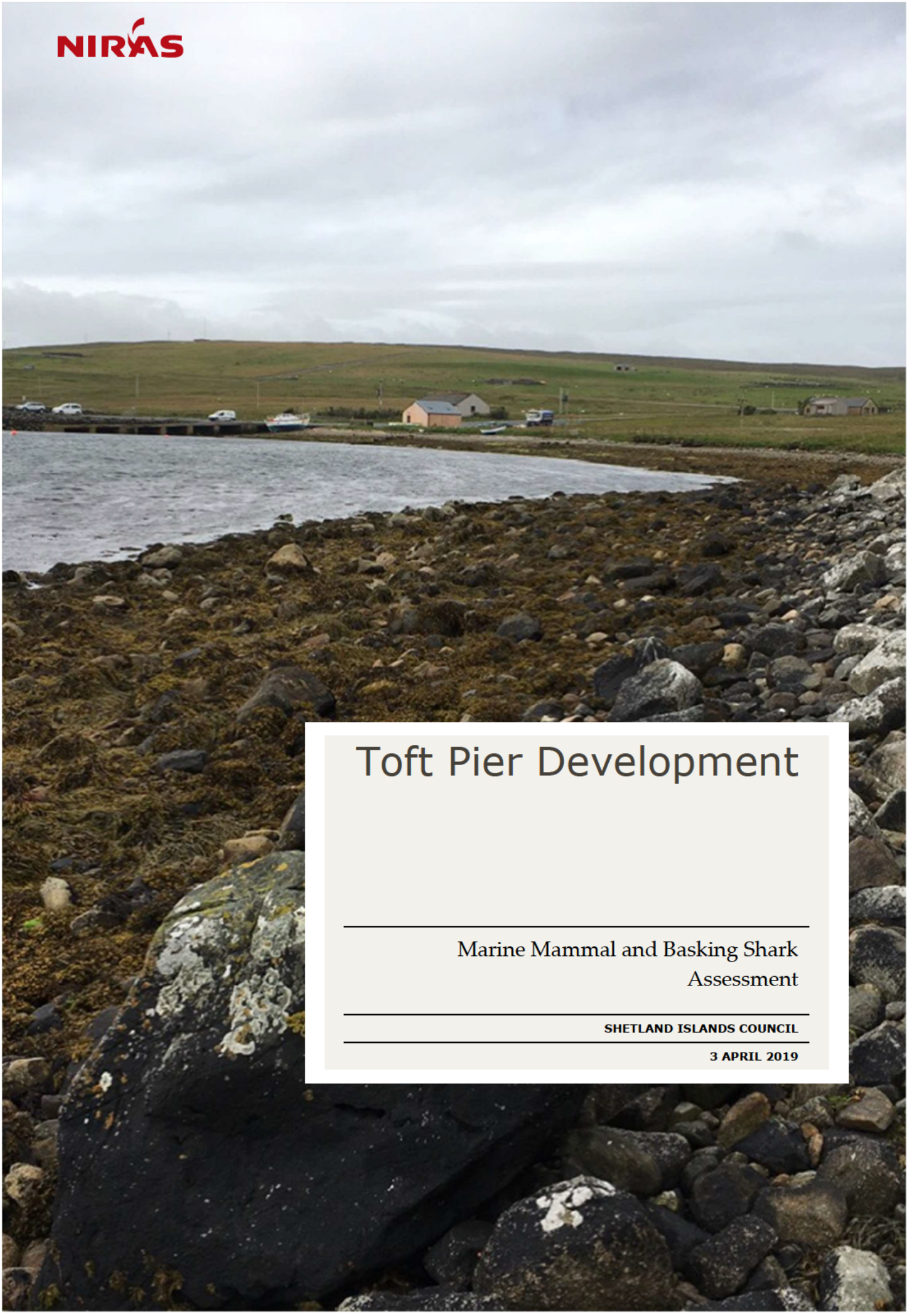

Toft Pier Development

Marine Mammal and Basking Shark Assessment

SHETLAND ISLANDS COUNCIL

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Table of Contents

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1 Introduction

Shetland Islands Council (SIC) are applying for a Marine Licence to undertake development works at Toft Pier on Mainland, Shetland (Figure 2.1).

