PENGUINS

PRA/282

ENVIRONMENTAL ASSESSMENT JUSTIFICATION

Asset	Penguins Field Floating Production Storage and Offloading (FPSO)
Originating company	Shell U.K. Limited
Document type	Environmental Assessment Justification
Security Classification	Confidential

Date	Prepared by	Reviewed by	Approved by
24-02-2020	[redacted]	[redacted]	
09-03-2020	[redacted]	[redacted]	[redacted]
20-04-2020	[redacted]	[redacted]	[redacted]
21-07-2021	[redacted]	[redacted]	[redacted]
28-04-2023	[redacted]	[redacted]	
24-05-2023	[redacted]	Shell	Shell
31-01-2024	[redacted]	[redacted]	See Final Sign Off
10-05-2024	Genesis	[redacted]	[redacted]
15-05-2024	Genesis	[redacted]	[redacted]

Portal tracking		
Date	**Permit Reference**	**Details**
11-03-2020	PRA/282	Initial Submission for Consent to Locate (CL/1903/0)
20-04-2020	PRA/282 CL/1093/1	Addition of Waverider Buoy
21-07-2021	CL/1093/3	Update to change the date and location of the buoy installation and minor update to cover 2020 EIA regulations
28-04-2023 (B2)	CL/1093/4	Update to support CtL SAT application (for installation of mooring rope, buoyancy and top chain).
24-05-2023 (B3)	PRA/282 CL/1093/4	Update to address regulator comments.
01/03/2024 (B4)	PRA/282	Inclusion of updated schedule and installation options
07/03/2024 (B5)	PRA/282	Inclusion of updated schedule and production data. Addition of information to support a Screening Direction
14/04/24	PRA/282	Update to Cumulative and Transboundary Impacts
29/04/24 (B7)	PRA/282	Update to address regulator comments
10/05/24 (B8)	PRA/282	Update to address further OPRED comments
15/05/24 (B9)	PRA/282	Update to address further OPRED comments

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Rev Genesis/Shell	**Date**	**Details**	**Issuer**	**Checker**	**Approver**
B1	22/12/22	Issued for Shell review (update to capture CtL changes, and add in previously prepared, but not submitted, production information)	[redacted]	[redacted]	[redacted]
B2	28/04/23	Update to Address Shell Comments on CtL and remove previously prepared, but not submitted, production information.	[redacted]	[redacted]	[redacted]
B3	24/05/23	Update to address regulator comments.	[redacted]	[redacted]	[redacted]
01/03/2024 (B4)	PRA/282	Inclusion of updated schedule and installation options	[redacted]	[redacted]	[redacted]
B5	07/03/24	Update to include production data with latest forecasts and addition of information to support a Screening Direction – Draft	[redacted]	[redacted]	[redacted]
B6	14/04/24	Cumulative and Transboundary Impacts	[redacted]	[redacted]	[redacted]
B7	29/04/24	Update to address regulator comments	[redacted]	[redacted]	[redacted]
B8	10/05/24	Update to address regulator comments	[redacted]	[redacted]	[redacted]
B9	15/05/24	Update to address regulator comments	[redacted]	[redacted]	[redacted]

CAUTIONARY STATEMENTS

a) Shell Companies - The companies in which Shell plc directly and indirectly owns investments are separate legal entities. In this document "Shell", "Shell Group" and "Group" are sometimes used for convenience where references are made to Shell plc and its subsidiaries in general.

b) Disclosure - We respectfully request you to promptly inform and consult with us in the event that this document is the subject of, or forms part of, a request under the Freedom of information Act 2000 and/or the Environmental Information Regulations 2004.

Contents

Acronyms and Abbreviations

Acronym/ Abbreviation	Description
AHV	Anchor Handling Vessel
BAT	Best Available Technology
BAC	Background Concentration
BEIS	Department for Business, Energy and Industrial Strategy (now known as DESNZ)
CCC	Committee on Climate Change
CH_4	Methane
CHARM	Chemical Hazard and Risk Management
CNS	Central North Sea
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CoP	Cessation of Production
CP	Chemical Permit
CSV	Construction Support Vessel
DECC	Department of Energy and Climate Change
DESNZ	Department for Energy Security and Net Zero (formerly BEIS)
DP	Dynamic Positioning
EAJ	Environmental Assessment Justification
EDG	Emergency Diesel Generator
EEMS	Environmental and Emissions Monitoring System
EIA	Environmental Impact Assessment
ELD	European Liability Directive
EPS	European Protected Species
ERL	Effects Range Low
ES	Environmental Statement
ESAS	European Seabirds at Sea
EUNIS	European Nature Information System
FLAGS	Far North Liquids and Associated Gas System
FPSO	Floating Production, Storage and Offloading Unit
GHG	Greenhouse Gas
GTG	Gas Turbine Generators
GWP	Global Warming Potential
HP	High Pressure
IAMMWG	Inter-Agency Marine Mammal Working Group
ICES	International Council for the Exploration of the Sea
IGG	Inert Gas Generator

Acronym/ Abbreviation	Description
IPCC	Intergovernmental Panel on Climate Change
ITOPF	International Tanker Owners Pollution Federation
JNCC	Joint Nature Conservation Committee
km	kilometre
m	metre
m^3	cubic metre
MAT	Master Application Template
MCZ	Marine Conservation Zone
MEI	Major Environmental Incident
MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
MU	Management Unit
LAT	Lowest Astronomical Tide
N_2O	Nitrous Oxides
NCMPA	Nature Conservation Marine Protected Area
NNS	Northern North Sea
NMFS	National Marine Fisheries Service
NMP	National Marine Plan
NMPi	National Marine Plan interactive
NO_x	Nitrogen Oxides
NSTA	North Sea Transition Authority (formerly OGA)
OEUK	Offshore Energies UK (formerly OGUK)
OGA	Oil and Gas Authority (now the NSTA)
OGUK	Oil and Gas UK (now OEUK)
OPEP	Oil Pollution Emergency Plan
OSD	Offshore Safety Directive
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
OVID	Offshore Vessel Inspection Database
PNEC	Predicted No Effects Concentration
PMF	Priority Marine Feature
PVA	Particularly Valuable Area
ROV	Remotely Operated Vehicle
RQ	Risk Quotient
SAC	Special Area of Conservation
SAT	Subsidiary Application Template

Acronym/ Abbreviation	Description
SCANS	Small Cetacean Abundance in the North Sea and Adjacent waters
SCI	Sites of Community Importance
Shell	Shell U.K. Limited
SMRU	Sea Mammal Research Unit
SNH	Scottish National Heritage (now NatureScot)
SO_2	Sulphur Dioxide
SO_x	Sulphur Oxides
SOSI	Seabird Oil Sensitivity Index
SPA	Special Protection Area

Acronym/ Abbreviation	Description
te	Tonnes
THC	Total Hydrocarbon Content
TOC	Total Organic Carbon
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
UKOOA	United Kingdom Offshore Operators Association
VMS	Vessel Monitoring System
VOC	Volatile Organic Compounds
WFD	Water Framework Directive
WHRU	Waste Heat Recovery Unit

SUMMARY INFORMATION

<table>
<tr><th>Project Name</th><th colspan="5">Penguins Production Operations</th></tr>
<tr><td>MAT Reference</td><td colspan="5">PRA/282</td></tr>
<tr><td>Short Description</td><td colspan="5">
The Penguins Field is located in the United Kingdom Continental Shelf (UKCS) Blocks 211/13 (Penguins West) and 211/14 (Penguins East), in the northern North Sea (NNS). The field is located approximately 150 km from the Scottish coastline (Northern Shetland) and runs adjacent to the UK/Norway median line. It is a cluster (Penguins A, C, D and E) of oil and gas condensate accumulations discovered in 1974. However, due to Cessation of Production (CoP) at Brent Charlie in 2021, Shell is redeveloping the Penguins Field to extend field life and production beyond the year 2035 at significantly reduced emissions intensity compared to the previous host, Brent Charlie.
The existing and new developments will be produced via additional subsea infrastructure to a new Floating, Production, Storage and Offloading (FPSO).
A previous version of this EAJ was submitted in support of the approved consents to Locate for waverider buoy deployment, FPSO mooring chains and piles.
This EAJ has been updated:

To support the Consent to Locate for the installation of the FPSO mooring ropes, buoyancy and top chain – this submission includes two options for installation, the EAJ will be updated with the option that was used during installation.
To add additional Subsidiary Application Templates (SAT) for Chemical Permit, OPPC and PPC as part of the production phase.
To seek a screening direction in support of changes to the production forecast reflecting move in start up from 2022 to 2024, and optimization of the well delivery programme.

</td></tr>
<tr><td></td><td>Duration</td><td>Requested Permit Period</td><td colspan="3">Associated Activity</td></tr>
<tr><td rowspan="3">Key Dates</td><td>22 days</td><td>April 2023 –April 2024</td><td colspan="3">
Installation of the mooring rope, buoyancy and top chain (Options A and B described in Sections 2.3 and 2.4).
Maersk Achiever (or similar vessel).
Note that transit time for interim mobilisations are not included in duration (expected to be circa 11 days)
</td></tr>
<tr><td>26 ~~16~~ days</td><td>April 2024 – September 2024</td><td colspan="3">
FPSO tow and hook-up (Options A and B described in Sections 2.5 and 2.6):

FPSO tow: 3 vessels comprising Maersk M & L Class vessels (which are interchangeable); and
FPSO hook-up: Maersk Achiever (or similar Maersk A-Class vessel).

</td></tr>
<tr><td>Life</td><td>From April 2024 (earliest)</td><td colspan="3">Production operations related to the FPSO (Section 2.7)</td></tr>
<tr><td rowspan="3">Location</td><td rowspan="2">Field</td><td rowspan="2">Block(s)</td><td colspan="3">Co-ordinates (WGS 84)</td></tr>
<tr><td>FPSO</td><td>Latitude</td><td>Longitude</td></tr>
<tr><td>Penguins</td><td>211/13
211/14</td><td>Sevan FPSO</td><td>61° 35' 01.02” N</td><td>01° 32' 54.06” E</td></tr>
<tr><td rowspan="2">Distance</td><td colspan="3">UK Coast</td><td colspan="2">Median Line</td></tr>
<tr><td colspan="3">150 km (Shetland, Scotland)</td><td colspan="2">5 km (UK/Norway)</td></tr>
</table>

Water Depth	162.0 – 170.3 m below LAT
EAJ Overview of activities included	• Section 2.2 describes the installation of the FPSO mooring chains, piles and waverider buoy. This information has been retained although these are now completed; • Sections 2.3 and 2.4 describes the activities associated with the installation of the mooring rope, buoyancy and top chain, FPSO tow and hook-up; • Sections 2.5 and 2.6 describes the FPSO tow and hook-up; and • Section 2.7 describes the production operations in support of the SATs (Chemical Permit, OPPC, PPC and Screening Direction) related to the FPSO.
Baseline Surveys	• Penguins FPSO Redevelopment Environmental Baseline Survey (Fugro, 2018a) • Penguins Redevelopment and Rig Site Survey Habitat Assessment (Fugro, 2018b) • Penguins Redevelopment Survey Marine Mammal Observer Report (Fugro, 2017) • Penguins FPSO Project Habitat Assessment Desktop Study (Fugro, 2015).
Key Sensitivities	**Habitats and Species**
	The main European Nature Information System (EUNIS) biotope complex was 'circalittoral coarse sediment' (A5.14). Recent surveys undertaken in the Penguins area did not identify any Annex I Habitats.
	Fish (ICES 52F1)
	Spawning: haddock, saithe and Norway pout Nursery: blue whiting and Norway pout Juveniles: anglerfish, hake, blue whiting and Norway pout
	Seabirds
	Breeding: Atlantic puffin (*Fratercula arctica*), black-legged kittiwake (*Rissa tridactyla*), and northern fulmar (*Fulmarus glacialis*) Winter: black-legged kittiwake, lesser black-backed gull (*Larus fuscus*), and northern fulmar. The sensitivity of seabirds to surface oil pollution in Block 211/8 is low throughout the year apart from November to January where sensitivity is high. In the immediately adjacent blocks 211/7 and 211/12 sensitivity is very high and medium in March respectively.
	Marine Mammals
	Atlantic white-sided dolphin, long-finned pilot whale, minke whale, harbour porpoise.
	Protected Areas (within 40 km)
	There are no protected areas within 40 km of Penguins.

1. INTRODUCTION

1.1. PURPOSE OF ENVIRONMENTAL ASSESSMENT JUSTIFICATION

The Penguins Development Environmental Statement (ES) (BEIS reference number: D/4184/2015) and subsequent Addendum were approved by DESNZ (formerly BEIS) on 5th December 2017. The Penguins Field Development Consent was granted by the NSTA on 15th January 2018. The Penguins Field Production Consent was granted by NSTA on 8th June 2022.

A Master Application Template (MAT) requires the submission of an Environmental Assessment Justification (EAJ) document. The EAJ provides information on the project; the environmental sensitivities description and any likely significant environmental effects of the project as required by Schedule 4 of The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020.

The EAJ also contains information required by law and provided as part of our applications for environmental permits. This includes (but is not limited to) the contents and requirements of permit applications, including information related to the carrying out an assessment of the risk of harm to the environment from the activities, as required under The Offshore Petroleum Activities (Oil Pollution Prevention and Control) 2005 (as amended) (Regulation 5); The Offshore Chemical Regulations 2002 (as amended) (Regulation 6); The Offshore Combustion Installations (PPC) Regulations 2013 (as amended) (Regulation 4) and The Energy Act 2008 (Part 4a).

1.2. PROJECT DESCRIPTION

The Penguins Field is located in the United Kingdom Continental Shelf (UKCS) Blocks 211/13 (Penguins West) and 211/14 (Penguins East), in the northern North Sea (NNS). The field is located approximately 150 km from the Scottish coastline (Northern Shetland) and runs adjacent to the UK/Norway median line (Figure 1-1).

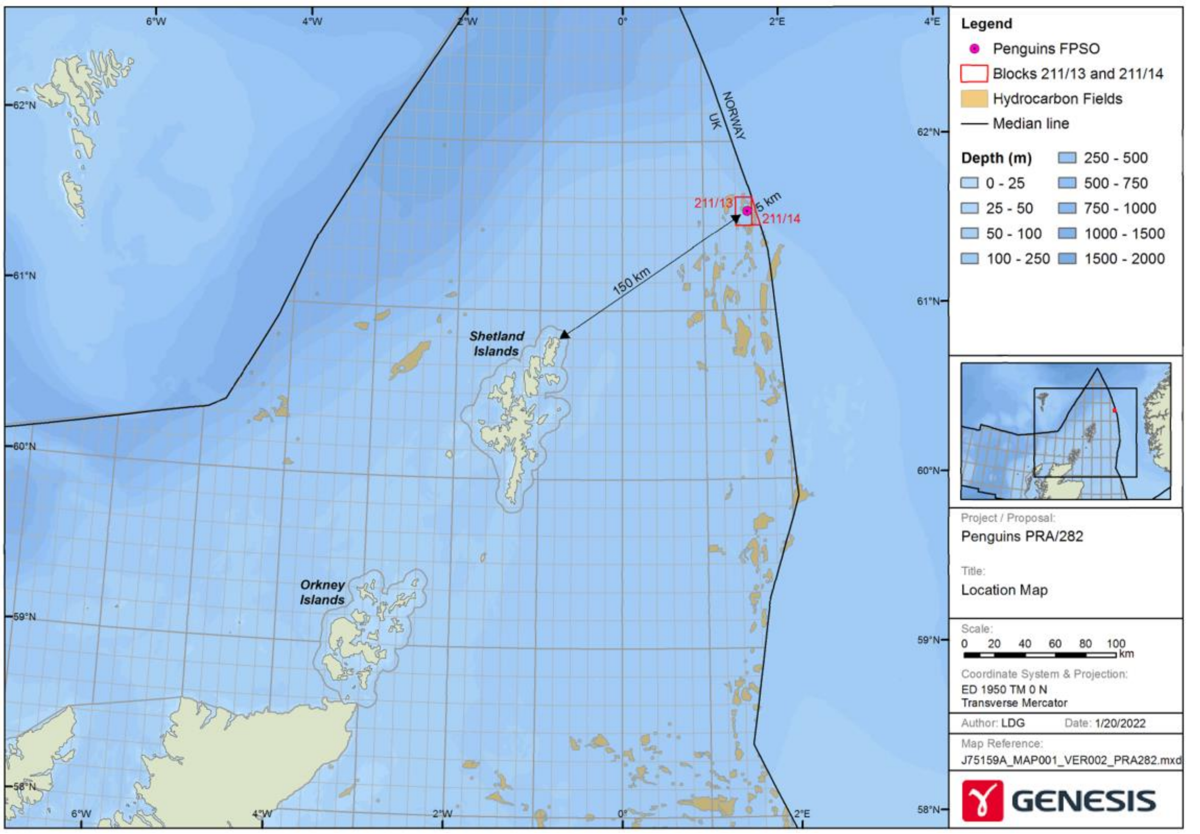


Figure 1-1: Penguins Location Map

The Penguins Field is a cluster (Penguins A, C, D and E) of oil and gas condensate accumulations discovered in 1974. The fields were brought online in 2003 as a subsea development via a tie-back to Brent Charlie (c. 50 km south). However, due to Cessation of Production (CoP) at Brent Charlie in 2021, Shell is redeveloping the Penguins Field to extend field life and production beyond the year 2035 at significantly reduced emissions intensity compared to the previous host, Brent Charlie. The existing and new developments will be produced via additional subsea infrastructure to a new Floating, Production, Storage and Offloading (FPSO) facility as shown in Figure 2-1.

The Tybalt ('Penguin A North-Tybalt') field located in Block 211/08 will be developed as a single production well and will also be produced via the Penguins FPSO.

In line with the Penguins Development Environmental Statement (ES) (BEIS reference number: D/4184/2015) and subsequent Addendum, Shell U.K. Limited installed mooring chains and associated mooring piles for the new Penguins FPSO, on the 7th May 2020 and completed (vessel demobilisation) on the 26th July 2020. The Waverider buoy was also installed in October 2021.

The next steps of the development proposed by Shell U.K. Limited are:

- The installation of the mooring rope, buoyancy and top chain (planned in Q1/Q2 2024);
- The FPSO tow and hook-up planned Q2/3 2024).

The new FPSO is due on location at Penguins in Q2 2024 at the earliest. Production is expected to commence in Q3/4 2024.

1.3. Updated EIA Regulations

The Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999 have been replaced by the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020.

1.4. Scope Of This EAJ

The Production Operations Master Application Template (MAT) (PRA/282) is the MAT for the Penguins field throughout the lifetime of the field and will be updated to reflect future workscopes and operations.

Of the activities considered in the ES, only the operations required for installation of the lower sections of the mooring chains and the mooring piles were covered by the original (previous version of this) application. The purpose of the Environmental Assessment Justification (EAJ) is in part to assess the impacts of installing the ground / lower mooring chains and mooring piles for the new Penguins FPSO, including their presence on the seabed in the medium-term until the FPSO arrives in the field during Q1-Q3 2024 and (within this revision) to assess the pre-lay of the remaining mooring components and installation of the Penguins FPSO. The installation of a Waverider Buoy is also assessed.

The EAJ has been updated to support workscopes involving the commissioning of the Penguins FPSO and later production operations. This EAJ document supports the following subsidiary application templates (SATs) for the proposed workscope:

- A Consent to Locate under Part 4a of the Energy Act 2008 for the installation of ground / lower mooring chains, mooring piles, Waverider Buoy (CL/1093), mooring rope, buoyancy and top chain.
- A Consent to Locate under Part 4a of The Energy Act 2008 for the installation of the Penguins FPSO (CL/1449).

In addition, the following SATs have been applied for as part of the production phase:

- A Screening Direction under the Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999 (as amended) for the production of hydrocarbons;

- A Chemical Permit (CP) application for the use and discharge of chemicals under the Offshore Chemicals Regulations 2002 (as amended);
- An Oil Discharge Permit (OLP) under the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended); and
- An Offshore Combustion Installation Permit under the Offshore Combustion Installations (Pollution Prevention and Control) (PPC) Regulations 2023 (as amended).

As an ES has previously been approved by Department for Energy Security and Net Zero (Formerly known as BEIS) for these activities, this assessment draws on the information presented in the ES and provides additional assessment where required to reflect any additions, changes or refinements in detail that have arisen during the ongoing engineering process.

1.5. National Marine Plan

Scotland's National Marine Plan (NMP) covers the management of both Scottish inshore waters (out to 12 nautical miles) and offshore waters (12 to 200 nautical miles) (Scottish Government, 2015). The aim of the NMP is to help ensure the sustainable development of the marine area through informing and guiding regulation, management, use and protection of the NMP areas.

The NMP also sets out general policies and objectives as part of the UK's shared framework for sustainable development. In accordance with the Department for Energy Security and Net Zero (DESNZ) (formerly known as BEIS) Guidance, the operations as described in this EAJ document have been assessed against all NMP objectives and policies, but specifically GEN 1, 4, 5, 9, 12, 13, 14 and 21:

GEN 1 - General Planning and Principle
Development and use of the marine area should be consistent with the Marine Plan, ensuring activities are undertaken in a sustainable manner that protects and enhances Scotland's natural and historic marine environment.

GEN 4 - Co–existence
Where conflict over space or resource exists or arises, marine planning should encourage Initiatives between sectors to resolve conflict and take account of agreements where this is applicable.

GEN 5 - Climate Change
Marine planners and decision makers should seek to facilitate a transition to a low carbon economy. They should consider ways to reduce emissions of carbon and other greenhouse gasses.

GEN 9 - Natural Heritage
Development and use of the marine environment must:

- Comply with legal requirements for protected areas and protected species.
- Not result in significant impact on the national status of Priority Marine Features (PMFs).
- Protect and, where appropriate, enhance the health of the marine area.

GEN 12 – Water Quality and Resource
Developments and activities should not result in a deterioration of the quality of waters to which the Water Framework Directive (WFD), Marine Strategy Framework Directive (MSFD) or other related Directives apply.

GEN 13 - Noise
Development and use in the marine environment should avoid significant adverse effects of man-made noise and vibration, especially on species sensitive to such effects.

GEN 14 – Air Quality
Development and use of the marine environment should not result in the deterioration of air quality and should not breach any statutory air quality limits.

GEN 21 – Cumulative Impacts
Cumulative impacts affecting the ecosystem of the marine plan area should be addressed in decision making and plan implementation.

Assessment of compliance against relevant policies has already been achieved through the impact assessment in this document (Section 4). The proposed pipeline operations do not contradict any of the NMP objectives and policies.

1.6. Oil and Gas Sector Specific Policies

In addition to the above general policies, the objectives and policies for the oil and gas sector were addressed. They should be read subject to those set out in Annex B and Chapter 4 of the NMP. It is recognised that not all of the objectives can necessarily be achieved directly through the marine planning system, but they are considered important context for planning and decision making.

Oil and Gas 1 - Environmental Risks & Impacts
The Scottish Government will work with DESNZ, the North Sea Transition Authority ((NSTA) formerly known as the Oil and Gas Authority (OGA)) and the industry to maximise and prolong oil and gas exploration and production whilst ensuring that the level of environmental risks associated with these activities are regulated. Activity should be carried out using the principles of Best Available Technology and Best Environmental Practice. Consideration will be given to key environmental risks including the impacts of noise, oil and chemical contamination and habitat change.

Oil and Gas 2 - Decommissioning
Where re-use of oil and gas infrastructure is not practicable, either as part of oil and gas activity or by other sectors such as carbon capture and storage, decommissioning must take place in line with standard practice, and as allowed by international obligations. Re-use or removal of decommissioned assets from the seabed will be fully supported where practicable and adhering to relevant regulatory process.

Oil and Gas 3 - Other Users of the Sea
Supporting marine and coastal infrastructure for oil and gas developments, including for storage, should utilise the minimum space needed for activity and should take into account environmental and socio-economic constraints.

Oil and Gas 4 - Aeronautical Constraints
All oil and gas platforms will be subject to 9 nautical mile consultation zones in line with Civil Aviation Authority guidance.

Oil and Gas 5 - Potential Environmental Risk & Hazards
Consenting and licensing authorities should have regard to the potential risks, both now and under future climates, to oil and gas operations in Scottish waters, and be satisfied that installations are appropriately sited and designed to take account of current and future conditions.

Oil and Gas 6 - Risk Reduction Measures
Consenting and licensing authorities should be satisfied that adequate risk reduction measures are in place, and that operators should have sufficient emergency response and contingency strategies in place that are compatible with the National Contingency Plan and the Offshore Safety Directive.

2. PROJECT DESCRIPTION

2.1. Overview

The existing Penguins Development comprises nine producing wells, four drill centres (DC2 to DC5), a multiphase production flow line, a gas lift line and an integrated umbilical for control, power and chemicals.

The Penguins Redevelopment Project involves tying the existing wells back to the new Penguins FPSO along with eight new production wells (with an option for additional wells in the future). Additional subsea infrastructure will comprise two pipeline bundles containing pipe-in-pipe production flowlines, gas lift flowlines and control systems. The FPSO will be positioned close to the centre of the field. Oil will be exported via tanker offload. Gas will be exported via an export pipeline comprising reused and new pipeline sections connected to the Far North Liquids and Associated Gas System (FLAGS) system via the existing Brent Charlie export route. Produced water will be treated and discharged overboard. The existing and new infrastructure is illustrated in Figure 2-1.

Section 2 will be updated as further detail becomes available and to support the additional SATs required as the project progresses. The following sub-sections describes the activities (and status):

- Section 2.2 describes the installation of the FPSO mooring chains, piles and waverider buoy (completed). This information has been retained on this version;
- Sections 2.3 and 2.4 describes the activities associated with two options (A and B) for the installation of the mooring rope, buoyancy and top chain (planned to commence in April 2024); (please note that the EAJ will be updated with option used after installation);
- Sections 2.5 and 2.6 describes the two options (A and B) for the FPSO tow and hook-up (planned to commence in Q1/3 2024) (please note that the EAJ will be updated with the option used after installation); and
- Section 2.7 describes the production operations related to the FPSO (from Q3/4 2024 at the earliest).

Furthermore, the description and assessment associated with activities covered under Section 2.2 (completed), Sections 2.3, 2.4, 2.5 and 2.6 will be retained in this document until the project moves into the production phase and details are included within this document.

Section 3 discusses the Environmental Baseline and outlines the main environmental sensitivities in the area that could be impacted by the proposed operations. The receptors considered are:

- Physical environment;
- Plankton;
- Habitats;
- Benthos;
- Fish and shellfish;
- Marine mammals;
- Seabirds;
- Protected sites and conservation features;
- Socio-economic environment; and
- The National Marine Plan (NMP).

Section 4 assesses the impacts associated with the proposed installation activities described in Section 2. The main impacts associated with this workscope are physical presence, seabed disturbance, atmospheric emissions and underwater noise. Accidental hydrocarbons spills and cumulative/transboundary impacts are also discussed.

Section 4.11 assesses the impacts associated with the changes to the production forecast reflecting move in start up from 2022 to 2024, and optimization of the well delivery programme.

The overall conclusion drawn is that the matters referred to in this EAJ will not cause significant impact to the environment.

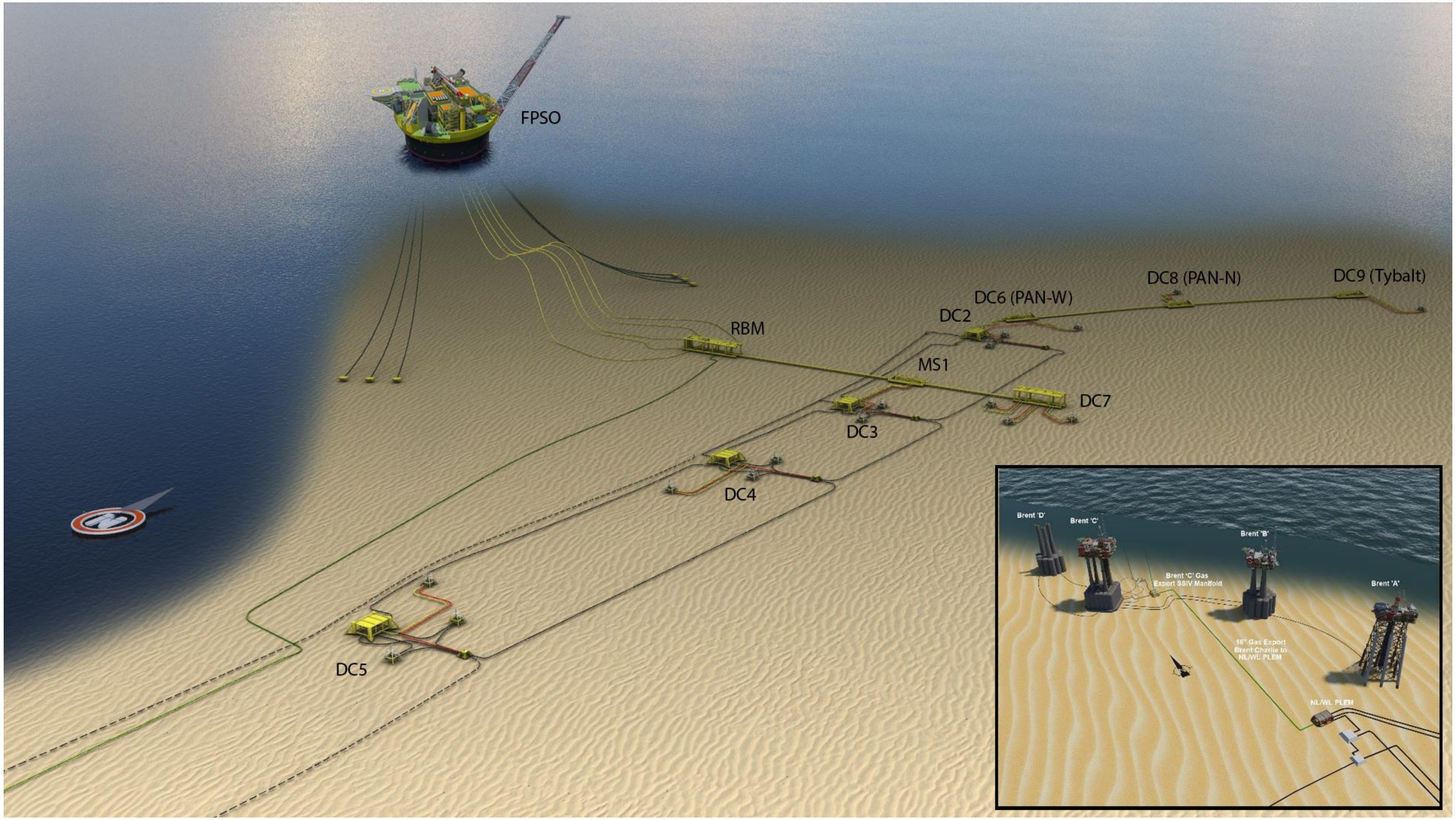


Figure 2-1: Proposed Penguins Field Redevelopment (including existing and new infrastructure (not at scale)) (Shell, 2019).

2.2. Installation of FPSO Mooring Chains, Piles and Waverider Buoy

This section relates to the Consent to Locate under Part 4a of the Energy Act 2008 for the installation of ground/ lower mooring chains, mooring piles, Waverider Buoy (CL/1093), mooring rope, buoyancy and top chain.

The Penguins Redevelopment Project includes a new FPSO which will be secured to the seabed using 12 mooring lines, divided into three clusters of four lines. The mooring lines will be constructed of a mooring pile, ground (or lower) chain, lower polyester rope section, buoyancy module, upper polyester rope section and top chain. The footprint will extend outside the FPSO's 500 m exclusion zone.

The ground / lower chain sections of each mooring lines have been secured to the seabed using piles. Each chain is held in place using a single pile.

The remaining Penguins mooring components (lower and upper mooring rope, buoyancy and top chain) will be installed prior to the FPSO arrival infield (expected installation Q1/Q3 2024) (Refer to Section 2.3 for more details).

The mooring and pile locations are detailed in Table 2-1 and illustrated in Figure 2-2.

Table 2-1: Coordinates of the Penguins FPSO and mooring line pile locations.

Location	ED50 TM0 Easting	ED50 TM0 Northing	Longitude ED50	Latitude ED50
FPSO	582201.56	6828936.28	01° 32' 54.06" E	61° 35' 01.02" N
Mooring Piles	580674.43	6828853.65	01° 31' 10.41"	61° 34' 59.52"
	580671.20	6828908.48	01° 31' 10.28"	61° 35' 01.29"
	580672.44	6828963.59	01° 31' 10.45"	61° 35' 03.07"
	580674.85	6829019.65	01° 31' 10.70"	61° 35' 04.88"
	582735.09	6829988.42	01° 33' 31.92"	61° 35' 34.60"
	582773.04	6829968.03	01° 33' 34.46"	61° 35' 33.91"
	582810.76	6829946.07	01° 33' 36.99"	61° 35' 33.17"
	582846.17	6829924.42	01° 33' 39.35"	61° 35' 32.45"
	582845.99	6827949.33	01° 33' 36.13"	61° 34' 28.64"
	582809.36	6827925.86	01° 33' 33.61"	61° 34' 27.91"
	582772.76	6827902.85	01° 33' 31.09"	61° 34' 27.20"
	582734.29	6827883.66	01° 33' 28.46"	61° 34' 26.61"
Coordinate System: European Datum 1950 TM0 [1311_23090]				

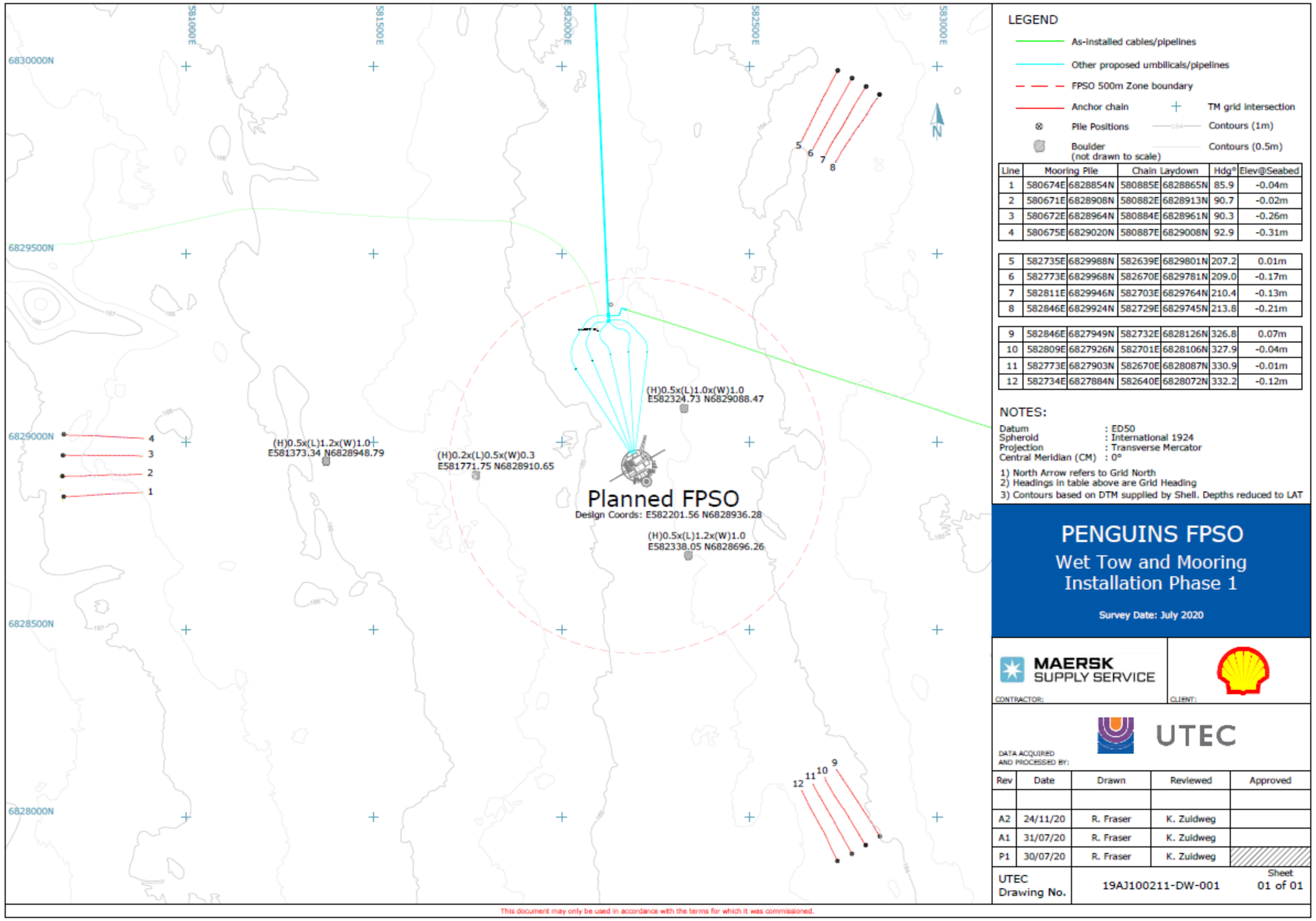


Figure 2-2: As installed mooring pile and ground chain location.

Each pile is 30 m in length and 2.44 m in diameter (see Table 2-2). Installation was undertaken using an anchor handling vessel (AHV) and a construction support vessel (CSV).

The AHV and CSV have capacity for six ground chains/piles, therefore the ground chains/piles were installed in two batches of six. After installation of the first six piles the AHV and CSV ~~will~~ returned to shore and remobilised with the remaining six ground chains/piles.

Table 2-2: Details of the proposed ground chains and piles.

Parameter	Value
Number of piles	12
Pile length	30 m
Pile diameter	2.44 m
Chain length	210 m
Chain diameter	177 mm

2.2.1. Waverider Buoy

A Waverider Buoy was deployed in October 2021. A location approximately 1.2 km to the south-west of the FPSO was selected. The location is shown in Figure 2-3.

The total length of the mooring line for the buoy is approximately 330 m and will comprise a rubber cord and polypropylene rope. A sinker and an in-line float were incorporated for stability. The anchor weight comprises of a bundled steel chain weighing approximately 500 kg. The buoy incorporates navigation lights which will flash during the hours of darkness. The buoy and mooring equipment configuration is shown in Figure 2-4.

The buoy was deployed from a AHV. As the vessel steamed slowly towards the deployment location, the buoy was deployed from the vessel stern. The mooring line was then paid out from the vessel winch. Once the mooring line was paid out, the anchor weight was connected to the end of the mooring line and the anchor was released to the seabed at the deployment location.

The Wave Buoy is a widely used tool for providing real time local environmental conditions (wave heights, near surface current and temperature). The buoy can provide this information via satellite or, once the FPSO is installed, directly to a receiver onboard.

Prior to the FPSO arrival infield, information received from the buoy will be used to assist with installation / drilling activities. Following FPSO arrival the data will be used as an independent reference against which the FPSO onboard environmental monitoring systems can be verified. It will also act as a contingency source of local environmental data.

The buoy diameter is approximately 0.7-0.9 m and weighs 192 kg. The buoy, once installed, will float on the water surface.

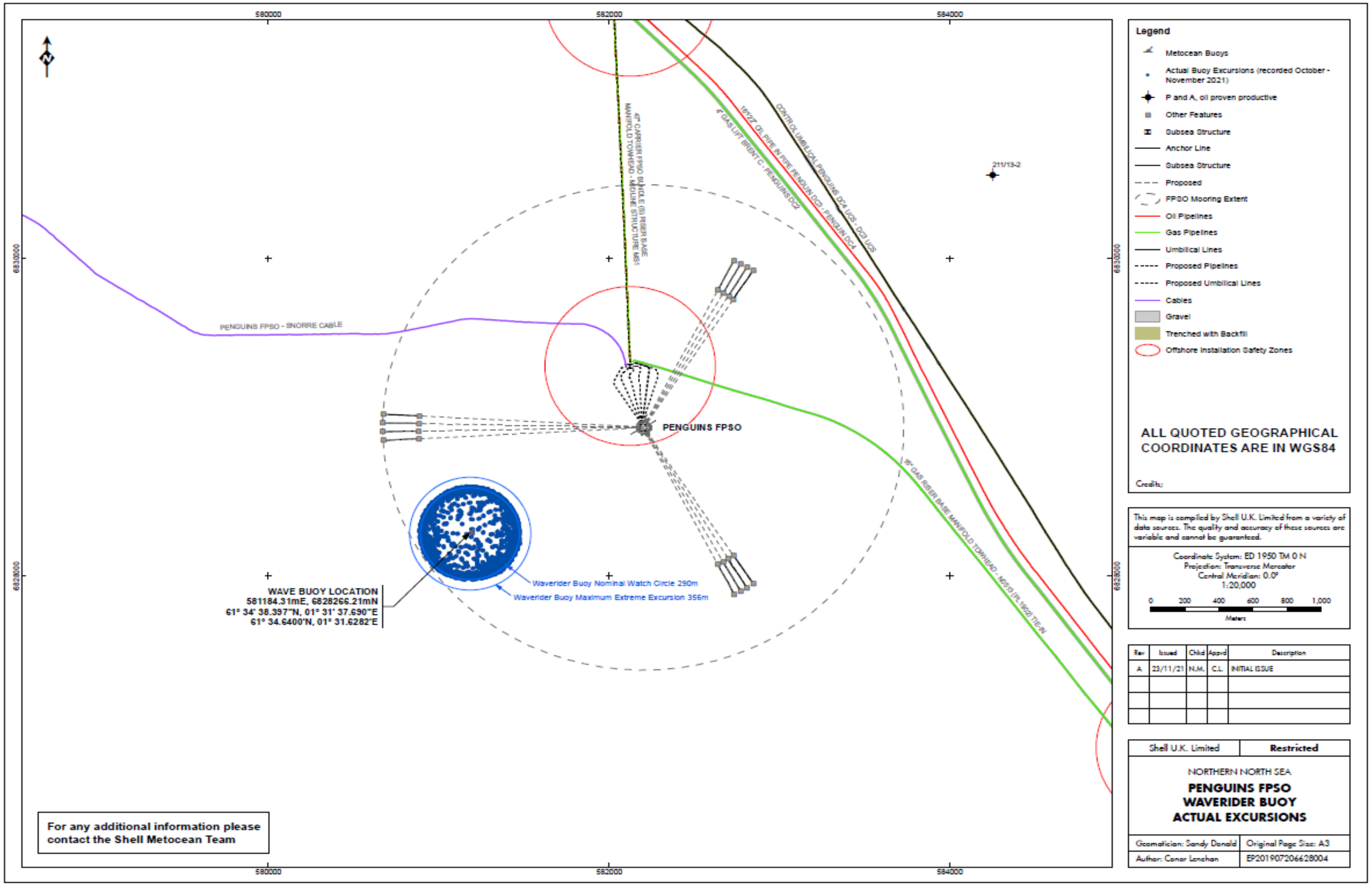


Figure 2-3: Waverider Buoy location.

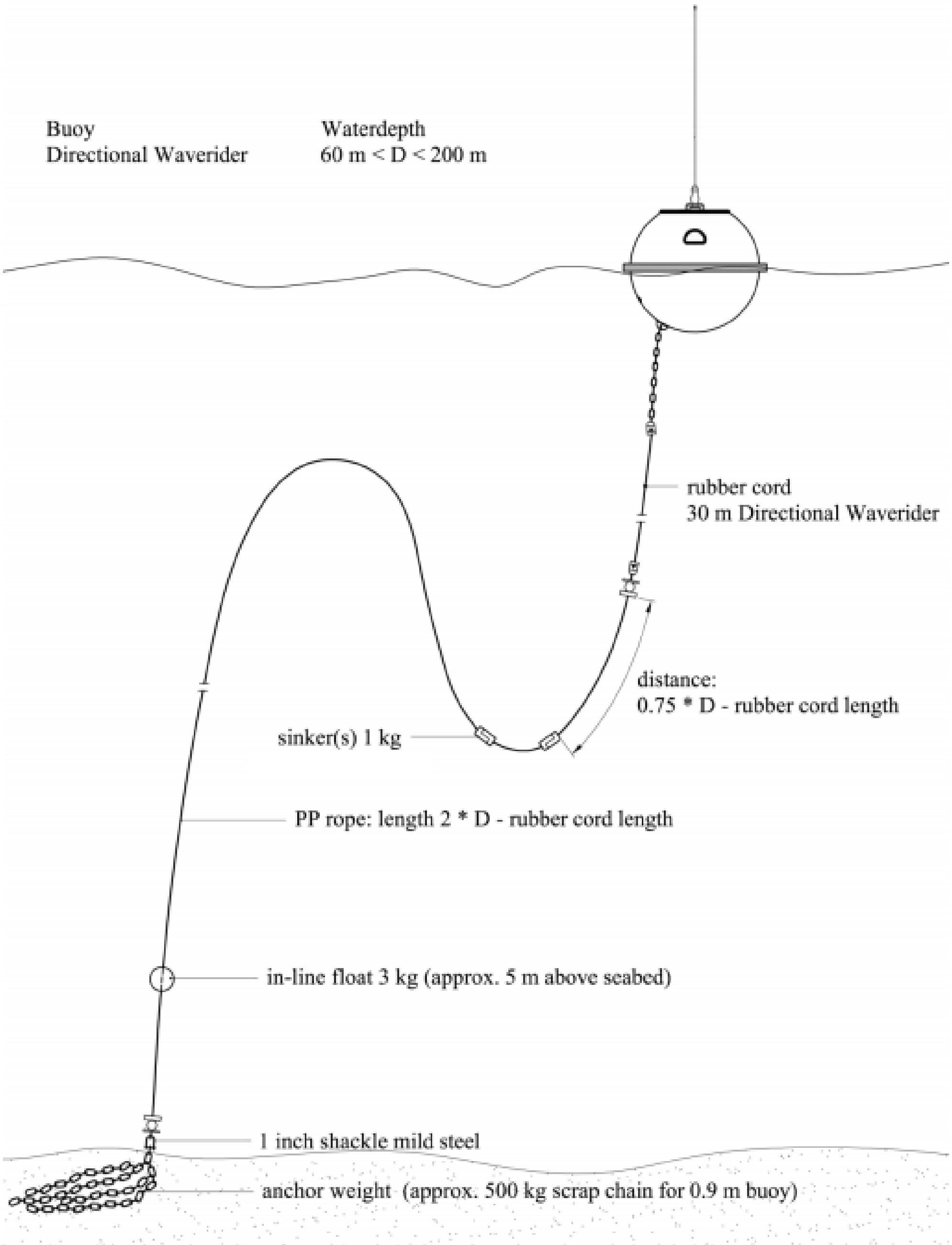


Figure 2-4 Waverider Buoy and components.

