Geophysical Surveys

Babcock Rosyth

Marine Mammal Risk Assessment

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1 Introduction

This Marine Mammal Risk Assessment has been produced to support a European Protected Species (EPS) licence application to disturb cetaceans. The licence is required to allow geophysical survey works (specifically sub-bottom profiling) to be undertaken by Aspect Land and Hydrographic Surveys near Rosyth, Firth of Forth, to facilitate development of the Babcock Rosyth marine engineering infrastructure site.

1.1 Background

The Firth of Forth is known to support several species of marine mammals (see Section 3: Marine Mammal Baseline). Marine mammal species present in the Firth of Forth are sensitive to anthropogenic underwater noise and therefore, the geophysical surveys which are proposed to be undertaken have the potential to disturb or cause harm to them.

All United Kingdom (UK) cetacean species are listed under Annex IV of the European Habitats Directive and Schedule 2 of the Habitat Regulations 1994 as EPS, which has been transposed into Scottish Law through the Wildlife and Countryside Act 1981 and The Conservation (Natural Habitats, &c.) Regulations 1994. Specifically, Regulation 39 (1) of the Habitats Regulations 1994 makes it an offence to deliberately or recklessly kill, injure, harass, or disturb an EPS.

Pinnipeds are not listed as Annex IV EPS species under the Habitats Directive however, both common and grey seals (*Phoca vitulina* and *Halichoerus grypus,* respectively) are included in Annex II, meaning that their core habitat must be protected under the Natura 2000 Network and managed in accordance with their ecological requirements. Under the Marine (Scotland) Act 2010, it is an offence to kill, injure or take a seal, as well as to harass a seal, deliberately or recklessly, at a significant haul out site.

Basking sharks may also be affected by underwater noise, and it is possible they could be present in the Firth of Forth. The species has been considered in this assessment in order to determine whether a Licence to disturb Basking Shark under the Wildlife and Countryside Act 1981 (as amended) is also required.

This document lays out the relevant information to support the licence application, including:

- A description of activities taking place which may cause injury and/or disturbance without mitigation (Section 2);
- The baseline information on cetacean and basking shark within the Firth of Forth (Section 3);
- The risk of potential impacts without mitigation (Section 4);
- Consideration of alternatives (Section 5); and,
- The mitigation and management strategies implemented to prevent harms i.e. the Marine Mammal Mitigation Plan (Section 6).

1.2 Scope of Work

Aspect Land & Hydrographic Surveys Ltd will conduct geophysical surveys on behalf of Babcock Rosyth. The resulting information will be used to inform capital dredging at the site in order to increase capacity and allow for the access of larger vessels. The surveys will allow determination of which areas require dredging and to what depths.

The acoustic system proposed for use in the survey period will use an acoustic signal with a frequency between 8 and 22 kHz to provide the highest data resolution possible. These systems are capable of visualising to a sediment depth of 150m, depending on the structure and type of substrate. As geophysical surveys have the potential to impact upon marine mammals, a more detailed description of the geophysical surveys is provided in Section 2: Description of Proposed Survey Operations.

1.3 Survey Area

The area of the geophysical survey is as shown in Figure 1.1., bounded by the red line. The survey area coordinates are as provided in Table 1.1. The survey is to be carried out within the area proposed for capital dredging, in order to be inform the activity with site specific, accurate data.

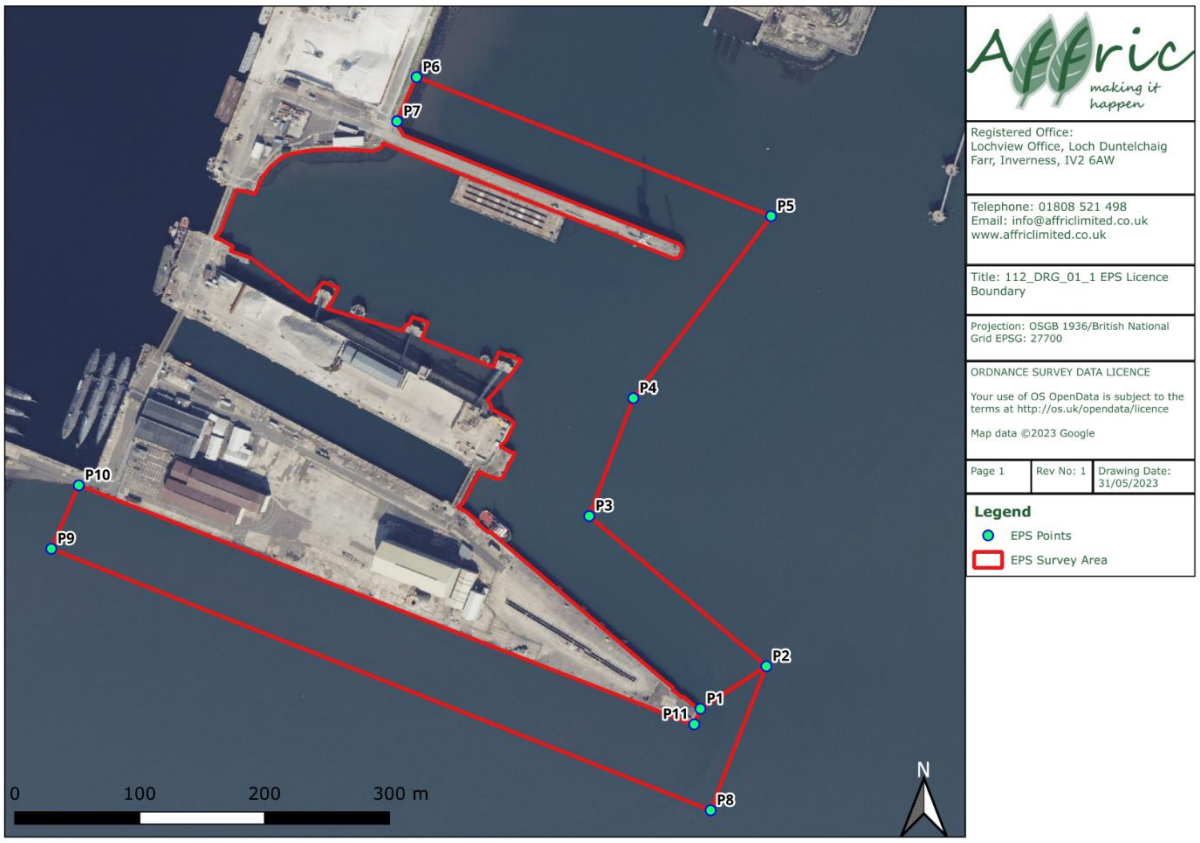

Figure 1.1: Survey Area.