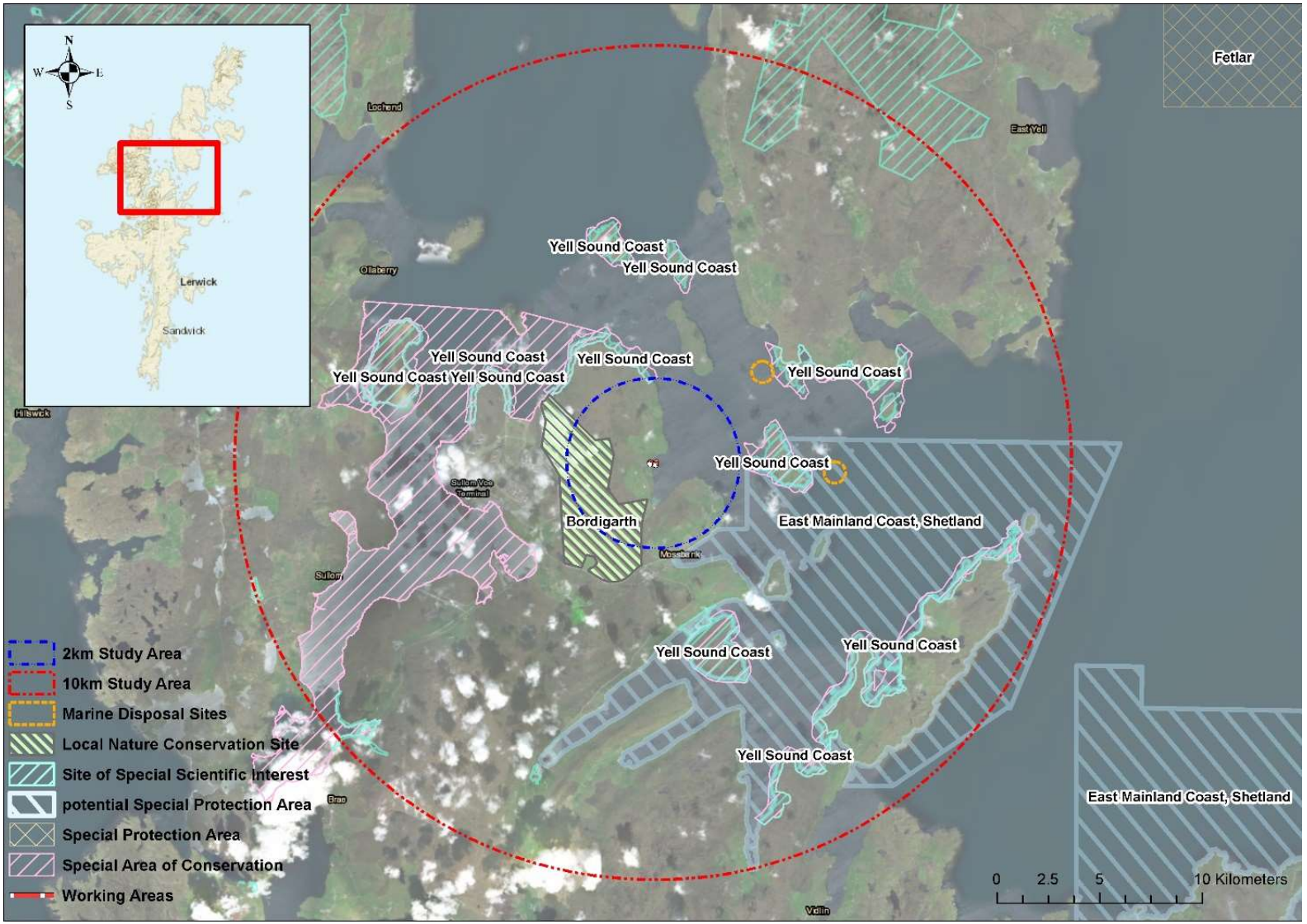
This assessment has been produced to inform decision making relating to requirements to mitigate against injury or disturbance to marine mammals, or basking shark *Cetorhinus maximus*[1], potentially arising from activities associated with the Toft Pier Development. Marine mammals have strong legal protection and are potentially sensitive to injury or disturbance associated with underwater noise produced as a consequence of activities such as pile driving which is planned during works on the development.

After a short description of the relevant work activities in relation to marine mammals and underwater noise (Section 2), this assessment considers the likely marine mammal species present (Section 3) and their legal protection together with relevant guidance relating to the proposed works (Section 4). An assessment of the potential for impacts to occur as a result of the proposed works is made in Section 5, taking into account mitigation measures which can be applied.

In Section 6 this assessment also considers whether it is appropriate to apply for a European Protected Species (EPS) licence in relation to disturbance of cetaceans or basking shark, given the outcome of the assessment.

[1] Basking shark are afforded legal protection within the 12nm limit in UK territorial waters (see Section 4) and are considered in this assessment which otherwise relates to marine mammals.

Figure 1 1: Designated Areas near Toft Pier Development



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

2 Proposed Works

2.1 Noise generating activities

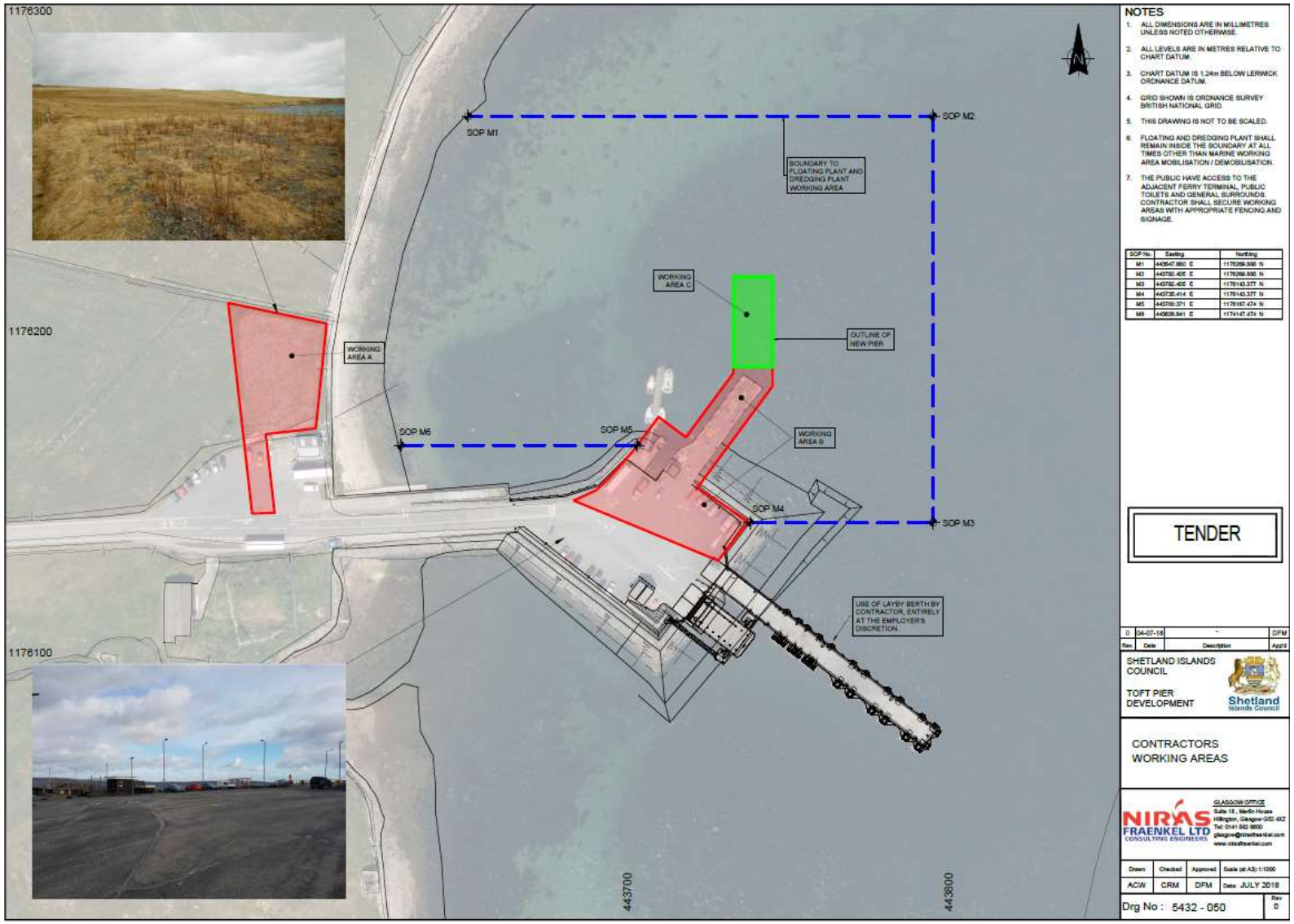
The proposed works, at locations indicated in Figure 2.1: Toft Pier DevelopmentFigure 2.1, comprise of the following particular requirements. At this stage, prior to appointment of the contractor and preparation of detailed method statements, activities are described in general terms. Those activities potentially generating underwater noise and identified as presenting risk of disturbance to marine mammals are underlined:

1. Surveys as required by the Contractor to ensure that the facilities when completed result in a comprehensive and durable construction.
    - Such surveys could include multibeam echo sounder (MBES) survey of nearshore areas in relation to dredging activities, below.
2. A single borehole at the location shown on the Tender Drawings (This is understood to be at the end of the proposed pier).
    - It is assumed that the borehole will be drilled which will result in the introduction of underwater noise to the marine environment.
3. Compliance with the requirements of the Environmental Management Plan during dredging works.
4. Demolition and removal off site (or recycled within the Works) of the existing concrete upstands on the pier, pier surfacing and adjacent small building.
5. Demolition and removal off site (or to SIC stores, as directed by the Project Manager) of fenders, bollards, ladders, fences, barriers.
6. Demolition and removal off site (or recycled within the Works) of elements of the existing pier structure as required to construct the Works.
    - (Whilst the general demolition works described above (4-6) will result in the introduction of some underwater noise into the marine environment this is expected to be at relatively low levels, associated with cutting and breaking of material above the water surface with some propagation into the water column but limited spread beyond the immediate area of works. Underwater noise levels are expected to be similar to those associated with dredging which is considered below.)
7. Removal and disposal off site (or recycled for reuse within the Works) of all dumped equipment, material stockpiles and rubbish within the site boundary.
8. Local removal and subsequent reinstatement of existing rock revetments, as required to construct the Works.
    - There will be some introduction of noise into the marine environment from this activity but at relatively low levels.
9. Mobilization of spread of equipment for dredging and disposal of dredged material.
10. Demobilization of spread of equipment for dredging and disposal of dredged material.
11. Excavation by dredging of seabed material.
12. Excavation by dredging of all soft bed material within the footprint of the new pier.
    - Dredging is associated with the generation of underwater noise from vessel activity and interaction with the seabed.
13. Removal of dredged material off Site to a land-based disposal site (NB offshore disposal is also being considered as an alternative).
14. New Pier structure, including retaining walls; anchor walls, ties, waling beams and all associated fittings; filling and compaction; reinforced concrete slab; fenders, bollards, ladders, lifebuoys and general quayside furniture.

- These works include installation of steel sheet piles using a hydraulic hammer (vibro and/or impact piling) and rock dumping to infill within the area enclosed by the installed sheet piles.

15. Design, installation, testing and commissioning of cathodic protection system.
16. Signage and road markings.
17. Mechanical and electrical works including area lighting, navigation light and ducts for future services.

Figure 2 1: Toft Pier Development Works



2.2 Expected noise levels

Sound is readily propagated underwater and many aquatic species are adapted to utilise sound for multiple purposes; for example, marine mammals use sound in various important contexts including social interaction, foraging and responding to predators (Southall *et al*., 2007). The introduction of sound into the marine environment from anthropogenic activities such as shipping, seismic survey, dredging, pile driving etc. may lead to adverse impacts upon marine fauna (e.g. Williams *et al*., 2015), the scale of which is related to the characteristics of the sound source, e.g. its magnitude and frequency characteristics, as well as the nature of the background environment (soundscape) since the same noise would be expected to have a relatively greater impact in a quiet environment than a noisy one. At a coarse level impacts may be characterised as physical (death or injury) or behavioural (e.g. negative phonotaxis/displacement) although there is a great range of potential effects.

Anthropogenic underwater noise is generally characterised as either impulsive or continuous, depending on its source. Examples of anthropogenic impulsive noise in the marine environment are underwater explosions, impact pile driving and seismic surveys airguns, whereas activities such as shipping, drilling and dredging are associated with continuous noise.

Impulsive noise is characterised by high energy over a short duration. Typical metrics for impulsive noise are Sound Exposure Level (SEL) and Peak sound pressure level (SPLpeak or SPLpeak-peak). The SEL is calculated over the pulse duration, which is commonly defined as the time occupied by the central portion of the pulse, where 90% of the pulse energy resides (Robinson *et al*., 2014).

Continuous noise is characterised by acoustic energy which is spread over a significant time, typically many seconds, minutes or even hours. The amplitude of the sound may vary throughout the duration, but the amplitude does not fall to zero for any significant time. The metric most suitable for continuous sounds is Sound Pressure Level (SPL), although a SEL can be calculated for continuous noise as well (Robinson *et al*., 2014). SPL is time averaged and most commonly expressed as a root mean square (RMS) value.

It is worth noting that whilst low frequency sound is able to propagate further and more efficiently underwater than high frequency sound, low frequencies cannot propagate in water shallower than a quarter wavelength ($\lambda/4$, where λ is the wavelength). In shallow waters especially, interactions between sound and the seabed are important in determining propagation, and whether sound is reflected back to the water, scattered or transmitted through sediments to emerge further along the propagation path back into the water (Farcas *et al*., 2016).

The following activities have been identified which could generate underwater noise, potentially resulting in impacts to marine mammals or basking shark:

- MBES survey
- Borehole sinking (drilling and percussive driving)
- Dredging (and demolition works which are likely to result in similar noise levels)
- Pile driving (sheet piles)
- Infilling (rock dump)

Further information on these activities, and expected underwater noise levels and characteristics, are provided below.

2.2.1 MBES survey

MBES is used to acquire water depth information by emitting a fan shaped swath of acoustic energy (sound waves) from beneath a ship's hull directed across the track of the vessel, these waves are reflected from the seabed to give an estimate of water depth to enable high resolution seafloor mapping.