2.2.2. Seabed Preparation - Boulder Repositioning

Repositioning of boulders from selected areas of seabed was necessary prior to installation of the mooring chains and mooring piles. The opportunity to reposition boulders (between the pile and FPSO centre location) ahead of pre-lay of the remaining mooring system was taken. This is to: aid installation of the mooring chains and piles; to minimise potential damage to the chains (and future pre-laid mooring ropes); and to help ensure the later safe functioning of the FPSO mooring system.

The exact number of boulders to be moved was determined once the vessel was on site, The boulders were moved by the CSV using a subsea boulder grab and moved outside the installation corridor (with the majority moved a maximum of 30 metres away from their original location). A total of 140 boulders required relocation.

2.2.3. Items Placed on the Seabed

During and after installation of the ground chains and mooring piles, the following items will be placed on the seabed:

- A pile guide frame at each pile location;
- After installation of the first six piles the AHV and CSV returned to shore to remobilise with the remaining six ground chains/piles. During this time the pile guide frame was wet stored on the seabed in the Penguins field for up to five days; and
- Following piling at each location, the ground chains have been laid on the seafloor towards the FPSO location where they will remain for approximately 15 months until the arrival and hook-up of the FPSO. It is possible the ground chains will remain on the seabed longer than this if the project is delayed.

Note: The mooring piles (and ground chains) were mobilised following the boulder repositioning campaign.

The Waverider Buoy was deployed subsequently as part of a different installation campaign.

2.2.4. Schedule

The installation of the ground chains/piles commenced on the 7th May 2020 and was completed (vessel demobilisation) on the 26th July 2020. The campaign included installation of the piles and 210 m of ground chain associated with each pile, connected by an anchor shackle. The piles have been driven flush with the seabed with the chains connected at 5 m below the surface. Each ground chain therefore extends approximately 205 m along the seabed from near the pile towards the future FPSO location.

The sequence for undertaking the operation is summarised below with further details in the following sections:

- Mobilise CSV (including pile installation equipment) and sail to field:
  - Perform infield boulder repositioning from inside to outside mooring lay corridor
  - Return to port to mobilise mooring equipment (mooring piles)
- Mobilise AHV and sail to field:
  - AHV transports 177 mm ground chain
- Deploy pile guide frame (Note potential for this activity to occur during boulder repositioning scope)
- Commence installation operations:
  - Ground chain deployed from AHV and cross-hauled to CSV to attach the pile
  - Pile and chain deployed into water column
  - CSV upends pile and lands into pile guide frame
  - CSV deploys hammer and drives pile flush with seabed
  - AHV lays ground chain towards FPSO location
- Recover hammer and reposition pile guide frame for next pile deployment
- Repeat above steps for the next five piles
- Wet store pile guide frame in field

- Return to shore to pick up remaining six piles and repeat process.

This process is completed and the installation of the Waverider buoy was also completed in October 2021.

2.2.5. Description of Pile Installation

The pile installation was undertaken in two phases: pile deployment and self-penetration; and piling operation.

Pile deployment and self-penetration

The pile guide frame was placed on the seabed at the first piling location. The pile guide frame is not fixed to the seabed and its approximate dimensions are 12 m long x 12 m wide x 8.4 m high. Its weight is approximately 142 te (in air) / 110 te (submerged). The ground chain and pile were then be lowered through the water column and landed in the pile guide frame as described below.

The ground chain was deployed from the AHV. Whilst one end remained attached to the AHV, the other end of the ground chain was lifted up by the CSV crane and attached to the pile using an anchor shackle. The pile was then be lowered into the water column in an approximately horizontal orientation.

The pile was upended by the CSV within the water column then moved over the pile guide frame. The pile guide frame is used to ensure the pile is in the correct position and driven at the right angle. The pile-was lowered into the pile guide frame and penetrated the seabed under its own weight.

The top of the pile was then disconnected from the CSV using a remotely operated vehicle (ROV). The pile guide frame ensured the pile remains stable prior to commencement of piling operations.

Figure 2-5 shows the sequence of the pile deployment and self-penetration.

The AHV and CSV have capacity for six ground chains/piles, therefore the ground chains/piles were installed in two batches of six. After installation of the first six piles, the AHV and CSV returned to shore and remobilised with the remaining six ground chains/piles.

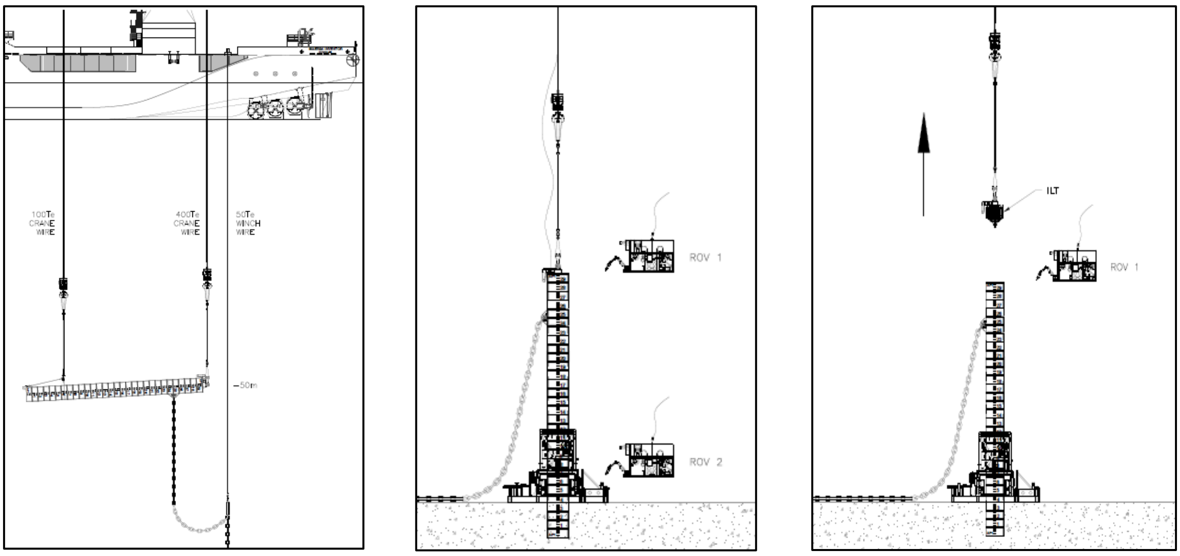


Figure 2-5 Pile deployment in water column and self-penetration into the seabed sequence.

Piling operation

The pile hammer was then be deployed from the CSV and hung below the hang-off pennant. Then, the pile hammer was lifted towards the pile. An ROV was used to connect follower into the pile, which will allow the piling hammer to keep in place during piling. The pile hammer will be now in place to drive the pile into the seabed.

Each pile was hammered until it was flush with the seabed and the ground chain is 5 m below the seabed (Figure 2-6). The pile guide frame was removed from the seabed and the AHV laid the ground chain in the direction of the FPSO location. The vessels then moved to the next pile location.

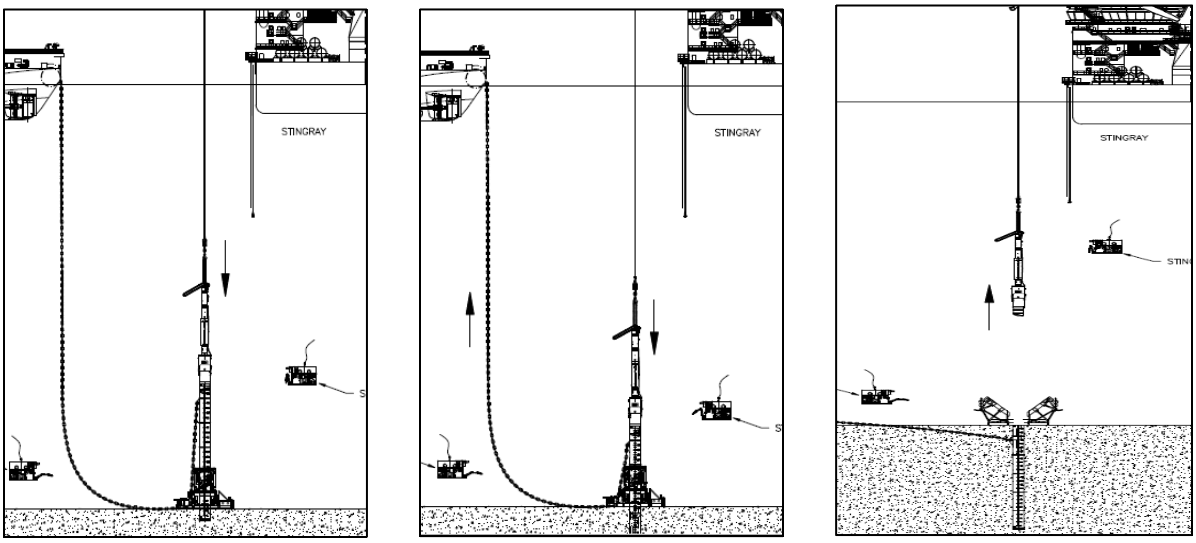


Figure 2-6 Pilling operation sequence.

2.2.6. Vessel Use for Installation of the FPSO mooring chains, piles

An AHV and a CSV were involved in the operations and both used dynamic positioning (DP) systems to maintain station. The CSV used was the Maersk Inventor, and the AHV was the Maersk Lifter. A guard vessel also covered the operations, but as this vessel is already in the field it is not assessed separately in this application. The fuel use associated with the project vessels is shown in Table 2-3. There is no increase in vessel days associated with installing the Waverider Buoy.

Table 2-3: Vessels and fuel use.

Vessel type	Days in transit**	Fuel use in transit (te/day)*	Days working**	Fuel use working (te/day)*	Total fuel use (te)**
Installation of FPSO Mooring Chains, Piles and Waverider Buoy					
AHV	13	50	18	5	740
CSV	13	22	36	18	934
Total vessel fuel use					**1,674**

*Source: Institute of Petroleum, 2000

** Estimated values updated based on total duration of scope execution

2.2.7. Changes in the Project Since the Environmental Statement

The Penguins Redevelopment Project Environmental Statement was submitted in May 2016 (reference number D/4184/2015). The Penguins Redevelopment Project Environmental Statement Addendum was subsequently submitted in November 2017 to reflect the outcome of an optimisation exercise for the subsea and wells elements of the project which altered the layout of pipelines, subsea structures, well locations and the FPSO location. The Addendum also contained revised production profiles and the addition of the Tybalt field for which Shell was granted a licence and which will be developed as part of the Penguins Field Redevelopment. Subsequent to the Penguins ES, Shell was granted a licence for a block located at the north of the Penguins Field (Tybalt) which Shell plans to develop within the scope of the Penguins Field Redevelopment project (Shell, 2017).

Changes Relating to the FPSO Mooring Lines and Mooring Piles

Since the ES Addendum there has been no significant change to the FPSO mooring location or the arrangement of the mooring lines and piles, however there will be a requirement to relocate numerous boulders which was not considered in the ES. The differences pertinent to the installation of the mooring piles and ground chains are summarised in Table 2-4.

Table 2-4: Pertinent revisions since ES / ES Addendum.

Parameter	ES	ES Addendum	Current Application
FPSO location	Not confirmed	Latitude 61° 35' 01.024” N Longitude 01° 32' 54.054” E	Latitude 61° 35' 1.02” N Longitude 1° 32' 54.06” E
Relocation of boulders at FPSO moorings	Not considered	Not considered	Up to 40 Boulders have been relocated
Pile diameter and length	2.5 m diameter 25 m long	No change	2.44 m diameter 30 m long
Duration of mooring piles/ chains installation	38 days	No change	36 days
Timing of mooring piles/ chains installation	Q3 of Year 2	Q3 2020	Q2-Q3 2020 Installed 2020
Waverider Buoy	Not considered	Not considered	Deployment included

2.3. Installation of Mooring Rope, Buoyancy and Top Chain – OPTION A

This section relates to the Consent to Locate under Part 4a of the Energy Act 2008 for the installation of ground / lower mooring chains, mooring piles, Waverider Buoy (CL/1093), mooring rope, buoyancy and top chain.

2.3.1. Mooring Ropes, Buoyancy and Top Chain

The mooring pile and chain installation campaign (as detailed in Section 2.2) was performed in advance of the mooring rope, buoyancy and top chain due to the geotechnical risk (subsurface boulder interaction) associated with pile installation. The mooring pile and chain campaign has set the boundaries and defined the extremity of the mooring spread, this subsequent (mooring rope, buoyancy & top chain) installation builds upon these previously installed items and will complete the pre-lay of the mooring system ahead of FPSO arrival infield.

The complete mooring line contains the following components (listed in order):

- Mooring pile (Installed as per Section 2.2)
- Mooring shackle (Installed as per Section 2.2)
- Mooring chain (ground chain) (Installed as per Section 2.2)
- H-link shackle (Awaiting pre-lay campaign)
  (interface between mooring rope and mooring chain)
- Mooring rope (lower 200m length) (Awaiting pre-lay campaign)
- Mooring buoyancy (270kN uplift SE & NE / 330kN uplift) (Awaiting pre-lay campaign)
- Mooring rope (upper 650m SE & NE/ 1000m length) (Awaiting pre-lay campaign)
- H-link shackle (Awaiting pre-lay campaign)

(interface between mooring rope and mooring chain)

- Top chain (173mm x 155m long) (Awaiting pre-lay campaign)

Figure 2-7 provides an overview of the mooring configuration and shows which items have been pre-installed.

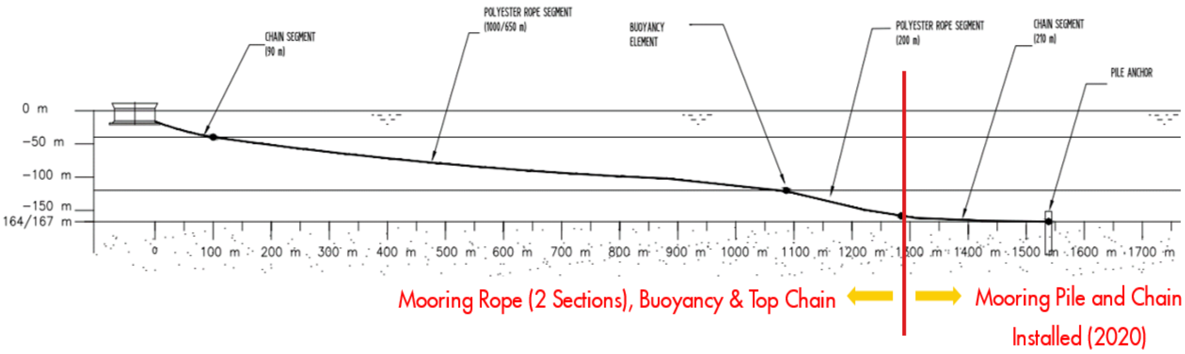


Figure 2-7: Pile deployment in water column and self-penetration into the seabed sequence.

While Figure 2-7 shows the mooring configuration once the FPSO is on site, Figure 2-8 gives a more representative view of the pre-lay configuration. Additional details and coordinates can be found on Figure 2-10.

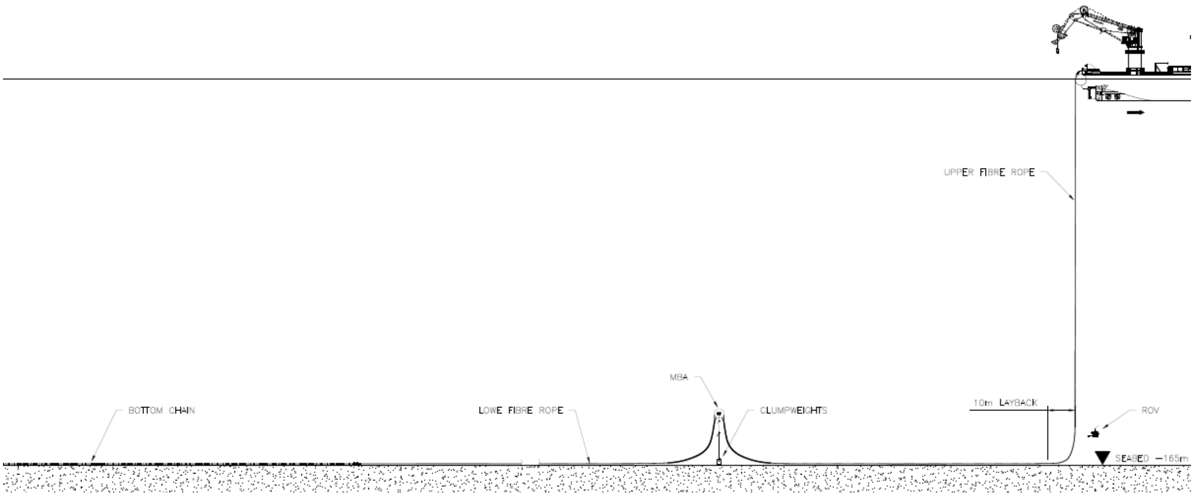


Figure 2-8: Mooring pre-lay configuration.

2.3.2. Seabed Preparation - Boulder Repositioning

The mooring rope is made from polyester fiber material and is therefore susceptible to abrasion damage. While every effort was made to reposition boulders (accounting for the mooring rope pre-lay) during the mooring pile and chain installation campaign (described in Section 2.2) there remains a possibility that additional boulders will need to be re-positioned following detailed design of the pre-lay route and as found conditions. Scenarios which will require boulder repositioning include:

- If a boulder is found to be in the lay route of the mooring rope; or
- If a boulder is found to be in close enough proximity to the rope (following pre-lay) to cause an abrasion risk.

There is no expectation for large scale boulder repositioning due to the work detailed (and completed) in Section 2.2.2. If required, boulders will be repositioned as locally as possible to remove the abrasion risk.

2.3.3. Items Placed on the Seabed

During and after pre-lay of the remaining mooring components, the following mooring items will, by the very nature of the pre-lay campaign, be temporarily placed on the seabed between the target FPSO centre and the previously installed piles / chain (Note the below list applies to each mooring line, of which there are 12):

- Ground chain (as detailed in Section 2.2)
- H-link shackle (interface between mooring rope and mooring chain)
- Mooring rope (lower 200m length)
- Mooring buoyancy sinking clump weights (21Te submerged weight & 2 off per line)*
- Mooring rope (upper 650m SE & NE/ 1000m length)
    - Potential for Mooring rope seabed restraint(s) to be deployed on top of the mooring rope adjacent to the buoyancy sections (concrete mattress (2.4Te submerged weight) / rock bags or similar, 2 per line, 24 in total & 3x6m each**)
    - Should the rope be deployed adjacent to a boulder which cannot be removed, and is identified as an abrasion risk, there may be a requirement to install 25 kg sand bags to act as a barrier between the rope and any abrasive materials. These will only be deployed if the integrity of the mooring rope is considered to be at risk by allowing contact with the objects in question and will be removed at the end of the FPSO installation campaign (latest).

- H-link shackle (interface between mooring rope and mooring chain)
- Top chain (173mm)

(*) The mooring buoyancy will be sunken to the seabed by means of two sinking clump weights attached on the extremities (see Figure 2-9). These clump weights will remain attached, holding the mooring line on the seabed, and only removed immediately prior to the FPSO arrival in field for hook up.

(**) The mooring rope seabed restraint may be required (depending on duration between pre-lay of the mooring system and FPSO arrival infield) to stabilise the mooring rope and prevent uncontrolled movement. It is also possible that multiple restraints will be deployed at each location to distribute the loading on the rope. The overall footprint however should remain unchanged.

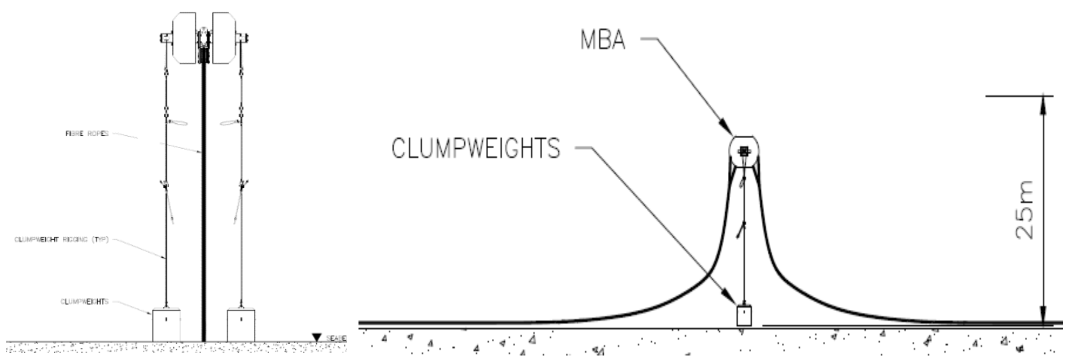


Figure 2-9: Buoyancy sinking clump weights.

Following (or immediately preceding) the FPSO arrival in field the mooring rope seabed restraints (if deployed) will be removed and buoyancy will be released from the sinking clump weights. The restraints (if deployed) and sinking clump weights will be temporarily placed in designated wet storage areas (listed in Table 2-5) awaiting recovery following completion of the FPSO mooring scope. Figure 2-10 shows the proposed clump weight temporary laydown areas.

In the event of an unexpected issue during mooring pre-lay (mooring component damage for example), it may be that the temporary laydown areas are used for temporary storage of equipment (most likely clump weights). This is not planned but remains a possibility. If used, items would be stored in these areas for the duration of the pre-lay campaign only. Figure 2-10 shows the temporary laydown areas.

Note, it may be that a small ROV work basket is lowered to the seabed outside these laydown areas to assist with local work scopes e.g. sand bag recovery etc.

Table 2-5: Temporary laydown / recovery areas.

ED50 TM0 Easting	ED50 TM0 Northing	ED50 TM0 Easting	ED50 TM0 Northing	ED50 TM0 Easting	ED50 TM0 Northing
Cluster 1 (West)		**Cluster 2 (North East)**		**Cluster 3 (South West)**	
580977	6829104	582420	6829590	582659	6828422
581177	6829093	582511	6829769	582768	6828254
581174	6829043	582555	6829746	582726	6828227
580974	6829054	582464	6829568	582617	6828394
580974	6828820	582617	6829480	582464	6828305
581174	6828830	582726	6829647	582555	6828126
581176	6828780	582768	6829620	582510	6828104
580977	6828770	582659	6829452	582419	6828282
Coordinate System: European Datum 1950 TM0 [1311_23090]					

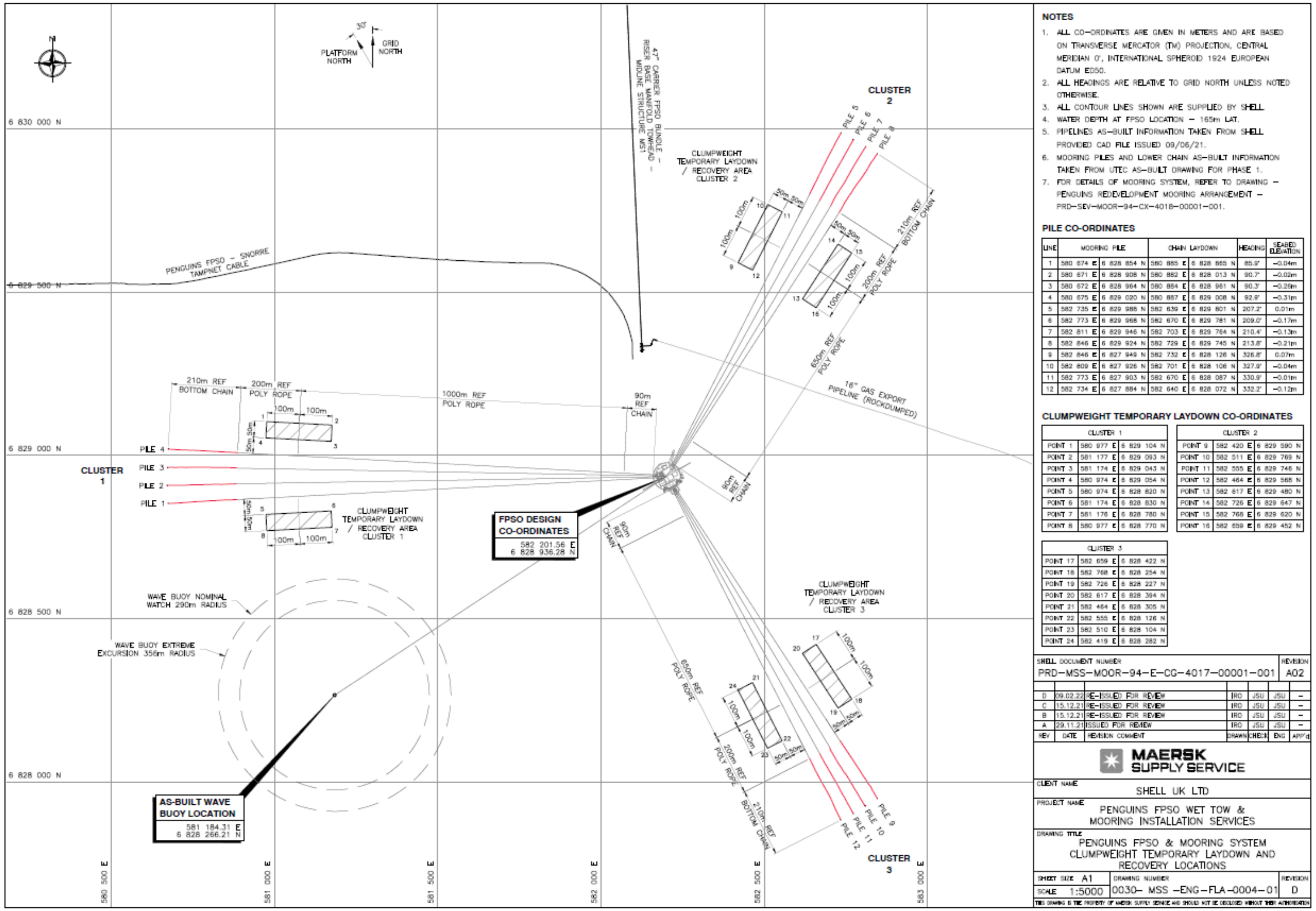


Figure 2-10: Temporary laydown / recovery areas.

2.3.4. Schedule

The pre-lay of the mooring system is scheduled to take 22 days in total during Q1/Q2 2024. The pre-laid mooring system will remain on the seabed until the arrival of the FPSO.

Once the sinking clump weights have been detached from the buoyancy modules (at the time of FPSO arrival infield – Section 2.4) they will be wet stored in the designated laydown / recovery areas for circa 2-3 weeks.

The sequence for undertaking the pre-lay of the mooring lines is as follows:

- Mobilise AHV and sail to field;
  - AHV has suitable deck space to complete the pre-lay of two mooring lines (mobilisation will take mooring rope (upper and lower), buoyancy and top chain)
- Perform as found survey;
- Commence pre-lay operations:
  - Recover previously installed chain (attached to mooring pile)
  - Attach chain to lower mooring rope and deploy
  - Attach lower mooring rope to buoyancy / attach upper mooring rope to buoyancy
  - Deploy buoyancy (c/w sinking clump weights) and upper mooring rope
  - Connect upper mooring rope to top chain and deploy
  - As left survey & boulder relocation (if required)
- Repeat for second mooring line;
- Return to port for interim mobilisation;
- Repeat until all 12 mooring lines have been pre-laid.

2.3.5. Vessel use for the installation of the mooring rope, buoyancy and top chain

The pre-lay campaign will utilise a single AHV equipped with dynamic positioning (DP) systems to maintain station. The fuel use associated with the project vessel is shown in Table 2-6. Note that interim mobilisation (and waiting on weather) days are excluded (total vessel days from commencement of mobilisation to completion of demobilisation is estimated at 35 days).

Table 2-6: Vessels and fuel use for mooring line pre-lay.

Vessel type	Days in transit	Fuel use in transit (te/day)*	Days working	Fuel use working (te/day)*	Total fuel use (te)
AHV	11	50	22	5	660
Total vessel fuel use for proposed operations					**660**
*Source: Institute of Petroleum, 2000					

Note: the above table does not account for weather downtime.

2.4. Installation of Mooring Rope, Buoyancy and Top Chain – Option B

This section relates to the Consent to Locate under Part 4a of the Energy Act 2008 for the installation of ground / lower mooring chains, mooring piles, Waverider Buoy (CL/1093), mooring rope, buoyancy and top chain.

2.4.1. Mooring Ropes, Buoyancy and Top Chain

The mooring pile and chain installation campaign (as detailed in Section 2.2) was performed in advance of the mooring rope, buoyancy and top chain due to the geotechnical risk (subsurface boulder interaction) associated with pile installation. The mooring pile and chain campaign has set the boundaries and defined the extremity of the mooring spread, this subsequent (mooring rope, buoyancy & top chain) installation builds upon these previously installed items and will complete the pre-lay of the mooring system ahead of FPSO arrival infield.

The complete mooring line contains the following components (listed in order):

• Mooring pile	(Installed as per Section 2.2)
• Mooring shackle	(Installed as per Section 2.2)
• Mooring chain (ground chain)	(Installed as per Section 2.2)
• H-link shackle (interface between mooring rope and mooring chain)	(Awaiting pre-lay campaign)
• Mooring rope (lower 200m length)	(Awaiting pre-lay campaign)
• Mooring buoyancy (270kN uplift SE & NE / 330kN uplift)	(Awaiting pre-lay campaign)
• Mooring rope (upper 650m SE & NE/ 1000m length)	(Awaiting pre-lay campaign)
• H-link shackle (interface between mooring rope and mooring chain)	(Awaiting pre-lay campaign)
• Top chain (173mm x 155m long)	(Awaiting pre-lay campaign)

Figure 2-11 provides an overview of the mooring configuration and shows which items have been pre-installed.

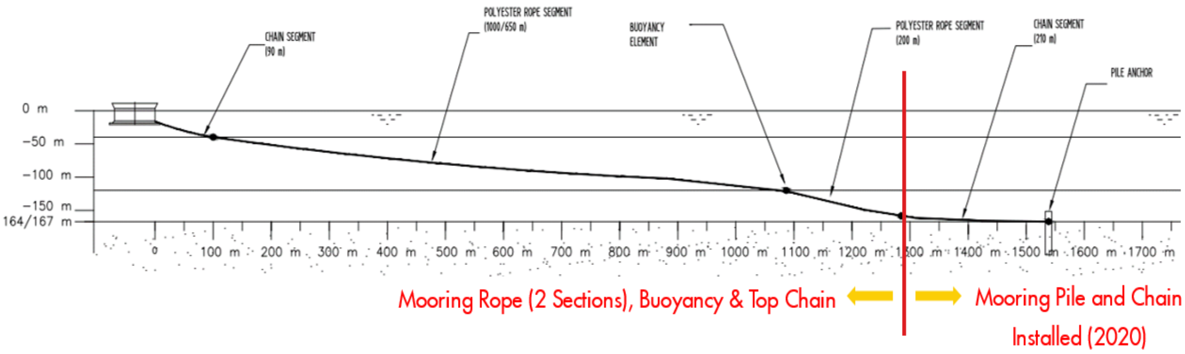


Figure 2-11: Pile deployment in water column and self-penetration into the seabed sequence.

While Figure 2-11 shows the mooring configuration once the FPSO is on site, Figure 2-12 and Figure 2-13 give a more representative view of the pre-lay configuration.

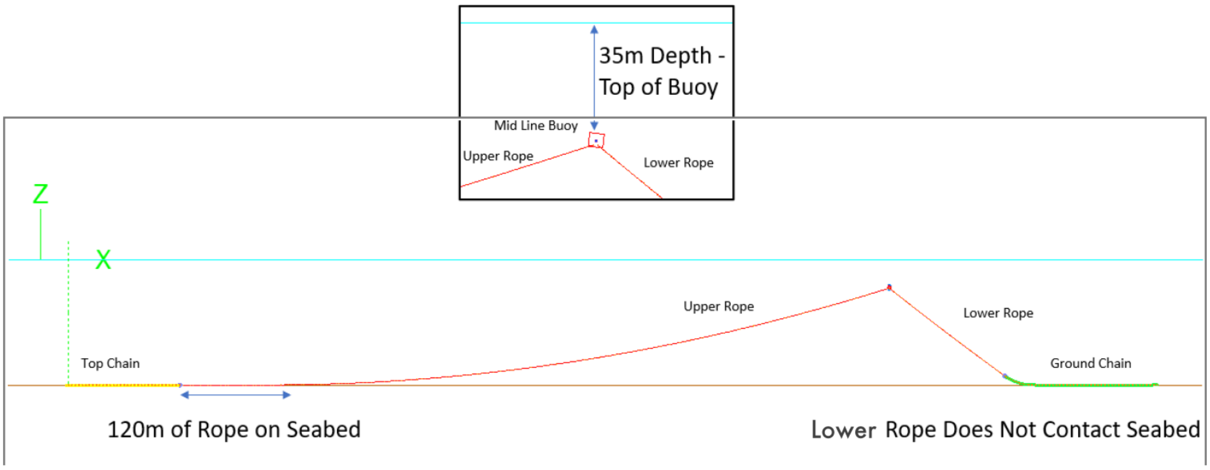


Figure 2-12: Mooring Pre-lay configuration (Lines 1-4)

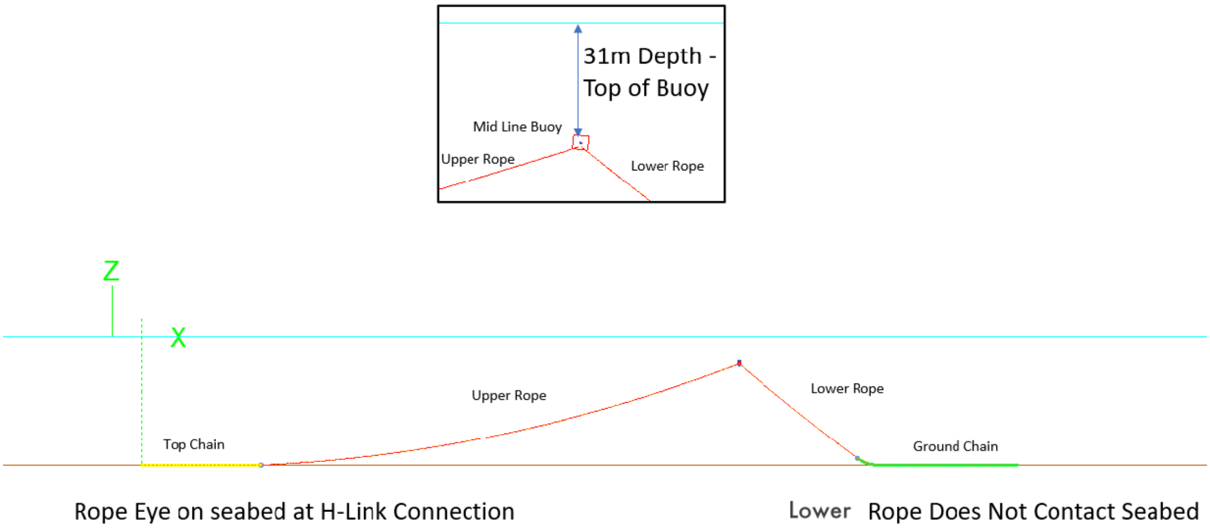


Figure 2-13: Mooring pre-lay configuration (Lines 5-12)

While this pre-lay option minimises the in-place rope on the seabed, during deployment a Tug is required to maintain position of the buoyancy. This is required to prevent the buoyancy run-off and keeps the tension in the upper rope to a minimum, allowing connection of the rope / top chain on the installation vessel. Figure 2-14 shows this temporary configuration. Once the top chain is connected (onboard the installation vessel), a nominal length deployed and the installation vessel moves forward, the Tug will disconnect from the buoyancy and the rope will pick-up off the seabed. The final pre-laid configuration will be as per Figure 2-12 or Figure 2-13.

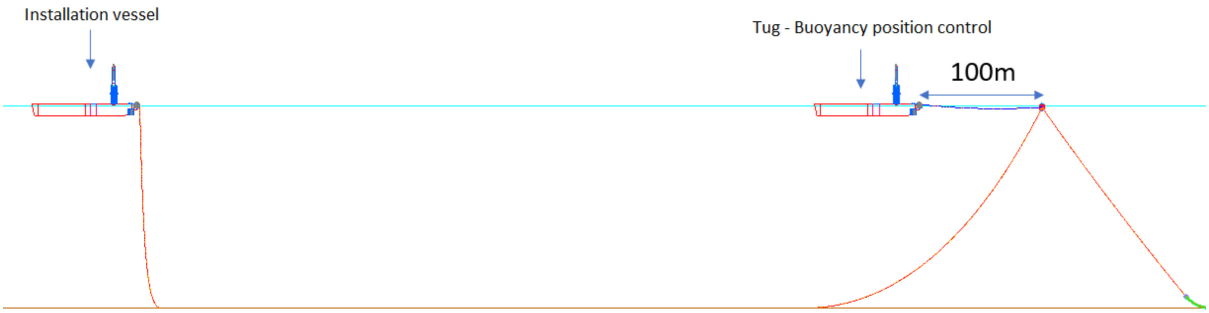


Figure 2-14: Mooring pre-lay, deployment stage

2.4.2. Seabed Preparation - Boulder Repositioning

The mooring rope is made from polyester fiber material and is therefore susceptible to abrasion damage. While every effort was made to reposition boulders (accounting for the mooring rope pre-lay) during the mooring pile and chain installation campaign (described in Section 2.2) there remains a possibility that additional boulders will need to be re-positioned following detailed design of the pre-lay route and as found conditions. Scenarios which will require boulder repositioning include:

- If a boulder is found to be in the lay route of the mooring rope; or
- If a boulder is found to be in close enough proximity to the rope (following pre-lay) to cause an abrasion risk.

There is no expectation for large scale boulder repositioning due to the work detailed (and completed) in Section 2.2.2. If required, boulders will be repositioned as locally as possible to remove the abrasion risk.

2.4.3. Items Placed on the Seabed

During and after pre-lay of the remaining mooring components, the following mooring items will, by the very nature of the pre-lay campaign, be temporarily placed on the seabed between the target FPSO centre and the previously installed piles / chain (Note the below list applies to each mooring line, of which there are 12):

- Ground Chain (as detailed in Section 2.2)
- H-link shackle (interface between mooring rope and mooring chain)
- Mooring rope (120 m of rope on lines 1-4 only)
    - Note. The optimised approach may require the installation of 25kg sand bags to act as a barrier between the rope and any abrasive materials (rocks) which cannot be repositioned. These will only be deployed if the integrity of the mooring rope is considered to be at risk by allowing contact with the objects in question.
- H-link shackle (interface between mooring rope and mooring chain)
- Top chain (173 mm)

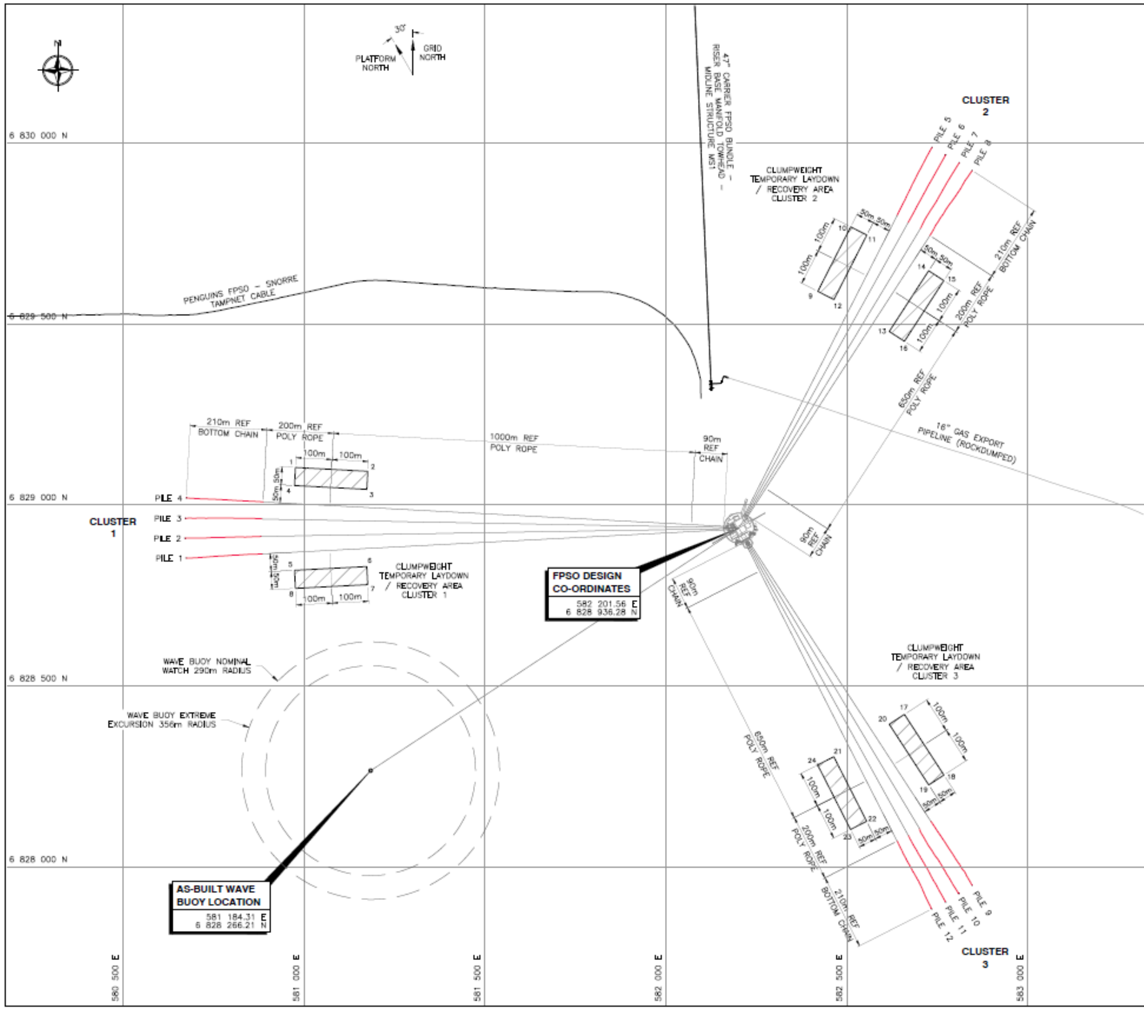
Following (or immediately preceding) the FPSO arrival in field the mooring rope abrasion protection sand bags (if deployed) will be removed. The sand bags (if deployed) may be temporarily placed in designated wet storage areas (listed in Table 2-7) or placed in a safe area outside the mooring corridor awaiting recovery following completion of the FPSO mooring scope. Figure 2-15 shows the proposed temporary laydown areas (note it may be that a small ROV work basket is lowered to the seabed outside these laydown areas to assist with local workscopes e.g. sang bag recovery etc).

The intent of the sand bags is to only deploy (if necessary) to create a barrier between the mooring rope on the seabed and any object which poses an abrasion risk. Should they be deployed, when the time comes to relocate, this will be done at the nearest location clear of the mooring line, this would prevent the need to transit to and from the closest wet store area, ultimately making the operation more efficient. Should they be relocated, this will be done by ROV who will have full visibility of the seabed prior to placing the sandbags down. The area will be safe as the bags would be positioned as close as possible to the mooring line cluster to enable easy recovery later, there will be a guard vessel infield marshalling the area.

In the event of an unexpected issue during mooring pre-lay (mooring component damage for example), the temporary laydown areas could be used for temporary storage of equipment. This is not planned. If used, items would be stored in these areas for a maximum duration of the pre-lay and FPSO installation Campaigns. Figure 2-15 shows the temporary laydown areas.

Table 2-7: Temporary laydown / recovery areas.

ED50 TM0 Easting	ED50 TM0 Northing	ED50 TM0 Easting	ED50 TM0 Northing	ED50 TM0 Easting	ED50 TM0 Northing
Cluster 1 (West)		**Cluster 2 (North East)**		**Cluster 3 (South West)**	
580977	6829104	582420	6829590	582659	6828422
581177	6829093	582511	6829769	582768	6828254
581174	6829043	582555	6829746	582726	6828227
580974	6829054	582464	6829568	582617	6828394
580974	6828820	582617	6829480	582464	6828305
581174	6828830	582726	6829647	582555	6828126
581176	6828780	582768	6829620	582510	6828104
580977	6828770	582659	6829452	582419	6828282
Coordinate System: European Datum 1950 TM0 [1311_23090]					



NOTES

1. ALL CO–ORDINATES ARE GIVEN IN METERS AND ARE BASED ON TRANSVERSE MERCATOR (TM) PROJECTION, CENTRAL MERIDIAN 0°, INTERNATIONAL SPHEROID 1924 EUROPEAN DATUM ED50.
2. ALL HEADINGS ARE RELATIVE TO GRID NORTH UNLESS NOTED OTHERWISE.
3. ALL CONTOUR LINES SHOWN ARE SUPPLIED BY SHELL.
4. WATER DEPTH AT FPSO LOCATION – 165m LAT.
5. PIPELINES AS–BUILT INFORMATION TAKEN FROM SHELL PROVIDED CAD FILE ISSUED 09/06/21.
6. MOORING PILES AND LOWER CHAIN AS–BUILT INFORMATION TAKEN FROM UTEC AS–BUILT DRAWING FOR PHASE 1.
7. FOR DETAILS OF MOORING SYSTEM, REFER TO DRAWING – PENGUINS REDEVELOPMENT MOORING ARRANGEMENT – PRD–SEV–MOOR–94–CX–4018–00001–001.

