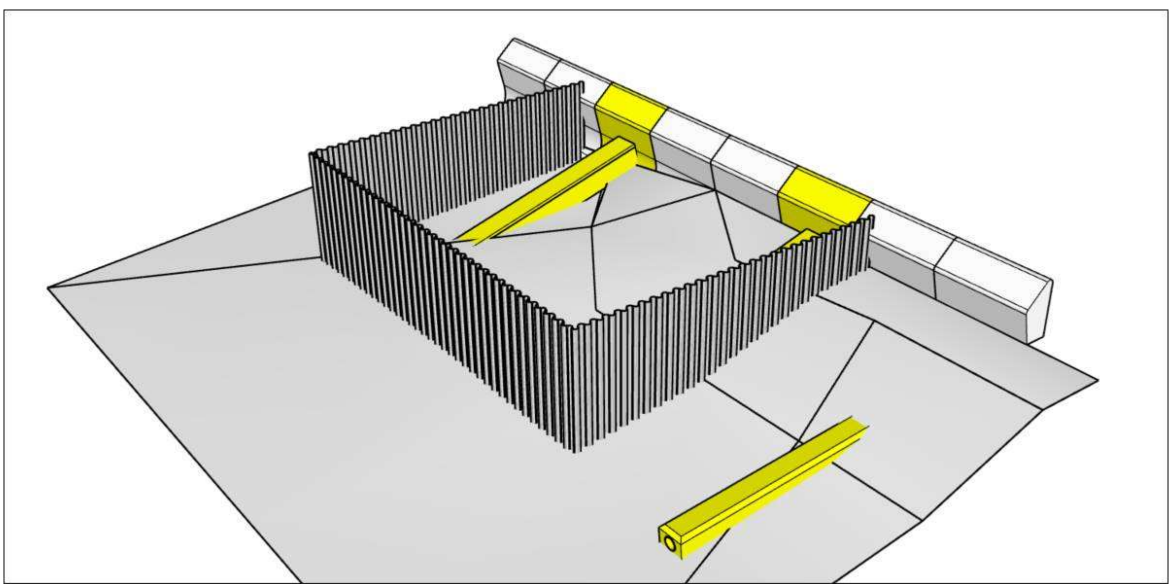

**Figure 2.1: Indicative Sketch of Cofferdam**


Figure 2.2: Example Image Showing Wailing Beam, props and tie rods within a Cofferdam

Table 2.2: Key Parameters

| Item | Details | Comments |
| --- | --- | --- |
| **Cofferdam Construction** | | |
| **Cofferdam** | • Cofferdam footprint is up to 40 m x 40 m.<br>• A 120 m perimeter crushed rock level platform is required for piling operations (up to 3 m wide).<br>• Conventional cofferdam constructed from steel sheet-piles to protect the foreshore working area.<br>• Steel sheet-piles may be complemented by vertical steel H-Piles to stiffen the structure (subject to detailed design).<br>• Internally, the sheet piles will be connected and stiffened using horizontal steel beams (waling beams) at multiple levels.<br>• It is likely that the waling beams will be diagonally braced for support (subject to detailed design).<br>• The steel-piles will likely be set into drilled “slots” on the seabed to achieve toe-fixity and be vibrated rather than percussively piled.<br>• The toe and landward connection points may need to be grouted to create a seal. | • Top of the cofferdam is at least the same level as the sea defence wall (subject to detailed design)<br>(+7 m OD is estimated). |

| Item | Details | Comments |
|---|---|---|
| **Anticipated method for installation and removal** | • Steel piles in pairs (assumed to be 1.4 m wide x 29no. x 12 m high per side x 3 sides) would be installed using a vibro hammer into the seabed to achieve the required penetration[6].<br>• Piling duration: conservative estimate of up to 60 working days has been assumed, (although a worst-case assumption of 6 hours a day over 30 working days has been applied to the review of environmental effects in Section 4).<br>• Excavate a narrow trench around the footprint of the Cofferdam to prepare for piling work.<br>• Where rock or difficult driving conditions are encountered it is anticipated that the ground will be prepared by pre-drilling to allow the piles to be advanced.<br>• The cofferdam would be constructed tight to the existing sea wall such that a seal could be formed to limit sea water entering the space: this will likely require an amount of grout/concrete to seal the toes of the sheet-piles and voids against/within the sea wall along with de-watering pumps.<br>• It is feasible that the cofferdam could be removed in full on completion of the works, however, depending on how the toes have been formed, it may be necessary to cut the sheet piles off just below bed level. | • Piling and excavation works expected to be completed in a period of eight to ten weeks.<br>• It is likely, given the ground conditions and nature of the existing sea wall, that water will enter the cofferdam and pumping will be needed.<br>• Any water that requires to be pumped out of the cofferdam will be pumped onshore to be filtered and returned or disposed of safely off site. |
| **Indicative programme** | • Installation anticipated to be Q4 2024 | • Cofferdam to be in place up to 18 months |
| **Expected plant and equipment** | • 45 te Long reach excavator to clear the line of the piles (rock grab attachment).<br>• 45 te Excavator with drill to break the rocky seabed and prepare for pile installation.<br>• 150 te+ Crawler crane to pitch and install the piles.<br>• Vibro-hammer to install the piles into the rock.<br>• 10 te dumper.<br>• Concrete pump to place grout.<br>• De-watering pumps.<br>• Mobile generators and lighting sets.<br>• Option: a spud-leg barge with deck crane may be needed to install the outer line of cofferdam piles if these are beyond the reach of the land-based crane. | |
| **Expected working area** | • The total working area for the cofferdam below MHWS would be 43 m x 46 m (plus working tolerance) = 2000m$^2$ | |

[6] Please note that MHWS is +2.71m ODN, therefore, the upper 3.8m (around 1/3) of the steel sheet-pile is above MHWS. However, all of the cofferdam materials are treated as deposits below MHWS.

| Item | Details | Comments |
|---|---|---|
| **Types & Quantities of deposited material below MHWS (incl. temporary deposits)** | • Anticipate the rock platform could be around 3 m wide and 0.5 m thick extending around the perimeter (40 x 40 x 40).<br>• The volume would be (120 x 3 x 0.5 =) 180m³, allowing for tolerances = 200m³. | |

21 If required, a narrow trench will be excavated around the footprint of the Cofferdam to prepare for piling work. This narrow trench (potentially 600 mm wide) will extend through soft deposits to help start piling works. The material excavated including native rocks, cobbles, gravels and sands, will be temporarily removed and stored alongside the line of the trench outside the footprint of the cofferdam in advance of the piling works and will be reinstated once the Cofferdam has been removed. Depth will vary depending on ground conditions at the time of commencement. Steel piles would be installed into the seabed using vibro piling to achieve the required penetration and is expected to take up to 60 working days.

22 The Cofferdam would be constructed tight to the existing sea defence wall such that a seal could be formed to limit sea water ingress: this will likely require grout/concrete to seal the toes of the sheet-piles and voids against/within the sea defence.

23 Where rock or difficult driving conditions are encountered, it is anticipated that the ground will be prepared by pre-drilling to allow the piles to be advanced. Assuming a worst-case, where the entire outer perimeter requires drilling to a depth of 1000 mm, the volume would be no more than 80 $m^3$ (40 m + 40 m + 40 m) x 1 m x 0.6 m). It is anticipated that any arisings from drilling would be recovered to the onshore storage areas. Materials would be stored and processed for reuse when reinstating the beach. The materials will derive from native rocks and likely be processed through drilling and onshore crushing to cobble, gravel, and sand sized materials.

24 The top of the piles would match the height of the existing sea defence wall. It is possible temporary props and other supports may be required to ensure stability. Gaps in the Cofferdam will be in place to enable moveable ‘gates’ or ‘stoplogs’ to be installed to enable the Export Cables to cross. The gates/stoplog section is also likely to include a bellmouth to receive the cables. Once these are installed the Cofferdam will be watertight. It is possible that de-watering pumps may be required, with seawater from the Cofferdam being pumped onshore to be filtered and returned or disposed of safely off site.

25 Whilst the sheet piles are not specifically designed as flood defences, they do afford a level of flood protection determined largely by the height of the Cofferdam.

26 Access to the foreshore would be via the temporary access road (included within the proposed Additional Landfall Works Marine Licence Application). The foreshore area will be required to be cleared of loose material, debris, and other obstructions to the work. The clearance and access roads are not covered within the application for the Cofferdam but form part of the Additional Landfall

Works marine licence application.

27 Cofferdam construction would use conventional land-based plant to access the foreshore and install piles during low-tides. Piles would be pitched and installed by vibro-hammer working from the landward edge. A crushed rock piling platform around the perimeter is also anticipated to allow safe piling operations. It is anticipated this would be approximately 3 m wide and 0.5 m thick extending around the perimeter. The volume would be 180 $m^3$ (120 m x 3 m x 0.5 m), however up to 200 $m^3$ would permit tolerances.

28 Subject to design development, following seabed clearance and immediately prior to Cofferdam installation, crushed rock would be placed to form the piling platform. Rock would be lifted from the onshore working area to the intertidal working area and be placed using excavators and bulldozers to form the platform. It is anticipated that a polypropylene geotextile geogrid (NAUE SecuGrid, or equivalent) could be used for the piling platform. It is assumed that the geotextile would be 3 m wide, and installed around the full perimeter of the cofferdam (i.e. 360 $m^2$). Up to 400 $m^2$ of geotextile has been assumed to permit tolerances.

29 Both the rock access road (included within the Additional Landfall Works Marine Licence Application) and piling platform are temporary works to help construction of the Cofferdam and would be removed fully when the Cofferdam is no longer required.

30 The aim is to completely remove the Cofferdam upon completion; however, it is anticipated that the grouted steel piles may be difficult to remove and could be cut 1 m below the seabed level, remaining *in-situ*. On the restored shoreline, the cut ends would be covered in rock armour. The scour potential at these locations is the same as the present seabed and therefore considered to be very low. The rock armour would be reused from the original beach deposits excavated and stored prior to construction, and therefore would be the same as original material as far as practicable. Allowance has however been made in the permanent deposits table (Table 2.3 below) for import of additional rock armour should this be required. No additional grouting of the cut piles beyond that required to seal the toe of the functioning cofferdam, is anticipated.

31 If a temporary onshore flood defence wall is required by the contractor, this will be above MHWS and therefore covered under the onshore consent.

## 2.3 Deposits

32 Tables 2.3 and 2.4 outline the estimated permanent and temporary deposits for the Cofferdam. The intention is that there are minimal permanent deposits (permanent deposits only remaining where they cannot be removed through standard means., e.g. steel piles not able to be fully removed but cut below surface and sealed/protected). Any potential permanent deposits are accounted for in Table 2.3.

**Table 2.3: Permanent Substance(s) or Object(s) to be Deposited Below MHWS**

| Type of Deposit | Description/number | Quantity & Dimensions (metric) |
|---|---|---|
| **Steel/Iron** | On removal of the cofferdam, the grouted steel piles could be difficult to remove and would then be cut 1 m below the seabed level. | No. |
| | | Dimensions: 120 m long perimeter.<br>AZ24-700 steel sheet-piles 120m x 200kg/m run x 1.5m height |
| | | Weight (Kg/tonnes) Approximately 40 tonnes |
| **Boulders (≥ 256.0 mm)** | Preferably, the seabed would be restored using the stockpiled native materials, however, if imported, non-native, materials were required then the following quantities would be required. | Volume ($m^3$) 900 |
| | | Weight (kg/tonnes) 1440 |
| **Timber** | Non anticipated. | No. |
| | | Dimensions |
| | | Weight (Kg/tonnes) |
| **Concrete** | Non anticipated. | No. |
| | | Dimensions |
| | | Weight (Kg/tonnes) |
| **Plastic/Synthetic** | Non anticipated. | |
| **Clay (< 0.004 mm)** | Non anticipated. | Volume ($m^3$) |
| | | Weight (kg/tonnes) |
| **Silt (0.004 ≤ Silt < 0.063 mm)** | Non anticipated. | Volume ($m^3$) |
| | | Weight (kg/tonnes) |
| **Sand (0.063 ≤ Sand < 2.0 mm)** | Non anticipated. | Volume ($m^3$) |
| | | Weight (kg/tonnes) |

| Type of Deposit | Description/number | Quantity & Dimensions (metric) |
|---|---|---|
| Gravel (2.00 ≤ Gravel < 64.0 mm) | Non anticipated. | Volume |
| | | Weight |
| Cobbles (64.0 ≤ Cobbles < 256.0 mm) | Non anticipated. | Volume ($m^3$) |
| | | Weight (kg/tonnes) |
| Boulders (≥ 256.0 mm) | Non anticipated. | Volume ($m^3$) |
| | | Weight (kg/tonnes) |
| Pipe | Non anticipated. | Length |
| | | External Diameter |
| Cable | Non anticipated. | Length (m) |
| | | External Diameter (cm/m) |
| Other (please describe below) | | |
| Concrete (disposal) | Non anticipated. | No. |
| | | Dimensions |
| | | Weight (Kg/tonnes) |