Table 1.1: Survey Location Co-ordinates.

Point	Latitude	Longitude
P1	56 N 1.081470	3 W 26.561111
P2	56 N 1.100390	3 W 26.510800
P3	56 N 1.163461	3 W 26.649842
P4	56 N 1.214513	3 W 26.618056
P5	56 N 1.293893	3 W 26.515128
P6	56 N 1.350513	3 W 26.790636
P7	56 N 1.331482	3 W 26.804365
P8	56 N 1.037369	3 W 26.551766
P9	56 N 1.144044	3 W 27.063991

P10	56 N 1.171777	3 W 27.043854
P11	56 N 1.074408	3 W 26.565661

1.4 Schedule of Works

Survey operations are not anticipated to exceed two days in total and all survey works are proposed to be complete by December 2023. It is noted that the geophysical survey shall not be allowed to commence without the award of an EPS licence.

1.5 Physical Environment

The Firth of Forth is a large estuary situated on the east coast of Scotland. It is 93km long with a large drainage basin that contains several rivers including the River Forth. Environmental conditions to the west of the Forth road and rail crossings (where the Firth narrows to ~1.8km, known as the Forth Estuary) are influenced by freshwater from rivers, whereas conditions to the east more closely represent the marine conditions within the North Sea. Water depths are largely <17m to the east of Rosyth and reach 59m around the fixed link crossings. A deep-water channel around 45m depth runs northeast out of the Firth (termed the North Channel) and reaches the wider North Sea beyond the Isle of May. Water depths in the South Channel, south of Inchkeith Island, are shallower and reach maximum depths of 13m. The tides within the Firth are semi-diurnal, and current speeds around Rosyth can reach a maximum of 0.8m/s. Shallow areas within the Firth create periods of stable current speeds, most common around slack water and termed the 'lackie' tide (Elliott & Neill, 2007).

2 Description of Proposed Survey Operations

2.1 Geophysical Survey (Sub-Bottom Profiling)

A geophysical survey of the area will be undertaken to determine the depth of sediment overlaying and rockhead profile, otherwise known as sub-bottom profiling. The sub-bottom profiling will be conducted utilising seismic reflection techniques and an acoustic boomer sub-bottom system. The outputs will seek to determine the depths to all significant seismic reflectors, particularly those that can be correlated to changes in geological strata, but will not quantify any strata (i.e., till, gravel, sand, mud, etc.). This information is required to inform the capital dredge for the Babcock Rosyth site.

The survey system is typically mounted on a catamaran towed behind a survey vessel. The survey lines will be at 10m line spacing over the proposed area, with additional cross lines for QA purposes. The acoustic boomer system will consist of an insulated metal plate and rubber diaphragm adjacent to a flat wound electrical coil, mounted on the towed catamaran. A short duration, high power electrical pulse, generated by the shipboard power supply and capacitor banks will discharge to the electrical coil and the resultant magnetic field explosively repels the metal plate, generating an acoustic pressure pulse in the water column. The frequency of this pulse is in the range 8kHz to 22kHz, with most of the energy being directed vertically downward at a maximum output of 200 joules (J) per pulse. A percentage of the acoustic energy is reflected from the sea floor, dependent upon the composition of the seabed materials. The remaining energy penetrates the seabed and is reflected from layers of contrasting acoustic impedance. Acoustic impedance is the product of the density and seismic velocity of a material. The character of the sub-bottom records is therefore dependent upon the way in which the acoustic signal is reflected. This is used to interpret the conditions present.

The reflections are detected by a multi-element hydrophone which is towed parallel to the source catamaran, astern of the vessel. This configuration is used to minimise the direct source-receiver signal. The reflections detected by the hydrophone are converted to an electrical signal and passed to a geophysical data acquisition system. This allows the data to be amplified, filtered, presented graphically, and recorded.

The acoustic boomer to be used in the proposed geophysical surveys at Babcock Rosyth will be an Applied Acoustics AA201 system. The system will operate at 200J but can operate between 100 and 300J. It has a maximum Source Level (SL) of 215 dB re 1µPa @ 1m. The present risk assessment examines the potential effect of operating the system at the maximum SL as a worst-case scenario.

3 Cetacean and Basking Shark Baseline

3.1 Harbour Porpoise (*Phocoena phocoena*)

The harbour porpoise (*Phocoena phocoena*) is distributed throughout temperate and subarctic waters of the North Pacific and North Atlantic oceans and is the most abundant cetacean to occur in northwest European shelf waters (Evans et al., 2003). They are also the UK's smallest, and most abundant cetacean, with the highest densities occurring along the North Sea coast, around the Northern Isles and the Outer Hebrides (Reid et al., 2003). Harbour porpoise are found within Scottish waters throughout the year (Evans et al., 2003; Hebridean Whale & Dolphin Trust (HWDT), 2022), but there is limited information on seasonal movements (Reid et al., 2003).

Since the 1990s, porpoise range and occurrence in the North Sea has shifted from more northerly latitudes to southern areas, with significant densities now found within the Wadden Sea, German North Sea, and around the Danish archipelago (Hammond et al., 2013). It is thought that changing prey availability and distribution has driven such range shifts (Ransijn et al., 2019). However, population trends within southern regions of the North Sea may be in decline (Nachtsheim et al., 2021).

