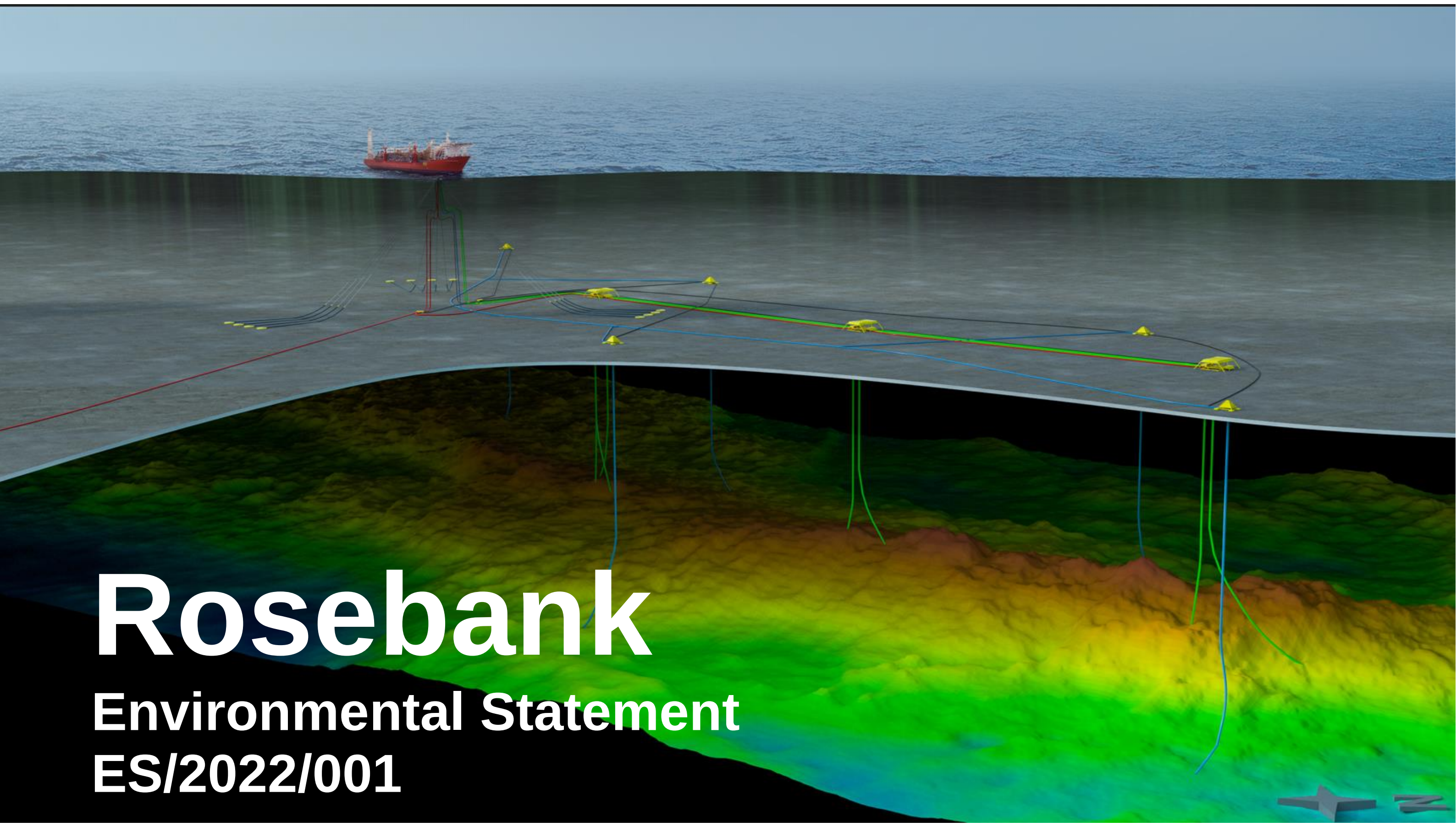


Rosebank

Environmental Statement
ES/2022/001

equinor

ITHACA ENERGY

SUNCOR ENERGY

ENVIRONMENTAL STATEMENT DETAILS

Section A: Administrative Information

A1 - Project Reference Number
ES/2022/001
A2 - Developer Contact Details

Company Name	Equinor UK Ltd
Contact name	Withheld
Contact Title	

A3 - ES Contact Details

Company name	Equinor UK Ltd
Contact name	Withheld
Contact Title	Withheld

A4 - ES Preparation

Please confirm the key expert staff involved in the preparation of the ES:

Name	Company	Title	Relevant Qualifications Experience
Withheld	Xodus	Withheld	Approximately 15 years of experience in undertaking EIA Project managed a number of large oil and gas projects, including west of Shetland projects
Withheld	Xodus	Withheld	Approximately 35 years of experience in marine environmental assessment PhD in marine fate assessment
Withheld	Xodus	Withheld	Approximately 20 years of experience in marine environmental assessment PhD in biochemistry
Withheld	Equinor UK Ltd.	Withheld	10 years in offshore oil and gas regulatory compliance
Withheld	Equinor UK Ltd.	Withheld	35 years oil and gas industry experience in various disciplines MSc Project Management

A5 - Licence Details

a) Licence(s) covering proposed activity or activities - Licence number(s):

P1026
P1191
P1272

Licensee	**Percentage Equity**
Equinor UK Ltd	40%
Suncor Energy UK Ltd.	40%
Ithaca SP E&P Limited	20%

Section B: Project Information

B1 - Nature of Project

Name of Project / ES: Rosebank Field Development

Brief description of the project

The proposed project is the development of the Rosebank field. The project is planned to be delivered in two phases, phase 1 comprises drilling 4 production and 3 water injection wells and, subject to learnings from initial wells, phase 2 will involve drilling up to a further 3 production and 2 water injection wells. The wells will be connected by new flowlines to a redeployed Floating Production Storage and Offloading vessel (FPSO) where the hydrocarbons will be processed. The gas will be exported from the FPSO via a new gas export pipeline to the existing West of Shetland Pipeline Systems (WOSPS). The oil will be offloaded using tankers. First production is expected Q4 2026.

B2 - Project Location

Block number(s): 213/26, 213/27a, 205/1a, 205/2a

	UKCS Block	Latitude ED50	Longitude ED50
Rosebank FPSO	205/2	60° 59' 58.0665" N	3° 46' 25.4301" W
Gas Export PLEM (Clair)	206/13	60° 36' 47.2390" N	2° 27' 21.6735" W
Gas Export Riser base	213/27	61° 00' 03.6885" N	3° 45' 40.3041" W

Distance to nearest UK coastline (km): 130km from the coast of Scotland

Distance to nearest international median line (km): 15km to the Faroes median line

B3 - Previous Applications

If the project, or an element of the project, was the subject of a previous consent application supported by an ES, please provide details of the original project

Name of project: Rosebank Project Environmental Statement

Date of submission of ES: July 2018 (Chevron North Sea Ltd)

Identification number of ES: D/4281/2018

Table of Contents

NON-TECHNICAL SUMMARY

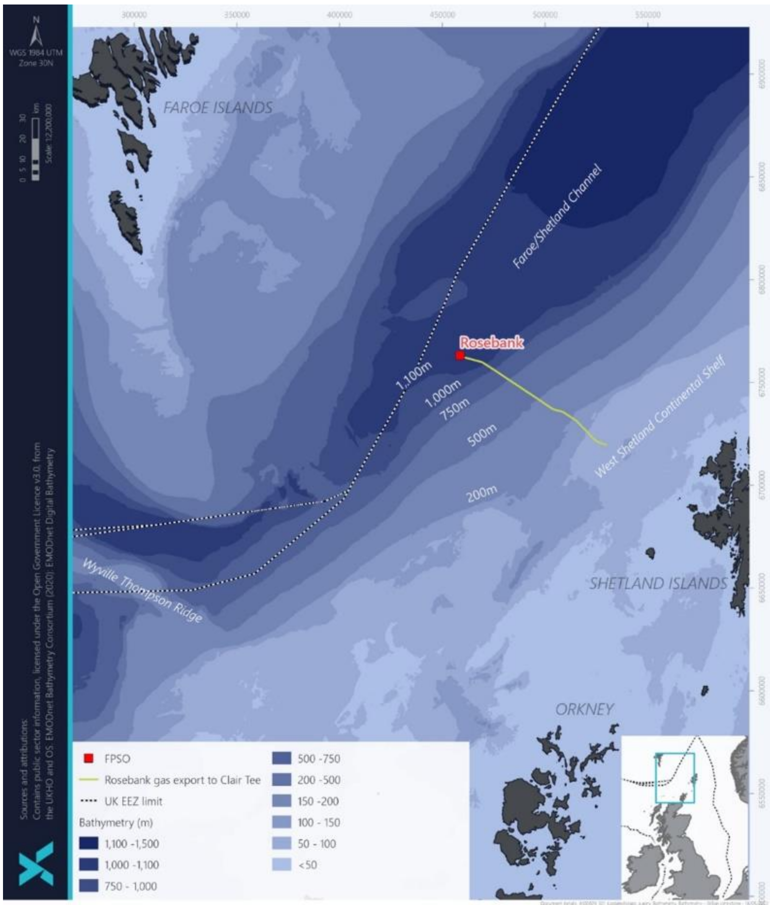
Introduction

This non-technical summary provides an overview of the Environmental Statement (ES) prepared for the Rosebank Development.

The Rosebank Development is a project involving the drilling of subsea wells in the Rosebank field, to extract oil and gas. The wells will be connected by new flowlines to a central production facility. A new gas export pipeline will be built to transfer the gas from the production facility to an existing pipeline called the West of Shetland Pipeline Systems. The oil will be exported from the production facility using tankers.

An Environmental Statement (ES) is a document that reports the results of an Environmental Impact Assessment (EIA). The goal of an EIA is to identify any potential adverse impacts to the environment from a development and to inform efforts to prevent, reduce or offset those impacts. An EIA allows a regulator to determine if consent should be given to a development and if any conditions need to be attached to that consent.

The Rosebank development ES is required under the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020. The ES is submitted to the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED), who must give consent to the operator before the development can begin.



Equinor will operate the Rosebank Development. The licences for the blocks in which the field is located are held by Equinor UK Limited, Suncor Energy UK Limited and Ithaca SP E&P Limited.

The Rosebank field is located in the Faroe-Shetland Channel on the north-west edge of the UK Continental Shelf (UKCS), as shown in Figure 1. The location is approximately 130 km north-west of Shetland, in water which is around 1100 m deep. The field is located in UKCS blocks 213/26b and 213/27a (licence P1026), block 205/1a (licence P1191) and block 205/2a (licence P1272). The pipeline will run from the deep area of the channel up the eastern slope to the West of Shetland continental shelf.

Figure 1 Location of the Rosebank Development

Consideration of alternatives

The consideration of alternatives is a process where a wide range of options are screened to ensure the final plans are optimal. For the Rosebank Development, options for elements such as facilities and equipment were considered, based on criteria that included economic viability, safety, environmental impact and carbon footprint.

Key elements of the alternatives consideration included the drilling rig, selection of which took into consideration the water depth and harsh weather at the location. A dynamically positioned, harsh environment semi-submersible drilling rig (Figure 2) was selected, which causes no seabed interaction from anchors, but comes with a higher emissions profile. The emissions will be offset by operational efficiency from a simplified well design (giving shortest well length) and high operation up time (ensuring the rig spends the minimum amount of time on location). The type of production well chosen (a combination of low angle and horizontal) limits the number of wells which need to be drilled. Drilling fluids used will predominantly be water-based, and where oil-based fluids are required, cuttings will be recovered and transported to shore for treatment.

Figure 2 Example of a Semi-submersible Drilling Rig

The production facility selection process evaluated existing infrastructure in the area, environmental factors and electrification potential. Of the final options, a semi-submersible with an oil export pipeline would cause seabed impact to marine protected areas from the pipeline where other equal or better alternatives would not cause this impact. A new-build floating production, storage and offloading vessel (FPSO) has significant emissions in the construction phase that can be avoided through the use of a suitable and commercially competitive redeployment alternative. The production facility selected is a redeployed, ship-shaped FPSO which is prepared for future electrification.

Equinor's net zero ambition was a key driver during consideration of alternatives for the Development. Optimisation for energy efficiency is an integral part of the Rosebank design development for all areas from subsurface to facilities and product transportation. Significant reductions have been achieved via integrated optimisation across subsurface, drilling & well and facilities Electrification, use of alternative fuels, and carbon capture and storage were all considered as additional carbon reduction options. The Rosebank field is not considered suitable for CCS and the redeployed FPSO is suited better to electrification, than alternative fuels. While the electrification strategy is still being determined, it is likely to involve a high voltage subsea power cable to connect a power source (onshore grid or offshore wind) to the production unit. The impact of this power cable is not part of the scope of this ES because it is part of a different set of regulations.

Project Description

The Rosebank Development is divided into phases, whereby seven wells will be drilled in Phase 1 and up to five wells will be drilled in Phase 2. Information about the reservoir and drilling, acquired during Phase 1, will be used to optimise the plans for Phase 2. Field installation activities will commence from 2024 and continue through 2026. This work will mainly be limited to the May to August weather windows. Phase 1 drilling is scheduled to start in the 2nd quarter of 2025. The FPSO will be towed to field and hooked up in 2026. Testing and preparing the FPSO and pipeline for production is anticipated to take 6-7 months. First production is expected in the 4th quarter of 2026.

Oil production is predicted to peak at 9,540 tonnes/day during 2027/2028, then plateau until 2033. After this, there is likely to be a steady decline over the life of the field. Gas production is predicted to peak at 1.72 million m^3/day between 2029 and 2031, before steadily declining. The reservoir will require water injection to maintain the pressure required during production.

Details of the activities occurring during the Development are provided in the table below.

Activity	Description
Drilling	Both production and water injection wells will be drilled. Each well will be drilled in five sections of successively smaller diameters. Fluids used during drilling include water-based mud and oil-based mud. When water-based mud is used, drill cuttings will be cleaned before disposal and the mud will be reused. When oil-based mud is used, the cuttings will be transferred onshore for treatment. Cement will be used to secure the steel well casings in place. The drilling rig will drill and suspend each well before returning to each well to remove wellbore barriers in preparation for subsequent activities.
Infrastructure Installation	The types of subsea in-field infrastructure include templates for drilling, flowlines for transport of oil and gas, manifolds and trees for directing and monitoring flow, foundations and pipelines for the water injection system, and umbilicals (small pipelines for communication cables). Vessels and remotely-operated vehicles will support the installation of this infrastructure and will maintain their position using dynamic positioning.
Gas Export Pipeline Installation	The gas export pipeline will be made of carbon steel and will be approximately 85 km in length and 10.75 inches in diameter. The pipeline will be assembled in a spool, which is mounted on the deck of a vessel. The spool sends the pipeline to the seafloor as it unwinds. Seabed infrastructure may need to be protected and stabilised using concrete mattresses or placement of rock.
FPSO Installation	 **Figure 3 The Rosebank Ship-shaped FPSO** The FPSO (Figure 3) receives the reservoir fluids, processes and stores them, then offloads the oil to tankers and the gas to the pipeline. The FPSO will be moored to the seabed using suction anchors. Initially, since there is not an existing source of renewable electricity available to supply power to Rosebank, the operations on board the FPSO will be powered by generators that can use gas or diesel, but it will be modified for future electrification before arriving at the field location.
Production	Prior to production, the integrity of the flowlines will be confirmed via testing such as leak detection. Chemicals used include oxygen scavengers, biocides, dye and monoethylene glycol in seawater. The flowlines and pipeline will then have all contents removed and will be dried. Vessels, helicopters and remotely-operated vehicles will support production and operation throughout the life of the Development.
Decommissioning	As decommissioning is likely to be far in the future, it is anticipated that technology and regulations may change before it occurs. As a result, activities are subject to change. In general, the pipelines and infrastructure is flushed and cleaned, the wells are plugged and sealed with cement, and the FPSO is transported offsite. Infrastructure may be removed, depending on environmental, safety and cost factors at the time of decommissioning.

Environmental Baseline

Detailed information about the environment in which the Development will take place was required as part of the EIA process. The following table provides a brief summary of the key information collated.

Bathymetry and Metocean Characteristics
The Development will occur on the east slope of the Faroe-Shetland Channel and some of the continental shelf. The shelf is relatively shallow, with the depth at the top of the slope around 100-200 m. The channel is between 1 and 2 km deep. Generally, the area experiences frequent rain, strong winds and changeable wind direction. The ocean here is characterised by multiple strong non-tidal currents interacting with relatively weak tidal flow.
Sediment Type and Seabed Features
The channel is characterised by fine sandy and muddy sediments, with various physical features including plough marks from icebergs and sediment fans. Moving up the slope, the seabed sediments become more variable in nature and include large sediment waves. Iceberg plough marks are also present and coarse gravel and stones have been detected.
Plankton
Due to the depth of the channel, the composition of plankton is varied through the water column. Different species of plankton dominate the different depths, including copepods in the deep water, and phytoplankton such as dinoflagellates and diatoms in the upper layers. Doliolids are also present, brought in on warmer streams of water. The species on the shelf are dominated by dinoflagellates, diatoms and copepods. Plankton are a crucial source of food for multiple species.
Seabed Habitat and Species
The channel floor has been shown to be sparsely distributed with stones to which are attached sponges and soft corals. The lower slope and channel seabed support various species including sea spiders and sponges (Figure 4). Deep-sea sponge aggregations are diverse groups of sponges growing together and are found on some areas of the slope. The shelf supports starfish, sea urchins, anemones and sponges. There is evidence that on the shelf, communities are sparse in sandy sediments, while areas with boulders and rock outcrops have a greater variety of species.  **Figure 4 A club sponge in the Faroe-Shetland Channel**
Fish and Shellfish
The channel waters are used by fish for a variety of purposes including, as a migration route, for spawning and as a nursery. Blue whiting, ling, mackerel and Norway pout use the area for spawning and nursing. Spurdog, common eel and Atlantic salmon are also found in the area. Deep-sea fish which use the area include lantern-fish, pearlside, rockling and eelpout. The continental shelf is likely to support multiple species of fish with commercial importance, including haddock, cod, herring and ling. Several species may use the area as nursery grounds, including anglerfish, blue whiting and herring. Sharks, skates and rays are also present in the area, including thresher, porbeagle and basking sharks.
Marine Mammals and Cephalopods
The channel is believed to be a corridor for migrating marine mammals including the fin whale and sperm whale. Other whales regularly spotted in the area include the blue whale and minke whale. Also known to be present in the area are several dolphin species, including Risso's dolphin and the bottlenose dolphin, as well as the harbour porpoise. Grey, harbour and hooded seals are the most likely seal species to be encountered in the area. A number of deepwater squid are likely to be present in the channel. On the shelf, bobtail squid are one of the most significant cephalopod groups.

Seabirds
Seabirds found in the area are likely to originate from major colonies in the Faroe Islands, Shetland and Orkney, and breeding areas in Iceland and Norway. Species present and densities vary with the time of year. The large variety of seabirds that use the area include the herring gull, Arctic skua, northern fulmar and black-legged kittiwake. The area is used for migration by species such as some shearwaters, skuas and geese. A variety of seabirds have colonies along nearby coastlines.
Conservation
There are no Special Areas of Conservation within 100 km of the Development, but there are several other conservation sites, including the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA). The thresher and porbeagle shark are considered vulnerable and the basking shark is endangered globally. Many other animal species are protected under European, UK and Scottish conservation regulations.
Other Sea Users
The area is fished by local and international vessels. Hake, monkfish / anglerfish, mackerel, ling and cod are dominant according to the available data. Commercial shipping activity is considered low and on the shelf most vessels are cargo, tanker and fishing vessels. Through the channel there are also ferries and cruise liners to and from the Faroe Islands.

EIA Methodology

The EIA process considers impacts and the resulting effects on receptors. This includes the duration, extent and, if necessary, the likelihood of an impact, as well as the sensitivity of a receptor. The consequence of impact on a receptor is then assessed, to identify any potentially significant impacts.

> EIA Terminology
>
> Impact – a measurable change to the environment resulting from an action.
>
> Receptor – an element of the environment, such as an organism or habitat.

The EIA process began with identification of the sources of potential impact which required further assessment. Identification of these sources was based on the specific proposed activities, relevant environmental sensitivities, a review of past EIA outcomes, and wider stakeholder input. A range of stakeholders were consulted during the EIA process, including the regulator OPRED and the North Sea Transition Authority.

The following issues were selected for assessment in the EIA:

- Seabed disturbance;
- Discharges to sea;
- Interaction with other sea users;
- Atmospheric emissions and climate;
- Underwater sound; and
- Accidental events.

Seabed Impacts

Activities such as the use of anchors, installation of infrastructure and deposition of drill cuttings on the seabed can lead to changes at the seabed and negative impacts including loss of species, loss of habitat, introduction of a new hard substrate and wider indirect disturbance from sediment suspension in the water. The area that will be occupied by the structures and materials noted above (the footprint), the timeframe and nature of activities and the duration of effects were assessed alongside benthic species sensitivity and tolerance, and features of the seabed and marine protected area. Seabed impacts were found to be not significant. Although the pipeline will pass through an NCMPA, surveys done along the proposed pipeline route have found no significant deep-sea sponge aggregations and the footprint is small compared to the size of the NCMPA.

To help avoid a significant impact, several steps will be taken, including:

- Environmental surveys will be used to allow the gas pipeline route to avoid sensitive locations;
- Installation of subsea facilities will use vessels that do not need anchors; and
- FPSO anchors will be placed to avoid sensitive areas where possible;
- Rock deposit's will be minimised as far as practicable.

Discharges to Sea

Activities that result in discharges to the sea will occur within drilling, installation and operation activities of the Rosebank Development. Discharges include cuttings and fluid from drilling, cement, and water-based fluids used inside the infrastructure. These discharges may lead to increased suspended solids in the water column and materials settling on the seabed. This may indirectly cause a change to the physical or chemical nature of the habitat or impairment of benthic organisms feeding or respiratory systems. The volume and content of the discharges, and their predicted dispersion through the water column were assessed alongside the sensitivity of species present, such as plankton and fish, and the recovery potential of the environment. Impacts to the water column and seabed were found to be not significant.

To help avoid a significant impact, several steps will be taken, including:

- Drilling muds will be recycled as far as practicable to reduce discharges;
- The drilling rig will be audited to ensure it conforms to all relevant guidelines and legislation;
- Chemical selection for drilling, commissioning, operation and intervention will take into account all relevant permit conditions and approvals based on an environmental risk assessment; and
- The produced water system will be designed to reduce the oil content in the produced water to the regulatory requirement as a minimum.

Other Sea Users

The presence of infrastructure, facilities and vessels have the potential to obstruct or exclude other sea users. The risk of vessel collision and snagging of fishing gear may be increased, and the use of the area may be reduced due to the safety zone established around the activities. The time during which the areas are occupied by vessels or infrastructure, the size of area occupied, and the nature of the vessels and infrastructure or equipment on the seabed were considered in the assessment. Details of fishing and other vessels using the area, types of fishing methods used and the depth of the seabed were also taken into account. Impacts to commercial fisheries and shipping were found to not be significant and the risk of snagging found to be low.

To help avoid a significant impact, several steps will be taken, including:

- The gas export pipeline and subsea facilities will be designed so that trawling can still occur over them at depths less than 800m;
- A dropped object protocol will be developed to reduce the risk of dropped objects from installation vessels;
- The operations centre will remotely monitor vessel traffic around the field; and
- A fishery liaison strategy will be developed and implemented.

Atmospheric Emissions

Emissions come from fuel consumption by the FPSO, the drilling rig, vessels and helicopters, subsea infrastructure installation, and flaring and venting. Gas emissions impact air quality, climate change and acid deposition. The types and worst-case volumes of gas emitted, along with the background air quality were assessed. The assessment found that significant impacts on local air quality are not expected. The atmospheric emissions assessment focused on ways to reduce emissions, which include (in addition to those discussed in the consideration of alternatives):

- Implementation of new digital solutions such as automated drilling to optimise energy efficiency;
- Minimisation of vessel time required to install subsea equipment from simplification of subsea design;
- Use of a vapour recovery system and closed flare on the FPSO to reduce emissions;
- Optimisation of field development strategy to minimise offshore facility power demand; and
- Modifications to the redeployed FPSO to enhance energy efficiency.

Underwater Noise

Noise generated by Development activities adds to the background sound in the environment. Noise can be generated by several activities, including drilling, operation of vessels and the FPSO, helicopters and surveys that use airguns within the subsea wells (seismic survey). Some animals may behave differently in response to this noise. The noise may block sounds they use for communication, or it may cause discomfort or injury. The intensity, frequency and duration of the noise was assessed with reference to sensitivities and likely presence of specific animals. The risk of disturbance to fish is considered moderate and habituation is unlikely due to the operations constantly moving and the short period of activity. There is a very low likelihood of injury or non-trivial disturbance to seals, whales, dolphins and porpoises.

To help avoid a significant impact, several steps will be taken, including:

- Use of suction on all subsea installation rather than piling;
- Ensuring a Marine Mammal Observer is present to monitor for the presence of marine mammals before and during the surveys. If animals are present, start up is delayed until they have passed; and
- Conducting a soft start for survey work. Activities that generate noise begin at low levels to allow time for animals to move away from the sound before the higher intensity noise begins.

Accidental Events

By their nature, oil and gas developments come with the risk of an accidental release of hydrocarbons. There are many sources of potential releases, including a failure of a well (known as a well blowout) and spilling of diesel from a vessel involved in the Development. The potential impact of an oil spill on the receiving environment has been assessed by considering environmental sensitivities, and factors such as properties of the material and probable direction of its movement. For each type of accidental event assessed, the worst case possibility was used. The likelihood of an event happening is also considered in this type of assessment. The assessment found that the worst case scenario well failure has the potential to lead to a major environmental incident. Impacts to individual receptors are considered either major or moderate. The probability of this occurring is very low.

The assessment was based on no steps being taken to stop the spill. In fact, many measures will be put in place to reduce the probability of an accidental release. These measures include:

- Installing suitable blowout preventers on wells;

- Putting in place procedures specific to the harsh environment of the location;
- Employing robust maintenance and inspection programmes; and
- Having suitable emergency response procedures in place.

Environmental Management

Equinor has developed an Environmental Management System (EMS) which is designed to ensure activities are executed in a way that protects people and the environment. The environmental elements of the EMS are aligned with the requirements of ISO 14001:2015 and the EMS undergoes auditing by a third party every two years. Equinor's commitment to environmental safety is reflected in their sustainability fundamentals, within the corporate framework, which are aligned with achievement of UK Net Zero emissions targets. Equinor Oil Spill Response Procedures will be applied during all operations and Emergency Response Bridging Documents are prepared for all offshore activities involving contractor facilities and vessels.

Conclusions

The Rosebank Development concept minimises the environmental footprint and supports the UK's net zero target, while maintaining a hydrocarbon supply and contributing to the UKs energy security. In assessing the environmental impact of the Development, the planned activities and the existing environmental sensitivities were considered. The environmental impacts arising from known and expected activities, were found to be not significant. The likelihood of injury to animals from noise was low. The potential impact to the environment from an unexpected worst case well failure is considered moderate or major, but the likelihood of it occurring is very low. Mitigation measures are in place to ensure any impacts or risks are reduced as much as possible as the Development progresses.

The Rosebank team will deliver the mitigation measures identified in this ES and work towards continual improvement in environmental performance beyond these commitments.

1 INTRODUCTION

1.1 Rosebank

Equinor UK Limited, Ithaca SP Energy E&P Limited, and Suncor Energy UK Limited (together known as the “Licensees”) will develop the Rosebank field and minimise the environmental impact of the Development by redeploying an FPSO that is electrification ready. All modifications to support the future electrification of the FPSO will be completed prior to the arrival at the field location, without taking the FPSO off station. Further, the FPSO will be equipped with a closed flare and vent system and will be retrofitted with energy efficient equipment. Finally, as the FPSO is redeployed, the project will minimise emissions from construction activities through avoiding building a new FPSO.

The Rosebank field is located in blocks 213/26b and 213/27a (licence P1026), block 205/1a (licence P1191) and block 205/2a (licence P1272) in the Faroe-Shetland Channel on the north-west edge of the UK Continental Shelf (UKCS) as shown in Figure 1-1. The location is approximately 130 km north-west of Shetland in around 1,100 m of water.

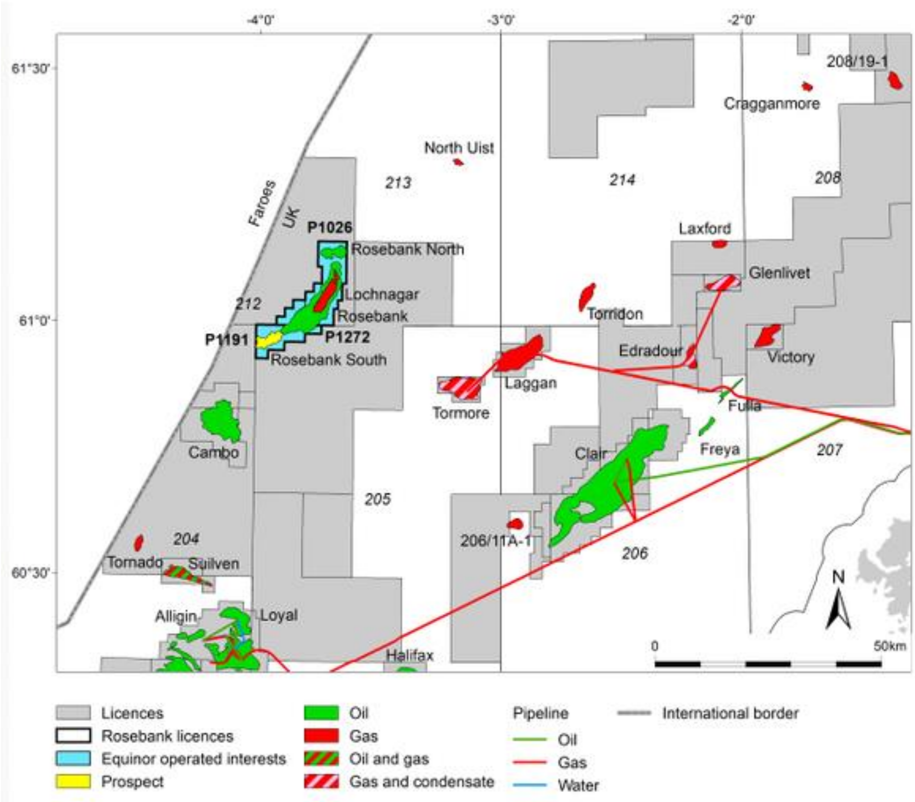


Figure 1-1 Location of the Rosebank field

Equinor on behalf of the P1026, P1191 and P1272 licensees, Ithaca SP Energy E&P Limited and Suncor Energy UK Limited, proposes to develop the Rosebank field (the “Development”) on the UKCS.