PILE CO-ORDINATES

LINE	MOORING PILE		CHAIN LAYDOWN		HEADING	SEABED ELEVATION
1	580 674 E	6 828 854 N	580 885 E	6 828 865 N	85.9°	–0.04m
2	580 671 E	6 828 908 N	580 882 E	6 828 013 N	90.7°	–0.02m
3	580 672 E	6 828 964 N	580 884 E	6 828 961 N	90.3°	–0.26m
4	580 675 E	6 829 020 N	580 887 E	6 829 008 N	92.9°	–0.31m
5	582 735 E	6 829 988 N	582 639 E	6 829 801 N	207.2°	0.01m
6	582 773 E	6 829 968 N	582 670 E	6 829 781 N	209.0°	–0.17m
7	582 811 E	6 829 946 N	582 703 E	6 829 764 N	210.4°	–0.13m
8	582 846 E	6 829 924 N	582 729 E	6 829 745 N	213.8°	–0.21m
9	582 846 E	6 827 949 N	582 732 E	6 828 126 N	326.8°	0.07m
10	582 809 E	6 827 926 N	582 701 E	6 828 106 N	327.9°	–0.04m
11	582 773 E	6 827 903 N	582 670 E	6 828 087 N	330.9°	–0.01m
12	582 734 E	6 827 884 N	582 640 E	6 828 072 N	332.2°	–0.12m

CLUMPWEIGHT TEMPORARY LAYDOWN CO-ORDINATES

CLUSTER 1		
POINT 1	580 977 E	6 829 104 N
POINT 2	581 177 E	6 829 093 N
POINT 3	581 174 E	6 829 043 N
POINT 4	580 974 E	6 829 054 N
POINT 5	580 974 E	6 828 820 N
POINT 6	581 174 E	6 828 830 N
POINT 7	581 176 E	6 828 780 N
POINT 8	580 977 E	6 828 770 N

CLUSTER 2		
POINT 9	582 420 E	6 829 590 N
POINT 10	582 511 E	6 829 769 N
POINT 11	582 555 E	6 829 746 N
POINT 12	582 464 E	6 829 568 N
POINT 13	582 617 E	6 829 480 N
POINT 14	582 726 E	6 829 647 N
POINT 15	582 768 E	6 829 620 N
POINT 16	582 659 E	6 829 452 N

CLUSTER 3		
POINT 17	582 659 E	6 828 422 N
POINT 18	582 768 E	6 828 254 N
POINT 19	582 726 E	6 828 227 N
POINT 20	582 617 E	6 828 394 N
POINT 21	582 464 E	6 828 305 N
POINT 22	582 555 E	6 828 126 N
POINT 23	582 510 E	6 828 104 N
POINT 24	582 419 E	6 828 282 N

SHELL DOCUMENT NUMBER PRD–MSS–MOOR–94–E–CG–4017–00001–001 REVISION A02

REV	DATE	REVISION COMMENT	DRAWN	CHECK	ENG	APP'd
D	09.02.22	RE–ISSUED FOR REVIEW	IRO	JSU	JSU	–
C	15.12.21	RE–ISSUED FOR REVIEW	IRO	JSU	JSU	–
B	15.12.21	RE–ISSUED FOR REVIEW	IRO	JSU	JSU	–
A	29.11.21	ISSUED FOR REVIEW	IRO	JSU	JSU	–

MAERSK SUPPLY SERVICE

CLIENT NAME: SHELL UK LTD

PROJECT NAME: PENGUINS FPSO WET TOW & MOORING INSTALLATION SERVICES

DRAWING TITLE: PENGUINS FPSO & MOORING SYSTEM CLUMPWEIGHT TEMPORARY LAYDOWN AND RECOVERY LOCATIONS

SHEET SIZE A1 | SCALE 1:5000 | DRAWING NUMBER 0030– MSS –ENG–FLA–0004–01 | REVISION D

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Figure 2-15: Temporary laydown / recovery areas

2.4.4. Schedule

The pre-lay of the mooring system is scheduled to take 21 infield (working) days in total during Q1/Q2-2024. The pre-laid mooring system will remain on the seabed until the arrival of the FPSO.

Any abrasion protection (sand bags) will be either recovered or wet stored pending FPSO hook-up.

The sequence for undertaking the pre-lay of the mooring lines is as follows:

- Mobilise AHV & Tug and sail to field;
    - AHV has suitable deck space to complete the pre-lay of two mooring lines (mobilisation will take mooring rope (upper and lower), buoyancy and top chain)
    - Tug will have a dual role, to prevent significant buoyancy displacement during the pre-lay operation and to act as a guard boat during the AHV interim mobilisations.
- Perform as found survey;
- Commence pre-lay operations:
    - Recover previously installed chain (attached to mooring pile)
    - Attach chain to lower mooring rope and deploy
    - Attach lower mooring rope to buoyancy / attach upper mooring rope to buoyancy
    - Deploy buoyancy and upper mooring rope
        - Tug is required to maintain the buoyancy position (within specified footprint) while the upper rope is being deployed (the buoyancy will remain on the sea surface until the upper chain is deployed)
    - Connect upper mooring rope to top chain and deploy
        - Once the upper chain is connected to the upper mooring rope the Tug can detach from the buoyancy.
    - As left survey, sand bag installation (if required) & boulder relocation (if required)
- Repeat for second mooring line;
- Return to port for interim mobilisation; and
- Repeat until all 12 mooring lines have been pre-laid.

2.4.5. Vessel use for the installation of the mooring rope, buoyancy and top chain

The pre-lay campaign will utilise a single AHV equipped with dynamic positioning (DP) systems to maintain station and a Tug to control the buoyancy and act as a mooring system guard vessel. The fuel use associated with the project vessels is shown in Table 2-8. Note that interim mobilisation (and waiting on weather) days are excluded (total vessel days from commencement of mobilisation to completion of demobilisation is estimated at 28 days).

Table 2-8: Vessels and fuel use for mooring line pre-lay.

Vessel type	Days in transit	Fuel use in transit (te/day)*	Days working	Fuel use working (te/day)*	Total fuel use (te)
AHV	8	50	21	5	~~485~~ 505
Tug	4	25	28	2.5	170
Total vessel fuel use for proposed operations					**~~655~~ 675**
*Source: Institute of Petroleum, 2000					

Note: The above table does not account for weather downtime

2.5. FPSO TOW AND HOOK-UP – OPTION A

This section relates to the Consent to Locate under Part 4a of the Energy Act 2008 for the installation of the Penguins FPSO (CL/1449).

Once, or immediately prior to FPSO arrival infield, the buoyancy will be released from the sinking clump weights and restraints removed (if deployed) and temporarily wet stored (as per Figure 2-10) and the pre-laid mooring lines will be ready for hook-up operations. Commencement of tow until hook-up of the FPSO is expected to take 17 days (excluding any weather delays).

2.5.1. Schedule

The sequence for completing the tow and hook-up of the FPSO is as follows:

- Mobilise hook-up AHV to field and commence removal of any seabed restraints and release of buoyancy clump weights;
- Mobilise station keeping AHVs (3 off) to FPSO location;
- Commence tow of FPSO to field and complete station keeping trials on arrival infield;
- 3 off station keeping AHVs to manoeuvre FPSO onto target location, hook-up AHV to commence mooring line hand-over to FPSO (complete all 12 lines);
- 3 off station keeping AHVs to demobilise;
- FPSO to perform mooring lines tensioning and FPSO final positioning operation using onboard winches;
- Hook-up AHV to complete as-left survey and demobilisation.

During the hook-up campaign, the hook-up AHV is scheduled to be deployed for approximately 17 days (infield), the station keeping AHVs (3 off) are scheduled to be deployed for 10 days each (tow and station keeping).

2.5.2. Items Placed on the Seabed

Following (or immediately preceding) the FPSO arrival in field the mooring rope seabed restraints (if deployed) will be removed and buoyancy will be released from the sinking clump weights. The restraints (if deployed) and sinking clump weights will be temporarily placed in designated wet storage areas (listed in Table 2-5) awaiting recovery following completion of the FPSO mooring scope. Figure 2-10 shows the proposed temporary laydown areas.

2.5.3. FPSO tow and hook-up

The FPSO hook-up campaign will utilise multiple vessels.

- A Single hook-up AHV will be deployed to pick-up and cross haul the pre-laid mooring lines to the FPSO.
- 3 off station keeping AHVs will be deployed to tow the FPSO to field and to perform infield station keeping duties. The estimated fuel use associated with the project vessels is shown in Table 2-9.

Table 2-9: Vessels and fuel use for FPSO Hook-up

Vessel type	Days in transit	Fuel use in transit (te/day)*	Days working	Fuel use working (te/day)*	Total fuel use (te)
Hook-up AHV	2	50	17	5	185
Station Keeping AHVs (3 off)	4 (12)	50	10 (30)	5	750
Total vessel fuel use for proposed operations					**935**
*Source: Institute of Petroleum, 2000					

Note: The above table does not account for weather downtime

2.6. FPSO TOW AND HOOK-UP – OPTION B

This section relates to the Consent to Locate under Part 4a of the Energy Act 2008 for the installation of the Penguins FPSO (CL/1449).

The FPSO requires a 10 day (including 50% contingency) working weather window in order to commence the tow to field. In order to have the optimum opportunity to take advantage of a weather window it is possible that the FPSO will commence the tow to field prior to completion of the mooring pre-lay scope (a minimum of 6 lines installed in the pre-lay configuration is required). The FPSO is considered storm safe when hooked up with 6 lines (2 from each mooring cluster).

The most significant optimisation would be when 6 lines are pre-laid and therefore this has been outlined below, in reality, the FPSO tow could commence when any number between 6-12 lines have been pre-laid on the seabed. This Option also considers the pre-lay is per Section 2.4 (Section 2.3 could equally apply, although this is considered less likely).

2.6.1. Schedule

The sequence for completing the tow and hook-up of the FPSO is as follows:

- AHV to complete a minimum pre-lay of 6 mooring lines;
- Mobilise station keeping AHVs (3 off) to FPSO location (Haugesund, Norway);
- Commence tow of FPSO to field and complete station keeping trials on arrival infield;
- 3 off station keeping AHVs to manoeuvre FPSO onto target location, hook-up AHV to commence mooring line hand-over to FPSO (complete hook-up of all pre-laid mooring lines (minimum of 6 lines);
- Continue with deployment of mooring lines (as detailed in Section 2.4, Installation of Mooring Rope, Buoyancy and Top Chain – Option B – Installation of Mooring Rope, Buoyancy & Top Chain- Option B) with direct hook-up of the lines to the FPSO replacing the requirement to lay down on the seabed;
- Install all 12 mooring lines onto the FPSO;

- 3 off station keeping AHVs to demobilise;
- FPSO to perform mooring line tensioning & FPSO final positioning operation; and
- Hook-up AHV to complete as-left survey and demobilisation.

Hook-up of the above scenario is expected to take approximately 26 days. This is without weather or applying any optimisations. Note that taking the FPSO to the field prior to all 12 lines being installed will decrease the vessel day estimates for the pre-lay but increase for the FPSO hook-up.

2.6.2. Items Placed on the Seabed

Following (or immediately preceding) the FPSO arrival in field, any abrasion protection sand bags (if deployed) will be recovered.

2.6.3. FPSO tow and hook-up

The FPSO hook-up campaign will utilise multiple vessels.

- A Single hook-up AHV will be deployed to pick-up and cross haul the pre-laid mooring lines to the FPSO
    - Once the pre-laid mooring lines are connected to the FPSO the pre-lay vessel will continue with mooring line deployment / direct hook-up
- 3 off station keeping AHVs will be deployed to tow the FPSO to field and to perform infield station keeping duties. The estimated fuel use associated with the project vessels is shown in Table 2-10.

Table 2-10: Vessels and fuel use for FPSO Hook-up

Vessel type	Days in transit	Fuel use in transit (te/day)*	Days working	Fuel use working (te/day)*	Total fuel use (te)
Hook-up AHV	4	50	22	5	310
Tug	2	25	19	2.5	97.5
Station Keeping AHVs (3 of)	3 (9)	50	19 (57)	5	(735)
Total vessel fuel use for proposed operations					**1,142.5**
*Source: Institute of Petroleum, 2000					

Notes:

- The above table assumes 6 lines have not been pre-laid as detailed within Table 2-10.
- The above table does not account for weather downtime

2.7. Production Operation Activities

2.7.1. Production Profiles

Production profiles have been developed for the field, including existing and new wells (Tybalt, PAN-N, PAN-W, PAN-NW, PC04, C-Triassic, C-UpDip Brent, C-UpDip Triassic, DT-04, Rockhopper). The anticipated high case total production profiles for oil, gas and produced water are presented in Table 2-11 ~~Table 2-12~~.

Table 2-11: Forecast Production Values.

Year	Oil Production Rate (m³/d)	Gas Production Rate (km³/d)	Water Production Rate (m³/d)
2024	1,387	573	82
2025	5,405	2,747	165
2026	3,765	2,747	104
2027	2,667	2,200	82
2028	2,016	1,765	72
2029	1,617	1,510	67
2030	1,333	1,300	59
2031	1,124	1,115	60
2032	995	1,006	60
2033	896	921	60
2034	815	846	60
2035	745	777	60
2036	676	698	63
2037	616	643	40
2038	534	548	58
2039	509	490	73
2040	473	454	87
2041	443	15.1	87
2042	419	14.2	90

2.7.2. Process Overview

The Penguins production fluids (comprising a mix of oil, produced water, associated gas and lift gas) are transported through the subsea flow lines and onboard the FPSO via two risers (Figure 2-1). All wells will be produced under natural depletion with gas-lift available to enhance production rates.

The processing facilities are designed to meet the stated quality specifications for oil and gas export and produced water discharge to sea. Oil will be temporarily stored and exported via tanker offload. Gas will be compressed, dehydrated and exported through the gas export pipeline tied into the existing FLAGS pipeline system. Gas will also be used for gas lift, fuel gas and cargo tank blanketing. Water will be treated and discharged overboard. A simplified process flow diagram for the Penguins FPSO topside is provided in Figure 2-16, and a Penguins FPSO layout is provided in Figure 2-17 (Shell, 2017).

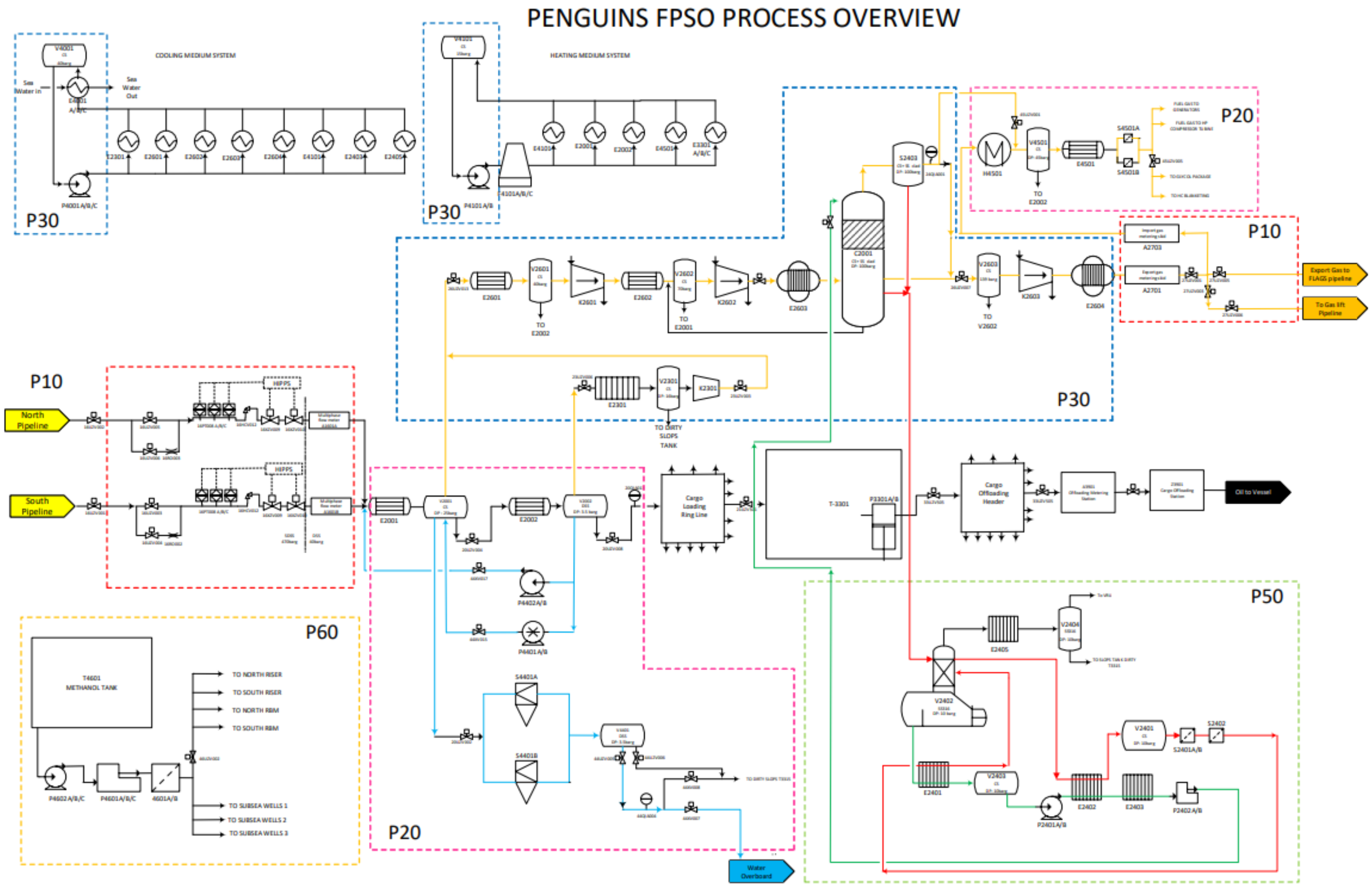


Figure 2-16: Penguins process flow diagram (topsides).

Figure 2-17: Penguins FPSO layout.

2.7.3. Oil Processing System, Storage and Offloading

The produced fluids will flow through the risers into the inlet heater before entering the 1st stage separator. Water and gas will be separated off with gas entering the gas processing system for fuel use or export into the FLAGS system to St Fergus. Produced water will enter the produced water system for treatment before discharge to sea.

Produced fluids will continue through the interstage heater to the 2nd stage separator. Stabilised crude oil from the 2nd stage separator will be pumped to the crude oil cooler. The crude oil will be stored in cargo tanks prior to offloading to shuttle tankers with North Sea Dynamic Positioning capability. Offloading will be carried out weekly in early production and will take approximately one day. After the early production phase (expected to last for the first 18 months), offloading will take place once every six weeks. The frequency of offloading will be proportional to the production rate.

Gas from the 2nd stage separator will enter the LP compression system before being fed into the High Pressure (HP) gas compression system where it will be used for fuel gas or exported into the FLAGS system.

Gas Processing System

The HP gas compression system comprises three stages of gas compression including the glycol contactor where moisture is removed from the gas stream to produce dry gas. Dry gas can then either be utilised as fuel gas, lift gas or exported into the FLAGS pipeline to St Fergus.

The Low Pressure (LP) gas compression system compresses gas from the 2nd stage separator and volatile organic carbons (VOCs) from the crude storage tanks allowing it to be fed back into the HP gas stream so it can be utilised as either fuel gas or exported.

Import gas will be used for fuel during times when produced gas is unavailable for start-up, gas-lift, fuel gas and gas blanketing.

2.7.4. Power Generation

Description of Combustion Equipment

A large combustion installation, for the purposes of the Offshore PPC Regulations 2023 (as amended), is any offshore oil or gas facility where the aggregated rated thermal input of the combustion equipment on the facility exceeds a threshold of 50 MegaWatt thermal (MW_{th}). This threshold applies to all operational combustion equipment.

The combustion equipment covered by the Penguins FPSO PPC permit is provided under the 'Description of equipment' table contained within the PPC SAT, along with details such as the maximum electrical rated output, the maximum thermal rating and the thermal efficiency. The process undertaken to select the Penguins combustion plant is described under the Best Available Techniques (BAT) Assessment (Shell, 2024), which is provided in the PPC SAT. In summary, the combustion equipment consists of:

- Three Taurus 70 Gas turbines for power generation (3 x ~~8.60~~ 7.3 MW;
- One Titan 130 turbine for driving the HP Compressor (15.9 ~~10~~ MW);
- One MTU emergency diesel generator (EDG) (1.95 ~~94~~ MW);
- Three MTU firewater pump diesel generators (3 x 2.32 ~~464~~ MW**);** and
- One Warstila inert gas generator (IGG).

The main power generation system for the FPSO will comprise of three gas turbine driven generators and an HP compressor turbine. All turbines installed for power generation will be capable of dual fuel (fuel gas and diesel).

Waste Heat Recovery Units (WHRUs), which heat circulating fluid (heating medium) by cooling down hot exhaust gases, have been fitted for the power generation turbines. The heating medium supplies the normal process heat duty to the FPSO topsides equipment and cargo storage systems. Combustion gases are discharged to the local environment through stand-alone discharge stacks (one per gas turbine) to ensure all components are dispersed and to enable maintenance of stand-by turbines without a facility-wide shut-down. Ports in the exhaust stacks are provided to enable sampling of effluent gases with a traversing probe.

The peak electrical power demand for the Penguins FPSO is estimated to be 8.35 ~~31~~ MW; this is the peak power during peak production and offloading operations ~~including offloading~~. The normal load during peak production, when not offloading, is 6.28MW. ~~Maximum normal and offloading off peak is 8.1 MW and will reduce to 7.7 MW during periods when there is no offloading~~ (Shell, 2024).

The emergency diesel generator will provide power to equipment such as radio and navigational equipment, emergency lighting, un-interruptible power source (UPS) and other life support systems.

The inert gas generator is not expected to run normally, but as a back-up for blanketing gas when fuel gas or the vapour recovery system is not available by providing a safe inert gas to maintain a slight positive pressure in cargo storage tanks during cargo oil offloading or during preparation for maintenance.

Fuel Supply

Fuel gas

Hydrocarbon gas produced from the Penguins wells will be treated in the FPSO topsides systems to provide de-hydrated and super-heated fuel gas to the installed combustion and utility systems:

- Fuel supply to the HP compressor power turbine;
- Primary fuel supply to gas turbine generators (GTGs);
- Blanketing gas for cargo tanks during offloading;
- Pilot gas and back-up purge gas for flare systems;
- Seal gas for HP compressor dry-gas seals during start-up or pressurized shutdown (with partial blowdown); and
- Stripping gas for the glycol regeneration system.

Fuel gas consumption is accurately metered, and turbine systems can determine the fuel characteristics to achieve optimal control of combustion. Solar's SoLoNOx™ dry low-emission combustion system controls are configured to prioritise low emissions. Fuel gas composition (Table 2-12) is expected to be stable, but some changes can be expected during the life of the development (Shell, 2024).

Table 2-12: Fuel Gas Composition.

Component	Mole (%)
Methane	~~72.200~~ 71.800
Ethane	13.21~~0~~
Propane	~~8.300~~ 8.420
Carbon Dioxide	~~2.500~~ 2.480
n-Butane	~~1.900~~ 2.110
Nitrogen	~~0.800~~ 0.780
i-Butane	~~0.700~~ 0.760
i-Pentane	0.200
n-Pentane	0.200
C6+	0.000
Water Vapour	0.000
Hydrogen Sulphide	0.000~~003530~~

Diesel

Low sulphur diesel conforming to the Marine Gas Oil ISO:8217, with a maximum Sulphur concentration of 0.1%, is transferred to the Penguins FPSO from supply boats. It is permanently stored in tanks for distribution and consumption when required. Diesel fuel is used to supply equipment that is not intended to be run continuously:

- Fire water pumps (A-7101A/A/B/C);
- Emergency diesel generator (A8401); and,
- Inert gas generator (A-~~8401~~6402).

Diesel fuel is also used as a back-up fuel source for gas turbines for infrequent events where enough super-heated fuel gas is not available e.g., during start-up or shut-down. Diesel is also supplied to life-boat stations for re-fueling. All diesel supply to the FPSO and consumption by combustion plant (i.e. gas turbine), is accurately metered.

Fuel Consumption

The estimated forecast for fuel gas and diesel consumption are presented in

Equipment / Fuel type	Power (kW) (Operating philosophy assumptions)	Running hours (h)	Fuel Gas rate (kg/h)	Diesel rate (kg/h)	Fuel gas (tonnes)	Diesel (tonnes)
2024						

Equipment / Fuel type	Power (kW) (Operating philosophy assumptions)	Running hours (h)	Fuel Gas rate (kg/h)	Diesel rate (kg/h)	Fuel gas (tonnes)	Diesel (tonnes)
GTGs / Fuel Gas	8,350 (Peak Normal & Offloading Load - 2 GTGs)	2,460	2,411.13	-	5,931.95	-
GTGs / Diesel	4,870 (Essential load)	3,420	-	1,906.01	-	6,518.1
HP / Fuel Gas	15,900 (Normal Shaft Power)	~~1,817~~ 2,172	3,451.~~70~~53	-	~~6,271.37~~ 7,496.72	-
EDG / Diesel	1,950 (peak load)	150	-	~~432.74~~ 434.60	-	~~64.91~~ 65.19
Fire Water Pump / Diesel	2,320 (peak load)	168	-	~~471.70~~ 434.60	-	~~79.25~~ 73.01
IGG / Diesel	N/A	750	-	192	-	144
Forecast totals					~~12,2023.82~~ 13,428.67	~~6,806.26~~ 6,800.3
2025						
GTGs / Fuel Gas	8,350 - Peak Normal & Offloading Load (2 GTGs)	6,833	2,411.13	-	16,474.75	-
GTGs / Diesel	4,870 (Essential load)	1,927	-	1,906.01	-	3,673.27
HP / Fuel Gas	15,900 (Normal Shaft Power)	~~6,833~~ 8,688	3,451.~~70~~53	-	~~23,584.80~~ 29,986.90	-
EDG / Diesel	1,950 (peak load)	150	-	~~432.74~~ 434.60	-	~~64.91~~ 65.19
Fire Water Pump / Diesel	2,320 (peak load)	168	-	~~471.70~~ 434.60	-	~~79.25~~ 73.01
IGG / Diesel	N/A	1,500	-	192	-	288
Forecast totals					~~40,059.55~~ 46,461.65	~~4,105.43~~ 4,099.47
2026						
GTGs / Fuel Gas	8,350 - Peak Normal & Offloading Load (2 GTGs)	7,268	2,411.13	-	~~17,523.01~~ 19,009.33	-
GTGs / Diesel	4,870 (Essential load)	~~1,420.44~~ 876	-	1,906.01	-	~~2,707.38~~ 1,669.67
HP / Fuel Gas	15,900 (Normal Shaft Power)	~~7,268~~ 8,688	3,451.~~70~~53	-	~~25,085.46~~ 29,986.90	-
EDG / Diesel	1,950 (peak load)	150	-	~~432.74~~ 434.60	-	~~64.91~~ 65.19
Fire Water Pump / Diesel	2,320 (peak load)	168	-	~~471.70~~ 434.60	-	~~79.25~~ 73.01

Equipment / Fuel type	Power (kW) (Operating philosophy assumptions)	Running hours (h)	Fuel Gas rate (kg/h)	Diesel rate (kg/h)	Fuel gas (tonnes)	Diesel (tonnes)
IGG / Diesel	N/A	1,500	-	192	-	288
Forecast totals					~~42,608.47~~ 48,996.23	~~3,139.54~~ 2,095.87

.

Table 2-13: Fuel use forecast (tonnes / year) (Shell, 2021).

Equipment / Fuel type	Power (kW) (Operating philosophy assumptions)	Running hours (h)	Fuel Gas rate (kg/h)	Diesel rate (kg/h)	Fuel gas (tonnes)	Diesel (tonnes)
2024						
GTGs / Fuel Gas	8,350 (Peak Normal & Offloading Load - 2 GTGs)	2,460	2,411.13	-	5,931.95	-
GTGs / Diesel	4,870 (Essential load)	3,420	-	1,906.01	-	6,518.1
HP / Fuel Gas	15,900 (Normal Shaft Power)	~~1,817~~ 2,172	3,451.~~70~~53	-	~~6,271.37~~ 7,496.72	-
EDG / Diesel	1,950 (peak load)	150	-	~~432.74~~ 434.60	-	~~64.91~~ 65.19
Fire Water Pump / Diesel	2,320 (peak load)	168	-	~~471.70~~ 434.60	-	~~79.25~~ 73.01
IGG / Diesel	N/A	750	-	192	-	144
Forecast totals					~~12,2023.82~~ 13,428.67	~~6,806.26~~ 6,800.3
2025						
GTGs / Fuel Gas	8,350 - Peak Normal & Offloading Load (2 GTGs)	6,833	2,411.13	-	16,474.75	-
GTGs / Diesel	4,870 (Essential load)	1,927	-	1,906.01	-	3,673.27
HP / Fuel Gas	15,900 (Normal Shaft Power)	~~6,833~~ 8,688	3,451. ~~70~~53	-	~~23,584.80~~ 29,986.90	-
EDG / Diesel	1,950 (peak load)	150	-	~~432.74~~ 434.60	-	~~64.91~~ 65.19

Equipment / Fuel type	Power (kW) (Operating philosophy assumptions)	Running hours (h)	Fuel Gas rate (kg/h)	Diesel rate (kg/h)	Fuel gas (tonnes)	Diesel (tonnes)
Fire Water Pump / Diesel	2,320 (peak load)	168	-	~~471.70~~ 434.60	-	~~79.25~~ 73.01
IGG / Diesel	N/A	1,500	-	192	-	288
Forecast totals					~~40,059.55~~ 46,461.65	~~4,105.43~~ 4,099.47
2026						
GTGs / Fuel Gas	8,350 - Peak Normal & Offloading Load (2 GTGs)	7,268	2,411.13	-	~~17,523.01~~ 19,009.33	-
GTGs / Diesel	4,870 (Essential load)	~~1,420.44~~ 876	-	1,906.01	-	~~2,707.38~~ 1,669.67
HP / Fuel Gas	15,900 (Normal Shaft Power)	~~7,268~~ 8,688	3,451.~~70~~53	-	~~25,085.46~~ 29,986.90	-
EDG / Diesel	1,950 (peak load)	150	-	~~432.74~~ 434.60	-	~~64.91~~ 65.19
Fire Water Pump / Diesel	2,320 (peak load)	168	-	~~471.70~~ 434.60	-	~~79.25~~ 73.01
IGG / Diesel	N/A	1,500	-	192	-	288
Forecast totals					~~42,608.47~~ 48,996.23	~~3,139.54~~ 2,095.87

2.7.5. Produced Water Treatment System

Produced Water Re-Injection (PWRI) was considered but was determined to be an unsuitable technique based on the stratigraphic, sedimentological, and structural configuration of the reservoirs combined with the produced water forecast for the redevelopment. The produced water which is separated from the produced oil and gas will be discharged overboard; this approach has been subject to a specific study to assess that the system represents BAT (Shell, 2019). The BAT report is attached in the OPPC SAT.

PW from the 1st stage separator is transferred to the Produced Water Treatment (PWT) system. A PW stream in the 2nd stage separator is also routed back to the 1st stage separator through the PW booster pumps.

PW first enters the PW hydrocyclones (S-4401 A/B) where oil is removed via centrifugal forces. The lighter oil phase migrates into the core and is removed from the PW stream and routed to either the dirty slops tank (T-3315) or clean slops tank (T-3314). Hydrocyclones consist of two vessels, each vessel is supplied with liners to handle 50% of the package capacity based on 10,000 BWPD case requirement. However, considering normal operation with low water flowrates to V-2001, one vessel is enough to process the produced water, thus, initial configuration of S-4401A/B is one duty with the other one on standby. When water break-out occurs, both hydrocyclones will be on duty.

The produced water can be routed two ways:

- Direct overboard via the Overboard Caisson North discharge. This is the primary route.
- To the slops tanks, then discharged overboard via Overboard Caisson North. The slops tank enables additional residence time for further separation prior to discharge. This is the route for off-spec water.

- A batch overboard method will be used when the treatment of produced water to remove oil takes place between batches via the slops tank

Produced water will be discharged to sea via north overboard water caisson. A sample point has been installed on the outlet of V-4401 (Degasser). All produced water will be metered before discharge to sea. Off-spec produced water will be routed to the slops tanks for oil recovery and water disposal through the FPSOs open drains system, as a batch discharge, rather than continuing to overboard discharge.

Drain and Slops Systems

The open drains are gravity based atmospheric drains collecting surface waste liquids. The FPSO topside is divided in two: the non-hazardous accommodation and utility areas and the hazardous process area. The FPSO topsides open drainage system consists of segregated non-hazardous and hazardous drainage areas. A coalescer package A-5602 is also installed to treat water from hazardous open drains tank prior to discharge to sea.

Open Non-Hazardous

The open non-hazardous drainage system provides drainage to areas designated non-hazardous, including rainwater, green water, fire water, wash water, and maintenance residues and spills. These areas are segregated from all other drainage systems to prevent the possibility of contamination from other drainage systems. Drainage into this system is via open gullies, drip pans, floor drains and a tundish for instrument drains.

The collected liquid flows by gravity into the non-hazardous open drain tank (T-5601) which has an internal plate pack. Water is discharge from T-5601 to the overboard Caisson via an effluent monitoring system comprising of on-line OIW analyser and a flowmeter. Water from T-5601 is expected to have an oil concentration below the average of 40 mg/l. If the OIW content is greater than the overboard effluent limit, it is routed to the hazardous open drain tank (T-5602) for further treatment.

The tank has an oil compartment which collects the separated oil from water. The Non-Hazardous Open Drain Pump will be used to empty the oil compartment to the Dirty slop tank T-3315.

Open Hazardous

The open hazardous drains system provides drainage from those areas which are designated hazardous (process area and main deck). The drainage from hazardous areas shall be completely segregated from any other drainage system to eliminate the risk of hydrocarbon vapour transmission to other areas.

The open hazardous drains system handles liquids collected from decks, drip pans, main deck gullies and tundishes in hazardous areas. Open hazardous drain systems shall also be used for draining residual hydrocarbon liquids from equipment via tundishes after the majority of the liquid hydrocarbons from the equipment have been transferred to other process systems and the equipment is completely depressurised. The collected liquid flows by gravity into the hazardous open drain tank (T-5602).

T-5602 has an internal plate pack, which is a corrugated plate interceptor designed to separate oil and water. Any oil is re-cycled to the dirty slops tank for transfer to cargo storage through the slop tanks.

Water from T-5602 is expected to have an oil concentration of below the average of 40 mg/l. If OIW is greater than this limit; it is routed to A-5602 (the drain and slop filter coalescer package) for further treatment. On-spec water from A-5602 is routed overboard; and the oil reject is routed to dirty slop tank T-3315. If the water treated from A5602 is not under the specified limit; it is routed T-3315 (dirty slops tank).

2.7.6. Flare System

Consideration was given whether to use a conventional open header flare system or a closed header flare system. Both options would include a Vapour Recovery Unit. The permanent availability of a clear flow path in the event of a major relief scenario was considered a significant advantage in supporting the selection of the open flare system.

The flare system will be divided into two separate streams, HP releasing hydrocarbons above 10 barg pressure and LP releasing hydrocarbons from sources with a pressure less than 10 barg. There will be no routine flaring under steady state operations.

2.7.7. Inert Gas System

On the Penguins FPSO, cargo tank pressure control is normally achieved by recovering and compressing hydrocarbon gas (during cargo loading) and by adding fuel gas (when cargo offloading). The inert gas generator is not expected to run normally and provides a back-up for blanketing gas when fuel gas or the vapour recovery system is not available. The inert gas generator can also be used to displace hydrocarbon gas from cargo tanks prior to maintenance. Any combustion gases from the inert gas generator are ultimately discharged to the environment via the cargo tank vent stack. Combustion gases are diverted to a blow-off line in the package during start-up and through a vent line between the inert gas generator and inert gas deck seal during a shutdown.

2.7.8. Chemicals

The need for production chemicals is defined by the technical risks identified at the initial stages of the project. While some risks are well known for Penguins, others are less defined and will only become known once the field is in production.

Specialist chemicals are used during production to maintain process efficiency. Depending on their properties these chemicals will partition between the oil and the water in the process. The reaction products and residual chemicals from those that partition to the water phase will be released to the marine environment with the produced water discharge.

Chemicals used during production operations include the following:

- Hydrate inhibitors
- Corrosion inhibitors
- Scale inhibitors

Chemicals will also be used to maintain pipelines and ensure pipeline integrity, including biocides and oxygen scavengers.

The Penguins washwater system mixes seawater with process fluids. There are well known risks associated with this operation and production chemicals are needed to inhibit corrosion and scale.

Since the original subsea carbon steel flowlines will be re-used for the field re-development, the flowlines will need to be protected from CO_2 corrosion using a corrosion inhibitor chemical. This is inline with the original development. The corrosion inhibitor system will be designed to deliver corrosion inhibitor to the drill centre manifolds.

It is difficult to predict how the process separation system will initially perform therefore some production chemicals have been chosen for contingency purposes – demulsifier, deoiler, H_2S scavenger, oil antifoam, glycol antifoam & glycol pH adjuster. If the need arises then these chemicals will be deployed to optimise process operations and meet product export and discharge specifications. However, it is possible that these chemicals will not be needed and will be removed from the chemical permit.

Chemical Selection

The production chemicals have been selected with a focus on HSE attributes as well as technical performance at minimal concentrations and in field optimisation will also take place.

Chemical selection is undertaken to identify the most environmentally acceptable chemical with the required technical performance.

All chemicals used during will be approved under the Offshore Chemical Regulations 2002 prior to use and discharge to sea. Where possible the use of chemicals will be minimised or eliminated altogether.

Chemical awareness training will be provided to staff and contractors to include chemical management, storage and handling offshore and chemical permitting requirements.

Measures have been established for the Penguins to minimise impacts as far as reasonably practicable.

Corrosion

Corrosion can occur under deposits, in crevices, weld points and in local high velocity areas including production and export flowlines. A suitable corrosion inhibitor will be continuously injected subsea to the Penguin manifolds to protect the carbon steel pipelines against carbon dioxide (CO_2) corrosion. A high initial concentration of corrosion inhibitor is required at the point of injection to ensure that there is enough residual chemical to maintain material integrity along the entire length of the flowline and mitigate against the cumulative effects of adsorption/desorption with distance from the chemical injection point.

Additionally, an oxygen scavenger will be continuously injected into the wash water system when in use, e.g. methanol washing of cargo oil during start-up. It is dosed to achieve an effective concentration in the wash water. It is applied to reduce the oxygen content of the wash water and reduce the risk of corrosion.

Separation

Separation of the oil, gas and water within the separators is dependent primarily upon fluid inlet temperature and the residence time of the fluids in the vessel. Due to a high oil to water ratio creating a stronger emulsion within the produced fluids, combined with other operational issues specific to an FPSO such as weather conditions, separation requires to be further enhanced by the injection of a demulsifier, upstream of the 1st stage separator. Additionally, an antifoam chemical that prevents formation of foam in crude oil will be applied. Foaming can cause inefficiency in crude separation, i.e. large quantity of liquid carry-over in gas stream and gas carry-over in liquid stream. Therefore, a suitable chemical will be injected upstream of the 1st stage separator at the inlet of the heater.

Scale

Due to the operation of the wash water package, a scale inhibitor will be continuously injected into the wash water system when in use, e.g. methanol washing of cargo oil during start-up. It is dosed to achieve a concentration in the water stream (wash water and produced water) sufficient to prevent the formation of barium sulphate scale when mixing seawater with produced water. Injection rates for the scale inhibitor are determined following a multi-tier assessment, including initial laboratory experimentation, manufacturer recommendations, and in-field data collated on the rate and severity of scale build up within the process system.

Hydrogen Sulphide

An H_2S (hydrogen sulphide) scavenger will be continuously injected into the gas stream, off the 1st stage separator. It is required to reduce the H_2S concentration of the gas to meet export quality specification.

Bacteria Control

Biocide will be applied to various areas of the process to control the growth of sulphate reducing bacteria and therefore prevent souring of the produced fluids and bio-fouling.

Specifically, biocide is administered into the Slops Vessels as well as the wash water system via batch treatment on a periodic basis. The use of biocide reduces the threat of microbial activity in the applicable systems and reduces the risk of microbial induced corrosion and H_2S generation.

Gas Treatment Chemicals

The gas produced from the main production separator will be saturated with water vapour, the amount depending on pressure and temperature. To remove this water prior, the gas is passed through a glycol contactor where the lean glycol absorbs the water vapour, thus drying the gas. As this glycol system is effectively a closed loop system, the glycol is then reheated above 100°C to drive off the absorbed water vapour and any engrained hydrocarbons. The pH control, to ensure that the system operates in the correct pH range of 7-8 to prevent corrosion, is achieved by the use of pH adjusted glycol.

Hydrates

Methanol is a thermodynamic gas hydrate inhibitor which is used to suppress the formation of gas hydrates upon cold start-up of wells. It will be batch dosed to the required subsea wellheads, typically when known hydrate producing wells are brought back into production after a shutdown period. It is also injected for pressure equalization for the riser emergency shut down valve and subsea isolation valve.

Utility Chemicals

Glycol and pH buffered glycol is used within the cooling system to increase the safe operating temperature range and increase the thermal conductivity of the media. Acidic compounds can be formed due to the thermal decomposition of the glycol within the systems, so buffering the glycol pH to alkaline levels reduces the risk of acidic corrosion. As the system operates above 100°C there are small evaporative losses on value actuations and a requirement for top-up to correct deficiencies in the glycol/water mix strength.

A corrosion inhibitor is required to maintain integrity. A nitrite based inhibitor is used where corrosion protection is provided by a protective “barrier” film that is formed by a chemical reaction between nitrite and the metal surfaces. There is a requirement for the occasional “top-up” when the corrosion inhibitor drops to the minimum inhibitor concentration.

Chemical Tracking

Penguins utilises chemical trackers to record the type of chemical used, quantities used and quantities discharged to the marine environment. Chemical use and discharge must be recorded and should not exceed the permitted allowances. The chemical tracker allows chemicals to be tracked for their specific use and/or discharge rather than the total quantity permitted.

Chemical trackers contain the following information (as a minimum):

- Name of chemical and chemical supplier (each permitted chemical relating to each process)
- Permitted amount of use (in kg)
- Permitted amount to discharge (in kg)
- Actual amount used and discharged (in kgs)

EmTrax is a cloud based auditable software with multi-user functionality which supports compliance with the Offshore Chemical Regulations and the facility production chemical permit. It is an online chemical tracking system tool that is used widely in industry to record, track and monitor offshore production chemicals against the approved chemical permit. EmTrax is ‘linked’ to the UK Energy Portal so it tracks against the latest approved chemical permit from the Regulator. Where more than 1 application of a chemical is required, these have separate entries in EmTrax for recording purposes.

EmTrax has a visual and email warning system to alert users when chemical use and / or discharge is nearing or has exceeded permitted limits. The defined thresholds are:

- Amber: ≥80% to ≤89%
- Purple: ≥90% to ≤99%
- Red: ≥100%

Accidental Release/Spill Reporting

Unintended releases to sea are considered to be a spill and must be reported to the Regulator utilising the IRS system as described on the Oil Pollution Emergency Plan (OPEP). The PON1 must be submitted within 6 hours of detection of the release.

This applies to chemicals (soluble in water) released through an open drainage system. Open drains systems must not be used as a means of disposing unused chemicals.

2.8. Decommissioning

Decommissioning will be carried out in compliance with national legislation and international agreements in place at the end of field life. Agreement to CoP will be sought from the regulator as a pre-requisite for approval of the decommissioning programme. Consideration has been made in the design and construction of the development to matters that will facilitate decommissioning of the field facilities.

It is anticipated that the FPSO will be towed off field for reuse elsewhere, or for recycling. The mooring lines will be fully removed. The piles will be cut below the seabed and the cut section will be removed but the lower sections are expected to be left in place.

3. ENVIRONMENTAL BASELINE

This section outlines the main environmental sensitivities in the area that could be impacted by the proposed operations.

The receptors considered are:

- Physical environment;
- Plankton;
- Habitats;
- Benthos;
- Fish and shellfish;
- Marine mammals;
- Seabirds;
- Protected sites and conservation features;
- Socio-economic environment; and
- The National Marine Plan (NMP).

The potential impacts on these receptors are discussed in Section 4.

This EAJ has been updated to reflect most recent changes in baseline data.

3.1. Environmental Surveys

Where applicable, the following environmental surveys have been used to inform the environmental baseline:

- Penguins FPSO Redevelopment Environmental Baseline Survey Report (Fugro, 2018a). An integrated shallow geophysical and ultra-high resolution multichannel seismic data acquisition. Completed within a 11.3 km x 16.1 km greater working area covering Penguins – site within Blocks 211/13a and 211/14;
- Penguins Redevelopment and Rig Site Survey - Habitat Assessment Report (Fugro, 2018b). Thirty-three grab samples, twenty-three drop-down camera stations and twenty-one drop-down camera transects were conducted. Provides information on environmental sensitivities potentially occurring in the area and details seabed characteristics for the placement of the new proposed FPSO;
- Penguins Redevelopment Survey Marine Mammal Observer Report (Fugro, 2017);
- Penguins FPSO Project – Habitat Assessment Desktop Study (Fugro, 2014). Historical geophysical data, collected in 2011, was analysed in association with ROV video data collected in 2005, to map and identify the habitats which occur in the Penguins site. This survey was used as a source of extra data to inform the environmental baseline – i.e. to identify any big differences in collected data which has occurred over time.

3.2. Physical Environment

3.2.1. Currents and Tides

The general pattern of water movement in the North Sea is driven by a combination of tides, winds, density gradients (caused by freshwater input) and pressure gradients (DECC, 2016). The waters of the NNS are influenced by three main water masses. The upper few hundred metres are dominated by the warm, saline water of the Norwegian Atlantic Current while deeper water depths are influenced by the bottom waters formed in the adjacent Arctic and Greenland Seas (DECC, 2016).

The current regime in the NNS is dominated by two main Atlantic inflows; the first flows around the north of Shetland, following the eastern boundary before flowing southwards along the western edge of the Norwegian Trench while the other input, the Fair Isle Current, flows south of Shetland, following the 100 m contour. The circulation in the centre of this area is variable and typically governed by the wind (DECC, 2016).

According to the National Marine Plan Interactive (NMPi) map the mean spring tidal range within the Penguins area (Blocks 211/13 and 211/14) range from 1.1 – 2.0 m, and the annual mean significant wave height within the area ranges between 2.71 – 3.00 m (Scottish Government NMPi).

3.2.2. Bathymetry

Water depths throughout the North Sea are variable with a general increase in depth from the west to the east. The seabed at Penguins is generally flat with isolated evidence of relict iceberg plough-marks and depths ranging from 152 m Lowest Astronomical Tide (LAT) to 227 m LAT (Fugro, 2018b). Figure 3-1 shows the survey area bathymetry overlain with completed survey transects. The water depth in the proposed well locations ranges from 162.0 to 170.3 m LAT.