**Table 2.4: Temporary substance(s) or object(s) to be deposited below MHWS**

| Type of Deposit | Description/number | Quantity & Dimensions (metric) |
|---|---|---|
| **Steel/Iron** | 120m length of steel sheet-pile cofferdam.<br>Two rows of wailing beams and props (plus additional 25% as allowance). | No. |
| | | Dimensions: 120 m |
| | | Weight (Kg/tonnes)<br>300 tonnes |
| Timber | Non anticipated. | No. |
| | | Dimensions |
| | | Weight (Kg/tonnes) |
| Concrete | Non anticipated. | No. |
| | | Dimensions |
| | | Weight (Kg/tonnes) |
| **Plastic/Synthetic** | Geotextile 3 m wide by 120 m - 400 $m^2$ included for working permit tolerances. | 400$m^2$ |
| Clay (< 0.004 mm) | Non anticipated. | Volume ($m^3$) |
| | | Weight (kg/tonnes) |

| Type of Deposit | Description/number | Quantity & Dimensions (metric) |
|---|---|---|
| **Silt**<br>**(0.004 ≤ Silt < 0.063 mm)** | Non anticipated. | Volume ($m^3$)<br>Weight (kg/tonnes) |
| **Sand**<br>**(0.063 ≤ Sand < 2.0 mm)** | Non anticipated. | Volume ($m^3$)<br>Weight (kg/tonnes) |
| **Gravel**<br>**(2.00 ≤ Gravel < 64.0 mm)** | Non anticipated. | Volume ($m^3$)<br>Weight (kg/tonnes) |
| **Cobbles**<br>**(64.0 ≤ Cobbles < 256.0 mm)** | Non anticipated. | Volume ($m^3$)<br>Weight (kg/tonnes) |
| **Boulders**<br>**(≥ 256.0 mm)** | Non anticipated. | Volume ($m^3$)<br>Weight (kg/tonnes) |
| **Pipe** | Non anticipated. | Length (m)<br>External Diameter (cm/m) |
| **Cable** | Non anticipated. | Length (m)<br>External Diameter (cm/m) |
| Other (please describe below) | | |
| **Crushed rock for the piling platform** | Anticipated to be around 3 m wide and 0.5 m thick extending around the perimeter.<br>The volume would be (120 x 3 x 0.5) 180m³, allowing for tolerances, up to 200m³ assumed.<br><br>This is temporary and will be removed upon completion. | 200 m³. |
| **Grout** | Toe grout: assume<br>0.5 m x 0.5 m x length<br><br>2 x grout seals between the cofferdam and seawall: assume<br>2 x 0.5 m x 0.5 m x height | Volume ($m^3$) 5 $m^3$ |

# 3 Review of Environmental Effects

33 This review and all subsequent assessments have been undertaken with particular regard to the environmental sensitivities of the geographical area that may be affected through a review of relevant designated sites, specifically those closest to the Cofferdam (shortest straight-line distances provided) (see Figure 3.1):

- Outer Firth of Forth and St Andrews Bay Complex Special Protection Area (SPA) (adjacent to working area);
- Firth of Forth SPA (adjacent to working area);
- Forth Islands SPA (13.0 km);
- Isle of May Special Area of Conservation (SAC) (34.7 km);
- Firth of Tay and Eden Estuary SPA (42.8 km);
- Firth of Tay and Eden Estuary SAC (43.5 km); and
- Berwickshire and North Northumberland Coast SAC (46.8 km).

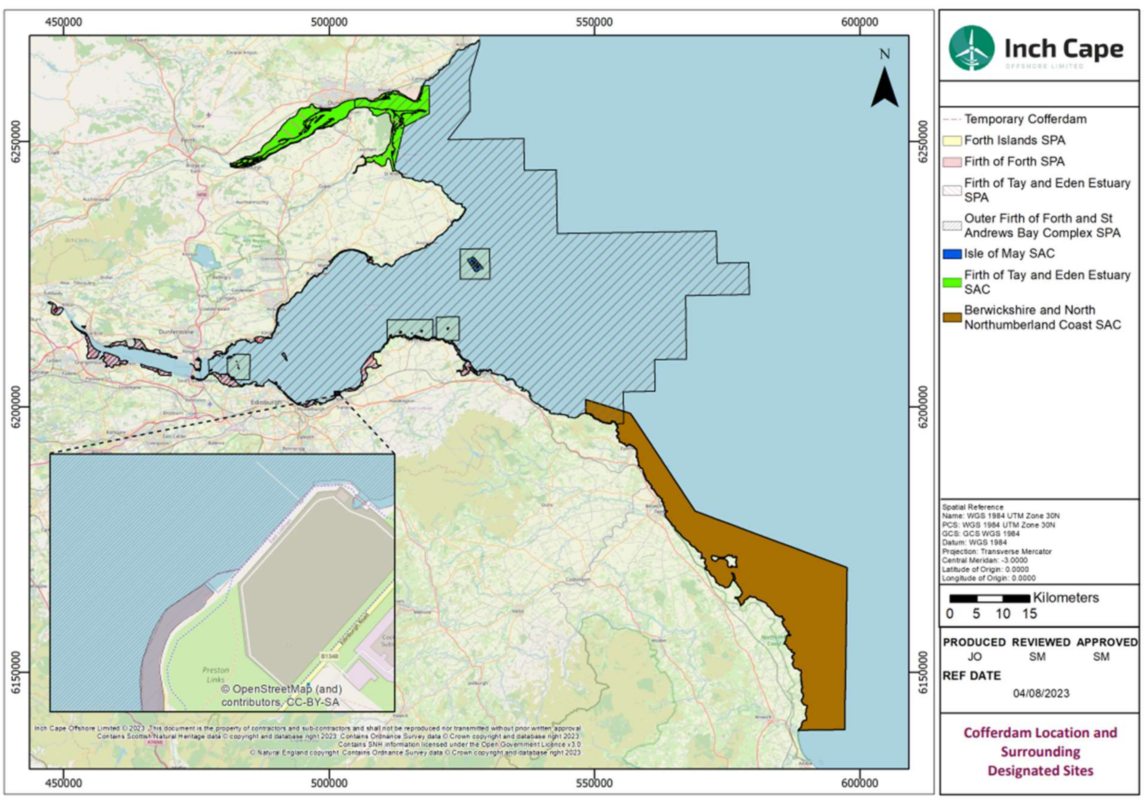


**Figure 3.1: Additional Landfall Works and surrounding SAC and SPAs**

34 A summary of potential significant environmental effects on receptors is identified in Table 3.1 below, with additional information provided in Section 4 (Further Technical Considerations), where necessary. Topics considered not to have the potential to lead to significant effects are also highlighted.

**Table 3.1: Summary of Potential Significant Effect Relating to the Cofferdam Works**

| Receptor | Requires Further Consideration? | Reasoning |
|---|---|---|
| **Metocean and Coastal Processes** | No | The presence of the Cofferdam in the intertidal zone has some potential to affect sediment transport processes by interrupting longshore sediment transport. However, any effects will be localised, temporary, and therefore reversible, and would not be enough to disrupt or alter the regional wave and tidal processes or the associated sediment transport in this area.<br><br>The placement of the structure and the dynamic nature of the Firth of Forth, would give to rise to only minor temporary and localised effects which are not considered to be significant and therefore no further assessment is required.<br>No potential for significant effects to arise, and as such no requirement for EIA. |
| **Benthic Ecology** | Yes | Some minor temporary disturbance on the intertidal area by construction plant may occur, and temporary habitat loss whilst the Cofferdam is in situ. Further consideration is presented in Section 4.1. |
| **Natural Fish and Shellfish** | Yes | The construction of the Cofferdam will require vibro-piling and therefore some minor temporary disturbance may occur. Further consideration is presented in Section 4.2. |
| **Marine Mammals** | Yes | The construction of the Cofferdam will require vibro-piling and therefore some minor temporary disturbance may occur. Further consideration is presented in Section 4.3. |
| **Ornithology** | Yes | Some minor disturbance on the intertidal area by construction plant may occur. Further consideration is presented in Section 4.4. |
| **Seascape, Landscape and Visual Impact Assessment (SLVIA)** | No | A temporary visual change would be expected. The cofferdam is expected to be at least the same height as the existing seawall with landward views largely unchanged.<br>No further assessment required.<br>No potential for significant effects to arise, and as such no requirement for EIA. |
| **Cultural Heritage and Marine Archaeology** | Yes | Some minor disturbance on the intertidal area by construction plant may occur. Further consideration is presented in Section 4.5. |

| Receptor | Requires Further Consideration? | Reasoning |
|---|---|---|
| **Commercial Fish** | No | All work will be undertaken intertidally or from the landward side of the Cofferdam, with construction plant accessing from an onshore direction. As such no effects on commercial fisheries will arise. No further assessment required.<br>No potential for significant adverse effects to arise, and as such no requirement for EIA. |
| **Shipping and Navigation** | No | All work will be undertaken intertidally or from the landward side of the Cofferdam, with construction plant accessing from an onshore direction.<br>As such no effects on shipping or navigation will arise. No further assessment required.<br>No potential for significant adverse effects to arise, and as such no requirement for EIA. |
| **Socio-Economics and Tourism** | No | No effects on socio-economic receptors. No potential for significant adverse effects to arise, and as such no requirement for EIA. |
| **Military and Civil Aviation** | No | No effects on military and civil aviation. No potential for significant adverse effects to arise, and as such no requirement for EIA. |
| **Other Human Considerations** | No | There may be very short periods of time during the works when partial closure of beach areas is required to maintain the safety of all beach users and construction workers.<br>Such short term and partial closures are not predicted to result in any significant effects on other users as large areas of amenity beach areas will remain accessible. As such there is no requirement for EIA.<br>The Cofferdam will be used as the temporary flood defence which will be in place prior to removal of sections of the seawall. This will afford the same protection in terms of flood risk, maintaining the crest level and overall sea defence. There would therefore be no change in flood risk to the area and as such, there is no requirement for EIA. |

| Receptor | Requires Further Consideration? | Reasoning |
|---|---|---|
| **Climate Change and Greenhouse Gases** | No | It is recognised that some greenhouse gas emissions, arising from vehicular sources will be emitted as part of this proposed work, and that additional construction materials will be required for the works. Where possible, all materials removed on the completion of the work will be recycled or re-used, with disposal used only where materials cannot be otherwise re-used or recycled. Due to the temporary and localised nature of the works, greenhouse gas emissions and waste materials are not considered to represent any potential for significant effects. It is considered that the works, as applied for, represent the lowest overall environmental effect compared to other options considered. There is no potential for significant adverse effects to arise, and as such, no requirement for EIA. |

# 4 Further Technical Considerations

35 Where identified as required in Table 3.1, further information and consideration of environmental effects arising from the Cofferdam Works are provided in this section through a review of existing OfTW environmental assessment conclusions, followed by an updated assessment for the Cofferdam Works.

36 The Cofferdam Works (including construction, operation and decommissioning), are analogous to other construction phase work that may be undertaken for the installation of an offshore wind farm (i.e. short duration and temporary, and utilised for facilitating the OfTW construction). It is therefore considered that the construction phase impacts from the existing EIA's are relevant to the consideration of whether significant effects may arise from the proposed work.

## 4.1 Benthic Ecology

### 4.1.1 Existing OfTW Assessment

37 The effects of the OfTW on the intertidal benthic ecology of the area is set out in Chapter 12 of the 2013 Inch Cape Offshore Environmental Statement. No further assessment was undertaken for the revised design (2018) EIA and benthic ecology was scoped out as the design changes proposed in the new application, coupled with no material changes to the baseline, were considered not to change the impact assessment conclusions. Effects were determined to be between minor and minor/moderate (not significant) (see Table 4.1).