The harbour porpoise is frequently found in coastal areas of the Scottish North Sea. They are regularly found within the Moray Firth, the Firth of Tay and the Firth of Forth (Scottish Government (Marine Directorate), 2019). Recent evidence suggests that porpoises may be more frequently utilising estuarine habitats in which to feed and can sometimes enter river systems for short time periods (Wenger et al., 2016; Sveegaard, 2012). In southern North Sea waters, the species is thought to take advantage of upwelling and spatiotemporal variation of salinities within these environments to hunt anadromous fish such as sparling (*Osmerus eperlanus*.; Weel et al., 2018). In the North Sea, harbour porpoises are known to prey on a variety of fish species, including sandeels (*Ammodytidae* spp.), gadoids, clupeids, flatfish and gobies (Mahfouz et al., 2018).

Estimations of harbour porpoise abundance and density within the Firth of Forth have yet to be conducted. However, several larger scale studies indicate the prevalence of the species within the general region. Aerial surveys conducted during the SCANS-III study estimated an abundance of 38,646 individuals and a density of 0.59 animals/km for survey block R which

contains the Firth of Forth (Hammond et al., 2017). However, it is worth noting that survey lines within this large area did not include the coastal waters and inner reaches of the Firth of Forth.

The East Coast Marine Mammal Acoustic Study (ECOMMAS) is a long-term Passive Acoustic Monitoring (PAM) survey of cetacean occurrence on the Scottish east coast. Out of three PAM stations positioned off the coast of Crail (~70km from Rosyth), the most porpoise detection positive hours (DPH; number of porpoise echolocation detections within an hour) were found on the station ~7km offshore (12-16 DPH), compared to those at ~2km (0-4 DPH) and ~10km (8-12 DPH) between 2013 and 2016 (Scottish Government (Marine Directorate), 2019). There were no PAM stations positioned within the Firth of Forth proper during the study.

Community science databases show variable harbour porpoise presence near the Babcock Rosyth facility. The HWDT Whaletrack sightings map lists three porpoise observations within 5km of the site between 2022 and 2023 (HWDT, 2023). Sightings detailed on the Forth Marine Mammals community science website indicate six sightings near the Firth bridges and larger numbers of observations in the outer Firth off the Kingshorn peninsula and to the north of Inchkeith Island (Figure 3.1, Forth Marine Mammals, 2023). No animals have been recorded within 5km of the Babcock Rosyth site in the database thus far (Forth Marine Mammals, 2023). Historical sightings of porpoise within 5km of the Babcock Rosyth facility have been documented within the NBN Atlas database, where eight sightings were made from 1995-1998 and in 2005 (NBN Atlas, 2023).

Based on the sightings data available, harbour porpoise are expected to be the cetacean most likely to be encountered during the survey period (see Table 3.1).

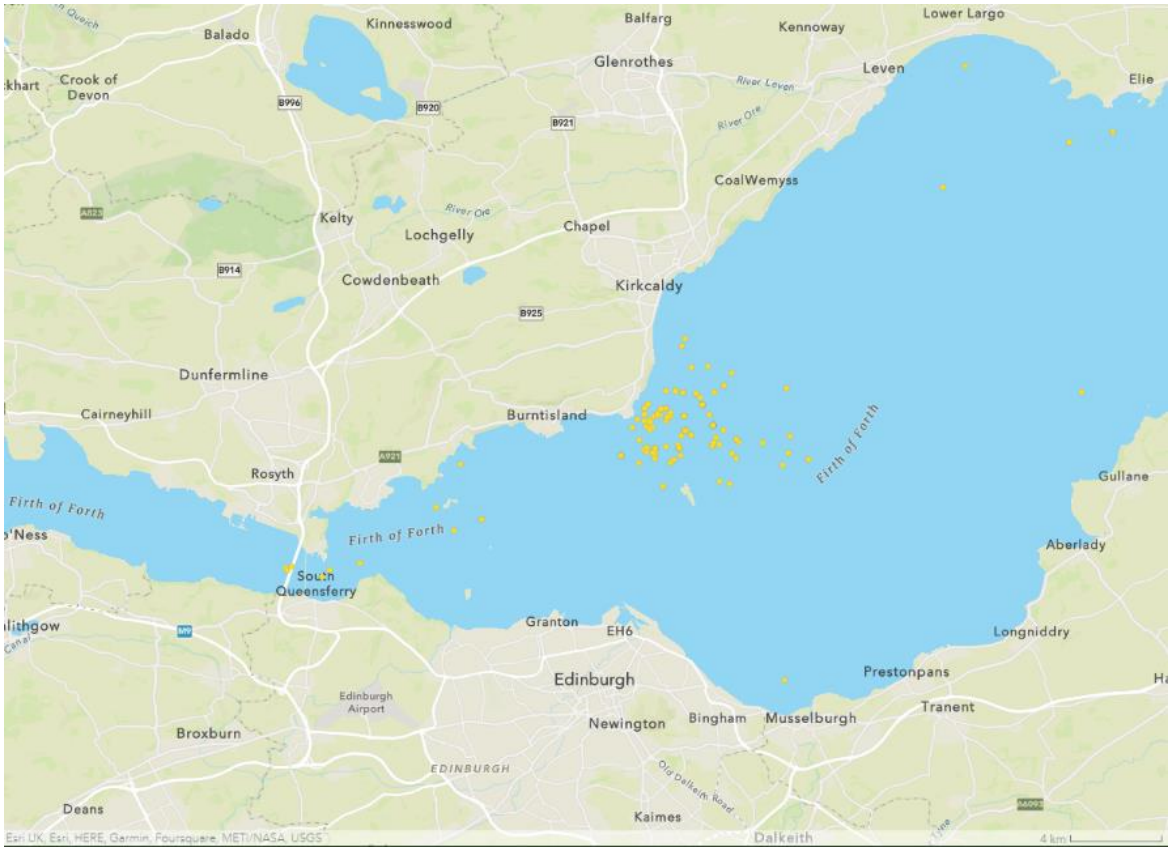

Figure 3.1: Harbour porpoise sightings documented on the community science Forth Marine Mammals sightings map from 2021-2023 (Forth Marine Mammals, 2023).