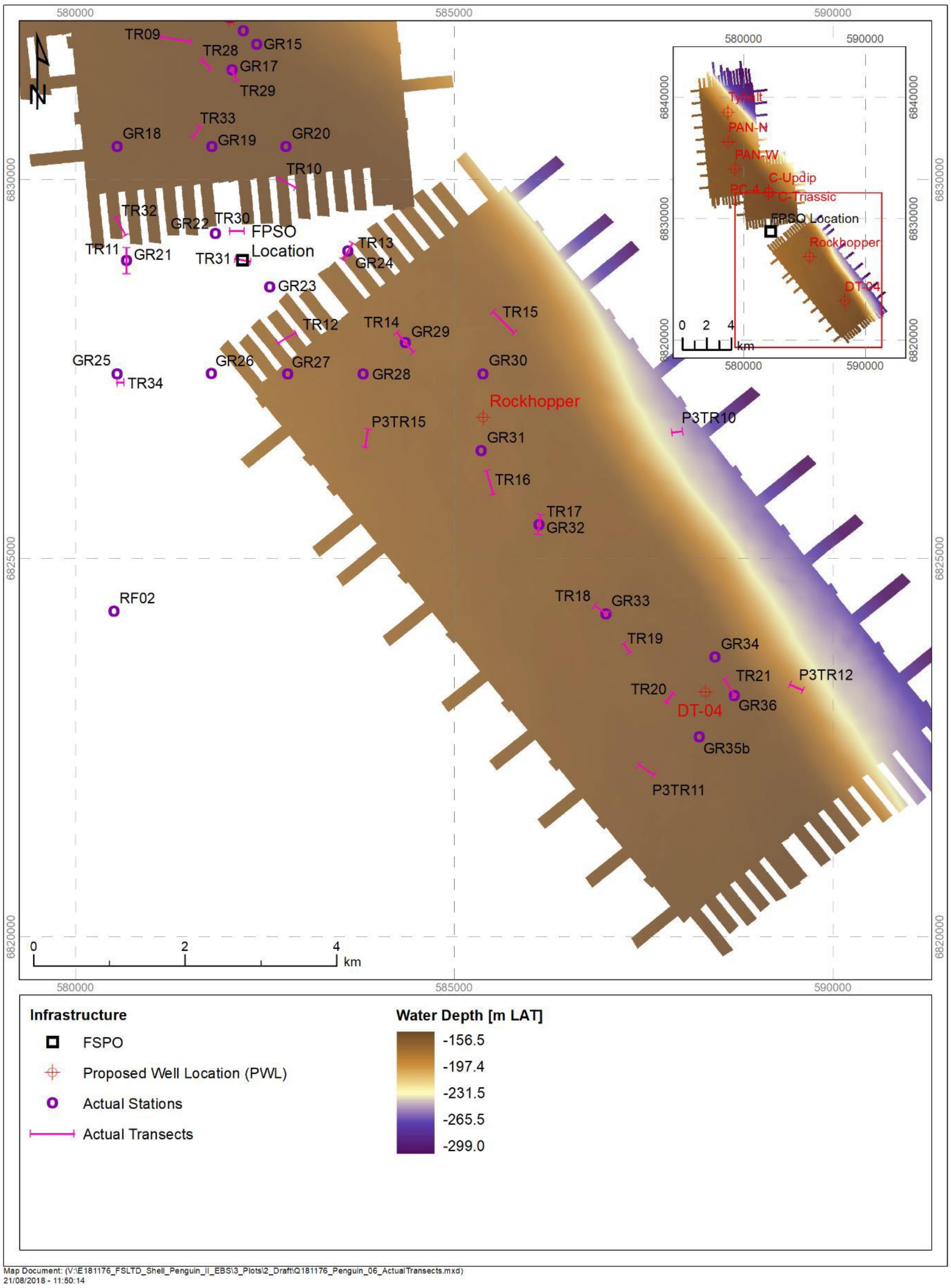


Figure 3-1: Survey area bathymetry and environmental survey locations in the Penguins area (Fugro, 2018b).

3.2.3. Seabed Sediments

The characteristics of the local sediments and the amount of sediment transport within a project area are important factors in determining the potential effects of possible developments (drill cuttings, installation of pipelines, anchor scouring) on the local seabed environment. Sediments in the North Sea are composed mostly of sand, gravel and muds (DECC, 2016). Sandy sediments occur within a wide range of water depths in the NNS, with significant regional variations in grain size, sorting and carbonate content. These reflect the spectrum of environments, from relatively high energy around Orkney and Shetland where there are sources of carbonate material, to areas of low energy further offshore where there is relatively little sediment input (DECC, 2016).

A review of seabed photography showed that most of the Penguins area comprised gravelly sand with varying proportions of shell accumulations, pebbles, cobbles and boulders, as shown in Figure 3-2. The sediment type was identified as one main biotope complex with two secondary biotope complexes (Table 3-1). The main European Nature Information System (EUNIS) biotope complex was 'circalittoral coarse sediment' (A5.14), with the two smaller areas being classified as 'circalittoral fine sand' (A5.25) and 'industrial waste' (J6.5) (Fugro, 2018a). This is similar to sediment samples which were obtained in earlier surveys in the area (Fugro, 2014).

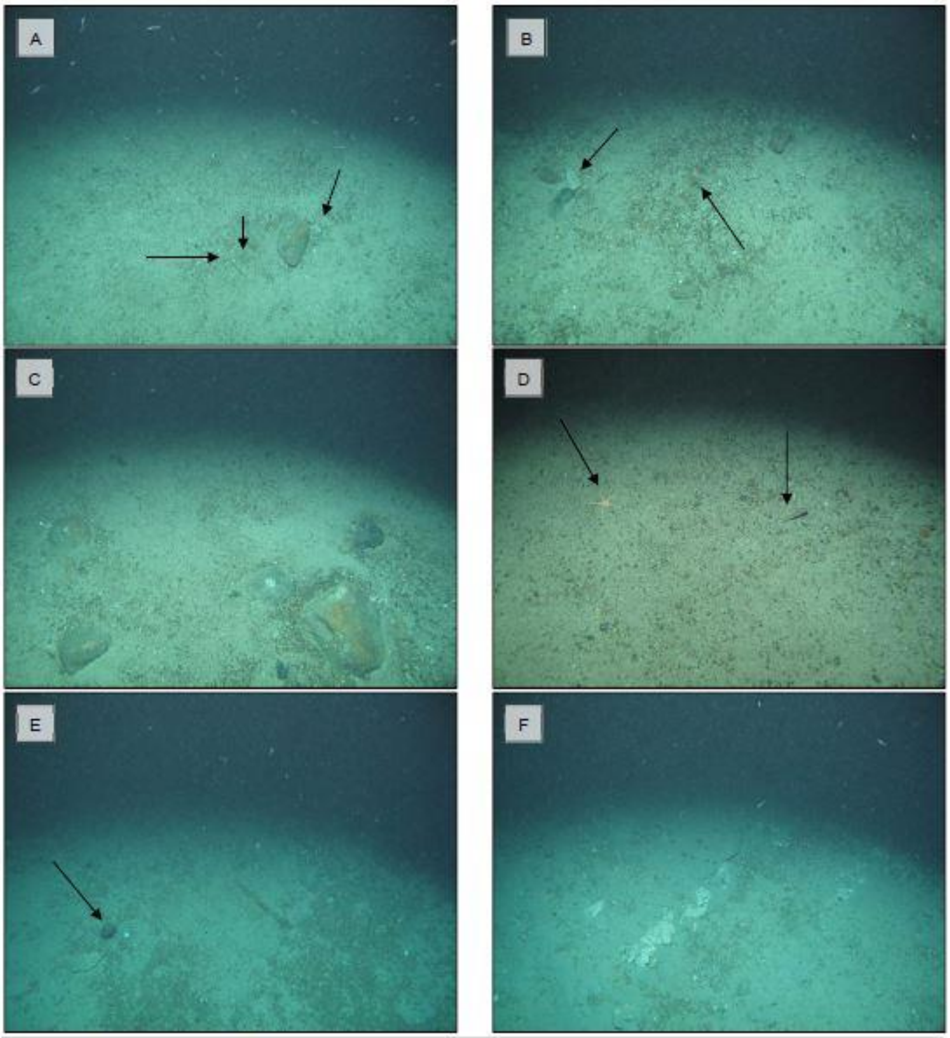


Photo A	TR16; Coarse mixed sediment with fish (*Trisopterus esmarkii*), calcareous worm tube cluster (*Salmacina dysteri/Filograna implexa*), and urchin (*Gracilechinus acutus*)
Photo B	TR16; Coarse mixed sediment with starfish (Asteroidea) and sponge (Porifera, possible *Phakellia* sp)
Photo C	TR17; Coarse mixed sediment with cobbles and boulders. Sponge and bryozoan crusts present
Photo D	TR17; Coarse mixed sediment with brittlestar (Ophiuroidea) and small fish (*Trisopterus esmarkii*)
Photo E	TR18; Coarse mixed sediment with burrowing anemone (Cerianthidae)
Photo F	TR18; Shallow clay ledging projecting from the coarse mixed sediment overlay

Figure 3-2: Seabed sediment and fauna observed at Penguins (Fugro, 2018b).

Table 3-1: Habitat classification Hierarchy: EUNIS Biotopes present in the Penguins area are shaded (EUNIS, 2018).

EUNIS Habitat Classification				Connor *et al*. (2004) classification
Environment (Level 1)	**Broad Habitat (Level 2)**	**Habitat Complex (Level 3)**	**Biotope Complex (Level 4)**	
Marine (A)	Sublittoral sediment (A5)	Sublittoral coarse sediment (A5.1)	Circalittoral coarse sediment (A5.14)	Circalittoral Coarse Sediment SS.SCS.CCS
		Sublittoral sand (A5.2)	Circalittoral fine sand (A5.25)	Circalittoral Mixed Sediment SS.SSa.CFiSa
	Waste Deposits (J6)	Industrial Waste (J6.5)	-	-

Sediment Contaminants

Sediment contaminants in the Penguins area were analysed in the 2018 environmental baseline survey (Fugro, 2018a). Total Organic Carbon (TOC) values were low and indicated low variability which were strongly correlated to finer sediments. Metal concentrations demonstrated low to high variability across all stations sampled with levels higher than the Effects Range Low (ERL) values for chromium at stations GR19 and GR28. The Background Concentration (BAC) levels for the NNS were exceeded for arsenic, cadmium, chromium, copper, nickel, lead and zinc at a number of stations. Positive correlations were noted between most metals and fine sediments (Fugro, 2018a).

Samples from the 2018 survey showed that Total Hydrocarbon Concentrations (THC) varied across the Penguins area. The majority of the THC values recorded across the Penguins Field were considerably lower than the Predicted No Effects Concentration (PNEC) of 50 μgg^{-1} (OSPAR Commission, 2002) and below the NNS mean Background Concentration (BAC) (10.82 μgg^{-1}) and 95th percentile (20.32 μgg^{-1}) values (UKOOA, 2001; Fugro, 2018a). The only exception to this was station GR33 which recorded 47.1 μgg^{-1} (Figure 3-3). This peak in THC was likely a result of the proximity to the abandoned well 211/14-1.

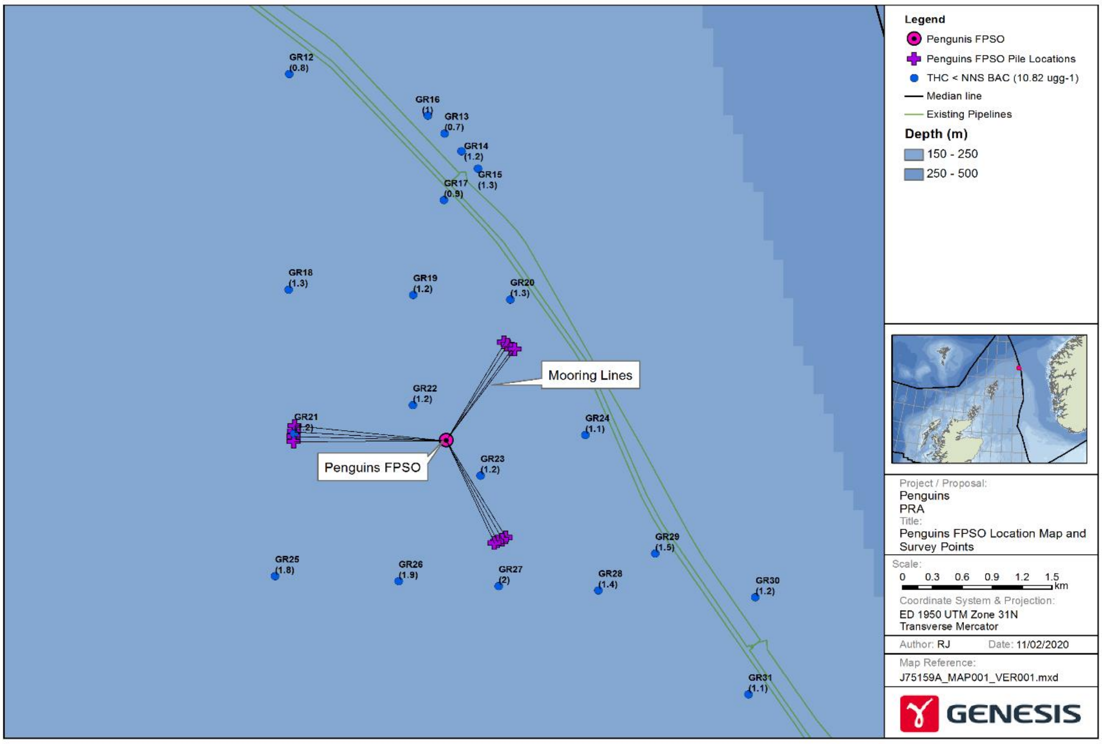


Figure 3-3: THC levels at stations in the vicinity of the Penguins FPSO mooring chains/piles (Fugro, 2018a).

3.3. Biological Environment

3.3.1. Plankton

Plankton forms the basis of marine ecosystem food webs with many species of larger animals such as fish, birds and cetaceans dependent upon the plankton for food. Densities of plankton fluctuate during the year. Sunlight intensity and nutrient availability are the primary factors affecting abundance and productivity, and these are ultimately affected by water column stratification (DECC, 2016).

The phytoplankton community is dominated by the dinoflagellate genus Ceratium (*C. fusus, C. furca, C. lineatum*), along with higher numbers of the diatom, Chaetoceros (subgenera *Hyalochaete* and *Phaeoceros*) (DECC, 2016). The zooplankton community comprises *C. helgolandicus* and *C. finmarchicus* as well as *Paracalanus spp., Pseudocalanus spp., Acartia spp., Temora spp.* and cladocerans such as *Evadne spp* (Pikesley *et al.* 2014).

3.3.2. Seabed Habitats

The Penguins area has been highlighted as an area of potential Annex I stony reef habitat, however, from the recent surveys it was considered that the substrate observed did not fulfil the criteria for Annex I stony reef. No Annex I or OSPAR listed habitats were identified from either the geophysical or photographic data in the Penguins area.

3.3.3. Benthos

Benthic species correlate with various sediment types within the NNS. The Penguins Field (as discussed in Section 3.2.3) features the EUNIS biotope complex 'circalittoral coarse sediment' (A5.14). The 2018 surveys found that increased species richness was associated with cobble clusters and boulders. A total of 10,544 individual animals were identified in the data, of which 6198 (59%) were annelids, 2258 (24%) were molluscs, 746 (7%) were arthropods, 119 (1%) were echinoderms and 923 (9%) were other phyla (Fugro, 2018a). The most abundant taxa were also some of the most dominant. The mollusc *Limatula gwyni* was the most dominant and abundant taxon, whereas the annelid *Galathowenia oculata* was the third most dominant and most abundant taxon. *L. gwyni* was the most abundant taxon in 17 stations whereas *G. oculata* in 11 stations.

Moreover, the most commonly observed benthic fauna included sea urchins (*Spatangus sp*. and *Gracilechinus acutus*), starfish (*Anseropoda placenta*, *Porania pulvillus, Astropecten irregularis, Asterias rubens, Luidia ciliaris* and *Luidia sarsi* and possible *Stichastrella rosea*) (see Figure 3-4), anemones (*Actiniaria, Parazoanthus anguicomus, Cerianthidae* and *Bolocera tuediae*), polychaetes (*Serpulidae*), hermit crabs (*Paguroidea)*, squat lobsters (*Munida sp*), shrimps (*Eucarida*), sponges (*Porifera*) and sea cucumbers (*Parastichopus tremulus*) (Fugro 2018a; Fugro 2018b).

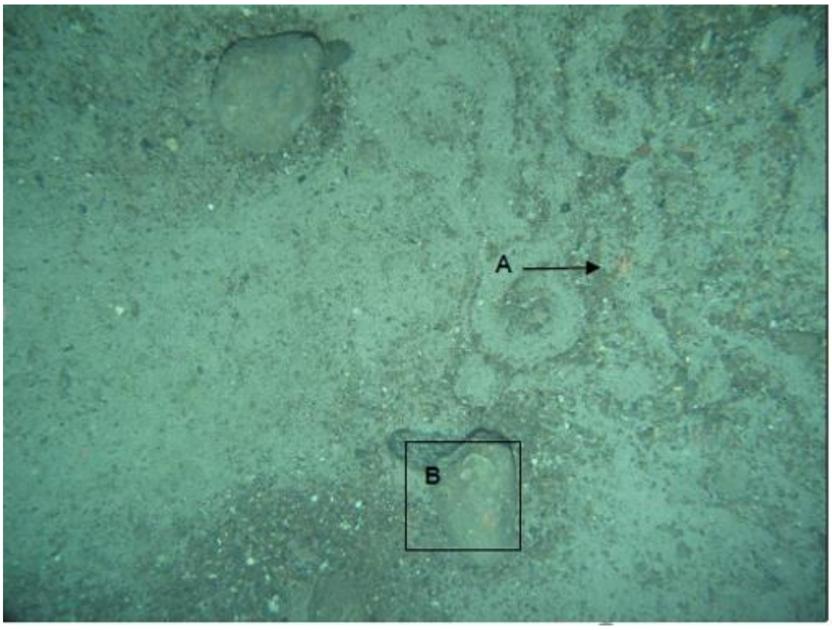
Photograph:
173036_PENG_GR001_02

Easting: 578 338.0 mE
Northing: 6 838 726.0 mN
Depth: 170 m

Sediment Type:
Gravelly sand with shell debris

Fauna:
A: Starfish (*Porania pulvillus*)
B: Sea urchin (*Gracilechinus acutus*)
C: Sea snail (Buccinidae)

Figure 3-4: Example of sediment type and associated benthic species from station GR001 (Fugro, 2018b).



Photograph:
173036_PENG_TR27_11

Easting: 581 923.0 mE
Northing: 6 832 258.0 mN
Depth: 169 m

Sediment Type:
Gravelly sand with shell fragments and occasional cobbles

Fauna:
A: Starfish (possible *Stichastrella rosea*)
B: Encrusting sponge (Porifera)
Faunal turf and tracks

Figure 3-5: Example of sediment type and encrusting sponge from transect TR27 (Fugro, 2018b).

Overall, diversity was relatively high across the Penguins Field with low variation observed with the macrofaunal community primarily dominated by annelids. That said, the diversity at station GR15 was significantly lower than all other diversity values due to the presence of large numbers of the polychaete *Filograna implexa* at this station. Moreover, the Priority Marine Feature (PMF) white cluster anemone (*Parazoanthus angicomus*) was observed within the survey area at Penguins at grab station GR27 and three other transect locations (TR12, TR13 and TR14). However, it should be noted that this species is not considered to be under threat or in decline in Scottish waters (Tyler-Walters *et al*., 2016).

Sponge aggregations encountered during the most recent survey (Fugro, 2018a; Fugro, 2018b) were assessed to determine whether they could be classed as the OSPAR 'Threatened and/or Declining Species and Habitats' deep sea sponge aggregations. During the survey, sponges were infrequently observed on the video footage across the area (Fugro, 2018b). Based on criteria outlined by Det Norske Veritas (DNV, 2014 as cited in Fugro, 2018b) and Norwegian environmental monitoring guidelines (NEA, 2015 as cited in Fugro, 2018b), the density of sponges falls under the category of 'no sponge/single specimen' (<1% cover) for most of the survey area. There were small patches (< 25 m^2) where the density increased to the 'scattered' category (1% to 5% cover), however, the percentage cover and size of the patches does not qualify as the OSPAR 'deep-sea sponge aggregations' habitat (Fugro, 2018b).

Recent surveys undertaken in the Penguins area did not identify any Annex I Habitats.

Priority Marine Features

The Scottish Natural Heritage (SNH) (now NatureScot) and the Joint Nature Conservation Committee (JNCC) have developed a priority list of 81 habitats and species considered to be of conservation importance in Scottish waters. This list underpins the Scottish Government's Marine Nature Conservation Strategy where respective aims and objectives are set out in order to protect and enhance marine biodiversity (JNCC, 2014a).

The sediment classified during the recent surveys conducted around Penguins fall within the broad habitat PMF 'offshore subtidal sands and gravels', however, this is not thought to be of conservation significance for the Penguins area as the sediment type is widely distributed and is represented elsewhere within the Scottish Marine Protected Area (MPA) network. See Section 3.4 for further information regarding protected areas.

A review of the photographic and video data revealed sporadic numbers of the white cluster anemone (*Parazoanthus anguicomus*). This is a PMF low or limited mobility species usually found at depths between 20 m to 400 m and normally found in the presence of encrusting sponges, worm tubes, corals and stone. It was found throughout the survey area, with higher densities found on transects P3TR02 and P3TR04 (closest to the Tybalt well location) attached to stones or anthropogenic debris present in the area. The white cluster anemone is likely to be relatively widespread but under-recorded in deep waters. It is not considered to be under threat or in decline in Scottish waters (SNH, 2016).

3.3.4. Fish and Shellfish

More than 330 fish species inhabit the shelf seas of the UKCS (Pinnegar *et al.,* 2010). Finfish species can broadly be divided into pelagic and demersal species. Pelagic species (e.g. herring, mackerel, blue whiting and sprat) are found in mid-water and typically make extensive seasonal movements or migrations. Demersal species (e.g. cod, haddock, sandeels, sole and whiting) live on or near the seabed and, similar to pelagic species, are known to passively move (e.g. drifting eggs and larvae) and/or actively migrate (e.g. juveniles and adults) between areas during their lifecycle.

The Penguins Field lies within the International Council for the Exploration of the Sea (ICES) Rectangle 52F1. Spawning and nursery grounds which occur in 52F1, along with potential juvenile presence, are outlined in the Environmental Considerations section of the Master Application Template (MAT), Identified spawning grounds for haddock, saithe and Norway pout are known to occur in the area (Coull *et al.* 1998; Ellis *et al.*, 2012). Aires *et al.* (2014) have also identified the presence of juvenile Norway pout, blue whiting, hake and anglerfish. Additionally, Ellis *et al.* (2012) found low density nursery grounds for cod, spurdog, tope shark, herring, European hake, ling, mackerel, anglerfish, plaice, sandeel, spotted ray, common skate, thornback ray, and blue whiting. Low intensity spawning grounds were also noted for cod, plaice and sandeel.

Only those with high spawning and nursery identified by Ellis *et al.*, (2012) are included in Table 3-2 and the associated MAT. Of the species listed, saithe, Norway pout, blue whiting, and anglerfish are Scottish PMFs (Tyler-Walters et al., 2016).

Table 3-2: Spawning and nursery activity for a selection of fish species within ICES rectangle 52F1.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anglerfish [3]	J	J	J	J	J	J	J	J	J	J	J	J
Blue whiting [1] [2] [3]	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Haddock [2]		S*	S*	S*	S							
Hake [3]	J	J	J	J	J	J	J	J	J	J	J	J
Norway Pout [2][3]	SNJ	S*NJ	S*NJ	SNJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Saithe [2]	S*	S*	S	S								

Key:
S: Spawning, S*: Peak Spawning, N: Nursery, J: Juveniles (i.e. 0 group fish) [3]
red highlighting indicates high intensity nursery grounds[1]
Sources:
[1] Ellis *et al.* (2012) [2] Coull *et al.* (1998) [3] Aires *et al.* (2014)

The North Sea Transition Authority (NSTA) (formerly the Oil and Gas Authority (OGA)) has published guidance (Other Regulatory Issues; OGA, 2019) which includes advice from government departments and external agencies on seasonal concerns for fish spawning in relation to offshore activities. Marine Scotland has indicated a period of concern from January to May in both blocks for seismic surveys.

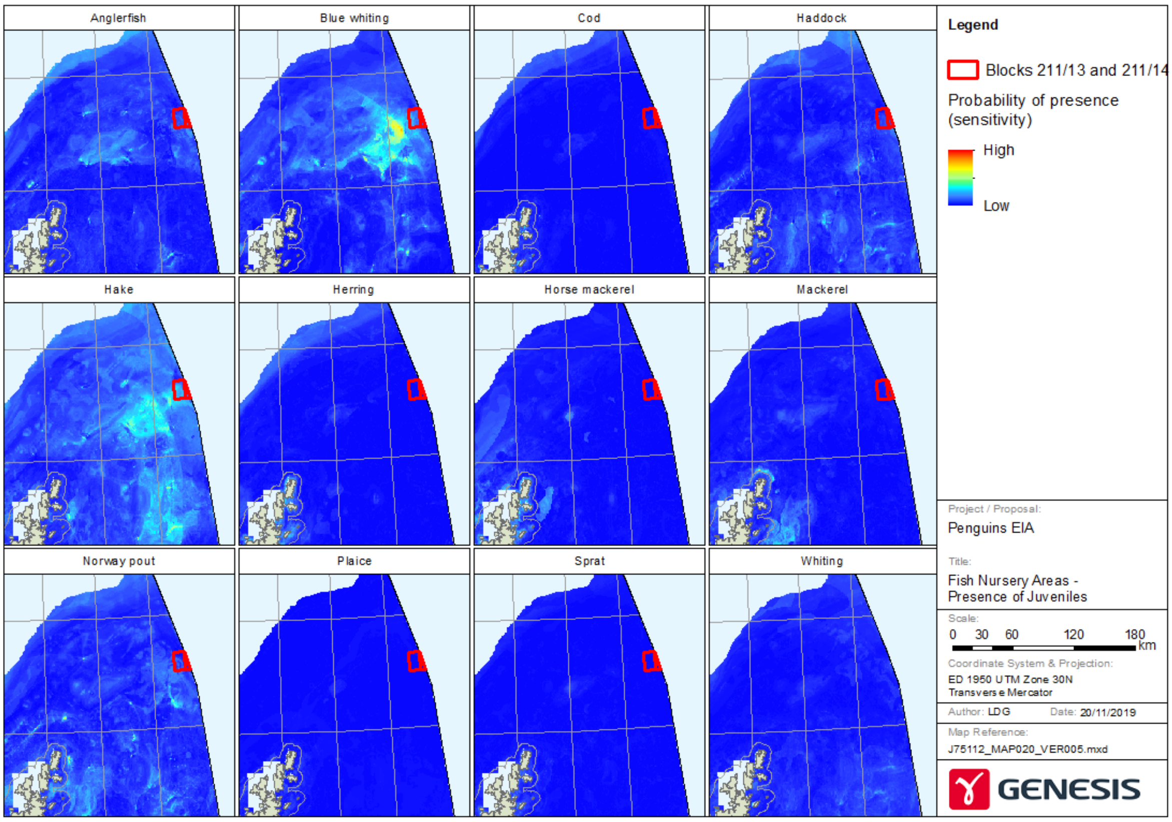


Figure 3-6: Presence of juveniles in the vicinity of Penguins (Aires *et al*, 2014).

The period for the installation operations (June 2022 to September 2024) does coincide with the spawning periods of Norway pout, haddock and saithe (Table 3-2). Aires *et al.*, (2014) noted the potential presence of juvenile (0-group) Anglerfish, Blue Whiting, Hake and Norway pout in the area, as shown in Figure 3-6.

3.3.5. Marine Mammals

Cetaceans

Cetacean species observed in the area include Atlantic white-sided dolphin (*Lagenorhynchus acutus*), white-beaked dolphin (*Lagenorhynchus albirostris*), minke whale (*Balaenoptera acutorostrata*) and harbour porpoise (*Phocoena phocoena*) (Reid, *et al*., 2003). Harbour porpoise are listed under Annex II of the EU Habitats Directive and all four species are Scottish PMFs. All cetacean species occurring in UK waters are European Protected Species (EPS). The proposed operational period for the installation of the mooring lines and FPSO town and hook up (~~April 2022 to September 2023~~ Q1-Q3 2024) coincides with sightings of all four species as shown in Table 3-3.

Table 3-3: Marine Mammal sensitivities in the vicinity.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Atlantic white-sided dolphin[1]							2					
Harbour porpoise[1]					3		3	3				
Long-finned pilot whale[2]							3	3				
Minke whale[2]							2					

Key: 1: High Density, 2: Moderate Density, 3: Low Density
Sources:
[1] Reid, J.B.; Evans, P.G.H.; Northbridge, S.P.; (2003). Atlas of cetacean distribution in north west European waters. Joint Nature Conservation committee

[2] Scottish Government National Marine Plan Interactive (NMPI) Map; http://www.gov.scot/Topics/marine/seamanagement/nmpihome

A series of small cetacean abundance in the North Sea (SCANS) surveys have been conducted to obtain an estimate of cetacean abundance in the North Sea and adjacent waters, the most recent of which is SCANS-~~III~~ IV(Gilles *et al*., 2023). Aerial and shipboard surveys were carried out during the summer of 2022 to collect data on the abundance of harbour porpoise, bottlenose dolphin, Risso's dolphin, white-beaked dolphin, white-sided dolphin, common dolphin, striped dolphin, pilot whale, all beaked whale species combined, sperm whale, minke whale and fin whale.

Blocks 211/13 and 211/14 are located within SCANS IV survey area "NS-F". Aerial survey estimates of animal abundance and densities (animals per km^2) within this area are provided in Table 3-4 (Gilles *et al*., 2023). The data suggest that harbour porpoise, white-beaked dolphin and minke whale may occur in the area (Gilles *et al*., 2023). It is very unlikely that bottlenose dolphin will occur within the area since they are typically only found in nearshore coastal areas (Reid *et al*., 2003).

Table 3-4: Cetacean abundance in SCANS-IV~~III~~ Survey Block NS-F (Gilles et al., 2023).

Species	Animal Abundance	Density (animals / km^2)
Harbour porpoise	26,383	0.4393
Minke whale	1,630	0.624
White-Beaked Dolphin	18,350	0.3056

Pinnipeds

Both grey seals (*Halichoerus grypus*) and harbour seals (also called common seals) (*Phoca vitulina*) live and breed in UK waters. Both species are listed under Annex II of the EU Habitats Directive and are considered Scottish PMFs.

Distribution maps based on telemetry data (1991 – 2016) and count data (scaled to the estimated population size in 2015) indicate that both harbour seals and grey seals are unlikely to occur in the vicinity of the proposed operations, with expected densities between 0-1 per 25 km^2 (Russell *et al*., 2017). Given that the Penguins Field is approximately 150 km from the nearest haul-out site it is unlikely that seals will frequent the area, particularly during the pupping and moulting seasons when they will spend more time ashore.

3.3.6. Seabirds

The North Sea and much of the coastal waters surrounding the UK are internationally important for breeding and feeding areas for seabirds. Northern and central areas of the North Sea often contain high abundances of species such as fulmars (*Fulmarus glacialis*), kittiwakes (*Rissa tridactyla*), guillemots (*Uria aalge*), gulls (*Larus spp*.) and gannets (*Morus bassanus*) (DECC, 2016).

Predicted maximum monthly abundance of seabirds in the area is based on an analysis of the European Seabirds at Sea (ESAS) data collected over 30 years (Kober *et al*., 2010). Continuous seabird density surface maps were generated using the spatial interpolation technique 'Poisson kriging' and fifty-seven seabird density surface maps were created to show particular species distribution in specific areas. Data from the relevant maps has been summarised for the area of interest (Table 3-5).

Distribution and abundance of these bird species vary seasonally and annually. Seabirds such as Atlantic puffin use the area in the breeding season (April – July), whereas other species such as the little auk are present in higher densities in the winter season (November - March).

Table 3-5 Predicted seabird surface density (maximum number of individuals/km^2) (Kober *et al.,* 2010).

Species	Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern fulmar	Breeding			1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0					
	Winter	1.0 – 5.0	1.0 – 5.0						1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0
Northern gannet	Breeding					≤1.0	≤1.0	≤1.0	≤1.0	≤1.0			
	Winter	≤1.0	≤1.0	≤1.0	≤1.0						≤1.0	≤1.0	≤1.0
Great skua	Breeding					≤1.0	≤1.0	≤1.0	≤1.0				
	Winter	≤1.0	≤1.0	≤1.0	≤1.0					≤1.0	≤1.0	≤1.0	≤1.0
Black-legged kittiwake	Breeding					1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0			
	Winter	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0						1.0 – 5.0	1.0 – 5.0	1.0 – 5.0
Arctic skua	Breeding					≤1.0	≤1.0	≤1.0	≤1.0				
Razorbill	Breeding					≤1.0	≤1.0						
European Storm Petrel	Breeding						≤1.0	≤1.0	≤1.0	≤1.0	≤1.0		
Great black-backed gull	Winter	≤1.0	≤1.0	≤1.0						≤1.0	≤1.0	≤1.0	≤1.0
Lesser black-backed gull	Winter	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0					1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0
Herring gull	Winter	≤1.0	≤1.0	≤1.0						≤1.0	≤1.0	≤1.0	≤1.0
Common guillemot	Additional								1.0 – 5.0	1.0 – 5.0			
	Winter	≤1.0	≤1.0	≤1.0	≤1.0						≤1.0	≤1.0	≤1.0
Glaucous gull	Winter	≤1.0	≤1.0	≤1.0							≤1.0	≤1.0	≤1.0
Little Auk	Winter	≤1.0	≤1.0	≤1.0								≤1.0	≤1.0
Atlantic Puffin	Breeding				1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0					
	Winter	≤1.0	≤1.0	≤1.0					≤1.0	≤1.0	≤1.0	≤1.0	≤1.0
ALL species combined	Breeding				5.0 – 10.0	5.0 – 10.0	5.0 – 10.0	5.0 – 10.0	5.0 – 10.0	5.0 – 10.0			
	Summer								10.0 - 20.0	10.0 - 20.0			
	Winter	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0								1.0 – 5.0	1.0 – 5.0

Key	Species not recorded	≤1.0	1.0 – 5.0	5.0 – 10.0	10.0 - 20.0	20.0 ->30.0

Seabirds are generally not at risk from routine offshore oil and gas production operations. However, they may be vulnerable to pollution from less regular offshore activities such as well testing and flaring, when hydrocarbon dropout to the sea surface can occasionally occur, or from unplanned events such as accidental oil or diesel spills (DECC, 2016). The potential for an accidental spill event is discussed in Section 4.6.

Certain seabirds such as Auk (e.g. guillemots, razorbills and puffins) are most vulnerable in the post-breeding season when they become flightless during periods of moult and therefore spending large amounts of time on the water surface. Oil sticks to the feathers of birds causing them to mat and separate and evidently impairing waterproof properties and subsequently leading to hypothermia, especially in colder waters like the North Sea. As a behavioural response, birds will instinctively try to get the oil off their feathers by preening causing ingestion of toxic compounds (Eluagu *et al.,* 2017).

The vulnerability of seabirds in the blocks and surrounding areas has been assessed according to Joint Nature Conservation Committee (JNCC) Seabird Oil Sensitivity Index (SOSI) (Webb *et al*., 2016). The purpose of this index is to identify areas where seabirds are likely to be most sensitive to oil pollution. The SOSI combines the seabird survey data with individual seabird species sensitivity index values. These values are based on a number of factors which can contribute towards the sensitivity of seabirds to oil pollution, which include:

- Habitat flexibility (the ability of a species to locate to alternative feeding grounds);
- Adult survival rate;

- Potential annual productivity; and
- The proportion of the biogeographical population in the UK (classified following the methods developed by Certain *et al.,* (2015).

The combined seabird data and species sensitivity index values were then subsequently summed at each location to create a single measure of seabird sensitivity to oil pollution. The mean sensitivity SOSI data for the area is shown in Figure 3-7 and associated seabird vulnerability listed in Table 3-6. For blocks with 'no data', an indirect assessment has been made (where possible) using JNCC guidance (JNCC, 2017). Seabird sensitivity of surface oil pollution is generally low throughout the year within Blocks 211/13 and 211/14, with exception to the months of November to December and March to May where sensitivity is predicted to be 'high' and 'medium', respectively (inclusive of indirect assessment) (Webb *et al*., 2016).

The proposed operational period coincides with low to medium seabird sensitivity as shown in Table 3-6.

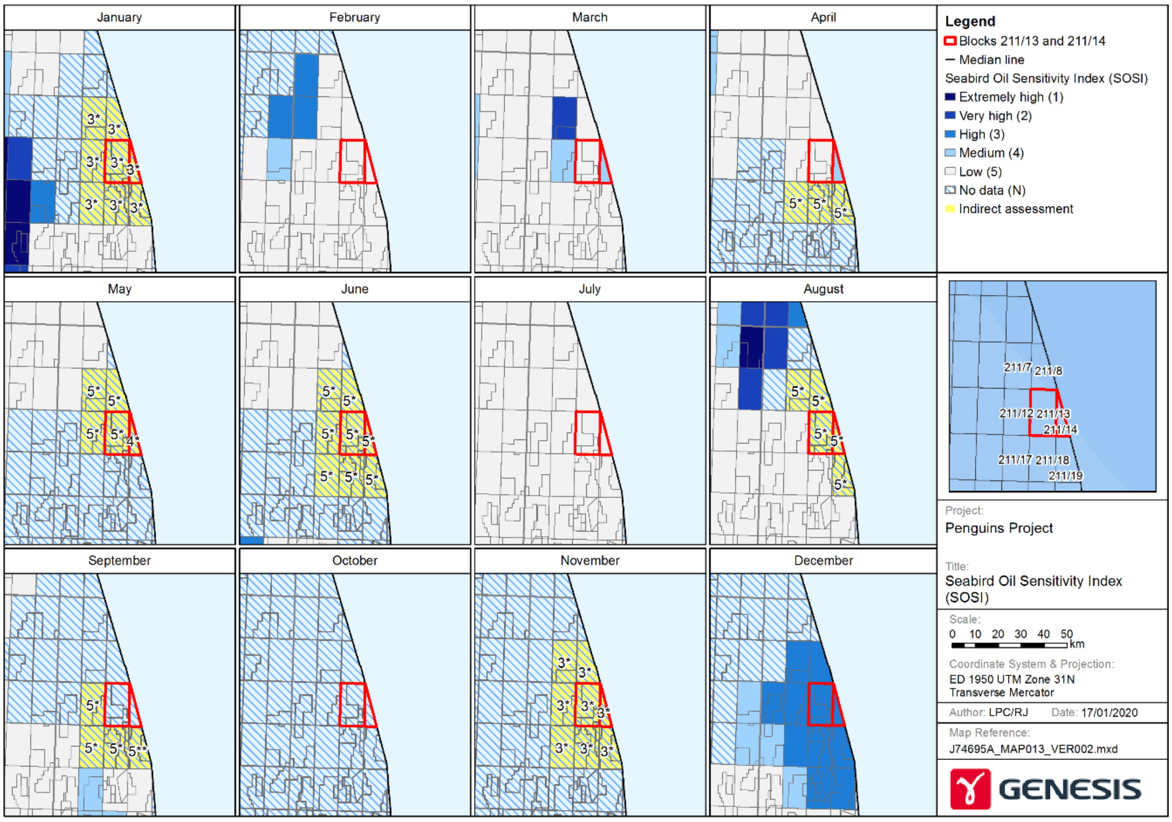


Figure 3-7: SOSI for Penguins and blocks adjacent (Webb *et al*., 2016).

Table 3-6: SOSI in blocks surrounding Penguins (Webb *et al.*, 2016).

Block	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
211/2	5*	5	5	5	5	5	5	5	N	N	N	N
211/3	5*	5	5	5	5*	5*	5	5*	N	N	N	N
211/7	3*	5	2	5	5*	5*	5	5*	N	N	3*	3
211/8	3*	5	5	5	5*	5*	5	5*	N	N	3*	3
211/12	3*	5	4	5	5*	5*	5	5	5*	N	3*	3
211/13	**3***	**5**	**5**	**5**	**5***	**5***	**5**	**5***	**N**	**N**	**3***	**3**
211/14	**3***	**5**	**4**	**4**	**4***	**5***	**5**	**5***	**N**	**N**	**3***	**3**
211/17	3*	5	5	5*	N	5*	5	5	4	N	3*	3
211/18	3*	5	5	5*	N	5*	5	5	5	N	3*	3
211/19	3*	5	5	5*	N	5*	5	5*	5	N	3*	3
** Data taken from same block in adjoining month ** Data taken from adjacent block in same month. Yellow shading means the SOSI value was indirectly assessed (JNCC, 2017).*												
Key	1 = Extremely high		2 =Very High		3 = High		4 = Medium		5 = Low		N= No data	

3.4. Conservation

A network of Marine Protected Areas (MPAs) are in place to aid the protection of vulnerable and endangered species and habitats through structured legislation and policies. These sites include SACs and Special Protection Areas (SPA), which were designated in the UK under the EU Nature Directives (EC Habitats Directive (92/43/EEC) and EC Birds Directive (2009/147/EC) respectively) prior to January 2021 and are now maintained and designated under the Habitats Regulations for England and Wales, Scotland and Northern Ireland. Amendments to the Habitats Regulations mean that the requirements of the EU Nature Directives continue to apply to how European sites (SACs and SPAs) are designated and protected. The Habitats Regulations also provide a legal framework for species requiring strict protection, e.g. EPS. Nature Conservation Marine Protected Areas (NCMPAs) designated under the Marine (Scotland) Act 2010 or the Marine and Coastal Access Act 2009 and Marine Conservation Zones (MCZ) designated under the Marine and Coastal Access Act 2009.

Figure 3-8 overleaf illustrates the protected areas closest to the Penguins field.

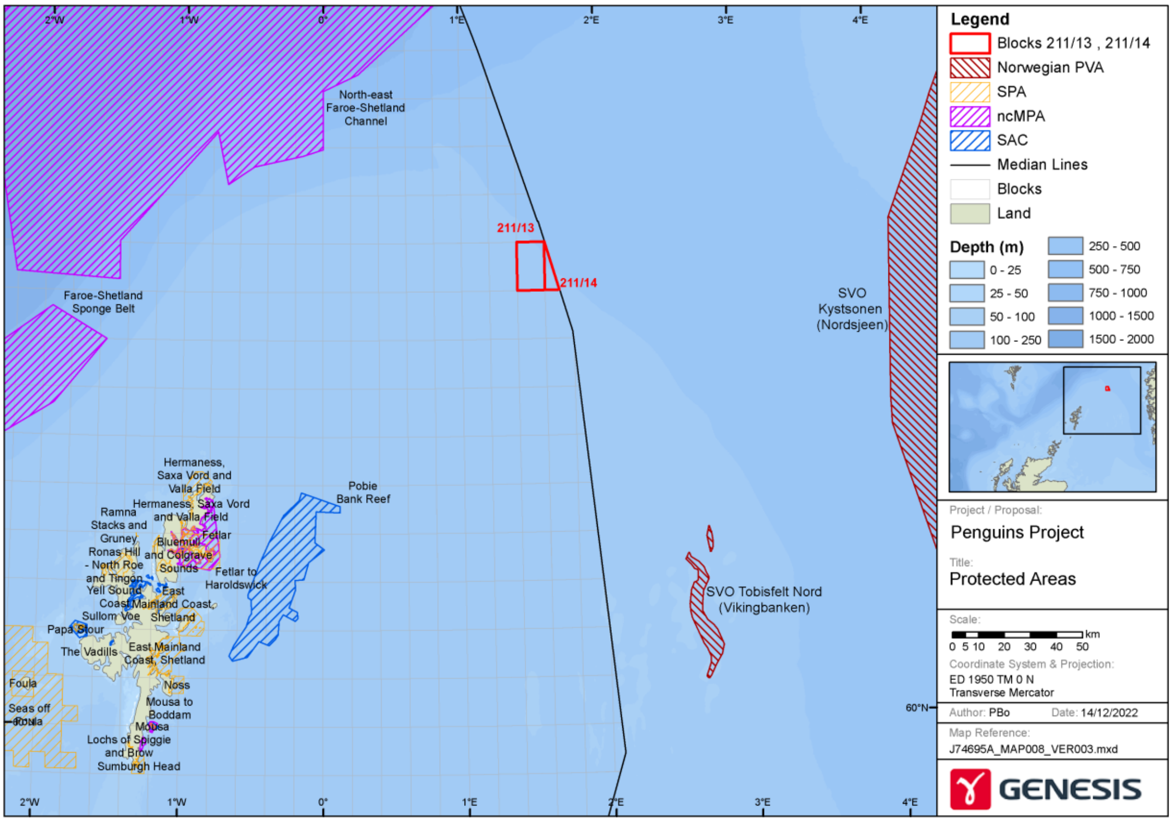


Figure 3-8: Protected areas in the vicinity of Penguins.

3.4.1. Special Areas of Conservation

The EU Habitats Directive lists those habitats and species (Annex I and II respectively) whose conservation requires the designation of protected areas.

As shown in Figure 3-8, there are no SACs, Sites of Community Importance (SCI) or SPAs are located within a 40 km radius of Blocks 211/13 and 211/14. The closest SAC is the Pobie Bank Reef approximately 108 km away. This site is designated for the Annex I Habitat ‘Reefs’ which provides a habitat to an extensive community of encrusting and robust sponges and bryozoans, which are found throughout the site. The conservation aims of this SAC are to maintain or restore the site and its respective features to favourable conditions (JNCC, 2020a).

From January 2021, SACs are designated and maintained under the Habitats Regulations.

There are four marine mammal species listed under Annex II of the Habitats Directive which occur regularly in UK waters; grey seal, harbour seal, bottlenose dolphin and harbour porpoise. Of these species, harbour porpoise may be present within the area (Section 0).

Under the Conservation of Offshore Marine Habitats and Species (2017) Regulations (as amended) it is an offence to deliberately disturb any EPS, or to capture, injure or kill an EPS at any time. Cetaceans are the only EPS likely to occur in the area.