Full licence interests in licences P1026 Block 213/27a & 213/26b, P1191 Block 205/1a and P1272 Block 205/2a:

- Equinor UK Limited (Operator) 40%;
- Suncor Energy UK Limited 40%; and

- Ithaca SP Energy E&P Limited 20% (In June 2022, Ithaca Energy (UK) Ltd completed their acquisition of Siccar Point Energy Limited)).

For Rosebank, the licensees have selected a development concept that minimises the environmental footprint including CO_2 emissions, is in line with the North Sea Transition Deal, supports the UK's net zero target and Equinor's climate ambitions, maximises economic recovery and minimises technical and commercial risk.

This Environmental Statement (ES) is prepared under regulation 5 of The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 (the "EIA Regulations"). Projects that fall under Schedule 1 to these Regulations require an environmental impact assessment. The Project falls under Schedule 1 of the EIA Regulations as follows:

- Extraction of oil and natural gas for commercial purposes where the amount extracted exceeds 500 tonnes per day in the case of oil and 500,000 cubic metres per day in the case of natural gas.

There have been two previously submitted ESs to the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) (then called the Department for Energy and Climate Change, DECC) for the development of the Rosebank field in 2013 and again in 2018 with the latter being approved. After acquiring a 40% licence interest, and Operatorship, of the Rosebank field in 2019, Equinor has conducted a full review and optimisation of the Development to ensure full adherence to the North Sea Transition Deal. The changes to previous proposals for the field, which Equinor believes have improved the environmental footprint, required a review of the EIA process and preparation of a new ES.

1.2 Equinor

Equinor is an international integrated energy company that aims to be a leader of the Energy Transition through continuing their industry leadership in carbon efficiency, profitable growth in renewables and accelerating decarbonisation. Equinor has a clear ambition to be a net zero energy company by 2050, including emissions from production and final consumption. Interim ambitions have also been set aiming to reduce net carbon intensity by 20% by 2030 and 40% by 2035. Equinor's purpose[1] is to turn natural resources into energy for people and progress for society, aiming to be a leading provider of energy and low carbon solutions, a global leader in offshore wind and a leader in carbon capture and storage (CCS), guided by the three strategic pillars – always safe, high value and low carbon.

Equinor is the leading energy company on the Norwegian Continental Shelf (NCS), with headquarters in Norway, and is listed on both the Oslo and New York stock exchanges. Over 25 surface production installations and over 500 subsea wells are operated in Norway by Equinor. Equinor has extensive experience with electrification of offshore oil and gas projects. On the NCS it has more than 10 offshore fields either electrified or due to be electrified, with a total power demand of more than 1,000 MW. Equinor has an international upstream business, including offshore Brazil and Canada, onshore USA and deep-water licence areas in the Gulf of Mexico, and the Mariner field on the UKCS. In 2020, Equinor supplied nearly 30% of the UK's natural gas demand and one fifth of its demand for oil, with these supplies being produced with one of the lowest carbon footprints in the industry, with natural gas from Norway being supplied to the UK in pipelines with around one fifth of the emissions of LNG imports. The reliability of natural gas imports is backed up by Equinor and SSE Thermal's Aldbrough storage facility in Yorkshire which provides around 7% of the UK's total gas storage.

Equinor has interests in 35 seaward production licences on the UKCS and is operator of 18 of these including the Mariner Field (Licence P335), the largest oil development in the UK for over a decade, where there is on-going

[1] https://www.equinor.com/about-us/strategy

production and development drilling, along with the Utgard and Barnacle producing assets. Details of recent, current and planned licence activity and Equinor's operatorship of wind energy projects offshore UK and in low carbon (CCS and Hydrogen) projects are provided in the 2021 OSPAR Offshore Environmental Performance Report[2] and shown graphically in Figure 1-2.

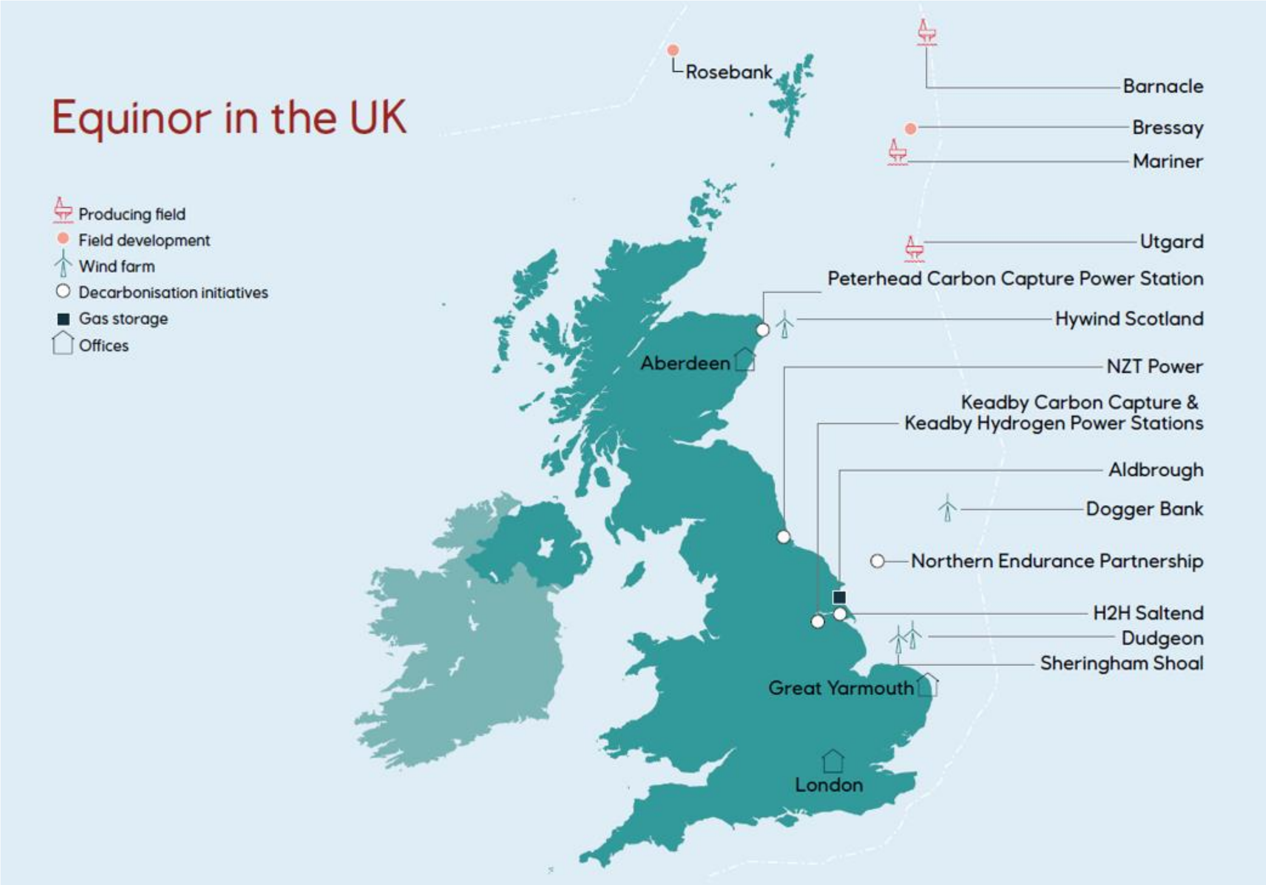


Figure 1-2 Key Equinor interests in the UK

Alongside developing and operating domestic oil and gas reserves and supplying gas to the UK from Norway, Equinor in the UK has offshore wind and low carbon solutions projects and is continuing to grow these businesses. A summary of some headline facts about Equinor's business in the UK is shown in Figure 1-3.

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[2] https://www.gov.uk/government/publications/oil-and-gas-public-statements-relating-to-2020-operations

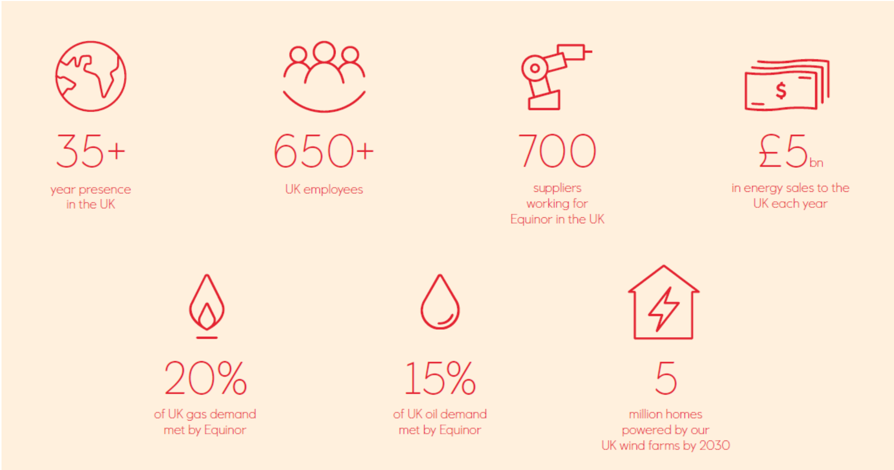

Figure 1-3 Key Equinor statistics

Equinor has three offshore wind farms in the UK, Sheringham Shoal and Dudgeon, along with Hywind Scotland, the world's first floating wind farm and one of the best performing wind farms worldwide, Alongside partners, Equinor is also currently building Dogger Bank, the largest offshore wind farm in the world, which will provide enough power for 5 million UK homes and represents a £9 billion investment in the UK. The North Sea is a key contributor for Equinor in its ambition to increase renewables capacity to 12-16GW by 2030.

Equinor has over 20 years of experience storing CO_2 in the NCS and producing hydrogen from natural gas. This experience is being leveraged to develop the East Coast Cluster in the UK alongside partners. Equinor is linking hydrogen and carbon capture projects in two of the UK's largest industrial clusters to shared CO_2 storage in the UK North Sea. Equinor's H2H Saltend project aims to supply low carbon hydrogen and power to heavy industry from the mid-2020s, and Equinor is planning to build further hydrogen production capacity in the Humber by the end of the decade. As part of the Zero Carbon Humber consortium Equinor is working to deliver low carbon hydrogen production facilities and essential carbon capture usage and storage (CCUS), together with region-wide infrastructure that will enable large-scale decarbonisation across the country's most carbon intensive region. As a partner in Net Zero Teesside, Equinor is working to decarbonise the Teesside industrial cluster with carbon capture. CO_2 emissions from both the Humber and Teesside will be transported through pipelines to permanent storage, both developed by Northern Endurance Partnership, making use of the substantial storage potential deep under the UK North Sea.

Equinor is committed to achieving excellence in Health, Safety and Environmental (HS&E) performance across all its operations. Information on Equinor's sustainability performance can be found in the 2021 Sustainability report[3]. Effective and responsible environmental stewardship is a driver of Equinor's vision and values, a key cornerstone of the delivery of excellence in HS&E performance.

1.3 Energy Transition and Net Zero Context

Equinor promotes policies supporting the goals of the Paris Agreement and forceful actions to accelerate the energy transition. Equinor actively works to ensure that the policy positions and advocacy of our membership organisations is supportive of and aligned with the objectives of the Paris Agreement (adopted in 2015; in force 2016). In line with

[3] https://www.equinor.com/news/archive/20220318-annual-sustainability-reports-2021

Article 4 of the Paris Agreement, the UK has submitted a Nationally Determined Contribution (NDC) which commits the UK to reducing greenhouse gas (GHG) emissions by at least 68% by 2030, compared to 1990 levels.

The North Sea Transition Authority (NSTA) regulates and influences the oil, gas and carbon storage industries. They help to drive the North Sea energy transition, while also realising the potential of the UK Continental Shelf as a critical energy and carbon abatement resource. The NSTA based their production forecasts on existing fields and fields that have not been developed yet but are likely to be developed in the near future. The NSTA production outlook was used in the UK sixth carbon budget as the reference point. Oil and gas fields can be developed, provided actions are taken to reduce emissions - such as electrification, zero routine flaring and venting, and addressing methane leakage.

To facilitate achievement of the NDC commitments, the UK government set a legally binding target for the UK to reduce its GHG from 1990 levels by 100 % by 2050 (The Climate Change Act 2008 (2050 Target Amendment) Order 2019). In Scotland the target year was set as 2045 via the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019. The UK's net zero targets are supported by a system of legally binding five-year 'carbon budgets' and an independent body to monitor progress, the Climate Change Committee (CCC). The UK carbon budgets restrict the amount of GHG the UK can legally emit in a defined five-year period. In 2020, the 6th carbon budget was published by the Committee on Climate Change for consideration by the UK Government and is the first budget to reflect the amended trajectory to 2050.

The UK Net Zero Strategy: Build Back Greener (October 2021) outlines policies and proposals for decarbonising all sectors of the UK economy to meet our carbon budgets and net zero emissions target by 2050 (and 2045 in Scotland) as follows:

- Sets out the UK government's vision for a prosperous, low carbon UK industrial sector in 2050; and
- Provides industry with the long-term certainty it needs to invest in decarbonisation.

The Energy White Paper Powering our Net Zero Future, published in December 2020, and the UK 10 Point Plan for a Green Industrial Revolution, published in November 2020, embed the UK Net Zero strategy by describing how the transition to clean energy can be achieved by 2050. To support the Energy White Paper and the Industrial Decarbonisation Strategy requirement the North Sea Transition Authority (NSTA) revised the oil and gas sector specific Maximising Economic Recovery ("MER") Strategy in February 2021 to include the following central obligation with underpinning requirements:

"Relevant persons must, in the exercise of their relevant activities, take the steps necessary to:

- Secure that the maximum value of economically recoverable petroleum is recovered from the strata beneath relevant UK waters; and, in doing so; and
- Take appropriate steps to assist the Secretary of State in meeting the net zero target, including by reducing as far as reasonable in the circumstances greenhouse gas emissions from sources such as flaring and venting and power generation, and supporting carbon capture and storage projects."

The revised NSTA Strategy, which came into force on 11th February 2021, reflects the ongoing energy transition and features a range of net zero obligations for the oil and gas industry, including increasing efforts to reduce production emissions, support carbon capture and storage (CCS) projects and unlock clean hydrogen production.

The revised guidance on the development of fields demonstrates where the net zero requirements are embedded in the NSTA assessment and approvals process. The NSTA expects the following requirements in relation to emissions from flare and vent sources:

- “Flaring and venting and associated emissions should be at the lowest possible levels in the circumstances;
- Zero routine flaring and venting for all by 2030; and
- All new developments should be planned and developed on the basis of zero routine flaring and venting”.

In addition, the NSTA has a set of Stewardship Expectations to provide operators and licensees with guidance on expected behaviours and good practice. Stewardship Expectation 11 – Net Zero (SE11) was published in March 2021 and sets out the NSTA’s view as to how industry should manage operations and new developments in order to reduce GHG emissions and support delivery of the UK’s net zero target. Delivering against this expectation demonstrates how the industry supports the wider UK Climate Change targets whilst recovering hydrocarbon resources which contribute to the UK’s energy security requirements as laid out in the British Energy Security Strategy.

The North Sea Transition Deal (BEIS, March 2021a) introduced a sector deal between the UK government and the offshore oil and gas industry. The North Sea Transition Deal sets out an ambitious plan for how the UK’s offshore oil and gas sector and the government will work together to deliver the skills, innovation and new infrastructure required to meet GHG emissions reduction targets. The Deal aims to support and anchor the expert supply chain that has built up around oil and gas in the UK, to both safeguard and create new high quality jobs. The deal will transform the sector in preparation for a net zero emissions future and catalyse growth throughout the UK economy ensuring a just transition of the energy sector.

The oil and gas industry through the OEUK (Offshore Energy UK previously OGUK) has developed the roadmap 2035: A Blueprint for Net Zero[4] in which the industry outlines the role the sector can play in decarbonisation.

There are five main ways in which Equinor is contributing to a net-zero society:

- Committed to reducing emissions from our production of oil & gas. (net 50% emissions reduction by 2030);
- Accelerating our investments in renewable energy and grow a profitable renewables business;
- Investing in new technology to create and build new low-carbon markets, value chains and industries;
- Investing in nature-based solutions; and
- Using our voice to support the goals of the Paris Agreement and policies that support net zero by 2050.

1.4 Rosebank Development Net Zero Strategy

The Licensees have the ambition to make “net zero” happen; as operator, Equinor is actively working with a broad range of stakeholders in Scotland, the UK and Europe to ensure that Rosebank is developed in line with the North Sea Transition Deal, UK net zero targets and Equinor net zero ambitions. All relevant alternative concepts and technologies that can be implemented to meet the North Sea Transition Deal agreed between the UK government and the oil and gas industry to create a net zero basin by 2050 have been thoroughly evaluated. In parallel, the Development has been optimised to minimise environmental impact and to deliver in accordance with the NSTA strategy.

The Licensees will invest around £80 million on modifications to support future electrification of the FPSO and these modifications will be completed prior to the arrival of the FPSO at the field location. As a result, Rosebank could become one of the first oil and gas developments west of Shetland to be powered by electricity, reducing the

[4] https://roadmap2035.co.uk/

emissions and meeting the North Sea Transition deal supply decarbonisation target of achieving a net-zero basin in the UK by 2050.

Equinor has worked systematically to reduce the carbon footprint of oil and gas developments. Key areas to achieve this has been reduction of power consumption through optimising design solutions, implementing closed flare & vent and electrification. As one of the most CO_2 efficient producers, Equinor will implement the learnings from its other assets including the broad experiences related to electrification of oil and gas developments on the NCS. Equinor will also implement all relevant learnings from the Licensees to reduce the environmental impact of the Development

The Licensees have substantially reduced the power consumption for the Development by utilising Equinor's broad experience to optimise across all areas of the Development. This is further described in Chapter 2, Consideration of Alternatives, resulting in considerable reductions in emissions.

Key criteria for selecting the redeployment FPSO concept was that it can meet the expectations both from the NSTA to contribute to net zero and Equinor's own sustainability priorities. This is achieved through:

- Re-use/repurposing of infrastructure and facilities (lower carbon footprint compared to a new build and saving 250 kt of CO_2 emissions);
- Re-use of an FPSO that was designed for future electrification, and making further modifications to allow for full electrification;
- Reduction in emissions from flaring and venting by zero routine flaring/venting;
- Retrofitting of the FPSO with energy efficient equipment; and
- Use of a digital twin and advanced reliability techniques to reduce offshore interventions.

The Licensees have clear ambitions to implement electrification of the FPSO to even further reduce the emissions, (see Chapter 9 Atmospherics and Climate). The FPSO original design supported electrification. Extensive study work performed in 2021/22 concluded that future electrification is technically feasible in the West of Shetland (WoS). Technology qualification, as described in Chapter 2 Consideration of Alternatives, is needed and this work is ongoing. Work is continuing at pace to mature the required technology and to conclude the possible schedule for delivery of electrification of the Development.

The Licensees have the ambition to meet the UK's net zero target and are targeting electrification as soon as possible. The Licensees have committed to take a proactive role to deliver electrification when technology is qualified and matured and necessary regulatory consents are in place. It is not the technical development and implementation of required facilities at the FPSO, but the confirmation of power source, grid connections and necessary offshore and onshore consenting that drive the electrification schedule. As a part of this, Equinor is also taking a proactive role in WoS work groups to mature potential area solutions, as further described in Section 1.5.

1.5 Collaboration

Equinor and the other licensees recognise that its activities impact the environment, society and the economy, and that it has an important role to play in collaboration with governments, industry, customers and society at large.

Equinor is a strategic partner to the Net Zero Technology Centre (NZTC) providing mentoring, and networking opportunities, including connecting innovative technology with potential projects for piloting and testing. The partnership will drive the industry towards meeting climate goals and enabling the use of sustainable energy resources.

Equinor is a member of the project ORION (Opportunity Renewables Integration Offshore Networks) Advisory Group. Project ORION is an energy hub concept established in Shetland in 2020 by Shetland Islands Council (SIC) and the NZTC (previously called Oil and Gas Technology Centre). The vision of the energy hub concept is to provide clean sustainable energy for the future. Its stated purpose is to provide domestic and industry users access to clean energy whilst reducing emissions, maximising the value of the oil and gas sector during energy transition and creating sustainable local and regional employment. A key factor to ensure success will be for stakeholders to work together in a collaborative way to test and deliver opportunities at pace. Within this overall agenda, a workgroup focussed on electrification of oil and gas opportunities WoS has been established. Along with SIC, NZTC, bp, Shell, Siccar Point Energy (SPE, now Ithaca SP E&P Limited) and Scottish and Southern Electricity (SSE), Equinor participates in the WoS Electrification workgroup to promote, support and facilitate WoS basin offshore electrification of new oil and gas developments and existing producing assets utilising wind power from onshore Shetland and possibly offshore where technically feasible.

In early 2021, bp, SPE and Equinor formed the WoS Operator Electrification workgroup ("WoSE") to investigate technical and commercial feasibility of the electrification (in whole or in part) of their existing assets and future developments WoS.

Equinor and the other licensees have been instrumental in the establishment of a West of Shetland electrification workgroup to explore opportunities to address the challenges of electrification through collaboration with other West of Shetland upstream oil and gas Operators and stakeholders.

Work to date through these workgroups supports the view that there is potential for collaboration, although significant technical, commercial and regulatory challenges remain to be addressed. Equinor is cooperating with other UK developers through initiatives like the WoSE to establish the infrastructure necessary for the electrification of other oil and gas operations in the area. This is needed to meet the North Sea Transition Deal supply decarbonisation target of achieving a net-zero basin in the UK by 2050.

1.6 The Rosebank Field

The Rosebank field lies WoS within the Faroe-Shetland Channel at a water depth of approximately 1,100 m. It is approximately 130 km North West of Shetland, 274 km from mainland Scotland, 15 km from the UK/Faroes median line, and 180 km from the Faroe Islands. The location of the Rosebank Development is shown in Figure 1-4.

The Rosebank field was discovered in 2004 and an appraisal drilling campaign consisting of five wells and side-tracks was carried out between 2006 and 2009. A well test was performed on the appraisal well in Block 205/1a to provide information regarding reservoir deliverability and volumes. In addition to the appraisal drilling, ocean bottom node seismic surveys were carried out in 2010 and 2011 to improve reservoir definition. Evaluation of the data to date has indicated the presence of an overall reservoir structure approximately 20 km long and 5 km wide.

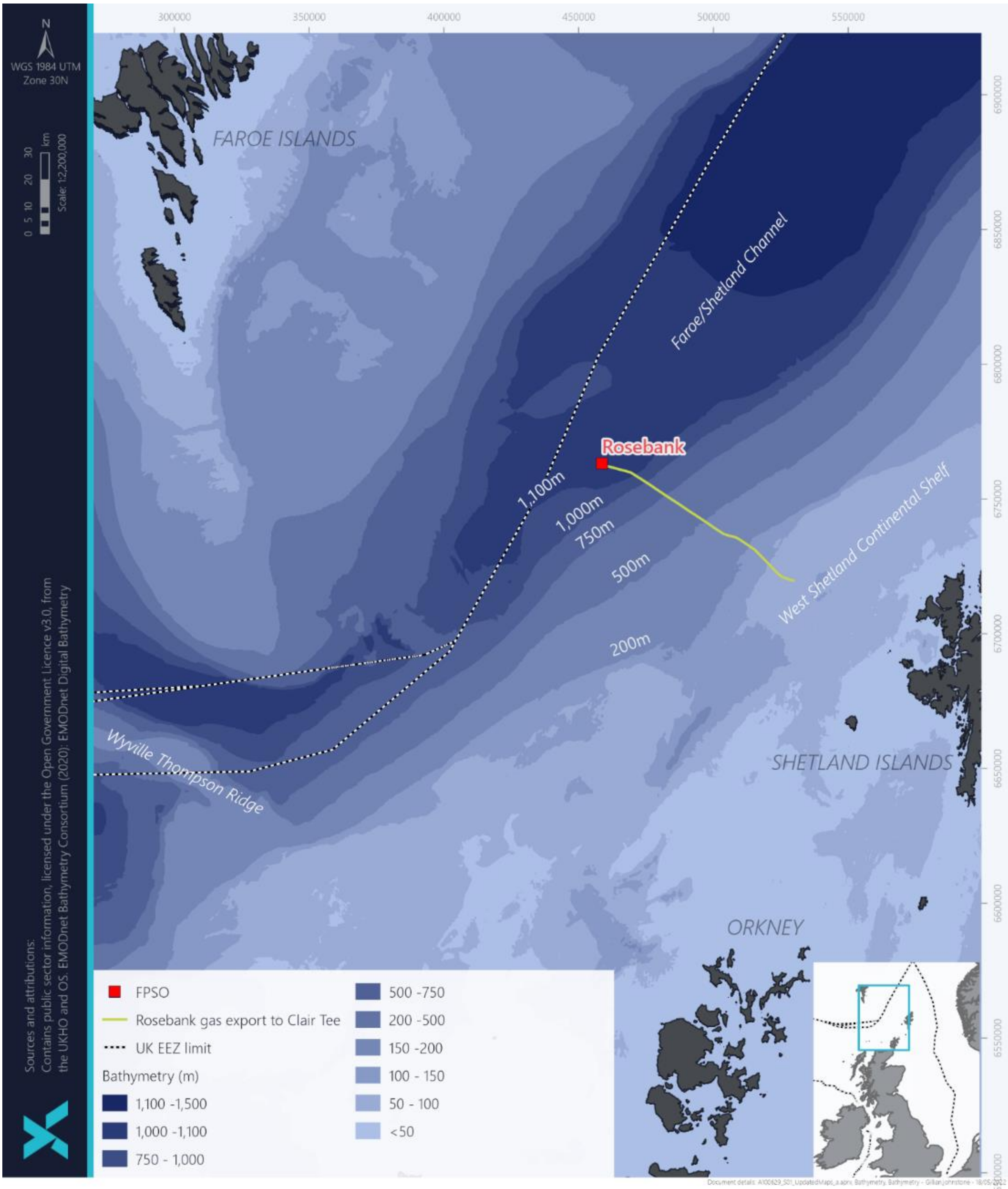

Figure 1-4 Location of the Rosebank Development

1.7 Overview of the Rosebank Development

Equinor is proposing to develop the Rosebank field with subsea wells tied back to the redeployed FPSO via the installation of new risers, flowlines and umbilicals. Oil will be off-loaded from the FPSO using tankers and gas will be exported via a new offshore gas export pipeline to tie into the existing West of Shetland Pipeline Systems (WOSPS) at the Clair Tee. There is no planned routine overboard discharge of water and no planned routine flaring. The FPSO will connect to the SHEFA-2 fibre optic cable which also provides data communications routing to other West of Shetland (WoS) operators.

A phased development plan has been selected for the drilling and the subsea, umbilical, riser and flowline (SURF) scopes with four production wells and three water injection wells in the first phase ("Phase 1"), and based on current assumptions, up to an additional five wells in the second phase ("Phase 2"). Phasing allows for optimal use of the FPSO processing capacities when considering the expected profile and the range of uncertainty. A key advantage of phasing is that subsurface uncertainty is addressed through targeted early data acquisition, which allows Phase 2 wells to be optimised based on static and dynamic reservoir learnings from the Phase 1 wells.

The phased development plan includes the ability to accelerate or delay Phase 2 (e.g. a shorter or longer drilling break and / or an accelerated Phase 1 well in low case reservoir outcomes). It enables the potential to increase recovery while producing from lower risk resource areas first.

A Final Investment Decision (FID) for Phase 1 is planned in February 2023, while FID for Phase 2, to be dependent on learnings and experience from Phase 1, currently is assumed to be approximately 5 years later.

The UKCS blocks that the Development is situated in are presented in Table 1-1. The high-level layout of the pipeline route is shown on the map in Figure 1-4.

Table 1-1 UKCS Blocks in which the Rosebank Development is located

Field/infrastructure	Block
FPSO	213/27a
Rosebank field	213/26b, 213/27a, 205/1a and 205/2a
Rosebank to Clair gas export pipeline	205/2, 205/3, 205/4, 205/5, 205/10, 206/6, 206/7, 206/12, 206/13

The indicative schedule for the execution of the installation is shown in Chapter 3 Project Description. Field installation activities will commence from 2024 and continue through 2026 and be mainly limited to 1 May to 31 August weather windows. Phase 1 drilling is scheduled to commence in 2Q 2025. The FPSO will be towed to field, anchored and hooked up to risers in 2026. It is anticipated the FPSO, pipeline and field commissioning will take 6-7 months to complete following installation. First oil is expected in 4Q 2026.

1.8 Scope of Environmental Impact Assessment (EIA)

The overall aim of the EIA is to assess the potential environmental impacts (both routine and accidental), that may arise from the Development and to identify the measures that will be put in place to reduce or avoid these potential impacts. The EIA process (see Chapter 5 EIA Methodology) is integral to the design of the Development, assessing potential environmental impacts and concept alternatives, and identifying design and operational elements to minimise the potential impacts of the Development as far as reasonably practicable. The process also incorporates stakeholder engagement which allows issues to be addressed at an early stage of design. This ensures that all planned activities comply with legislative requirements and with Equinor's Health, Safety and Environment (HSE) policy (Section 1.11).