3.2 Bottlenose Dolphin (*Tursiops truncatus*)

Bottlenose dolphins (*Tursiops truncatus*) are present in UK waters all year round and can often be seen close to shore. Bottlenose dolphin populations within Europe and the UK are separated into two distinct ecotypes. 'Offshore' dolphins are wide-ranging, and typically found >4km away from the coast in deeper shelf edge waters (Cheney et al., 2013). 'Inshore' coastal groups of bottlenose dolphins are distributed around the UK and display greater site fidelity and residency. Three populations are identified within Scottish waters and in total number between 200-300 individuals (Cheney et al., 2013). Two populations are found on the west coast (the 'Inner Hebrides' and 'Sound of Barra' communities), while the better known 'east coast' community can be found largely within the Moray Firth in the northeast. Inshore bottlenose dolphins in the North Sea are known as the Coastal East Scotland Management Unit (MU; JNCC, 2023). This population has received extensive study since the 1990s, one of the longest running studies on a free-ranging mammal population in the world.

Bottlenose dolphins within the east coast community are semi-resident, with many individuals remaining within the Moray Firth. However, some individuals within the community use a larger portion of the coastline, ranging from the outer Moray Firth to Aberdeenshire and even beyond as far south as Northumberland (Cheney et al., 2013). Male dolphins appear to show the greatest propensity to range outside the Moray Firth, but dispersal patterns also differ among individuals and within sub-groups (Robinson et al., 2012; Quick et al., 2014). Bottlenose dolphin communities are typically described as fission-fusion, where groups frequently split and join together across temporal scales (Connor et al., 2000).

Bottlenose dolphins are opportunistic predators and have been found to forage on gadoids, cephalopods, sandeels (*Ammodytidae* spp.), and flatfish (Santos et al., 2001). On the east coast of Scotland, they may also be Atlantic salmon (*Salmo salar*) specialists and will congregate to hunt migrating fish at salmon rivers such as the Spey and Dee (Santos et al., 2001; Wilson et al., 1997).

Survey data from the SCANS-III surveys estimate bottlenose dolphin density within block R (containing the Firth of Forth) at 0.030 animals/km^2 (Hammond et al., 2017). However, the aerial surveys conducted for this research did not include the coastal regions within the inner or outer Firth of Forth.

Bottlenose dolphin encounter rates were estimated based on photo-identification survey data gathered by Quick et al. (2014) between 2009 and 2013. The outer portions of the Firth of Forth were estimated to have low encounter rates (0 number of encounters/number of effort lines), with higher encounter rates (0.1-0.3 number of encounters/number of effort lines) off the coastal areas of Earlsferry, Piteenweem, Anstruther and Crail (Quick et al., 2014). The overall population of dolphins using coastal areas between Aberdeen and the Firth of Forth were estimated to be 119 in 2013. All the observations used to estimate population abundance were made north of Earlsferry, ~40km northeast of the Babcock Rosyth facility (Quick et al., 2014).

Community science databases indicate a similar pattern of occurrence, with few sightings made within the Firth of Forth within 5km of the Babcock Rosyth facility. One sighting was documented in 2022 (NBN Atlas, 2023), while two sightings documented by the Forth Marine Mammals group in 2021 and 2022 were within 5km of the facility, but to the east of the Forth Road Bridges (Forth Marine Mammals, 2023). In each case, groups of 20-30 animals were

observed (Forth Marine Mammals, 2023). No records of the species were documented within 5km of Babcock Rosyth within the HWDT WhaleTrack sightings map (HWDT, 2023).

3.3 Minke Whale (*Balaenoptera acutorostrata*)

The minke whale (*Balaenoptera acutorostrata*) is the most common baleen species recorded in British shelf waters, and high densities are present off the west coast of Scotland, particularly in the Minch (Reid et al., 2003). Insufficient data on population size, however, has made it difficult to establish the conservation status of minke whales and as such, their conservation status is unknown (Marine Scotland Science, 2020). Research suggests that minke whales are most commonly observed in the North Sea between April and November, however, their presence is documented year-round (Risch et al., 2019). Movement of whales to more coastal regions appears to occur in the late summer months and are greatest within the Moray Firth at this time of year (Risch et al., 2019).

Minke whales appear to use both fine and large-scale oceanographic features such as fronts to forage (de Boer, 2010). Within the Outer Moray Firth to the north of the Firth of Forth, the Southern Trench Marine Protected Area (MPA) was designated for the presence of minke whales, where deep water and upwelling provides optimal foraging habitat for the species (NatureScot, 2019). While sightings of minke whales appear to coincide with the summer months in the wider Firth of Forth (Forth Marine Mammals, 2023), there have been no studies to identify foraging grounds influenced by oceanographic or bathymetric features in the area thus far.

Broadband acoustic recorders deployed across the Scottish east coast as part of the ECOMMAS project detected minke whale vocalisations in the Moray Firth and off the coast of Arbroath (Risch et al., 2019). There were no PAM stations within the Firth of Forth as part of the project, however, detections occurred in water depths >23m across all stations (Risch et al., 2019). Aerial surveys conducted as part of the SCANS-III project estimated a density of 0.039 minke whales/km^2, however survey did not include the Firth of Forth (Hammond et al., 2017).

A search of community science databases (NBN Atlas, Forth Marine Mammals and HWDT WhaleTrack map) did not reveal any recent (last 20 years) sightings of minke whales within 5km of the Babcock Rosyth site. The available data suggests that minke whales are unlikely to occur within the inner Firth of Forth, particularly as water depths in close proximity to the site are <20m.