MBES survey is expected to be undertaken in relation to planned dredging activity to confirm water depths. A very limited programme of work is anticipated, of the order of a few days.

The works could take place at any time of year but are assumed most likely to occur in summer.

Survey equipment specifications are to be confirmed but typical MBES survey equipment and assumptions carried into the assessment are described in Table 2.1. The final specifications will depend on the selected survey contractor but sound frequency characteristics and source pressure level parameters are given for typical equipment expected to be used.

Table 2 1 Assumptions for assessment in relation to geophysical survey equipment

Activity	Example Equipment	Typical frequency characteristics	Duration	Estimated source pressure level (impulsive/continuous)
MBES	Kongsberg EM2040 or Reson Seabat 7125	200kHz - 400kHz	< 1 week	~220dB Peak; 213dB rms (continuous)

2.2.2 Borehole sinking

Drilling and/or standard penetration testing (SPT) is expected to be used to sink a borehole to around 10 m depth below seabed level at the end of the planned position of the new pier. SPT involves hammering a small tube into the ground, e.g. at the bottom of the borehole.

This activity is likely to occur in summer but could potentially take place at any time of year.

Borehole sinking will be a relatively quick activity; it is expected that the works will take a few days with actual drilling or SPT hammering a smaller proportion of this time.

Erbe & McPherson (2017) reported source noise levels for typical geotechnical site investigations prior to marine construction. Drilling (120 kW, 83mm diameter drillbit, 1500 rpm, 16–17 m drill depth in sand and mudstone) and SPT (50 mm diameter test tube, 15 mm wall thickness, 100 kg hammer, 1 m drop height) by a jack-up rig in 7–13 m of water were recorded with a drifting hydrophone at 10–50 m range. Source levels were 142–145 dB re 1 µPa rms @ 1 m (30–2,000 Hz) for drilling and 151–160 dB re 1 μPa^2s @ 1 m (20–24,000 Hz) for SPT.

Additional information on drilling is available from two studies which measured noise associated with a relatively large (4.2m diameter) drill bit and a smaller (20cm diameter) drill. Ward & Needham (2012) estimated a source level of 153.4 dB_{peak} re 1 µPa @ 1 m for the larger drill; Willis *et al*. (2010) estimated a source level of 135.8 dB_{peak} re 1 µPa @ 1 m. for the smaller drill. Whilst ground conditions will also influence source noise levels, drill diameter is also understood to be a factor and it is not considered likely that the source level for a smaller borehole such as required at Toft would exceed around 150dB dB_{peak} re 1 µPa @ 1 m.

Assumptions for assessment are summarised in Table 2.2.

Table 2 2 Assumptions for assessment in relation to borehole sinking

Activity	Example Equipment	Typical frequency characteristics	Duration	Estimated source pressure level (impulsive/continuous)
Borehole sinking	Drilling	30–2,000 Hz	< 1 week (intermittent)	150dB dB_{peak} re 1 µPa @ 1 m (continuous)
	SPT hammering	20–24,000 Hz	< 1 week (intermittent)	160 dB re 1 μPa^2s @ 1 m (impulsive)

2.2.3 Dredging

Dredging is planned to create sufficient water depth to allow for construction of the extended pier and subsequent access and berthing for vessels. Dredging is expected to be undertaken using a backhoe dredger or similar, operated from a barge with material transferred to a hopper either ashore or on a barge for disposal. Around 5,000m^3 of material needs to be dredged.

Dredging is expected to occur in June 2019 but could potentially take place at any time of year. Dredging works are likely to last for some weeks.

Noise and dredging Noise arises from dredging activity from several sources, notably the excavator interacting with the seabed surface and vessel noise. The magnitude and characteristics of the noise depend on the specific vessel and dredging equipment used together with environmental conditions including water depth and ground type. Literature information from other sites therefore needs to be treated with caution, but may be usefully informative.

Reine et al. (2012) estimated a source level of 163 $dB_{(assumed\ peak)}$ re 1 µPa @ 1 m for bucket extraction while Nedwell et al. (2008) estimated a source level of 179 $dB_{(assumed\ peak)}$ re 1 µPa @ 1 m for sediment extraction using a backhoe during dredging works at Lerwick Harbour, Shetland. This was the loudest activity associated with the operation; however, the noise was not detectable beyond 175 m from the source.

The noises produced from dredging activity are usually continuous, broad-band sounds mostly below 1 kHz (Todd *et al*. 2015).

Some rock cutting may be required if there are hard outcrops This is expected to result in similar noise levels to drilling using a larger diameter drill (approximately 160 dB dB_{peak} re 1 µPa @ 1 m); however, in a review of dredging noise Jones & Martin (2016) suggest that source levels for cutting appear to range from 157.5-187 dB re 1 µPa@1 m depending on the vessel size, activity being undertaken and the environmental conditions at the time of monitoring. The higher figure in this range is conservatively adopted here.

Demolition works which are likely to result in similar noise levels. Assumptions for assessment are summarised in Table 2.3.

Table 2 3 Assumptions for assessment in relation to dredging

Activity	Example Equipment	Typical frequency characteristics	Duration	Estimated source pressure level (impulsive/continuous)
Dredging	Backhoe excavator	Assumed broadband	Approximately 1 month (intermittent)	179 $dB_{(peak)}$ re 1 µPa @ 1 m (continuous)
	Rock cutting	Assumed broadband	< 1 week (intermittently within period of dredging)	<187 dB dB_{peak} re 1 µPa @ 1 m (continuous)

2.2.4 Sheet piling

Steel sheets will be installed to provide the structure of the extended pier. These are driven into the seabed using vibratory (vibro) or impact piling. Vibro piling will be used initially with impact piling available if sheets meet refusal before target depth.

Sheet piling is expected to commence in June 2019 but could potentially occur at any time of year.

Piling works will take place over a total period of around one month; however, piling will by no means be continuous. In practice, piling is expected to occur for a few hours on a more or less daily basis, over a period of approximately one month, until completion.

Sheet piling typically used a vibro piling method and requires relatively low energy levels compared to impact piling of alternative foundation types such as monopiles. Measurements of source sound levels from sheet piling are scarce but FEMM (2013) assumed a conservative figure of 190dB re 1µPa@1m based on measurements at the German ports of Brake and Cuxhaven. The comparability of these specific locations, or the particular equipment utilised, to Toft site is unknown but underwater noise levels are expected to be of a similar magnitude.