The EIA scope includes installation, commissioning, and operational activities of the Development as detailed:

- Installation, commissioning, and operation of subsea and surface infrastructure (flowlines, subsea facilities and FPSO);
- Installation, commissioning, and maintenance of a gas export pipeline;
- Development well construction; and
- Operational shipping and loading activities

Decommissioning activities are subject to a separate environmental appraisal process and are not covered by the EIA Directive requirements. However, where relevant, the EIA scope indicates how future decommissioning requirements may influence project design.

Routine and non-routine activities (e.g., well start-up can result in production upsets) and the risk of accidental events with possible environmental implications are included in the impact identification, assessment and mitigation process.

The following activities are outside the scope of this EIA as they arise from activities not directly controlled by Equinor but will be subject to Equinor's guiding values and governance and assurance processes as appropriate:

- Pre-construction, maintenance and transport of infrastructure outside the Rosebank field (e.g., at ports), including the modification works on the FPSO;
- The transport of oil via shuttle tanker once it leaves the Rosebank field;
- Transport of gas once it enters the WOSPS;
- Further activities that might be undertaken at prospects for which the Development infrastructure could act as an enabler; such development, should it occur, would be the subject of any necessary additional environmental assessment and approval from OPRED;
- A possible future installation of a high voltage cable to provide electrical power to the FPSO; subject to a separate consent and approvals process; and
- A subsea fibre optic system to be provided to connect the FPSO for telecommunications to the SHEFA-2 fibre optic cable, being available prior to start of operations. A third party will be responsible for the cable consenting and approval process, which will be separate to the Field Development Plan (FDP) and to this ES.

Environmental considerations have been included in the Development decision-making process from the start (from concept screening and selection) and will continue throughout the Development lifecycle. Refer to Chapters 2 and 3 for further details on Consideration of Alternatives and Project Description.

1.9 Legislation and Policy

1.9.1 Summary of Legislation

The following regulations applying to offshore oil and gas activities are elaborated on in the relevant sections of this ES as required:

- **The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020** (July 2021, Revision 03) details the requirements of the EIA with guidance provided[5];
- **The Offshore Petroleum Activities (Conservation of Habitat) Regulations 2001**. The impacts of a project on the integrity of a protected site from the UK national site network are assessed and evaluated as part of the Habitat Regulations Assessment (HRA) process;
- **The Conservation of Offshore Marine Habitats and Species Regulations 2017** include provisions for the designation and protection of areas that host important habitats and species in the offshore marine area and for the assessment of the impact of offshore oil and gas activities;
- **Energy Act 2008, Part 4A** allows the installation of an offshore structure or the carrying out of offshore operations providing they are undertaken in accordance with the consent conditions and with the appropriate navigational markings;
- **The Greenhouse Gas Emissions Trading Scheme Order 2020** relating to combustion installations with a maximum rated thermal input exceeding 20 megawatts;
- **The Offshore (PPC) Regulations 2013** (as amended) cover specific atmospheric pollutants from combustion installations (with a thermal capacity rating ≥ 50 MW) on offshore platforms;
- **The Energy Savings Opportunity Scheme Regulations (ESOS) 2014** is a mandatory energy assessment and energy saving identification scheme applicable to the offshore oil and gas industry sector;
- **Fluorinated Greenhouse Gases Regulations 2015** aim to protect the environment by reducing emissions of F-Gases in equipment;
- **The Ozone-Depleting Substances Regulations 2015** prohibits and controls the production and use of ozone depleting substances thereby reducing atmospheric emissions of these substances in line with the Montreal Protocol;
- **The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005** and as amended 2010, 2011, 2016 and 2017 aims to prevent and eliminate pollution by oil and other substances caused by discharges of produced water into the sea;
- **The Offshore Installations (Emergency Pollution Control) Regulations 2002** provide powers to the Secretary of State to prevent and reduce pollution, and the risk of pollution, following an accident involving an offshore installation where there may be significant pollution, or an operator is failing or has failed to implement effective control and preventative operations;
- **The Offshore Chemicals Regulations (OCR) 2002 and amendments (2005, 2010, 2011, 2016 and 2017)** for the use and/or discharge of chemicals during all relevant offshore energy activities, including well operations, production operations, pipeline operations, and decommissioning operations; and
- **The Offshore Safety Case Regulations 2015** to reduce as far as possible the occurrence of major accidents relating to offshore oil and gas operations and to limit their consequences.

All applications for relevant permits, consents, licences and approvals under these regulations are made via the UK Energy Portal Environmental Tracking System (PETS) or Emissions Trading Scheme Workflow Automation Project (ETSWAP). Equinor will seek approval for the necessary applications ahead of project activities commencing.

Several other key regulatory drivers and requirements are applicable to the Development including:

[5] https://www.gov.uk/guidance/oil-and-gas-offshore-environmental-legislation#offshore-oil-and-gas-exploration-production-unloading-and-storage-environmental-impact-assessment-regulations-2020

- **The Marine Strategy Regulations 2010** providing a UK-wide framework to put in place measures to achieve or maintain good environmental status (GES) in the marine environment;
- **Marine (Scotland) Act 2010** which establishes the need for a National Marine Plan, and drives the designation and protection of Nature Conservation Marine Protected Areas;
- **The Merchant Shipping (Prevention of Oil Pollution) Regulations 2019** implement the MARPOL Annex I (to the International Convention for the Prevention of Pollution from Ships, 1973, as amended by the Protocol of 1978);
- **The Merchant Shipping (Cargo Ship) (Bilge Alarm) Regulations 2021** implement the MARPOL Annex I (to the International Convention for the Prevention of Pollution from Ships, 1973, as amended by the Protocol of 1978);
- **The Merchant Shipping (Prevention of Pollution by Garbage from Ships) Regulations 2020** implement the Annex V to the International Convention for the Prevention of Pollution from Ships, 1973, as amended by the Protocol of 1978. Annex V contains regulations for the Prevention of Pollution by Garbage from Ships;
- **The Merchant Shipping (Prevention of Pollution by Sewage from Ships) Regulations 2020** implement Annexes IV (Regulations for the Prevention of Pollution by Sewage) and V (Regulations for the Prevention of Pollution by Garbage) of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating to that Convention. They concern, among other things: surveys to be carried out and Sewage Certificates; the prohibition the disposal of plastics into the sea; and powers of inspection and detention of ships;
- **The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008 (as amended)** implement Annex VI (Regulations for the Prevention of Air Pollution from Ships) of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978. The Regulations, among other things: provide for control emissions of ozone-depleting substances, nitrogen oxide and sulphur oxide; provide for the survey and certification of ships; make provision in relation to powers of inspection and detention of ships;
- **The Merchant Shipping (Oil Pollution Preparedness, Response Co-operation Convention) (Amendment) Regulations 2015** setting requirements for a Shipboard Oil Pollution Emergency Plan (SOPEP) setting out arrangements for responding to incidents that cause marine pollution by oil;
- **Environmental Protection Act (1990)** requires persons concerned with controlled waste are under a duty of care, to ensure that waste is managed properly, recovered or disposed of safely, does not cause harm to human health or pollution of the environment and is only transferred to someone who is authorised to receive it. This duty applies to any person, who produces, imports, carries, keeps, treats, or disposes of controlled waste or as a broker has control of such waste; and
- **Radioactive Substances Act 1993 (RSA 93) as superseded by the Environmental Authorisations (Scotland) Regulations 2018** requires the operator to have authorisation from SEPA for the accumulation, storage or disposal of radioactive waste or be able to demonstrate compliance with the conditions contained in specific exemption orders.

1.9.2 Environmental Impact Assessment

The key piece of environmental legislation for the Development is The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 (EIA Regulations). OPRED acting on behalf of the Secretary of State (SoS) regulates the environmental aspects of offshore oil and gas activities with authorities who are likely to be interested in a project due to their particular environmental responsibilities or regional/local competence. This includes Marine Scotland and the Joint Nature Conservation Committee (JNCC). The EIA and this ES is the means whereby the Secretary of State is assured that the environmental impacts of a proposed oil and gas development have been properly considered. Once OPRED has reached a conclusion of the significant effects of the project on the environment, it advises the developer and the NSTA that, notwithstanding any new information on the project arising prior to grant of the consent, the SoS is ready to agree or refuse to agree to the grant of consent by the NSTA via a Production Consent and the Field Development Plan.

The EIA summarised in this ES has been undertaken in accordance with the above legislation and in line with the latest OPRED Guidance, issued July 2021.

1.9.3 Scotland's National Marine Plan

Scotland's National Marine Plan (Scottish Government, 2015) provides an overarching framework for marine activity in Scottish waters out to 200 nautical miles (370.4 km). The aim of the marine plan is to enable sustainable development and the use of the marine area in a way that protects and enhances the marine environment, whilst promoting both existing and emerging industries. The plan includes a core set of general policies which apply across existing and future development and use of the marine environment and policies specific to the offshore oil and gas sector. Appendix A outlines how the Development aligns with the National Marine Plan.

1.10 Environmental Statement Structure

The scope of the EIA was developed in consultation with statutory stakeholders. Full details of the process applied during the assessment is described in Chapter 5 EIA Methodology and the results of the assessment are summarised in this ES. The ES is submitted to OPRED to inform the decision on whether to grant consent for the Development, based on the residual levels of potential impact, and is subject to formal public consultation. The key elements of this ES are:

- A non-technical summary;
- Introduction including background, scope of the Development, legislation and policy context (this Chapter);
- Consideration of Alternatives (Chapter 2);
- Project Description (Chapter 3);
- Environmental baseline and identification of the key environmental sensitivities which may be impacted by the Development (Chapter 4);
- EIA Methodology, describing the method used to identify and evaluate the potential environmental impacts (Chapter 5);
- Detailed assessment of potential impacts, including cumulative or transboundary impacts (Chapters 6 to 11);
- Description of Equinor's environmental management system (EMS) including delivery of Net Zero requirements (Chapter 12);
- Conclusions (Chapter 13);
- References (Chapter 14); and
- Appendices.

1.11 Environmental Management

Equinor manages activities according to the Equinor management system (as modified to reflect local conditions and regulations) and best industry practices. In all business activities Equinor complies with applicable laws, acts in an ethical, sustainable and socially responsible manner, practises good corporate governance and respects internationally recognised human rights. Equinor will ensure that the procedures developed for the Development are followed during the proposed activities and that continual improvement in environmental performance is always maintained. The HSE policy is shown in Figure 1-5. The Climate policy[6], the Energy Transition Plan[7] and the Equinor Sustainability Report[8] describe the policies and how protecting the environment and targeting net zero are embedded in the company way of working.

Further detail on Equinor's environmental management and delivery of the commitments in this ES is provided in Chapter 12 Environmental Management System.

[6] https://www.equinor.com/en/sustainability/climate-polices.html

[7] https://cdn.sanity.io/files/h61q9gi9/global/6a64fb766c58f70ef37807deca2ee036a3f4096b.pdf?energy-transition-plan-2022-equinor.pdf

[8] https://www.equinor.com/news/archive/20220318-annual-sustainability-reports-2021

Equinor UK HSE Policy

We aim to always conduct safe, secure operations and respect the environment

We are committed to providing a safe and sustainable environment for everyone working at our facilities. Equinor's safety and security vision is zero harm. We provide an environment recognised for its equality and diversity, and we treat everyone with fairness, respect and dignity. We do not tolerate any discrimination or harassment of colleagues or others affected by our operations.

EQUINOR WILL

- Comply with applicable laws, regulations and our management system and act in an ethical, sustainable and socially responsible manner
- Practise good corporate governance and respect internationally recognised human rights
- Minimise harm to the environment and aim for outstanding natural resource and efficiency in our business activities
- Provide the workforce with a positive working environment, preventing any adverse impact on their health and wellbeing
- Drive emission reductions in all areas of our business to deliver a low carbon future
- Integrate risk management in our performance framework
- Systematically identify, evaluate and manage risk in order to create sustainable value and avoid incidents
- Maintain our values, code of conduct and governance framework in all our activities
- Commit to continuously improve our safety and security culture
- Monitor and execute assurance activities to ensure that processes and corresponding actions are effective to safeguard and continuously improve our operations

Leaders in Equinor are role models for our values. This means always putting the health, safety and security of our people first, understanding risks and acting with integrity and high ethical standards in everything they do. Our leaders will drive the development of a strong safety culture founded on our values.

SAFETY IS INTEGRATED IN EVERYTHING WE DO

Every employee and contractor are personally accountable for safety, sustainability and security and to continuously demonstrate this commitment through actions including setting goals related to our "I Am Safety" expectations.

I AM SAFETY

- I understand and manage risks
- I look after my colleagues
- I am visible and engaged in my team's safety and security
- I stop unsafe behaviour and activities
- I openly report and learn from all incidents
- I systematically use Compliance and Leadership
- I continuously improve safety and security
- I actively search for weak signals and act

"Always Safe
High Value
Low Carbon

Arne Gürtner

SVP EPI

Figure 1-5 Equinor's Health, Safety and Environment (HSE) Policy

2 CONSIDERATION OF ALTERNATIVES

2.1 Introduction

In considering the Development, the team developing the project drew on Equinor's experience both on the UKCS, the NCS and in other parts of the world. A wide range of potential field development solutions, alternative facilities concepts and export options were considered for the Development. During the evaluation work it has been important to always consider the effect on the complete value chain from reservoir to market. This section of the ES provides a comparison of the main alternatives that were considered and summarises the advantages and disadvantages of each option, with particular emphasis on the associated environmental impact.

During the design selection process, the following main principles were applied:

- Zero harm to people;
- Minimise the environmental footprint including CO_2;
- Maximise economic recovery;
- Technical feasibility; and
- Optimise cost and schedule.

The screening of alternatives embedded a consideration of the potential environmental impacts, using a comparison of best available techniques (BAT) and best environmental practice (BEP) when selecting the concept for the Development.

Some key elements to this are:

- Balancing efficiency with NSTA expectations to start production early;
- Reuse of a modern, efficient FPSO – resulting in a lower carbon footprint during construction;
- Minimise the subsea installations - minimising seabed footprint and emissions during construction;
- Minimise the well length and drilling time – resulting in reduced emissions from drilling;
- Reinject the produced water to avoid overboarding;
- Normally closed flare and minimum flaring during limited periods driven by technical issues – to minimise GHG emissions;
- Volatile Organic Compounds (VOCs) recovery from storage tanks and process – to minimise GHG emissions; and
- Preparing for a low carbon future with an FPSO driven by electricity from renewables - starting by making the FPSO electrification ready prior to tow-to-field and by maturing electrification supply – to enable import of power when technology is qualified, and consenting is in place.

2.2 Project Design Process

Equinor utilises a phased, structured and gated project development process with the following time period definitions:

- Screening phase (i.e. Concept Screening) between Decision Gate ("DG") 0 and DG1;
- Select phase (i.e. Concept Development) between DG1 and DG2;
- Define phase (i.e. maturation of Selected Concept) between DG2 and DG3; and
- Execute phase between DG3 and DG4.

This process ensures a structured project development with defined evaluation criteria from business case identification through to the Final Investment Decision (FID) at DG3- (Figure 2-1). The process includes effects on the total value chain from reservoir to market.

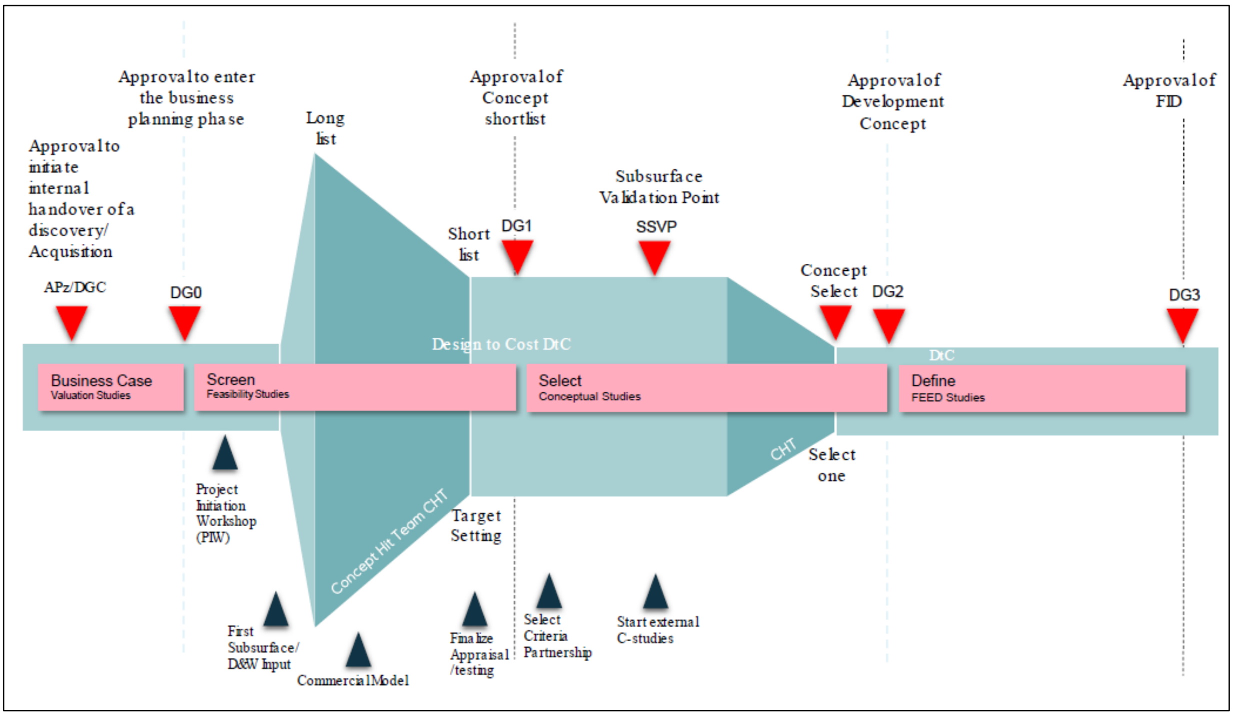

Figure 2-1 Equinor stage gated project development process

The objective of the Concept Screening phase is to mature the reservoir understanding and carry out a wide screening of possible options in all areas of the project from reservoir to market and identify a shorter list of alternatives that are environmentally, technically and economically feasible.

The objective of the Select phase is to mature the subsurface understanding and conclude optimum drainage strategy leading to the maturing of the shortlist of viable development concepts, select a preferred concept from reservoir to market (Concept Select) based on the pre-defined selection criteria.

The key activity in the Define phase is the facilities front end engineering and design (FEED) (also referred to as pre-engineering), and well design and planning. The purpose of this phase is to further develop, define and document the business case based on the selected concept to such a level that a FID can take place (DG3), the relevant applications for development and production consent can be submitted to the authorities and the basis for awarding contracts can be established.

The process and results of the screening and concept selection for the Development are presented in this Chapter of the ES.

2.3 Concept screening and selection decision process

The Equinor defined concept screening process was used to find the right concept for the Development, measured by the impact on value, safety and environmental impact, including carbon footprint. Environmental considerations, and in particular carbon emissions, provided an important contribution to the selection of the development concept.

Adoption of a structured screening process allowed Equinor to select a development concept that maximises the expected value of economically recoverable production, reduces technical and commercial risk, minimises environmental impact, and supports the UK's net zero target and the energy transition.

The options were screened based on whether they met the following Development key success criteria:

1. Generating zero harm to people and environment - supporting net zero commitments.
2. Maximising Economic Recovery (MER).
    a. Maximising project value.
    b. Maximising project robustness.
    c. Meeting MER expectations.
3. Minimising risk and maximising robustness and operability.
4. Delivering on licence commitments.

Equinor took the approach of starting from the basic project elements irrespective of previous studies on the field. All potential alternative concepts were reviewed and considered in line with strategies for the area, UK requirements in the energy transition and Equinor strategies. A wide range of options within the following project elements were considered:

- Resources, drainage strategy and reservoir management;
- Drilling and wells;
- Subsea infrastructure;
- Offloading and transportation of the produced fluids;
- Operational mode – manned or unmanned;
- Facilities – standalone (including capacity) or tie-back;
- Development schedules; and
- Commercial considerations.

A high-level presentation of the concept selection results is shown in Figure 2-2.

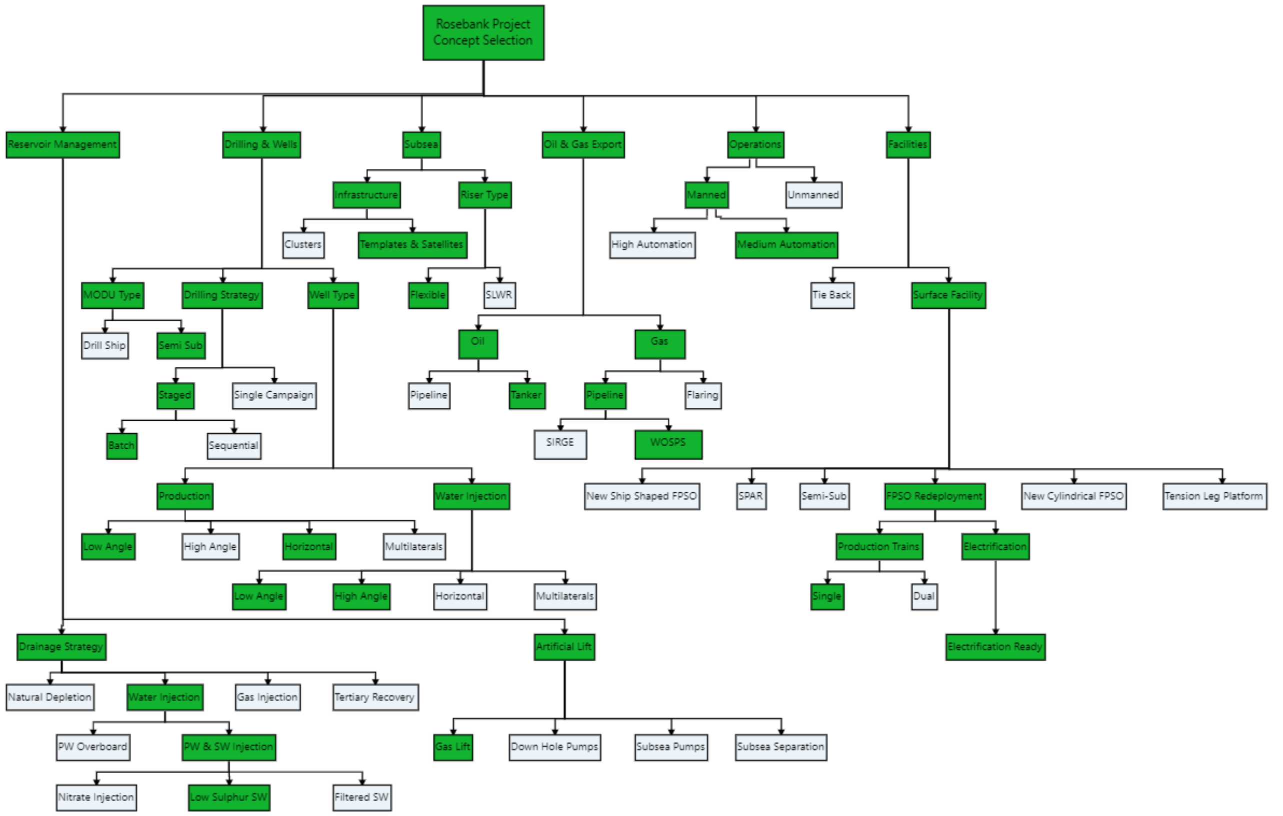

Figure 2-2 Overview of options considered for the development of the Rosebank field with highlight of the options selected for the Development concept (further detail is provided in subsections below)

2.4 Reservoir and Drilling & Well Concept Screening

2.4.1 Reservoir Management

The options considered for reservoir management are presented in Figure 2-3.

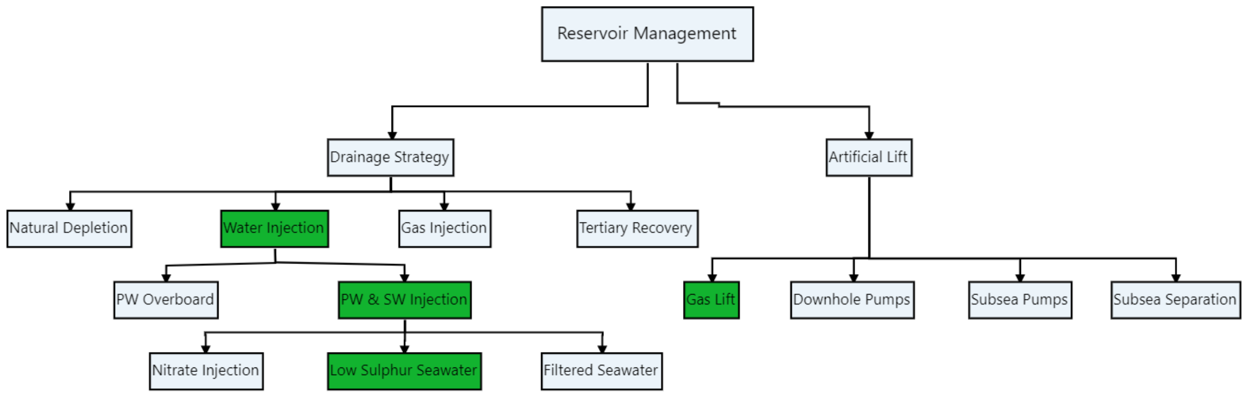

Figure 2-3 Summary of options considered for reservoir management

Depletion Strategy

All Rosebank in-field and near-field resources were screened through simulation and economic analysis which confirmed that the Colsay-1, Colsay-3 and Colsay-4 reservoirs would form the base development (Chapter 2.1 Project Description). Other reservoir opportunities, including the Rosebank North discovered resource and the Rosebank South exploration prospect, will be further evaluated based on data acquired during development drilling. Further development of those resources may occur as later phases of the Development if the business case supports, but they are not included within the current scope. Similarly, infield Improved Oil Recovery (IOR) opportunities will also be assessed.

Hydrocarbon resources in the near area outside of the Rosebank licences have been evaluated and do not add economic value to the Development, so they are not included in the Development. These resources will be considered for future tieback opportunities if data acquired in the future were to change this evaluation.

Depletion strategy alternatives were tested through simulation and economic analysis. The selected depletion strategy is water injection (WI) for voidage replacement from the start of production with initially seawater injection moving to combined sea and produced water reinjection (PWRI) once produced water breaks through. Alternatives such as natural depletion or under-injecting of water and allowing the reservoir pressure to drop resulted in less efficient reservoir drainage i.e. reduced recoverable oil and were therefore eliminated as options. PWRI is considered BAT as it avoids the need for routine overboard discharge of produced water and is the mechanism of providing the needed reservoir pressure support which has the least environmental impact.

Gas Management

Gas management was a key focus area of the subsurface analysis. Screened alternatives evaluated included crestal gas injection and crestal gas injection with downdip water injection on Water Alternating Gas (WAG) application in the injection wells. Both scenarios showed the potential for small incremental produced oil volumes but were not economically viable and, due to Rosebank's relatively thin, large area and low relief reservoirs, the injected gas will migrate rapidly to the producers and a high proportion is recycled, thus still requiring a disposal solution for the gas. Gas injection disposal sites were evaluated surrounding the Development. The Colsay-1 North gas cap was evaluated however, this structure is assessed as being filled to spill and further injection leads to migration into the Colsay-1 South development wells and recycling of gas. Other nearby potential disposal sites (Rosebank North, Stelkur-Sula, and Aberlour) were deemed unsuitable due to significant seal integrity risk, raising the likelihood of loss of containment of the injected gas.

The selected concept is to provide a gas export route through a new Rosebank pipeline that enables maximum recovery of resources from the field, minimum environmental impact by selecting the shortest route, gas sales to the UK grid and can be used for future gas import (should the Rosebank field become gas deficient in terms of ability to power the FPSO). Electrification, if technically qualified and necessary consents are in place, is anticipated to be operational before the field becomes gas deficient.

H_2S Management

Reservoir souring and production of hydrogen sulphide (H_2S) gas at Rosebank was evaluated using a coupled SourSim RL - Eclipse model. An important aspect of the analysis was benchmarking the predictions against other assets using metrics such as souring index. Overall, the analysis shows that sea water injection at Rosebank reservoir leads to reservoir souring and H_2S generation. Contributing factors include reservoir temperature, proximity of injectors to the oil water contact and injection water breakthrough and cycling. Consequently, souring management is required to ensure safety and integrity of the plant for the life of the field. The FPSO design includes a Sulphate Removal Unit (SRU) which reduces the sulphate ion concentration in the sea water from 2800 mg/l to 40 mg/l. Reducing the sulphate content of the sea water reduces the severity of souring to a level that can be managed by topside scavenger. An assessment of scaling potential found that low sulphate sea water injection was effective in mitigating the threat of Barium Sulphate and Iron Sulphide precipitation. Overall, the scaling risk was found to be low however provision for continuous downhole inhibitor injection is included in the production wells to mitigate against the threat of Calcium Carbonate precipitation in the tubing. Rosebank fluids contain ARN acids[9]. ARN acids are associated with the deposition of Calcium Naphthenate (CaN) which typically form in separators and water treatment facilities. The capability to inject Naphthenate inhibitor will be provided upstream of the subsea choke to mitigate the threat of CaN deposition.

Reservoir Optimisation

Over the producing field life, the fluid column density in the wells and subsea flowlines and risers will increase in line with water-cut. Artificial lift is required to start wells following a shutdown and to maximise recovery. Four technologies are available to Equinor and were assessed as follows:

- Subsea separation;
- Subsea pumps;
- Downhole pumps; and
- Gas lift, including assessment of downhole or manifold base gas lift.

Subsea separation is at an early stage of readiness for routine production deployment and provided negative value due to high cost and reduced regularity without providing additional value compared to gas lift in wells. It was therefore screened out. Downhole pumps were screened out due to reliability concerns in conjunction with the met ocean conditions resulting in long periods each year when intervening on wells for maintenance may not be possible. Subsea pumps were also investigated for artificial lift but compared to gas lift the technical risk and cost was higher without providing any significant benefit and therefore subsea pumps were also screened out. Downhole gas lift resulted in higher production and improved economics compared to manifold base gas lift. Downhole gas lift was therefore selected as the best option for supporting the production at the Development.