3.4 Humpback Whale (*Megaptera novaeangliae*)

Humpback whales are a large baleen whale, inhabiting both shallow and deep waters and capable of diving to depths of over 600m (Derville et al., 2020). They are a migratory species, migrating from feeding grounds in the Northeast Atlantic and Barents Sea to breeding grounds in the Caribbean and the Cape Verde and Azores islands. Recent data collected largely by the Forth Marine Mammal Project (FMMP) has shown humpback whales frequenting the Firth of Forth over the winter months. Sightings have been of solitary whales and the maximum number of individuals seen at any one time was three in 2018. Sightings in the Forth were predominantly in the deepwater channel passing Inchkeith Island towards Inchmickery and in deeper water to the east during periods of low tide. From photography and analysis of flukes, dorsal fins, and ventral images, four individuals have been identified with one being matched

to an image taken in Norwegian waters. It has been suggested that the Firth of Forth may represent a feeding or resting opportunity during their southbound migration. Alternatively, it has been suggested that these could be juvenile animals requiring more breaks than adults, or individuals not making full migrations (O'Neil et al., 2019).

The sudden seasonal occurrence of humpback whales in the Firth of Forth follows a slow increase in sightings over the past two decades and could be driven by wider population recovery (O'Neill et al., 2019). Humpback whale numbers in the Atlantic have been increasing alongside several key prey fish species such as herring (*Clupea harengus*; Leopold et al., 2018).

Although humpback whales have been regularly sighted within the Firth of Forth, a search of the NBN, Forth Marine Mammals and HWDT sightings maps did not reveal any sightings within 5km of the Babcock Rosyth base. From the literature and accessible databases, it can be anticipated that humpback whales are unlikely to be within the area of proposed surveys or in the immediate vicinity. Humpback whales will therefore not be considered further in the assessment.

3.5 Basking Shark (*Cetorhinus maximus*)

Basking sharks (*Cetorhinus maximus*) are the second largest cartilaginous fish globally and the largest found in UK waters. They can grow up to 10m in length and are filter feeders, foraging solely on plankton. Basking sharks have been recorded around the whole of the Scottish coast, with a peak in sightings over the summer months (Marine Scotland, 2019). The species are included in Scotland's list of Priority Marine Features and are a protected species in Scotland under Schedule 5 of the Wildlife and Countryside Act 1981 (as amended). They are listed on the OSPAR (The Convention for the Protection of the Marine Environment of the North-Atlantic) list of Threatened and Declining Species and are classed globally as Endangered by the International Union for the Conservation of Nature (IUCN).

No agreed population assessments for basking sharks are available for Scotland, the North-East Atlantic, or globally, and there is little information on overall population trends. Basking sharks are known to migrate over large distances in both offshore and coastal waters to depths of over 750m. They are particularly associated with tidal fronts on the continental shelf and shelf edges where they feed in areas of high productivity (Sims, 2003). More recent research into the migration of basking sharks revealed a variety of movements with some sharks spending the colder months off the Scottish continental slope, some migrating south to the Bay of Biscay and others migrating to the Azores islands before returning the following summer (Doherty et al., 2017). Basking sharks have also been recorded migrating north to colder waters with individuals travelling to the Faroe Isles (Doherty et al., 2017) and Norway (Dolton et al., 2020).

Statistical modelling of basking sharks in Scottish Territorial Waters was carried out to identify areas of importance for the species. Various environmental data were used and analysed to allow for seasonal and annual predictions about densities of animals in different locations around the country. The datasets recorded basking shark primarily in the Sea of the Hebrides and to the north of Aberdeenshire (Paxton et al., 2014).

A review of the National Biodiversity Network (NBN) Atlas revealed one record from 2003 of a basking shark within 5 km of Babcock Rosyth. The record shows a basking shark to the east of the Forth Road Bridge off the coast of South Queensferry. A review of Marine Directorate's

National Marine Plan Interactive (NMPi) showed one record from 2010. This record was in a similar location to the one identified from the NBN. Further reviews of a community science databases (Forth Marine Mammals and HWDT) did not reveal any further records of basking sharks within the vicinity of the proposed survey area.

From the literature and accessible databases, it can be anticipated that basking shark are unlikely to be within the area of proposed surveys or in the immediate vicinity. Basking shark will therefore not be considered further in the assessment and a licence is deemed not required.

3.6 Cetacean Baseline Summary

A summary of the cetacean species that are most likely to be present within 5km of the Babcock Rosyth facility in the Firth of Forth during the survey is provided in Table 3.1. Table 3.1 outlines the likelihood of occurrence for each species, density estimates retrieved from the SCANS-III survey, and the estimated group sizes based on the information retrieved from community science sightings data.

Table 3.1: Cetacean Baseline Summary. *Hammond et al., 2017. **Forth Marine Mammals, 2023; HWDT WhaleTrack, 2023.

Species	Likelihood of Occurrence	Density Estimate per km²*	Estimated Average Group Size**
Harbour Porpoise	Likely	0.59	1.1
Bottlenose Dolphin	Occasionally	0.030	21.3
Minke Whale	Occasionally	0.039	1

4 Risk Assessment

In order to assess the impacts on marine mammals due to underwater noise arising from the proposed survey operations, it is necessary to address the following aspects:

- The hearing sensitivities of the species most likely to be present within or close to the works area (as described in Section 4.1);
- The frequency of the sounds that will be produced from the relevant proposed survey operations (as described in Section 4.1.1);
- The risk of acoustic injury to marine mammals (as described in Section 4.2); and
- The risk of disturbance to marine mammals (as described in Section 4.3).

With specific regard to the risks of acoustic injury (Section 4.2) or disturbance (Section 4.3), only those species which were considered as 'Likely' to be present, or 'Occasionally' present are assessed in the present report. Section 4.3 specifically discusses the likelihood of underwater noise to impair an individual's (i.e., marine mammal) ability to survive, breed, reproduce, or raise young, or the likelihood that an individual may be displaced from an area for a longer period than would occur during normal behaviour.

4.1 Hearing Thresholds of Receptors and Auditory Injury Criteria

This section identifies the hearing thresholds of the marine mammals likely to be present. The latest marine mammal auditory injury criteria provided by Southall et al. (2019) groups marine mammals into functional hearing groups and applies filters to the unweighted noise to approximate the hearing response of the receptor.

4.1.1 Receptor Hearing Thresholds

The hearing groups given by Southall et al. (2019) for marine mammals are summarised in Table 4.1. Table 4.1 also lists the species within each group most likely to be encountered within the vicinity of the works.