**Table 4.1: Assessment conclusions relevant to intertidal ecology during construction from the Inch Cape Offshore Export Cable ES (2013) at the Cofferdam location (northern half of Cockenzie landfall)**

| Impact | Receptor (for description see Table 4.2 below) | Pre-Mitigation Effect | Mitigation | Post-Mitigation Effect |
|---|---|---|---|---|
| **Direct Temporary Disturbance of seabed habitats caused by Construction Activities;**<br><br>**Potential release of pollutants from construction plant.** | LR.MLR.BF.PelB, LR.HLR.MusB.Cht.Cht, LR.MLR.BF.FspiB, IR.MIR.KR.Ldig.Ldig, LR.LLR.F.Fspi.FS | Minor | N/A | Minor |
| **Indirect impacts of temporary increases in Suspended Sediment Concentrations (SSC) from construction-based activities;**<br><br>**Deposition of resuspended sediments leading to smothering;**<br><br>**Release of contaminants** | LR.MLR.BF.PelB, LR.HLR.MusB.Cht.Cht, LR.MLR.BF.FspiB, IR.MIR.KR.Ldig.Ldig, LR.LLR.F.Fspi.FS | Negligible/ Minor | N/A | Negligible/ Minor |

| Impact | Receptor (for description see Table 4.2 below) | Pre-Mitigation Effect | Mitigation | Post-Mitigation Effect |
|---|---|---|---|---|
| **bound in sediments; and**<br>**Secondary impacts of decreased primary production due to increased SSC of the water column.** | | | | |
| **Introduction of Non-Indigenous Species (NIS)** | LR.MLR.BF.PelB, LR.HLR.MusB.Cht.Cht, LR.MLR.BF.FspiB, IR.MIR.KR.Ldig.Ldig, LR.LLR.F.Fspi.FS | Minor/ Moderate | N/A | Minor/ Moderate |

### 4.1.2 Baseline

38 During baseline surveys undertaken for the OfTW, nine biotopes were observed along the intertidal area surveyed at Cockenzie (Table 4.2).

**Table 4.2: Biotopes recorded at the Cockenzie Landfall**

| Biotope Code | Name |
|---|---|
| **LS.LSa.St.Tal** | Talitrids on the upper shore and strandline |
| **LR.MLR.BF.PelB** | *Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock |
| **LR.HLR.MusB.Cht.Cht** | *Chthamalus spp*. On exposed upper eulittoral rock |
| **LR.MLR.BF.FspiB** | *Fucus spiralis* on exposed to moderately exposed upper eulittoral rock |
| **LS.LCS.Sh.BarS** | Barren littoral shingle |
| **LR.FLR.Eph.BlitX** | Barnacles and *Littorina* spp. on unstable eulittoral mixed substrata |
| **LR.FLR.F.Fspi.X** | *Fucus spiralis* on full salinity upper eulittoral mixed substrata |
| **LS.LSa.MuSa.Lan** | *Lanice conchilega* in littoral sand |
| **IR.MIR.KR.Ldig.Ldig** | *Laminaria digitata* on moderately exposed sublittoral fringe bedrock |

39 The surveyed area, which includes the Cofferdam area, could be divided into distinct southern and northern areas. The southern half of the site was composed of mixed sediments, backed by soil composite. Below the strandline biotope (LS.Lsa.St.Tal), the mixed sediment was composed of sand and gravel, providing a habitat for limited fauna (LS.LCS.Sh.BarS). The gravel substrate below this supported a green algal community due to the numerous freshwater runoffs (LR.FLR.Eph.BlitX). The lower shore was covered by a fucoid community (LR.FLR.F.Fspi.X). On the extreme low shore, the kelp biotope of IR.MIR.KR.Ldig.Ldig was recorded with an area of sandy sediment characterised by the sand mason worm (LS.Lsa.MuSa.Lan).

40 The northern half of the intertidal area, where the Cofferdam will be located, was characterised by hard substrata, ranging from cobbles to boulders and bedrock. A seawall was also present, extending over 200 m into the surveyed area and beyond the northern limit of the survey area. Below the seawall, a narrow area of large boulders supported a fucoid community (LR.MLR.BF.PelB) mixed with a sparse barnacle community (LR.HLR.MusB.Cht.Cht). The barnacle community extended down the shore but gave way to the fucoid, Fucus spiralis biotope (LR.MLR.BF.FspiB). On the extreme low shore and extending into the infralittoral, the kelp biotope (IR.MIR.KR.Ldig.Ldig) was recorded on boulders and bedrock.

41 The biotopes LR.MLR.BF.PelB, LR.HLR.MusB.Cht.Cht, LR.MLR.BF.FspiB, and IR.MIR.KR.Ldig.Ldig are listed under the EC Habitats Directive under the Annex I reef habitat type (JNCC, 2010). Additionally, LR.FLR.F.Fspi.X is a biotope classified as typical of the Annex I large shallow inlet and bay physiographic type. LS.Lsa.MuSa.Lan is listed under the Annex I mudflats and sandflats not covered by seawater at low tide habitat type.

#### 4.1.3 Effect of the Cofferdam Works

42 Potential effects from the Cofferdam Works include:

- Temporary disturbance / loss of habitat;
- Temporary increases in SSC leading to decreased primary productivity and smothering;
- Potential accidental release of pollutants from construction plant; and
- Introduction of Non-Indigenous Species (NIS).

43 The installation of the Cofferdam (along with any preparatory works including the rock piling platform perimeter and excavated trench), may result in the temporary loss and disturbance to intertidal habitats for up to 18 months, particularly those at the top of the shore within the 40 x 40 m area contained by the cofferdam. This area contains a mosaic of bare rock, fucoids and sparse barnacles which are likely to recover quickly after any disturbance as the species present are ubiquitous, typically found in high energy areas where disturbance and recolonisation occur regularly, and are present in the surrounding area which will facilitate rapid recolonisation and recovery upon completion of the works. There are discreet areas where rock protection may be required after the removal of the cofferdam if all the sheet piles cannot be removed in full, and are instead cut off below the surface level. In this instance, it is envisaged that original beach material can be re-used for protection, however there is the possibility that additional material may need to be brought in for this purpose. In this eventuality, it is expected that the material will function in the same manner as that already present on the shore, providing a substrate for colonisation of the species local to the

area, and any such additional material will not lead to any long-term changes in the habitats, species, or zonation in the intertidal area.

44 There may be a temporary increase in SSC and associated smothering of habitats during and just after installation and removal of the cofferdam, as areas of disturbed sediment are mobilised by tidal and wave activity. It is considered that such areas of disturbed sediment will be quickly restored to their pre-impacted state due to the nature of the shore which is considered moderately exposed. In addition, due to the location within the Firth of Forth, the habitats present are already considered to be reasonably tolerant to relatively high levels of SSC and as such only negligible effects are predicted in relation to reductions in primary productivity and smothering.

45 Biosecurity and standard pollution prevention measures will be in place to reduce any potential for pollution events or introduction of NIS as far as is reasonably practicable.

#### 4.1.4 Conclusion and Screening Outcome

46 No significant effects will arise on the intertidal ecology of the area as a result of the Cofferdam Works. The impacts which may occur are also considered to be lesser in scale and magnitude than those already consented (and assessed as not significant) for installation of the Inch Cape Offshore Export Cables.

### 4.2 Natural Fish and Shellfish

#### 4.2.1 Existing OfTW Assessment

47 The effects of the construction of the consented Inch Cape Offshore Export Cable works on natural fish and shellfish ecology were assessed in Chapter 12 of the original application submitted in 2013 and determined to be between minor / moderate, and negligible (i.e., not significant). No further assessment was undertaken for the revised design (2018) EIA on fish and shellfish ecology from the OfTW as the design changes proposed in the new application, coupled with no material changes to the baseline, were considered not to change the impact assessment conclusions.

48 The assessment of OfTW impacts is presented in Table 4.3 below.

**Table 4.3: Assessment conclusions relevant to fish and shellfish ecology from the Inch Cape Offshore Export Cable ES (2013) at the Cofferdam location**

| Impact | Receptor | Pre-Mitigation Effect | Mitigation | Post-Mitigation Effect |
|---|---|---|---|---|
| **Direct temporary habitat disturbance via Export Cable installation** | Mobile fish<br>Hearing specialists<br>Prey species<br>Electro-sensitive elasmobranchs<br>SAC qualifying species<br>Shellfish | Negligible / Minor<br>Minor<br>Minor<br>Negligible / Minor<br>Minor / Moderate<br>Negligible / Minor | N/A | Negligible / Minor<br>Minor<br>Minor<br>Negligible / Minor<br>Minor / Moderate<br>Negligible / Minor |

| Impact | Receptor | Pre-Mitigation Effect | Mitigation | Post-Mitigation Effect |
|---|---|---|---|---|
| **Indirect disturbance as a result of sediment deposition and temporary increases in SSC** | Mobile fish<br>Hearing specialists<br>Prey species<br>Electro-sensitive elasmobranchs<br>SAC qualifying species<br>Shellfish | Negligible / Minor<br>Minor<br>Minor<br>Negligible / Minor<br><br>Minor / Moderate<br>Negligible / Minor | N/A | Negligible / Minor<br>Minor<br>Minor<br>Negligible / Minor<br><br>Minor / Moderate<br>Negligible / Minor |
| **Disturbance or physical injury associated with construction noise** | Mobile fish<br>Hearing specialists<br>Prey species<br>Electro-sensitive elasmobranchs<br>SAC qualifying species<br>Shellfish | Negligible / Minor<br>Minor<br>Minor<br>Negligible / Minor<br><br>Minor / Moderate<br>Negligible / Minor | Piling operations will incorporate a soft start procedure | Negligible / Minor<br>Minor<br>Minor<br>Negligible / Minor<br><br>Minor / Moderate<br>Negligible / Minor |

### 4.2.2 Baseline

49 During baseline surveys undertaken for the OfTW, an analysis of potential sandeel habitat in and around the Offshore Export Cable Corridor (and the Development Area) was undertaken due to the importance placed on sandeel as a prey resource. Sampling of 45 subtidal locations along the Offshore Export Cable Corridor revealed the dominant sediment classification was slightly gravelly muddy sand ((g)mS) and slightly gravelly sand ((g)S) accounting for approximately 70% of the samples. It was concluded that the Offshore Export Cable Corridor had only one small area which indicated suitability for sandeel, with the remainder being comprised of 'unsuitable' habitat (Appendix 13B (2013 ES), Sandeel Habitat Mapping).

50 The area of the Cofferdam is not within a herring or sandeel spawning ground (Ellis et al., 2012[7]; Coull et al., 1998[8]).

### 4.2.3 Effect of the Cofferdam Works

51 Potential effects from the Cofferdam construction include:

- Disturbance or physical injury associated with construction noise;
- Direct temporary habitat disturbance; and
- Indirect disturbance as a result of sediment deposition and temporary increases in SSC.

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

[8] Coull, K.A., Johnstone, R., and Rogers, S.I. (1998). *Fisheries Sensitivity Maps in British Waters*. Published and distributed by UKOOA Ltd.

52 The impacts will be temporary in nature (with the worst-case piling duration estimated to be approximately six weeks (not including weather or down time)) and will be highly localised. Recent modelling undertaken by Subacoustech (Appendix A) revealed the maximum range for fish (where the swim bladder is involved in hearing), to display a temporary threshold shift (TTS) is 40 m, and the maximum range for which recoverable injury is predicted is 20 m from the noise source. As the piling activities will all be in the upper shore area, it is considered that risk of significant effects arising on fish receptors is negligible.

53 Direct temporary habitat disturbance within the intertidal zone will occur during low tide and the presence of species likely to be affected is low, given that the majority of fish and shellfish species covered within this topic are subtidal i.e., not found within the intertidal zone. As such, it is considered that risk of significant effects arising on fish receptors is negligible.

54 There may be a temporary increase in SCC as areas of disturbed sediment are mobilised by tidal and wave activity. It is considered that such areas of disturbed sediment will be quickly restored to their pre-impacted state due to the nature of the shore which is considered moderately exposed. In addition, due to the location within the Firth of Forth, any species present in the area are considered to be tolerant to relatively high levels of SSC, as they would be within the area of wave affected natural sediment disturbance and as such only negligible effects are predicted.

#### 4.2.4 Conclusion and Screening Outcome

55 No significant effects will arise on the natural fish and shellfish ecology of the area as a result of the Cofferdam Works. These are considered to be lesser in scale and magnitude than those already consented (and assessed as not significant) for installation of the Inch Cape Offshore Export Cables.

### 4.3 Marine Mammals

#### 4.3.1 Existing OfTW Assessment

56 The effects of construction of the consented Inch Cape Offshore Export Cable works on marine mammals were assessed as part of the revised application in 2018 (EIAR, Chapter 10) and determined to be minor (i.e., non-significant). The assessment of OfTW impacts is presented in Table 4.4 below.