Reservoir and Well Design

During the concept screening phase of the project an initial well count of 15 wells (including both producing and water injection wells), based on a mid-range subsurface outcome and low to high angle wells, was found to be favourable. Use of existing temporary abandoned wells was ruled out due to being in the wrong location and not being able to fulfil Equinor's Company Tubular Design Standards for development wells such as material selection for 25 year life of well and strength requirements.

A revised drilling strategy was then developed, consisting of vertical/deviated and horizontal wells. Vertical/deviated wells have the advantage to present a low drilling risk, maximise the likelihood of successfully drilling the wells early in the drilling programme, and enable multizone production. The horizontal wells have a longer reach, allowing hydrocarbon production from larger areas and are associated with a lower water production. This strategy thus allowed reducing the well count from fifteen to twelve wells (seven producers and five injectors) whilst maintaining the hydrocarbon production levels based on a mid-range subsurface outcome. Additionally, the longer reach of the

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[9] High molecular weight naphthenic acids.

horizontal wells also allowed reducing the number of production templates. In terms of environmental impact, the selected strategy reduces the seabed footprint of the Development by reducing the number of wells and production templates. Overall, this strategy delivered the best business case and consequently was selected as the preferred alternative.

The Rosebank Development team has selected a phased development plan for the drilling and SURF (subsea umbilicals, risers and flowlines) scope. Phasing allows for optimal use of the FPSO processing capacities when considering the expected profile and the range of uncertainty. A key advantage of phasing is that subsurface uncertainty is addressed through targeted early data acquisition, which allows Phase 2 wells to be optimised based on static and dynamic reservoir learnings from the Phase 1 wells. The phased development plan includes the ability to accelerate or delay Phase 2 should different reservoir outcomes require (e.g. a shorter drilling break and / or an accelerated Phase 1 well in low case reservoir outcomes). It enables the potential to increase recovery (including the potential for 4D seismic benefits should the Phase 1 results support 4D acquisition) while delivering from lower risk resource areas first.

Reservoir Drainage Strategy

Several elements of the selected drainage strategy will result in emissions reductions due to energy efficiencies through reducing the volume of produced water as far as possible and maximising oil produced. Minimising the produced water volumes reduces the volume of water required for injection and also the amount of gas lift required and hence lowers energy requirements:

- A low well count facilitated by the inclusion of a mix of single and multi-zone deviated and single zone horizontal wells results in significantly less produced water to be re-injected and less gas lift than the alternative solutions;
- Tubing size selection considered both value and emissions reduction. The selected 7 inch tubing in the water injection wells (which will become 5 1/2-inch further down the wells) significantly reduces the frictional pressure losses in the well compared to the alternative of a 5 1/2-inch option for the entirety of the well. The topside injection pump pressure is reduced, and the CO_2 emissions associated with water injection is reduced by approximately 25%; and
- Selection of a phased development concept will allow for later wells to be located based on reservoir learnings from initial drilling. This will allow for better placement and greater energy efficiency in the wells in Phase 2 which target more oil relative to produced water with lower water injection and gas lift requirements. In addition, the inclusion of inflow control valves on the injector wells will promote efficient placement of injected water and reduce energy inefficiency associated with any misplaced water injection.

Reservoir Selection Strategy Summary

Option	Pros	Cons
Natural Depletion	• Lower capital expenditure; and • Lower emissions.	• Poor reservoir drainage and does not maximise economic recovery; • Overboard water discharge; and • Lack of pressure support will cause rapid drop in reservoir pressure and significant loss of reserves.

Option	Pros	Cons
Water Injection (Seawater + produced water)	• Maximises recovery and reservoir sweep; and • Produced water re-injection avoids need for overboard discharge so considered BAT.	• Risk of souring and scaling (mitigated through SRU and chemical injection); and • Increased power requirements (mitigated by use of intelligent completions).
Gas Injection	• No major items identified	• High gas rates in production wells; • Lower recovery than from water injection; • Increased power requirements for high pressure gas injection; and • Increased gas handling on FPSO.
Water Alternating Gas (WAG) Injection	• No major items identified	• High capital expenditure (additional gas injection line to injectors); • High gas rates in production wells; • Lower recovery than from water injection; • Increased power requirements for high pressure gas injection; and • Increased gas handling on FPSO.

Artificial Lift Selection Summary

Option	Pros	Cons
Subsea Separation	• No major items identified	• Early stage of readiness for the depth of water and technology for West of Shetland application; and • High cost and low regularity.
Subsea Pumps	• Allows for simplified SURF scope.	• Higher capital expenditure; • Less economic than gas lift; • Less flexibility to optimise individual wells; • Technology qualification less mature for subsea application in deep water; • Additional emissions due to increased water handling; and • Impact on regularity due to Rosebank met ocean challenges.
Downhole Pumps	• No major items identified	• Reliability concerns and met ocean conditions for intervention and repair; and • Higher downhole and interface complexity.
Manifold Gas Lift	• Reduced downhole complexity.	• Increased vulnerability to flow instability; and • Difficulty starting / unloading wells and lower recovery.

Option	Pros	Cons
Down hole Gas Lift	• Higher production and improved economics compared to all other options; and • Robust and stable across range of operating conditions.	• Increased well design complexity Intervention requirements if gas lift valves fail.

Final Selected Drainage strategy:

- Maintain reservoir pressure with produced water and seawater injection;
- Use downhole gas lift in wells;
- Phased drilling of wells;
- Well count: 12 wells (7 production, 5 water injection);
- Production and injector well type: Mix of single zone and multi zone deviated and horizontal wells; and
- Reservoir souring and scale management: Sulphate removal unit & downhole chemical injection.

2.4.2 Drilling and Wells

The options considered for drilling and wells are presented in Figure 2-4.

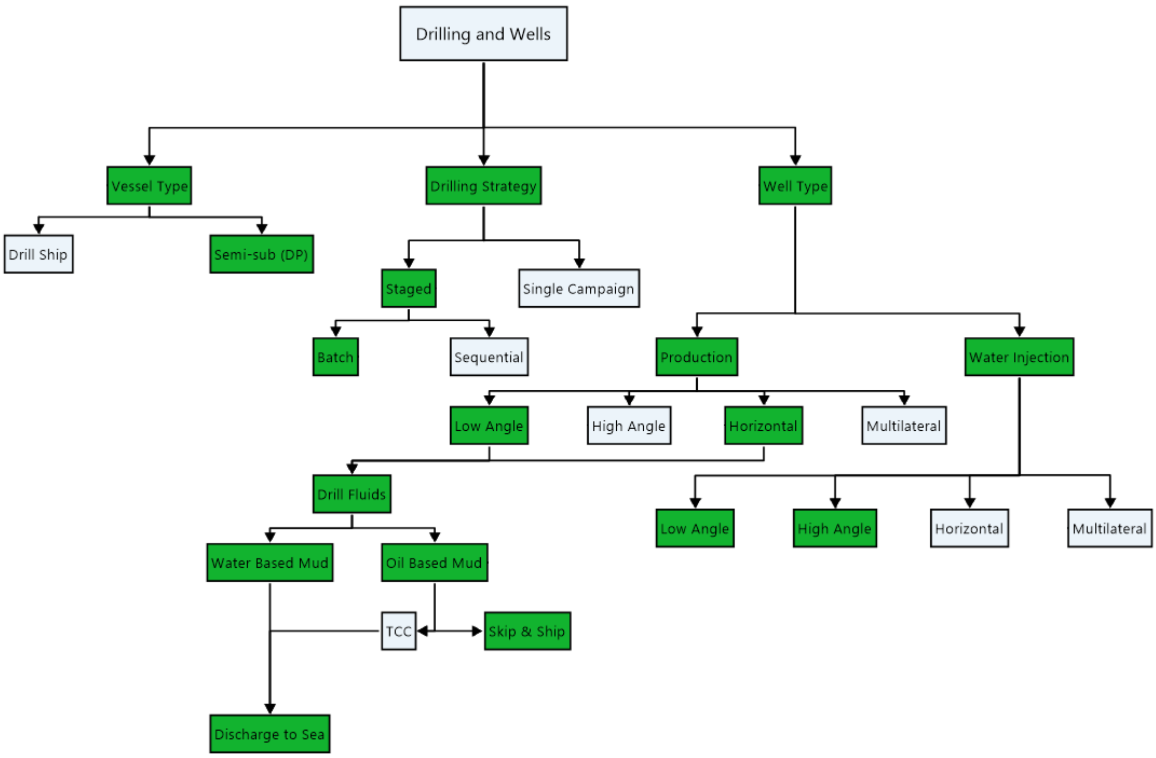


Figure 2-4 Summary of options considered for drilling and wells

The selected well designs have been optimised to ensure standardisation, utilising proven design elements to ensure learning, efficient drilling operations and hence minimising non-productive time (NPT). This will minimise the time and cost risk as well as reducing environmental impact associated with working in a deep water WoS environment.

2.4.2.1 Mobile Offshore Drilling Unit (MODU) Type

Due to the water depth (approximately 1100m) and the distance between wells, a semi-submersible MODU is the only feasible option for the drilling / completion scope. Furthermore, a dynamically positioned (DP) MODU (as opposed to wire/chain moored) is required for ease and speed of moving between various drilling locations. This also reduces the potential environmental impact from anchors. The nature of the batched drilling programme is such that MODU moves will be frequent. DP drill ships were ruled out due to early field experience where the unfavourable hull design led to a high percentage of time spent waiting on weather and therefore an increased frequency of 'disconnects' during drilling operations.

To carry out the designed well construction scope for the Development, MODU specifications considered to be minimum requirements include:

- Ability to operate in deep water in a harsh environment;
- Favourable motion characteristics under harsh environment conditions west of Shetland; and
- Operational efficiency in subsea completions.

Equinor recognises that the carbon footprint of a DP MODU is higher than with an anchored rig. However, anchor handling operations in deep waters are associated with a significantly higher safety risk in comparison to shallower water and therefore in the context of the Development, this safety consideration was considered paramount in the selection of the drilling rig type. In addition an anchored rig is less efficient when frequent rig hops are required with batch operations.

Key to reducing the emissions from drilling and well activities is to fundamentally select a rig that will have the highest operational uptime as a result of a design that is fit for purpose for Rosebank conditions, crew competence and a total logistics strategy that supports and maintains rig uptime. In addition to this, selecting the drainage strategy giving the shortest total well length reduces the total time in the field. The selected well concept does that. Equinor have reduced the carbon emissions and seabed footprint of the Development in comparison to the original concept. The reduction in total well count and simplification of the well design has reduced the total drill metres by 40% and the total drilling days by 50% from 2019 when Equinor took operatorship of the field. This equates to a reduction of scope on CO_2 emissions for drilling and well activities of approximately 45%.

Although the MODU contract is yet to be set, the MODU is expected to have a system for energy management assuring a continuous, systematic and target oriented evaluation of measures that can be implemented to achieve an optimal energy efficient operation. Optimising energy efficiency and GHG emission reduction will be part of the evaluation criteria for rig tendering.

Rig Selection Summary

Option	Pros	Cons
Drill ship	• Favourable mobility, transit speed and deck load capacity.	• Less stable in the water west of Shetland verses semi-sub; and • Drill ships ruled out due to experience of hull design leading to high percentage waiting on weather.
Semi-Sub spread moored	• Less cost and more fuel efficient.	• Water depth, anchor handling in the west of Shetland and deep water not considered As Low as Reasonably Practical (ALARP); and • Higher environmental impact.
Semi Sub	• Greater stability, flexibility resulting in higher uptime resulting in reduced risk of disconnection; and • Reduced environmental impact as no anchoring. Higher uptime also minimises the time to drill and complete the wells.	• Higher day rates and slightly higher carbon footprint however outweighed by anchor handling risks.

Rig Selection: Dynamically positioned harsh weather MODU

2.4.2.2 Well Type

Four well types were considered for the oil producer and water injector wells:

- Option 1 – Low angle (<30 degrees);
- Option 2 – High angle (30 to 80 degrees);
- Option 3 – Horizontal (80 to 90 degrees); and
- Option 4 – Multilateral wells.

All development wells have been planned to avoid all identified shallow hazards, also there is sufficient well control for landing well sections which means that no planned pilot holes are required for well construction.

There is a mix of single and multizone targets for both production and water injection wells.

Production Well Type

The Development well construction objective is to achieve maximum reservoir recovery from the simplest possible well design. The advantage of multilateral wells (i.e. those with multiple branches from the same well bore) is that they can allow access of multiple reservoir sections within the same well, which reduces the required well count and the construction costs of the upper hole sections. However, the disadvantage is that the multilateral design itself can introduce extra complications and risks for a successful completion. There were no significant data to demonstrate that multilateral wells in the Development would be cost efficient. Furthermore, multilateral wells did not meet the simple well design objective. As a result, the multilateral well option was eliminated. The remaining three options were considered and a combination of the options 1 and 3 for the oil producing wells was selected. This means that low angle wells will primarily be drilled for most of the multiple reservoir zone producers and sub horizontal wells will primarily be drilled for most of the single zone oil producers. This combination of well designs increases field production and avoids potential shallow gas hazards. The use of such wells limits the number of wells which need to be drilled and hence the potential environmental impacts which could arise (e.g. drill cuttings, energy and resource use).

Water Injector Well Type

The key objective for the water injection wells is that they have a simple reliable well design, prevent out of zone injection, and that they have ability to maintain zonal voidage replacement to achieve producer recovery targets. Neither the horizontal nor the multi-lateral option met this requirement. The water injection wells will be high angle wells, with a typical maximum inclination of 70°. This is driven by the completion selection of cased hole-oriented perforation (CHOP) and to mitigate risk of loss of containment (out of zone injection). An inclination of at least 55 to 60° is required to accommodate the successful application of the CHOP technique. Whilst these wells will bring some potential environmental impacts (i.e. discharge of cuttings), the ability for the Development to return produced water to the reservoir instead of discharging it to sea outweighs any potential short-term impact from the wells being drilled. Also water injection is the mechanism of providing the necessary reservoir pressure support with the least environmental impact.

Production and injector well design: Combination of vertical, deviated and horizontal wells. No pilot holes.

2.4.2.3 Batch Drilling

Two well construction alternatives were considered for the wells:

- Option 1 - Batch drilling and completion:
    - Drill certain upper sections of a well before moving onto the next well to drill the same upper sections. Each well would be re-entered at a later date (or dates) and the remaining sections drilled and completed.
- Option 2 - Sequential drilling:
    - Drill and complete one well at a time. Once one well is drilled and completed then the MODU will be moved to the next well location.

The option selected was batch drilling and completion operations. This decision was primarily driven by the harsh weather conditions at the Rosebank Project area to maintain operational efficiency and to minimise risk of environment impact. In winter, the prevailing weather conditions can lead to significant downtime particularly with regards to weather sensitive completion and tree installation operations.

Well sections will be batch drilled down to the production casing in the winter months then suspended until the following summer when the remaining weather sensitive well operations will be carried out in the summer months. This will reduce downtime and maintain operational efficiency.

As the open water part of the drilling operation (conductor and 26" hole sections) does not involve the use of the marine riser, planning of batch drilling in the winter reduces the risk of potential environmental impacts by limiting the frequency of disconnecting the marine riser due to the weather conditions.

Well construction: Batch drilling, completion and Xmas Tree installation

2.4.2.4 Drill Fluids and Cutting Disposal

Two options were identified:

- Option 1 - Water based mud (WBM) with treated cuttings disposal to sea; and
- Option 2 - Low Toxicity Oil Based Mud (OBM) with either skip and ship or offshore clean-up/disposal to sea.

The base case drilling fluid design will follow option 1, the concept proven in Rosebank offset wells. The use of WBM has been successful in meeting drilling objectives in the exploration and appraisal of Rosebank while providing the benefits of lower environmental risk as a consequence of reduced cuttings handling, treatment and transportation requirements.

The upper hole sections (conductor and 26") will be drilled with seawater, with regular sweeps of bentonite used to remove cuttings. Since no drilling riser will be in place until the 20" casing is set, the drill cuttings and any drilling fluid from the upper hole sections will be discharged directly onto the seabed.

Once the drilling riser is in place, cuttings will be recovered to the MODU. The 17 ½'' section will be drilled with Water-based Mud (WBM).

For the and 12 ¼'' and 8 ½'', it will also primarily be WBM, but it is possible that an Oil-based Mud (OBM) will be used, depending on results of the reservoir formation damage study. For the sections using WBM, cuttings may be discharged to sea on location under UK legislation.

OBM cuttings, could either be treated at the rig with a thermomechanical cuttings cleaner (TCC) and discharged, or the cuttings could be loaded in skips and treated onshore.

Due to the very limited amount of OBM cuttings potentially produced from the wells, it is not environmentally nor economically beneficial to install a TCC unit on the rig. The CO_2 footprint of a “skip and ship” solution is significantly lower at approximately 1/3 of total CO_2 calculated for the TCC. This is therefore the treatment option of choice from an environmental and cost point of view, should OBM be used for the reservoir section of the oil producer wells.

Drilling fluids:

- WBM for surface / intermediate section; and
- WBM with OBM as an option for production / reservoir section.

Cuttings disposal:

- OBM - skip and ship; and
- WBM - discharged to sea.

2.5 Facilities Evaluations

The options considered for facilities are presented in Figure 2-5.

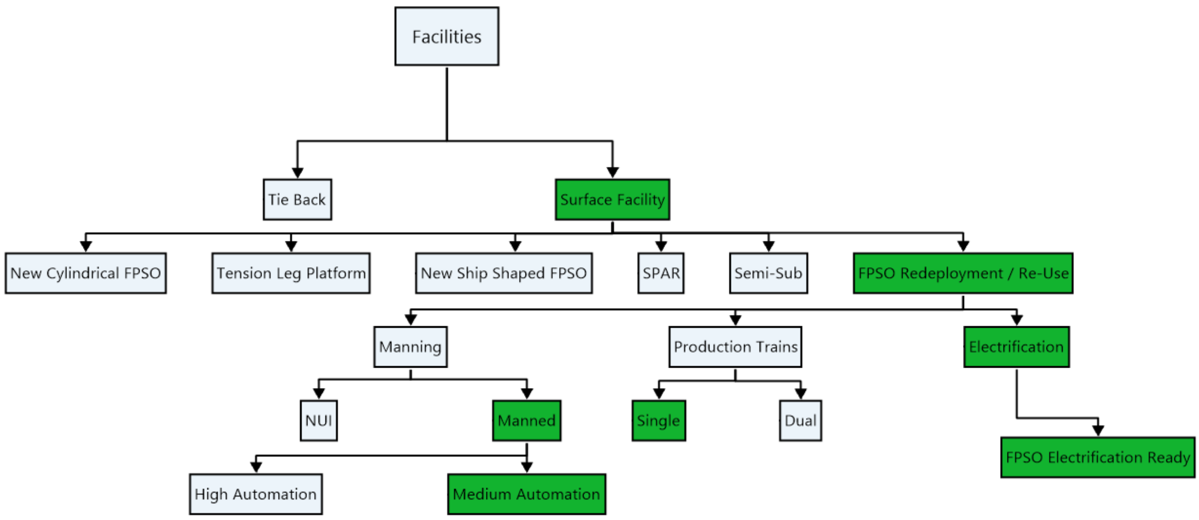


Figure 2-5 Summary of options considered for facilities

2.5.1 Tie-in to Third Party Hosts

Clair, Schiehallion, Foinaven and Laggan-Tormore were existing developments in the area at the time of the high-level screening that were identified as possible candidates for tie-in options. A tie-back to third-party hosts was considered technically feasible but due to distance would require upgrading existing technology for pipe-in-pipe (PiP) flowlines, deployed with electrical trace heating (ETH) significantly beyond existing experiences.

The distance from Rosebank to these pre-existing facilities is 70 km or more (except Laggan-Tormore which is a subsea to shore development) and would require the following simplified technical solutions in addition to the subsea design that would be required for an FPSO option:

- A subsea multiphase pump at Rosebank for pumping of fluid to host (feasibility may be challenging first year due to gas to oil ratio) – Assumed power rating 3.5 MW;
- Flowlines:
  - Multiple ETH PiP flowlines from field to host dependent on lay method (ETH required due to the risk of gelling, wax and hydrates);
  - 18” (ca 46cm) diameter flowline for water injection from the host to the field as water injection is necessary to realise the reserves; and
  - Umbilical from the host to control the wells.
- Power cables from the host to:
  - Power the subsea multiphase pump; and
  - Provide electrical heating of flowlines.
- Power distribution system at Rosebank; and
- A minimum number of additional riser slots would be needed at the host – 4 risers and 3 umbilical risers (including control and power for pump and ETH).

This initial simplified case did not consider all flow assurance issues (including need for regular pigging) at field which are expected to be challenging (gelling and wax formation are potentially significant issues common to all the potential oil pipeline export options) and assumed gas lift would not be needed.

Laggan-Tormore is a subsea development with well streams to the Shetland Gas Plant (SGP). Installation of a new flowline to Laggan-Tormore tying in to one of the existing flowlines is not considered technically feasible as there is likely to be severe waxing problems in the flowline from Laggan-Tormore to shore due to the characteristics of the Rosebank fluids. Tying in to Schiehallion, Clair or Foinaven was also reviewed and discussed with the operator for these fields. These alternatives were all screened out due to challenging flow assurance issues due to flowline length and low seabed temperature in this area and also due to high cost and lack of available host capacities for oil, water and supply of electricity needed for these alternatives.

An alternative case with subsea separation and water reinjection at the Rosebank field was not considered feasible as oil-only flow in a production pipeline would result in too low a flow rate later in the life of the Development such that the full potential of the reserves in the field would not be realised. The above additional subsea infrastructure to hosts, technical complexities with the design and the lack of host capacities within the required timeframe resulted in the tie-back option being excluded from further evaluation.

During the screening process a dialogue was held with potential hosts to ensure a proper judgement was made.

Due to lack of flow assurance feasibility, lack of available host platform capacities and high cost, all the tie-back to host platform cases were therefore not pursued further. Due to lack of flow assurance feasibility being the critical issue, environmental considerations were not critical to this decision.

2.5.2 Unattended/Low-Manned Concepts

The key enabler of the unattended concept is the removal of the living quarters, the significant reduction in utilities systems and use of new technology in certain areas to reduce maintenance. For the Development, the hull would have to be a Spar concept to avoid the need for active systems to control positioning. This concept was not found feasible for the Development due to the substantial topside requirements creating more maintenance than could be safely and economically maintained in such a concept.

2.5.3 Initial Platform Screening

Several floating platform options were screened for suitability in the specific environmental conditions at the Rosebank location and to facilitate the maximising economic recovery from the reservoir. All these options were able to accommodate electrification and none of the platform concepts differentiated substantially on environmental impact.

High-Level 'Early Facilities' Screening of Concept Options

The aim of this wide screening was to narrow the options down to a limited feasible range that would be investigated to a greater depth (see Figure 2-1). A comprehensive set of screening criteria were established to ensure a thorough process. The following ranking of project key screening criteria was applied:

1. Health, Safety and the Environment (HSE) including ability to be electrified; and
2. Net Present Value (NPV); and
3. Maximising Economic Recovery (MER); and
4. Risk exposure, robustness, and operability.

Recognition was given that some options were interdependent e.g. limited topsides facility with seabed storage for the oil, and others would not be feasible e.g., not technically, to meet the success criteria of the project. The result of the initial screening excluded some of these options e.g., natural depletion of the field would result in reduced recoverable oil and less favourable economics and was therefore excluded. The following options were excluded from further consideration as concepts for the Development.

Tension Leg Platform (TLP)

The TLP is an expensive concept, and the key benefit is dry Xmas Trees on the platform which permit simple well access and maintenance, rather than subsea Xmas Trees. At Rosebank the proposed well locations to achieve the required reservoir drainage strategy are spread too far apart to allow the Xmas Trees to be located on a platform. Only a few of the wells would be reachable from any platform location. There was therefore no driver for a TLP solution, and it was screened out.

Semi-submersible / deep-draft semi-submersible

The primary benefit of the semi-submersible concept compared to a ship-shape FPSO is the elimination of the turret, which reduces technical complexity. The turret for these conditions is a qualified product but the riser solution is not fully qualified. The additional cost of the requirement of separate storage from the semi-submersible makes this alternative unattractive economically in addition to the fact that deep sea storage technology for the volumes required is not yet certified under the pressures at the depths found at the operating location (i.e. not technically qualified). A deep-draft semi-submersible could secure feasibility of steel lazy-wave risers. However, cost savings from the steel risers cannot compensate for the added cost of the deep draft semi-submersible hull and external storage. As a standalone option, this alternative was screened out. It was brought forward to the final concept select stage as a part of an oil pipeline to shore case.

Ship-shape FPSO

A ship shape FPSO is a proven concept WoS and was brought forward due to well known design, cost competitiveness and ability to provide oil storage for direct offloading to tanker. From an environmental or carbon emissions perspective it was considered to be equal to the alternative floater alternatives. Both new build and redeployed FPSO was brought forward to the final concept select. The ship-shape FPSO has a slightly higher power consumption and thus CO_2 emissions due to infrequent use of thrusters for weather-vaning but this was considered small and not driving concept select

Cylindrical FPSO
A large capacity cylindrical FPSO (specifically a SEVAN Semi-submersible platform designed hull). Key challenges of the SEVAN hull option include potentially added costs of hull due to limited yard experience and more complex topside construction due to limited deck space. Execution risk and cost uncertainty would also be higher due to limited experience with this design. However, the option would present an opportunity to reduce capex (capital expenditures) due to the lack of a turret and electrification is made simpler due to no need for electricity transfer trough turret. A cylindrical FPSO was therefore maintained as a viable option towards final concept select.

Spar
As with the semi-submersible solution, the spar concept may have been an option where no storage is required. However, the spar hull is significantly more expensive (CAPEX) than a semi-submersible due to higher weight and more complex construction. Cost savings from the steel catenary risers and elimination of the turret cannot compensate for the added cost of the spar hull, the added costs of more complex topside construction and execution schedule. This alternative was therefore screened out.

Area solution
An area solution also recovering oil from fields outside of the Rosebank licences was discussed, but no basis was identified in sufficient close proximity of Rosebank to make it technically of economically feasible to select a higher capacity FPSO serving a larger resource base than Rosebank from ‘Day One’. This alternative was therefore screened out.

Screening
A relative comparison screening of the facilities options was carried out at this stage using, again, an extensive set of screening criteria to ensure a thorough process. The following were the key criteria:

- Commercial robustness;
- HSE;
- Carbon footprint;
- Risk exposure to Equinor; and
- Operability.

Facilities Concept Selection

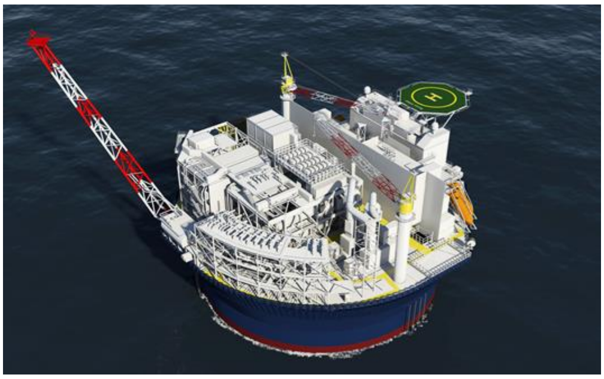
Option	Pros	Cons
Cylindrical FPSO	• No need for turret; • No need for active heading control; and • Ease of electrification due to no need for high voltage swivel in turret.	• Longer construction time; • Limited experience of deploying a cylindrical FPSO of the size required in the metocean conditions seen west of Shetland; • Constrained deck space limits ease of operations; and • Compact topside less desirable from an HSE perspective compared to a redeployed FPSO (e.g. topsides close to accommodation).
Shipped Shaped FPSO	• Well proved design; and • Cost efficient.	• Requires turret – a large and complex unit; • Electrification requires a high voltage swivel in turret – a solution with limited track record; • Need for use of thrusters for heading control under certain conditions – adding power consumption and CO_2 emissions; and • Yearly power consumption from this is small and thus not a driver for the concept select.
TLP	• The benefit of dry Xmas trees - but this cannot be utilised on Rosebank due to spacing of wells.	• Complex design with high cost; • Can only reach a very few well targets from a single location; and • Weather conditions and water depth at Rosebank will add further challenges for this concept.
SPAR	• Less motions in normal weather conditions potentially simplifying riser design.	• Complex construction and high cost; and • As riser design is considered feasible for a ship-shape FPSO this is not a driver towards a SPAR design
Semi-Sub	• Less motion than FPSO; • Ability to tie in larger number of risers; and • Electrification easier due to no turret.	• Requires separate oil storage/oil pipeline to shore; • High total cost compared to ship shape FPSO; • No need for added riser capacity and this is therefore not a benefit; and • Added marine impact from pipeline.
Area Solution	• Reduced unit cost through joint development in area.	• No extended resource base in the Rosebank area to support this has been identified.

Floating Facilities Final Selection

At the final concept select the following options were evaluated:

- Newbuild FPSO;
- Redeployment of an existing FPSO; and
- Semi-submersible production facility.

New Build FPSO



Evaluation of ship shaped (new-build and redeployed) and cylindrical FPSO indicated that the Knarr redeployment was the optimum business case in terms of cost and schedule whilst meeting the early start up originally communicated to the NSTA. The high cost and the environmental impact associated with building a new FPSO ruled out this option.

Redeployment

The Altera owned Knarr FPSO currently (at the time) deployed at the Shell-operated Knarr field in Norway, becoming available in the market in Q3 2022, was suitable and available for redeployment in the harsh environment of the North Atlantic with a remaining life expectancy that would enable maximum recovery of reserves from the Development.

The Knarr FPSO is a modern FPSO (first installed in 2015) and from an operations emissions perspective is considered equivalent to a new build. Systems for closed flare and vent are already in operation on the FPSO, the design will be energy efficient on Rosebank, it is prepared for future electrification with available space allocated in the turret and at the deck. Redeployment of the FPSO was also considered the most economically viable option and was the only option that could achieve first production by 2026. It was therefore selected as the concept for the Rosebank Development.