No information has been found on noise levels associated with impact piling of sheet piles. There is considerable focus on impact piling of monopile foundations, for example for offshore wind farms; however, this involves much higher piling energy levels (thousands of kJ compared to a likely maximum of around 100kJ for Toft) and is not directly comparable because of the difference between a three dimensional monopile and effectively two dimensional sheet pile. To be conservative it is assumed that source sound levels are likely to greater than sheet piling and potentially similar to smaller diameter monopiles for which there is a general relationship between pile driving sound pressure level measurements and pile diameter (Bellman, 2014). Reinhall and Dahl (2011) suggested that peak sound pressure levels from impact pile driving are in the order of 220 dB re 1 µPa at a range of ~10 m from 0.75 m diameter piles. This is likely an over-estimation of equivalent source (@ 1m) levels for sheet piles but is adopted here as a conservative value.

By way of comparison between impact and vibro piling, measurement of underwater noise associated with first vibro and then impact pile driving were made to 0.91 m diameter steel piles in a dock at Cook Inlet, Alaska, by Blackwell (2005). Peak values (SPLs) and sound exposure levels (SELs) were reported for impact pile driving; SPLs were reported for vibratory piling. Mean SPL for vibratory piling was around 164 dB re 1 µPa (56 m range) and SEL for impact piling of the order 180 dB re 1 µPa2-s (62 m range).

Assumptions for assessment are summarised in Table 2.4.

Table 2 4 Assumptions for assessment in relation to sheet piling

Activity	Example Equipment	Typical frequency characteristics	Duration	Estimated source pressure level (impulsive/continuous)
Sheet piling	Vibro hammer	Assumed broadband	Approximately 1 month (intermittent)	190dB re 1µPa@1m (continuous)
	Impact hammer	Assumed broadband	< 1 week (intermittently within period of piling)	220 dB re 1 µPa @1m (impulsive)

2.2.5 Rock dumping

Rock fill will be used to create the new pier once sheet piles are installed.

This activity is expected to take place in summer 2019 but could potentially take place at any time of year.

There is very little information available on the noise levels associated with rock dumping. One case of rock dumping in around 70 m water depth off Shetland was reported in the Galloper Offshore Wind Farm environmental statement (2011), in this example noise was not detectable above background.

Whilst there is expected to be some additional noise as a result of stones interacting with the sheet piles it is also expected that these will serve to limit propagation of noise into the marine environment for the majority of the operation.

Overall it is concluded that rock dumping is unlikely to result in underwater noise levels significantly in excess of background.

3 Species present

3.1 Marine mammals

A Preliminary Ecological Appraisal Report (PEAR) was completed in August 2018 following a site visit and desk study. This report compiled initial information on marine mammals which is summarised and updated here.

Grey seal (*Halichoerus grypus*) are known to be present within 10 km of Toft Pier, one individual was observed briefly in waters close to Toft Pier during the walkover survey.

Aggregations of grey seals are known to be present at Swarta Skerry (13.3km, southeast), Sand Skerry (8.9 km, east-southeast) and Lunna Holm (9.0 km east-southeast).

Harbour seal (*Phoca vitulina*) is more regularly recorded within 10 km of Toft Pier although none were recorded on the walkover survey.

There is a designated haul out for harbour seal (non-breeding) northwest of Bigga, some 3.5 km north of Toft Pier (Marine Scotland, 2018).

Many harbour porpoise (*Phocoena phocoena*) sightings will not be submitted (i.e. they tend to be under-recorded) but they are regular in winter, notably in the Little Roe – Mio Ness – Swarta Taing triangle (OS National Grid reference HU4078).

Killer whale (*Orcinus orca*) and minke whale (*Balaenoptera acutorostrata*) are more regularly reported in summer (April-September) but are known to be present at other times of the year.

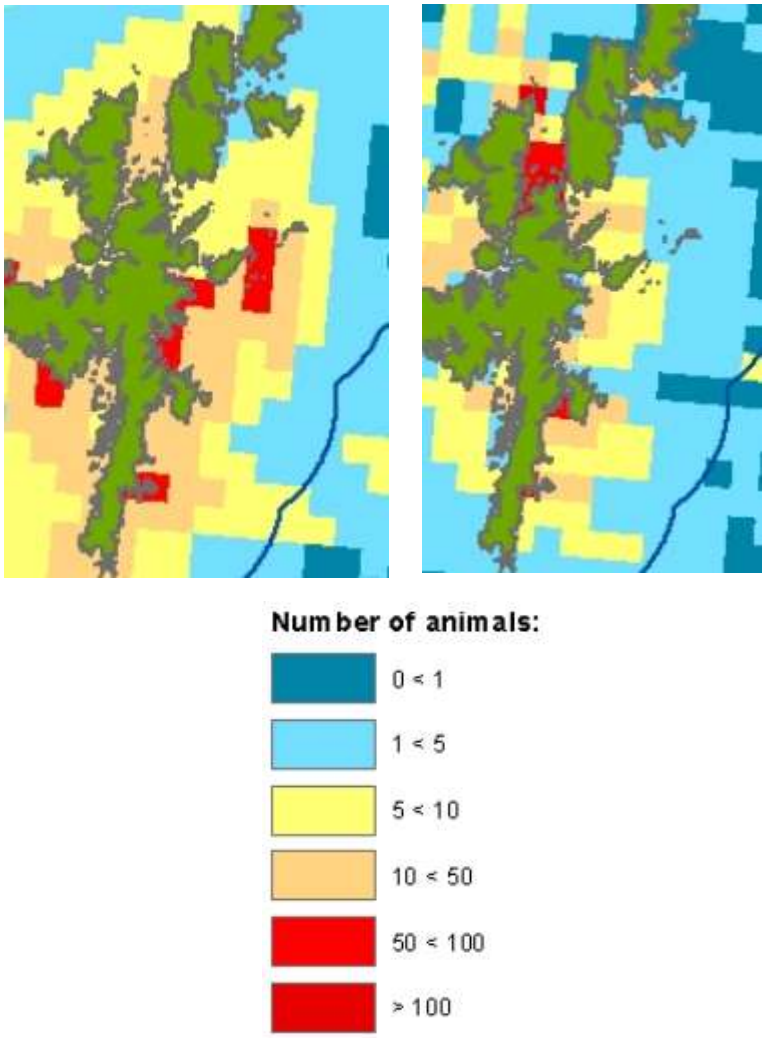
Small numbers of other marine mammals have been recorded less frequently, including sei whale (*Balaenoptera borealis*), humpback whale (*Megaptera novaeangliae*), pilot whale (*Globicephala* sp.), long-finned pilot whale (*Globicephala melas*), common dolphin (*Delphinus delphis*), Risso's dolphin (*Grampus griseus*), white-sided dolphin (*Lagenorhynchus acutus*) and white-beaked dolphin (*Lagenorhynchus albirostris*).