**Table 4.4: Assessment conclusions relevant to marine mammals from the Inch Cape Offshore EIAR (2018) at the Cofferdam location**

| Impact | Receptor | Pre-Mitigation Effect | Mitigation | Post-Mitigation Effect |
|---|---|---|---|---|
| **Increase in underwater noise** | Marine mammals (Harbour porpoise (*Phocoena phocoena*) used as a worst-case proxy) | Minor | N/A | Minor |
| **Increased vessel movement** | Marine mammals | Minor | N/A | Minor |

| Impact | Receptor | Pre-Mitigation Effect | Mitigation | Post-Mitigation Effect |
|---|---|---|---|---|
| **Use of ducted propellors** | Harbour seal (*Phoca vitulina*)<br>Grey seal (*Halichoerus grypus*) | Minor<br><br>Minor | N/A | Minor<br><br>Minor |
| **Change in the availability of prey species** | Foraging marine mammals | Minor | N/A | Minor |

### 4.3.2 Baseline

57 The most common species recorded in the Firths of Forth and Tay are as follows:

- Minke whale (*Balaenoptera acutorostrata*);
- Bottlenose dolphin (*Tursiops truncatus*);
- White-beaked dolphin (*Lagenorhynchus albirostris*));
- Harbour porpoise (*Phocoena phocoena*);
- Grey seal (*Halichoerus grypus*); and
- Harbour seal (*Phoca vitulina*).

58 Of the marine mammal species listed, grey seal, harbour seal, and bottlenose dolphins are of particular relevance with regard to the work on the Offshore Export Cable Corridor. Though other cetaceans such as minke whales and white-beaked dolphins do occur on a seasonal basis within the Firths of Forth and Tay they are considered less likely to be present in the area, particularly closer to shore where the Cofferdam Works are proposed.

59 The conservation status of all cetaceans and pinnipeds likely to be found in the area is listed as “favourable”. However, while the overall status of harbour seal is favourable, the local population in the Firth of Tay and Eden Estuary SAC is predicted to be in an overall decline.

60 The Offshore Export Cable Corridor passes relatively close to the south-west of the Isle of May (approximately 5.5 km at the nearest point), an area designated as an SAC for grey seal. Around 2,000 pups are born each year on the island, with lower numbers recorded on smaller islands in the southern half of the Firth of Forth. A fast-growing colony can also be found at Fast Castle, on the southern outer reaches of the Forth.

61 Bottlenose dolphins (*Tursiops truncatus*) are primarily coastal, generally in waters less than 25 m deep, and whilst there appears to be no reports of bottlenose dolphins near to Cockenzie they have been recorded along the Northumberland coast, suggesting they occur across the Offshore Export Cable Corridor.

#### 4.3.3 Effect of the Cofferdam Works

62 Potential effects from the Cofferdam Works include:

- Increase in underwater noise; and
- Change in the availability of prey species.

63 The impacts will be temporary in nature (with the worst-case piling duration estimated to be approximately six weeks (not including weather time)) and will be highly localised. Modelling (see Appendix A), revealed that the maximum predicted impact ranges for vibro-piling noise are predicted for the low frequency (LF) hearing cetacean group (i.e., all mysticetes including minke whale) (Southall et al., 2019), with cumulative sound exposure level (SELcum) ranges for up to 50m for TTS, based on a stationary receptor during a six-hour piling window. No SACs overlap this range, the closest, Isle of May is >30 km from the works, and the predicted range is based on highly precautionary parameters, particularly around stationary species, given their high mobility in the marine environment. As such, effects on marine mammals from underwater noise are considered to be negligible.

64 A change in available prey species as an indirect impact via disturbance to the seabed is not anticipated given the works will be undertaken in the upper area of the intertidal zone and that effects on fish and shellfish are considered negligible and not significant.

#### 4.3.4 Conclusion and Screening Outcome

65 No significant effects will arise on the marine mammal features in the area as a result of the Cofferdam Works. These are considered to be lesser in scale and magnitude than those already consented (and assessed as not significant) for installation of the OfTW.

### 4.4 Ornithology

#### 4.4.1 Existing OfTW Assessment

66 The effects of construction of the consented Inch Cape Offshore Export Cable works nearshore to MHWS (including in the intertidal area) on ornithology have been assessed as part of Chapter 15 of the 2013 ES (ICOL, 2013) and determined to be negligible (not significant) for all Valued Ornithological Receptors (VORs) (Table 4.5). This was not reassessed for the revised design as the design changes were deemed to fall within the existing worst case assessed.

**Table 4.5: Assessment conclusions relevant to ornithology from the Inch Cape Offshore Export Cable ES (2013) at the Cofferdam location**

| Impact | Receptor | Season | Residual Effects |
|---|---|---|---|
| **Direct habitat loss during construction** | All ornithological receptors | All | Negligible |
| **Direct disturbance during all phases** | | | |
| **Indirect impacts on birds via prey** | | | |

### 4.4.2 Baseline

67 The Offshore Export Cable Corridor passes through the intertidal area of the Firth of Forth, passing near to the Firth of Forth SPA, Ramsar site and SSSI, and through the Outer Firth of Forth and St Andrews Bay Complex. This shoreline contains a variety of coastal and estuarine habitats which attract large numbers, and a wide variety of over-winter and passage wetland birds (waders and waterfowl) to the area. During intertidal ornithology surveys undertaken for the 2013 ES, the Cockenzie Power Station location supported a reasonably high number of species, recorded in significant proportions of their respective Firth of Forth SPA population estimates, compared to other areas.

### 4.4.3 Effect of the Cofferdam Works

68 Potential effects from the Cofferdam Works include:

- Direct Disturbance (visual and noise stimulus);
- Habitat loss; and
- Indirect effects on bird communities via effects on prey species.

69 The impacts on ornithological receptors from the Cofferdam Works will be temporary in nature and/or highly localised. Given the available foraging areas in the wider Firth of Forth, the spatial extent of any impact represents a very slight change from baseline conditions. Disturbance is therefore predicted to represent effects which will lie within the limits of natural variation and as such will not lead to any significant effects.

70 Noise levels from vibro-piling have been recorded as 80-90 dBA @ 10m[9]. The Waterbird Disturbance Mitigation Toolkit (Cutts et al., 2013), notes that noise levels of this magnitude are likely to fall to non-disturbing levels within approximately 85 m of the source. It is noted that visual disturbance effects on waterbirds will, in most cases, trigger a disturbance effect before any associated noise will and flight responses in intertidal species may be triggered within approximately. 100-150 m of visual stimuli.

71 The area over which the effects of disturbance and associated displacement (and resulting temporary loss of habitat) are likely to occur are considered to be negligible in the context of the wider availability of similar (or preferential) intertidal habitat within the Firth of Forth.

72 During the Cofferdam Works, indirect effects on bird communities through impacts on prey availability may occur. The impacts on prey species may result from temporary habitat disturbance and an increase in SSC and deposition. The Cofferdam Works are very localised, and any effects on benthic and intertidal communities are likely to be negligible (see above). It is considered that seabird communities would not be affected as impacts would not significantly extend beyond the area of works or be of sufficient scale to impact prey abundance or distribution.

### 4.4.4 Conclusion and Screening Outcome

73 No significant effects will arise on ornithological receptors as a result of the Cofferdam Works, which are considered to be lesser in scale and magnitude than those already consented (and assessed

[9] https://wsdot.wa.gov/sites/default/files/2021-10/Env-Noise-MonRpt-AirborneVibratory.pdf

as not significant) for the installation of the Inch Cape Offshore Export Cables.

## 4.5 Cultural Heritage and Marine Archaeology

### 4.5.1 Existing Assessment

74 The effects of construction of the consented Inch Cape Offshore Export Cable works on cultural heritage assets have been assessed in Chapter 17 of the original ES (2013) and determined to be minor (not significant) after mitigation in the form of implementation of a Written Scheme of Investigation (WSI) (Table 4.6).

**Table 4.6: Assessment conclusions relevant to cultural heritage receptors in the Inch Cape Offshore Export Cable ES (2013) at the Cofferdam location**

| Impact | Receptor | Pre-Mitigation Effects | Mitigation | Post-Mitigation Effects |
|---|---|---|---|---|
| **Damage to or removal of heritage features resulting from direct physical impacts.** | Known maritime features, unconfirmed locations of shipwrecks and known intertidal heritage assets. | Major Adverse Significance | Implementation of Written Scheme of Investigation | Minor |
| **Damage to or removal of features.** | Unknown maritime, aviation and intertidal heritage features. | Major Adverse Significance | Reporting Protocols, programme of mitigation works. | Minor |

### 4.5.2 Baseline

75 Baseline data on known cultural heritage receptors and assessment of the potential for unknown receptors has been made here only for assets falling partially or completely between the MHWS and MLWS.

76 The ES (2013) identified a total of ten known cultural heritage assets within the intertidal section (up to MHWS) of the Offshore Export Cable Corridor study area, defined as the Offshore Export Cable Corridor plus a one-kilometre buffer (which includes the location of the Cofferdam). These include a small number of prehistoric finds including a worked flint and various pieces of Iron Age metalwork thought to relate to a hoard buried on the beach. There are three harbours within the intertidal zone, two of which are still in use. Although most of the physical remains of these harbours lie above the MHWS mark, they are included here as they extend into the intertidal zone. All three were first constructed in the 16th/17th centuries. The two harbours still in use are the focus of the Cockenzie and Port Seton Conservation Areas. Morrison's Haven is the site of a medieval harbour, built in the 16th century by the monks of Newbattle and it fell out of use during WWII and has since been largely covered by an area of mining spoil known locally as 'the cast' although a significant part of the structure appears to be intact within the spoil heap.

77 There are also several industrial archaeological features in the intertidal element of the Offshore

Export Cable Corridor study area. These include rock-cut salt pans with associated remains of walls and a disused circular domed cement structure (which formerly served as a cap for an air shaft from Preston Grange Colliery).

78 None of these features are within the location of the Cofferdam construction area. The closest is an intertidal feature of cultural heritage interest (a Worked Flint WA – 1003), approximately 1 km to the west of the installation.

#### 4.5.3 Effect of the Cofferdam Works

79 Potential effects from the Cofferdam Works in the intertidal zone include:

- Direct damage to archaeological deposits and material; and
- Disturbance or destruction of relationships between deposits and material and their wider surroundings.

80 There are no known archaeological features within the intertidal area of the Cofferdam but there is a potential for currently unknown archaeological features being identified. This stretch of East Lothian coastline has a high archaeological potential and has been extensively settled throughout human history. The intertidal archaeological sites in the wider area attest to a variety of activities, including salt panning, pottery manufacture, coal mining and related maritime activities such as fishing.

81 As such, it is considered that all mitigations in place for the installation of the Offshore Export Cables be implemented for any intertidal works required under this application. This will include:

- Implementation of a WSI; and
- Implementation of reporting protocols and development of an agreed programme of mitigation in the event of any removal requirements.

#### 4.5.4 Conclusion and Screening Outcome

82 With mitigation, no significant effects will arise on cultural heritage receptors as a result of the Cofferdam Works, which are considered to be lesser in scale and magnitude than those already consented (and assessed as not significant) for the installation of the Inch Cape Offshore Export Cables.

### 4.6 Cumulative Considerations

83 As the Cofferdam Works are very localised in extent and will not result in any significant adverse effects on any receptor, it is considered that there is no potential for significant cumulative effects to arise.

84 The only other plans or projects that could be considered to act cumulatively are the Additional Landfall Works (application screened and no EIA is required), and the installation of the Inch Cape Offshore Export Cables in the intertidal area (no significant effects predicted), as this work will be undertaken during the same timeframe and at the same spatial location.

85 All effects of the installation of the Inch Cape Offshore Export Cable were considered to be not-significant, as are any effects that may result from the Cofferdam Works and the Additional Landfall

Works. As such, it is therefore considered that all effects at a cumulative level will also not be significant, due to the short duration of works, and limited spatial scale over which all will act.

86 As no significant cumulative effects will arise, it is considered there is no requirement for EIA.

## 4.7 Habitats Regulation Assessment (HRA)

87 The European protected nature conservation sites in proximity to the proposed work are identified in Section 3, Figure 3.1. An assessment to consider the potential for adverse effects on site integrity on these sites will be undertaken as part of a Habitats Regulations Appraisal submitted alongside the marine licence application for the works.

88 Due to the temporary nature and small spatial scale of the works, which will result in only those receptors in the immediate vicinity of the works being affected, it is not anticipated that any adverse effects on site integrity will arise.