It was determined that the redeployment of the Knarr FPSO significantly reduced GHG emissions compared to fabrication and transport of a new-build FPSO (Figure 2-6).

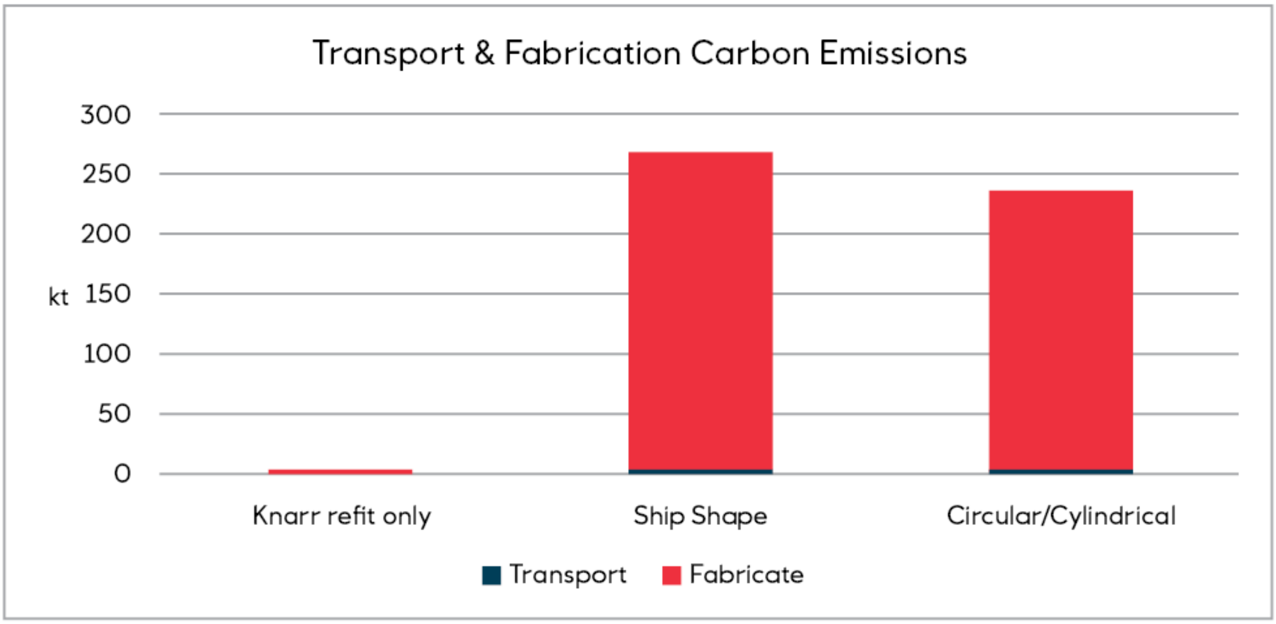


Figure 2-6 Estimated CO_2 emissions from FPSO refit, fabrication and transport

Semi-Submersible

Economic evaluations determined that a semi-submersible (with oil pipeline for export) were significantly less economically viable than redeployment of the FPSO or installation of a new-build FPSO. A semi-submersible with oil export via pipeline was not seen as having any environmental benefits. Carbon emissions were equal compared to the FPSO alternatives.

Final Facilities Selection

Option	Pros	Cons
Newbuild FPSO	• Has the preferred facilities capacity. Can be built to own specifications.	• Time and cost for construction; • Higher GHG emissions when fabricating a new build facility and later start of production; and • Less attractive business case.

Option	Pros	Cons
Redeployment of an existing FPSO	• Suitable for redeployment in the harsh environment of the North Atlantic with a remaining life expectancy that would enable maximum recovery of reserves from the Development; • Lower cost than new build was also determined; • The redeployment of an existing FPSO significantly reduced GHG emissions, compared to fabrication and transport of a new-build FPSO; • Facilities designed with closed flare hydrocarbon recovery system; • FPSO turret allows for future electrification; and • Allows for phased drilling and wells improving reservoir management.	• Facilities capacity smaller than new build options. This has however the benefit of enabling a phased drilling of wells where learnings from Phase 1 will improve the phase 2 wells and there improve the drainage strategy.
Semi-submersible production facility	• Has the preferred facilities capacity. Can be built to own specifications.	• Total cost of this option much higher. • Higher GHG emissions when fabricating a new build facility. • Needs an oil export pipeline or a separate storage unit

Selected field center concept: Redeployed ship-shape FPSO

2.5.4 Export of Hydrocarbons

2.5.4.1 Oil Export

The options considered for oil export are presented in Figure 2-7.

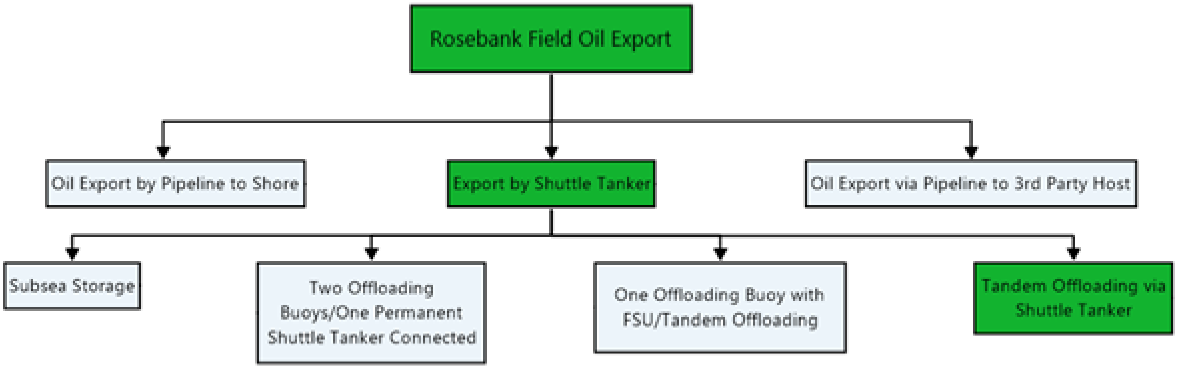


Figure 2-7 Summary of options considered for oil export

Oil export using a pipeline enables the use of Floating Production Units (FPU) without integrated storage. Several possible oil pipeline export destinations, including the Sullom Voe Terminal, were evaluated. Rosebank crude has a high waxing potential, and any pipeline export route would have a significant flow assurance risk due to gelling and waxing. These risks could be mitigated by heated pipelines or chemical inhibition, but these mitigating measures carry high technical risks and both high capex and opex (operating expenses).

In terms of environmental criteria, the oil pipeline was unfavourable mainly due to passing of a protected area where other alternative solutions were available (offloading directly from shuttle tanker at field) and due to the energy and materials used in the construction of the pipeline. A heated pipeline would require additional power therefore increasing emissions from the power generation system. Although there are carbon emissions associated with tanker offloading this was the only technically feasible solution.

Terminals also carry a significant tariff cost (particularly in late life) and any incremental value addition through blending with other crudes has a high degree of uncertainty. Economic analyses showed that the business case for Rosebank standalone pipeline export alternatives were significantly worse than tanker offloading. For these technical economic reasons oil export by pipeline was excluded.

2.5.4.2 Infield Storage of Oil

As with an oil export pipeline, a separate infield oil storage facility would enable alternative floating production unit concepts without integrated storage. Separate infield oil storage could be achieved in the following principal ways:

1. Subsea storage – This storage method is not qualified for the volumes required, and it was therefore screened out.
2. Two separate offloading buoys (e.g., the manufacturer NOV's Submerged Turret Loading system) with one shuttle tanker always connected (cost includes purchase of one shuttle tanker for comparison purposes). This solution is technically proven but may trigger a requirement for two lines and possibility for

circulation/pigging. Estimated capex for this alternative was >650 million U.S. dollars (MUSD) excluding risers and flowlines. Due to the high capex and opex this option was screened out.

3. One offloading buoy with a floating Storage Unit and tandem offloading to shuttle tanker. This solution is considered technically proven although due to mooring and riser loads, the buoy would be significantly larger than a conventional buoy. As with option 2 above, it will likely trigger the need for two lines and possibility for circulation/pigging increasing cost and the estimated capex for this alternative was >400 MUSD excluding risers and flowlines. Again, due to high capex and opex this option was screened out.

A combined qualitative and quantitative evaluation of the options was conducted, and the output from this work led to tanker offloading being selected as the crude oil transport route.

2.5.5 Gas Export

Concept screening identified possible gas export options to be via either Shetland Islands Regional Gas Export System (SIRGE) or the West of Shetland Pipeline System (WOSPS). There were ten variations or sub-options for these gas export routes:

1. Rosebank – SIRGE – FUKA – NTS/SEGAL;
2. Rosebank – WOSPS – SVT SF – EOSPS – Magnus – NLGP – FLAGS – NTS/SEGAL;
3. Rosebank – WOSPS – SVT SF – EOSPS (offshore sale);
4. Rosebank – Cambo – WOSPS – SVT SF – EOSPS – Magnus – NLGP – FLAGS – NTS/SEGAL;
5. Rosebank – Cambo – WOSPS – SVT SF – EOSPS (offshore sale);
6. Rosebank – WOSPS – SVT SF - XOVER – SIRGE – FUKA – NTS/SEGAL;
7. Rosebank – Cambo – WOSPS – SVT SF – XOVER – SIRGE – FUKA – NTS/SEGAL;
8. Rosebank – GLA – SGP – SIRGE – FUKA – NTS/SEGAL;
9. Rosebank – Cambo – GLA – SGP – SIRGE – FUKA – NTS/SEGAL; and
10. Rosebank – WOSPS – SVT SF – EOSPS – Magnus – NLGP – Statfjord – Statpipe – Kårstø.

Based on a joint commercial and technical review of the available gas export routes, exporting gas via a new pipeline tying into WOSPS was selected. The full route to the sale point (option 2 above) would be WOSPS – SVT SF – EOSPS – Magnus – NLGP – FLAGS – NTS/SEGAL. This route includes the construction of a new circa 85 km long pipeline to the tee in WOSPS immediately south of Clair (Figure 2-8).

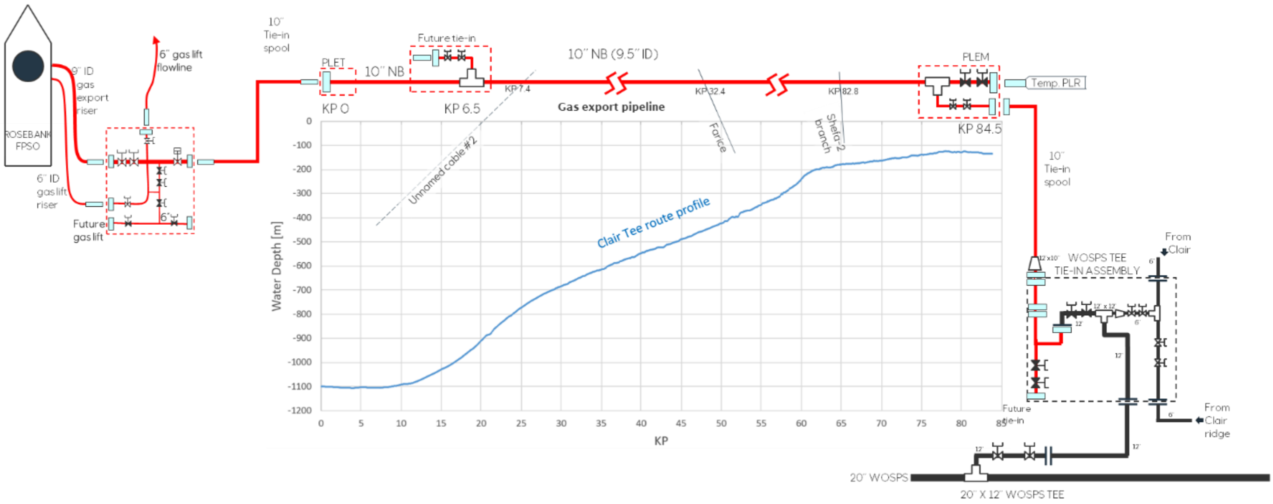


Figure 2-8 Technical summary of the selected route

This aligns Rosebank with other WoS fields (Clair and Schiehallion) which also use WOSPS, SVT SF, EOSPS and Magnus as their current gas export route.

There are significant strengths to this route which include:

- It is the shortest feasible route to WOSPS and results in the lowest friction losses enabling a lower export compressor discharge pressure and resultingly lower power requirements and CO_2 emissions in support of SE11;
- Most economic route based on offers provided; and
- WOSPS pipeline has a high historical availability and is operated with a focus on maximising oil production with coordinated planned maintenance and line packing when necessary to maximise Rosebank production efficiency and minimise non-routine GHG emissions.

The weaknesses of this route include:

- The route is subject to Magnus cessation of production (CoP) in early 2030's and a bypass may be required for late-life users (although this could be mitigated by anticipated construction of XOVER to SIRGE – see below);
- Risk of downtime and lower efficiency constraints due to multiple systems;
- Infrastructure and commercial risk associated with SVT; and
- Route crosses a Marine Protected Area.

By selecting the shortest feasible Rosebank export route to WOSPS, the total seabed footprint from installation of the new pipeline will also be reduced, although it is noted that the route would be through the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA), further assessment of which is undertaken in Section 6 Seabed Impacts.

The Cambo option would have involved the installation of a new pipeline route from the Rosebank field to the Cambo field. As part of the Cambo field development (which is outside the scope of the Rosebank Development), a new gas export pipeline was planned to be installed from Cambo to the PLEM at WOSPS, thus allowing the produced gas from Rosebank to be exported via Cambo to WOSPS. However, the Cambo development has been paused therefore that export route is no longer considered an option.

From the selection process the gas export pipeline route is to WOSPS, joining at the Clair Tee. The new pipeline will include a tie-in point near the Clair Tee and a tie-in point close to the Rosebank field for future West of Shetland developments (e.g., the Cambo field). Following selection of the gas export pipeline route, studies have been undertaken to define various aspects of the pipeline installation method:

- Mechanical design
    - Wall thickness was assessed using industry standard specifications, and given the water depth, determined to be approximately 16 mm.
- Pipeline installation
    - Considering water depths, both S-lay and reeled lay are acceptable for the installation of the gas export pipeline.
- Free span support
    - Simplified on-bottom roughness analyses has identified numerous free spans along the route, mostly on the seabed slope towards Clair where the seabed is relatively un-even.
- Gas export pipeline protection
    - Minimising seabed footprint in sensitive habitats has been an important part of defining the installation method for the export route, and given the technical feasibility of the option, surface lay without protection where possible has been proposed;
    - Upheaval buckling and required resistance on buried pipeline has been evaluated analytically according to industry standards, and some of the gas export pipeline has been identified as requiring support. The support will take the form of trench and backfill, except for any sections which cannot be trenched, in which case rock cover will be placed. It was evaluated that alternative control such as rock placement or concrete mattresses would be required, and trenching was considered preferred against these options; and
    - Protection against third party interaction is a key reason to protect the gas export pipeline, and this has been deemed necessary in <800 m water depth where bottom-contact fishing may take place. Trenching has been preferred to rock placement or concrete mattresses, in order to limit the material placed on the seabed,. Initial trenching analysis surveys have identified some areas where rock placement will be required, such as presence of boulders and crossings of other infrastructure. Further detailed surveys will be required to identify the precise requirements for protective and stabilisation material deposits along the pipeline route.

2.5.6 Subsea Infrastructure

The optio7ns considered for subsea infrastructure are presented in Figure 2-9.

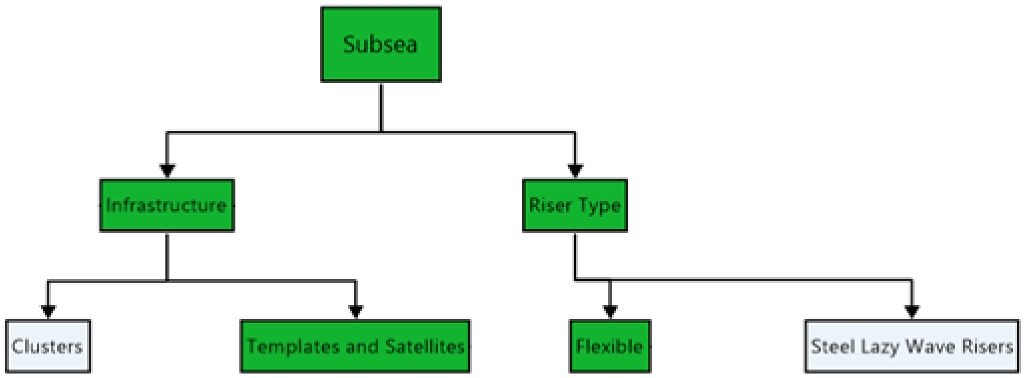


Figure 2-9 Summary of options considered for subsea infrastructure

Alternative arrangement of subsea infrastructure both for the water injection wells and production wells were carefully considered. The key issue was to minimise the environmental impact by optimising the pipeline length, sub-sea infrastructure, multiple well drilling templates and the number of marine operations. The selection was done in careful cooperation with drilling and well and petroleum technology teams.

The production wells are located along the crest of the field and the optimum arrangement was concluded to have three well centres. Supporting this and to provide future flexibility for adding more producers if required, three 4-slot production templates were selected. Choosing a template solution rather than a cluster solution significantly reduces the footprint of infrastructure placed on the seabed at the expense of marginally longer wells. A flowline loop with all three templates daisy-chained in a single flowline loop with two flowlines were required to mitigate flow assurance issues.

The water injectors are located on the flanks of the reservoir and due to distance between the wells individual satellite wells were the only viable solution. The water injection satellites are daisy-chained on two separate flowlines to reduce pressure drop, and thereby reducing water injection pump power consumption and emissions.

The subsea concepts allow for the additional future installation of new templates and thus provides flexibility.

GHG emission reduction initiatives for the Rosebank subsea infrastructure are centred on minimising the additional equipment to be installed. Minimisation of additional equipment achieves GHG reductions during fabrication, installation and maintenance during life of field.

Following DG1 and the decision to consider horizontal wells, the following subsea layout options were selected to minimise environmental impact/GHG emissions, minimise cost and maximise economic recovery:

- Moving the FPSO from the centre of the Rosebank field to a southern field location; and
- Using a single flow loop to connect all subsea templates instead of using two (South and North) flow loops.

The optimised layout also reduced the safety risk associated with installation activities due to the reduced number of structures requiring installation in comparison to alternative options. The flow assurance risk is also reduced with a single production loop.

Equinor will minimise the vessel time required to install subsea umbilical, riser and flowline equipment by executing the installation during the summer period with less waiting on weather. Furthermore, Equinor intends to award contracts to contractors which can offer construction vessels with reduced fuel consumption and energy efficient operations; information to support this will be requested during tendering activities.

Subsea layout: Southern FPSO location with a single flow loop and subsea templates for production wells

2.5.7 Floating Facilities Final Selection

2.5.7.1 Environmental Optimisation of the Development

The FPSO was originally designed to minimise GHG emissions. The FPSO is designed to operate without the need for routine flaring of hydrocarbons for operational purposes through the implementation of the following measures:

Volatile Organic Compounds (VOC) Recovery Unit is provided to prevent continuous flaring during normal operation, it receives vapor from cargo tanks during production operation and also receives the vapor from the flare system which comes from continuous leak paths such as CFU's and glycol generation, etc. during offloading.

There is a HC gas blanketing system that will take care of cargo vent gas and re-fill HC gas back to the cargo tanks during offloading. Hydrocarbon gas is taken from the process during offloading. The HC gas blanketing system and the flare recovery system is an integrated package.

In addition, an atmospheric vent system has been designed to handle the flash gas discharged from the cargo tanks during filling and during hot weather in a controlled manner when the VOC recovery unit is out of service. Sufficient distance between the vent exit pipe and topsides & flare is provided to prevent accidental ignition or harm to personnel

Heat recovery derived from turbine exhaust gases will be used to heat the processing and utility plant. The steam boiler can burn both gas and diesel.

A third-party BAT assessment of Rosebank's power and heat generation has been completed and it concludes that the FPSO current single (open) cycle gas turbines and Waste Heat Recovery Units (WHRUs) are BAT.

The existing single (open) cycle system is considered BAT when compared against a combined cycle system, as the possible energy efficiency gain of replacing the system to a combined cycle system is considered to be too low in an overall assessment of environment, technical and cost. The current turbines employ Dry Low Emissions (DLE) technology (SoloNOx nozzles) to reduce NOx generation from the turbines. The basic principle of operation in the DLE technology is close control of the flame temperature, ensuring 25 ppmv of NOX emissions (measured on dry off gas, 15% O2). The DLE technology does not require additional chemicals or energy, compared to a turbine without a low NOx solution. By incorporating lean pre-mix combustors in the turbine, DLE systems allow for reduced NOx emissions without the use of steam or water suppressors, and without increasing CO emissions. DLE provides the best environmental performance compared to other techniques, so is considered BAT.

The WHRUs are fitted at the turbine exhausts. The waste heat from the turbine exhausts is used to provide the required heat production for the FPSO. Other alternatives for heat production include fired heaters, which utilise direct combustion or liquid fuel, and electric heaters, which would be powered from main generation. Both fired heaters and electric heaters will increase fuel consumption and hence also the CO_2 emissions. As the WHRU system makes use of waste heat from the turbine exhausts, it neither uses fuel directly nor does it create additional emissions. As WHRUs provide the best environmental performance when compared to other alternatives, it is considered BAT.

As the FPSO currently has single (open) cycle gas turbines with WHRUs installed, no modifications will be required to ensure BAT for power and heat generation.

An evaluation of measures to reduce the energy consumption on the FPSO and thereby reduce GHG emissions via the gas turbines, has been integrated into the development process. The most significant reductions are achieved via integrated optimisation across subsurface, drilling and well and facilities while at the same time maximising economic recovery. The selection of type and placement of wells has reduced the water production. Reduced water production leads to reduced gas lift demand and thus reduced energy consumption for gas compression. Reduced water production also reduces the demand for injection water to maintain reservoir pressure and consequently the water injection energy demand is reduced.

The FPSO already has a modern, energy efficient topside design, and the extent of the FPSO modification scope, and consequent schedule effects from rebuilding, needs to be balanced against the achievable GHG reductions. Significant measures will, however, be taken via modification or replacement of equipment to improve the efficiency of the FPSO and thereby reduce average yearly GHG emissions.

Note that all the floating facilities alternatives brought forward to the concept screening phase can be electrified and it is not the electrification of the facilities that is driving the electrification schedule, rather it is the onshore and offshore consenting process, which is the same for all the concepts.

2.6 Operational Optimisation Focus Areas

Equinor considered several options to optimise operational efficiency with a focus on emissions. The philosophy is to strive for zero flaring. Below is a list of flare management opportunities that are being evaluated and considered to reduce the requirement for flaring:

- The FPSO is designed to eliminate routine flaring and venting;
- Identification of all sources of gas that could contribute to a requirement to flare:
  - Visualisation of the flow rates from the sources; and
  - Look for ways to reduce flow from each source.
- Maintain high rates for gas export and/or gas injection;
- Route pressure relief to the process rather than the flare;
- High production effectiveness leads to low flaring;
- Shut down high GOR wells quickly when top side problems occur;
- Plan well intervention for minimum flaring;
- Undertake lessons learned and improve procedures based on incidents;
- Daily focus on flare rates through the energy and production optimisation (ePog) dashboard;
- Reduce tank pressure when flaring is anticipated to be necessary. Use the VOC compressors to build pressure and avoid flaring;
- Mix condensate into turbine fuel gas instead of using diesel when low gas availability during normal operations:
  - Offloading;
  - Production start-up;
  - Low availability on tank inert gas; and
  - During late life production, when gas production is low.
- Pre-offloading:
  - Increase tank pressure before offloading, to have more gas available to refill during offloading. Reduces offloading vessel stay duration; and
  - Mix condensate into turbine fuel gas instead of using diesel when low gas availability.
- Normal operation and slugging conditions, i.e., accumulated water, oil or condensate in pipeline:
  - Optimise production; and
  - Choke topside choke to control slugging (use of installed smart choke program).
- Inspection:
  - Topside drone technology to reduce inspection personnel offshore;
  - Infrared technologies for early identification of fugitive emissions such as methane leak detection and measurement; and
  - Sub-sea drones to reduce intervention vessel inspection times.
- Flare emissions reduction checks:
  - Use of flare recovery system;

- Identification of sources; and
- Look at ways to reduce flow from source.

The following opportunities to reduce emissions during routine operations have been identified and will be implemented by Equinor:

- Power generation;
    - Use of electrical motors with variable speed drives on main drives to reduce power consumption and in turn emissions; and
    - Energy mapping to optimise energy use.
- Digital twin/ WiFI;
    - Reduced visits to site for planning, less helicopter and vessel travel to the field; and
    - Inspection work done from shore improving operational efficiency.
- Multi-skilling the workforce to reduce offshore staffing and helicopter travel and adopt a low staffing philosophy;
- Logistics;
    - Optilift technology (remote controlled crane and lifting operations) to improve cargo handling and reduce vessel time;
    - Equinor is forming a cross industry vessel and helicopter sharing group with other fields the aim of which is to improve vessel efficiency;
    - Direct flights to the field without a fixed wing travel segment;
    - Utilising Shetland as a logistics base;
    - Use of hybrid vessels for intervention scopes if available
    - Use of hybrid vessels/tankers with shore side plug in points;
    - Advanced technology application for emergency response and rescue vessel, supply vessels and tankers including possible use of low sulphur, bioethanol fuels or alternative fuels including ammonia and electricity;
    - Super medium category helicopters (e.g. Airbus Helicopters H175 and AgustaWestland AW189) that are more efficient with lower carbon emissions than traditional heavy category helicopters;
    - Combine intervention operations with other operators in the area. Using common inspection practises; and
    - Use of electric vehicles and smart warehousing. i.e., energy efficient light bulbs, electric forklifts etc.

2.7 Low Carbon Concepts

2.7.1 Summary

The ability to provide electrification in future was a key driver for concept select and preparations for future electrification of the FPSO in project design. However, electrification does not form part of the project under consideration in this ES and will be subject to separate regulatory approvals

The options considered for the low carbon concept are presented in Figure 2-10.

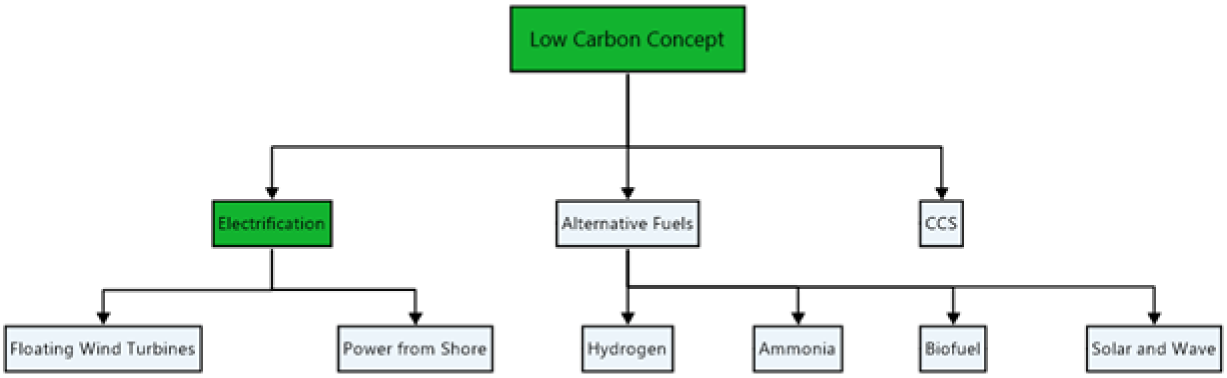


Figure 2-10 Summary of options considered for the low carbon concept

Equinor's Net Zero strategy, in accordance with the SE11 guideline was a key driver in the concept screening and selection process for the Development. The three major alternative carbon reduction technologies considered were:

- Electrification - electrical power to the field development supplied either from shore-side electrical grid, potentially integrated with a windfarm, called power from shore (PfS), or supplied by a small-scale local offshore wind farm at the Rosebank field);
- Alternative fuels for supply of power, and carbon for use in turbine driven generators on FPSO; and
- Carbon capture and storage (CCS).

2.7.2 Option 1 – Electrification

Equinor, following on from similar achievements in Norway, is working to realise the opportunity to source electric power for the Development, and thereby reduce operating emissions and optimise oil and gas production. The ongoing transfer of the UK power grid to renewable energy sources, the development of wind power on the Shetland Islands, the establishment of a direct current (DC) link between Shetland and the UK mainland, and the development of floating wind turbines all represent opportunities to facilitate a possible future electrification of the Development. This alternative has been investigated from the start of the screening process. The project has engaged with several stakeholders since inception to fully understand the issues and opportunities related to electrification. Stakeholders engaged to this date include the NSTA, BEIS, OPRED, Marine Scotland, Shetland Islands Council, Crown Estate Scotland, fisheries organisations and the Office of Gas and Electricity Markets (Ofgem). The project has engaged with SSEN Transmission and Ofgem to understand the required development process and schedule and requirements for connecting to the electricity grid on Shetland. Equinor is involved with the WoSE together with other WoS operators to explore the joint development and implementation of low carbon electrical power to the fields in this area. Electrification is subject to the availability of resource and maturation schedule of the infrastructure, much of which is subject to government regulatory and statutory provider requirements.

The distance of the Development from Shetland and the deep water and harsh metocean conditions requires innovation of existing electrification technologies. A significant amount of work has been carried out and is ongoing to mature electrification of the field development. Due to the level of maturity of technologies, the stage of renewable electricity supply from Shetland, and the anticipated consenting timeline, this electrification option is being managed as a discrete component of the Development. Electrification has been a key criterion in the screening of the wide range of options narrowing towards the selected development concept. The electrification alternatives have been screened as summarised below.