3.4.2. Special Protection Areas

The EU Birds Directive requires member states to identify and nominate sites as SPAs for the protection of birds listed in Annex I of the Directive or sites that hold significant populations of regularly occurring migratory species. The majority of SPAs occur along the UK coastline with the closest site being Hermaness, Saxa Vord and Valla Field SPA, located > 140 km from Penguins.

Due to the distance of these coastal protected sites from the Penguins development, no significant impacts are expected as a consequence of the proposed operations.

3.4.3. Nature Conservation Marine Protected Areas

There are no Nature Conservation Marine Protected Area (NCMPA) sites within a 40 km radius of Penguins. The closest protected site is the North East Faroe Shetland Channel NCMPA approximately 82 km from Penguins. This site is designated for deep-sea sponge aggregations, offshore deep-sea muds, subtidal sands and gravels, continental slope and various other features which are representative of the West Shetland Margin Palaeo-depositional, Miller Slide and Pilot Whale Diapirs Key Geodiversity Area (JNCC, 2020b).

Due to the distance of these protected areas from the Penguins development, no significant impacts are expected as a consequence of the proposed operations.

3.4.4. Marine Conservation Zones

There are no Marine Conservation Zones (MCZ) within 40 km of Penguins.

3.4.5 Particularly Valuable Areas

Several Norwegian Particularly Valuable Areas (PVAs) are also located to the north of the Penguins FPSO. The Norwegian PVA 'Eggakanten srr' is the closest designated area to the Penguins FPSO, located c. 61 km north and designated due to its presence as a deep-water fish species spawning area (Oljedirektoratet, 2022).

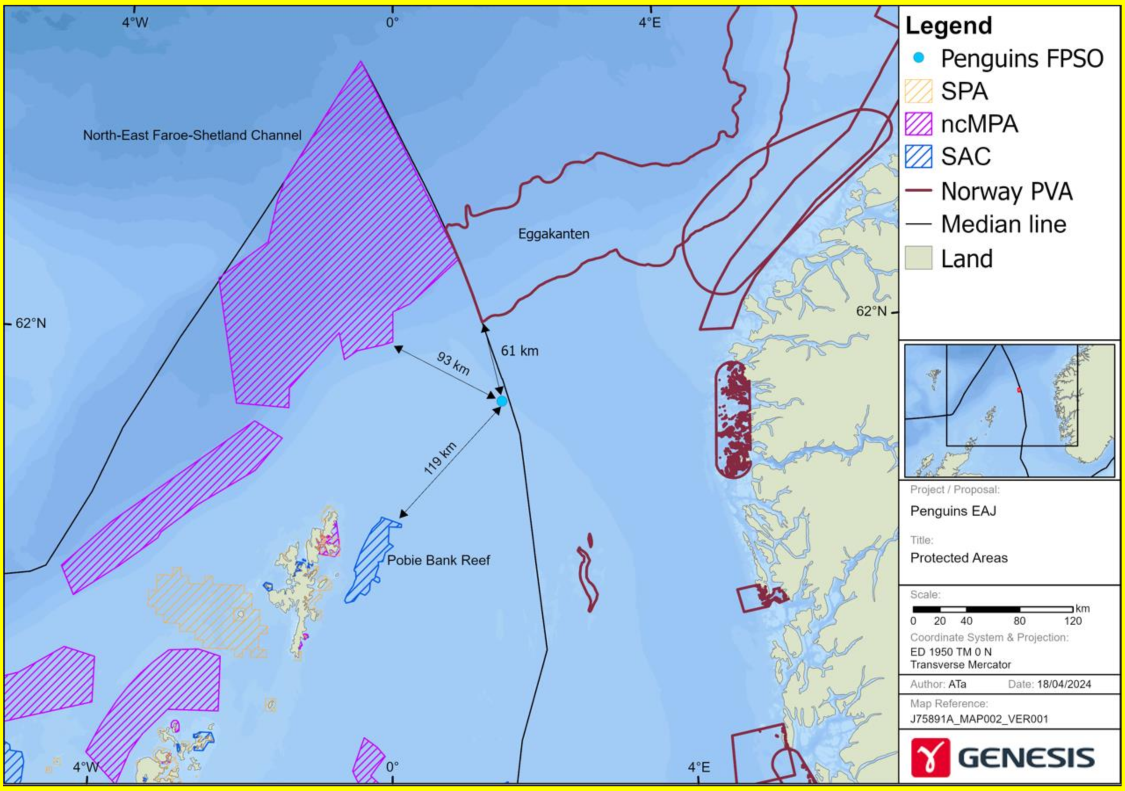


Figure 3-9: Protected sites around the Penguins FPSO.

3.5. Socio-Economic Environment

3.5.1. Commercial Fishing

Vessel activity associated with the operations has the potential to interfere with fishing activities. The International Council for the Exploration of the Sea (ICES) collates fisheries information for area units termed ICES rectangles measuring 30 nm by 30 nm. The importance of an area to the fishing industry is assessed by measuring the fishing effort, which is defined as the number of days (time) multiplied by the fleet capacity (tonnage and engine power). Due to the requirement by UK fishermen to report catch information such as total landings (includes species type and tonnage of each), and location of hauls and catch method (type of gear / duration of fishing), it is possible to get an indication of the value of an area (ICES rectangle) to the UK fishing industry. It should be noted, however, that fishing activity may not be uniformly distributed over the whole area of the ICES rectangle.

Blocks 211/13 and 211/14 are located within ICES rectangle 52F1. Based on data provided by the Scottish Government, UK annual fishing effort in ICES rectangle 52F1 can be considered to be relatively low between 2018 and 2022, with the greatest effort (110 days) recorded in 2021 and lowest effort (21 days) recorded in 2018 (see Table 3-7).

The landings in 2022 from ICES rectangle 52F1 into UK ports were predominantly demersal species in terms of weight and value. Marine Scotland, 20~~2~~23).

To put fisheries landings data into context, Table 3-8 shows the weight (tonnes) and value of UK landings relative to ICES rectangle 52F1.

Table 3-7: Commerical fisheries effort taken from ICES rectangle 52F1 for ~~2017 – 2021~~ 2018 - 2022 (Marine Scotland, ~~2022~~ 2023).

Year	Effort / Days in 52F1	UK Total Effort	Value (£)	Weight (te)
2018	21	124,843	258,004	283
2019	23	126,245	802,326	691
2020	36	103,808	265,069	203
2021	110	105,642	836,023	821
2022	58	94,467	642,378	492
Average	**49**	**111,001**	**560,760**	**498**

Table 3-8: Landings (by species type) from ICES rectangle 52F1 in ~~2021~~ 2022 (Marine Scotland, ~~2022~~ 2023).

Species Type	52F1		UK Total		52F1 as % of UK Total	
	Weight (te)	Value (£)	Weight (te)	Value (£)	Weight (te)	Value (£)
Demersal	491	639,852	95,037	163,744,471	0.5	0.4
Pelagic	-	0	318,442	293,572,304	0	0
Shellfish	0.5	2,526	67,919	227,181,181	0.001	0.001
Total	**492**	**642,378**	**481,398**	**684,497,956**	**0.5**	**0.4**

The latest data available from Marine Scotland represents average aggregate fishing effort data for 2010-2020 which is split into three fishing method groups: bottom trawls, dredges and crustaceans caught by bottom trawl (namely *Nephrops*). Data indicates that crustaceans caught by bottom trawl and dredges are scarcely used within ICES rectangle 52F1. However, bottom trawl intensity is recorded in the area, with levels ranging between 5-hours to >3-days (see Figure 3-10) (NMPi, 2023).

Vessel tracks recorded by Automatic Identification Systems (AIS - mandatory for all vessels ≥ 15 m in length) shows a general band of fishing vessels running north-west to south-east in the Penguins area (Anatec, 2021).

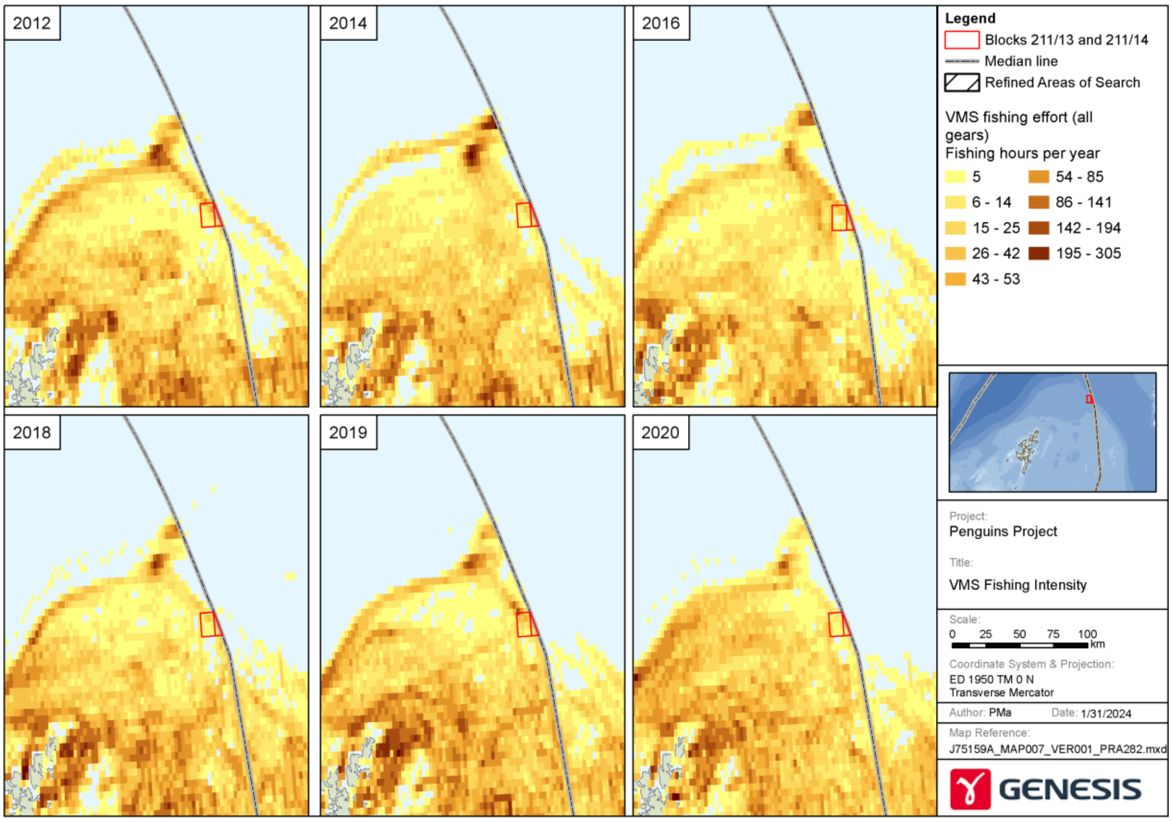


Figure 3-10: Average Intensity (hours) of Fishing (2010-2020) (NMPi, 2023)

3.5.2. Commercial Shipping

The NSTA (formerly The Oil and Gas Authority (OGA)) use density to categorise shipping activities in the North Sea, ranking each block as having a very low, low, moderate, high or very high shipping density. The blocks surrounding Penguins are classified by the OGA as an area of 'very low' shipping density (OGA, 2016) (Figure 3-9).

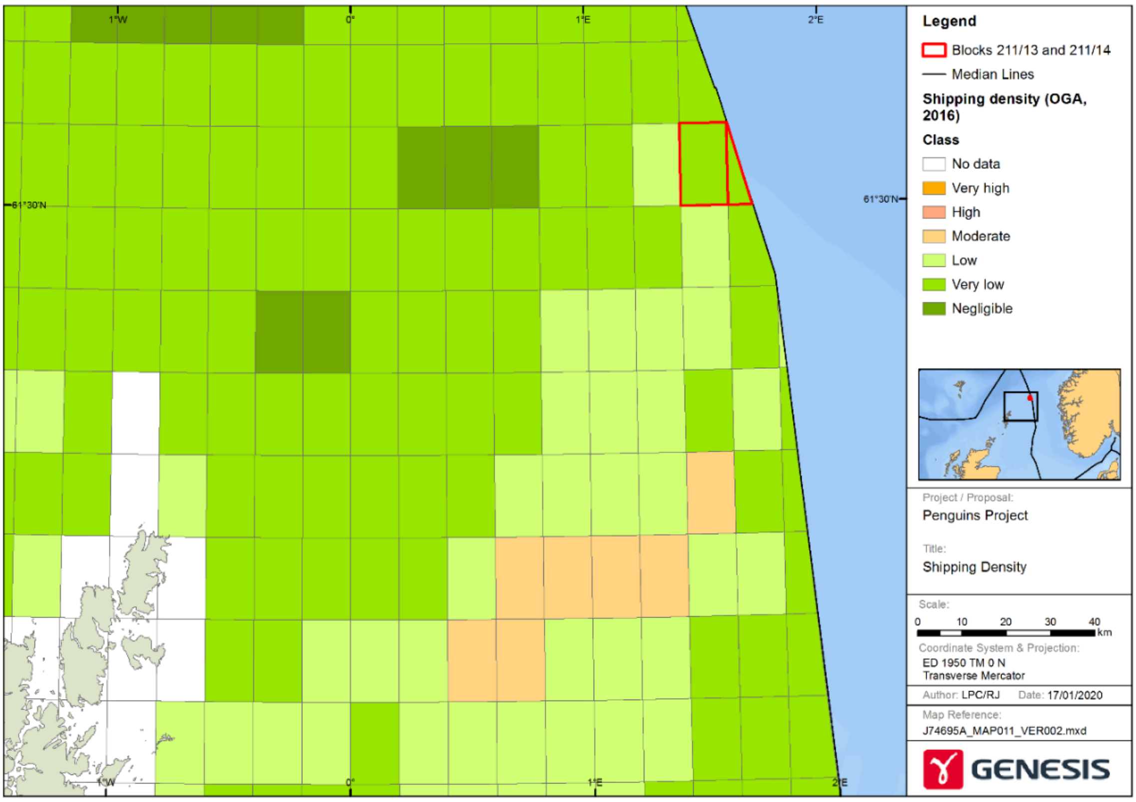


Figure 3-11: Shipping density in the North Sea.

3.5.3. Oil and Gas Activities

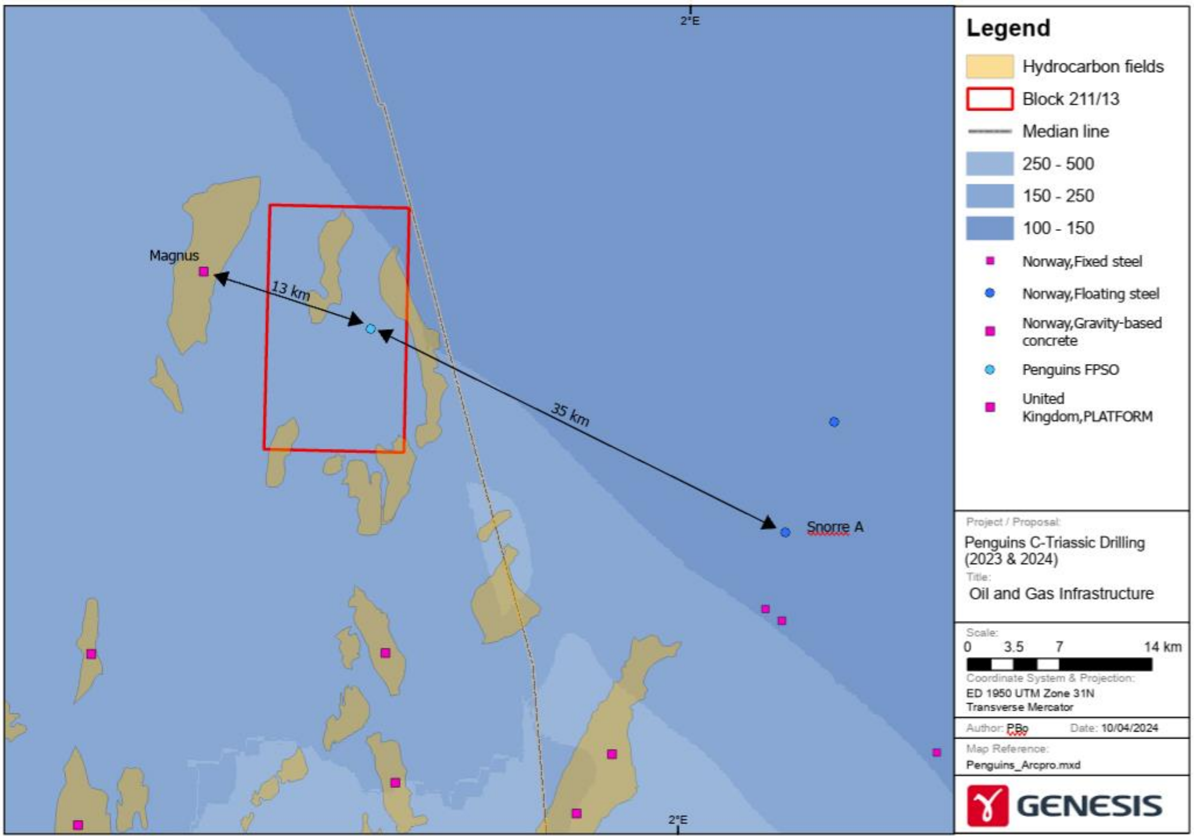


Figure 3-12: UK and Norwegian Owned Oil and Gas Infrastructure in the Vicinity of Penguins.

Penguins is located within a well-developed oil and gas production area with a number of pipelines and umbilicals present, see Figure 3-13 (overleaf). The closest installation to Penguins is the Magnus platform, located *c.* ~~9~~ 13 km north west of Penguins, shown in Figure 3-12. The nearest occupied Norwegian owned oil and gas infrastructure in the vicinity of the Penguins FPSO is the Snorre A floating platform located *c.* 35 km southeast. ~~See Figure 3-13 (overleaf) for asset locations.~~

3.5.4. Other Activities

According to the NMPi, there are no subsea telecommunications cables, aggregate extraction areas, military exercise areas or existing or proposed renewable energy developments within the vicinity of Blocks 211/13, 211/14 & 211/8. An unknown wreck is located approximately 4.3 km northwest of Block 211/8 and another unknown wreck within 211/8. Other than wrecks, the closest feature is the active CANTAT 3 cable located approximately 35 km east of Blocks 211/13, 211/14 & 211/8 in Norwegian waters (Figure 3-11, overleaf); Scottish Government NMPi).

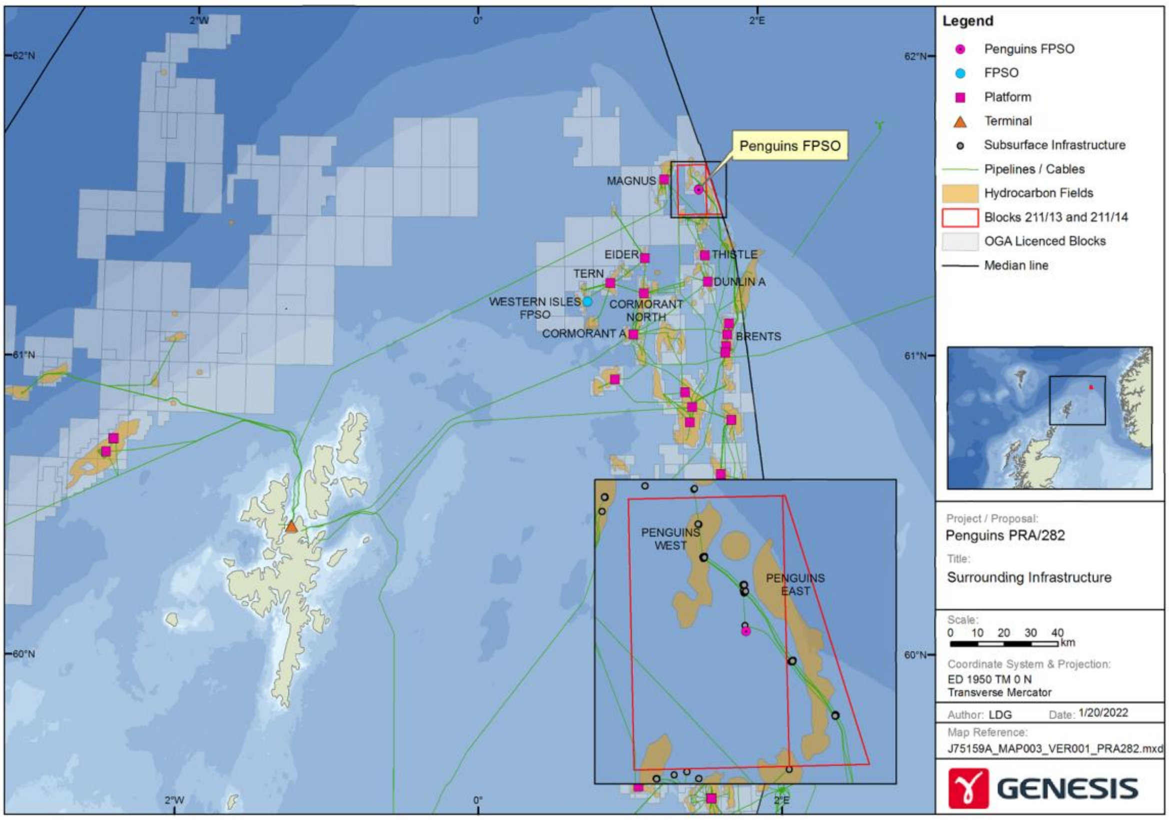


Figure 3-13: Oil and gas infrastructure in the vicinity of Penguins.

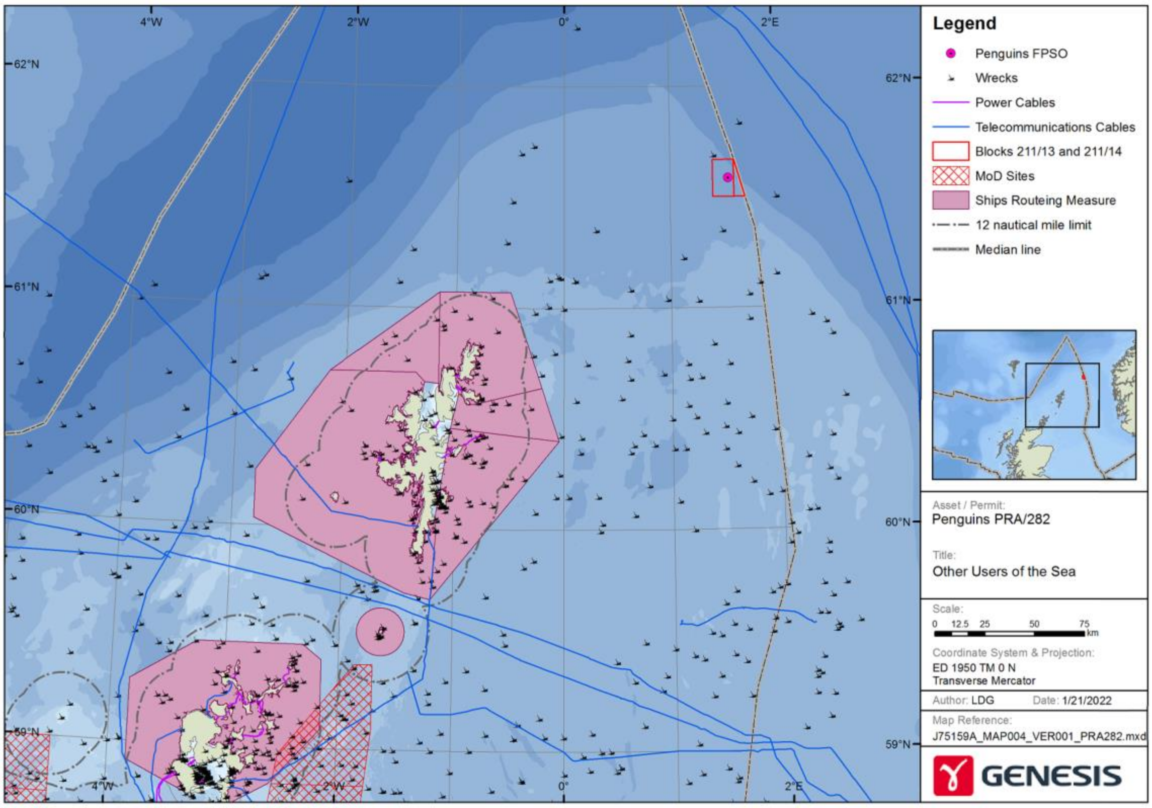


Figure 3-14: Other activities within the vicinity of the Penguins area in the North Sea.

4. ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACT ASSESSMENT

This section assesses the impacts associated with the proposed installation and production activities associated with the FPSO described in Section 2. The main impacts associated with this workscope are physical presence, seabed disturbance, atmospheric emissions, ~~and~~ underwater noise and discharges to sea. Accidental hydrocarbons spills and cumulative/transboundary impacts are also discussed.

The overall conclusion drawn in the Penguins Redevelopment ES was that the proposed Penguins Redevelopment Project can be completed without causing significant impact to the environment. More detail of the potential impact of installing the mooring chains and mooring piles and production activities are ~~is~~ included in this section and will be updated in the future ~~with~~ as more activities are added.

4.1. Impact Assessment Methodology

The impact assessment has the following main steps:

- Identify impacts that will happen as a consequence of project activities;
- Predict the magnitude of an impact, taking into consideration all the mitigation measures that are relevant to that impact;
- Evaluation of the significance of the residual effect taking into consideration the importance and sensitivity of the affected resource or receptor; and
- Determine the residual effect.

Mitigation measures Shell intends to implement in order to avoid, reduce, remedy or compensate for potential negative effects, and the actions to be taken to create or enhance positive benefits of the project, are defined.

The significance of the impacts that remain following application of the mitigation measures (also called residual effects) are then assessed against the matrix in Table 4-1.

Impacts are assessed as either having an effect or as having no effect. Those that are assessed as having an effect are classified, in ascending order, as Negligible, Minor, Moderate or Major significance. The definitions for each effect classification are shown in Table 4-2.

Table 4-1: Significance Evaluation Matrix

MAGNITUDE OF IMPACT		SENSITIVITY		
		LOW	MEDIUM	HIGH
MAGNITUDE	NO EFFECT	No effect	No effect	No effect
	SLIGHT	Negligible	Negligible	Negligible
	SMALL	Negligible	Minor	Moderate
	MEDIUM	Minor	Moderate	Major
	LARGE	Moderate	Major	Major

Table 4-2: Impact Significance Definitions

IMPACT	DEFINITION
Major	**"Significant"** Impacts with a "major" significance are likely to disrupt the function and value of the resource/ receptor, and may have a broader systemic (e.g. ecosystem or social well-being) consequences.
Moderate	**"Significant"** Impacts with moderate significance are likely to be noticeable and result in lasting changes to baseline conditions, which may cause degradation of the resource or receptor, although the overall function and value of the resource or receptor is not disrupted.
Minor	**Detectable but not significant** Impacts are expected to be noticeable changes to baseline conditions, beyond natural variation, but are not expected to cause hardship, degradation or impair the function and value of the resource or receptor.
Negligible	**Not significant** Any impacts are expected to be indistinguishable from the baseline or within the natural level of variation.
No effect	-

4.2. Physical Presence

This section relates to the Consent to Locate under Part 4a of the Energy Act 2008 for the installation of ground / lower mooring chains, mooring piles, Waverider Buoy (CL/1093), mooring rope, buoyancy and top chain.

This section provides an assessment of the potential effects from the physical footprint of the project and discusses the measures implemented to mitigate those effects. The term physical footprint refers to the physical presence of the offshore installations, vessels, and subsea equipment and the effects of these on the physical environment and associated resources and receptors.

4.2.1. Vessels

During the proposed installation activities, and until the FPSO arrives on site, there will be no FPSO 500 m exclusion zone in place (note there are currently 500 m zones on adjacent wellheads / drill centres and the riser base manifold). Once the FPSO arrives on site, a 500 m zone will be in place. The presence of the vessels may cause interference to other users of the sea including shipping traffic and fishing vessels.

The annual fishing and shipping effort within the area can be considered to be low and very low respectively (Marine Scotland, 2023; OGA, 2016). This corresponds to the latest information supplied by the Vessel Traffic Survey (VTS) where it is reported an average of one vessel per day passes within the Penguins vicinity (Anatec, 2019). Shell have in place a robust system for ensuring that the appropriate authorities are informed prior to the commencement of operations. This includes:

- Notification to the UK Hydrographic Office;
- Notification and regular updates to the fortnightly Kingfisher Bulletin/ Fishsafe;
- Notification to Navigational Warnings; and
- Regular meetings are held with the SFF to ensure they are aware of upcoming operations.

A guard vessel is already engaged to patrol the Penguins field and will cover these operations. All vessels undertaking the works will be marked in accordance with applicable legal requirements. Due to the temporary nature of vessel operations, and the low fishing and shipping effort within the area, the increase in vessel activity is not expected to have a significant impact on other sea users.

4.2.2. Structures on the Seabed

The total duration between pile guide frame deployment and recovery was 30 days (including periods of wet storage and pile driving activities).

The lower chain sections of the mooring chains (210 m in length) will be laid on the seabed for approximately 15 months prior to arrival and hook-up of the FPSO.

The remaining pre-laid mooring lines (331.6 m in length) and sinking clump weights (and potentially seabed restraints or 25 kg sand bags) will be laid on the seabed prior to arrival and hook-up of the FPSO (detailed in Sections 2.3 and 2.4, Installation of Mooring Rope, Buoyancy and Top Chain – Option A/B).

These items will present a potential hazard to fishing gear. The guard vessel which patrols the Penguins field will cover the pile and mooring chain locations. The guard vessel will remain on location until the arrival of the Penguins FPSO.

Following hook-up of the FPSO, the mooring lines will extend beyond the 500 m exclusion zone. Shell will inform the fishing community of the presence of the mooring lines. This will be done through consultation, by having the area marked and identified on Admiralty charts, the Kingfisher Information System and FishSAFE, and having the ERRV in the project area to communicate directly with using radio communication (Shell, 2016).

4.2.3. Waverider Buoy

The Waverider Buoy will be deployed for the duration of the Penguins FPSO operations. The anchor weight comprises of a bundled steel chain weighing approximately 500 kg and it covers an area of seabed approximately 1 m^2. The anchor weight is bundled to reduce the likelihood of the buoy causing the anchor weight to hop along the seabed in large storms, however Shell has historically seen anchor weights move up to 100 m from their deployment location (Note the buoy contains a GPS which allows it to be tracked should it detach from its moorings or move location). The buoy may present a potential hazard to fishing gear. The guard vessel which patrols the Penguins field covers the Waverider Buoy location.

The Waverider Buoy was deployed outside the 500 m exclusion zone, within the mooring pattern. Shell informed the fishing community of the presence of the Waverider Buoy. This was done through consultation, by having the area marked and identified on Admiralty charts, the Kingfisher Information System and FishSAFE, and having the guard vessel in the project area to communicate directly with using radio communication.

4.2.4. Conclusion

Vessel exclusion zones and the presence of subsea infrastructure are expected to have a small magnitude of impact to other sea users due to the small area affected and wider availability of space in the marine environment. Other marine users are considered of medium importance and sensitivity. The area is of low importance to the commercial fishing industry and shipping industry. The Penguins fields have been producing oil and gas via the Brent Charlie Platform since 2003. The supporting operations and all associated environmental interactions have not resulted in any significant effects. The residual effect on other sea users is assessed as being of minor significance.

Given the mitigation measures, the potential impact of physical presence from the operations on other sea users is considered to be minor and therefore impacts may be detectable but not significant ~~low~~. The proposed operations do not contradict the NMP objectives GEN 1 (General Planning and Principle); GEN 4 (Co-existence); GEN 21 (Cumulative Impacts); Oil and Gas 1 (Environmental Risks & Impacts); Oil and Gas 3 (Other Users of the Sea); Oil and Gas 5 (Potential Environmental Risks & Hazards) and Oil and Gas 6 (Risk Reduction Measures).

4.3. Seabed Disturbance

This section relates to the Consent to Locate under Part 4a of the Energy Act 2008 for the installation of ground / lower mooring chains, mooring piles, Waverider Buoy (CL/1093), mooring rope, buoyancy and top chain.

This section provides an assessment of the potential effects relating to seabed disturbance from the project and discusses the measures implemented to mitigate those effects on the physical environment and associated resources and receptors.

Seabed disturbance will occur on a temporary, medium-term and long-term ('permanent') basis. Temporary disturbance will occur during the installation phase; medium term disturbance will occur when the chains are left on the seabed prior to arrival of the Penguins FPSO; and permanent disturbance will occur due to the long-term presence of the chains following hook-up to the FPSO and due to the permanent relocation of the boulders.

The disturbance associated with deployment of the Waverider Buoy anchor weight will be permanent as it will be on location for the duration of the FPSO operations. Temporary disturbance may occur if the anchor weight moves over the seabed, for example during large storms. (Note the buoy contains a GPS which allows it to be tracked should it detach from its moorings or move location).

- Temporary seabed disturbance:
  - Placement of pile guide frame at each piling location
  - Placement of pile guide frame during wet storage
  - Movement of Waverider Buoy anchor weight over the seabed
- Medium term seabed disturbance:
  - Storage on the seabed of ground chains, mooring rope, potentially clump weights, rope restraints and sand bag prior to arrival of the FPSO
- Permanent seabed disturbance:
  - Presence of piles in the seabed
  - Presence of ground chains following hook-up to the FPSO
  - Relocation of boulders
  - Presence of Waverider Buoy anchor weight on the seabed.

4.3.1. Quantification of Impact

The relocation of boulders and the installation of the piles, ground chains and Waverider Buoy anchor weight are likely to cause the direct physical injury or death of individual benthic organisms present within the area of impact. Temporary impacts will arise from abrasion of the seabed by the chains and Waverider Buoy anchor weight, which is likely to cause a short-term alteration of seabed habitats, including smothering of benthic organisms, due to re-suspension and settling of sediment.

The anticipated maximum area of disturbance associated with the operations is summarised in Table 4-3. The following assumptions have been made (Note that operations within 2.3 Installation of Mooring Rope, Buoyancy and Top Chain – Option A are reported as these represent a worst case seabed disturbance scenario in comparison with Option B detailed in Section 2.4):

- Temporary disturbance associated with placement of the pile guide frame is based on the pile guide frame dimensions (12 m x 12 m) with an assumed additional 1 m of disturbance around the perimeter;
- Temporary disturbance associated with movement of the Waverider Buoy anchor weight based on a footprint of 1 m^2 with an assumed additional 1 m of disturbance each side of a 100 m corridor (wave buoy will remain in-situ for FPSO life – covered below under permanent disturbance);

- Medium term disturbance associated with the wet storage of clump weights based on a footprint of, 6.25 m^2 (2.5 m x 2.5 m) per location (24 locations);
- Medium term disturbance due to the mooring chains being placed on the seabed is based on 205 m of chain in contact with the seabed (5 m of chain attached to pile below surface) and an assumed lateral disturbance of 1 m;
- Medium term disturbance due to the remaining mooring lines is based on a total rope area pre-laid on seabed of 11,600 m^2 (200m x 12 + 650m x 8 + 1000m x 4). Top chain contact area with the seabed of 1,860 m^2 (155m x 12). A lateral disturbance of 1m is assumed (rope diameter of 265 mm and top chain diameter of 173 mm (0.58m wide links)).
    - Potential existing (depending on duration between mooring pre-lay and FPSO arrival infield) for mooring rope restrains to be temporarily deployed. Expectation (TBC) is that these will be concrete mattresses or rock bags (6x3m each = 432m^2)
- Medium term disturbance due to the potential requirement for 60 x 25kg sandbags (circa 9m^2) to act as a barrier between the mooring rope and any abrasive materials.

Total conservative seabed area is therefore 13,460 m^2 (includes length of rope suspended by buoyancy modules as contingency) (potential to increase to 13,892 m^2 if mooring rope restraints are deployed). These items will not be in contact with the seabed once the FPSO is installed.

- Permanent disturbance associated with:
    - the presence of the piles in the seabed is based on 12 piles (each with a diameter of 2.44 m and length of 30m);
    - mooring chains in contact with the seabed based on 205 m of chain in contact with the seabed with an assumed lateral disturbance of 1 m;
    - permanent boulder relocation (up to 40 boulders with an average size of 1 m x 1 m); and
    - permanent presence of the Waverider Buoy anchor weight based on a footprint of 1 m^2.

The overall area of seabed anticipated to be permanently impacted is 0.0025 km^2, whilst an area of 0.01 km^2 is expected to be impacted on a temporary to medium term basis. Given the small area affected, the magnitude of impact is considered to be small.

Table 4-3: Seabed disturbance.

Item	Area (m²)	Area (km²)
Temporary seabed disturbance		
Pile guide frame at each piling location (12 locations)	**2,352**	**0.0024**
Pile guide frame during wet storage (1 location)	**196**	0.0002
Sinking Clump Weight wet storage (24 locations)	150	0.00015
Potential for mooring rope seabed restraints (24 locations*)	432	0.00043
Potential movement of the Waverider Buoy anchor weight	300	0.0003
Total	**3,430**	**0.00348**
Medium-term seabed disturbance		
Location of 12 chains on seabed prior to FPSO arrival	2,460	0.0025
Location of 12 pre-laid mooring lines on seabed prior to FPSO arrival	13,460	0.0013
Potential for 60 Sandbags	540	0.0005
Total	**16,280**	**0.0163**
Permanent seabed disturbance		
Presence of piles in seabed (12 piles)	56	0.0001
Presence of 12 ground chains following FPSO hook-up	2,400	0.0024
Relocation of boulders	40	0.00004
Presence of Waverider Buoy anchor weight	1	0.000001
Total	**2,497**	**0.0025**

*24 installed unless weight distribution requires additional as detailed in 2.3.3. Area is not expected to increase.

4.3.2. Impact Assessment

The receptors are considered to have low sensitivity to impacts from the project footprint. Benthic species in the area are considered to be of low to high importance, are characteristic of the wider area and are found in low abundance. No habitats of conservation value have been identified (Shell, 2016). The environmental surveys identified isolated areas of contamination but sediments are largely representative of the wider area with THC values below the BAC for the NNS in the vicinity of the FPSO and mooring pile locations (Figure 3-3).

Benthic Habitats and Species

The proposed operations will physically disturb the benthic communities and their habitat within the area, resulting in loss of habitat and destruction of benthos. The PMF white cluster anemone (*P. angicomus*) was observed at grab station GR27 (approximately 0.5 km south of the southern mooring pile cluster (Figure 3-3)) and three other transect locations (TR12, TR13 and TR14)). However, this species is not considered to be under threat or in decline in Scottish waters (Tyler-Walters *et al.*, 2016).

The seabed disturbance will cause some sediment to be re-suspended, with resulting turbidity. The particles can affect the breathing functions (gills and membranes) and feeding functions of organisms in the vicinity.

The ICES report on the structure and dynamics of the North Sea benthos concluded that the ecological effects of anthropogenic influences arising from oil and gas installations and aggregate extraction were not identifiable on a large ICES block scale, and that there was no evidence of the footprint associated with clusters of installations, rather that, any variations identified were associated predominantly with natural forces (Rees *et al*., 2007).

Fish Spawning

The operational period for the installation of the mooring chains and piles was from April 2020 to July 2020 and coincides with spawning periods for haddock, saithe and Norway pout including peak spawning for haddock and saithe (Table 3-2). The operational period for the installation of the mooring lines (April 2023 to September 2024) and FPSO hook up (April to September 2024) coincides with the spawning periods of Norway pout, haddock and saithe (Table 3-2). Once the FPSO commences production in Q3/4 2024 (at the earliest) the operational period (year-round) will also overlap with spawning periods of Norway pout, haddock and saithe. Most species spawn into the water column of moving water masses over extensive areas so the localised nature of the operations are unlikely to have a significant impact. As production activities will be undertaken on the Penguins FPSO, there is no potential for physical disturbance to benthic spawners during production. It is expected that any juvenile fish in the immediate area will be able to avoid any direct impacts.

Given the following, the expected impact to fish spawning is considered to be very low:

- The temporary nature of the proposed installation activities;
- The relatively small area potentially impacted by the operations when compared to the suitable areas of seabed available for spawning and nursery grounds in the central North Sea (CNS); and
- The relatively short life span (a few years) and high reproduction rates of the spawning species associated with the area.

Conclusion

When taking into account the localised nature of the seabed impacts associated with the operations, and the low sensitivity of receptors (present in the immediate area in low abundance), the environmental effects from seabed disturbance are considered to be negligible and therefore not significant ~~low~~. The proposed operations do not contradict the NMP objectives GEN 1 (General Planning and Principle); GEN 4 (Co-existence); GEN 12 (Water Quality and Resource) GEN 21 (Cumulative Impacts); Oil & Gas 1 (Environmental Risks & Impacts); Oil & Gas 5 (Potential Environmental Risks & Hazards); and Oil & Gas 6 (Risk Reduction Measures).

4.4. Atmospheric Emissions

This section provides an assessment of the potential effects from the atmospheric emissions during the installation of and production from the Penguins FPSO and discusses the measures implemented to mitigate those effects on the environment and associated resources and receptors.

Further information on the emissions modelling is contained within the Atmospheric Dispersion Modelling System (ADMS) which is contained within the PPC permit.

4.4.1. Emissions during Installation Works

This section relates to the Consent to Locate under Part 4a of the Energy Act 2008 for the installation of ground / lower mooring chains, mooring piles, Waverider Buoy (CL/1093), mooring rope, buoyancy and top chain.

In 2019, the UK's independent Committee on Climate Change (CCC) released their publication 'Net Zero: The UK's contribution to stopping global warming' (CCC, 2019). In the report, the CCC concluded that it is achievable for the UK to implement a new target of net-zero greenhouse gas (GHG) emissions by 2050 in England and Wales, and by 2045 in Scotland.

To achieve the net-zero goal, the CCC report calls for concerted effort and action by all to reduce emissions and for any remaining emissions in 2050 to be offset. As part of this, the offshore oil and gas industry is focussed on the continued management and reduction of its operational emissions (OGUK, 2019). Shell announced our 'Net Carbon Footprint' ambition in 2017 with an intention of reducing our Net Carbon Footprint by around 50% by 2050 and by around 20% by 2035 as an interim measure. In April 2020, Shell announced that we will accelerate our Net Carbon Footprint ambition, aiming to reduce it by around 65% by 2050 and by around 30% by 2035. Shell will do this through a range of options, which include improving the efficiency of our operations.

It is expected that emissions during the activities at Penguins will result in emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxides (N_2O), which are all GHGs. There will also be emissions of sulphur oxides (SO_x), oxides of nitrogen (NO_x), carbon monoxide (CO) and volatile organic compounds (VOCs). Atmospheric emissions may cause effects at local, regional and global scales, the effects of which may include respiratory illness, ground-level ozone, acid rain, and contributing to global climate change.

Greenhouse gases differ in their abilities to trap heat. Global Warming Potential (GWP) is a relative measure of how much heat a greenhouse gas traps in the atmosphere; usually expressed as CO_2 equivalent (CO_2e) Overall, CO_2e emissions from UK upstream oil and gas operations in 2018 contributed three percent (14.63 million tonnes) of total domestic CO_2e emissions. Of this, around 3.5 million tonnes of CO_2e was generated from flaring gas offshore (OGUK, 2019).

Table 4-4 shows the expected vessel emissions based on predicted vessel requirements in Section 2.2.6, 2.3.5 and 2.5.3 respectively. Table 4-5 and Table 4-6 shows the expected vessel emissions of the two options for installation of the mooring ropes, buoyancy and top chain, detailed in Sections 2.3 and 2.4. The emissions associated with the two options for the FPSO tow and hook up (detailed in Sections 2.5 and 2.6) are shown in Table 4-7 and Table 4-8. Emissions factors in use were provided by the Environmental Emissions Monitoring System (EEMS) Atmospheric Emission Calculations guidance (EEMS, 2008).

Table 4-4: Predicted atmospheric emissions (installation of mooring chains and piles).

Source		**Atmospheric Emissions (Te)** (4)							
		CO_2	**NO_x**	**N_2O**	**SO_2**	**CO**	**CH_4**	**VOC**	**CO_2e**
EEMS emissions factor (1)		3.2	0.0594	0.00022	0.002	0.0157	0.00018	0.002	1/28/265(3)
Vessel	**Total fuel use (te)** (4)								
AHV	740	2,368	44	0.16	1.48	11.62	0.13	1.48	2,415
CSV	934	2,989	55	0.21	1.87	14.66	0.17	1.87	3,048
Total		**5,357**							
2018 UKCS CO_2 Emissions (2)		**13,200,000**							
Proposed operations as % of UK 2018 total		**0.04**							

1. Emissions calculated using EEMS emission factors
2. Source: Oil & Gas UK Environmental Report 2019
3. IPCC Fifth Assessment Global Warming Potentials 100 year time horizon
4. Updated values based on actual figures scope execution. Vessel days and fuel use are shown in Table 2.3.

Table 4-5: Predicted atmospheric emissions (installation of the mooring ropes, buoyancy and top chain) – OPTION A

Source		Atmospheric Emissions (Te)							
		CO_2	NO_x	N_2O	SO_2	CO	CH_4	VOC	CO_2e
EEMS emissions factor (1)		3.2	0.0594	0.00022	0.002	0.0157	0.00018	0.002	1/28/ 265(3)
Vessel	**Total fuel use (te)**								
AHV	660	2,112	39	0.15	1.32	10.36	0.12	1.32	1,566
Total		**2,112**							
2018 UKCS CO_2 Emissions (2)		**13,200,000**							
Proposed operations as % of UK 2018 total		**0.016**							

1. Emissions calculated using EEMS emission factors
2. Source: Oil & Gas UK Environmental Report 2019
3. IPCC Fifth Assessment Global Warming Potentials 100 year time horizon
4. Fuel use and vessel days are shown in Table 2.6.

Table 4-6: Predicted atmospheric emissions (installation of the mooring ropes, buoyancy and top chain) – OPTION B

Source		Atmospheric Emissions (Te)							
		CO_2	NO_x	N_2O	SO_2	CO	CH_4	VOC	CO_2e
EEMS emissions factor [1]		3.2	0.0594	0.00022	0.002	0.0157	0.00018	0.002	1/28/ 265[3]
Vessel	**Total fuel use (te)**								
AHV	505	1,616	30	0.11	1.01	7.93	0.09	1.01	1,648
Tug	170	544	10	0.038	0.34	2.67	0.03	0.34	554.9 1
Total		**2,160**							
2018 UKCS CO_2 Emissions [2]		**13,200,000**							
Proposed operations as % of UK 2018 total		**0.016**							

1. Emissions calculated using EEMS emission factors
2. Source: Oil & Gas UK Environmental Report 2019
3. IPCC Fifth Assessment Global Warming Potentials 100 year time horizon
4. Vessel days and fuel use are shown in Table 2.8.