# 5 Summary and Conclusions

89 The Cofferdam is small scale, temporary and will take place within the existing consented Inch Cape Offshore Export Cable Corridor. Based on the above consideration of effects on all potential environmental receptors, it can be concluded that the Cofferdam Works (as described in Section 2) will not result in any potential significant effects. As such, it is considered that an EIA is not required, and an application for a marine licence can be progressed with a proportionate level of supporting environmental information.

## Appendix A – Subacoustech Noise Modelling Report

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# Modelling of underwater noise from vibro-piling for cofferdam installation: inshore works for Inch Cape Offshore Wind Farm

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*This report is a controlled document. The report documentation page lists the version number, record of changes, referencing information, abstract and other documentation details.*

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# Glossary

| Term | Definition |
|---|---|
| Decibel (dB) | A customary scale commonly used (in various ways) for reporting levels of sound. A difference of 10 dB corresponds to a factor of 10 in sound power. The actual sound measurement is compared to a fixed reference level and the “decibel” value is defined to be $10\log_{10}(actual/reference)$ where $(actual/reference)$ is a power ratio. Because sound power is usually proportional to sound pressure squared, the decibel value for sound pressure is $20\log_{10}(actual\ pressure/reference\ pressure)$. The standard reference for underwater sound is 1 micropascal (µPa). The dB symbol is followed by a second symbol identifying the specific reference value (e.g., re 1 µPa). |
| Peak pressure | The highest pressure above or below ambient that is associated with a sound wave. |
| Permanent Threshold Shift (PTS) | A permanent total or partial loss of hearing caused by acoustic trauma. PTS results in irreversible damage to the sensory hair cells of the ear, and thus a permanent reduction of hearing acuity |
| Sound Exposure Level (SEL) | The constant sound level acting for one second, which has the same amount of acoustic energy, as indicated by the square of the sound pressure, as the original sound. It is the time-integrated, sound-pressure-squared level. SEL is typically used to compare transient sound events having different time durations, pressure levels, and temporal characteristics. |
| Sound Pressure Level (SPL) | The sound pressure level is an expression of sound pressure using the decibel (dB) scale; the standard frequency pressures of which are 1 µPa for water and 20 µPa for air. |
| Temporary Threshold Shift (TTS) | Temporary reduction of hearing acuity because of exposure to sound over time. Exposure to high levels of sound over relatively short time periods could cause the same level of TTS as exposure to lower levels of sound over longer time periods. The mechanisms underlying TTS are not well understood, but there may be some temporary damage to the sensory cells. The duration of TTS varies depending on the nature of the stimulus. |
| Unweighted sound level | Sound levels which are “raw” or have not been adjusted in any way, for example to account for the hearing ability of a species. |
| Weighted sound level | A sound level which has been adjusted with respect to a “weighting envelope” in the frequency domain, typically to make an unweighted level relevant to a particular species. Examples of this are the dB(A), where the overall sound level has been adjusted to account for the hearing ability of humans in air, or the filters used by Southall *et al*. (2019) for marine mammals. |

# 1 Introduction

Subacoustech Environmental have been requested by Inch Cape Offshore Limited to carry out underwater noise modelling for vibro-piling activity to install a cofferdam as part of the inshore works for the Inch Cape Offshore Wind Farm.

## 1.1 Site description

The cofferdam site for the inshore works is located on the southern bank of the Firth of Forth, near Cockenzie, Lothian, Scotland as shown in Figure 1-1. Modelling has been undertaken at a single location along the northern edge of the site (6202544N, 501546E, UTM 30N) in the deepest waters, which tend to lead to the highest noise levels. This gives a worst-case scenario.

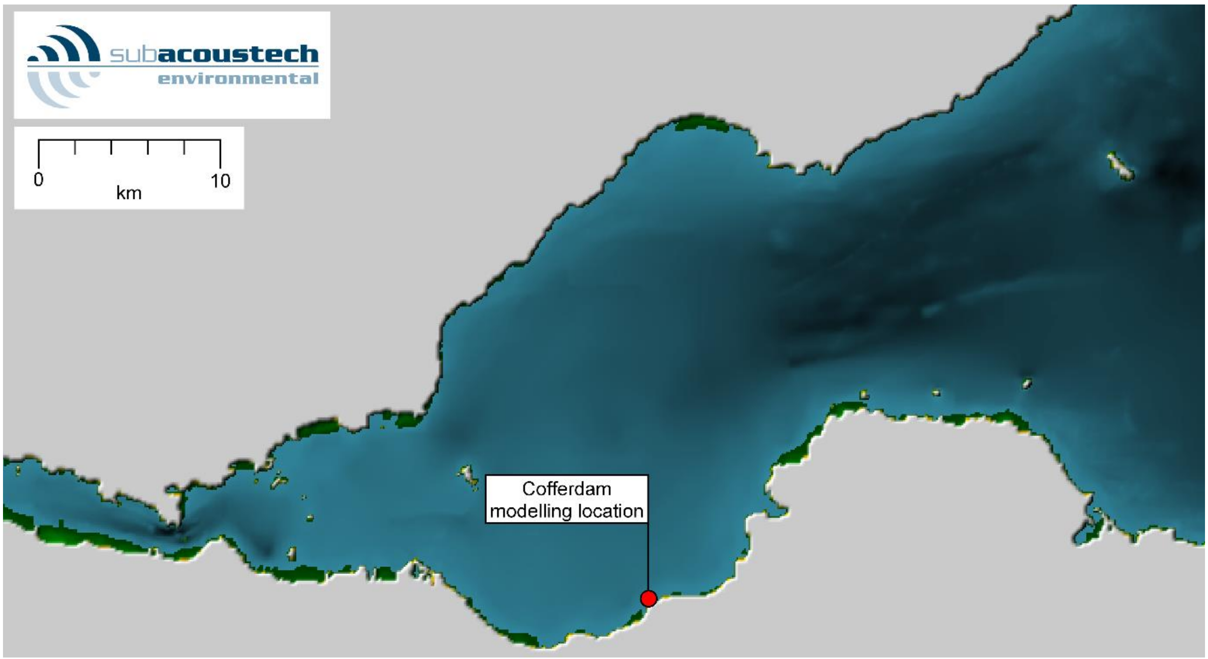


*Figure 1-1 Location of the cofferdam modelling location and the surrounding bathymetry in the Firth of Forth*

## 1.2 Vibro-piling noise

The cofferdam installation involves driving AZ24-700 type sheet piles, which measure 1.4 m wide, secured in the seabed using a vibratory hammer. The anticipated model of hammer for these works is a Movax SG75.

A vibratory hammer works by using spinning counterweights to create vibration combined with vertical pressure to drive the pile into the soil.

At the site there is a six-hour tidal working window per day, so, for cumulative noise impact criteria, it has been assumed that the vibro-piling noise will be present for the entire six-hour window as a worst-case.

# 2 Background to underwater noise metrics

Sound travels much faster in water (approximately 1,500 $ms^{-1}$) than in air (340 $ms^{-1}$). Since water is a relatively incompressible, dense medium, the pressures associated with underwater sound tend to be much higher than in air. As an example, background levels of sea noise of approximately 130 dB re 1 µPa for UK coastal waters are not uncommon (Nedwell *et al*, 2003 and 2007).

It should be noted that stated underwater noise levels should not be confused with noise levels in air, which use a different scale.

## 2.1 Units of measurement

Sound measurements underwater are usually expressed using the decibel (dB) scale, which is a logarithmic measure of sound. A logarithmic scale is used because, rather than equal increments of sound having an equal increase in effect, typically each doubling of sound level will cause a roughly equal increase of "loudness."

Any quantity expressed in this scale is termed a "level." If the unit is sound pressure, expressed on the dB scale, it will be termed a "sound pressure level."

The fundamental definition of the dB scale is given by:

$$Level = 10 \times \log_{10}\left(\frac{Q}{Q_{ref}}\right)$$

where $Q$ is the quantity being expressed on the scale, and $Q_{ref}$ is the reference quantity.

The dB scale represents a ratio. It is therefore used with a reference unit, which expresses the base from which the ratio is expressed. The reference quantity is conventionally smaller than the smallest value to be expressed on the scale so that any level quoted is positive. For example, a reference quantity of 20 µPa is used for sound in air since that is the lower threshold of human hearing.

When used with sound pressure, the pressure value is squared. So that variations in the units agree, the sound pressure must be specified as units of Root Mean Square (RMS) pressure squared. This is equivalent to expressing the sound as:

$$Sound\ pressure\ level = 20 \times \log_{10}\left(\frac{P_{RMS}}{P_{ref}}\right)$$

For underwater sound, a unit of 1 µPa is typically used as the reference unit ($P_{ref}$); a Pascal is equal to the pressure exerted by one Newton over one square metre, one micropascal equals one millionth of this.

## 2.2 Quantities of measurement

Sound may be expressed in different ways depending upon the particular type of noise, and the parameters of the noise that allow it to be evaluated in terms of a biological effect. These are described in more detail below.

### 2.2.1 Sound pressure level (SPL)

The Sound Pressure Level (SPL) is normally used to characterise noise and vibration of a continuous nature, such as drilling, boring, continuous wave sonar, or background sea and river noise levels. To calculate the SPL, the variation in sound pressure is measured over a specific period to determine the RMS level of the time-varying sound. The SPL can therefore be considered a measure of the average unweighted level of sound over the measurement period.

Where SPL is used to characterise transient pressure waves, such as that from impact piling, seismic airgun or underwater blasting, it is critical that the period over which the RMS level is calculated is quoted. For instance, in the case of a pile strike lasting a tenth of a second, the mean taken over a tenth of a second will be ten times higher than the mean averaged over one second. Often, transient sounds such as these are quantified using “peak” SPLs or Sound Exposure Levels (SELs).

Unless otherwise defined, all SPL noise levels in this report are referenced to 1 µPa.

### 2.2.2 Peak Sound Pressure Level ($SPL_{peak}$)

Peak SPLs are often used to characterise transient sound from impulsive sources, such as percussive impact piling. $SPL_{peak}$ is calculated using the maximum variation of the pressure from positive to zero within the wave. This represents the maximum change in positive pressure (differential pressure from positive to zero) as the transient pressure wave propagates.

A further variation of this is the peak-to-peak SPL ($SPL_{peak\text{-}to\text{-}peak}$) where the maximum variation of the pressure from positive to negative is considered. Where the wave is symmetrically distributed in positive and negative pressure, the peak-to-peak pressure will be twice the peak level, or 6 dB higher.

### 2.2.3 Sound Exposure Level (SEL)

When considering the noise from transient sources, the issue of the duration of the pressure wave is often addressed by measuring the total acoustic energy (energy flux density) of the wave. This form of analysis was used by Bebb and Wright (1953, 1954a, 1954b, 1955), and later by Rawlins (1987), to explain the apparent discrepancies in the biological effect of short and long-range blast waves on human divers. More recently, this form of analysis has been used to develop criteria for assessing injury ranges for fish and marine mammals from various noise sources (Popper *et al*., 2014; Southall *et al*., 2019).

The SEL sums the acoustic energy over a measurement period, and effectively takes account of both the SPL of the sound and the duration it is present in the acoustic environment. Sound Exposure (SE) is defined by the equation:

$$SE = \int_0^T p^2(t)dt$$

where $p$ is the acoustic pressure in Pascals, $T$ is the total duration of sound in seconds, and $t$ is time in seconds. The SE is a measurement of acoustic energy and has units of Pascal squared seconds ($Pa^2s$).

To express the SE on a logarithmic scale by means of a dB, it must be compared with a reference acoustic energy (${p^2}_{ref}$) and a reference time ($T_{ref}$). The SEL is then defined by:

$$SEL = 10 \times \log_{10}\left(\frac{\int_0^T p^2(t)dt}{{p^2}_{ref}T_{ref}}\right)$$

By using a common reference pressure ($p_{ref}$) of 1 µPa for assessments of underwater noise, the SEL and SPL can be compared using the expression:

$$SEL = SPL + 10 \times \log_{10} T$$

where the SPL is a measure of the average level of broadband noise and the SEL sums the cumulative broadband noise energy.

This means that, for continuous sounds of less than (i.e., fractions of) one second, the SEL will be lower than the SPL. For periods greater than one second, the SEL will be numerically greater than the SPL (i.e., for a continuous sound of 10 seconds duration, the SEL will be 10 dB higher than the SPL; for a sound of 100 seconds duration the SEL will be 20 dB higher than the SPL, and so on).