Electrification is technically challenging due to the high transmission power required, the length of the subsea cable from the Shetland Islands, the modification scopes for in the FPSO and the deep water and harsh weather conditions. All electrification options and associated technology qualifications that would be required to support the UK's net zero target have been evaluated and would require the following basic infrastructure:

- A power source facility (connection to onshore grid, an offshore wind farm or a combination);
- A high voltage subsea power cable from the power source to the FPSO with a dynamic cable at the facility;
- A high voltage transformer and voltage regulation or conversion equipment (either on the FPSO, or subsea, or both); and
- A high voltage swivel for the transfer of the electrical power through the turret of the FPSO.

2.7.2.1 Power from Shore

Electrification connected to the electrical grid on Shetland has the greatest potential for GHG reduction with the proposed wind farms on Shetland providing a low carbon source of energy via cable to the FPSO. The DC link between Shetland and the UK mainland will provide backup when the electricity production on Shetland is insufficient. The electrification infrastructure would consist of the following:

- Onshore:
  - Transmission network connection: Depending on the location, either new indoor Gas Insulated Switchgear (GIS) switching station or a connection directly to an existing substation (in any case including circuit breaker(s), disconnector arrangement, and metering) as well as new overhead lines or underground cabling on Shetland;
  - Cables from the grid connection point to the designated substation near shore;
  - Substation with a gas-insulated switchboard, transformers, a reactor and a static synchronous compensator, (subject to further study); and
  - Cable(s) from the substation to the landfall, at the landfall and cable to sea.
- Subsea:
  - Static subsea power cable to the field (150 – 175 km, depending on landfall location);
  - Subsea transformer and possibly subsea reactor (subject to more detailed analysis); and
  - Dynamic power cable.
- On the FPSO:
  - Dynamic power cable developed for an FPSO in the harsh Rosebank weather conditions and water depth;
  - Power cables;
  - High voltage electrical swivel;
  - Electrical building with transformers, gas-insulated switchboard and ancillary equipment;
  - Electrical boilers; and
  - Heating, ventilation, air conditioning, structural access platforms and stairs, piping and pipe supports, etc.

An evaluation of both alternating current (AC) and direct current (DC) transmission to the Rosebank field has been performed. High voltage AC (HVAC) is the recommended transmission solution due to the major technology development programme needed to qualify high voltage DC (HVDC) swivels, floating HVDC/AC converter stations and HVDC cables. A HVDC or medium voltage DC (MVDC) solution would also require a larger footprint and higher weight on the FPSO than a HVAC solution. Preliminary simulation modelling and Equinor experience from other similar cases have shown that HVAC transmission is feasible with acceptable power losses at a transmission voltage of 90-100 kV (cable rating 145 kV). Reactive power compensation is required onshore and potentially also offshore.

More detailed system analyses will be required, however sufficient technical information about the onshore grid and the HVDC link between Shetland and the UK mainland is not yet available for these analyses to be performed. The landfall location on Shetland and consequently the cable length will also impact the analyses. A subsea transformer would be required to reduce the transmission voltage from subsea to topside to a medium high voltage level since a 145 kV dynamic cable and swivel are technologically too immature and would increase the size requirement of the FPSO topsides.

Technology qualification will be required for the subsea cable, the dynamic power cable, the subsea transformer, the high voltage swivel and the electric boiler. As previously mentioned, there is currently limited technical information available about the grid connection on Shetland. In meetings with SSEN Transmission, Equinor has been advised that detailed models of the HVDC link between Shetland and the UK mainland are still to be developed.

Landfall alternatives on the Shetland Islands are being identified and initial assessment performed. The evaluation and selecting the location for the landfall and onshore substation will involve local stakeholders and communities.

Electricity from shore can potentially be combined with a preferably larger windfarm WoS serving multiple fields.

Extensive work has been undertaken in cooperation with relevant competent contractors to understand the time needed for consenting to develop a PfS option. Equinor's understanding is that the schedule for power from Shetland is driven by the consenting process for both the onshore scope to be executed by the Rosebank project (i.e. a landfall and a substation), and the development of a connection from the FPSO to the SSEN transmission network. The time needed for consenting and then development does not allow for PfS to be available for initial start-up.

2.7.2.2 Electricity from Local Offshore Wind Turbines Serving Only Rosebank

WoS and the Development area have good wind conditions and there might be potential to achieve partial electrification of the FPSO with power supplied from a floating wind farm that could be installed close to the FPSO (i.e. not connected to shore). The water depths in the area prevent the use of bottom fixed offshore wind turbines however floating offshore wind turbines are a less mature technology than bottom fixed turbines and the costs are currently significantly higher. Also, the small scale of a local wind farm serving only the Development will increase the unit energy cost significantly. The costs are however expected to reduce as the technology matures and commercial scale projects are developed over the coming years. Equinor have engaged with industry to ensure this alternative is properly evaluated.

The infrastructure would consist of the following:

- Marine/Subsea:
  - Floating wind turbine(s) (mooring, sub-structure, tower, wind turbine generator);
  - Subsea transformer (requirement depending on voltage);
  - Storage (battery) facility; and
  - Dynamic power cables.
- FPSO:
  - High voltage electrical 'swivel'; and
  - Local cabling; and
  - Electrical building with transformers, gas-insulated switchboards, panels, distribution boards etc.;
  - HVAC, structural access platforms and stairs, piping and pipe supports, cables and instruments etc.; and
  - An advanced power management system.

Equinor is the operator of the world's first floating offshore wind farm, Hywind Scotland (30 MW). Hywind Tampen (88 MW), an offshore floating wind farm which will supply power to oil and gas installations in Norway, is under construction. The weather conditions are harsher at Rosebank location and the water depth considerably greater (1,100 m) than at Hywind Tampen, which means that designing a floating wind turbine with the lifetime required in this location would be challenging, however a Hywind Tampen-like concept could be feasible. Other substructure concepts are also likely technically feasible. The mooring system would be very different, with a significantly higher cost, and the substructure must be adapted to the conditions. As the offshore wind turbine generators continue to move rapidly towards larger capacities and thus weights, the tower bending moments and fatigue challenges increase with potential lower availability due to increased downtime required for ongoing maintenance. Further design and technology development of the mooring, substructure and tower are required to define a robust solution for floating wind at Rosebank with the larger wind turbine generator models required expected to be commercially available towards 2026 and beyond.

Technology qualification will also be required for the dynamic power cables, the subsea transformer and the high voltage swivel (as for PfS). Equinor is undertaking and will continue to work at pace with competent suppliers to close the technology gaps. The Hywind design was used in early evaluations due to availability of as-built design information. Equinor has also been in dialogue with multiple suppliers providing alternative designs and business models.

Due to the inconsistent nature of wind, wind turbines alone will not produce power with sufficient reliability to support economic oil and gas production. It will be necessary to continuously operate at least one offshore gas turbine at reduced load in parallel with a wind farm, and thus it will not be feasible to reduce the CO_2 emissions from the gas turbines on the FPSO by more than around 30-35%. Large-size battery technology is developing rapidly and could possibly reduce the use of gas turbine backup in the future but will not eliminate it completely. Oversizing the total wind turbine capacity could potentially also reduce the need for gas turbine spinning reserve, but not eliminate the need for at least one gas turbine in operation. Waste heat from the running turbine will, however, cover most of the heat demand on the FPSO. An advanced power management system and detailed wind predictions/forecasts will be required in operation at the FPSO.

As gigawatt scale offshore wind projects are being developed in the UK and worldwide, and floating wind demo-projects move upwards in size towards and beyond 100 MW, reduced vendor interest for smaller, engineering intensive projects such as a ~30 MW Rosebank wind farm in a heated supplier market could pose a risk of schedule delay. Also, the operational and maintenance unit costs would be high for a small wind farm.

The "Sectoral Marine Plan for Offshore Wind for Innovation and Targeted Oil and Gas Decarbonisation (INTOG) - Planning Specification and Context Report" (Marine Scotland, 2021) details a planning process, parameters and specifications that will apply to projects seeking to progress in the INTOG round, and an indicative outline of the leasing process to be delivered by Crown Estate Scotland. Furthermore, the INTOG plan sets out the spatial data considered in the opportunity, which includes 2 areas WoS, one of which could support a standalone wind farm on Rosebank and the other could possibly support a hub solution for WoS fields.

A schedule for the development of a local wind farm near Rosebank location is difficult to establish at this time due to lack of defined consenting process and timeline, required technology development due to deep water and harsh environment, and supplier constraints in the wind turbine generator market making supply times and cost estimates for a small-scale wind farm difficult to define. Based on experience with existing floating wind farm alternatives, having a local wind farm in operation from first oil in 2026 is considered not to be a realistic option.

2.7.2.3 Technology Development for Electrification

Significant technology gaps would need to be closed to enable electrification of the FPSO however the modifications will address these issues hence not a factor in option selection. Several technology gaps are being pursued through dedicated technology development programmes in cooperation with the suppliers to mature electrification towards becoming technically viable in the future. These are summarised below:

- A dynamic power cable will be needed to connect to the wind turbines or to the cable to shore. Considering the water depth, environmental conditions and required electrical voltage this is beyond current industry experience. Work is ongoing with suppliers on these issues;
- A subsea transformer is required to reduce the transmission voltage from subsea to topside to a medium-high voltage level since 145kV dynamic cable and swivel are technologically too immature as well as too space consuming. There are still some design aspects not fully qualified to confirm the feasibility of the required subsea transformer;
- The electrical swivel needed in an FPSO turret is at the limits of existing products and further work is ongoing with the suppliers to finally conclude solutions and finalise technical qualifications however all indications are that the technology will be qualified prior to project sanction; and
- Battery power could reduce the use of gas turbines backup in the future of power production from the wind farm but will not eliminate the requirement for back-up turbine use. Equinor (through their dedicated Research & Development unit) is following battery development closely and evaluate options when relevant; and
- Floating wind turbines are outside current experience due to the water depth and site-specific metocean conditions and thus require design development.

2.7.2.4 Moving Electrification Forward

For all the electrification alternatives, Equinor is actively working with other parties in order to mature and select the electrification solution at pace. These other parties include:

- SSEN Transmission –For the PfS alternatives more detailed system analyses will be required in order to conclude on system and equipment design, and sufficient technical information about the onshore grid and the HVDC link between Shetland and UK mainland is not yet available for these analyses to be performed;
- Shetland Islands Council / landowners / onshore wind farm owners - For the PfS alternatives the selection of landfall location on Shetland will impact the electrical design (e.g. grid connection and offshore cable lengths). This selection is dependent on land access and consenting processes on Shetland;
- Marine Scotland – For the windfarm alternatives, a planning process is required to help decarbonise the oil and gas sector;
- Crown Estate – For the windfarm alternatives, a leasing process is required which will coincide with the above Marine Scotland planning process;
- Offshore floating wind industry suppliers – For the windfarm alternatives, further studies are required; and
- WoS electrification joint solutions – The Clair operator bp, the Cambo operator Ithaca SP E&P Limited and Equinor is currently collaborating with the other key stakeholders to agree a plan for future work.

Equinor is also in engagement with Ofgem's ongoing Offshore Transmission Network Review.

Equinor is actively engaged in the WoSE together with the operators for the Clair and Cambo fields to seek the best area solution.

All electrification alternatives require multiple new technologies to be developed/qualified and these qualification exercises would need to be concluded before a final electrification solution can be selected for the Development. Work is currently ongoing to fully qualify these solutions.

The FPSO original design supports future electrification. Study work performed in 2021/2022 confirmed the feasibility of this, including confirming that suitable space exists in the turret for the installation of an electrical swivel and necessary deck space for electrical equipment. The work undertaken therefore supports the expectation that the swivel will have the necessary transfer capacity. The ability to be deployed in the Rosebank field as electrification-ready was a significant factor in the selection of the FPSO.

FPSO preparations for electrification whilst the FPSO is at the yard (before mobilisation to the Rosebank field) will consider the flexibility required in order to accommodate the final life of field electrification solution when it is selected.

Equinor will collaborate with appropriate supply chain experts, and engage with associated parties on consents, permitting and interface management with the transmission owner and power supplier as required.

2.7.3 Option 2 - Alternative Fuel Sources

Hydrogen

Equinor has considered gaseous hydrogen import and/or export as a method of minimising GHG emissions. However, significant regional infrastructure changes/additions would be required to enable the import or export of hydrogen (e.g., installation of a new hydrogen pipeline or the conversion of WOSPS to hydrogen). Further, this would require development of new technology and a major modification scope on the FPSO, with several safety related issues, e.g., pressurised hydrogen import through turret. In principle, hydrogen could be imported from a dedicated carrier also in liquefied form to serve as fuel. The uncertainty around liquefied hydrogen supply solutions and the expected high cost, plus the need to integrate dedicated cryogenic tanks, loading system and vaporiser system, which are all unqualified, makes this currently an unrealistic solution. Finally, there can be options for importing hydrogen via a Liquid Organic Hydrogen Carrier (LOHC). This option involves handling and storage of very large liquid volumes, and a double set of tanks since dehydrogenated LOHC need to be returned. An extensive topside dehydrogenation facility with large heat input is also needed. Again, this seems to have very limited potential for fuelling an offshore oil and gas facility in general, and for the FPSO, the space and weight constraints or tank and topside equipment make it not feasible. This solution is not considered feasible for the FPSO or within the project timeframe and has not been progressed further.

Liquid ammonia

Liquid ammonia can serve as zero carbon fuel, but currently the outlook is primarily for marine propulsion type engines that would not fit into the FPSO. In addition, dedicated fuel tanks and offloading systems would have to be fitted. The potential for offshore gas turbines to run on ammonia is limited, and a high temperature cracking system would have to be installed. Ammonia also introduces new safety issues through its toxicity, and a potential environmental issue if accidentally released, and the combination of hydrocarbons and ammonia can give difficult scenarios in relation to major accidents and evacuation. This alternative was not progressed.

Biofuel

Imported biofuel (biodiesel or bio-methanol) could serve as gas turbine fuel if some of the in-hull tank volume was converted to hold biofuel, and if it was possible to install a dedicated loading system. A main challenge is sustainable sourcing of sufficiently large amounts of biofuel (e.g. biodiesel), where conflict with food production or deforestation is, or may become, problematic. There is also a risk that more Nitrogen Oxides (NOx) than from a gas fired dry low emission (DLE) turbine could be expected. Maintenance intervals would also be shortened. This alternative was therefore not progressed.

Solar and Wave Power

Solar and wave power are not considered feasible solutions at Rosebank due to limited available space and level of technology readiness.

2.7.4 Option 3 - Carbon Capture and Storage

Compact post-combustion CO_2 capture technologies were reviewed by Equinor for use at the Development. Aker Solutions 'Just Catch™' compact CCS technology was evaluated as it was deemed to be the most feasible for an FPSO. The 'Just Catch™' process removes CO_2 from the gas turbine exhaust and puts it into a water injection stream for subsurface disposal. However, for the Development, due to the circulation of the injected water back into the production wells, the CO_2 injected with the injection water will cause additional risks of CO_2 circulation. Finally, any additional CCS facilities to be sited on the FPSO would be large and there is no available space for these. For the reasons stated above, CCS technology is not to be pursued further.

The Rosebank reservoir is not considered to be a suitable candidate for CCS on cessation of production for both technical and logistical reasons. The seal capacity of the overburden is only sufficient to support a limited hydrocarbon column. There is also evidence of gas leakage through the overburden (gas chimneys and shallow gas anomalies) and therefore the Rosebank area is not optimal as a storage reservoir. In addition, the deep water, harsh environment and lack of nearby infrastructure to support CCS would make this a much more challenging candidate than other alternative receiving reservoirs.

2.7.5 Selected Option

The above options were screened by the Licensees and electrification was selected as the preferred option to further decarbonise the Development. The ability to provide electrification in future was a key driver in concept selection and project design, however electrification does not form part of the project under consideration in this ES as it is subject to separate regulatory approvals

Equinor has an extensive experience with electrification of offshore oil and gas projects with more than 10 offshore fields with electrification in operation or in development, with a total power demand of more than 1,000 MW.

The Licensees have the ambition and drive to meet the UK's net zero target and are targeting electrification as soon as possible. The Licensees commit to take a proactive role to deliver electrification without delay when technology is qualified and matured and necessary consents are in place.

Decarbonising strategy: Electrification selected as option for further decarbonising Rosebank

3 PROJECT DESCRIPTION

3.1 Development Overview

The Rosebank field is located on the north-west edge of the UKCS, in approximately 1,100 m of water (Figure 1-1). The conceptual layout of the Development is presented in Figure 3-1 and the indicative schedule is provided in Table 3-1 with first production expected in Q4 2026.

The Rosebank field will produce via subsea production well templates (3 x4 slot templates B, C and D in Figure 3-1) and flexible risers to an FPSO (A in Figure 3-1). Oil will be exported from the FPSO using tankers and gas will be exported via a new offshore gas export pipeline to tie into WOSPS at the Clair Tee junction, and then through existing infrastructure to the SAGE gas terminal in St Fergus.

A phased development plan has been selected for the drilling and subsea, riser and flowline scope with four production wells and three water injection wells in Phase 1, and based on current assumptions, up to an additional five wells (three producers and two water injectors) in Phase 2. Phasing allows for optimal use of the processing capacities when considering the expected profile and the range of uncertainty. A key advantage of phasing is that subsurface uncertainty is addressed through targeted early data acquisition, which allows Phase 2 wells to be optimised based on static and dynamic reservoir learnings from the Phase 1 wells.

The phased development plan includes the ability to accelerate or delay Phase 2 should different reservoir outcomes require (e.g. a shorter or longer drilling break and / or an accelerated Phase 1 well in low case reservoir outcomes). It enables the potential to increase recovery while delivering from lower risk resource areas first.

Produced water and treated seawater will be injected into the reservoir for pressure support and as enhanced oil recovery to maximise the recovery of the Rosebank field reserves. Downhole gas lift will be required for the production wells to reduce the start-up time of wells, increase the production rates, and maintain flow stability in the production flowlines. The FPSO will be powered by dual fuel (field gas and diesel) generators from the start of the production. The gas produced that is not used as fuel for the generators or in gas lift will be exported via the proposed new pipeline. The provision of power from electricity to reduce carbon emissions has been discussed in Chapter 2 Consideration of Alternatives but as it is not within the scope of the current EIA it is not included in this chapter. The potential impact on atmospheric emissions as a result of electrification of the FPSO from shore is, however, discussed in Chapter 9 Atmospherics and Climate as intrinsic to the planned development of the life of field.

Details of the Development including the reservoir, drilling activities, FPSO, subsea infrastructure and the gas pipeline are included in the project description below. All activities will be carried out in compliance with the operational permits and consents.

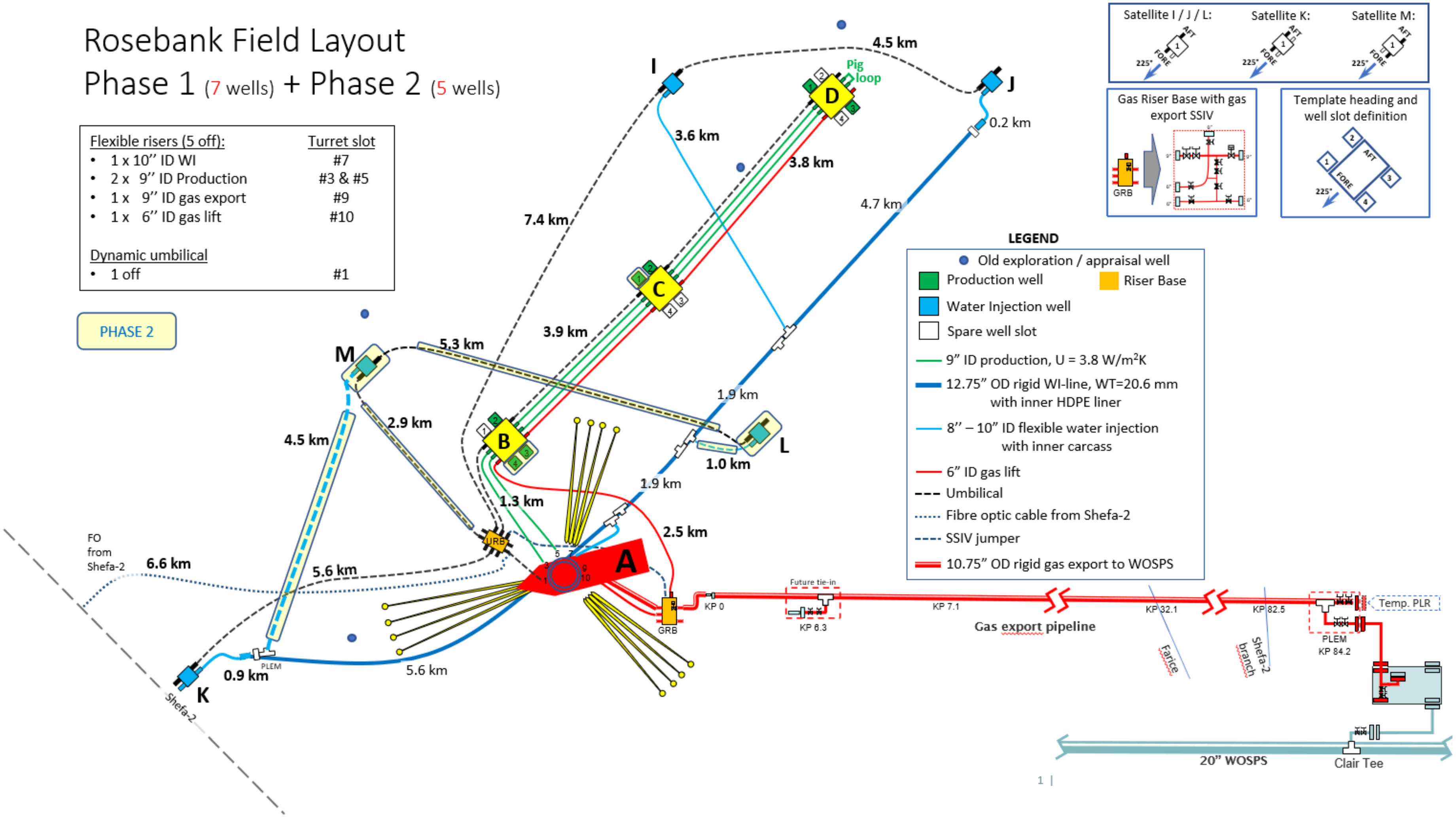


Figure 3-1 Rosebank Development conceptual field layout

Table 3-1 Rosebank phase 1 development schedule

Activity	2024				2025				2026			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Drilling						■	■	■	■	■	■	
SURF installation		■	■			■	■			■	■	
Gas Export Pipeline installation						■	■			■	■	■
FPSO installation, hook up and commissioning										■	■	■
First production												■

3.2 Reservoir and Fluid Characteristics

The Rosebank field is a large but relatively narrow structure of approximately 20 km long by 5 km wide. The field was discovered in 2004 by well 213/27-1Z, which found a series of oil and gas-bearing sandstones of Late Palaeocene to Early Eocene age (Rosebank) and Jurassic age (Lochnagar). The Rosebank Colsay Formation sandstones are overlain by and interbedded with volcanic sediments. The exploration and appraisal wells drilled to date have encountered high quality sandstones filled with a mix of light oil and gas. The volcanic and siliciclastic shales (silica-bearing sedimentary rocks) act as a seal. Figure 3-2 shows a cross-sectional view of the reservoirs in the Rosebank field. The Development aims to produce from the Colsay reservoirs, initially focusing on the Colsay-1, Colsay-3 and Colsay-4 reservoirs.

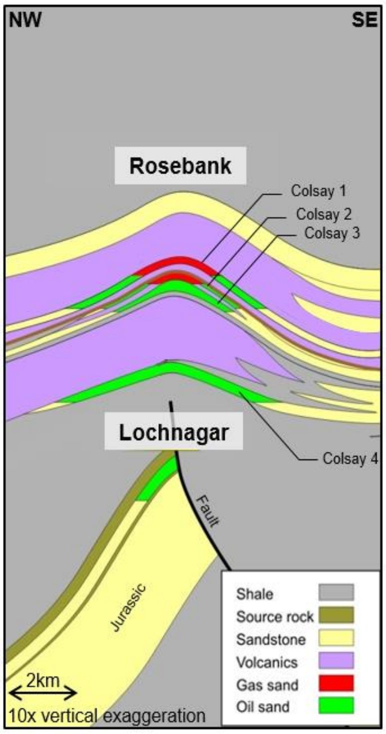


Figure 3-2 Reservoir layout of the Rosebank field

As production is planned from three reservoirs (Colsay-1, Colsay-3 and Colsay-4) the fluid properties such as gas to oil ratio and density will exhibit some variation across the field. As such, representative oil characteristics for the Rosebank field have been defined and are summarised in Table 3-2.

Table 3-2 Oil characteristics

Oil characteristic	Value
Density (at saturation pressure)	0.687 to 0.695 grams per cubic centimetre
Specific gravity (from separator test)	34.6 to 35.3º American Petroleum Institute (API)
Viscosity (at reservoir conditions)	0.59 to 0.65 centipoise
Wax content	15.8 weight percent
Asphaltenes	0.83 weight percent
Gas to oil ratio (from separator test)	130 to 140 standard cubic meter gas / standard cubic meter oil
Pour point	20-38 degrees Celsius (ºC)

The Rosebank crude oil is a light crude which has a low density and flows freely at room temperature. As a light oil it has a low viscosity, low specific gravity and high API gravity due to the presence of a high proportion of light hydrocarbon fractions. The Rosebank reservoir will require sea water injection to achieve voidage replacement for reservoir pressure maintenance from first production. As a result, the reservoir is expected to sour during its production lifetime. Souring severity will be minimised through the injection of low sulphate sea water which also mitigates the risk of barium sulphate scale precipitation. The souring severity will vary from well to well and is controlled by factors including sea water injection breakthrough fraction. Downhole chemical injection will be included to mitigate the risk of calcium carbonate scaling. ARN acids are present in Rosebank crude and therefore calcium naphthenate (CaN) can form in the production system under the right conditions. A CaN mitigation strategy is under development but will include chemical injection tanks, injection points and a surveillance plan to enable injection of Naphthenate inhibitor.

3.3 Expected Production

The oil, gas and water production figures are presented in Table 3-3 and the Phase 1 and 2 profiles for the life of field are shown in Figure 3-3 to Figure 3-5 respectively. The estimated start up from Phase 1 is expected to occur in Q4 2026 and therefore 2027 is the first full year of production. The production predictions are based on an ensemble of reservoir models which reflect the identified range of uncertainty in reservoir parameters. The oil and gas production presented represents the highest values[10] (production efficiency of 92% uptime) expected from the whole life of the Development and align with the application for development and production consent which will be submitted to the NSTA. The highest predicted hydrocarbon case represents the greatest potential for environmental impact, and it is therefore the most appropriate estimate on which to assess the environmental impact. The impact assessment presented in this ES (and all associated calculations such as air emissions calculations) has been carried out using the high hydrocarbon case production scenario.

[10] High oil case production values.

Table 3-3 Rosebank Phase 1 and 2 Development oil, gas, and water production volumes, based on the high oil case production profile

Year	Oil		Gas		Water	
	tonnes*/day	bbls/d	MMSm^3/day	MMscf/day	m^3/day	bbls/d
2026	2584	19188	0,47	16	0	0
2027	9540	70840	1,62	57	0	0
2028	9540	70840	1,67	59	23	144
2029	9436	70067	1,72	61	304	1908
2030	9090	67490	1,72	61	577	3629
2031	8712	64688	1,72	61	624	3922
2032	9389	69716	1,66	58	1823	11461
2033	8895	66045	1,58	56	3127	19667
2034	8231	61122	1,47	52	4151	26111
2035	7868	58420	1,39	49	4790	30130
2036	7463	55419	1,33	47	5354	33678
2037	7365	54682	1,39	49	5549	34901
2038	6622	49169	1,35	48	6047	38037
2039	6073	45097	1,27	45	6877	43257
2040	5965	44292	1,26	45	7328	46095
2041	5604	41611	1,21	43	7526	47337
2042	5447	40449	1,05	37	7305	45947
2043	5454	40497	0,98	34	8095	50920
2044	4635	34414	0,84	29	8561	53849
2045	4353	32317	0,72	25	8949	56286
2046	3967	29457	0,61	21	9414	59216
2047	3716	27595	0,52	18	9672	60837
2048	3289	24422	0,48	17	10340	65038
2049	2953	21930	0,45	16	10703	67325
2050	2633	19548	0,40	14	11107	69864
2051	2410	17900	0,37	13	11371	71526

**assuming 847.1kg/sm^3*

The total oil production is expected to peak at 9,540 tonnes/day early in field life in the first two full years of production in 2027/2028, with relatively stable plateau rate until 2033 after which there is a steady decline through the life of the field (Figure 3-3). Total gas production from the wells in the first full year of production (1.62 MMSm^3/day) in 2027 rising to a peak in 2029-2031 (1.72 MMSm^3/day) before steadily declining over field life (Figure 3-4).