Table 4-7: Predicted atmospheric emissions (FPSO tow and hook-up) – OPTION A

Source		Atmospheric Emissions (Te)							
		CO_2	NO_x	N_2O	SO_2	CO	CH_4	VOC	CO_2e
EEMS emissions factor (1)		3.2	0.0594	0.00022	0.002	0.0157	0.00018	0.002	1/28/ 265(3)
Vessel	**Total fuel use (te)**								
AHV hook-up	185	592	11	0.04	0.37	2.90	0.03	0.37	587
AHV station keeping (3 off)	750	2,400	45	0.17	1.50	11.78	0.14	1.50	2,448
Total		**2,992**							
2018 UKCS CO_2 Emissions (2)		**13,200,000**							
Proposed operations as % of UK 2018 total		**0.02**							

1. Emissions calculated using EEMS emission factors
2. Source: Oil & Gas UK Environmental Report 2019
3. IPCC Fifth Assessment Global Warming Potentials 100 year time horizon
4. Vessel days and fuel use are shown in Table 2.9.

Table 4-8: Predicted atmospheric emissions (FPSO tow and hook-up) – OPTION B

Source		**Atmospheric Emissions (Te)**							
		CO_2	**NO_x**	**N_2O**	**SO_2**	**CO**	**CH_4**	**VOC**	**CO_2e**
EEMS emissions factor [1]		3.2	0.0594	0.00022	0.002	0.0157	0.00018	0.002	1/28/ 265[3]
Vessel	**Total fuel use (te)**								
AHV hook-up	310	992.00	18.41	0.07	0.62	4.87	0.06	0.62	1012
Tug	~~58~~ 97.5	~~184~~ 312	~~3~~ 5.79	~~0.01~~ 0.02	~~0.12~~ 0.20	~~0.90~~ 1.53	~~0.01~~ 0.02	~~0.12~~ 0.20	~~2,203~~ 2,366
AHV station keeping (3 off)	735	2,352.00	43.66	0.16	1.47	11.54	0.13	1.47	2399
Total		**~~1,103~~ 5,776**							
2018 UKCS CO_2 Emissions [2]		**13,200,000**							
Proposed operations as % of UK 2018 total		**~~0.027~~ 0.028**							

1. Emissions calculated using EEMS emission factors
2. Source: Oil & Gas UK Environmental Report 2019
3. IPCC Fifth Assessment Global Warming Potentials 100 year time horizon
4. Vessel days and fuel use are shown in Table 2.10

The emissions associated with these operations may result in short-term deterioration of local air quality within the vicinity of the development, however, in the exposed conditions that prevail offshore, these emissions are expected to disperse rapidly such that emissions from the vessel is not considered to have a significant impact.

The impact of the vessel emissions will be mitigated by optimising vessel efficiency and hence minimising fuel use and avoiding the unnecessary operation of power generation/combustion equipment. Shell will review the Offshore Vessel Inspection Database (OVID) as part of the vessel assurance process. Due to the high dispersion rates and minimal nature of the emissions in relation to total UKCS emissions, no further mitigation measures are proposed.

~~The emissions associated with the proposed operations are not considered to have a significant impact and they do not contradict the NMP objectives GEN 5 (Climate Change); GEN 14 (Air Quality); and GEN 21 (Cumulative Impacts); Oil & Gas 1 (Environmental Risks & Impacts); Oil & Gas 5 (Potential Environmental Risks & Hazards); or Oil & Gas 6 (Risk Reduction measures).~~

4.4.2. Emissions during Production

Due to Cessation of Production (CoP) at Brent Charlie in 2021, Shell is redeveloping the Penguins Field to extend field life and production beyond the year 2035 at significantly reduced emissions intensity compared to the previous host, Brent Charlie.

This section relates to the Offshore Combustion Installation Permit under the Offshore Combustion Installations (Pollution Prevention and Control) (PPC) Regulations 2013 (as amended).

The main sources of emissions to air from the Penguins FPSO during production operations result from the combustion equipment discussed in Section 2.7.4 ~~2.7.4~~ and from non-routine gas flaring.

The most likely impact on air quality from the use of combustion plant would be that from the discharge of exhaust gas mainly comprising carbon dioxide (CO_2), nitrogen and water with small quantities of carbon monoxide (CO), oxides of nitrogen (NOx) and sulphur dioxide (SO_2) and volatile organic compounds (VOCs). The impacts on the environment from the release of these gases can be local, regional or global.

Local impacts from emissions tend to be on air quality and are associated with potential health problems caused by increased concentrations of certain pollutants: NO_x, SO_2, VOCs, particulates and CO. The importance of air quality is reflected in the adoption, Europe-wide, of a series of air quality standards and objectives. In addition to local impacts, emissions to air also contribute to regional impacts (for instance, eutrophication and ground level ozone formation) and global impacts (global warming). These are also discussed here in relation to the Environmental Statement.

The emissions profile describes the pollutant "signature" of the equipment. This information may be based on manufacturer's specifications, the results of emissions monitoring or estimated based on the performance of similar equipment.

The Emission Profiles table as presented in the PPC SAT shows the pollutant signatures for the main items of combustion plant on the Penguins FPSO. Profiles have not been provided for equipment that is not material, for example:

- The equipment has a thermal capacity of < 1 MW(th); or
- The equipment is run for less than 500 hours per annum.

Sources

Flaring

Releases to the flare system are primarily governed by:

- Category A : Streams for the safe operation of the asset based on its current design and operating at optimum efficiency (excluding Category C)
- Category B: Flaring and venting occurring during normal operations beyond levels optimum for the installation.
- Category C: Emergency disposal and gas streams required specifically for the operation of safety critical equipment/elements

During normal steady state operation very little gas is expected to be flared. The flare pilots will be continuously lit but their fuel gas consumption rates will be very small. There may be flaring during the following operational scenarios:

- Start-up (prior to starting the low-pressure (LP) and high pressure (HP) compressors
- Shut down
- Slugging events
- Equipment depressurisation for maintenance purposes
- Emergency depressurisation (EDP) in the event of a fire and gas initiated shutdown
- Equipment failure (compressors, passing valves)

Combustion Power

Atmospheric emissions from power generation are permitted under the Offshore Combustion installation permit (PPC) and UKETS permit.

The combustion equipment on the Penguins FPSO is summarised in Section 2.7.5.

Venting

Cold venting occurs infrequently on Penguins only during process restart and to relieve pressure for maintenance events.

Emission Factors

Emissions are calculated based on the fuel forecasts and the relevant emission factors. Emissions factors for the GTGs have been estimated using vendor information for NOx, CO, and UHC emissions. SOx emissions have been estimated using EEMS factors for the turbines and exhaust gas parameters from the vendor information. All other Emissions factors are taken from the EEMs database. The emissions factors used for the calculation of emissions from combustion equipment on the Penguins FPSO are presented in Table 4-9. Fuel forecasts are ~~discussed~~ shown in

Equipment / Fuel type	Power (kW) (Operating philosophy assumptions)	Running hours (h)	Fuel Gas rate (kg/h)	Diesel rate (kg/h)	Fuel gas (tonnes)	Diesel (tonnes)
2024						
GTGs / Fuel Gas	8,350 (Peak Normal & Offloading Load - 2 GTGs)	2,460	2,411.13	-	5,931.95	-
GTGs / Diesel	4,870 (Essential load)	3,420	-	1,906.01	-	6,518.1
HP / Fuel Gas	15,900 (Normal Shaft Power)	~~1,817~~ 2,172	3,451.~~70~~53	-	~~6,271.37~~ 7,496.72	-
EDG / Diesel	1,950 (peak load)	150	-	~~432.74~~ 434.60	-	~~64.91~~ 65.19
Fire Water Pump / Diesel	2,320 (peak load)	168	-	~~471.70~~ 434.60	-	~~79.25~~ 73.01
IGG / Diesel	N/A	750	-	192	-	144
Forecast totals					~~12,2023.82~~ 13,428.67	~~6,806.26~~ 6,800.3
2025						
GTGs / Fuel Gas	8,350 - Peak Normal & Offloading Load (2 GTGs)	6,833	2,411.13	-	16,474.75	-
GTGs / Diesel	4,870 (Essential load)	1,927	-	1,906.01	-	3,673.27
HP / Fuel Gas	15,900 (Normal Shaft Power)	~~6,833~~ 8,688	3,451.~~70~~53	-	~~23,584.80~~ 29,986.90	-
EDG / Diesel	1,950 (peak load)	150	-	~~432.74~~ 434.60	-	~~64.91~~ 65.19
Fire Water Pump / Diesel	2,320 (peak load)	168	-	~~471.70~~ 434.60	-	~~79.25~~ 73.01
IGG / Diesel	N/A	1,500	-	192	-	288

Equipment / Fuel type	Power (kW) (Operating philosophy assumptions)	Running hours (h)	Fuel Gas rate (kg/h)	Diesel rate (kg/h)	Fuel gas (tonnes)	Diesel (tonnes)
Forecast totals					~~40,059.55~~ 46,461.65	~~4,105.43~~ 4,099.47
2026						
GTGs / Fuel Gas	8,350 - Peak Normal & Offloading Load (2 GTGs)	7,268	2,411.13	-	~~17,523.01~~ 19,009.33	-
GTGs / Diesel	4,870 (Essential load)	~~1,420.44~~ 876	-	1,906.01	-	~~2,707.38~~ 1,669.67
HP / Fuel Gas	15,900 (Normal Shaft Power)	~~7,268~~ 8,688	3,451.~~70~~53	-	~~25,085.46~~ 29,986.90	-
EDG / Diesel	1,950 (peak load)	150	-	~~432.74~~ 434.60	-	~~64.91~~ 65.19
Fire Water Pump / Diesel	2,320 (peak load)	168	-	~~471.70~~ 434.60	-	~~79.25~~ 73.01
IGG / Diesel	N/A	1,500	-	192	-	288
Forecast totals					~~42,608.47~~ 48,996.23	~~3,139.54~~ 2,095.87

Equipment / Fuel type	Power (kW) (Operating philosophy assumptions)	Running hours (h)	Fuel Gas rate (kg/h)	Diesel rate (kg/h)	Fuel gas (tonnes)	Diesel (tonnes)
2024						
GTGs / Fuel Gas	8,350 (Peak Normal & Offloading Load - 2 GTGs)	2,460	2,411.13	-	5,931.95	-
GTGs / Diesel	4,870 (Essential load)	3,420	-	1,906.01	-	6,518.1
HP / Fuel Gas	15,900 (Normal Shaft Power)	~~1,817~~ 2,172	3,451.~~70~~53	-	~~6,271.37~~ 7,496.72	-
EDG / Diesel	1,950 (peak load)	150	-	~~432.74~~ 434.60	-	~~64.91~~ 65.19
Fire Water Pump / Diesel	2,320 (peak load)	168	-	~~471.70~~ 434.60	-	~~79.25~~ 73.01
IGG / Diesel	N/A	750	-	192	-	144
Forecast totals					~~12,2023.82~~ 13,428.67	~~6,806.26~~ 6,800.3
2025						

Equipment / Fuel type	Power (kW) (Operating philosophy assumptions)	Running hours (h)	Fuel Gas rate (kg/h)	Diesel rate (kg/h)	Fuel gas (tonnes)	Diesel (tonnes)
GTGs / Fuel Gas	8,350 - Peak Normal & Offloading Load (2 GTGs)	6,833	2,411.13	-	16,474.75	-
GTGs / Diesel	4,870 (Essential load)	1,927	-	1,906.01	-	3,673.27
HP / Fuel Gas	15,900 (Normal Shaft Power)	~~6,833~~ 8,688	3,451.~~70~~53	-	~~23,584.80~~ 29,986.90	-
EDG / Diesel	1,950 (peak load)	150	-	~~432.74~~ 434.60	-	~~64.91~~ 65.19
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IGG / Diesel	N/A	1,500	-	192	-	288
Forecast totals					~~40,059.55~~ 46,461.65	~~4,105.43~~ 4,099.47
2026						
GTGs / Fuel Gas	8,350 - Peak Normal & Offloading Load (2 GTGs)	7,268	2,411.13	-	~~17,523.01~~ 19,009.33	-
GTGs / Diesel	4,870 (Essential load)	~~1,420.44~~ 876	-	1,906.01	-	~~2,707.38~~ 1,669.67
HP / Fuel Gas	15,900 (Normal Shaft Power)	~~7,268~~ 8,688	3,451.~~70~~53	-	~~25,085.46~~ 29,986.90	-
EDG / Diesel	1,950 (peak load)	150	-	~~432.74~~ 434.60	-	~~64.91~~ 65.19
Fire Water Pump / Diesel	2,320 (peak load)	168	-	~~471.70~~ 434.60	-	~~79.25~~ 73.01
IGG / Diesel	N/A	1,500	-	192	-	288
Forecast totals					~~42,608.47~~ 48,996.23	~~3,139.54~~ 2,095.87

~~Section 0~~.

Table 4-9: Emission Factors (Genesis, 2024a)

Fuel	Equipment	CO_2	NO_X	SO_2	CO	CH_4	VOC
Diesel	**GTGs**	3.2	0.01724	0.002	0.00092	0.0000328	0.000295
	Other Diesel Engines	3.2	0.0594	0.002	0.0157	0.00018	0.002
Fuel Gas	**GTGs**	2.73	0.00472	0.0000128	0.22428	0.12274	0.000036

	HP Compressor	2.73	0.00368	0.0000128	0.005	0.00153	0.000036

Emission Loads

Emission loads forecasts for the equipment falling under PPC are presented in the PPC SAT and in Table 4-10 for CO_2, NOx, SO_2, CO, CH_4 and VOC emissions. The emission loads are dependent mainly on the power requirement of the FPSO. This power requirement is summarised in Section 2.7.4. Energy efficiency measures and emission control technologies are discussed in the BAT Assessment (Genesis, 2024b). During the hook up and commissioning (HUC) phase, power generation will predominantly use diesel fuel with gas systems being brought online at a later date.

These emission loads are based on:

- Worst-case runtime taken from Year 2026 (major turnaround);
- Generator Turbines have been designed with a dry low emission (DLE) burners, so overall NO_x and SO_x emissions should be less than reported;
- Normal operating philosophy is two Generator Turbines online 50% load to satisfy heat demand in early production;
- Three Fire Pumps online where required; and
- Flaring emissions include pilot gas to the flare tips and a conservative estimate of safety flaring.

Table 4-10: Predicted maximum emission loads (tonnes/year) (Genesis, 2024a).

Year[1]	**Emissions (Te)**						
	CO_2	**NO_x**	**SO_x**	**CO**	**CH_4**	**VOC**	**Dust (PM)**
2024	~~61,008~~ 60,988	137	13	2,134	1,220	3	N/A
2025	~~144,016~~ 143,996	278	7	5,858	3,321	3	N/A
2026	~~144,548~~ 144,528	279	3	6,750	3,810	3	N/A

1. Emissions calculated include a contingency for start-up and commissioning and include flaring

Receptors

Nearest occupied Installations to Penguins FPSO are shown in Table 4-11.

Table 4-11: Nearest receptors

Installation Name	Block	Distance (km)

Magnus	211/12A	13 ~~9~~
Thistle	211/18A	24
Snorre	34/4 and 34/7	~~40~~ 35

Cumulative and Transboundary Impacts

The Penguins FPSO is located in the UK Continental Shelf (UKCS), approximately 4km from the UK/Norway median line, approximately 150 km off the coast of the Shetland Islands. During the installation and operations of the Penguins FPSO, there are/will be drilling and well intervention applications to support production of the Penguins field. These will have associated atmospheric emissions (such as through vessel and helicopter use).

Due to the close proximity of the FPSO to the UK/Norway median line, transboundary air quality effects require to be determined. Limited guidance is available providing suitable criteria for which to screen for air quality impacts in offshore locations, however, the UK Government provides guidance (EA, 2023) on how to screen for protected areas for onshore applications. This guidance provides an indication of the screening criteria acceptable for pollutants in close proximity to protected areas and serves as a useful comparator. The guidance states that where a long-term process contribution (PC) is greater than 1% and the Predicted Environmental Concentration (PEC) is less than 70% of the applicable long-term environmental standard then the emissions are deemed insignificant.

Block 211/14 is adjacent to the UK/Norwegian median line and modelling (Genesis, 2024c) was undertaken to estimate the transboundary impact of emissions from the FPSO. The modelling showed that that no significant transboundary impacts are expected from installation and production operations and at all points on the model grid and at all receptors the PEC is less than 70%. As the predicted effects under normal and maximum operational conditions are considered to be negligible in the area immediately surrounding the Penguins FPSO, the transboundary effects will therefore be negligible.

The Snorre Platform is located in the Norwegian sector of the North Sea, approximately 35 ~~40~~ km away from the Penguins FPSO (see Figure 3-9), and is the nearest Norwegian human receptor. Both normal and maximum emissions to atmosphere from the Penguins combustion plant are predicted to give rise to concentrations on the nearest Norwegian installations that are significantly less than the environmental air quality standards set out in DEFRA's Air Quality Strategy, 2007, and are not predicted to be of concern to human health and will not result in a significant negative effect on the Norwegian environment. ADMS modelling was carried out to support the PPC permit, which assessed the impact to the nearest human receptors.

Predicted concentrations on the nearest land (the coast of the Shetland Islands), will be considerably lower than those predicted at the nearest offshore occupied installations and will therefore be insignificant compared to the environmental air quality standards set out in DEFRA's Air Quality Strategy, 2007 and not of concern to human health and will not result in a significant negative effect on the Shetland Islands environment.

As noted in Section 3.4.5, the nearest sensitive natural receptors within Norwegian waters are deep-water fish species within the Norwegian PVA Eggakanten srr, located 61 km north of the Penguins FPSO. Given the distance to the nearest receptors, predicted concentrations will be insignificant compared to the air quality standards set out in DEFRA's Air Quality Strategy (2007) and therefore will not result in a significant effect on sensitive natural receptors within Norwegian waters.

Data in Table 4-12 shows that annual emissions from the Penguins FPSO (using predicated maximum emission loads for 2026 as a worst case) makes up only a small percentage of those from all production installations in the UKCS. As such, emissions to air are unlikely to have a significant regional or transboundary impact.

Table 4-12: Comparison of Annual Penguins Emissions Against Annual UKCS Emissions.

Emission Loads	NO_X	SO_2	CO	CH_4	VOC	CO_2

~~Forecast Emissions from Penguins combustion equipment (tonnes) [2024]~~	~~112~~	~~5~~	~~248~~	~~4~~	~~3~~	~~120,140~~
Emissions from Penguins FPSO[2] ~~Forecast Emissions from Penguins combustion equipment~~ (tonnes) [2026]	279	3	6,750	3,810	3	~~144,548~~ 144,528
Actual Emissions from UKCS 2018 (tonnes)[1]	-	-	-	43,500	50,100	13,200,000
Forecast emissions from Penguins as a % of UKCS emissions	-	-	-	8.76%	0.006%	1.10%

1. Based on EEMS 2018 Data (OGUK, 2019).
2. The forecast emission loads include flaring.

4.4.3. Conclusion

The primary sources of emissions during the installation phase are associated with the vessels required for the installation activities. The emissions are considered to be of small magnitude and as having a short term impact that is localised at the point of discharge. The sensitivity of the local air quality to atmospheric emissions is considered low due to the absence of existing pollution sources and absence of sensitive receptors in the area. The residual effects are therefore assessed as negligible significance.

The magnitude of impact from emissions during normal production operations is considered small. However, it is recognised that worst case upset conditions (when diesel (rather than gas) fuel is required for power generation, and flaring is continuous) could potentially result in temporary, localised adverse effects to air quality. Given the low sensitivity of local air quality, the residual effect is assessed as being of negligible significance.

Overall, the atmospheric emissions associated with the proposed installation and production activities are not considered to be significant. The proposed operations do not contradict the NMP objectives GEN 1 (General Planning and Principle); GEN 5 (Climate Change); GEN 14 (Air Quality); GEN 21 (Cumulative Impacts); Oil & Gas 1 (Environmental Risks & Impacts); Oil & Gas 5 (Potential Environmental Risks & Hazards); and Oil & Gas 6 (Risk Reduction measures).

Given the distance to the nearest landfall and the negligible predicted air quality effects under normal and maximum operational conditions, the potential for any cumulative effects will be negligible. No significant transboundary air quality effects are predicted from the Penguins FPSO combustion plant under normal and maximum operational conditions on either UK receptors or receptors of other member states.

4.5. Underwater Noise

This section relates to the Consent to Locate under Part 4a of the Energy Act 2008 for the installation of ground / lower mooring chains, mooring piles, Waverider Buoy (CL/1093), mooring rope, buoyancy and top chain.

This section provides an assessment of the potential effects from underwater noise due to vessels during the installation and production of the Penguins FPSO and discusses the measures implemented to mitigate those effects on the marine environment and associated resources and receptors.

Marine mammals use sound for navigation, communication and prey detection (see reviews in Southall *et al.*, 2007). As such, the introduction of anthropogenic underwater sound has the potential to impact marine animals if it interferes with the animal's ability to use and receive sound. Human activities at sea generate underwater sound. The characteristics of the sound produced, in terms of the amplitude, range of frequencies and temporal characteristics, vary with the type of activity and vessel type. For example, piling and blasting creates sudden, powerful and repetitive sounds which, without mitigation, can produce noise levels capable of causing injury.

Sound levels in the marine environment diminish with distance from the source. Underwater noise can also cause injury and behavioural disturbance in fish.

The underwater sound sources during the proposed works will be vessel noise.

4.5.1. Vessel Noise

Vessel noise, mainly from the propellers, propulsion and other machinery is considered to be below the levels which would present a significant risk to marine mammals as identified by Southall *et al*., (2019) and the NOAA thresholds (NMFS, 2018). It is therefore considered that impacts to marine mammals from underwater noise will not be significant.

4.5.2. Conclusion

Underwater sound generated during the proposed operations is considered to have a slight magnitude of impact and receptor sensitivity is considered to be low. Therefore, the impact from underwater noise is deemed to have negligible significance ~~not significant~~ and will not contradict the NMP objectives: GEN 1 (General Planning and Principle); GEN 9 (Natural Heritage); GEN 13 (Noise); GEN 21 (Cumulative Impacts); Oil & Gas 1 (Environmental Risks & Impacts); Oil & Gas 5 (Potential Environmental Risks & Hazards); and Oil & Gas 6 (Risk Reduction Measures).

4.6. Discharges to Sea

This section relates to the Oil Discharge Permit (OLP) under the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended).

This section provides an assessment of the potential effects from the discharges to sea from the production operation activities of the Penguins FPSO and discusses the measures implemented to mitigate those effects. The discharge of produced water to sea has been considered in this section and the effects of this on the marine environment and associated resources and receptors.

Planned operational discharges (see Table 4-13) to sea will occur during commissioning and production operations. Such discharges have the potential to interact with the marine environment, reducing water and sediment quality and affecting those communities which rely on them. This section presents an evaluation of the impacts that could arise from the discharge of produced water to sea during ongoing production operations.

Table 4-13: Summary of permitted discharges.

Asset	Produced Water	Produced Water Reinjection (PWRI)	Drains	Sand		
				Offline	Online	Online PWRI
Penguin FPSO	Yes	N/A	Yes	N/A	N/A	N/A

4.6.1. Produced Water

During normal operation, produced water (PW) that is accumulated in the 1st Stage Separator (V-2001) will be processed to the PW Hydrocyclones (S-4401). PW will then be introduced to the PW Degasser V-4401 to remove trapped gases and light hydrocarbons, as well as to separate trace amounts of heavy hydrocarbons.

The PW will then be routed to the overboard caisson for discharge to sea if the required OIW concentration is met. If the concentration of OIW is not met, then the PW will be routed to the slops tank for oil recovery prior to batch discharge to sea via the open drains system.

4.6.2. Drains

Shell normal platform practices minimise the volume of hydrocarbon fluids directed to the platform drains systems. In addition, the discharges from the drains are variable in concentration, influenced by factors such as platform activities and in some cases rainfall. Therefore, the potential for adverse environmental impact from the drains discharges is thought to be low.

4.6.3. Cumulative and Transboundary Impacts

Produced water and drain discharges such as those from the operation of the Penguins FPSO will be undetectable within a few tens of metres from the discharge point due to natural dispersion and dilution. Therefore, cumulative effects from these sources are not expected.

Studies of the fate and impacts of produced water discharge indicate that such discharges pose little risk to the marine environment. Various processes lead to the rapid dilution and dispersion of produced water and its components. It is generally accepted that the concentration of water borne contaminants becomes diluted to below environmental effect levels within around 500 m of the installation. Given the distance between Penguins and nearby installations, and the highly dispersive environment between them, it is deemed highly unlikely that discharges could accumulate in any significant fashion. The lack of potential for cumulative effects suggests that there would be no significant risk to the environment in general.

In addition, there are no SACs, SCIs SPAs, NCMPAs or MCZs within a 40 km radius of Penguins, as discussed in Section 3.4. The closest protected site is the North East Faroe Shetland Channel NCMPA approximately 82 km from Penguins. Given that discharges from Penguins are unlikely to accumulate with other installations, and considering the distance from protected sites, no significant risks to these protected sites are expected as a result of cumulative impacts.

The Penguins FPSO is located approximately 4 km from the UK/Norway median line and, therefore, no significant transboundary effects are predicted from surface discharges. Some subsea infrastructure will be located closer to the median line (1-2 km) but will only discharge very minor volumes of hydraulic fluid from valve activations.

The ~~increase in~~ production increase (Section 4.11) is not anticipated to significantly contribute to cumulative or transboundary impacts.

4.6.4. Impacts of produced water and associated oil discharge

Penguins produced via Brent Charlie from 2003-2021 and all produced water was discharged to sea with no significant effects on the environment. The cumulative water production for the Penguins Field for 2003-2021 was approximately 51,000 bbl, which is considered low for offshore oil and gas developments.

The new configuration at Penguins is expected to continue to produce low volumes of produced water and wastewater. Water production is assumed to be less than 7% of the total liquid production rate. As discussed in the ES, a technical feasibility study has been carried out into the possibility of PWRI at the Penguins field. The study considered disposal into a shallower overburden zone and the conversion of a current producer well into an injection well. PWRI was considered but was determined to be an unsuitable technique based on the stratigraphic, sedimentological, and structural configuration of the reservoirs combined with the produced water forecast for the redevelopment. ~~(See Section 2.7.5).~~

Due to the limitations identified with PWRI, overboard discharge has been identified as the base-case for the Penguins Redevelopment Project. Produced water will be compliant with the approved Oil Discharge Permit and will meet the regulatory requirement of less than 30 mg/l monthly average dispersed oil in water. The Penguins FPSO has an enhanced degasser design and an off-spec processing facility using polishing unit which should result in lower concentrations of OIW being realised in practice during routine operations.

The Project has conducted a series of studies, including produced water dispersion modelling using the Dose Related Risk and Effect Assessment Model (DREAM), to evaluate disposal options onboard the FPSO. The result of this assessment considered the base case design as a suitable option and is discussed in the Produced Water and Drains BAT Assessment (Shell, 2019). The plume resulting from a small volume of near continuous produced water discharge will likely only be detectable within a few tens of metres of the discharge point. There would be the potential for impacts on water quality (as a consequence of entrained hydrocarbons and other components such as metals) in the vicinity of the FPSO as a result of produced water discharges.

Provision will be made to allow injection of additional chemicals including deoiler, water clarifier and demulsifier if required to improve separation during operations.

As a consequence, the produced water is likely to contain small amounts of chemicals, in addition to dispersed oil, not removed by the produced water treatment facility. The potential for adverse environmental effects from the remaining constituents in the produced water discharge have been ~~will be~~ investigated in the relevant CP SAT Chemical Risk Assessment.

As mentioned in Section 2.7.7, chemical selection is undertaken to identify the most environmentally acceptable chemicals with the required performance. All chemicals will be approved under the Offshore Chemical Regulations 2002 prior to use and discharge to sea. Where possible the use of chemicals will be minimised or eliminated altogether. All use and discharge of chemicals will be monitored offshore to ensure compliance with the chemical permit, which is then reported to the regulators.

The Chemical Hazard and Risk Management (CHARM) risk assessment provided in the Chemical Risk Assessment shows the majority of risk quotients (RQ's) for the CHARMable chemicals are <1, indicating that these discharges would not be expected to pose a significant risk to the receiving environment. Of the products that produce RQ's of >1, the products are water soluble so will be readily diluted and dispersed in the water column surrounding the Penguins FPSO and will be undetectable within a few tens of metres from the discharge point. It is therefore concluded that the chemical use associated with the Penguins platform is predicted to have no significant effect upon the surrounding environment.

Extensive research has been undertaken to assess the environmental effects of produced water discharges in many of the oil producing regions of the world (OGP, 2005). The potential environmental impacts of produced water are dependent upon a range of chemical, physical and biological processes that vary depending on the volume and density of the discharge, its dilution, the volatility of low molecular weight hydrocarbons and biodegradation of organic compounds (OSPAR, 2000).

There would also be possible secondary effects on marine organisms (e.g. plankton, larger invertebrates and fish). Phytoplankton and zooplankton communities seasonally present in the vicinity of the FPSO are likely to be the most sensitive group to effects from produced water discharges due to the elevated levels of hydrocarbons in the discharge. Although fish will be present under and around the FPSO they are unlikely to be exposed to any significant effects as they are mobile and the residence time within the discharge plume will be short. Toxicity studies on produced water discharges have shown that the concentrations of toxic chemicals in most produced waters are well below the test species 96 hour LC50 (lethal concentration for 50% of the individuals tested over a 96 hour period) indicating that acute toxicity is unlikely beyond the immediate vicinity of the discharge (GESAMP, 1993). Given the small scale of produced water discharges and small area affected relative to the baseline, the magnitude of impact is considered small ~~to medium.~~

4.6.5. Conclusion

The impact from produced water is predicted to be of small magnitude. The plume that results from a continuous discharge of produced water is likely only be detectable within a few tens of metres from the discharge point. The produced water will have a very small amount of entrained hydrocarbons (and other chemicals), but will meet UK regulatory standards. The surrounding water is considered of low sensitivity, supporting species of low to high importance in low abundance. The residual effect is therefore assessed as a negligible significance.

Overall, the discharges to sea associated with the proposed production activities are not considered to have a significant impact on the environment. The proposed operations do not contradict the NMP objectives GEN 1 (General Planning and Principle); GEN 9 (Natural Heritage); GEN 12 (Water Quality); GEN 21 (Cumulative Impacts); Oil & Gas 1 (Environmental Risks & Impacts); Oil & Gas 5 (Potential Environmental Risks & Hazards); and Oil & Gas 6 (Risk Reduction measures).

4.7. Accidental Hydrocarbon Spills

4.7.1. Spills During Installation

The worst-case risk of an accidental hydrocarbon spill during the proposed operations is the loss of one or both of the vessels' diesel inventory, e.g. due to a vessel collision. The possibility of such a hydrocarbon spill will be covered under the vessels' approved Shipboard Oil Pollution Emergency Plans (SOPEPs). The fuel inventory on the CSV is 2,272 m^3 and the fuel inventory on the AHV is 1,893 m^3.

Stochastic modelling of an instantaneous release of 4,165 m^3 (combined inventory of both vessels) was carried out using the Oilmap spill modelling software and has been used to aid in the assessment of probable impacts. The modelling results indicate that there is 100 % probability for diesel to cross the UK/Norway median line within 1 – 2 hours. However, no beaching of material occurred, and no protected sites were identified for being at risk from the loss of inventory.

The sensitivity of seabirds to surface oil pollution in the area is generally low throughout the year and low to medium during the proposed operations.

As diesel is a non-persistent hydrocarbon, its residence in the marine environment is low, as such, a diesel spill is likely to rapidly disperse and rapidly evaporate at the water surface and the risk to the marine environment from accidental spills is considered to be very low and effectively managed.

The likelihood of such a release is low. The prevention of hydrocarbon spills is of the highest environmental priority during Shell operations. As such, procedures, systems and training are in place to mitigate the chance of a spill occurring and to ensure a rapid response to any such event. All appropriate notifications to mariners will be made prior to the operations and operating procedures will be in place. Shipping levels in Blocks 211/13 and 211/14 are classed as 'very low' (Section 3.5.2). As diesel is a non-persistent hydrocarbon, its residence in the marine environment is low, as such, the risk to the marine environment from accidental spills is considered to be very low and effectively managed.

4.7.2. Spills During Operation

The worst-case risk of an accidental hydrocarbon spill during operations would be from either an uncontrolled well release from a well blowout or from a release of the stored crude inventory on the FPSO. The 2017 ES stated that the PAN-W well represented the worst case well blowout at the Penguins Field with a total well blowout of 413,367m3 of crude oil over 120 days. In 2019, Stochastic (probability) modelling using OSCAR was carried out for drilling operations at Penguins. The Rockhopper well now represents the worst case well blowout at the Penguins Field. The expected release duration is 115 days (time taken to drill a relief well). The average discharge of oil over this period is 9,388 m^3/day resulting in a worst-case total discharge of 1,079,620 m^3. Modelling was also conducted for the total loss of FPSO crude storage. The maximum storage capacity of the FPSO is 88,006 m^3.

The Rockhopper well blowout modelling indicates that the highest probability of beaching along the UK coastline is 70-80% along Eastern Shetland (Figure 4-2) in < 10 days between March – May (Figure 4-1), ~~shown in Figure~~ 4-1, shown in Figure 4-1. Due to the relatively short distance from the Penguins area to the median line, there is a 100% probability of oil crossing the UK/Norway median line in less than a day during all seasons, shown in Figure 4-2. The modelling shows there is a high probability of shoreline impact in western Norway (up to 80%), with a lower probability of other mainland European countries being impacted, Denmark (1 - 5%) and Sweden (≤1%), during the period of proposed operations, shown in Figure 4-3. The total worst-case of crude oil to beach is predicted to be 7,695 m^3 (6,348 tonnes).

Modelling indicated that in the event of total loss of FPSO storage, oil would cross the UK/Norway median line in 3 hours, shown in Figure 4-4. The quickest time to reach the UK shoreline is 6 days 11 hours during summer (Jun-Aug), and within 10 days 4 hours for the Norwegian shoreline during spring (Mar-May). It should be noted that arrival time is dependent on season with arrival times varying greatly, e.g., in winter (Dec-Feb) oil is not modelled to beach in the UK but will beach in Norway after 11 days and 14 hours. The worst-case shoreline oiling scenario (winter: Dec-Feb) would see 871 m^3 (1,046 tonnes) of emulsion on Norwegian shorelines, shown in

Figure 4-5. The season with the highest probability of UK shoreline oiling is spring (Mar-May), which has a 22% chance of oiling.

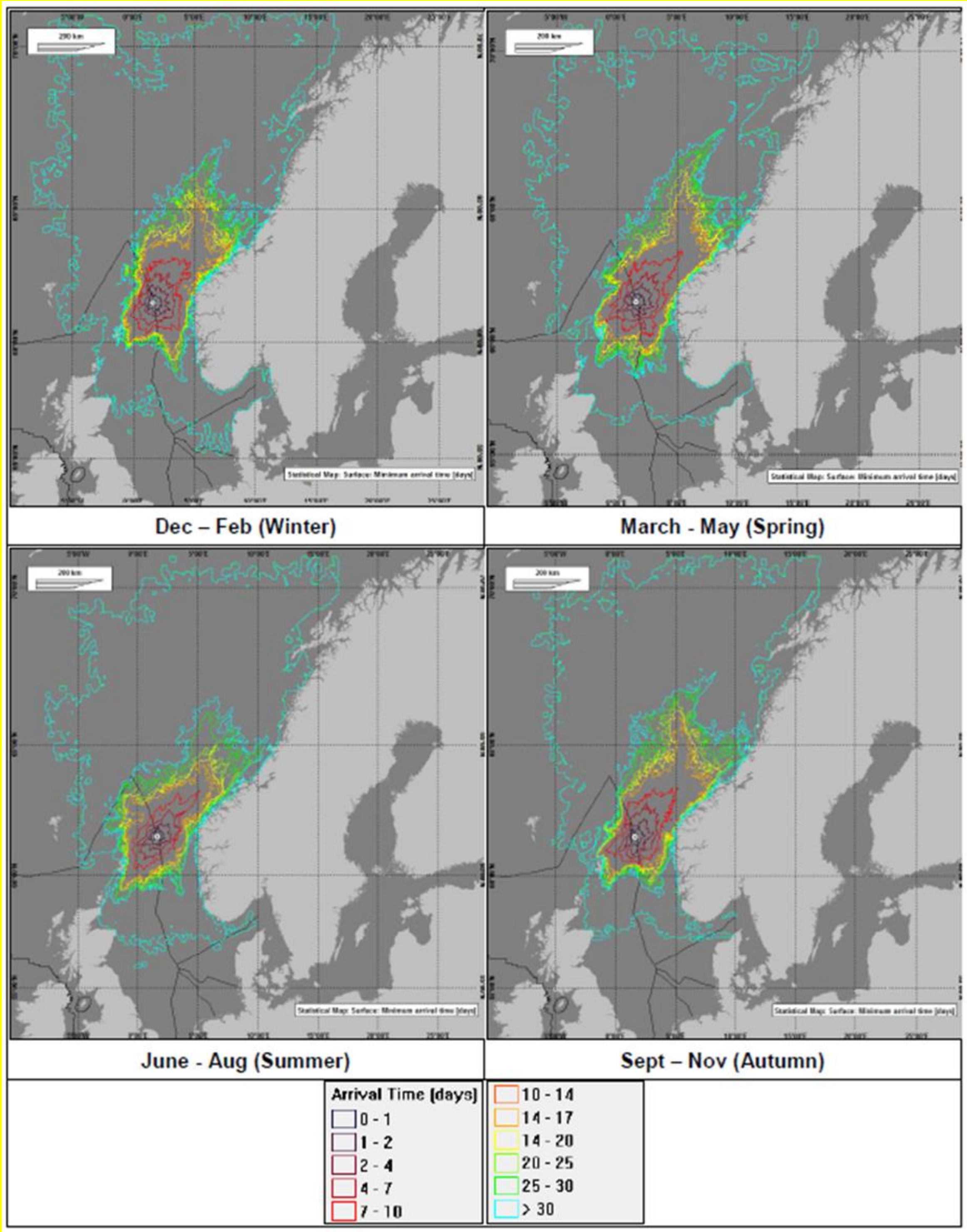

Figure 4-1: Seasonal arrival time plot (well blowout at Penguins Rockhopper well)

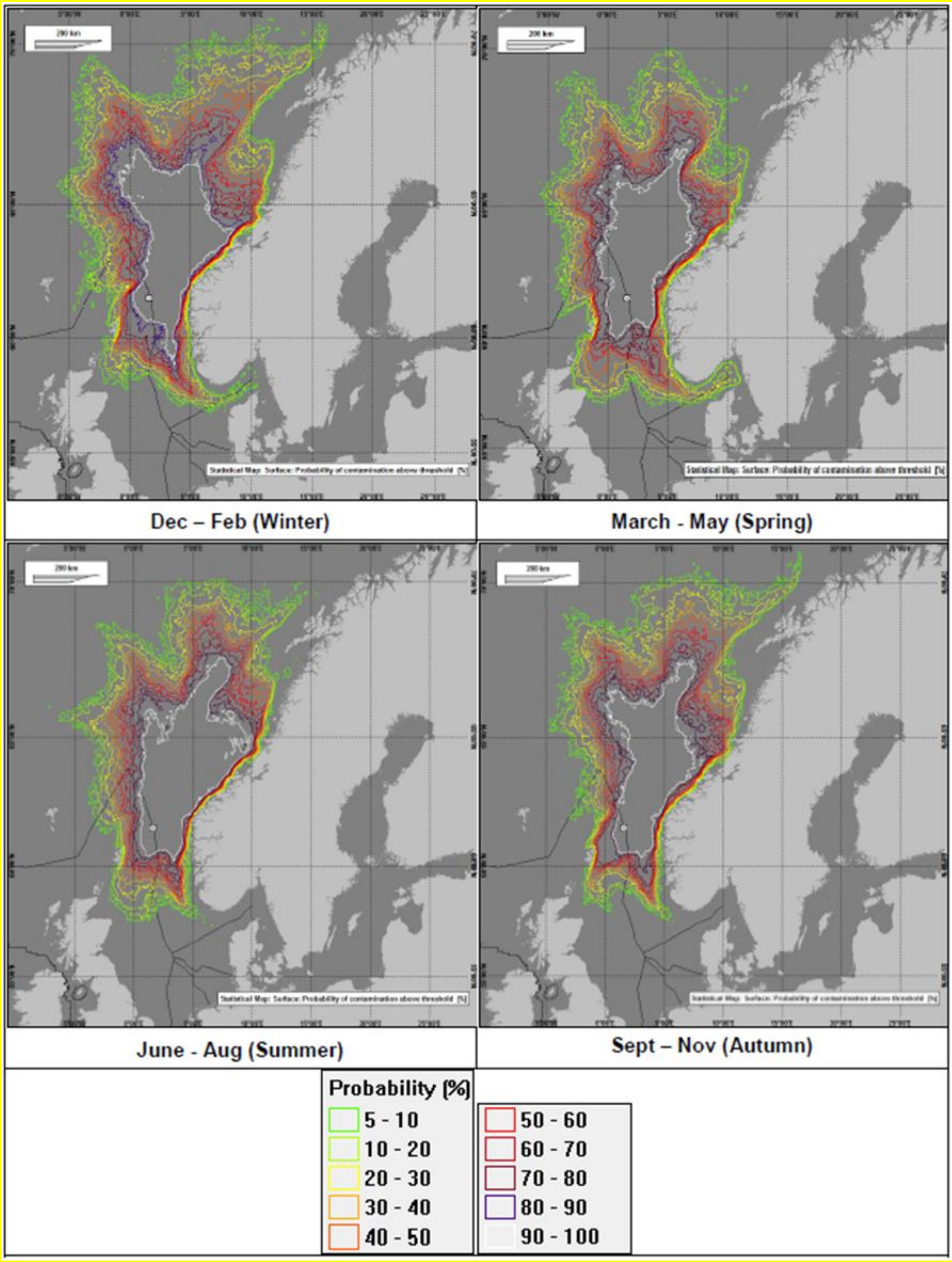

Figure 4-2: Probability of Oil beaching and crossing the median line (well blowout at Penguins Rockhopper well)

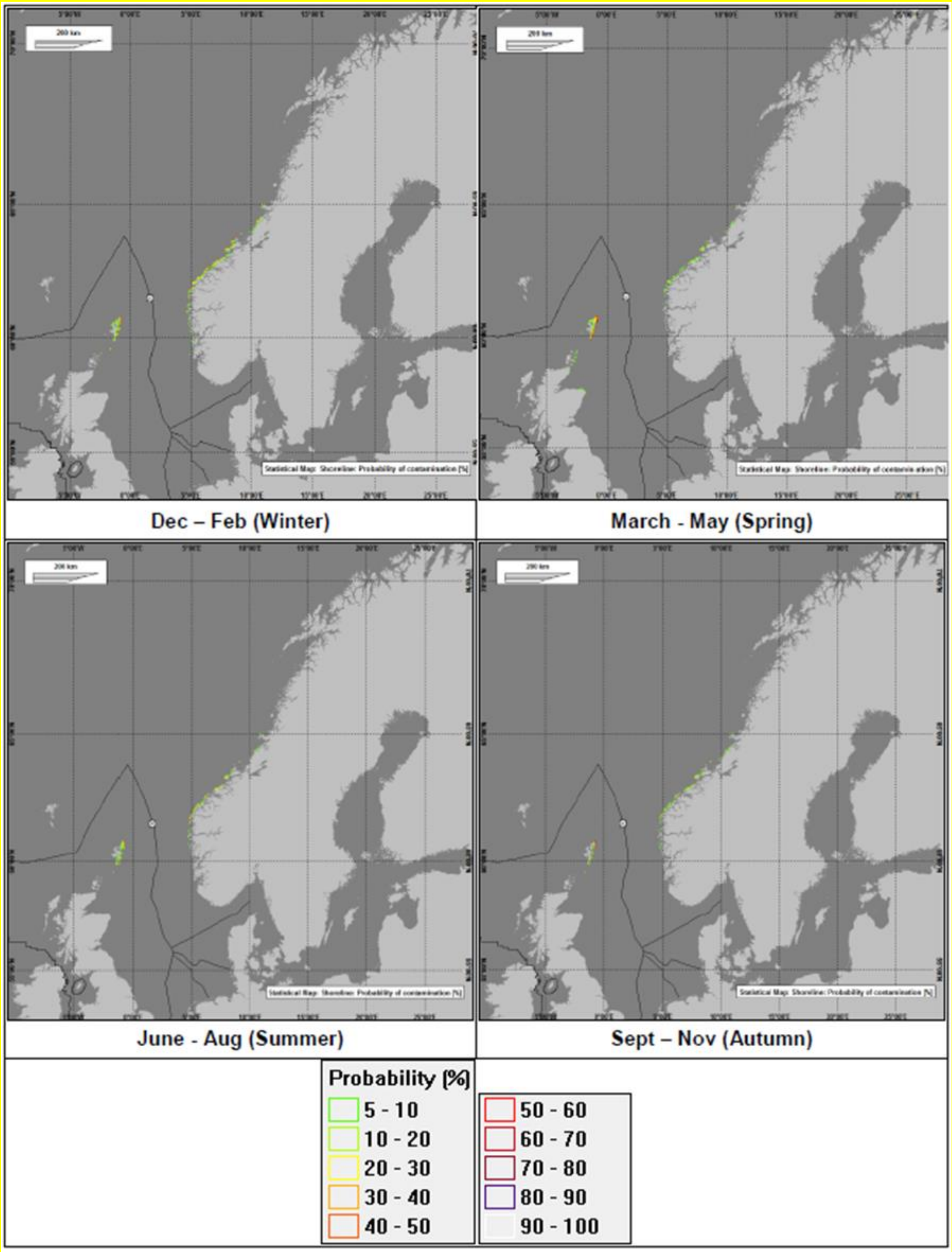

Figure 4-3: Probability of shoreline contamination (well blowout at Penguins Rockhopper well)