The above information from the PEAR Study is consistent with a summary of marine mammal sightings information presented in the Shetland Islands' Marine Spatial Plan (SIMSP: NAFC, 2015) which identified sightings of grey and harbour seal, harbour porpoise and killer whale local to Toft Pier and a wider range of cetacean species as potentially present. Information presented in the SIMSP suggests that seal density at sea is relatively high and this is reflected in surface density plots (Figure 4.1) showing high levels for harbour seal and intermediate densities for grey seal relative to other areas.

3.2 Basking shark

Basking shark should also be considered as potentially present with local sightings noted in NAFC (2015). The PEAR noted that this species has been recorded in small numbers (1-2) between July and September. This is consistent with the occurrence of this plankton feeding species in UK coastal waters during summer months.

Figure 3 1: Grey seal (left) and harbour seal (right) at-sea usage map



Data source: SMRU and Marine Scotland (2017)

4 Legal protection and Guidance relating to marine mammals

4.1 Protected and priority species

4.1.1 Wildlife and Countryside Act 1981 and the Nature Conservation (Scotland) Act 2004 (W&CA)

This legislation applies to inshore waters (within 12 nm of the coast). Schedule 6 of the Nature Conservation (Scotland) Act 20046 states:

> Subject to the provisions of this Part, any person who, intentionally or recklessly, disturbs or harasses any wild animal included in Schedule 5 as a—
>
> (a) Dolphin, whale or porpoise (cetacea); or
>
> (b) Basking shark (*Cetorhinus maximus*),
>
> shall be guilty of an offence.

4.1.2 European Habitats Directive: Conservation (Natural Habitats, &c.) Amendment (Scotland) Regulations 2007

This legislation also applies to inshore waters.

All cetaceans are European Protected Species (EPS) as a result of their listing in Annex IV of the EU Habitats Directive (species of community interest in need of strict protection). The Conservation (Natural Habitats, &c.) Amendment (Scotland) Regulations 2007 contains a definition of the disturbance offence for EPS (Regulation 39) which states:

> 39.—(1) It is an offence–
>
> (a) deliberately or recklessly to capture, injure or kill a wild animal of a European protected species;
>
> (b) deliberately or recklessly–
>
> (i) to harass a wild animal or group of wild animals of a European protected species;
>
> (ii) to disturb such an animal while it is occupying a structure or place which it uses for shelter or protection;
>
> (iii) to disturb such an animal while it is rearing or otherwise caring for its young;
>
> (iv) to obstruct access to a breeding site or resting place of such an animal, or otherwise to deny the animal use of the breeding site or resting place;
>
> (v) to disturb such an animal in a manner that is, or in circumstances which are, likely to significantly affect the local distribution or abundance of the species to which it belongs;

(vi) disturb such an animal in a manner that is, or in circumstances which are, likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young; or

(vii) to disturb such an animal while it is migrating or hibernating;

(c) deliberately or recklessly to take or destroy the eggs of such an animal; or

(d) to damage or destroy a breeding site or resting place of such an animal.

(2) Subject to the provisions of this Part, it is an offence to deliberately or recklessly disturb any dolphin, porpoise or whale (cetacean).

4.1.3 Priority Marine Features

Scottish Natural Heritage and Marine Scotland have identified the most important components of Scotland's marine biodiversity. Priority Marine Features (PMF) are a prioritised list of 80 marine habitats and species considered to be of national conservation importance. They should be taken account of in Environmental Statements and through relevant licensing/consenting decisions.

All cetacean species likely to occur and both seal species are PMFs.

4.2 Designated nature conservation sites (statutory and non-statutory)

Annex II of the Habitats Directive requires the establishment of a network of sites that will contribute to the protection of the species listed. Harbour porpoise and bottlenose dolphin are two of the cetacean species listed while both grey and harbour seal are included.

One such designated site is present of relevance to the Toft Pier development. Yell Sound Coast Special Area for Conservation (SAC) is within approximately 2 km of Toft Pier at its closest point (Figure 1.1). The site citation includes the following in relation to harbour seal:

Yell Sound Coast in the Shetland Islands is the most northerly UK site selected for the harbour seal. The rocky shores and uninhabited islands and skerries within Yell Sound support a colony representing over 1% of the UK population.

4.3 Guidance

Marine Scotland (2014) has been consulted to assist in understanding when a disturbance offence is at risk of being committed in relation to cetaceans.

Guidance provided by JNCC (2017) has been referred to specifically in relation to geophysical surveys (MBES).

Guidance on minimising the risk of injury to marine mammals from piling noise (JNCC, 2010) has been utilised. This has also been adopted in relation to other potentially significant noise generating activities.

SNH (2016) guidance relating to marine wildlife will be adopted by project vessel and onshore personnel.

5 Assessment

The following provides an assessment of the risk of injury or disturbance to marine mammals and basking shark. Activities considered are those in Section 2.2 with the exception of rock dumping for which it was concluded that significant noise levels would not result.

5.1 Injury

Injuries from underwater noise may results from the exposure of marine mammals to high levels of underwater noise. Injury may range from a shift in hearing threshold at one or more frequencies to, at the extreme end of the scale, lethal effects. Sub-lethal injury may affect an individual's vital rates and is therefore a potentially serious consequence. Temporary threshold shift (TTS) in hearing is generally regarded as an extreme form of behavioural disturbance; permanent threshold shift (PTS) is considered to represent the lower limit for injury.