Table 4.1: Marine Mammal Hearing Groups (Southall et al., 2019).

Hearing Group	Relevant Receptors	Generalised Hearing Range
Low Frequency (LF) Cetacean	Minke Whale	7Hz to 35kHz
High Frequency (HF) Cetaceans	Bottlenose Dolphin	150Hz to 163kHz
Very High Frequency (VHF) Cetaceans	Harbour Porpoise	160Hz to 275kHz

4.1.2 Auditory Injury Criteria for Receptors

Southall et al. (2019) presents acoustic injury onset-thresholds for both unweighted sound pressure level peak criteria (SPL_{peak}) and cumulative (i.e., more than a single sound impulse) weighted sound exposure level criteria (SEL_{cum}). As each species does not perceive frequencies equally, the weighted threshold values account for the frequency specific hearing of the group in question (Tougaard & Dähne, 2017). The hearing groups are presented as received level thresholds at which onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) may occur. PTS is defined as unrecoverable hearing damage, and TTS a temporary reduction in hearing sensitivity for the relevant marine mammal species.

Table 4.2 presents the Southall et al. (2019) criteria for the onset of PTS and TTS risk for each of the key marine mammal hearing groups when considering impulsive noise sources.

Table 4.2: Impulsive criteria for PTS and TTS in marine mammals (Southall et al., 2019).

Functional Hearing Group	Impulsive			
	Unweighted SPL_{peak} (dB re 1 µPa)		Weighted SEL (dB re 1 μPa^2s)	
	PTS	TTS	PTS	TTS
LF Cetaceans	219	213	183	168
HF Cetaceans	230	224	185	170
VHF Cetaceans	202	196	155	140

4.2 Risk of Acoustic Injury

As the geophysical survey will be completed by means of seismic reflection techniques, the risks of acoustic injury to marine mammals from SBP have been assessed based on existing literature surrounding the effects of seismic surveys on marine mammals.

Section 2 of this report has detailed the equipment to be utilised in the geophysical surveys, identified the significant noise sources, and provided the frequency bands and sound pressure levels in which they operate. The SBP equipment proposed for the geophysical surveys at Babcock Rosyth utilises noise sources within the hearing range of LF, HF and VHF cetaceans. The risks of acoustic injury to marine mammals that may be within the vicinity of the Babcock Rosyth facility in the Firth of Forth are summarised in Table 4.4 in Section 4.4: Summary of Risks.

4.2.1 Geophysical Survey (Sub-Bottom Profiling)

The proposed SBP surveys will produce intermittent sound pulses, at more intense noise levels than that emitted from other marine anthropogenic activities in the area, such as vessel engine noise. A comparison of the likely source levels from SBP with the impulsive unweighted SPL_{peak} levels determined by Southall et al. (2019; Table 4.2), identified that PTS and TTS levels for some of the cetacean receptor species identified within this report could be exceeded.

For the minke whale, as a LF cetacean, the threshold for TTS could be exceeded by 2 dB from SBP surveys operating at a worse-case SPL of 215dB re1µPa @ 1m. PTS levels were not exceeded. However, as the depth of the survey area is mostly <20m, and shallower than 5 m in places, the presence of this species is unlikely. Furthermore, in shallow water signals attenuate rapidly, and will not travel far from the survey area, decreasing the likelihood of TTS thresholds being exceeded for this species. However, as there is a low potential risk of TTS, it is recommended mitigation efforts include the potential for minke whale presence.

For the bottlenose dolphin, as a HF cetacean, neither TTS nor PTS would be incurred from exposure to SPB signals during the proposed surveys. The bottlenose dolphin has received the most extensive study in terms of noise exposure response. Hearing level shifts in bottlenose dolphins have not been observed in animals exposed to seismic airguns at source levels from 196 to 210dB re 1µPa SPL_{peak} and unweighted 193 to 195dB re 1µPa^2s SEL_{cum} (Finneran et al., 2015). The SBP SL in this context may be slightly higher (~215dB re 1µPa maximum SPL), yet using unweighted SPL_{peak} thresholds, no hearing threshold shift would occur during the SBP surveys. The Babcock Rosyth facility is a busy urbanised environment that would be unlikely to have extensive presence of bottlenose dolphins, as shown by the available data in Section 3.2. It is also unlikely any animals would remain in close proximity to the survey equipment once surveys were initiated.

The threshold shift estimations proposed by Southall et al. (2019) indicate that both TTS and PTS could be induced for harbour porpoises (VHF cetacean) through exposure to SBP surveys conducted at 215 dB re 1µPa @ 1m. In shallow waters (~4m), one study indicated that TTS could be induced in a porpoise at 350m by exposing it to an airgun pulse with a weighted SEL of 164 dB re µPa^2s (Lucke et al., 2009). In a reassessment of the same study, Lucke et al. (2020) found that the VHF-weighted TTS onset was reduced to 138 dB re 1µPa^2s. It is important to note however, that in each study and in the figures estimated for this risk assessment, estimates were based under a conservative assumption that the porpoise would remain stationary. As highlighted by Hermannsen et al. (2015), porpoises perceiving such noise sources would likely move away and therefore leave the range of PTS. Considering this aspect, as well as the threshold shift distances identified in other studies, the risk of TTS/PTS may still be likely within 350m (Hermannsen et al., 2015; Lucke et al., 2009; Pace et al., 2021) and harbour porpoises should be considered within the mitigation protocols.

4.3 Risk of Acoustic Disturbance

Disturbance effects, as defined under the European Habitats Directive, will occur if animals incur sustained or chronic disruptions to behaviour that are likely to impair an individual's ability to survive, breed, reproduce, or raise young. In addition, disturbance effects include those that are likely to result in an individual being displaced (i.e., startle effects) from an area for a longer period than would occur during normal behaviour (Scottish Government, 2020). The risks of acoustic disturbance to marine mammals that may be within the vicinity of the

Babcock Rosyth facility in the Firth of Forth are summarised in Table 4.4 in Section 4.4: Summary of Risks.