Where a single impulse noise such as the soundwave from a pile strike is considered in isolation, this can be represented by a “single strike” SEL or $SEL_{ss}$. A cumulative SEL, or $SEL_{cum}$, accounts for the exposure from multiple impulses or pile strikes over time, where the number of impulses replaces the $T$ in the equation above, leading to:

$$SEL_{cum} = SEL + 10 \times \log_{10} X$$

Where SEL is the sound exposure level of one impulse and $X$ is the total number of impulses or strikes. Unless otherwise defined, all SEL noise levels in this report are referenced to 1 µPa²s.

# 3 Assessment approach

This section presents a summary of the modelling approach used to assess the expected underwater noise levels from vibro-piling activity related to cofferdam installation, as well as the criteria used to assess the noise impact on the relevant marine species.

The modelling approach presented herein conforms to the recommendations found in the National Physical Laboratory (NPL) Good Practice Guide 133 for Underwater Noise (Robinson *et al*., 2014).

## 3.1 Modelling methodology

To estimate the likely underwater noise levels from vibro-piling activity, noise propagation modelling has been carried out using an approach that is widely used and accepted by the acoustics community, in combination with publicly available environmental data, information provided by Inch Cape, and data from Subacoustech Environmental’s measurement library.

Modelling of underwater noise is complex and can be approached in several different ways. In this case, Subacoustech Environmental have chosen to use a numerical modelling approach that is based on both a parabolic equation (PE) method for low frequencies (12.5 Hz to 400 Hz) and a ray tracing method for high frequencies (500 Hz to 100 kHz). The PE method is widely used but has computational limitations at high frequencies. Ray tracing is more computationally efficient but is not suited to low frequency noise (Etter, 1991). This study implements these numerical solutions using the dBSea software (v2.3)

This model uses a wide array of input parameters including bathymetry, sediment data, sound speed and source frequency to ensure the results are as detailed and accurate as possible. These parameters are described in detail in Sections 3.1.1 and 3.1.2.

By its nature, mathematical modelling will produce results which indicate a precise range at which a criterion (Section 3.2) will be reached, but this does not reflect the inherent uncertainties in the process. The results give a specific numeric value to a problem with a vast number of variables and parameters, including many that change constantly in real world conditions. Most modelling parameters, such as the source noise level, the duration of operation and its location, are selected to be precautionary, to avoid the risk of underestimating the impact. The results given in Section 4 present specific ranges at which each impact threshold is met, to determine where environmental effects may occur in receptors during the survey activity. Due to the natural fluctuations noted above, the ranges should be taken as indicative, albeit worst case.

### *3.1.1 Modelling inputs*

The bathymetry data used in the modelling was obtained from the European Marine Observation and Data Network (EMODnet), which has a grid resolution of 1/16 arc minutes (approximately 115 m). This data has been adjusted to high tide using tidal data from Cockenzie: 5.3 m above LAT.

The speed of sound has been calculated for the average annual temperature and salinity data for the survey areas obtained from Marine Scotland's National Marine Plan Interactive (NMPi) tool[1]. The calculations were based on equations from Mackenzie (1981) and the resulting profile is shown in Figure 3-1.

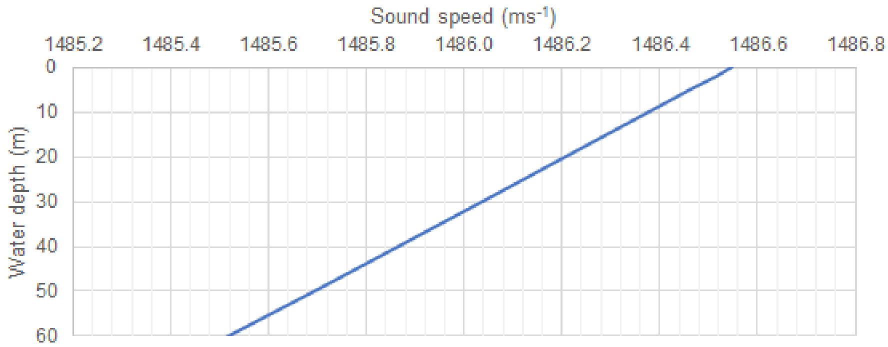


*Figure 3-1 Sound speed profile used for modelling in the Firth of Forth*

Based on information from the British Geological Survey (BGS) the characteristics of the seabed around the modelling locations assume sediment of sandy mud above a limestone bedrock. Geo-acoustic properties have been based on available data for this sediment type from Jensen *et al*. (2011), and the properties for the bedrock were derived from Jensen *et al*. (1994) and Alden (2020). The specific details for the ground types used for modelling are given in Table 3-1.

*Table 3-1 Details of the seabed parameters used for modelling*

| Material type | Speed of sound | Density | Attenuation |
|---|---|---|---|
| Sandy mud | 1,675 $ms^{-1}$ | 1,700 $kg/m^3$ | 0.9 dB/wavelength |
| Limestone | 3,000 $ms^{-1}$ | 2,500 $kg/m^3$ | 0.1 dB/wavelength |

### *3.1.2 Source noise levels and frequency content*

The vibratory hammer anticipated to be used for the cofferdam installation is a Movax SG75. This is a hydraulically powered hammer with an eccentric moment of 7.6 kgm and a maximum centrifugal force of 750 kN.

For this study, measurements undertaken by Subacoustech Environmental of the larger ICE 1412C hydraulic vibratory hammer have been used and modified based on the specifications of the Movax SG75. The ICE 1412C hammer has a larger eccentric moment of 110 kgm and maximum centrifugal force of 2,300 kN. A scaling factor based on the centrifugal force of the hammers has been used, as the Movax hammer outputs approximately one third as much as the ICE hammer, and the pressure level has been reduced by the same factor. This means an unweighted $SPL_{RMS}$ source level of 202.9 dB re 1 µPa @ 1 m has been used for modelling.

The 1/3rd octave band source spectrum used for the modelling is shown in Figure 3-2.

[1] Marine Scotland (2021). *National Marine Plan Interactive (NMPi)*. Accessed May 2023. https://marinescotland.atkinsgeospatial.com/nmpi/

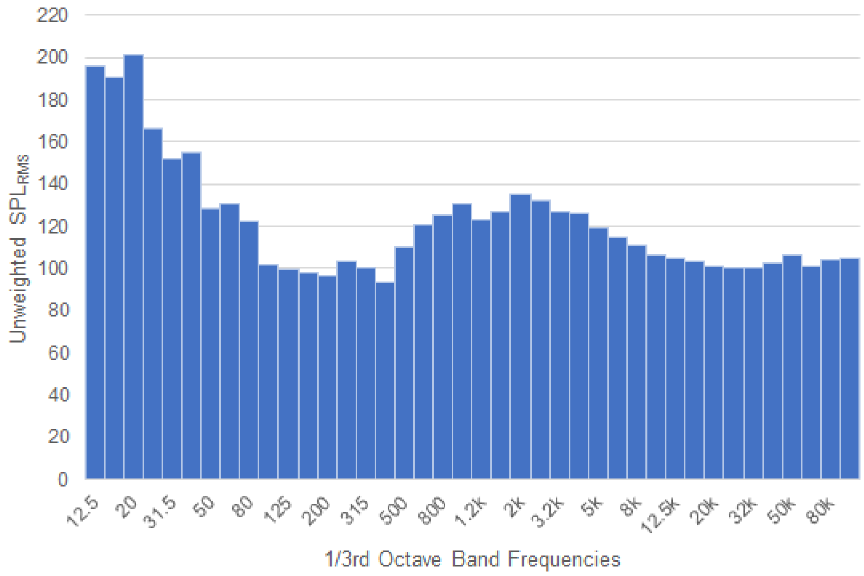


*Figure 3-2 1/3rd octave band source level frequency spectral used in this modelling for vibro-piling*

## 3.2 Assessment of underwater noise

### *3.2.1 Criteria to be used*

Over the last 20 years it has become increasingly evident that noise from human activities in and around underwater environments can have an impact on the marine species in the area. The extent to which intense underwater sound might cause adverse impacts in species is dependent upon the incident sound level, source frequency, duration of exposure, and/or repetition rate of an impulsive sound (see, for example, Hastings and Popper, 2005). As a result, scientific interest in the hearing abilities of aquatic species has increased. Studies are primarily based on evidence from high level sources of underwater noise such as blasting, impact piling and seismic airguns, as these sources are likely to have the greatest immediate environmental impact and therefore the clearest observable effects, although interest in chronic noise exposure is increasing.

The impacts of underwater sound on marine species can be broadly summarised as follows:

- Physical traumatic injury and fatality;
- Auditory injury (either permanent or temporary); and
- Disturbance.

The following sections discuss the underwater noise criteria used in this study with respect to species of marine mammals and fish that may be present around the study area in the Firth of Forth.

The main metrics and criteria that have been used in this study to aid assessment of environmental effects come from two key papers covering underwater noise and its effects:

- Southall *et al*. (2019) marine mammal exposure criteria; and
- Popper *et al*. (2014) sound exposure guidelines for fishes and sea turtles.

At the time of writing these include the most up-to-date and authoritative criteria for assessing environmental effects for use in impact assessments.

### *3.2.2 Marine mammals*

The Southall *et al*. (2019) paper is effectively an update of the previous Southall *et al*. (2007) paper and provides identical thresholds to those from the National Marine Fisheries Service (NMFS) (2018) guidance for marine mammals (although describing marine mammal categories slightly differently).

The Southall *et al*. (2019) guidance categorises marine mammals into groups of similar species and applies filters to the unweighted noise to approximate the hearing sensitivities of the receptor in question. The hearing groups given by Southall *et al*. (2019) are summarised in Table 3-2 and Figure 3-3. Further groups for sirenians and other marine carnivores in water are given, but these have not been included in this study as those species are not commonly found in and around the Firth of Forth.

*Table 3-2 Marine mammal hearing groups (from Southall et al., 2019)*

| Hearing group | Generalised hearing range | Example species |
|---|---|---|
| Low-frequency cetaceans (LF) | 7 Hz to 35 kHz | Baleen whales |
| High-frequency cetaceans (HF) | 150 Hz to 160 kHz | Dolphins, toothed whales, beaked whales, bottlenose whales (including bottlenose dolphin) |
| Very high-frequency cetaceans (VHF) | 275 Hz to 160 kHz | True porpoises (including harbour porpoise) |
| Phocid carnivores in water (PCW) | 50 Hz to 86 kHz | True seals (including harbour seals) |

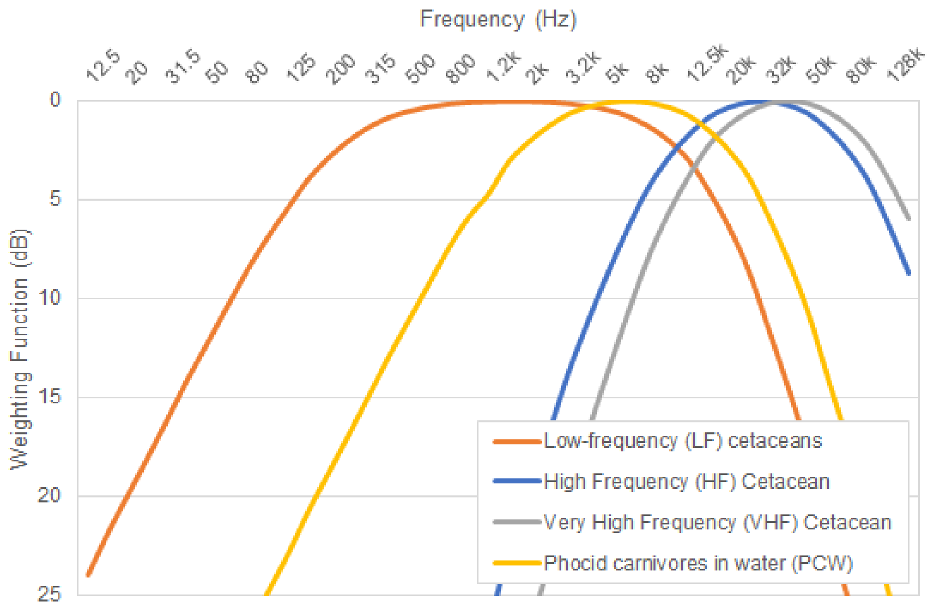


*Figure 3-3 Auditory weighting functions for low-frequency cetaceans (LF), high-frequency cetaceans (HF), very high-frequency cetaceans (VHF), and phocid carnivores in water (PCW) (from Southall et al., 2019)*

Southall *et al*. (2019) also gives individual criteria based on whether the noise source is considered impulsive or non-impulsive. Southall *et al*. (2019) categorises impulsive noises as having high peak sound pressure, short duration, fast rise-time and broad frequency content at source, and non-impulsive sources as steady-state noise. Explosives, impact piling and seismic airguns are considered impulsive noise sources and sonars, vibro-piling, drilling and other such low-level continuous noises are generally considered non-impulsive. A non-impulsive noise does not necessarily have to have a long duration. Under these criteria vibro-piling is considered a non-impulsive noise.