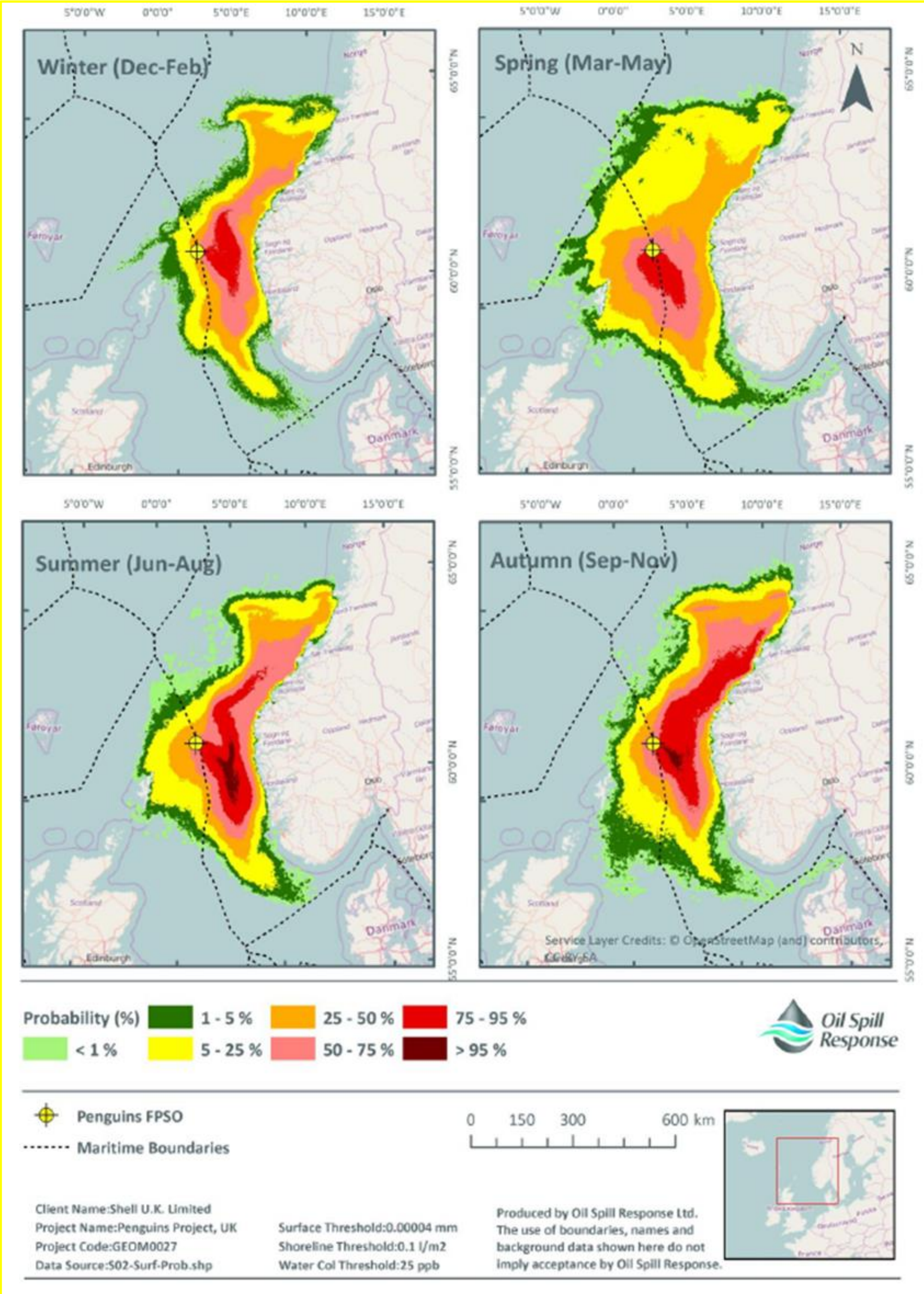

Figure 4-4: Probability of oil reaching the sea surface (FPSO inventory release)

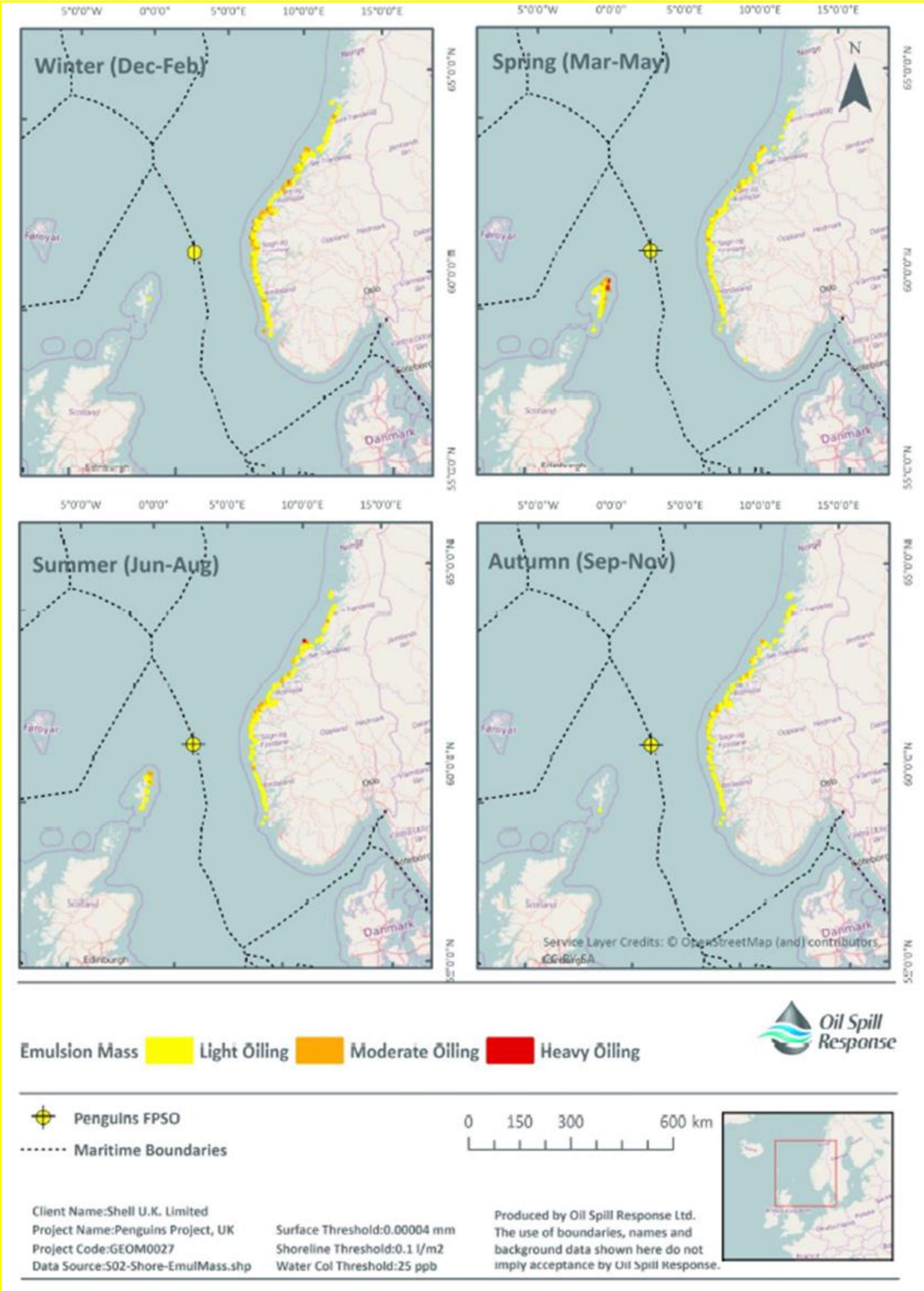

Figure 4-5: Maximum Emulsion mass on shoreline (FPSO inventory release)

The volume of oil beaching on coastlines is dependent on a number of factors such as the properties of the oil, and weather and sea conditions, where rougher seas are expected to break up and disperse surface oil more readily. The oil modelled for the Penguins Rockhopper well is a Type II hydrocarbon, which ITOPF (2014) suggests feature low asphaltene content (<0.5), are less likely to form emulsions and are therefore more able to readily disperse.

It should be noted that the modelling detailed assumes no intervention/response methods in order to determine the environmentally worst case. In reality the OPEP would be implemented to respond to the spill.

All wells in the UK are subject to well examination schemes as per the Offshore Safety Directive (OSD) 2015. The purpose is to provide assurance that the well is designed and constructed properly and is maintained adequately. This provides a scheme of quality control and quality assurance and incorporates current industry guidance. It is essential for the examination to demonstrate that the pressure boundary of the well is controlled throughout the well's life cycle and that the pressure containment equipment that forms part of the well is suitable for this purpose. Examination of planned well programmes and operations must be carried out by an independent and competent person. All Shell operations are in accordance with the Offshore Safety Directive as per Shell's Well Examination Scheme and Guidance Document.

Independent examination ensures that 'Good Oilfield Practice' and company standards are incorporated during drilling and well intervention operations. This contributes to risk reduction and prevention of loss of containment through application of the 'as low as reasonably practicable' (ALARP) principle.

The probability of an accidental hydrocarbon release occurring is very low and with mitigation measures in place, the likelihood of a spill occurring is further reduced. In the event of a spill, Shell will follow the response measures detailed in the Penguins FPSO and Field OPEP (Shell, 2023) and Shell's North Sea Operations Onshore OPEP, which include, but are not limited to the following:

- Monitoring and Surveillance;
- Dispersant application (vessel and aerial);
- Offshore Containment and Recovery;
- Relief well drilling in parallel with deployment of a capping device; and
- Shoreline protection and clean-up.

The availability of some, or all, of these responses will be weather dependant and any mitigation measures will be modified accordingly throughout any response and based on the Tier of response required (discussed further in Section 4.7.4).

4.7.3. Accidental Hydrocarbon Release – Conclusion

Given that the potential for oil to reach the coastline in both modelling scenarios is high, the consequence of the environmental impact is considered to be high. However, as the likelihood of a well blowout and total loss of FPSO storage occurring are remote, the environmental risk may be considered to be low/moderate. Following the application of mitigation measures (see Section 4.7.4), the risk to the marine environment is tolerable and can be reduced to ALARP.

Worst case well blowout has been updated to reflect latest information, however this does not result in any change to the consequence of the environmental impact or the spill response strategy.

4.7.4. Spill Response Strategy

In the event of an accidental release, response measures to be utilised would include, but are not limited to; monitoring and surveillance, dispersant application, capping or relief well drilling, etc.

Shell recognise three tiers of hydrocarbon spill incident:

- Tier 1 – Level of response that is locally available;
- Tier 2 – Level of response that can be mobilised within the required response times; and
- Tier 3 – An event which may require Shell to call on national and international resources.

The Penguins FPSO and Field OPEP (Shell, 2023) details specific response strategies for Tier 1 responses, and the process for elevating the tier response to levels 2 and 3, at which point Shell's North Sea Operations Onshore OPEP would take over. Should an incident require a Tier 2 or Tier 3 response, the Shell Onshore Emergency Response Team, in conjunction with Technical Specialists, would determine the appropriate response strategy, taking account of current weather conditions, spill size and sea state, along with any safety considerations.

4.8. Major Environmental Incident

A Major Environmental Incident (MEI), as defined under the Environmental Liability Directive (ELD) (Directive 2004/35/EC), refers to damage to protected species and natural habitats, which is "any damage that has significant adverse effects on reaching or maintaining the favourable conservation status of such habitats and species" (identified by reference to the Birds and Habitats Directives). In the event of a well blowout a multitude of species would be exposed significant volumes of crude oil. These include marine mammals, seabirds, fish, and microorganisms. Crude oil is also likely to enter a number of protected sites.

For an incident to be classified as an MEI, it first must meet the criteria to be considered a Major Accident Hazard (MAH). For an event to be classified as a MAH there must be:

a) an event involving a fire, explosion, loss of well control or the release of a dangerous substance causing, or with a significant potential to cause, death or serious personal injury to persons on the installation or engaged in an activity on or in connection with it;

b) an event involving major damage to the structure of the installation or plant affixed to it or any loss in the stability of the installation causing, or with a significant potential to cause, death or serious personal injury to persons on the installation or engaged in an activity on or in connection with it

c) the failure of life support systems for diving operations in connection with the installation, the detachment of a diving bell used for such operations or the trapping of a diver in a diving bell or other subsea chamber used for such operations;

d) any other event arising from a work activity involving death or serious personal injury to five or more persons on the installation or engaged in an activity on or in connection with it; or

e) any major environmental incident resulting from any event referred to in paragraph (a), (b) or (d)

Due to Shell's strict safety and risk reduction systems this is a highly unlikely eventuality. However, if a MAH did occur as a result of a well blowout, the spill is not automatically qualified as a MEI. As stated, an MEI is an incident which results in significant adverse effects on the conservation status of habitats and species.

The following Sections discuss the potential impact of an accidental hydrocarbon release on protected sites, habitats, and species of conservation importance. Section 4.8.1 concludes the MEI Assessment, while Section 4.7.4 outlines Shell's spill response strategy.

4.8.1. Potential Impact on Protected Sites and Habitats

In the UK there is a network of MPAs in place to support the protection of vulnerable and endangered species and habitats through structured legislation and policies (see Section 3.4).

The sites along the Norwegian coast have been established to maintain, conserve or restore biodiversity, natural heritage, habitats, species or landscapes with legal protection status. Breisunddjupet and Sularevet aim to protect the species *Lophelia Pertusa,* an anthozoan found in deep-water coral reefs.

Many of the Swedish sites protected under the Natura 2000 network are coastal sites, with species which would be considered highly vulnerable to a crude spill such as seabird and wildfowl breeding/overwintering grounds and coastal seal populations. Highly sensitive, low energy coastal habitats such as seagrass meadows, wetlands and saltmarsh are also present.

Natura 2000 sites on the Danish coast could also be potentially impacted. These sites are designated for the protection of numerous species and habitats listed under the EU Birds and Habitats Directives and would be directly affected by a spill reaching the coast.

Table 4-14 summarises the sites which will be impacted from the worst-case predicted modelled spill in offshore and coastal regions.

Table 4-14: Sites predicted to be impacted by surface oiling and potential beaching.

Region	Protected Area Type	Site	Probability (%) in Region	Protected Features
UKCS	NCMPA[1,2]	The North-East Faroe Shetland Channel	52%	Deep-sea sponge aggregations, offshore deep-sea muds, subtidal sands and gravels, continental slope and other features representative of the West Shetland Margin Palaeo-depositional, Miller Slide and Pilot Whale Diapirs Key Geodiversity Areas
		Faroe-Shetland Sponge Belt	18%	Deep-sea sponge aggregations, offshore subtidal sands and gravels, ocean quahog (*Arctica islandica*) aggregations, continental slope, channels, iceberg ploughmarks, prograding wedges, sand and sediment wave fields and slide deposits representative of West Shetland Margin Palaeo-depositional, Miller Slide and Pilot Whale Diapirs Key Geodiversity Areas
		North-West Orkney	9%	Sandeels, sandbanks and sand/sediment wave fields representative of West Shetland Margin Palaeo-depositional, Miller Slide and Pilot Whale Diapirs Key Geodiversity Areas
		Fetlar to Haroldswick	52%	Black guillemot, circalittoral sand and coarse sediment, horse mussel beds, kelp and seaweed communities, maerl beds and shallow tide-swept coarse sands with burrowing bivalves
		Mousa to Boddam	52%	Sandeels and marine geomorphology of the Scottish shelf seabed
		Papa Westray	22%	Black guillemot and marine geomorphology of the Scottish shelf seabed and sand wave fields
		Wyre and Rousay Sounds	22%	Kelp and seaweed communities on sublittoral sediment, maerl beds and marine geomorphology of the Scottish shelf seabed
		Central Fladen	5%	Burrowed mud (seapens and burrowing megafauna and tall seapen components) and sub-glacial tunnel valley representative of the Fladen Deeps Key Geodiversity Area
		Southern Trench	5%	Annex I habitat burrowed mud, shelf deeps. Annex II species minke whale (Balaenoptera).
	SAC/cSAC[3]	Pobie Bank Reef	52%	Annex I habitat 'Reefs'
		Papa Stour	18%	Annex I habitat reefs and submerged or partially submerged sea caves
		Sanday	9%	Annex I habitat reefs, sandbanks which are slightly covered by seawater all the time, mudflats and sandflats not covered by seawater at low tide and Annex II species harbour seal
		Faray and Holm of Faray	9%	Annex II species grey seal
		Sullom Voe	18%	Annex I habitat large shallow inlets and bays, coastal lagoons and reefs
		Yell Sound	52%	Annex II species otter and harbour seal

Region	Protected Area Type	Site	Probability (%) in Region	Protected Features
		Braemar Pockmark	2%	Annex I habitat submarine structures made by leaking gases
	SPA/pSPA[4]	Hermaness, Saxa Vord and Valla Field	52%	Seabird assemblage of European importance and international importance listed in Article 4.2 of Directive (79/409/EEC) for: red-throated diver, gannet, great skua, puffin, guillemot, kittiwake, shag and fulmar
		Fetlar	52%	Seabird assemblage of European importance and international importance listed in Article 4.2 of Directive (79/409/EEC) for: Arctic tern, red-necked phalarope, dunlin, great skua, whimbrel, Arctic skua and fulmar
		Noss	22%	Seabird assemblage of European importance and international importance listed in Article 4.2 of Directive (79/409/EEC) for: gannet, great skua, guillemot, puffin, kittiwake and fulmar
		Foula/Seas of Foula	22%	Seabird assemblage of European importance and international importance listed in Article 4.2 of Directive (79/409/EEC) for: great skua, northern fulmar, Arctic skua, common guillemot and Atlantic puffin
		Sumburgh Head	22%	Seabird assemblage of European importance and international importance listed in Article 4.2 of Directive (79/409/EEC) for: Arctic tern, guillemot, kittiwake and fulmar
		Fair Isle	22%	Seabird assemblage of European importance and international importance listed in Article 4.2 of Directive (79/409/EEC) for: Arctic tern, Fair Isle wren, guillemot, puffin, razorbill, kittiwake, great skua, Arctic skua, shag, gannet and fulmar
Norwegian Waters[5]		Protected areas which potentially transect the worst-case oil spill: Sularevet, Breisunddjupet, Ytre Hvaler, Flekkefjord, Jærstrendene, Oksøy-Ryvingen, Orrevatnet, Kjørholmane, Heglane og Eime, Nordre Rennesøy, Vignesholmane, Aatholmane and erkingstadøyene		
Danish Waters[6]		Protected areas which potentially transect the worst-case oil spill: Gule Rev, Jyske Rev, ThyborØn Stenvolde, Sandbanker ud for ThyborØn, Sandbanker ud for Thorsminde, Harboøre Tange, Plet Enge og Gjeller Sø, Lillefiskerbanke, Store Rev, Skagens Gren og Skagerak, LØstrup RØdgrund, Sydilige NordsØ		
Swedish Waters[7]		Protected areas which potentially transect the worst-case oil spill: Vrångöskärgården SCI and SPA, Måseskär SCI, Gullmarsfjorden, Malmöfjord SCI, Pater Noster-skärgården SCI, Sälöfjorden SPA and SCI, Stigfjorden SPA and SCI, Breviks kile-Toftenäs		
Sources: [1] JNCC (2015); [2] SNH (2016); [3] JNCC (2018a); [4] JNCC (2018b); [5] Marine Conservation Institute (2016); [6] EEA (2016); [7] Naturvardsverket (2019)				

The highest probability of a spill reaching coastlines is predicted for the UK and Norway. The probability of oil beaching in Denmark and Sweden is less than 5%. Worst-case results show that certain protected areas may be negatively impacted within these countries. It is therefore considered that an unmitigated spill to sea as a result of a well blow-out could result in a potential MEI to the UK and neighbouring countries.

Oil beaching has the potential to impact a number of UK and Norwegian coastal sites including International Union for Conservation of Nature (IUCN) protected landscapes, wildlife conservation areas and nature reserves. These areas contain diverse habitats and species, and oil beaching is likely to have a detrimental impact on them.

The behaviour and persistence of oil at the coastline depends on a number of factors including: the type of oil (e.g. heavy crude/refined fuel); the type of coastline (e.g. silty sand/rocky shore) and the environmental conditions (e.g. temperature, wave action). Oil spills from a well blowout scenario could have a long-term environmental impact. For example, 21 years after the Exxon Valdez oil spill in the Prince William Sound, Alaska, an estimated 97 tonnes of oil remained on Alaska's coastline, breaking down at an estimated rate of <4% per year (NOAA, 2010). It is possible that impacts to coastal protected areas affected could be long term.

4.8.2. Potential Impact on Species of Conservation Importance

PMF fish species described throughout Section 3.3 may be affected by a well blowout scenario. Exposure of fish to contaminants can occur either through uptake of dissolved fractions across the gills or skin, or direct ingestion of the pollutant. Once oil disappears from the water column, fish generally lose their hydrocarbon content very quickly. This rapid loss of oil from fish tissue is linked to the fact that fish will metabolise accumulated hydrocarbons very rapidly (Krahn *et al*., 1993). Fish are not expected to be significantly impacted from surface oil pollution.

All cetacean species occurring in the UKCS are protected under the Habitats Directive as EPS and as PMFs. Marine mammals may be exposed to oil in one of two ways: internally (swallowing contaminated water, consuming prey containing oil-based chemicals, or inhaling of volatile oil related compounds); and externally (swimming in oil or dispersants contacting the skin). Cetaceans in the vicinity of an oil spill are likely impacted by surface oil pollution when surfacing to breathe and may suffer moderate to significant effects. In the months following the Exxon Valdez spill there were numerous observations of grey whales, harbour porpoises, Dall's porpoises and killer whales swimming through light to heavy crude oil sheens (Harvey and Dahlheim, 1994), suggesting the potential for long term effects on cetacean populations.

Grey and harbour seals are also PMFs, however their abundance in the Penguins area is low (see Section 3.3.5). It is expected that these species are unlikely to be impacted in offshore areas, however they could be significantly impacted in coastal regions where evidence of oil-beaching may be a concern. Significant effects of hydrocarbon pollution around seal haul-out sites would constitute an MEI in accordance with the OSD and ELD definitions.

Surface pollution from a well blowout scenario is unlikely to impact offshore seabed habitats such as Pobie Bank Reef which is designated for Annex I reef habitats. However, coastal sites such as Hermaness, Saxa Vord and Valla Field SPA could be significantly affected from hydrocarbon pollution. This SPA site is designated for protection under the Birds Directive and located approximately 140 km from Penguins. As discussed in Section 3.3.6, seabirds are highly vulnerable to surface oil pollution and hydrocarbon contamination. Between November and January, seabird sensitivity to surface oil pollution in the Penguins area is predicted to be 'high'. Contamination of this area could constitute an MEI in accordance with the OSD and ELD definitions, if an MAH occurs.

The ELD covers habitats and species protected under the EU Habitats Directive and EU Birds Directive and defines environmental damage to as "any damage that has significant adverse effects on reaching or maintaining the favourable conservation status" of such habitats or species. Under this definition, given the high probability of beaching along the Norwegian coastline for a number of protected coastal sites, including protected birds, Annex I habitats and Annex II species, it is considered that a worst case release from the Rockhopper well has the potential to cause sufficient environmental damage that could result in MEI, although it should be noted that the likelihood of such an event is rare.

4.8.1. Potential Impacts on Aquaculture and Shellfish Water Protected Areas

The worldwide decline of ocean fisheries stocks has provided impetus for the rapid growth of aquaculture. For example, between 1987 and 1997 global production of farmed fish and shellfish more than doubled in weight and value (Naylor *et al.,* 2000). The aquaculture industry is important to Scotland's economic growth and is supported by the Aquaculture and Fisheries (Scotland) Act 2013, which aims to ensure that the interactions between farmed and wild fisheries are managed effectively to maximise their contribution to supporting sustainable economic growth.

The Water Environment (Shellfish Water Protected Areas: Designation) (Scotland) Order 2013 provides for the protection of water bodies in Scotland for a number of special purposes, including shellfish harvesting. This recognises the need for clean water in shellfish production areas to ensure a good quality product which is safe for human consumption. A number of sites have been designated as such on the Shetland and Orkney Islands. Water bodies can be impacted by pollution from various sources, such as run-off from agricultural land or discharges from sewage treatment works. These sites are not expected to be impacted by the proposed operations; however, they may be at risk in the event of an accidental spill.

The nearest finfish and shellfish farms to the proposed operations are *c.* 150 km away (Figure 4-6). Again, they are not expected to be impacted by the proposed operations; however, the sites may be at risk in the event of a well blowout.

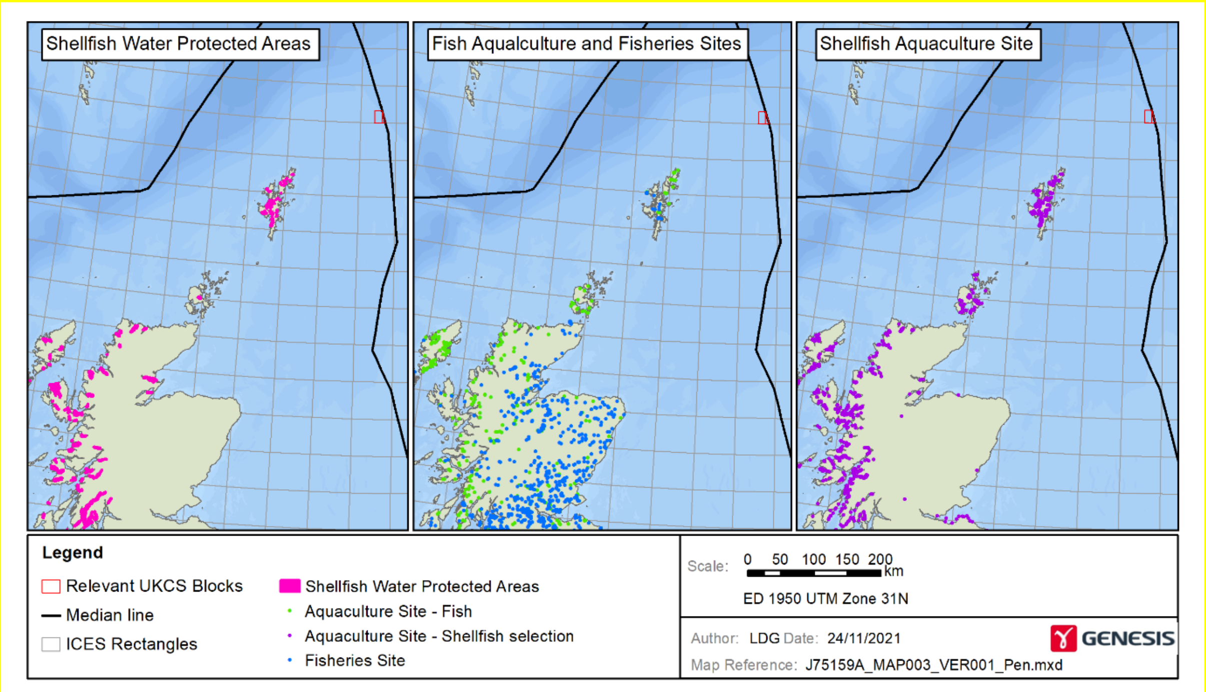

Figure 4-6: Location of Shellfish Water Protection Sites, finfish, and shellfish aquaculture sites in relation to the proposed operations (Scottish Government NMPi).

Oil spill modelling shows that there is a moderate to high probability (52 – 73% depending on the time of year) of beaching at Shetland and a low probability (1-17% depending upon the time of year) of beaching at Orkney and the north-east Scotland coastline, where aquaculture and Shellfish Water Protection Sites do occur (see Figure 4-6). Modelling results indicates a 30 – 79% probability of aquaculture sites along the west coast of Norway being impacted.

Shell recognises that there a number of salmon, rainbow trout and other fish farms on the coastline which, should a worst case well blowout at the Penguins field occur as a result of the proposed operations, would be expected to have to close for a couple of years until remediation has been allowed to occur. However, given the low probability of an oil spill occurring, the preventative measures in place to reduce the likelihood of a spill and the response resources and procedures set out in the event of a spill, the overall environmental risks to aquaculture and shellfish sites from the proposed operations are deemed to have been reduced to an acceptable level.

4.8.2. MEI Assessment

The well specific risk assessment process, along with vessel specific hazard identification studies have been used to help identify potential risks that could constitute a MAH, and subsequently an MEI, in accordance with the requirements and definition of the OSD and ELD. Of the MAHs identified, only a loss of well control could potentially result in an MEI during the proposed operations.

As discussed in Section 4.7, the worst-case modelled oil release is predicted to result in shoreline impacts to the UK, Norway, Denmark and Sweden. Given the maximum worst-case flowrate of the Rockhopper well it cannot be concluded with any certainty that an MEI would not occur. Additionally, based on the modelling results, an accidental release is likely to reach a range of protected sites in both the UKCS and neighbouring foreign waters, as well as impact a number of species and habitats of conservation importance.

Even though the worst case well blowout is now the Rockhopper well, there is no change to the MEI Assessment.

4.8.3. NMP Criteria

The proposed operations do not contradict the NMP objectives GEN 9 (Natural Heritage); GEN 12 (Water Quality and Resource); GEN13 (Noise); GEN 21 (Cumulative Impacts); Oil & Gas 1 (Environmental Risks & Impacts); Oil & Gas 5 (Potential Environmental Risks & Hazards); and Oil & Gas 6 (Risk Reduction measures).

4.9. Transboundary and Cumulative Impacts

Due to the localised nature of the installation works and production operations, none of the nearby oil and gas fields and installations, or other sea users, are likely to be impacted by the operations. The works will result in disturbance to the seabed, atmospheric emissions and underwater noise but are not considered to significantly increase cumulative impacts from surrounding oil and gas assets.

Limited guidance is available providing suitable criteria for which to screen for air quality in offshore locations, however, the UK Government provides guidance (EA, 2023) on how to screen for protected areas for onshore applications. This guidance provides an indication of the screening criteria acceptable for pollutants near protected areas and serves as a useful comparator. The guidance states that where a long-term process contribution (PC) is greater than 1% and the Predicted Environmental Concentration (PEC) is less than 70% of the applicable long-term environmental standard then the emissions are deemed insignificant.

Block 211/14 is adjacent to the UK/Norwegian median line and modelling (Genesis, 2024c) was undertaken to estimate the transboundary impact of emissions from the FPSO. The modelling showed that that no significant transboundary impacts are expected from installation and production operations and at all points on the model grid and at all receptors the PEC is less than 70%.

~~Block 211/14 is adjacent to the UK/Norwegian median line, however no significant transboundary impacts are expected from installation and production operations.~~

4.10. Environmental Management System

Shell is committed to conducting its activities in a manner that cause no harm to people, protects the environment, respects its neighbours and contributes to the societies in which it operates. The company seeks continued improvement in its environmental performance through the establishment of effective management systems. Shell's Health Safety and Environment [HSE] Management System is fully embedded within its Business Management System [BMS]. The 'Shell U.K. Limited HSE Management System Manual' provides the country specific overview of the HSE Management System for offshore operated ventures in the UKCS.

All activities will be conducted within the HSE Management System which is certified to the ISO 14001 standard. The HSE Management System Manual provides an overall framework of control to ensure compliance with legislation, prevention of pollution and the continued improvement of environmental performance. In particular Shell has adopted the Shell Group 'Goal Zero' aspiration of 'No Harm, No Leaks'. The aim of Goal Zero is to build a strong safety culture focusing on personal safety and process safety, barrier thinking and protecting the environment by driving positive behaviours.

In addition, as required by legislation, the UK sites have implemented the 'Shell Limited Corporate Major Accident Prevention Policy' which:

- Establishes the overall aims and arrangements for controlling the risk of a major accident;
- Describes how those aims are to be achieved and those arrangements put into effect; and
- Stipulate that business leaders are accountable for ensuring the policy is suitable, implemented and operates as intended

This policy is reviewed regularly and communicated to all personnel.

The Management System processes are periodically reviewed by both internal and external audits of the system. An additional requirement of these systems is appropriate contractor management and control with regard to HSE issues.

4.11. Additional Production Assessment

A future variation will be submitted for an anticipated production increase in 2025.

5. CONCLUSIONS

In line with the Penguins Development Environmental Statement (reference number D/4184/2015) (Shell, 2016) Shell proposed to install mooring chains and mooring piles in anticipation for the arrival of the new Penguins FPSO. These operations have now been completed. The proposed operations updated as part of this EAJ are the installation of the mooring rope, buoyancy and top chain, followed by FPSO tow and hook-up and subsequent production start-up.

The potential environmental sensitivities and impacts to the marine environment have been identified and assessed. Environmental sensitivities comprise benthos, plankton, fish, marine mammals, seabirds, protected sites and species, and other users of the sea. The potential impacts arise from physical presence, seabed disturbance, emissions to air, underwater noise and accidental hydrocarbon spill. The assessment incorporates the additional impacts (if any) associated with the production increase and associated Screening Direction.

The assessment took into account the magnitude of impact, mitigation measures, and the sensitivity of the receptor to determine the overall the impact significance.

- The physical presence of the vessels and proposed new subsea infrastructure for the workscope is not expected to have a significant impact on other sea users.
- Temporary placement of the mooring rope, buoyancy (including clump weights and potential seabed restraints) and top chain on the seabed is not likely to result in direct physical injury or death of individual animals, no habitats of conservation concern have been identified, the area affected is small and as a result, the impact of seabed disturbance is considered to be of negligible significance ~~low~~.
- Atmospheric emissions from the vessels represented 0.04 % of the CO_2 emissions produced by the UKCS in 2018 for the installation of the mooring chains and piles. Expected emissions are approximately 0.01 % (Options A and B) for the installation of the mooring rope, buoyancy and top chain, ~~and~~ 0.02 % (Options A and B) for the FPSO tow and hook-up, and 0.91 % for the production operations. No significant additional impact will occur as a result of these operations.
- Underwater noise associated with vessels is not expected to have a significant impact on any marine mammal or fish populations.
- Spill prevention measures will be implemented on all vessels. In the event of a diesel spill, procedures are in place, including the SOPEPs, to ensure effective management of any spill. The risk of an accidental hydrocarbon spill is considered to be low and effectively managed.
- No significant long term cumulative or transboundary effects are expected as a result of the Penguins Development.
- The operations are not considered to contradict the objectives of Scotland's NMP.
- No significant additional impacts on the marine environment are expected as a result of the forecast change in production.

~~All activities are to be managed according to Shell's Health Safety and Environmental (HSE) Management System, which is certified to the ISO 14001 standard (last re-certified in November 2022) and fully embedded within its Business Management System (BMS) requirements to eliminate or minimise potential impacts on the environment. Shell therefore concludes that the proposed operations do not present a significant impact to the surrounding environment.~~

All activities are to be managed according to Shell's Business Management System requirements to eliminate or minimise potential impacts on the environment. Shell therefore concludes that the proposed operations do not present a significant impact to the surrounding environment, including ecological receptors, protected sites and species, and other users of the sea.

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7. CHANGE SUMMARY

15/05/24: Update to address further regulator comments on the EAJ.

- Minor updates to Section 2.7.4 to align with PPC SAT.
- Update to CO_2 emission loads in Table 4-10 and Table 4-12 to align with PPC SAT.
- Amendment to text in Section 3.5.3 to clarify occupied Norwegian assets.
- Distance in Table 4-11 updated to align with other sections of the EAJ/ ADMS modelling in the PPC SAT.
- Table 4-12 updated to confirm comparison is for annual emission loads and includes flaring.
- Table 4-15 and Table 4-16 updated.
- Section cross-reference updated in Section 4.11.2.

10/05/24: Update to address further regulator comments on the EAJ.

- Section 2.7.4 Power Generation
- Section 4.4.2 Emissions during Production
- Section 4.11 Additional Production Assessment
- Further minor changes were made throughout the document.

29/04/24: Update to address regulator comments on EAJ

- Section 2.7.1 Production Profiles
- Section 2.7.3 Oil Processing System, Storage and Offloading
- Section 3.5.3 Oil and Gas Activities
- Section 4.1 Impact Assessment Methodology
- Section 4.11 Additional Production Assessment
- Further updates have been made throughout the EAJ to clarify the transboundary effects of the project

12/04/24: Update to address regulator comments on PPC:

- Section 4.3.2 Cumulative and Transboundary Impacts

14/03/24: Update to add the following sections:

- Section 1.1 Purpose of EAJ
- Section 2.7 Production Operations
- Section 4.3.2 Emissions during Production
- Section 4.5 Discharges to Sea
- Section 4.6.3 Spills during operation
- Section 4.6.4 Accidental hydrocarbon release
- Section 4.6.5 Spill response strategy
- Section 4.7 Major Environmental Incident
- Section 4.10 Additional Production Assessment

14/03/24: Update to address regulator comments:

- Section 1.2 update new CTL/ CL/1449 for the FPSO

- Section 2.3 Clarification on H link shackle
- Section 2.4.3 Clarification on what circumstances the designated wet storage area would not be used and how Shell will ensure that this (non wet storage location) is a safe area
- Section 2.4.5 total vessel days changed to 28 days
- Section Table 4.1 changed to 60 sandbags

01/03/24: Update to add the following sections:

- Section 2.3 and 2.4 – Inclusion of two options for installation works (Options A and B)
- Sections 2.5 and 2.6 - Inclusion of two options for installation works (Options A and B)

24/05/23: update to address regulator comments

1. Table 3-3 – There is a slight discrepancy between the harbour porpoise data in this table compared with the MAT entry. Please clarify.
    - **Response:** The harbour porpoise data has been amended in the MAT entry to reflect that outlined in Table 3-3.
2. Section 3.4.3 – The protected areas are incorrectly identified as coastal sites. Please clarify.
    - **Response:** The text has been amended to "protected areas" in Section 3.4.3.
3. Section 3.5.3 – This section states that Magnus is located 9km south west of Penguins where Penguins is located south east of Magnus. Please clarify.
    - **Response:** The text has been amended in Section 3.5.3 to clarify that the Magnus platform is located *c.* 9 km north west of Penguins.
4. Section 4.1.2 – Please confirm that a guard vessel remains on location at Penguins until the Penguins FPSO arrives.
    - **Response:** The text has been amended to specify that the guard vessel will remain on location until the arrival of the Penguins FPSO.

28/04/23: update to include CtL CL-1093-4

- Section 1.2 - This EAJ document supports the submission / variation of the subsidiary application template (SAT) as described.
- Section 1, 2, 4 & 5 - This EAJ document has been updated to describe the next proposed activities (Section 2), potential impacts (Section 4) and conclusions (Section 5) associated with:
    - The installation of the mooring rope, buoyancy and top chain.
    - Tow and installation of the FPSO

CL-1093-3

- Updates to the location and installation date of the waverider buoy and updates to reflect the installation of piles and chains that has already occurred.
- Updates have also been added to reflect the updates to regulations.

CL-1093-2

- No changes to the EAJ were made

CL-1093-1:

- Variation to add in the deployment of the Waverider buoy

Initial Submission

APPENDIX A: NOISE MODELLING

This appendix presents underwater noise modelling that has been carried out to assess potential impacts to marine mammals and fish from underwater noise generated during the Penguins Redevelopment Project. The noise modelling focusses on the piling of the FPSO mooring lines since this will be the loudest sound source associated with the Penguins Redevelopment Project.

The Penguins FPSO will be installed using 12 mooring lines each of which will be piled in place using a single pile. Each pile will be 30 m in length and 2.44 m in diameter. It is estimated that each pile will take about 4 hours to install and one pile will be installed per day (resulting in a total of 12 piling days). Piling of the mooring lines is expected to be conducted in April to mid-July 2020.

A.1 Piling Source Characterisation

A pile under percussive driving is a very complex underwater acoustic source. The sound levels generated during piling depend on many factors, such as hammer energy, mechanical properties and dimensions of the pile, water depth, and sea bed properties. The hammer energy has the biggest influence on the sound levels generated during piling, with higher energy hammers generating higher sound levels (Robinson *et al*., 2007).

To derive source levels for use in the propagation model, a representative third octave band Sound Exposure Level (SEL) frequency spectrum measured during pile-driving with an 800 kJ hammer (Ainslie *et al*., 2012) has been used. The proposed piling is expected to be conducted with a maximum hammer energy of 1,400 kJ. For use in the modelling, the measured SEL spectrum from Ainslie *et al*., (2012) has been scaled to account for the fact that the proposed piling will be conducted with a hammer operating at higher energy than that which was measured in Ainslie *et al*., (2012). It has been assumed that the source SEL scales linearly with hammer energy, which has been demonstrated by measurements made during pile-driving in Robinson *et al*. (2007). The third octave band SEL spectrum for the 800 kJ hammer measured in Ainslie *et al*., (2012) and the scaled SEL spectra for the 1,400 kJ maximum hammer energy that has been used in the modelling are shown in Figure A-0-1.

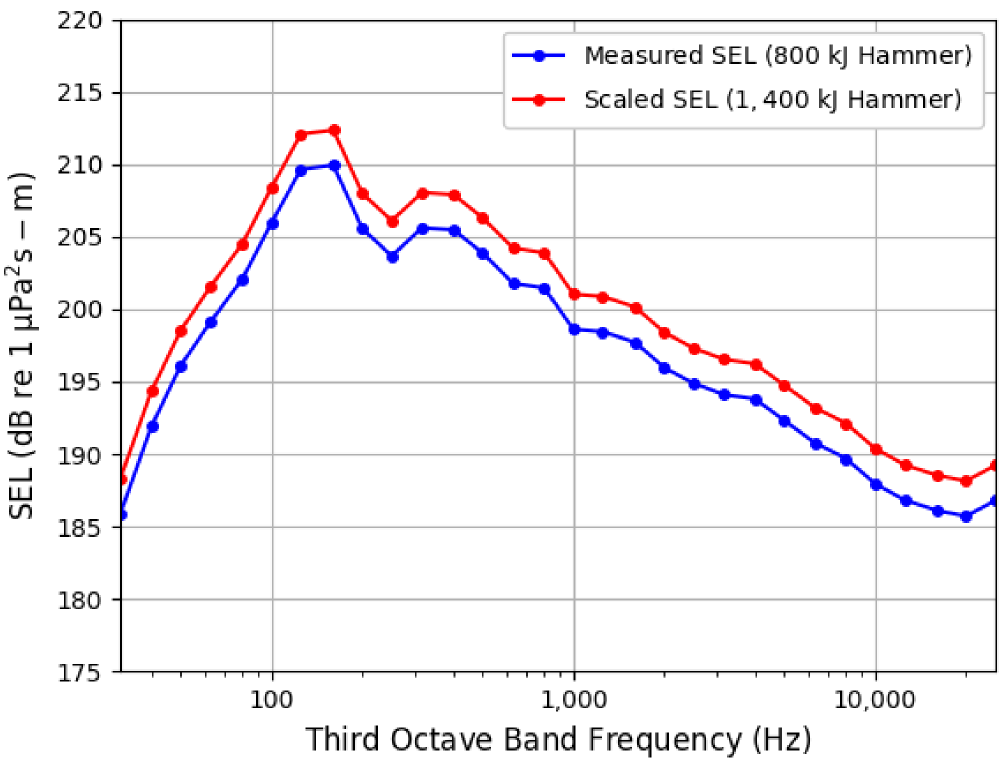

Figure A-0-1: Measured third octave band SEL spectrum for 800 kJ hammer and scaled third octave band SEL spectrum for 1,400 kJ hammer.

During piling, a soft-start/ramp-up of the hammer is typically employed where the hammer initially starts at a reduced energy and ramps up in energy over time. JNCC suggest that the soft-start period should be no less than 20 minutes (JNCC, 2010b). It has been assumed in the modelling that the hammer will initially start at 10% of the maximum blow energy. The soft-start/ramp-up procedure that has been included in the modelling is shown in Table A-0-1. As discussed previously, the SEL source levels shown in Table A-0-1 have been obtained by scaling the measured broadband source level from Ainslie *et al*., (2012). The zero-to-peak Sound Pressure Level (SPL) source levels have been estimated based on measurements made in Gardline (2010) and have been obtained by adding 26 dB to the SEL source levels.

Table A-0-1: Soft-start/ramp-up procedure assumed in the modelling for piling.

Hammer Energy (kJ)	Duration (minutes)	Blow Rate (blows/second)	Source Level	
			SEL (dB re 1 µPa²s-m)	Zero-to-peak SPL (dB re 1 µPa-m)
140	20	3	209.3	235.3
280	20	2	212.3	238.3
560	20	2	215.3	241.3
840	20	2	217.0	243.0
1,120	20	2	218.3	244.3
1,400	160	2	219.3	245.3

A.2 Propagation Model

The Genesis in-house software FARAM (Faunal Acoustic Risk Assessment Model) has been utilised for modelling sound propagation. FARAM is an underwater sound propagation model that incorporates site-specific environmental data such as a full bathymetric grid, varying water column temperature and salinity profiles, and geo-acoustic properties of the seabed. By explicitly modelling the factors affecting sound propagation, results can be obtained that are more accurate and relevant to the area of interest than would be obtained with more simplistic models (Farcas *et al.,* 2016). FARAM contains implementations of a parabolic equation (PE) and ray tracing algorithms, which have been used to estimate received sound levels from piling.

A.2.1 Parabolic Equation Algorithm

PE algorithms approximate the wave equation, allowing a solution to be found computationally (Jensen *et al*., 2011). This is one of the most popular wave-theory techniques for modelling sound propagation in spatially-varying environments (Jensen *et al*., 2011). The computational scheme used in this assessment is based on the Range-dependent Acoustic Model (RAM) implementation of the PE (Collins, 1993).

PE techniques are complex and require careful selection of environmental parameters (e.g. variation in bathymetry and sound speed profiles) and computational parameters (e.g. depth and range resolution) to ensure that the solution is accurate. The PE algorithm is best suited to calculation of low frequency sound propagation since the computational complexity (and hence implementation time) of the PE method significantly increases with frequency. For the modelling conducted in this assessment, the PE algorithm has been used to estimate the propagation of frequencies up to 1 kHz. A ray tracing algorithm has been utilised for sound propagation of frequencies above 1 kHz.

A.2.2 Ray Tracing Algorithm

The ray tracing method that has been utilised for modelling higher frequencies is the Bellhop Gaussian beam ray tracing model (Porter and Liu, 1994), which is an efficient algorithm that is well suited for the modelling of higher frequency sound.