4.3.1 Geophysical Surveys (Sub-Bottom Profiling)

For LF cetaceans, there are limited studies that have investigated the potential impact of SBP on behaviour and distribution. Low frequency (~100Hz) seismic activity was found to reduce the prevalence of singing humpback whales when the received level (RL) was between 111 and 156.7dB re 1µPa (Cerchio et al., 2014). Sonar signals with similar characteristics to those expected in the proposed SBP surveys (3kHz) were found to initiate avoidance behaviours in humpback whales in Hawaiian waters (Maybaum, 1993). It is possible that the proposed SBP surveys could elicit disturbance for minke whales, however, there is a low likelihood of the species presence in the vicinity of the surveys due to the water depth and lack of previous sightings in the area.

When considering the risks of disturbance to HF and VHF marine mammals from seismic surveys, short-term responses have not typically resulted in broad-scale displacement (Thompson et al., 2014). Despite this, observed reductions of echolocation activity could be indicative of changes to foraging or social behaviour (van Beest et al., 2018). Acoustic data indicated that harbour porpoise remaining in seismic survey impact areas reduced their echolocation activity by 15% during the seismic survey (Pirotta et al., 2013). In addition, the probability of detecting vocalisations when porpoises were present increased with distance from the source vessel, suggesting that probability of vocalising was dependent upon received noise intensity (Pirotta et al., 2013). Small cetaceans (including harbour porpoise) have a tendency to swim away at speed (Stone, 2003) from seismic airguns, or tend to avoid seismic survey vessels when airguns are firing at a distance of up to ~1km (Moulton & Miller, 2005; Moulton & Holst, 2010; Pirotta et al., 2013). However, these estimations were based on surveys conducted in deeper waters than those within the proposed survey area. In reality, as sub-bottom profiler sounds are more directed towards the seafloor, they will attenuate much more rapidly thereby reducing the ensonified zone (Southall et al., 2007). As such, disturbance ranges are likely to be much less than 1km.

Short-term and irregular disturbance events are unlikely significantly affect the energetic status of a porpoise (Hoekendijk et al., 2018), particularly when surveys are conducted in shallow waters where sound cannot propagate as far. In addition, the present surveys are expected to occur over a maximum of two days, and not frequently repeated. As such, the risks of chronic disturbance which impact upon an individual's ability to survive, breed, reproduce or raise young, are limited.

Overall, due to the low potential for marine mammals to persist close to the Babcock Rosyth facility as identified in Section 3: Cetacean Baseline, in addition to the likelihood for both short disturbance ranges and timescales of the works, the chances of SBP surveys causing effects at a level to impact upon an individual's ability to survive, breed, reproduce or raise young are highly unlikely for all identified marine mammal receptors.

4.4 Summary of Risks

Table 4.4 provides a summary of the risks of acoustic injury and disturbance from geophysical surveys to marine mammals likely to be present near the Babcock Rosyth facility.

Where the assumed range for risks of acoustic injury and disturbance have been assumed, the density of individuals likely to be affected can be assumed. This is calculated by using the following equation:

$$\boldsymbol{D} \times \boldsymbol{A} = \boldsymbol{N}$$

Whereby *D* is the density of animals per km^2; *A* is the affected area (i.e., hearing threshold or disturbance range in km); and *N* is the number of animals affected in the specified area, *A*. This value has been shown in Table 4.4 for each receptor species likely to be present in the Firth of Forth during the surveys.

It is important to note, however, that density estimates do not provide accurate representations on the actual number of individuals likely to be affected if animals enter the range of risk, and as such, group size estimates should be taken note of as in Section 3.6: Cetacean Baseline Summary.

Table 4.4: Summary of the risks of acoustic injury and disturbance to marine mammals from the proposed SBP surveys.

Species	Density (animals/km^2)	PTS Range (m)/ Number Affected	TTS Range (m) / Number Affected (*N*)	Disturbance Range (km) / Number Affected (*N*)
Minke Whale (LF)	0.039	No threshold shift	2 m/ 0	0.5 km*/ 0.03
Bottlenose Dolphin (HF)	0.03	No threshold shift	No threshold shift	1 km**/ 0.09
Harbour Porpoise (VHF)	0.599	Within 350m*/ 0.21	Within 350 m* / 0.23	<1 km** / 1.8

*Stone, 2003. **Pirotta et al., 2013. ***Lucke et al., 2009.

5 Consideration of Alternative Techniques

5.1 Do Nothing

Babcock Rosyth is one of the largest waterside manufacturing and repair facilities in the UK. Doing nothing will not allow the site to increase their capacity and will prevent larger vessels from entering due to draught restrictions. By doing nothing and not carrying out capital dredging, the base will be inaccessible to larger vessels requiring maintenance. Many of such vessels are within the UK Royal Navy fleet and other services, including land and aviation defence, civil nuclear and critical response sectors.

5.2 Survey Methodologies

An alternative to geophysical surveys would be to carry out detailed ground investigation by taking numerous core samples from the seabed within the survey boundary, however this would result in extended survey durations and likely more repeated disruptions to marine mammals through vessel movements. In addition to this, geophysical surveys will not cause any physical disturbance to the seabed.

An alternative survey location was considered however due to a dredge being required to inform development design; site specific data is necessary. The area to be dredged lies within

an existing port and dredging further out from shore may increase the likelihood of impacts on cetaceans.

6 Marine Mammal Mitigation Plan

The mitigation measures outlined are based on the Joint Nature Conservation Committee's (JNCC) Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from geophysical surveys (JNCC, 2017).

6.1 Mitigation Strategy

In order to minimise potential impacts to marine mammals, the survey vessels will adhere to the provisions of The Scottish Marine Wildlife Watching Code (SMWWC).

In addition, Marine Mammal Observation (MMO) will be utilised. It should be noted that the standard Joint Nature Conservation Committee (JNCC) geophysical survey protocol is designed for offshore waters which have typically deeper waters (JNCC, 2017) and therefore the mitigation has been adapted as appropriate for geophysical surveys within the Firth of Forth.