Southall *et al*. (2019) presents cumulative weighted sound exposure criteria for both permanent threshold shift (PTS), where unrecoverable (but incremental) hearing damage may occur, and temporary threshold shift (TTS), where a temporary reduction in hearing sensitivity may occur in individual receptors.

Table 3-3 presents the weighted $SEL_{cum}$ criteria for marine mammals from Southall *et al*. (2019) for non-impulsive noise.

*Table 3-3 Non-impulsive $SEL_{cum}$ criteria for PTS and TTS in marine mammals (Southall et al., 2019)*

| **Southall *et al*. (2019)** | **Weighted $SEL_{cum}$ (dB re 1 µPa$^2$s)** | |
|---|---|---|
| | **Non-impulsive** | |
| | **PTS** | **TTS** |
| Low-frequency cetaceans (LF) | 199 | 179 |
| High-frequency cetaceans (HF) | 198 | 178 |
| Very high-frequency cetaceans (VHF) | 173 | 153 |
| Phocid carnivores in water (PCW) | 201 | 181 |

For these $SEL_{cum}$ thresholds a worst-case stationary animal model has been used, assuming that a receptor does not flee from the noise source.

### *3.2.3 Fish*

The large number of, and variation in, fish species leads to a greater challenge in production of a generic noise criterion, or range of criteria, for the assessment of noise impacts. The publication of Popper *et al*. (2014) provides an authoritative summary of the latest research and guidelines for fish exposure to sound and uses categories for fish that are representative of the species present in UK waters.

The Popper *et al*. (2014) study groups species of fish by whether they possess a swim bladder, and whether it is involved in its hearing; groups for sea turtles and fish eggs and larvae are also included. The guidance also gives specific criteria for a variety of noise sources. (It is recognised that these are related to sound pressure, whereas more recent documents (e.g., Popper and Hawkins, 2019) state that many fish species are most sensitive to particle motion. This is discussed in section 3.2.3.1.)

Vibro-piling noise falls under the continuous sounds category in the Popper *et al*. (2014) criteria; these are summarised in Table 3-4.

*Table 3-4 Criteria for recoverable injury, and TTS in species of fish from shipping and continuous sounds (Popper et al., 2014)*

| **Type of animal** | **Impairment** | |
|---|---|---|
| | **Recoverable injury** | **TTS** |
| Fish: swim bladder involved in hearing | 170 dB RMS for 48 hours | 158 dB RMS for 12 hours |

Where insufficient data are available, Popper *et al*. (2014) also gives qualitative criteria that summarise the effect of the noise as having either a high, moderate, or low effect on an individual in either the near-field (tens of metres), intermediate-field (hundreds of metres), or far-field (thousands of metres). These qualitative effects for continuous sounds are reproduced in Table 3-5. These include masking, where an introduced noise source is loud enough such that the audibility of natural, useful noises is impaired, and general, but substantial, behavioural effects, such as changes to feeding sites and distribution.

*Table 3-5 Summary of the qualitative effects on species of fish from shipping and continuous sounds (Popper et al., 2014) (N = Near-field; I = Intermediate-field; F = Far-field)*

| Type of animal | Mortal and potential mortal injury | Impairment | | | Behaviour |
|---|---|---|---|---|---|
| | | Recoverable injury | TTS | Masking | |
| Fish: no swim bladder | (N) Low<br>(I) Low<br>(F) Low | (N) Low<br>(I) Low<br>(F) Low | (N) Moderate<br>(I) Low<br>(F) Low | (N) High<br>(I) High<br>(F) Moderate | (N) Moderate<br>(I) Moderate<br>(F) Low |
| Fish: swim bladder is not involved in hearing | (N) Low<br>(I) Low<br>(F) Low | (N) Low<br>(I) Low<br>(F) Low | (N) Moderate<br>(I) Low<br>(F) Low | (N) High<br>(I) High<br>(F) Moderate | (N) Moderate<br>(I) Moderate<br>(F) Low |
| Fish: swim bladder involved in hearing | (N) Low<br>(I) Low<br>(F) Low | See Table 3-4 | See Table 3-4 | (N) High<br>(I) High<br>(F) High | (N) High<br>(I) Moderate<br>(F) Low |
| Sea turtles | (N) Low<br>(I) Low<br>(F) Low | (N) Low<br>(I) Low<br>(F) Low | (N) Moderate<br>(I) Low<br>(F) Low | (N) High<br>(I) High<br>(F) Moderate | (N) High<br>(I) Moderate<br>(F) Low |
| Eggs and larvae | (N) Low<br>(I) Low<br>(F) Low | (N) Low<br>(I) Low<br>(F) Low | (N) Low<br>(I) Low<br>(F) Low | (N) High<br>(I) Moderate<br>(F) Low | (N) Moderate<br>(I) Moderate<br>(F) Low |

#### *3.2.3.1 Particle motion*

The criteria defined in the above section define the noise impacts on fishes in terms of sound pressure or sound pressure-associated functions (i.e., SEL). It has been identified by researchers (e.g., Popper and Hawkins, 2019; Nedelec *et al*., 2016; Radford *et al.,* 2012) that many species of fish, as well as invertebrates, actually detect particle motion rather than acoustic pressure. Particle motion describes the back-and-forth movement of water, substrate or other media as a sound wave passes, rather than the pressure caused by the action of the force created by this movement. Particle motion is usually defined in reference to the velocity of the particle (often a peak particle velocity, PPV), but sometimes the related acceleration or displacement of the particle is used. Note that species in the “Fish: swim bladder involved in hearing” category, the species most sensitive to noise, are sensitive to sound pressure.

Popper and Hawkins (2018) state that in derivation of the sound pressure-based criteria in Popper *et al.* (2014) it may be the unmeasured particle motion detected by the fish, to which the fish were responding: there is a relationship between particle motion and sound pressure in a medium. This relationship is very difficult to define where the sound field is complex, such as close to the noise source or where there are multiple reflections of the sound wave in shallow water. Even these terms “shallow” and “close” do not have simple definitions.

The primary reason for the continuing use of sound pressure as the criteria, despite particle motion appearing to be the physical measure to which so many fish react or sense, is a lack of data (Popper and Hawkins, 2018) both in respect of predictions of the particle motion level as a consequence of a noise source, and a lack of knowledge of the sensitivity of a fish, or a wider category of fish, to a particle motion value. There continue to be calls for additional research on the levels of and effects with respect to levels of particle motion. Until sufficient data are available to enable revised thresholds based on the particle motion metric, Popper and Hawkins, 2019 states that “since there is an immediate need for updated criteria and guidelines on potential effects of anthropogenic sound on fishes, we recommend, as do our colleagues in Sweden (Andersson *et al*., 2017), that the criteria proposed by Popper *et al*. (2014) should be used.”

# 4 Modelling results

This section presents the noise modelling carried out in the Firth of Forth for vibro-piling noise as discussed in section 3.

For the results presented in the following sections, calculated impact ranges which fall below 10 m have not been shown, as the modelling processes used are unable to specify that level of accuracy with confidence due to complex acoustic effects at close range.

## 4.1 Unweighted noise levels

The modelled underwater noise levels, as $SPL_{RMS}$ from vibro-piling noise are presented in Figure 4-1, to show the distribution of noise into the surrounding area. These results are analysed in terms of the assessment criteria discussed earlier for marine mammals and fish in sections 4.2 and 4.3.

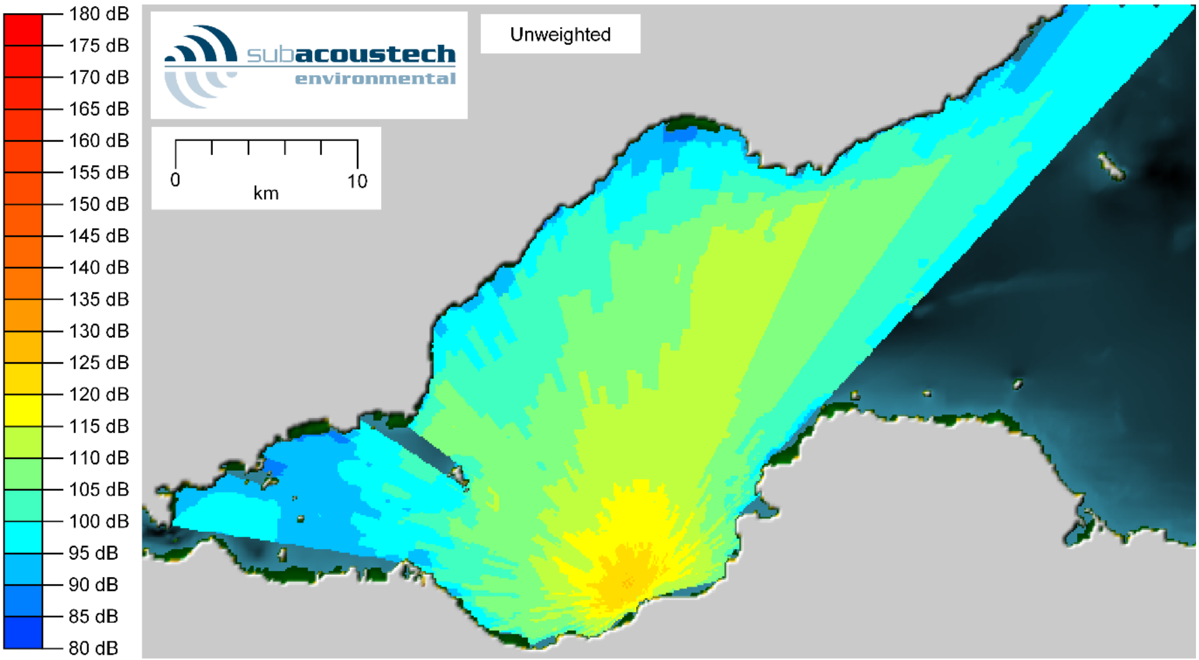


*Figure 4-1 Predicted vibro-piling noise, unweighted $SPL_{RMS}$*

## 4.2 Marine mammal criteria

Predicted PTS and TTS impact ranges for marine mammals are given in Table 4-1 using the relevant weighted non-impulsive $SEL_{cum}$ criteria from Southall *et al*. (2019) assuming a stationary animal during a six-hour piling operational window. In addition, the weighted noise levels for the four marine mammal groups are presented in Figure 4-2 to Figure 4-5. Some of the figures demonstrate images ranges which may be too small to be visible.

The LF cetacean weighting results in the largest impact ranges as the other species groups with greater sensitivity to higher frequencies are more insensitive to vibro-piling noise, which is predominantly low frequency at range. This effectively means the vibro-piling noise is much less audible for these groups.

The results show maximum TTS ranges of up to 50 m predicted for LF cetaceans, with impact ranges for all other criteria predicted to be less than 10 m.