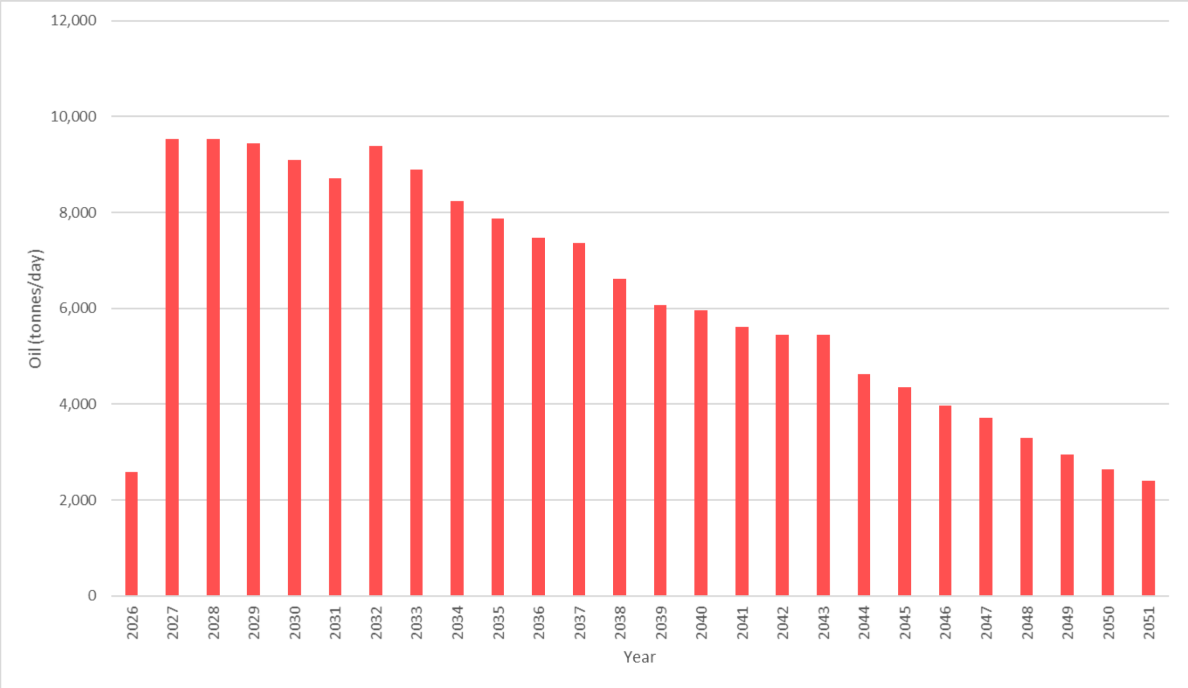


Figure 3-3 Rosebank Phase 1 and 2 Development oil production profile

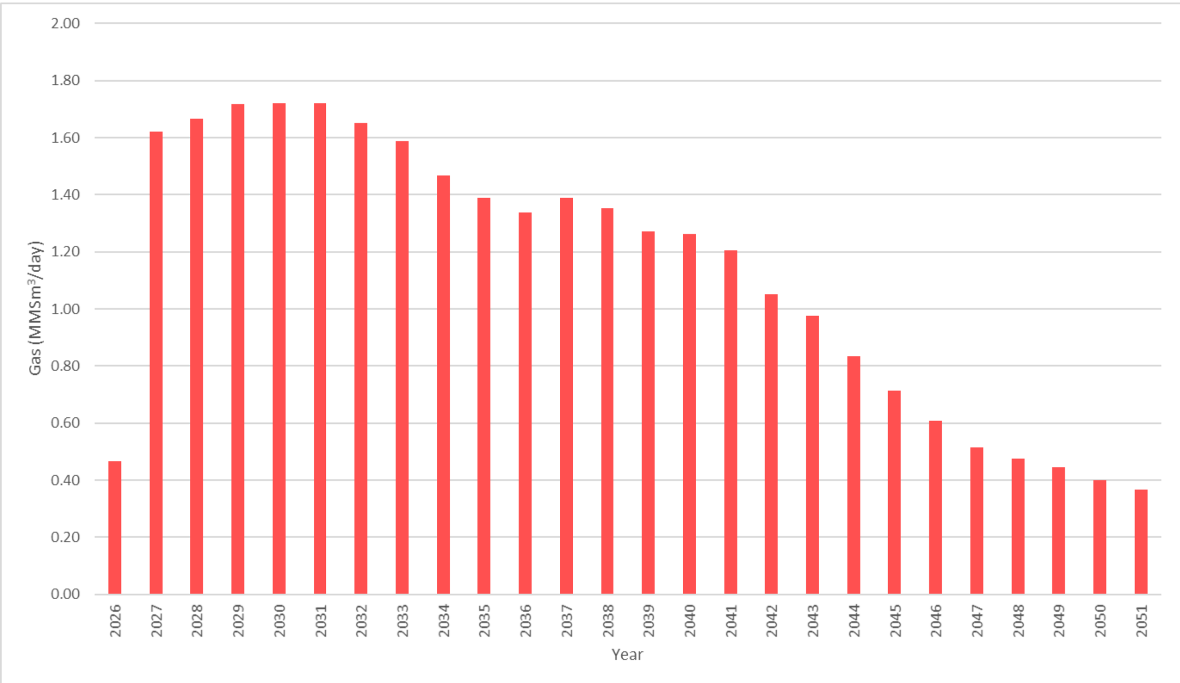


Figure 3-4 Rosebank Phase1 and 2 Development gas production profile

Produced water from the wells is expected to increase gradually from water breakthrough in 2028 to a peak at around 12,360 Sm^3 per day in 2051 (Figure 3-5).

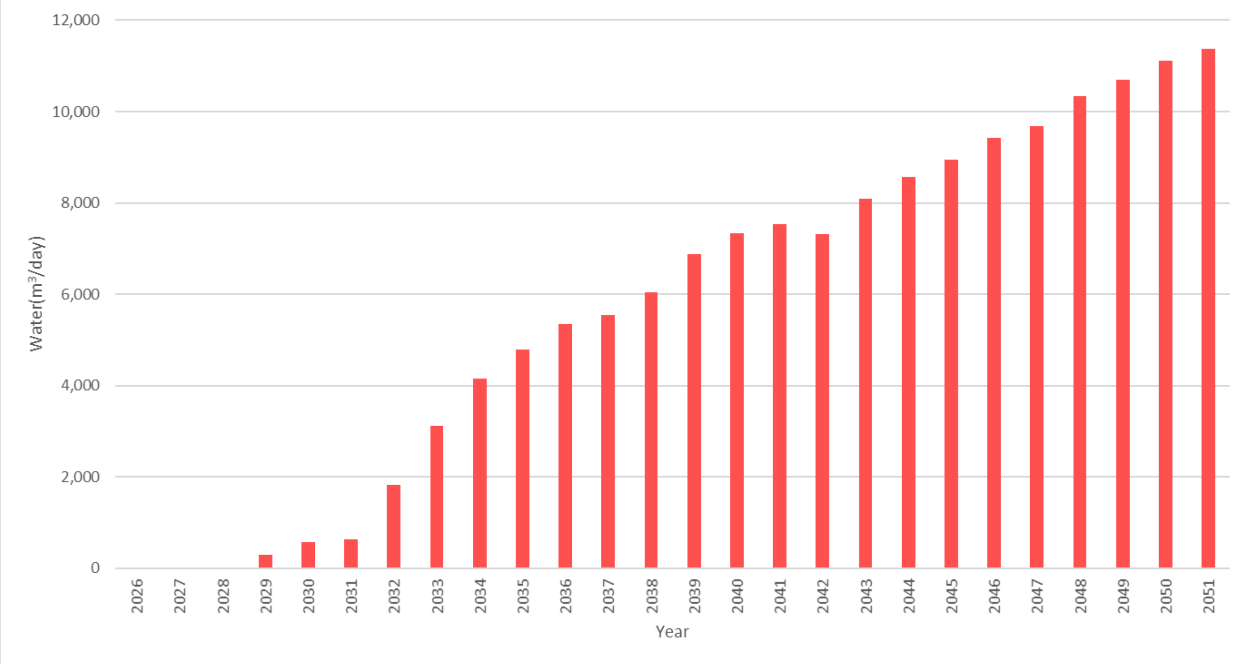


Figure 3-5 Rosebank Phase 1 and 2 Development water production profile

3.4 Wells and Drilling

3.4.1 Overview

The drilling of the wells will be carried out in two phases. Initially four production wells plus three water injection wells in Phase 1 with, based on current assumptions, up to a further three producing wells and two water injection wells in Phase 2.

The phased development allows for later wells to be located based on reservoir learnings from initial drilling. This will allow for better placement and greater energy efficiency in the wells in Phase 2 which could target more oil relative to produced water with lower water injection and gas lift requirements. In addition, the inclusion of inflow control valves on the injector wells will promote efficient placement of injected water and reduce energy inefficiency associated with any misplaced water injection.

This drainage strategy is planned to secure delivery of production whilst learnings from the initial wells will improve future wells performance, reduce risk of poor production and manage subsurface uncertainty.

In Phase 1 the four oil producing wells will be a combination of low and high angle and horizontal wells and the three water injection wells will all be high angle. The low angle wells maximise the likelihood of drilling the wells successfully early in the drilling programme and enable production from and injection into multiple reservoir zones. The horizontal wells enable the drainage of larger areas of the field due to a longer reach and lower formation water ingress from the reservoirs.

All the production wells will be drilled from the three fixed four well-slot templates, located along the structural crest of the field. The water injection wells are planned as remote satellite wells around the flank of the field. The location of the well templates is shown in Figure 3-1 and a description of the template and installation is provided in the subsea infrastructure section of this chapter (Section 3.5). Phase 1 drilling is expected to take place between April 2025 and August 2026. Table 3-4 gives the details of the anticipated timing for the individual wells.

Table 3-4 Well information, location on the templates and estimated timing of well completion

	#	Well Name	Template / Surface Location	Well Type	Estimated Year of Completion
Phase 1	1	KI1	K1	Injector	2025
	2	BP2	B2	Producer	2025
	3	DP1	D1	Producer	2026
	4	DP3	D3	Producer	2026
	5	JI1	J1	Injector	2026
	6	CP2	C2	Producer	2026
	7	II1	I1	Injector	2026
Drilling Break					
Phase 2	8	BP4	B4	Producer	2031
	9	MI1	M1	Injector	2031
	10	BP3	B3	Producer	2031
	11	LI1	L1	Injector	2031
	12	CP1	C1	Producer	2031

3.4.2 Drilling Rig

The wells will be drilled and completed using a DP Harsh Environment semi-submersible Mobile Offshore Drilling Unit (MODU) (example shown in Figure 3-6) capable of operating in the metocean conditions and deep-water and harsh environment of the Development area. The semi-submersible drilling rig will have a main operating deck which will include drilling, storage and accommodation facilities as well as a ballast system. The ballast system, when flooded, will stabilise the MODU, reducing its susceptibility to wave motion, particularly rolling and pitching, and providing a stable platform for the drilling operations.

As the MODU will be retained on station by DP, no anchoring will be required, and a 500 m radius safety zone will be in place around the rig during all drilling operations. The DP technology uses satellite navigation and acoustic transponders on the seabed to keep the MODU in place. The acoustic transponders are deployed in an array using clump weights. The transponders emit a signal which is received by the MODU, which in turn calculates position and adjusts its thrusters as required to maintain position. Transponders are typically deployed for the duration of the drilling campaign and are normally recovered by remotely operated vehicle (ROV) once the drilling campaign is finished.

Figure 3-6 Example semi-submersible drilling rig (Source: Seadrill)

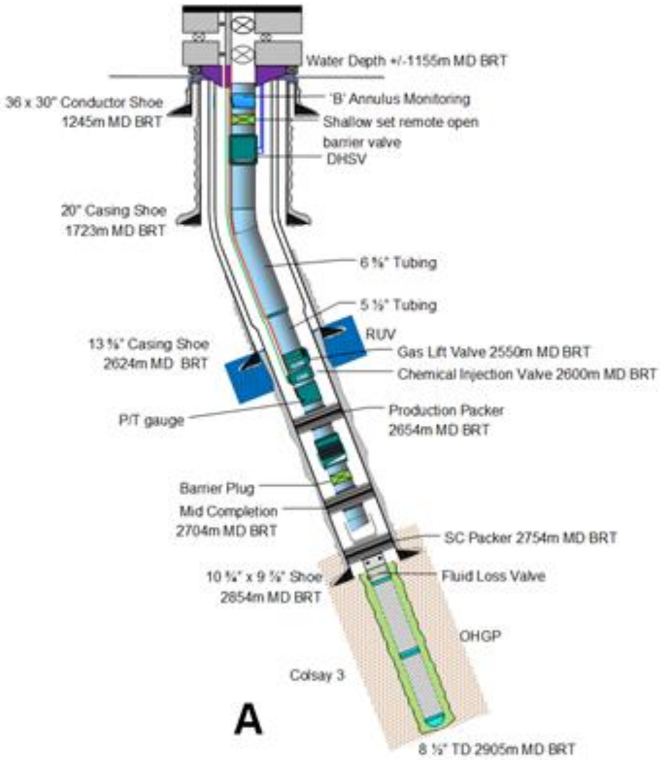
3.4.3 Well Design

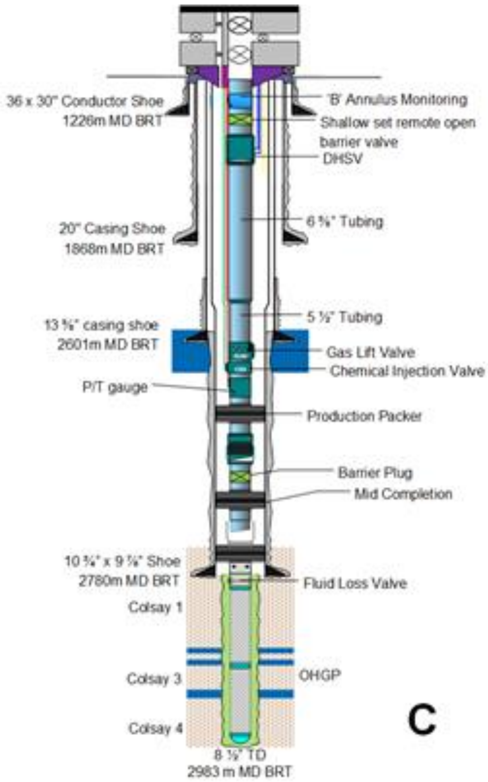
All wells will be drilled in five sections of successively smaller diameters (i.e.,42”/36", 26", 17½", 12½" and 8½"). The maximum measured depth of any of the wells will be for the producing well CP2 at approximately 4,565 m (14,977 ft). Table 3-5 provides the well section diameters and proposed well lengths, along with the anticipated drilling mud type to be used. A summary of the well designs is shown in Figure 3-7 for the producing wells and Figure 3-8 for the water injection wells.

Table 3-5 Expected well section dimensions

Section	Mud type	Discharge point	Length (m)											
			DP3	DP1	CP2	BP2	II1	JI1	KI1	BP4	MI1	BP3	LI1	CP1
42/36"	Seawater and sweeps	Seabed	90	90	90	90	90	90	90	90	90	90	90	90
26"	Seawater and sweeps	Seabed	478	478	484	642	515	464	661	646	725	645	515	485
17 1/2"	WBM	Rig	1162	901	1251	733	967	1073	845	919	723	868	937	911
12 1/4"	LTOBM / WBM	Skip and ship for LTOBM. Rig for WBM	461	230	588	179	669	429	564	337	679	398	641	185
8 1/2"	LTOBM / WBM	Skip and ship for LTOBM. Rig for WBM	949	51	1012	203	N/A	N/A	N/A	833	N/A	998	N/A	90

equinor


Water Depth +/-1155m MD BRT
36 x 30" Conductor Shoe
1245m MD BRT
'B' Annulus Monitoring
Shallow set remote open
barrier valve
DHSV
20" Casing Shoe
1723m MD BRT
6 ⅝" Tubing
5 ½" Tubing
13 ⅜" Casing Shoe
2624m MD BRT
RUV
Gas Lift Valve 2550m MD BRT
Chemical Injection Valve 2600m MD BRT
P/T gauge
Production Packer
2654m MD BRT
Barrier Plug
Mid Completion
2704m MD BRT
SC Packer 2754m MD BRT
10 ¾" x 9 ⅞" Shoe
2854m MD BRT
Fluid Loss Valve
OHGP
Colsay 3
A
8 ½" TD 2905m MD BRT


36 x 30" Conductor Shoe
1226m MD BRT
'B' Annulus Monitoring
Shallow set remote open
barrier valve
DHSV
6 ⅝" Tubing
20" Casing Shoe
1868m MD BRT
13 ⅜" casing shoe
2601m MD BRT
5 ½" Tubing
Gas Lift Valve
Chemical Injection Valve
P/T gauge
Production Packer
Barrier Plug
Mid Completion
10 ¾" x 9 ⅞" Shoe
2780m MD BRT
Fluid Loss Valve
Colsay 1
Colsay 3
OHGP
Colsay 4
C
8 ½" TD
2983 m MD BRT

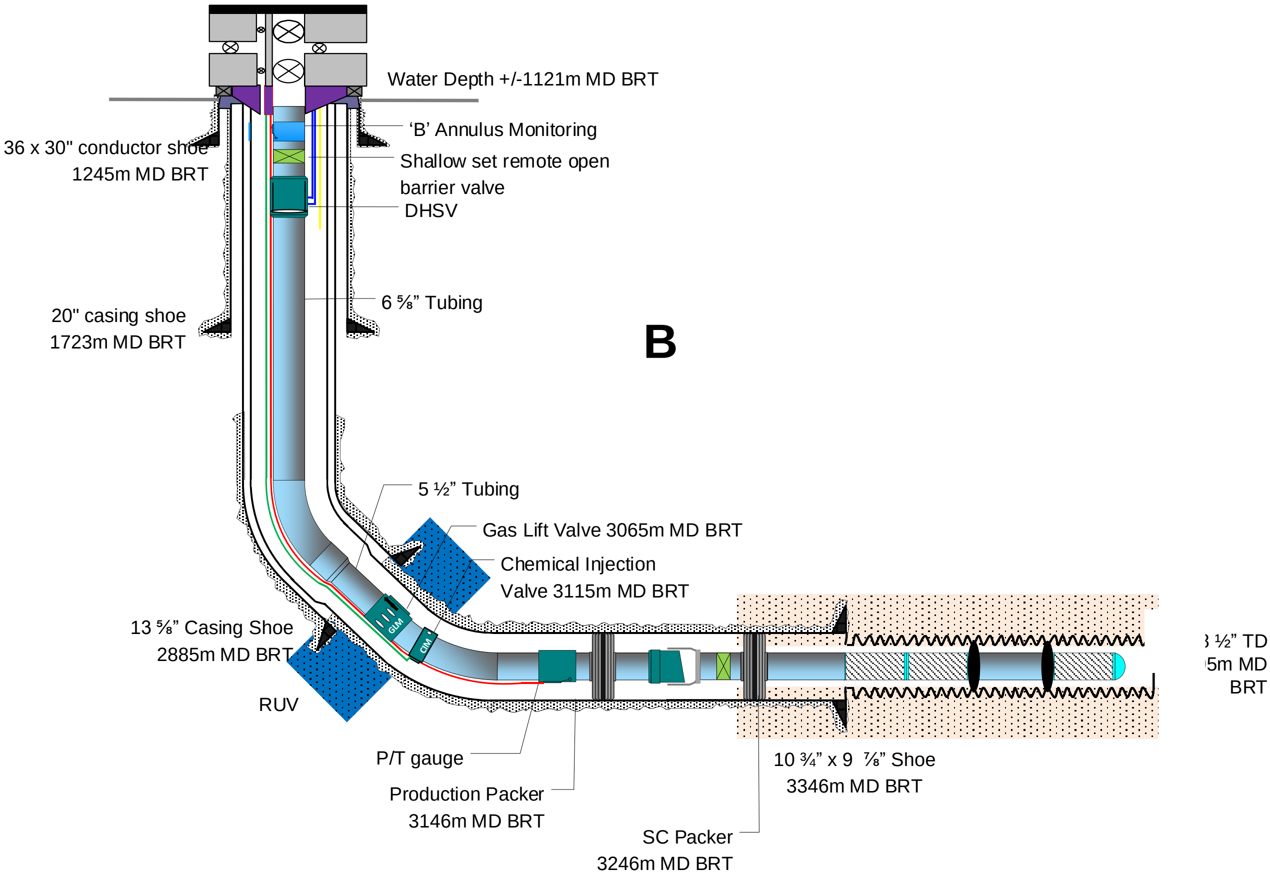

Water Depth +/-1121m MD BRT
'B' Annulus Monitoring
36 x 30" conductor shoe
1245m MD BRT
Shallow set remote open
barrier valve
DHSV
6 ⅝" Tubing
20" casing shoe
1723m MD BRT
B
5 ½" Tubing
Gas Lift Valve 3065m MD BRT
Chemical Injection
Valve 3115m MD BRT
13 ⅜" Casing Shoe
2885m MD BRT
RUV
GLM
CIM
½" TD
5m MD
BRT
P/T gauge
Production Packer
3146m MD BRT
10 ¾" x 9 ⅞" Shoe
3346m MD BRT
SC Packer
3246m MD BRT

Figure 3-7 Design of single zone production well (A), horizontal production well (B) and multizone production well (C)

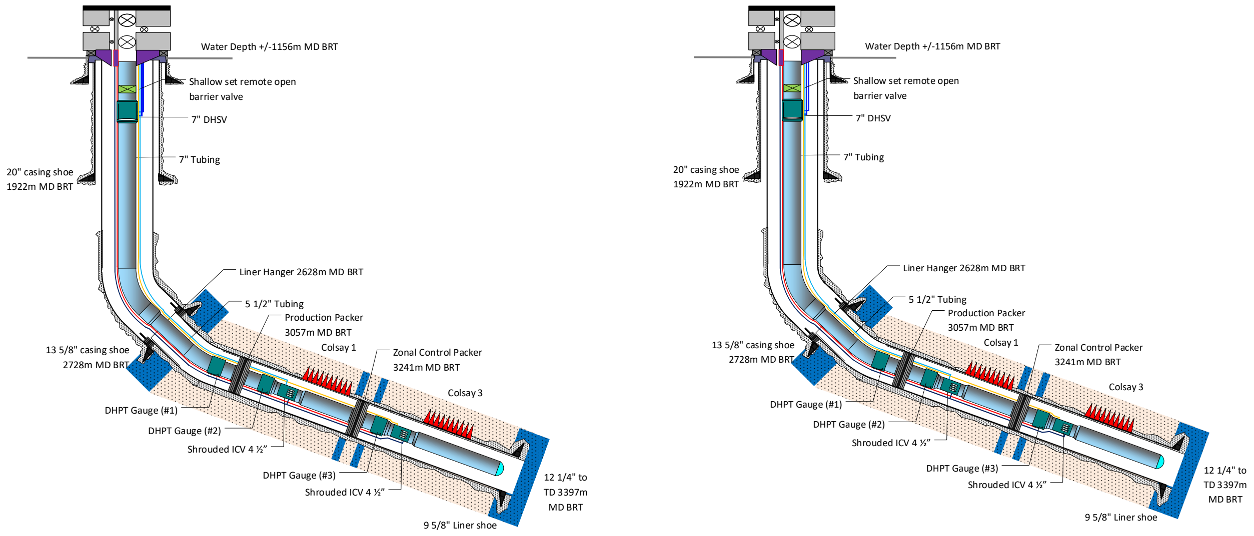


Figure 3-8 Design of single zone water injection well (left) and multizone intelligent water injection well (right)

3.4.4 Well Activities

As the activities required to complete the wells and install subsea trees (Section 3.5.4 for details of the Xmas Tree) are sensitive to weather conditions, it is planned to undertake most of these completion operations in the calmer sea conditions prevalent in the summer period (defined as between 1st April and 30th September). Drilling operations from the initial spudding[11] of the well through to the end of the production drilling, casing and logging[12] are planned in the winter months between October and March. In some cases, the liner installation which is part of the completion may also be performed in the winter months. The batching nature and well completion order securing completion of wells early dictates that some wells could be suspended for over twelve months prior to being put on production.

Each well operation can be divided into batches as follows:

- Drill 42"/36" hole section to approximately +/-70m below mud line with seawater with sweeps and displace to water-based mud (WBM) prior to running and cementing 36"/30" conductor;
- Drill 26" hole section with seawater with sweeps and displace to water-based mud prior to running and cementing 20" surface casing;
- Drill 17 ½" hole section with water-based mud (WBM); the section is then cased-off with 13 5/8" intermediate casing;
- Drill 12 ¼" hole section with either WBM or Low Toxicity Oil Based Mud (LTOBM) and install a 10-3/4" x 9-7/8" casing for producers and a 9-5/8" liner for the water injectors; and

---

[11] The start of the drilling process where rock etc. is moved by the drill bit.
[12] The measurement of formation properties during or immediately after the drilling of the well.

- Drill 8 ½” hole section with either WBM or LTOBM. The section is then completed with standalone screens or open-hole gravel pack for the producer wells only.

The surface hole sections will be drilled riserless. Upon installation of the high pressure housing a blowout preventer (BOP) will be installed for drilling the 17½", 12½" and 8½" phases.

The wells will be suspended temporarily using wellbore barriers awaiting completion and installation of the subsea Xmas Tree later in the schedule. The BOP will be disconnected to allow the MODU to move to the next well slot to perform batch drilling operations. This activity will be repeated until all intended wells have been drilled and suspended. The MODU will then return to the previously suspended wells and the wellbore barriers will be removed before the next operation commences.

3.4.5 Mud Selection and Cuttings Discharge

The drilling fluids, or muds, used to drill the various sections of a well have several functions, including:

- Maintenance of downhole pressure to avoid formation fluids flowing into the wellbore (also called “a kick”);
- Removal of drill cuttings from the drill bit to permit further drilling and transporting cuttings to the surface cuttings handling equipment on the rig;
- Lubrication and cooling of the drill bit, bottom hole assembly and drilling string; and
- Deposition of an impermeable “mudcake” on the walls of the well bore, which seals and stabilises the open hole formations in the wall of the wellbore.

Drilling fluids can consist of various materials including weighting agents and other chemicals to achieve the required weight, viscosity, gel strength, fluid loss control and other characteristics to meet the technical requirements of drilling and completing the well. Generally, drilling fluids can be divided into two categories based on their base fluid types:

- Water-based mud (WBM), where the base fluid is water; and
- Low toxicity oil-based mud (LTOBM), where the base fluid is a synthetic oil that presents lower environmental toxicity.

Various chemicals may also be added to either type of drilling fluid to achieve specific functions, which are mainly driven by formation pore pressures and fracture gradients, downhole temperatures, geological characteristics etc. Different types of mud are planned to be used for the different well sections.

For the top two sections (42”/36” and 26”), the wells will be drilled riserless with seawater and regular bentonite sweeps and displaced to WBM prior to running casing. The WBM will be pumped downhole to provide enough weight and viscosity to turn the drill bit, keep the hole stable while running the 20’’ casing in hole, remove the cuttings and keep the hole clean. Cuttings from the top-hole sections will be discharged directly from the wellbore at the seabed. WBM cleaned from cuttings will be re-used, where possible, minimising waste.

For the 17 ½", 12 ¼" and 8 ½" sections, a marine riser will be installed between the well and the drilling deck so that cuttings and drilling fluid are circulated back up to the rig. Drill cuttings from sections drilled with WBM will be treated at the drill rig and then discharged to sea. ‘Skip and ship’ has been selected as the preferred option for drill cuttings waste handling for sections drilled with LTOBM because of the low total volume of cuttings generated from drilling the production/reservoir sections. This method involves transferring drilling waste into drill cuttings skips on the rig. The skips are then transferred from the rig via a vessel to onshore treatment facilities.

Table 3-6 details the quantities of cuttings expected to be generated during the drilling of each well section, the type of mud used, and the cuttings handling method.

Table 3-6 Cuttings generated during drilling

Section	Cuttings generated (Te)												
	DP3	**DP1**	**CP2**	**CP1**	**BP3**	**BP2**	**BP4**	**II1**	**JI1**	**KI1**	**LI1**	**MI1**	**Total**
42"/36"	191	191	191	191	191	191	191	191	191	191	191	191	2,292
26"	382	382	386	387	515	512	516	411	370	549	411	579	5,400
17 1/2"	420	326	452	329	314	265	332	350	388	280	339	261	4,056
12 1/4"	82	41	104	33	71	32	60	119	76	87	114	120	939
8 1/2"	82	4	87	8	86	18	72	N/A	N/A	27	N/A	N/A	384

3.4.6 Cementing

Steel casings will be installed in the well during the drilling operation to provide structural strength and isolate unstable formations and formation fluids. The casings will be cemented in place and the cementing plan is as follows:

- The conductor will be drilled and cemented into a 42"/36" hole. The conductor will be cemented with a high early strength development slurry with the anticipated top of cement at seabed. To ensure that the casing is securely cemented in place more cement (300% excess) than is required to fill the hole will be circulated, and any resulting excess cement being discharged to the seabed;
- The surface casing in the 26" hole will be fully cemented from the casing shoe to the seabed with a high early strength development slurry. To ensure that the casing is securely cemented in place, more cement (150% excess) than is required to fill the hole will be circulated. The majority of the cement will remain between the surface casing and formation however there is likely to be excess cement which will be discharged to the seabed;
- The Intermediate casing in the 17 ½" hole will be cemented (20% excess) with the anticipated top of cement around 300 m below the surface casing. Any excess cement remains in the wellbore;
- The Production casing (Oil Producers) in the 12 ¼" hole will be cemented (20% excess) with the anticipated top of cement around 140 m inside the previous intermediate casing. Any excess cement remains in the wellbore; and
- The Production liner (Water Injectors) in the 12 ¼" hole will be cemented (20% excess) with the anticipated top of cement to the top of liner. Any excess cement above the top of liner will be circulated out and discharged to skips.

Cementing operations may involve discharges to sea of cement when the cement unit is cleaned between each cementing operation. However, it is anticipated that the majority of the cement will be mixed and used as required, and as a result there should be limited discharges of any mixed cement or unused mix water. Exact cement use and discharge volumes will be determined as well and drilling design continues and will be minimised as far as possible. There is also the potential that the cement job may have to be aborted due to unforeseeable circumstances (e.g., mechanical/electrical failure of equipment, or of a blockage (either on surface or down the wellbore) in the lines through which the cement and additives are pumped). All cement discharges will be included in the relevant chemical permit.

3.4.7 Chemicals

Equinor aims to minimise environmental impact during its operations. Chemicals with low or no potential for environmental impact (e.g. PLONOR) will be selected wherever possible and all chemical use and discharge will be risk assessed and subject to regulatory approval. The chemicals that will be used during drilling of the Rosebank wells, as well as their fate, are described in Table 3-7.