The JNCC protocol currently provides a disproportionate level of mitigation for the proposed geophysical survey works, which is not justified by the perceived risk to marine mammals (see Section(s) 4.2 – 4.4). As such, the JNCC protocols have been modified in order to ensure the geophysical survey marine mammal mitigation is proportionate to the perceived risk to marine mammals, and not unduly restrictive. A summary of the changes made to the JNCC protocols, together with the supporting rationale is provided in Table 6.1.

Table 6.1: Summary of Modifications to the JNCC Geophysical Marine Mammal Protocols

Aspect	Change	Rationale
Pre-Watch Duration	The duration of the pre watch (both visual and acoustic) is reduced from 30min to 20min.	The 30-minute pre watch is designed to maximise detection probability within the mitigation zone. It allows for deeper diving marine mammals to be detected which may be present but submerged for long periods of time. However, given that water depths within the 500m mitigation zone do not exceed 8m and the deepest parts of the shipping channel do not exceed 20m, deep diving species and prolonged deep dives are unlikely. The species most likely to be encountered are not considered deep diving species and would not be anticipated to stay submerged for longer than 20 minutes in such shallow waters.
Delays After Detection in Mitigation Zone	The delay following a detection within the mitigation zone during the pre-watch is reduced from 20min to 10min.	For the reasons stated above, a period of 10min following the last detection within the mitigation zone provides sufficient confidence that the mitigation zone is clear of marine mammals, allowing surveys to commence.

7 Mitigation Plan

7.1.1 Visual Monitoring Protocols

Marine mammal observations during daylight, good visibility, and sea states less than 4, will be conducted visually by an MMO based on the acoustic survey vessel. The MMO's vantage point will be located at a high position on the vessel and afford the MMO clear all-round visibility of the mitigation zone. The vantage point will also be in a safe location; away from machinery, ropes, high power transmitters etc., and provide some protection from the prevailing conditions. The MMO will be equipped with 7x50 magnification binoculars.

The MMO protocol is outlined below:

1. The Survey Party Chief will inform the MMO of the intention to commence acoustic survey operations, at least 30min prior to arrival at the Start of Line (SoL) position.
2. The MMO will commence a continuous watch using binoculars, at least 20 min before the intended arrival at the SoL.
3. If marine mammals are observed the MMO will advise the Survey Party Chief, so that measures can be taken to minimise the impacts of any potential delays on the survey operations.
4. When the vessel is arriving at the SoL and 20 min pre-watch is complete the Survey Party Chief will ask the MMO whether acoustic survey operations can commence.
    - If the 500m mitigation zone around the survey vessel has been clear of marine mammals for at least 10min, the MMO will give permission to commence acoustic survey operations.
    - If marine mammals have been observed inside the mitigation zone within 10 min, the MMO will delay acoustic survey operations until at least 10min after the last sighting within the mitigation zone.
5. Once the acoustic survey operations have commenced there will be no requirement to stop if a marine mammal enters the mitigation zone, so long as the operation does not stop for a period exceeding 10min.
6. In the event that a break in survey operations exceeding 10min is required, the Survey Party Chief will inform the MMO who will conduct a continuous watch for the duration of the break in operations.
    - If the break is less than 20min in duration, and the mitigation zone remains clear of marine mammals, the operations can resume immediately.
    - If the break exceeds 20min, or marine mammals are sighted within the mitigation zone, as full start-up procedure will be required (Steps 1-4 above).
7. When a turn between survey lines is required, the following provisions will be made:
    - If the turn duration will not exceed 20min; the acoustic equipment shall continue to operate. As such the survey operation will be continuous and no additional watches are required.

- If the turn duration will exceed 20min (highly unlikely in this instance); the acoustic equipment should be turned off and the procedure for a break in operations exceeding 10min should be followed (Step 6 above).

8. If the visibility falls to below 500m around the survey vessel, or the sea state increases to greater than 3, then surveys will be postponed until conditions improve.

8 Conclusions

This report has demonstrated that the proposed geophysical survey within the Firth of Forth, through the adoption of effective and proportionate mitigation measures, poses no risk of acoustic injury to marine mammals. Due to the highly directional nature of the survey methodology, the characteristics of the physical environment surrounding the Babcock Rosyth facility, and limited extent and duration of the surveys, it is very unlikely that disturbance will be significant to individual animals or at a population level. An EPS licence is required to be sought however, as marine mammals may experience some short-term, instantaneous disturbance out with the mitigation zone. An EPS licence is being sought for disturbance to harbour porpoise, bottlenose dolphin and minke whale.

Alternative techniques have been considered for Sub-bottom Profiling which comprises the geophysical survey, however, none exist which do not add extended timescales to the duration of the current methodologies. Extended timeframes to the surveys are not justified by the risks to marine mammals.

This document supports the application for an EPS Licence to Disturb Cetaceans for geophysical surveys.

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10 Glossary

Acronym	Definition
dB	Decibels
DPH	Detection Positive Hours
ECOMMAS	East Coast Marine Mammal Acoustic Study
EPS	European Protected Species
FMMP	Forth Marine Mammal Project
HF	High Frequency
HWDT	Hebridean Whale and Dolphin Trust
Hz	Hertz
IUCN	International Union for Conservation
J	Joules

Acronym	Definition
JNCC	Joint Nature Conservation Committee
kHz	Kilohertz
km	Kilometres
LF	Low Frequency
m	Metres
Min	Minutes
m/s	Metres per second
MMO	Marine Mammal Observer
MPA	Marine Protected Area
MU	Management Unit
NBN	National Biodiversity Network
NMPi	National Marine Plan Interactive
OSPAR	The Convention for the Protection of the Marine Environment in the North-East Atlantic
PAM	Passive Acoustic Monitoring
PTS	Permanent Threshold Shift
RL	Received Level
SBP	Sub-Bottom Profiling
SEL_{cum}	Cumulative Sound Exposure Level
SMWWC	Scottish Marine Wildlife Watching Code
SPL_{peak}	Sound Pressure Level (peak)
Spp.	Species
SoL	Start of Line
TTS	Temporary Threshold Shift
UK	United Kingdom
µPa	Micropascal
VHF	Very High Frequency