PTS onset thresholds are not derived empirically for ethical reasons but estimated based on extrapolating from TTS onset thresholds. For pulsed noise, such as piling, NOAA (NMFS, 2018) have set the onset of TTS at the lowest level that exceeds natural recorded variation in hearing sensitivity (6dB), and assumes that PTS occurs from exposures resulting in 40 dB or more of TTS measured approximately 4 min after exposure. The use of PTS-onset thresholds does not mean that all animals will experience PTS, rather, PTS thresholds are used to indicate the range below which there is certainty that no PTS will occur. PTS-onset is therefore a conservative indication of the numbers of animals potentially at risk of PTS, rather than those predicted to actually develop PTS.

Injury (PTS) thresholds are presented in Table 5.1. These are dual criteria in that exceedance of either a cumulative or instantaneous threshold is considered to risk injury. They make reference to functional hearing groups originally derived from Southall *et al*. (2007) which related to the effective hearing ranges of relevant species and are defined as follows:

- low-frequency cetaceans (minke whale) 7Hz to 22kHz
- mid-frequency cetaceans (bottlenose and white-beaked dolphin) 150Hz to 160kHz
- high-frequency cetaceans (harbour porpoise) 200Hz to 180kHz
- pinnipeds in water (harbour and grey seal) 75Hz to 75kHZ

Table 5 1 NOAA (NMFS, 2018) PTS thresholds for pulsed noise

Hearing Group	PTS Threshold (received level)	
	SELcum [dB re 1 µPa^2 s]*	Peak SPL [dB re 1 µPa] unweighted
Low-frequency cetaceans	183	219
Mid-frequency cetaceans	185	230
High-frequency cetaceans	155	202
Pinnipeds in water	185	218
* weighted according to NMFS (2016) Audiogram weighting functions for each hearing group and accumulated over a 24 hour period.		

For continuous noise the thresholds indicated in Table 5.2 are used.

Table 5 2 NOAA (NMFS, 2018) PTS thresholds for continuous noise

Hearing Group	PTS Threshold (received level)
	SELcum [dB re 1 µPa^2 s]*
Low-frequency cetaceans	199
Mid-frequency cetaceans	198
High-frequency cetaceans	173
Pinnipeds in water	201
* weighted according to NMFS (2016) Audiogram weighting functions for each hearing group and accumulated over a 24 hour period.	

Basking shark are not considered to be at risk of injury from underwater noise associated with Toft pier development. Lacking a swim bladder, sharks along with other elasmobranchs are only sensitive to the particle motion component of underwater noise rather than sound pressure associated with tissue trauma injury and are considered to have low sensitivity to sound pressure (Popper *et al.*, 2014).

5.1.1 MBES

Although there is no overlap between the expected operating frequency of MBES (200kHz - 400kHz) and the upper hearing limit of even high frequency cetaceans (180kHz, relevant to harbour porpoise) the potential for injury will still need to be considered if animals could be exposed to sound pressure of sufficient magnitude to cause hearing damage or other harm.

In terms of injury risk, this is not considered likely in shallow waters (<200m) where MBES can utilise higher frequencies which attenuate relatively rapidly. JNCC (2017) do not advise that mitigation to avoid injury from MBES use is necessary in these circumstances.

5.1.2 Borehole sinking

Anticipated noise levels for drilling (150 dB dB_{peak} re 1 µPa @ 1 m, continuous) lie below thresholds for injury.

Anticipated noise levels for SPT hammering (160 dB re 1 µPa^{2}s @ 1 m, impulsive) also lie below thresholds for injury.

Cumulative exposure over a prolonged period is not expected to be a risk since animals would be expected to move away from higher levels of noise (see Section 5.2.2) and no injuries to marine mammals are anticipated.

5.1.3 Dredging

Anticipated noise levels for backhoe excavator use (179 dB dB_{peak} re 1 µPa @ 1 m, continuous) and rock cutting (187dB re 1 µPa^{2}s @ 1 m, continuous) are potentially of concern if considered over a 24 hour exposure period, especially for high frequency cetaceans (harbour porpoise) which have the lowest injury threshold. However, it is likely that animals will move away from the area long before cumulative exposure becomes problematic. This is consistent with conclusions of other assessments for dredging activity involving rock cutting, including for

example the Aberdeen Harbour expansion project (Kongsberg, 2015) where no risk of injury to marine mammals was identified from backhoe dredging, other than at unfeasibly close range (<10 m) to the activity.

5.1.4 Sheet piling

Anticipated noise from sheet piling using vibro hammer (190 dB re 1 µPa@1 m, continuous) is not believed likely to represent an injury risk to marine mammals. Because of the relative uncertainty about the likely noise levels which will result it is considered sensible to implement a soft start procedure so that vibro piling energy levels are ramped up steadily, as explained in Section 5.1.5.

The impact hammer is associated with potentially higher underwater noise levels (220 dB re 1 µPa @1 m, impulsive). This is in exceedance of thresholds for low and high frequency cetaceans such as minke whale and harbour porpoise respectively, together with seal species, but below the level expected to result in hearing injury (PTS) to mid-frequency cetaceans such as dolphin species and killer whale.

Mitigation is required to minimise the risk of such injuries occurring. Appropriate mitigation for pile driving is detailed in JNCC (2010) and will be applied. This is summarised in Section 5.1.5

The mitigation should be applied to all marine mammal species (i.e. including mid-frequency cetaceans) to minimise associated disturbance impacts.

5.1.5 Mitigation and residual assessment

Measures have been identified as necessary to avoid injury occurring to marine mammals as a result of impact piling of sheet piles. Protocols detailed in JNCC (2010) will be adopted as described below.

The following assumes that all installation of sheet piles will be restricted to daylight hours only (consistent with planning restrictions on construction periods).

1. A final detailed Mitigation Plan will be developed following finalisation of Contractor selection and confirmation of construction techniques, including hammer energy and associated underwater noise levels. The requirement for mitigation will be reviewed in light of this information (if noise levels will be below injury thresholds then mitigation may not be required).
2. Hammer energies should be the minimum required to achieve the required penetration depth.
3. A marine mammal observer (JNCC accredited) will be appointed to implement the following:
   - 3.1. A Mitigation Zone (MZ) of 500m radius will be established around the construction point (hammer location);
   - 3.2. The MMO will undertake a minimum 30 minute pre-piling search of the MZ before commencement of piling;
   - 3.3. Piling will not commence until after at least 20 minutes without marine mammals in the MZ;
   - 3.4. Piling will commence with a soft start, whereby hammer energy will be gradually ramped up over a period of not less than 20 minutes, starting from the lowest practical energy level. Blow frequency (for impact piling) will also be progressively increased;
   - 3.5. If a marine mammal enters the MZ during soft start piling will pause and the process re-start at Step 3.2;
   - 3.6. If there is a pause in piling operations for a period of greater than 10 minutes, then the pre-piling search and soft-start procedure will be repeated.