Similar to the RAM PE algorithm discussed previously, Bellhop also incorporates acoustic propagation effects resulting from range dependent sound speed depth profiles and geo-acoustic properties. However, in contrast to the RAM PE algorithms, Bellhop also accounts for increased sound attenuation due to volume absorption. This type of sound attenuation becomes more prominent at higher frequencies and cannot be neglected without significantly over estimating received levels at large distances from the sound source.

A.3 Environmental Input Data

The implemented propagation algorithms account for various site-specific environmental properties including a bathymetric grid, geographically and depth varying sound speed profiles and geo-acoustic properties of the sediment. To model the effects of these environmental properties, input data is required that describes the surrounding environment. The environmental input data sets that are utilised in the propagation model are discussed in the following sections.

A.3.1 Sound Speed Profile

A major factor that influences the propagation of sound in water is the speed of sound through the water column, which influences how an acoustic wave refracts. A positive sound velocity gradient near the sea surface can form a surface sound channel, where sound energy can get trapped. A surface channel therefore acts like a waveguide that prohibits the sound from interacting with the ocean bottom and therefore significantly reduces transmission loss and consequently increases propagation distances. Conversely, a negative sound speed gradient refracts the acoustic wave toward the ocean bottom, increasing transmission loss and consequently decreasing propagation distances.

Sound speed data is typically not available through any databases but can be derived from measurements/modelling of temperature and salinity which are more readily available. Sound speed profiles for the model location were derived from temperature and salinity profiles taken from the World Ocean Atlas (WOA) from 2013 (WOA, 2013). WOA is an objectively analysed 1° resolution database where temperature and salinity data are given based on historical data. Since the sound speed profile is a function of temperature, pressure (which is a function of depth) and salinity, this database can be used to calculate the sound speed profile. The empirical formula in (Jensen *et al*., 2011) has been used to calculate sound speed profiles based on temperature, salinity and depth.

A.3.2 Bathymetry and Seabed Properties

Accurate bathymetry data is important for sound propagation modelling since the seabed strongly influences the propagation characteristics of sound. In shallow water regions, there is significant interaction of the sound with the sea bed through reflections and scattering effects, and strong attenuation may occur as sound penetrates the seabed. In deep water regions, there is typically less interaction of sound with the seabed and attenuation due to bottom loss is small, which can result in longer propagation distances.

The bathymetry data that has been used in the noise model is provided by EMODnet, which is a high resolution digital terrain model for European Seas (EMODnet, 2019a). The EMODnet bathymetry is based on almost 10,000 datasets obtained from bathymetric surveys, with bathymetric data provided at a spatial resolution of 1/16 arc minutes.

The implemented propagation model accounts for attenuation effects of sound due to interactions with the seabed. The modelling has assumed a sandy seabed and the main geo-acoustic properties associated with the seabed that have been used in the modelling are shown in Table A-0-2 (Jensen *et al.*, 2011).

Table A-0-2: Geo-acoustic parameters that have been used in the model.

Geo-acoustic Parameter	Value
Predominant sediment	Sand
Sound speed in sediment	1650.0 m/s
Sound attenuation in sediment	0.8 dB/wavelength
Sediment density	1,900 kg/m^3

A.4 Noise Impact Assessment Method

It is an offence under the Conservation of Offshore Marine Habitats and Species Regulations 2017 to:

a) *deliberately capture, injure, or kill any wild animal of a European protected species;* (termed 'the injury offence'),
b) *deliberately disturb wild animals of any such species* (termed 'the disturbance offence').

Here, injury is defined as a permanent threshold shift (PTS) i.e. a permanent shift in the hearing of an EPS, and disturbance of animals includes any event that is likely to:

a) *impair their ability to survive, breed or reproduce, or to rear or nurture their young, or (in the case of animals hibernating or migratory species), to hibernate or migrate;*
b) *affect significantly the local distribution or abundance of the species to which they belong.*

It has become increasingly evident that noise from human activities can potentially have an adverse impact on marine species (see e.g. Richardson, *et al*., 1995; Southall *et al*., 2007; NMFS, 2018; Popper *et al.,* 2014, Southall *et al*., 2019). Sound is important for marine mammals for navigation, communication and prey detection, and the introduction of anthropogenic sound therefore has the potential to impact marine mammals. Sound may also interfere with acoustic communication, predator avoidance, prey detection, reproduction and navigation in fish (see e.g. Slabbekoorn *et al*., 2010).

The extent to which underwater sound might cause an adverse environmental impact is dependent on numerous factors. The assessment method used here is largely based on the JNCC guidance on the protection of marine EPS from injury and disturbance (JNCC, 2010a). JNCC recommends considering the following factors when assessing potential impacts of sound:

a) Duration and frequency of the activity;
b) Intensity and frequency of sound and extent of the area where the disturbance and injury thresholds may be exceeded, taking into consideration species-specific sensitivities;
c) The most up to date thresholds for injury and behavioural responses;
d) Whether the local abundance or distribution could significantly be affected.

The current assessment has followed these guidelines and considered the JNCC recommendations to assess the potential impacts of the proposed piling activities.

A.4.1 Marine Mammal Impact Thresholds

Potential impacts to marine mammals have been assessed using several thresholds for injury and disturbance. The thresholds used in this assessment are based on a comprehensive review of evidence for impacts of underwater sound on marine mammals.

A.4.1.1 PTS

Numerous studies have been conducted to estimate the sound levels that can potentially cause injury to marine mammals. Thresholds for estimating potential impacts to marine mammals have been suggested by the National Oceanic and Atmospheric Administration (NOAA) (NMFS, 2018) and Southall *et al.,* (2019) based on the most recent studies and are now recognised as the appropriate criteria for assessing potential impacts to marine mammals.

NOAA and Southall proposed thresholds for marine mammals grouped into different functional hearing groups. It is noted that there is a slight difference in nomenclature between the NOAA guidance and that of Southall: NOAA grouped marine mammals into low-frequency (LF) cetaceans, mid-frequency (MF) cetaceans, high-frequency (HF) cetaceans, and phocid pinnipeds. Southall proposed equivalent hearing groups but refers to them as LF cetaceans, HF cetaceans, very high-frequency (VHF) cetaceans and phocid pinnipeds, respectively. Table A-0-3 shows the corresponding NOAA and Southall marine mammal hearing groups and lists some marine mammal species that are known to occur in the North Sea (Hammond *et al.,* 2017) categorised according to these hearing groups.

Table A-0-3: Marine mammal species categorised according to the hearing groups proposed by NOAA (NMFS, 2018) and Southall *et al.,* (2019).

Marine Mammal Hearing Group		Species [1]
NOAA (NMFS, 2018)	**Southall *et al.,* (2019)**	
LF cetaceans	LF cetaceans	**Minke whale**
MF cetaceans	HF cetaceans	**Atlantic white-sided dolphin, long finned pilot whale, beaked whale,** White-beaked dolphin, bottlenose dolphin, common dolphin, Risso's dolphin, striped dolphin, killer whale
HF cetaceans	VHF cetaceans	**Harbour porpoise**
Phocid pinnipeds	Phocid pinnipeds	Grey seal, harbour seal

[1] Species highlighted in bold are those that are more likely be present in the vicinity of the proposed piling operations. Other listed species or those that are known to occur in the North Sea but are unlikely to be present in the area during the timing of the proposed surveys.

Despite the difference in the naming of the marine mammal hearing groups, the thresholds for PTS onset proposed by Southall *et al.,* (2019) are precisely the same as those proposed by NOAA (NMFS, 2018) and are shown in Table A-0-4. In the rest of this impact assessment, only the nomenclature used by Southall *et al.,* (2019) for the marine mammal hearing groups is used.

The thresholds are expressed in terms of both zero-to-peak SPL and cumulative SEL. As dual-metric criteria, the onset of PTS is considered to potentially occur when either of the thresholds are exceeded (NMFS, 2018; Southall *et al.,* 2019).

The zero-to-peak SPL thresholds are used to assess the potential for injury to occur in marine mammals due to instantaneous sound pressure and do not take into consideration the hearing range of any marine mammals. In contrast, the cumulative SEL metric considers the hearing capability of the species under consideration by weighting the received SEL using generalised auditory weighting filters that have been derived for different marine mammal hearing groups. NOAA and Southall proposed the same auditory weighting filters, which are shown in Figure A-0-2.

Table A-0-4: Thresholds for potential PTS onset to marine mammals.

Marine Mammal Hearing Group		Sound Metric	Threshold for PTS onset
NOAA (NMFS, 2018)	**Southall *et al.,* (2019)**		
LF cetaceans	LF cetaceans	Unweighted zero-to-peak SPL	219 dB re 1 µPa
		Cumulative weighted SEL	183 dB re 1 µPa^{2}s
MF cetaceans	HF cetaceans	Unweighted zero-to-peak SPL	230 dB re 1 µPa
		Cumulative weighted SEL	185 dB re 1 µPa^{2}s
HF cetaceans	VHF cetaceans	Unweighted zero-to-peak SPL	202 dB re 1 µPa
		Cumulative weighted SEL	155 dB re 1 µPa^{2}s
Phocid pinnipeds	Phocid pinnipeds	Unweighted zero-to-peak SPL	218 dB re 1 µPa
		Cumulative weighted SEL	185 dB re 1 µPa^{2}s

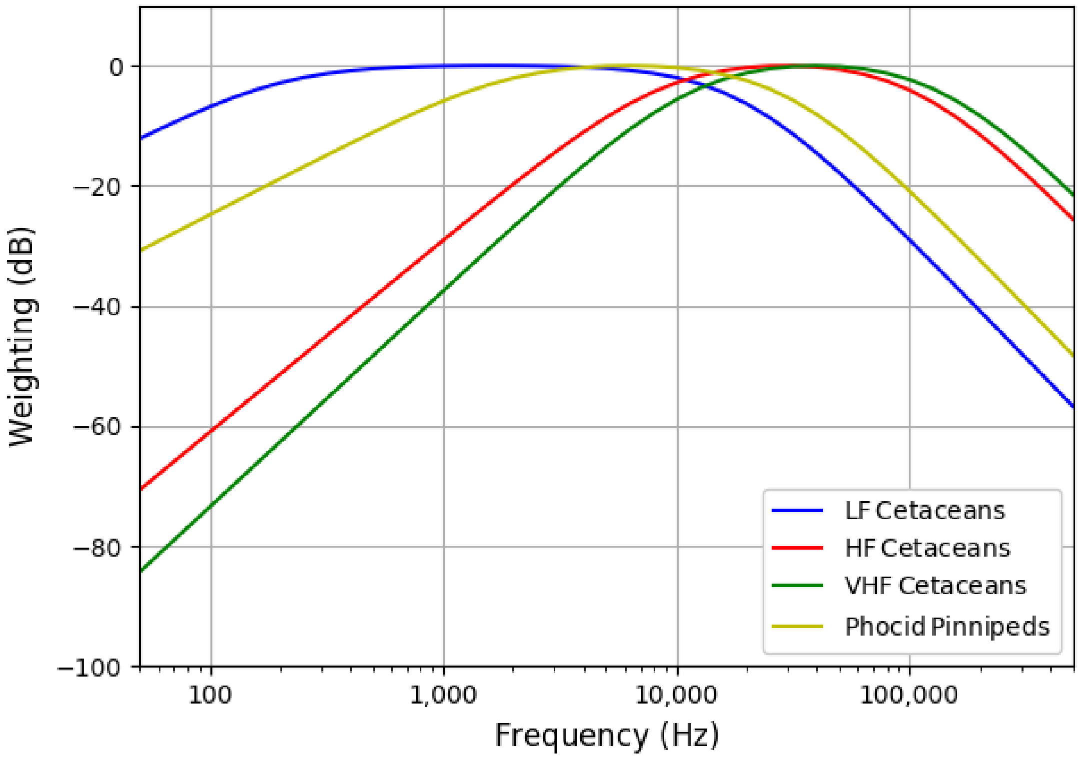

Figure A-0-2: Auditory weighting functions for different marine mammal hearing groups.

A.4.1.2 Behavioural Disturbance

Another important consideration in assessing the impacts of sound on marine mammals is the mammals' behavioural response. However, there are no generally accepted thresholds for behavioural disturbance to marine mammals (Southall *et al.,* 2007; NMFS, 2018; Southall *et al.,* 2019). This is because behavioural disturbance can range greatly from low level minor disturbance, such as small changes in swimming behaviour and vocalisation, to higher levels of disturbance such as strong avoidance of an area. Southall *et al.,* (2007) concluded that the available data on marine mammal behavioural responses were too variable and context-specific to justify proposing single disturbance criteria for all marine mammals. Instead, Southall *et al.* (2007) recommended assessing whether a noise from a specific source could cause disturbance to a particular species by comparing the circumstances of the situation with empirical studies reporting similar circumstances.

Thompson *et al.,* (2013) showed that harbour porpoise (which are VHF cetaceans) exhibited avoidance from a commercial 2D seismic survey at SEL sound levels between 145 - 151 dB re 1 µPa²s. Lucke *et al.,* (2008) have also reported that a captive harbour porpoise consistently showed behavioural responses at SEL levels exceeding 145 dB re 1 µPa²s. A threshold of 145 dB re 1 µPa²s has therefore been used in this assessment to signify areas of likely avoidance by VHF cetaceans.

The studies reviewed by Southall *et al.,* (2007) suggest that LF cetaceans could exhibit behavioural responses at root mean square (rms) SPLs from 150 - 160 dB re 1 µPa and would likely show avoidance at rms SPL above 160 dB re 1 µPa. An rms SPL threshold of 160 dB re 1 µPa has therefore been used to signify areas of likely avoidance by LF cetaceans. This threshold is also adopted by NMFS, (1995) as a threshold for significant disturbance to all marine mammals from impulsive sound.

There have been limited observations or measurements of sound levels that elicit behavioural responses in HF cetaceans (note that this group was originally referred to as MF cetaceans in Southall *et al.,* (2007)) and phocid pinnipeds. The studies reviewed by Southall *et al.,* (2007) suggested that HF cetaceans would only show strong avoidance for rms SPL sound levels exceeding 170 dB re 1 µPa and pinnipeds would likely show avoidance at rms SPL sound levels exceeding 190 dB re 1 µPa. However, given the lack of specific data for these species, the NMFS threshold of 160 dB re 1 µPa has been adopted as a conservative threshold for signifying areas where HF cetaceans and pinnipeds may possibly show avoidance behaviours.

The behavioural disturbance thresholds that have been adopted in this assessment are summarised in Table A-0-5. The rms SPL thresholds shown in Table A-0-5 have been converted to equivalent SEL thresholds for easier comparison with the predicted SEL sound fields from the noise propagation model. The conversion from rms SPL to SEL is dependent on the pulse width of the received signal. The pulse width of a piling pulse elongates (spreads in time) as it propagates away from the piling location (Robinson *et al.*, 2007). The integration time of most marine mammals' ears is approximately 125 ms (Tougaard *et al.,* 2015). As a conservative measure, a smaller integration time of 100 ms has been used to convert rms SPL thresholds to equivalent SEL thresholds. This is conservative because, for a given rms SPL threshold, a smaller integration time results in a lower equivalent SEL threshold.

Table A-0-5: Marine mammals behavioural disturbance thresholds used in this assessment.

Marine Mammal Hearing Group	Behavioural Disturbance Thresholds		Possible Response
	Rms SPL	SEL [1]	
LF cetaceans	160 dB re 1 µPa	150 dB re 1 µPa²s	Likely individual and/or group avoidance
HF cetaceans	160 dB re 1 µPa	150 dB re 1 µPa²s	Possible individual and/or group avoidance
VHF cetaceans	N/A	145 dB re 1 µPa²s	Likely individual and/or group avoidance
Phocid pinnipeds	160 dB re 1 µPa	150 dB re 1 µPa²s	Possible individual and/or group avoidance

1 Rms SPL converted to SEL assuming a pulse width of 100 ms.

A.4.2 Fish Impact Thresholds

A.4.2.1 Injury

Popper *et al*., (2014) have defined criteria for injury to fish based on a review of publications related to impacts to fish, fish eggs, and larvae from various high-energy sources including piling. Popper *et al.,* (2014) is the most comprehensive review available for potential impacts to fish species. The hearing capability of fish largely depends on the presence or absence of a swim bladder. Different injury thresholds are derived in Popper *et al*., (2014) for the following fish groups:

- Fishes with no swim bladder or other gas chamber;
- Fishes with swim bladders in which hearing involves a swim bladder or other gas volume;
- Fishes with swim bladders in which hearing does not involve the swim bladder or other gas volume; and
- Fish eggs and larvae.

The thresholds for mortality and potential mortal injury proposed in Popper *et al*., (2014) for these fish groups exposed to piling noise are shown in Table A-0-6.

Table A-0-6: Thresholds for potential mortal injury to fish.

Fish Group	Sound Metric	Threshold for Potential Mortal Injury
Fishes with no swim bladder	Unweighted zero-to-peak SPL	213 dB re 1 µPa
	Unweighted cumulative SEL	219 dB re 1 $\mu Pa^2 s$
Fishes with swim bladder involved in hearing	Unweighted zero-to-peak SPL	207 dB re 1 µPa
	Unweighted cumulative SEL	207 dB re 1 $\mu Pa^2 s$
Fishes with swim bladder not involved in hearing	Unweighted zero-to-peak SPL	207 dB re 1 µPa
	Unweighted cumulative SEL	210 dB re 1 $\mu Pa^2 s$
Eggs and larvae	Unweighted zero-to-peak SPL	207 dB re 1 µPa
	Unweighted cumulative SEL	210 dB re 1 $\mu Pa^2 s$

A.4.2.2 Behavioural Disturbance

Documented behavioural effects of sound on fish behaviour are variable, ranging from no discernible effect (Wardle *et al*., 2001) to startle reactions followed by immediate resumption of normal behaviour (Wardle *et al*., 2001; Hassel *et al*., 2004).

Despite some documented behavioural effects there are no well-established criteria or thresholds for assessing behavioural disturbance to fish. In fact, it was concluded in Popper *et al*., (2014) that there lacked sufficient evidence to recommend thresholds that correspond to behavioural disturbance for fish.

A.5 Assessment of Potential Impacts

This section presents the underwater noise modelling results and discusses any potential impacts to marine mammals and fish from the proposed piling operations.

A.5.1 Potential Impacts to Marine Mammals

Potential impacts have been predicted for marine mammals classified into the functional hearing groups proposed by Southall *et al.,* (2019) i.e. for marine mammals classed as LF cetaceans, HF cetaceans, VHF cetaceans and phocid pinnipeds. Table A-0-3 highlights the different species that could potentially be present in the area during the proposed piling categorised according to these functional hearing groups.

A.5.1.1 PTS Onset

The potential for PTS onset to marine mammals has been predicted by comparing estimated received sound levels to the zero-to-peak SPL and cumulative SEL thresholds discussed in Section A.4.1.1. PTS onset is considered to have occurred when either the zero-to-peak SPL threshold or the corresponding cumulative SEL threshold is exceeded (Southall *et al.,* 2019; NMFS, 2018).

Zero-to-peak SPL

Received sound levels in terms of unweighted zero-to-peak SPL have been predicted to identify potential areas where the instantaneous onset of PTS may occur to marine mammals. Figure A-0-3 shows the predicted zero-to-peak SPL from single pile strikes during the mooring line piling when the hammer is operating at the maximum energy of 1,400 kJ. This figure shows the maximum unweighted zero-to-peak SPL over all depths and does not signify the zero-to-peak SPL at any specific depth layer. The contours in Figure A-0-3 highlight the zero-to-peak SPL thresholds for the potential onset of PTS to marine mammals (see Table A-0-4).

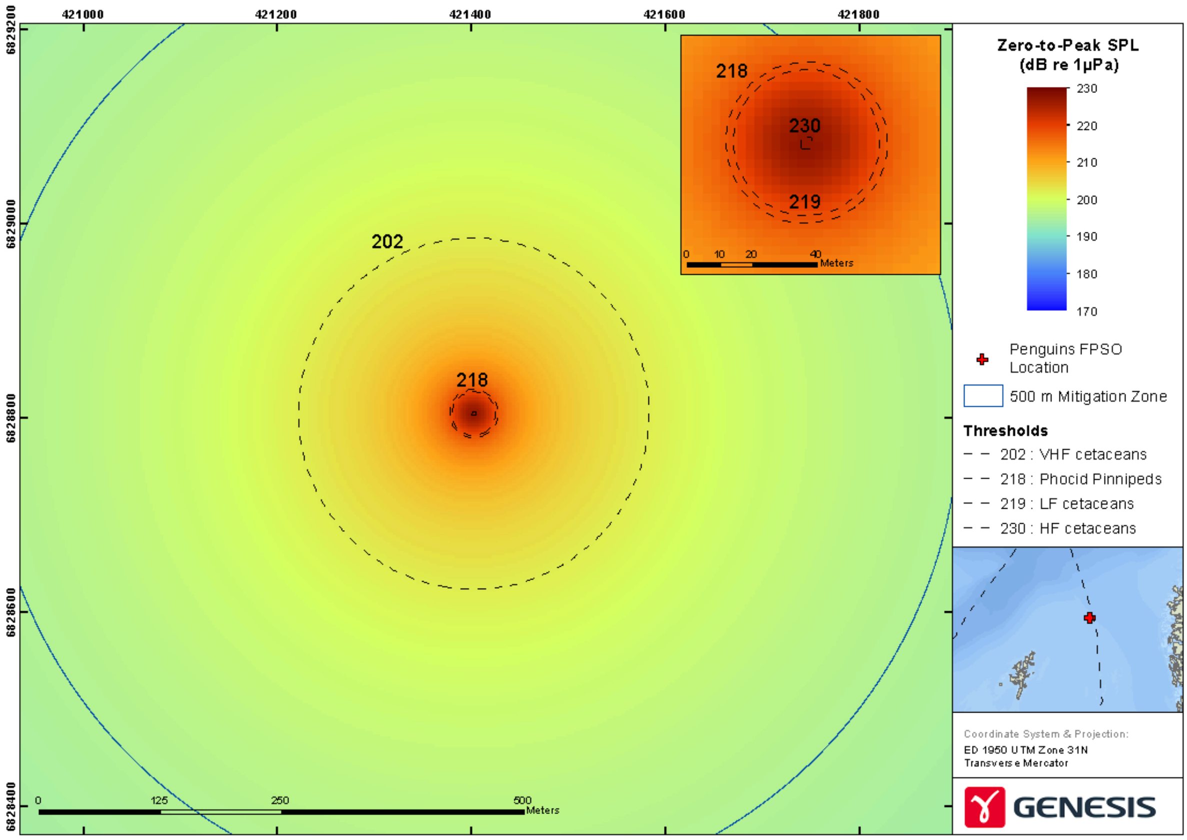

Figure A-0-3: Predicted unweighted zero-to-peak SPL during installation of the mooring line piles with the hammer operating at maximum energy of 1,400 kJ.

The predicted maximum distances where the zero-to-peak SPL thresholds for PTS onset are exceeded are summarised in Table A-0-7. It is predicted that the zero-to-peak SPL will fall below the PTS thresholds for all marine mammal hearing groups within the standard 500 m mitigation zone normally employed during piling operation. Therefore, if the 500 m mitigation zone is adhered to, the probability of zero-to-peak SPL sound levels produced by the piling causing PTS to marine mammals is considered to be low.

Table A-0-7: Predicted maximum distances from the piling locations where the zero-to-peak SPL thresholds for PTS onset to marine mammals are exceeded.

Marine Mammal Hearing Group	Zero-to-peak SPL PTS Threshold	Maximum Distance to Threshold Exceedance [1]
LF cetaceans	219 dB re 1 µPa	20 m
HF cetaceans	230 dB re 1 µPa	10 m
VHF cetaceans	202 dB re 1 µPa	180 m
Phocid pinnipeds	218 dB re 1 µPa	30 m

[1] Predicted distances have been rounded up to the nearest 10 m.

Cumulative SEL

The cumulative SEL received by marine mammals from the proposed piling operations has been estimated for mammals swimming away from the piling location and calculating the (weighted) cumulative SEL received over the full piling sequence (see Table A-0-1). The cumulative SEL modelling has been conducted for marine mammals swimming away from the piling at different swim speeds and initial starting distances from the piling location. Results are presented that show the furthest initial starting distances mammals must be at the commencement of piling in order to be able to swim away at a given swim speed and not be exposed to cumulative SEL sound levels exceeding the cumulative SEL thresholds for PTS onset.

Table A-0-8 shows the maximum distances that marine mammals must be at the start of piling (i.e. safety distances) in order not to be exposed to weighted cumulative SEL exceeding the thresholds for PTS when they swim away from the piling location at a given swim speed.

Table A-0-8: Predicted initial starting distance from the piling where cumulative SEL thresholds for potential PTS onset are exceeded for marine mammals swimming away from the piling at different swim speeds.

Marine Mammal Hearing Group	Cumulative SEL PTS Threshold	Swim Speed	Distance to Threshold Exceedance [1]
LF cetaceans	183 dB re 1 µPa²s	2.0 m/s	1,300 m
		2.5 m/s	320 m
HF cetaceans	185 dB re 1 µPa²s	> 2.0m/s	Threshold not exceeded
VHF cetaceans	155 dB re 1 µPa²s	2.0 m/s	620 m
		2.5 m/s	370 m
Phocid Pinnipeds	185 dB re 1 µPa²s	2.0 m/s	Threshold not exceeded

[1] Predicted distances beyond 1 km have been rounded up to the nearest 100 m and predicted distances less than 1 km have been rounded up to the nearest 10 m.

The modelling predicts that cumulative SEL PTS thresholds for HF cetaceans and phocid pinnipeds will not be exceeded when they swim away from the piling at speeds greater than 2 m/s. Therefore, the risk of PTS occurring to species in these hearing groups is considered to be low.

It is predicted that the thresholds for LF cetaceans and VHF cetaceans will not be exceeded outside the 500 m mitigation zone provided that these mammals swim away from the piling at speeds of at least 2.5 m/s. The LF cetaceans and VHF cetaceans that could potentially be in the area during the piling at Penguins are minke whale and harbour porpoise, which are LF cetaceans and VHF cetaceans, respectively, (see Table A-0-3). The normal swimming speed of a minke whale is 2.1 m/s (Williams, 2009) although they have been observed swimming at speeds of up to 7.2 m/s during migration (Lockyer, 1981). The mean swim speed of harbour porpoise is approximately 1.4 m/s (Westgate *et al.,* 1995), but they have been recorded swimming at speeds of up to 4.3 to 6.2 m/s (Culik *et al.,* 2001; Otani *et al.,* 2001). It is expected that marine mammals will swim away from the piling at a reasonably fast swimming speed if the sound levels are causing discomfort or stress.

Given the cumulative SEL results shown in Table A-0-8, it is considered unlikely that any marine mammal species will suffer PTS if they are outside the 500 m mitigation at the commencement of piling and swim away from the piling location. If any marine mammals are observed within the 500 m mitigation zone, piling will be delayed for at least 20 minutes following the last sighting of any marine species. Given this mitigation measure, it is expected that the risk of PTS onset to marine mammals will be low.

A.5.1.2 Behavioural Disturbance

To predict potential behavioural disturbance to marine mammals, received sound levels in terms of unweighted SEL for single pile strikes have been estimated and compared to the adopted behavioural disturbance thresholds (see Table A-0-5).

Figure A-0-4 shows the predicted unweighted SEL from single pile strikes during the mooring line piling at Penguins when the hammer is operating at the maximum energy of 1,400 kJ. This figure shows the maximum unweighted SEL over all depths and does not signify the SEL at any specific depth layer. The contours in Figure A-0-4 highlight the adopted behavioural disturbance thresholds for marine mammals.

The predicted distances and areas where the adopted behavioural disturbance thresholds are exceeded are summarised in Table A-0-9. The modelling predicts that LF cetaceans, HF cetaceans and phocid pinnipeds could experience behavioural disturbance within 15 km from the piling, whilst VHF cetaceans are predicted to experience disturbance within 30 km from the piling and manifold piling operations.

The predicted disturbance distances are consistent with observations made in the field during piling. Aerial surveys conducted during piling with a 500 kJ hammer at the Alpha Ventus Offshore Wind Farm showed that harbour porpoise (which are VHF cetaceans) were displaced out to distances of 15 to 25 km (Dahne *et al.,* 2013). The disturbance distances predicted by the modelling for the proposed mooring line piling operations are larger than those observed at Alpha Ventus since the proposed piling operations will be conducted with a higher hammer energy of 1,400 kJ compared to the 500 kJ hammer energy used at Alpha Ventus.

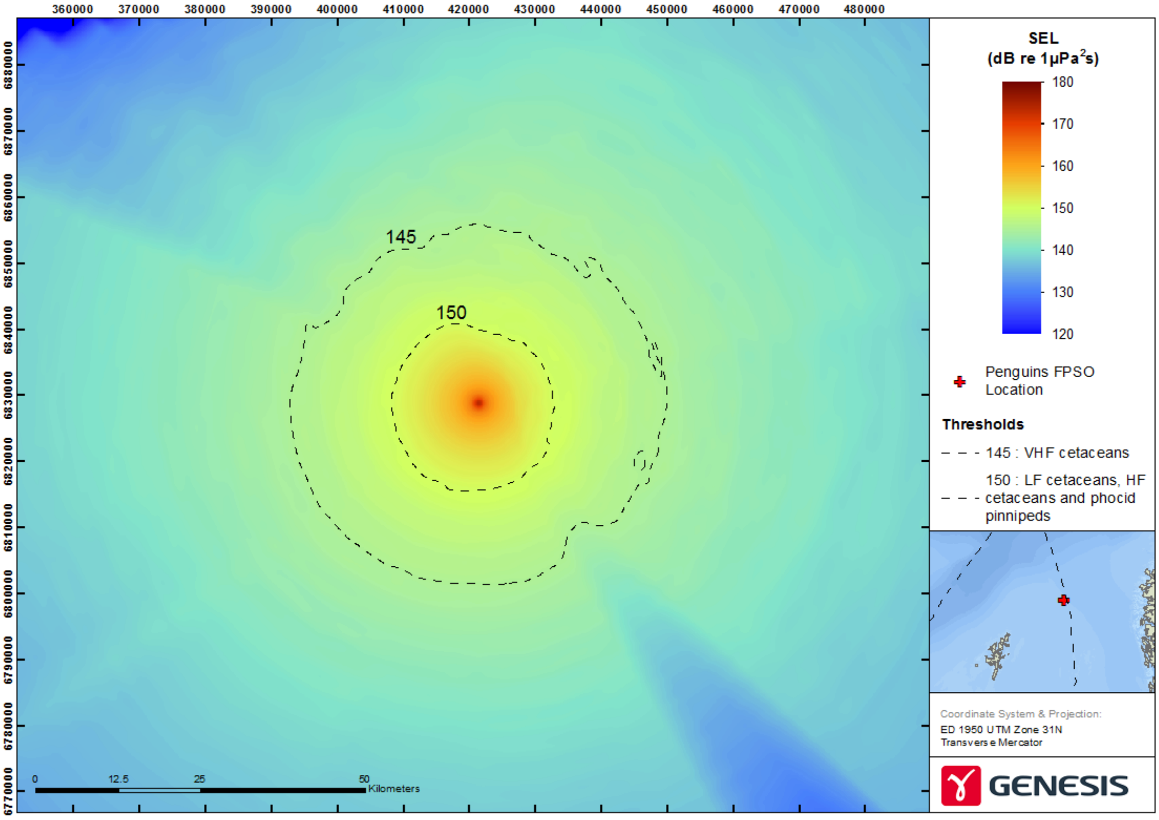

Figure A-0-4: Predicted unweighted SEL during installation of the mooring line piles with the hammer operating at maximum energy of 1,400 kJ.

Table A-0-9: Predicted distances and areas where the adopted behavioural disturbance thresholds are exceeded.

Marine Mammal Hearing Group	Behavioural Disturbance Threshold	Predicted Maximum Distance to Threshold Exceedance [1]	Predicted Area of Threshold Exceedance [2]
LF cetaceans	150 dB re 1 µPa²s	15 km	500 km²
HF cetaceans	150 dB re 1 µPa²s	15 km	500 km²
VHF cetaceans	145 dB re 1 µPa²s	30.0 km	2,335 km²
Phocid pinnipeds	150 dB re 1 µPa²s	15 km	500 km²

[1] The predicted distances have been rounded *up* to the nearest 1 km.

[2] The predicted areas have been rounded *up* to the nearest 1 km².

The number of animals that could potentially be disturbed or exhibit behavioural responses due to the proposed piling operations have been calculated based on the predicted disturbance zones and estimated densities of animals in the area (Hammond *et al.,* 2017). The estimated number of animals that could potentially be disturbed or exhibit behavioural responses from the proposed piling operations are shown in Table A-0-10. The number of marine mammals that may be disturbed by the proposed piling operations are relatively small compared to overall management unit (MU) populations (IAMMWG, 2015). The mooring line piling at Penguins is expected to be completed within 12 working days. Therefore, any disturbance to marine mammals will be temporary. It is expected that any marine mammals disturbed from the area will return shortly after cessation of activities. This is supported by studies undertaken during piling operations where harbour porpoises were observed to return to the area within three days once the piling ceased (Tougaard *et al.,* 2006; Brandt *et al.,* 2016).

Table A-0-10: Estimated number of animals and percentage of MU population disturbed.

Species	Disturbance Area	Animal Density [1]	Number of Animals Disturbed	MU Population [2]	Percentage of MU Population Disturbed
Harbour porpoise	2,335 km^2	0.321	750	227,298	0.32996 %
White-sided dolphin	500 km^2	0.003	2	69,293	0.00289 %
Minke whale	500 km^2	0.015	8	23,528	0.03400 %
Beaked whale	500 km^2	0.001	1	N/A	N/A

[1] Animal densities are from Hammond *et al*., (2017)

2 MU populations are from IAMMWG, (2015). MU areas and populations

A.5.2 Potential Impacts to Fish

A.5.2.1 Injury

To quantitatively assess any potential injury to fish from the proposed piling, received sound levels in terms of unweighted zero-to-peak SPL and unweighted cumulative SEL have been predicted and compared to the Popper *et al*. (2014) thresholds for injury (see Table A-0-6.

Table A-0-6).

Figure A-0-5 shows the predicted zero-to-peak SPL from pile strikes during the mooring line piling at Penguins when the hammer is operating at maximum energy of 1,400 kJ. The contours in this graphic highlight the Popper *et al*. (2014) zero-to-peak SPL thresholds for potential injury to fish species. The predicted distances where the zero-to-peak SPL thresholds are exceeded are shown in Table A-0-11, whilst the predicted distances where the Popper unweighted cumulative SEL thresholds are exceeded are shown in Table A-0-12.

The modelling predicts that, when the hammer is operating at maximum blow energy, injury to fish could potentially occur out to a maximum distance of 50 - 90 m from the proposed piling operations. However, it is expected that most fish would disperse from the area during the soft start of the hammer. The proposed piling operations could potentially be conducted during spawning of haddock, Norway pout and saithe. However, given the small area of estimated potential impact to fish species, it is not expected that the proposed piling will have a significant injurious impact on spawning fish.

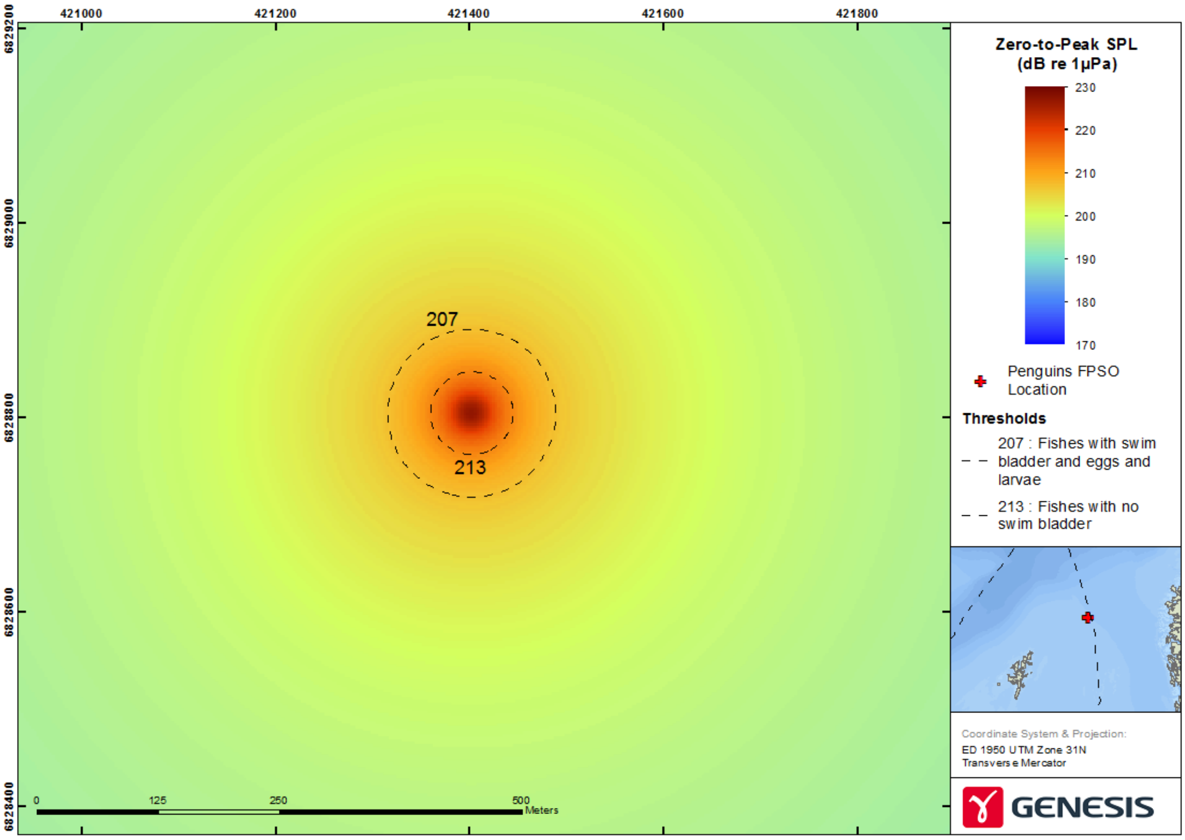

Figure A-0-5: Predicted unweighted zero-to-peak SPL during installation of the mooring line piles with the hammer operating at maximum energy of 1,400 kJ.

Table A-0-11: Predicted maximum distances from the piling locations where the Popper zero-to-peak SPL thresholds for fish injury are exceeded.

Fish Group	Zero-to-peak SPL Injury Threshold	Maximum Distance to Threshold Exceedance [1]
Fishes with no swim bladder	213 dB re 1 µPa	50 m
Fishes with swim bladder involved in hearing	207 dB re 1 µPa	90 m
Fishes with swim bladder not involved in hearing	207 dB re 1 µPa	90 m
Eggs and larvae	207 dB re 1 µPa	90 m

[1] Predicted distances have been rounded up to the nearest 10 m.

Table A-0-12: Predicted initial starting distance from the piling location where the Popper cumulative SEL thresholds for fish injury are exceeded.

Fish Group	Cumulative SEL Injury Threshold	Swim Speed	Maximum Distance to Threshold Exceedance
Fishes with no swim bladder	219 dB re 1 µPa²s	2.0 m/s	Threshold not exceeded
Fishes with swim bladder involved in hearing	207 dB re 1 µPa²s	2.0 m/s	Threshold not exceeded
Fishes with swim bladder not involved in hearing	210 dB re 1 µPa²s	2.0 m/s	Threshold not exceeded
Eggs and larvae	210 dB re 1 µPa²s	2.0 m/s	Threshold not exceeded

A.5.2.2 *Behavioral Disturbance*

Behavioural disturbance to fish could not be predicted from the propagation modelling since there are no well-established disturbance thresholds for fish. However, fish are mobile animals that would be expected to move away from a sound source that had the potential to cause them harm. If fish are disturbed by sound, evidence suggests they will return to an area once the activity generating the sound has ceased (Slabbekoorn *et al*., 2010). It is concluded that the proposed survey will not have a significant impact on any fish species.

A.5.3 Cumulative noise

There are no known planned seismic surveys or other piling operations in the area during the time that the proposed piling will be conducted. Given the short duration of the proposed piling operations, it will unlikely have a significant contribution to cumulative noise.

A.6 Mitigation Measures

To minimise the risk of potential impacts of sound from the piling further, the JNCC guidelines for minimising the risk of injury to marine mammals from piling noise (JNCC, 2010b) will be followed. The following mitigation measures will be employed:

- A dedicated, properly qualified, trained and equipped marine mammal observer (MMO) will be used.
- The MMO will visually monitor a mitigation zone of 500 m radius around the piling location to detect any marine mammals.
- If any marine mammals are observed within the 500 m mitigation zone, the start of piling will be delayed for at least 20 minutes following last sighting.
- The MMO will carry out a 30-minute pre-piling survey of the mitigation zone and, if an animal is detected, the piling will be delayed until all marine mammals vacate the 500 m mitigation zone.
- A soft start to the piling of at least 20 minutes will be conducted;
- If there is a break in piling for a period longer than 10 minutes, then the pre-piling search and soft-start procedure will be repeated before piling recommences; and
- Passive Acoustic Monitoring (PAM) will be used during the piling operations. This can be a useful supplement to visual monitoring during periods of poor visibility but is only effective for species that regularly vocalise. PAM systems are particularly useful for detecting harbour porpoises.

With these mitigation measures in place and taking into account the results of the noise modelling assessment, it is expected that the risk of injury to marine mammals will be reduced to negligible levels.

A.7 CONCLUSIONS

This assessment has considered the potential impacts from piling operations at Penguins. Sound propagation modelling was conducted for the piling of 12 mooring lines. The propagation modelling results were used to assess any potential impacts to marine mammals based on a comparison of estimated received sound levels with the Southall *et al.,* (2019) and NOAA (NMFS, 2018) thresholds for potential PTS onset. Potential injury to fish species was assessed by comparing predicted sound levels to the injury thresholds established by Popper *et al*. (2014).

Comparison of received sound levels to the thresholds for potential PTS onset to marine mammals suggested that sound levels generated from the proposed piling operations would be expected to decrease to below the thresholds within the 500 m mitigation zone that will be established during the piling. MMOs will observe the 500 m mitigation zone before the commencement of piling and if any marine mammals are observed, the piling will be delayed until all mammals have vacated the mitigation zone for at least 20 minutes following the last sighting. Furthermore, a soft-start of the impact hammer will be deployed at the start of piling where the hammer will be ramped up over a period of at least 20 minutes. The soft-start of the hammer will allow any marine mammals in the vicinity of the piling location to swim away to distances where they will only be exposed to lower sound levels. Given these mitigation measures, as well as the other mitigation measure that will be employed, it is considered that the risk of any marine mammal experiencing the onset of PTS is low.

Possible areas of behavioural disturbance were also predicted from the underwater noise modelling. It was predicted that harbour porpoise could be disturbed out to 30 km from the pipeline initiation piling, whilst other species could be disturbed out to 15 km. Although it is predicted that the proposed piling operations will result in behavioural disturbance to marine mammals, the number of marine mammals that could potentially be disturbed is estimated to be relatively small compared to MU populations. The piling is expected to be completed within 12 working days. Given the short duration of the proposed piling operations, any disturbance caused to marine mammals will only be temporary and it is expected that any marine mammals disturbed from the area would return after cessation of the survey. It is therefore concluded that any disturbance caused will not have a significant impact on any marine mammal population.

The modelling predicted that the thresholds for injury to fish species could be exceeded out to a maximum distance of 90 m from the piling locations. It is expected that the soft start of the impact hammer would disperse any fish to safe distances where they would not experience sound levels that could cause injury. Fish eggs and larvae, which will not be able to move away from the piling location, may suffer injury at distances of up to 90 m from the piling locations. However, the predicted area where fish eggs and larvae may be injured is very small in comparison to the size of known spawning grounds. It is therefore unlikely the sound from the proposed piling operations will have any significant impact on spawning fish or their eggs and larvae.

Overall, it is concluded that there will be low risk of injury to any marine mammals or fish species from the proposed piling operations, and any potential disturbance will be short term. The proposed piling will therefore not have a significant impact on any marine mammal or fish populations.

ACRONYMS AND ABBREVIATIONS

dB	Decibels
dB re 1 µPa	Decibels relative to one micro-Pascal
dB re 1 µPa-m	Decibels relative to one micro-Pascal referred to one metre
dB re 1 μPa^2s	Decibels relative to one micro-Pascal square second
dB re 1 μPa^2s-m	Decibels relative to one micro-Pascal square second referred to one metre
EAJ	Environmental Assessment Justification
EC	European Commission
ED	European Datum
EEC	European Economic Community
EIA	Environmental Impact Assessment
EMODnet	European Marine Observation and Data network
EPS	European Protected Species
EU	European Union
FARAM	Faunal Acoustic Risk Assessment Model
FPSO	Floating Production and Offloading
HF	High Frequency
Hz	Hertz
IAMMWG	Inter Agency Marine Mammal Working Group
ICES	International Council for the Exploration of the Seas
JNCC	Joint Nature Conservation Committee
kg/m^3	Kilograms per cubic metre
kHz	Kilo-Hertz
kJ	Kilo-Joules

km	Kilometres
km^2	Square kilometres
LF	Low Frequency
m	Metres
m/s	Metres per second
MF	Mid Frequency
MMO	Marine Mammal Observer
MPA	Marine Protected Area
ms	Milli-seconds
MU	Management Unit
NCMPA	Nature Conservation Marine Protected Area
NMFS	National Marine Fisheries Service
NMP	National Marine Plan
NMPi	National Marine Plan interactive
NNS	Northern North Sea
NOAA	National Oceanic and Atmospheric Administration
OGA	Oil and Gas Authority
OSPAR	Oslo and Paris Convention
PE	Parabolic Equation
PMF	Priority Marine Feature
PTS	Permanent Threshold Shift
RAM	Range-dependent Acoustic Model
rms	Root mean square
SAC	Special Area of Conservation
SCANS	Small Cetacean Abundance in the North Sea
SCOS	Special Committee on Seals

SEL	Sound Exposure Level
SMRU	Sea Mammal Research Unit
SNH	Scottish Natural Heritage
SPA	Special Protection Area
SPL	Sound Pressure Level
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
UTM	Universal Transverse Mercator
VHF	Very High Frequency
WOA	World Ocean Atlas