*Table 4-1 Summary of the weighted $SEL_{cum}$ PTS and TTS ranges for vibro-piling using the non-impulsive Southall et al. (2019) criteria for marine mammals*

| Southall *et al*. (2019) Weighted $SEL_{cum}$ criteria | | | **Maximum range** | **Mean range** | **Minimum range** |
|---|---|---|---|---|---|
| **PTS** | LF | 199 dB | < 10 m | < 10 m | < 10 m |
| | HF | 198 dB | < 10 m | < 10 m | < 10 m |
| | VHF | 173 dB | < 10 m | < 10 m | < 10 m |
| | PCW | 201 dB | < 10 m | < 10 m | < 10 m |
| **TTS** | LF | 179 dB | 50 m | 50 m | 50 m |
| | HF | 178 dB | < 10 m | < 10 m | < 10 m |
| | VHF | 153 dB | < 10 m | < 10 m | < 10 m |
| | PCW | 181 dB | < 10 m | < 10 m | < 10 m |

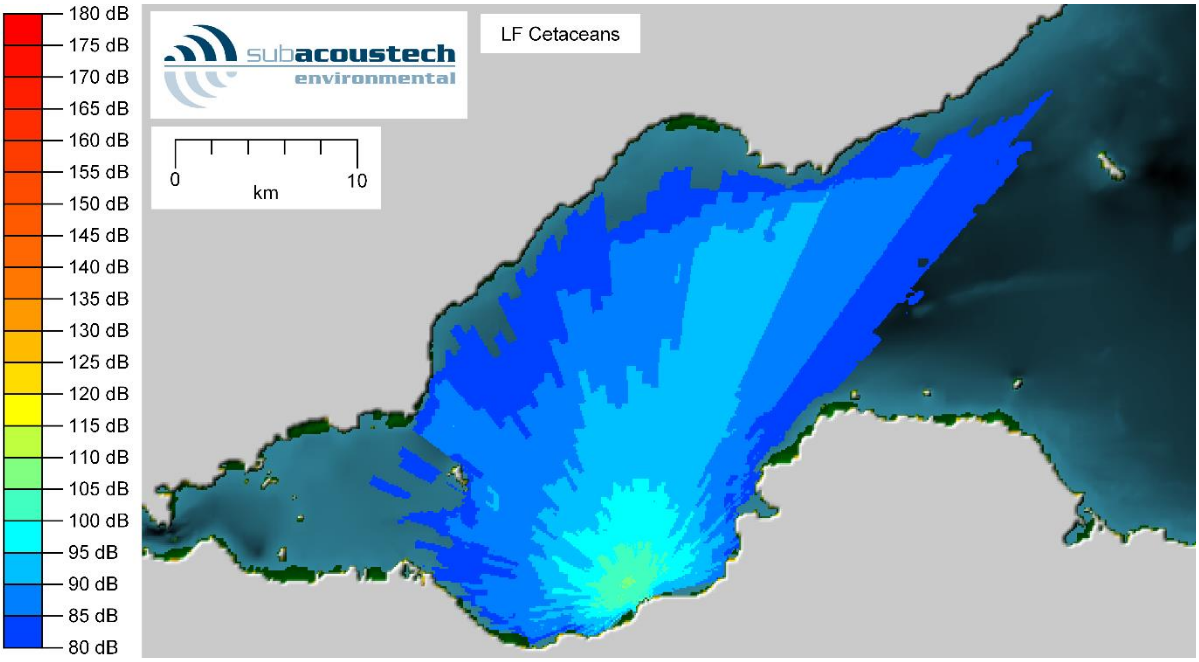


*Figure 4-2 Predicted weighted $SPL_{RMS}$ vibro-piling noise for LF cetaceans*

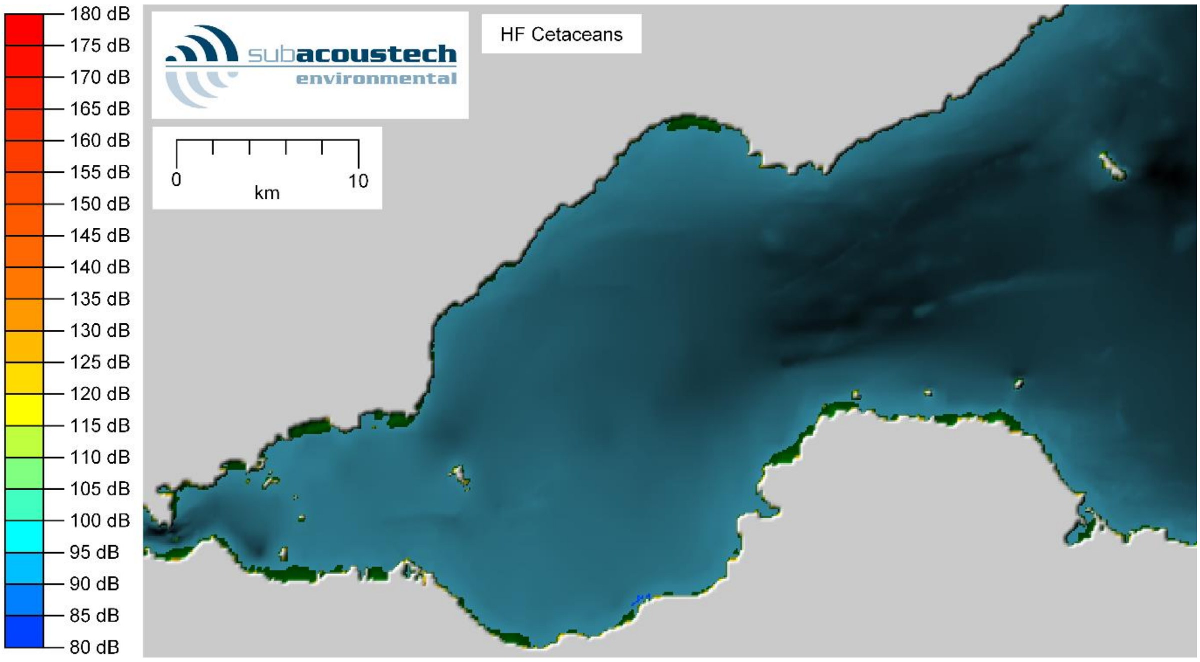


*Figure 4-3 Predicted weighted $SPL_{RMS}$ vibro-piling noise for HF cetaceans*

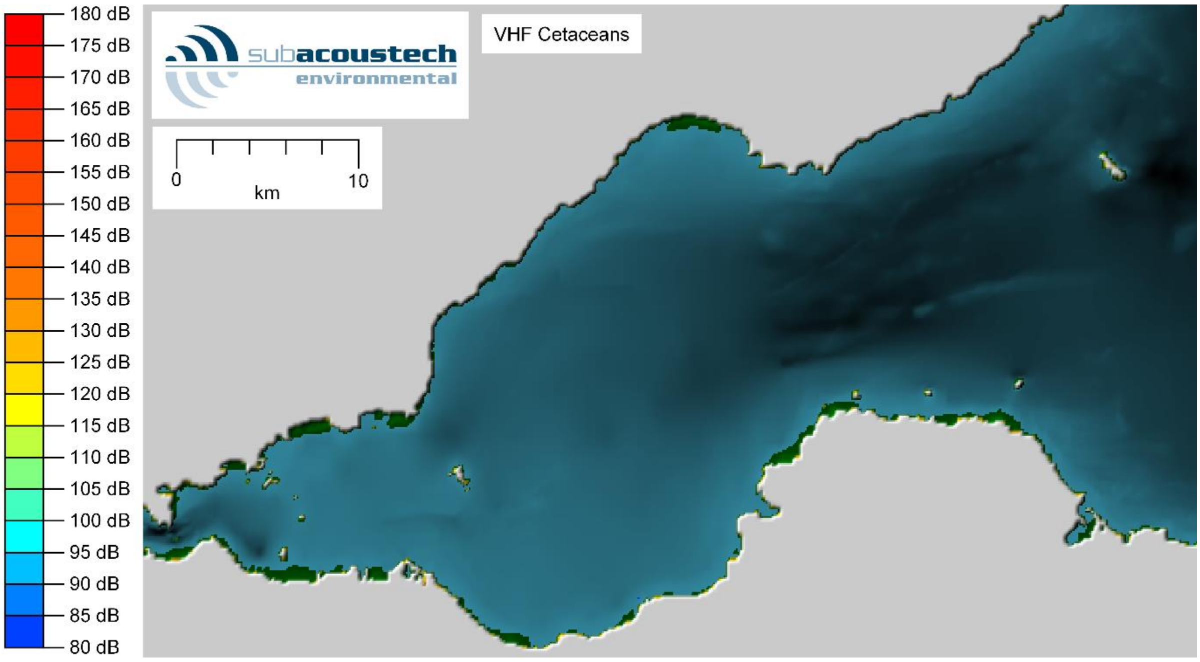


*Figure 4-4 Predicted weighted $SPL_{RMS}$ vibro-piling noise for VHF cetaceans*

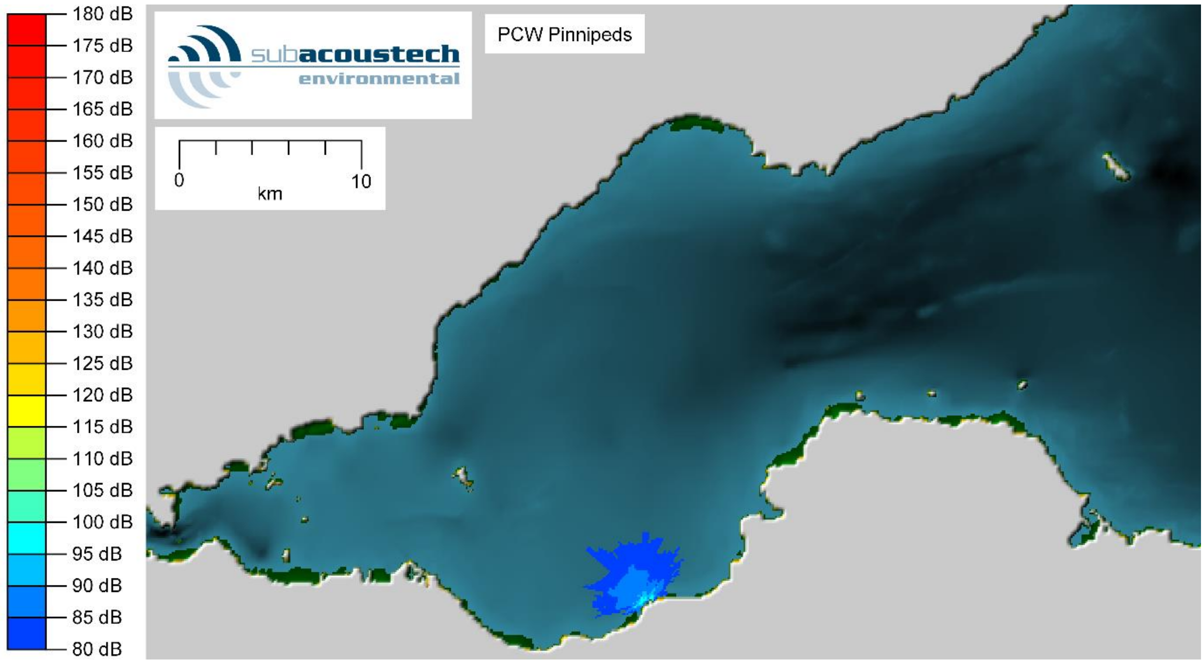


*Figure 4-5 Predicted weighted $SPL_{RMS}$ vibro-piling noise for PCW pinnipeds*

## 4.3 Fish criteria

Table 4-2 gives the maximum, mean and minimum impact ranges for species of fish from vibro-piling noise using the Popper *et al*. (2014) guidance for continuous sounds.

The unweighted $SPL_{RMS}$ criteria show that recoverable injury from vibro-piling noise could be expected at ranges up to 20 m, and that TTS could occur out to 40 m. The attenuation of this noise into the Firth of Forth is shown in Figure 4-1.

*Table 4-2 Summary of the unweighted $SPL_{RMS}$ recoverable injury and TTS ranges for vibro-piling using the continuous sounds Popper et al. (2014) criteria for fish*

| Popper *et al*. (2014) Unweighted $SPL_{RMS}$ criteria | | | **Maximum range** | **Mean range** | **Minimum range** |
|---|---|---|---|---|---|
| **Fish: swim bladder is involved in hearing** | Recoverable injury | 170 dB (48 hours) | 20 m | 20 m | 20 m |
| | TTS | 158 dB (12 hours) | 40 m | 40 m | 40 m |

# 5 Summary and conclusions

Subacoustech Environmental has undertaken an underwater noise modelling study on behalf of Inch Cape Offshore Limited to assess the effect of underwater noise from vibro-piling activity during the installation of a cofferdam as part of the inshore works for the Inch Cape Offshore Wind Farm.

The level of underwater noise has been estimated using a combined parabolic equation and ray tracing modelling methodology. The modelling considers a wide array of input parameters including source level, sound frequency content, seabed properties and the sound speed profile in the water column. Full account is also taken of the bathymetry in the areas surrounding the survey site.

The maximum predicted impact ranges for vibro-piling noise are predicted for the LF cetacean group from Southall *et al*. (2019) with $SEL_{cum}$ ranges of up to 50 m for TTS, based on a stationary receptor during the six-hour piling window. For fish, ranges based on the Popper *et al*. (2014) guidance for continuous sounds gave recoverable injury ranges of up to 20 m and TTS ranges of up to 40 m from the vibro-piling.

Finally, it should be stressed that, by its nature, mathematical modelling will produce results that indicate a precise range at which a criterion will be reached, but this does not reflect the inherent uncertainty in the process. The results give a specific numerical value to a process with a vast number of variables and parameters, including many that change constantly under real world conditions. Most modelling parameters, such as the source noise level, the duration of operation and the location, are selected to be precautionary to avoid the risk of underestimating an impact. While the results present specific ranges at which each impact threshold is met based on the modelling results, the ranges should be taken as indicative, albeit worst case, in determining where environmental effects may occur in receptors during the proposed operations.

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