Additionally, the soft start element of the above protocols (Step 3.4) will be applied during commencement of both vibro and impact piling.

It is not proposed to use acoustic deterrent devices (see Section 5.2).

SNH (2016) guidance relating to 'watching wildlife' (on the sea) will be adopted by vessels working on the project and by onshore personnel to reduce the risk of injuries (e.g. through collision with vessels. This will apply to all marine wildlife, including basking sharks.

With the above mitigation in place it is considered that the risk of injury to marine mammals can be reduced to as low a level as reasonably possible.

5.2 Disturbance

A number of general considerations and factors specific to the project site have been taken into account in relation to the assessment for disturbance.

The location of the site within an embayment will limit the propagation of noise to both the north and south, although not to the east. Additionally, it is assumed that marine mammals, especially resident animals such as seals, will be accustomed to vessel traffic because of the existing ferry terminal and other local marine traffic. This may serve to minimise the impact of increased vessel activity associated with construction of the new pier.

There is recent evidence (Brandt *et al*., 2018) that harbour porpoise leave offshore construction areas well before the start of piling and activation of ADDs, possibly as a result of the piling vessel set up and generally increased activity on site and associated disturbance. In addition, recent preliminary analysis of data collected at the Beatrice offshore wind farm, also suggested that porpoise activity reduced prior to the ADD deployment and that the use of ADDs may contribute to disturbance. For this reason no ADD use is proposed at least until after consultation with statutory bodies including SNH.

It is assumed most likely that the planned activities will take place in summer but possible that they will occur in any month of the year. The sensitivity of marine mammal species present does vary over the year, for example harbour seal are present all year round but are likely to be onshore, or close to haul out sites, between August and September when they moult. Some species, such as killer whale, are more likely to be present in summer but could potentially occur at any time of year.

Basking shark are only likely to be present in summer months; however, their sensitivity to underwater noise is low (Popper *et al*., 2014) and it is not considered likely that noise associated with pier construction will cause disturbance. Interactions with vessels can be problematic for basking shark, however, and therefore SNH (2016) guidance relating to 'watching wildlife' (on the sea) will be adopted by vessels working on the project to avoid unnecessary disturbance. This precaution will also apply to marine mammals both onshore and offshore.

Finally, the duration of disturbance is very limited, not more than around one month for any discrete activity and a matter of days in others.

5.2.1 MBES

As there is no overlap between the expected operating frequency of MBES (200kHz - 400kHz) and the upper hearing limit of even high frequency cetaceans (180kHz, relevant to harbour porpoise) there is no potential for disturbance to occur as a result of the use of this equipment.

5.2.2 Borehole sinking

Noise levels associated with borehole sinking (150 dB re 1 µPa@1 m drilling, 160 dB re 1 μPa^2s @ 1 m) are similar to, or lower than, those associated with many vessels, for example Richardson et al. (1995) provide reference data for a range of vessels suggesting that noise levels are of the order 156 to 186 dB re 1 µPa@1 m. Taking inti account the existing use of the facility for commercial traffic it is not considered likely that construction of a single borehole over a matter of days will represent a significant disturbance.

5.2.3 Dredging

Dredging is expected to generate relatively loud noise compared to existing vessel activity, albeit over a short period of up to approximately one month. Disturbance of marine mammals around the immediate area of works is expected, especially for cetacean species which may be more sensitive than seals (this is believed to be a reasonable assumption since there is good evidence that both grey and harbour seal are relatively less sensitive to underwater noise than harbour porpoise, for example. The recent Hornsea Project 03 assessment predicted that harbour porpoise could be displaced up to tens of km but pinnipeds less than 2 km by pile driving of large diameter offshore wind turbine foundation monopiles (Ørsted, 2018)).

However, disturbance effect ranges are expected to very limited, especially to the north and south because of the shelter of the coast; for example, the assessment for dredging activity at Aberdeen harbour predicted aversive behaviour by harbour porpoise around dredging up to no more than several hundred metres distance.

Taking into account the short duration of works and limited effect range there is not considered to be a risk of a significant impact to any marine mammal species from disturbance due to dredging noise.

5.2.4 Sheet piling

Sheet piling works, especially when requiring impact hammer use to achieve required penetration depths, are expected to result in localised disturbance to marine mammals. Limited information is available on likely effect ranges. Subacoustech (2018) predicted that temporary threshold shift (TTS), which may be indicative of disturbance/displacement, was expected up to 690 m from sheet piling (120 kJ hammer) at the Cromarty Port for both low and high frequency cetaceans, with substantially smaller ranges for mid-frequency cetaceans and pinnipeds. Similar predictions relating to disturbance by sheet piling can be found in various assessments but empirical evidence is lacking.

On balance, given the expected restriction of noise propagation other than in an easterly direction, the short duration of works (including night time restriction) and expected limited spatial effect it is concluded that a significant disturbance impact to any marine mammal species from piling works is unlikely.

6 Conclusions

6.1 Injury risk

Potential has been identified for injury to occur to marine mammals in relation to impact piling which can be reduced to negligible levels by the adoption of standard mitigation (JNCC, 2010) including establishment and monitoring by a marine mammal observer of a 500 m radius mitigation zone and soft start to piling.

The assessment is based on conservative assumptions in terms of injury risk and it is possible that a more refined assessment, based on more detailed evaluation of finalised construction methods, will be able to conclude that no injury risk is present which would negate the requirement for mitigation. However, the stated mitigation is concluded to be required until confirmed otherwise.

6.2 Disturbance risk

No potential for significant disturbance impacts to any marine mammals species, or basking shark, has been identified.

Disturbance levels will however be minimised by using the lowest practical energy levels for piling of sheet piles and following best practice guidance in relation to interactions with marine wildlife (SNH, 2016).

With the assessment concluding no potential for significant disturbance impacts to any marine mammals species, or basking shark, an EPS licence application is not required.

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