Table 3-7 Chemical usage and fate during the drilling phase

Activity	Chemical use	Chemical fate
Drilling mud system (LTOBM / WBM Synthetics etc.)	WBM and LTOBM	• WBM discharged • LTOBM skip and ship for cuttings and fluids returned to shore
Drilling additives (emulsifiers, wetting agents, viscosifiers, fluid loss additives, thinners, weighting agents etc.)	WBM additives: Barite (Weighting agent), viscosifier, fluid loss control, defoamer, $CaCO_3$ bridging agents, pH modifiers, KCl brine, glycols, oxygen scavenger, biocides. LTOBM additives: Base oil, $CaCl_2$ brine, emulsifier, viscosifier, fluid loss control additive, $CaCO_3$ bridging agent. Clean-up pills: As above, plus surfactants	• WBM Additives: discharged • LTOBM Additives: returned to shore
Cementing chemicals	Cement slurry: Class G cement, retarder, dispersant, fluid loss control additive, antifoam, Gasblok, anti-settling agent Cement spacer: Weighting material (barite), oxygen scavenger, citric acid, viscosifier and mutual solvent (in case of LTOBM used in the section to be cemented)	• Retained in the cement within the well bore with some discharged to sea
Completion chemicals	Working Brine: KCl/NaCl/NaBr with non-emulsifier Gravel Pack fluid: Either a KCl/NaCl/NaBr mixed-brine, gel, surfactant or an oil-based carrier fluid Filter Cake Breaker: KCl/NaCl/NaBr mixed-brine with breaker, delayed acids precursor Screen running fluid: solids free WBM or solids free oil-based completion fluid Packer Fluid: NaCl brine with 40% MEG Control Line Fluid	• Working Brine: discharged • Gravel Pack fluid: in well & excess discharged if water-based system or returned to shore if oil based • Filter Cake Breaker: in well • Screen running fluid: in well & excess discharged if water-based system or returned to shore if oil based • Packer Fluid: in well

3.4.8 Vertical Seismic Profiling

A VSP utilises borehole seismic measurements to obtain images of higher resolution than surface seismic images. The data is primarily used to calibrate the time-depth relationship of the seismic images. Additionally, the VSP image can be used for establishing primary reflection energy as, unlike surface seismic, they do not contain multiple energy. There is already a comprehensive VSP dataset over Rosebank and as such the acquisition of Zero-offset VSP during field development is planned only as a contingency for a maximum of three wells. The acquisition in these wells is contingent on logging while drilling (LWD) and / or wireline data collection to ensure a good well to seismic tie in is obtained in this scenario.

3.4.9 Well Bore Completion

During well bore clean-up and completion operations fluids may be discharged to sea. Typical fluids in the well before clean-up and the anticipated volumes to be discharged are presented in Table 3-8. As the reservoir section of the well may be drilled using LTOBM, there is a potential for the discharged completion fluids to contain residual quantities of LTOBM and/or reservoir hydrocarbons. If the gravel packing operation requires the use of an oil base carrier fluid, there will be no discharge to sea.

Sandface completion will vary depending on the specifics of the well:

- Sandface completion for both single zone and multi-zone injector wells:
  - Selective Cased hole-oriented perforation. A 9 5/8" liner will be set and cemented across the target reservoir zone(s). The production liner will subsequently be perforated.
- Sandface completion for the low inclination single zone and multizone oil production wells:
  - Open hole gravel pack. A gravel pack sand screen will be run in the open hole reservoir section and the annulus between the screens and formation will be packed with proppant (a solid material that is typically sand, treated sand or man-made ceramic materials).
- Sandface completion for the horizontal oil production wells:
  - Standalone screens. A sand screen will be run in the open hole reservoir section. Depending on the intervals encountered while drilling there may be a requirement to run swell packers and blank pipe sections to isolate non reservoir formations. The swell packers and blank pipe could be located at several sections along the length of the horizontal.

For the oil production wells, gas lift will be provided by injecting gas into the tubing through a gas lift mandrel, which will be installed in the lower section of the tubing, above the production packer. The produced fluid inside the tubing will then be mixed with the injected gas, reducing the overall fluid column density, thereby increasing the well production rate and overall recovery from the reservoir.

3.4.10 Well Flowback and Clean-up

All producing wells shall initially be flowed and cleaned up back to the FPSO test separator to remove any waste and debris remaining from the drilling activities. A system for collecting and handling any non-separable fluids for export to shore shall be implemented. The topside and storage facilities shall be designed to handle clean-up fluids which will contain high concentration of particles and chemicals. The fluid will go to FPSO slops tanks, oil will be skimmed off and sent to cargo, water will be processed and directed to the produced water management system.

A combination of gas lift and reduced operating pressure in the test separator will be required at the start of the well clean-up. The required lift gas rate during well clean-up will be 0.2 MSm^3/day and will be imported from WOSPS until there is sufficient infield gas to provide the gas lift service to the wells. The commissioning sequence and strategy will minimise gas flaring during clean-up as far as practicable, but some flaring is expected to occur. Well clean-up is expected to take up to 15 hours per well, with a liquid rate of 140 Sm^3/h. Overall, a total of 1.8-2 tonnes of gas will be flared at the FPSO for each of the seven production wells (Phase 1 & 2). There will be no hydrocarbon flowback to the rig, or well testing activities, during the drilling and completion activities.

Table 3-8 Summary of typical fluids in the well before clean-up

Fluid type	Well zone	Volume	Composition
Completion brine	Upper completion	41 m^3 (25 bbls)	KCl/NacCl/NaBr
Packer fluid	Upper completion	60 m^3 (377 bbls)	NaCl brine with 40% MEG
Screen Running Fluid	Lower completion	36 m^3 (226 bbls)	KCl/NacCl/NaBr
			Oil base solids free fluid
Gravel pack carrier fluid	Lower completion	30 m^3 (189 bbls)	KCl/NacCl/NaBr
			Oil based gravel pack
Filter cake	Reservoir	Still to be determined	CaCO3, Barite
Mud filtrate	Fluid invaded zone	27 m^3	Still to be determined
Formation solids	Reservoir	n/a	Sand/clay

During clean-up, the production wells are expected to produce small quantities of sand. Further details on sand production and processing are described in Section 3.7.6.

3.4.11 Well Workovers and Interventions

The completion and subsea tree will be designed to eliminate the requirement for any routine intervention. Well intervention will only be required to repair or replace failed well equipment or optimise well production, for example, to remove build-up of scale deposits. During the life of the field, it may be required to perform interventions which will be carried out by a MODU or Well Intervention Vessel (LWIV or HWIV) with deep water capabilities.

There are no plans for a MODU after the drilling campaigns for phase 1 and 2, a well requiring intervention may be down for an extended period while a suitable vessel is sourced and approved to work in the area. The OPEX estimate includes an expected case of 35 interventions LoF (Life-of-Field).

3.5 In-field Subsea Infrastructure

3.5.1 Structures

An indicative representation of the overall subsea layout for the Development is given in Figure 3-1 and Table 3-9 provides an overview of the in-field subsea infrastructure that is planned to be installed. The gas riser base and umbilical riser base will be located in the FPSO 500 m safety zone. No further safety zones are proposed. In addition, there will be a fibre optic cable of approximately 5 km length connecting the FPSO with the SHEFA-2 cable providing telecommunications. This cable is outwith the scope of this EIA as it will be covered by a different regulatory regime. The geographical coordinates of the subsea infrastructure that will be installed as part of the Development are detailed in Table 3-10. All the infield subsea infrastructure will be installed below 800 m and nothing will be visible above the sea surface. There are no plans to apply for a safety zone other than for the FPSO. The infrastructure will be marked on the maritime charts as is routine for this type of structure.

Table 3-9 Overview of the Development subsea in-field structures

Subsea structure	Number	Dimensions	Dry weight
Templates	3 templates with 4 production slots and 4 suction anchors per template	10 m (L) x 20 m (W) x 22 m (H) Height includes 4 x 10 m long suction anchors	350 Te each
Production manifolds	3 Mounted on the templates	10 m (L) x 20 m (W) x 22 m (H)	155 Te each
Water injection satellite foundations	5 3 in phase 1 and 2 in phase 2 4 suction anchors per foundation	14m x 14m x 17m (H)	170 Te each
Xmas trees	7 in phase 1 5 in phase 2	4.8 m (L) x 5 m (W) x 4 m (H)	45 Te each
Umbilical riser base (URB)	1	13 m (L) x 10 m (W) x 5.5 m (H)	115 Te each
Gas riser base including subsea isolation valve (SSIV)	1	9 m (L) x 7 m (W) x 5 m (H)	83 Te
Water injection rigid flowline double in-line tees	3	6 m (L) x 3 m (W) x 3 m (H)	34 Te each
Water injection pipeline end termination (PLET)	1	4 m (L) x 3 m (W) x 2 m (H)	14 Te
Water injection pipeline end manifold (PLEM)	1	8 m (L) x 3 m (W) x 3 m (H)	24 Te
Gas export pipeline end termination (PLET)	1	5 m (L) x 3 m (W) x 2 m (H)	10 Te
Gas export pipeline in line tee (KP6)	1	7 m (L) x 3 m (W) x 3 m (H)	17 Te
Gas export pipeline end manifold (PLEM)	1	7 m (L) x 3 m (W) x 3 m (H)	23 Te
FPSO mooring system	12 mooring lines (polyester/chain). 12 suction anchors	Approximately 500 m of the chain lies on the seabed surface, and 50 m is beneath the ground. The suction anchor is a cylinder of up to 11 m diameter and 23 m in height, with 19 m penetrating the seabed	115 Te for the suction anchors

Table 3-10 Geographical coordinates of the Development infrastructure

Facility	Northing	Easting	Water depth (m)
	UTM50 30 N		
FPSO	6 763 080	458 020	1,100
Template B	6 764 580	457 035	1,102
Template C	6 767 314	459 600	1,105
Template D	6 770 200	461 900	1,120
Water Injection I	6 769 805	459 745	1,122
Water Injection J	6 770 055	463 985	1,116
Water Injection K	6 762 500	451 625	1,109
Water Injection M	6 765 430	455 545	1,108
Water Injection L	6 765 150	460 625	1,101

3.5.2 Production Template

The production wells will be drilled through three subsea templates (A, B and C), located approximately 3.9 km apart, each containing four well drilling slots (Figure 3-9). The templates will have an integrated suction anchor foundation with four suction anchors and a levelling system.

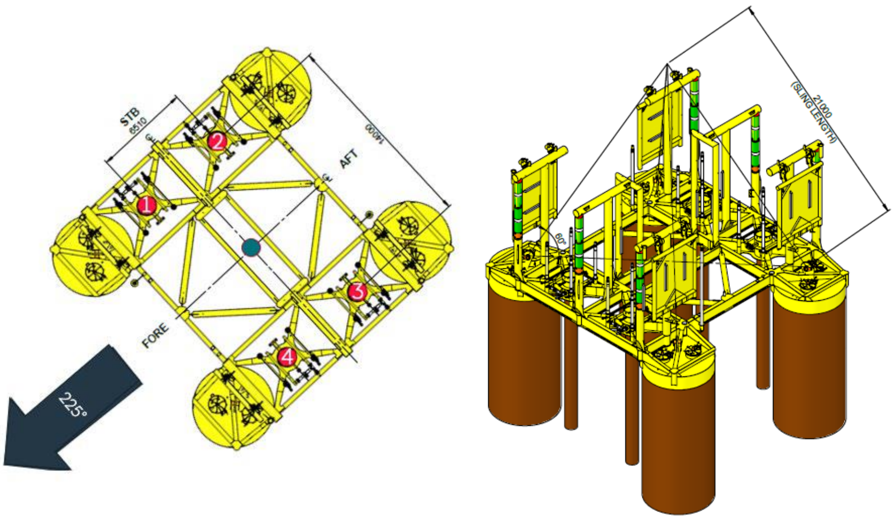


Figure 3-9 Structure of the drilling template and manifold

The three subsea templates will each support a dual header[13] production manifold with four slots. Gas lift will be provided to each manifold via a single header, distributed to all well slots. An umbilical will connect the manifolds in series, each with hydraulics, chemicals, electrical power and fibre optics.

[13] The manifold can accommodate pigging and has the capability of routing production from a particular tree to a particular flowline.

3.5.3 Water Injection Well Foundation

The water injection satellite wells will be supported by a foundation structure with 4 suction anchors, with load share between the conductor and the foundation. A flow base will connect to the Xmas Trees and to the umbilical and water injection lines with diverless horizontal connections.

3.5.4 Wellheads and Subsea Trees

Upon running the well completion of each well, the Xmas Tree will be installed. Proposed Xmas Tree and manifold/template designs are shown in Figure 3-10 and Figure 3-11. The final design is subject to confirmation following final contractor selection. The Xmas Trees will be connected to the umbilicals for well control, production rigid pipeline and the gas lift flowline and thereafter back to the FPSO via the risers.

The water injection wellheads will be connected to the rigid pipeline with 10" Internal Diameter (ID) flexible pipe from the FPSO water injection system via the riser.

3.5.5 Flowlines

There will be a number of flowlines connecting the wells manifolds and trees to the FPSO to provide controls, seawater injection, gas lift and to carry the production from the reservoir. The dimensions of the infield flexible and rigid flowlines are provided in Table 3-11 and a diagram of a flexible flowline is shown in Figure 3-12.

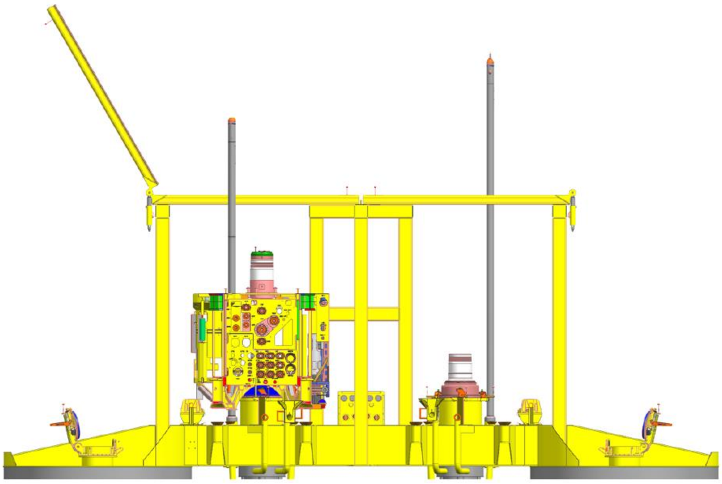


Figure 3-10 A typical template with a Xmas tree side view

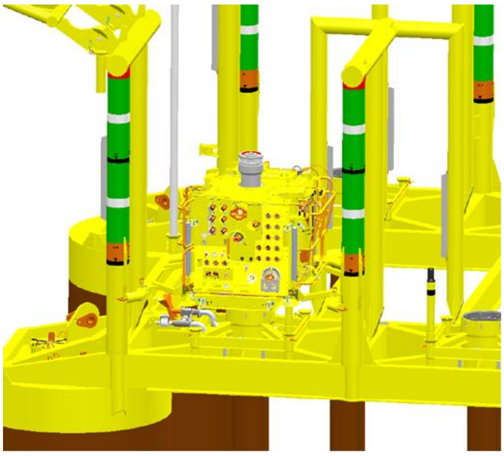


Figure 3-11 3D drawing of a typical template and Xmas tree

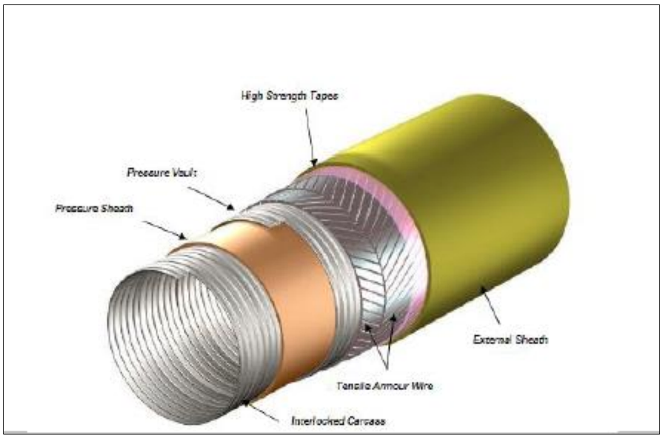


Figure 3-12 Diagram of a flexible flowline[14]

Table 3-11 Infield flowlines

Service	Type	From	To	Outer diameter (mm)	Length (km)
Production	Flexible	Umbilical Riser Base	Template B	490	1.4
		Umbilical Riser Base	Template B		1.4
		Template B	Template C		3.9
		Template B	Template C		3.9
		Template C	Template D		3.8
		Template C	Template D		3.8

[14] Internal layer called a ‘carcass’ provides resistance to collapse.

Service	Type	From	To	Outer diameter (mm)	Length (km)
Gas lift	Flexible	Gas Riser Base	Template B	290	2.1
		Template B	Template C		3.9
		Template C	Template D		3.8
Gas export	Rigid	PLEM at Rosebank	PLET at WOSPS Clair Tie-in	273 mm carbon steel	84.5
Water injection	Rigid	Satellite J	Satellite K	324	14
	Flexible	WI Rigid Pipeline	Satellite I	390	3.6
			Satellite J		0.3
			Satellite K		0.9
			Satellite L		1.1
			Satellite M		4.4

The production manifolds will be connected in series in a daisy-chain layout by two production flexible pipes and one gas injection flexible pipe. The production flowlines will all be insulated and have a removable pigging loop at the furthest manifold (D) to facilitate wax removal. The water injection system utilises a rigid flowline and flexible pipe. There will be an inner liner of High Density Polyethylene to protect against internal corrosion.
In addition to the infield infrastructure there will also be rigid tie in spools to join the infrastructure.

3.5.6 Umbilicals

The subsea umbilicals for Rosebank will consist of a single conventional electro-hydraulic type of umbilical with fibre optics, copper wires, hydraulic control lines, methanol and chemical service lines. The single dynamic umbilical riser from the FPSO to the umbilical riser base will serve the system from the FPSO to the Rosebank field subsea structures. The Umbilical Rise Base (URB) connects to all the static umbilicals to distribute fluid, power and signals to the three production templates within one umbilical plus an umbilical for each of the three water injection wells in Phase 1. The SSIV umbilical for control will go from the URB to the gas riser base (GRB) a length of approximately 1.7 km.

All production templates will be connected to the same static umbilical. The subsea control system shall use water-based hydraulic fluid with open return system. In addition to fibre and electrical lines the production umbilicals will contain high pressure (HP) and low pressure (LP) hydraulic fluid, methanol/service lines, chemical injection, spare fluid lines. All water injection umbilicals will have the same functions as the production umbilicals apart from chemical injection. Quantities and dimensions of the six production and water injection umbilicals leaving the URB are detailed in Table 3-12.

Table 3-12 Infield umbilical lines

Type	From	To	Outer diameter (mm)	Total length (km)
Water injection	Umbilical Riser Base	Satellite I	123	7.5
	Satellite I	Satellite J	123	4.3
	Umbilical Riser Base	Satellite K	123	5.7
	Umbilical Riser Base	Satellite M	123	3.0
	Satellite M	Satellite L	123	5.2

Type	From	To	Outer diameter (mm)	Total length (km)
Production	Umbilical Riser Base	Template B	183	1.5
	Template B	Template C	183	3.9
	Template C	Template D	183	3.7
SSIV control	Gas Riser Base	Umbilical Riser Base	76	1.0
Dynamic umbilical	Umbilical Riser Base	FPSO	285	1.5

3.5.7 Risers and Riser Bases

Flexible pipe risers will connect all the production flowlines and umbilicals to the FPSO through the turret in a pliant lazy wave configuration as in Figure 3-13. The production risers go between the FPSO and template A and water injection risers go to an inline Tee on the WI flowline. The gas risers will be connected to the gas riser base.

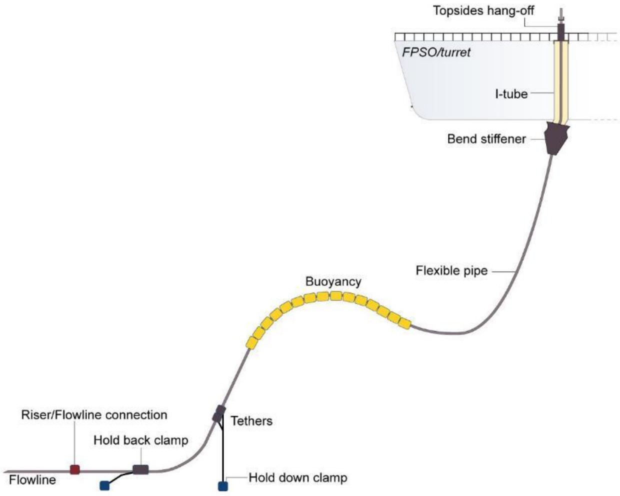


Figure 3-13 Concept of the riser system configuration from the seabed riser bases to the FPSO turret. Note Bend-stiffeners will be in place to avoid stress from connection of the risers with the I-tube of the FPSO turret

The riser system will consist of the following key ancillaries: bend stiffeners, diverless bend stiffener connectors, buoyancy modules, and hold down and hold back clamps with suctions anchors on the seabed. Each riser may consist of two flexible pipes with a midline/end-fitting connection, allowing design optimisation of the flexible pipe for the water depth, facilitating load transfer from a clamp and optimising potential future replacement strategy. The riser concept is shown in Figure 3-13 and the preliminary sizes presented in Table 3-13. Due to water depth each riser will be managed in segments (L1, L2 and L5) with each riser having midline connections.

Table 3-13 Riser system overview for the Development with preliminary sizes

Riser service	Type	From	To	Outer diameter (mm)	Approximate Length (km)
Dynamic to static flowline interface	Flexible	FPSO	Umbilical Riser Base	260	1.5
Gas lift	Flexible	FPSO	Gas Riser Base	340	1.6
Gas Export	Flexible	FPSO	Gas Riser Base	500	1.5
Water Injection	Flexible	FPSO	Water Injection	500	1.5
Production Riser	Flexible	FPSO	Template B	480	1.5
Production Riser	Flexible	FPSO	Template B	480	1.5

There will be a Gas Riser Base and Umbilical Riser Base (URB) Valve structures providing support for the risers at the FPSO end of gas export pipeline. The risers and base structures will be located within the FPSO safety zone. One single dynamic umbilical riser containing all the functional elements will connect the FPSO to the URB on the seabed. The gas riser base (including the SSIV gas export header) installed on the seabed approximately 500 m from the centre of the FPSO turret. The gas riser base also includes gas lift connections, with a crossover between the gas lift header and the gas export header, to enable contingency use of the gas lift riser for export of gas. There will also be rigid spool between the pipeline and the gas riser base.

Provision has been made for the future inclusion of the power cable and additional production, water injection and another dynamic umbilical within the FPSO riser turret slot allocation.

3.5.8 Subsea Installation

Subsea installation (production templates and satellite well infrastructure) is planned to start in May 2024 and be completed in 2026. All vessels to be employed in the subsea infield infrastructure will use DP station keeping with no anchors or chains to the seabed.

The pre-installation survey program will be completed in Q3 2022, which will inform if any seabed preparations are needed prior to the installations.

The installation of all the Development subsea structures will use proven installation methods. A construction vessel is planned to install all three of the production templates ahead of drilling. These structures will be lowered through the water column using a crane and set on the ocean floor then levelled using suction anchors to the required location. ROVs will be used to monitor the position at all times and to disconnect the rigging once the installation process is complete.

The flowlines and umbilicals will be laid as is routine by guiding through the water column and visual verification of exact placement of location by ROV prior to laying on the seabed. The ROV will also be used after the operation to visually inspect and to confirm the exact location. Connection of the flowlines and umbilicals to the wells will then be carried out.

The risers will be laid on the seabed from the in-field area towards the FPSO. All buoyancy modules, tether clamps, etc. will be attached to the risers during the laying of the risers. The FPSO end of the risers will be lowered from the vessel and connected to a pre-deployed winch wire from the FPSO. The FPSO winch will then be used to pull the riser into the FPSO turret where the riser will be connected to the hang-off at the top of the I-tube, which is a protective column through which the flexible riser passes. Both underwater cameras and ROV will be used to provide visual inspection in real-time of the installation process which will allow correction if required and inspection of the risers and catenary after pulled-in to the FPSO.

The infield flowlines, umbilicals and the gas export pipeline will cross existing cables on the seabed. A total of 19 crossings is anticipated, where each crossing shall have up to six mattresses installed. The existing cables will be protected from damage by installation of three concrete mattresses per crossing. Industry standard articulated concrete mattresses with approximate dimensions of 3 m x 6 m x 0.3 m will be used. The only post lay material that will be required infield is for mitigation of free-spans and buckling. There will be no post infrastructure installation of protection material infield for protection of other users of the sea as this is not required below a depth of 800 m. All seabed pre and post lay deposits are detailed in Chapter 6 Seabed Impacts. A final survey will be undertaken of the infrastructure prior to the installation vessels leaving the field to confirm location and as-built status.

Protection for the gas export pipeline is described in Section 3.8.

3.6 Pre-commissioning

After installation and connection of all the in-field infrastructure and hook up to the FPSO pre-commissioning operations will be carried out and are estimated to take approximately one month. Integrity of the flowlines will be carried out using hydrotests and leak detection with oxygen scavenger, biocide, dye and MEG in seawater. The same pre-commissioning and commissioning process will be followed for Phase 1 wells and Phase 2 wells.

Following the pre-commissioning tests and completion of system leak test, pipeline needs to be dewatered and conditioned (dried) before gas introduction into the gas flowlines and export pipeline. The dewatering of the gas export line will be carried out by importing gas from WOSPS and using this to propel a six-pig train through the pipeline. The fluid will be propelled to the FPSO and received in a temporary pig receiver to be routed into the process. The fluid will be managed within this system for injection downhole as water injection or discharged to sea if the specification is acceptable. The dewatering of the gas lift riser and the infield lines will be carried out using nitrogen from the FPSO.

No pigging is planned for the water injection system due to the internal plastic liner in the flowline. Flushing with treated fresh water treated with dye will be performed after tie-in and prior to start of water injection to ensure integrity of the water injection flowlines. Thereafter, during start up, the dye will be injected down hole into the reservoir formation.

3.7 Floating Production, Storage and Offloading Unit (FPSO)

3.7.1 Facilities and Process Overview

The FPSO will provide services for the reception of reservoir fluids, processing, storage and offloading of crude oil and export of gas via pipeline.

The ship-shaped FPSO, shown in Figure 3-14, will be redeployed from current operations on the NCS to the Development after modifications to meet the Rosebank process requirements. Once on location it will be designated an installation with a 500 m safety zone on the UKCS and subject to all laws, regulations and practices required of a UK oil & gas producing facility and workplace. All required information on the locating of the FPSO and mooring details will be made available to maritime organisations and interested parties through the routine channels. The geographical coordinates of the location of the FPSO at the Rosebank field are given in Table 3-10 and the main characteristics of dimensions and capacities of the FPSO in Table 3-14.

Figure 3-14 The ship-shaped FPSO which will be redeployed at Rosebank

Table 3-14 FPSO main dimensions and processing capacities

Parameter	Dimension/capacity
Length (m) excluding helideck	256
Breadth (m)	48
Depth (m)	26.6
Total cargo storage in 12 tanks (m^3)	127,500
Total diesel/gas oil storage (m^3)	4,700
Total ballast water (m^3 %of DWT)	74
Processing capacities	
Oil production	~12,500 Sm^3/sd (77 kbpd)
Water production	~15,000 Sm^3/sd (93 kbpd)
Total liquid production	~17,500 Sm^3/sd (110 kbpd)
Seawater treatment (SRU)	~15,000 Sm^3/sd (95 kbpd)
Water injection	~18,000 Sm^3/sd (115 kbpd)
Gas lift	1.1 MSm^3/sd (39 MMscfd)
Gas export	1.7 MSm^3/sd (60 MMscf)
Total Gas handling	1.87 MSm^3/sd (66 MMscfd)

The FPSO installation operator is planned to be Golar-Nor (UK) Limited, referred to as Altera throughout the document as wholly owned by Altera.

The FPSO will be designed to collect reservoir fluids from the wells and direct them towards the equipment in place on the topsides for processing. This processing will separate the oil, gas and water from the recovered fluids into three streams and condition each stream for subsequent use:

- The oil will be processed to produce a stabilised crude oil product suitable for storage in the FPSO crude oil tanks and subsequent export by shuttle tanker;

- The gas will be dehydrated (i.e., water will be removed) and, should H_2S arise, the gas will be processed to meet the WOSPS entry specification of 2.3 ppm of H_2S. The gas will be used as fuel gas on the FPSO, for gas lift in the wells to aid production or exported to shore. Excess gas from the storage tanks will be handled by the VOC flare recovery system which supports zero routine flaring. Flaring will only be for safety related reasons; and
- The water separated from the oil and gas (known as produced water) will be used for water injection purposes. The produced water will be treated and then combined with treated seawater to be used as the injection water to provide reservoir pressure support. In very limited circumstances there would be a discharge to sea of the produced water after treatment to overboard permit specifications e.g., if water injection is unavailable for maintenance.

Stabilised crude is stored in the 12 FPSO hull storage tanks for offloading to tankers.

FPSO storage capacities are presented in Table 3-14 which for production chemicals and diesel fuel shall be designed for 14 days of normal operation given the challenging weather conditions WoS. A simplified diagram of the Development FPSO process facilities is shown in Figure 3-15. The FPSO has an existing oil capacity of 63,000 bbl/d which will be modified to increase the capacity to around 70,000 bbl/d and process the Rosebank fluids. The project is carrying out debottlenecking studies to potentially increase capacity up to 77,000 bbl/d.

Modifications to be made to the FPSO prior to arrival at Rosebank will include:

- Demolishing of Debutanizer module M-510;
- Installation of a new process module R-510 containing:
    - New 3rd stage HP Gas export compressor trains;
    - New 3rd Stage HP Gas Lift Compressor trains;
    - New inlet heaters for Test Separator;
    - New produced water hydrocyclones;
    - New produced water compact flotation units; and
    - New sand treatment package.
- Installation of 2 new Ultra filtration vessels;
- Installation of 3 new Compressor panels in the Central Electrical Equipment Room, accompanied with approx. 1,500 m of HV cable run;
- Structural reinforcements and replacement of the turret mooring table in order to accommodate increased riser and mooring loads;
- Structural reinforcements to the hull to meet Rosebank environmental conditions;
- Green sea protection modifications to bulwark in bow area; and
- Preparation for electrification as further described in 3.7.8.2.

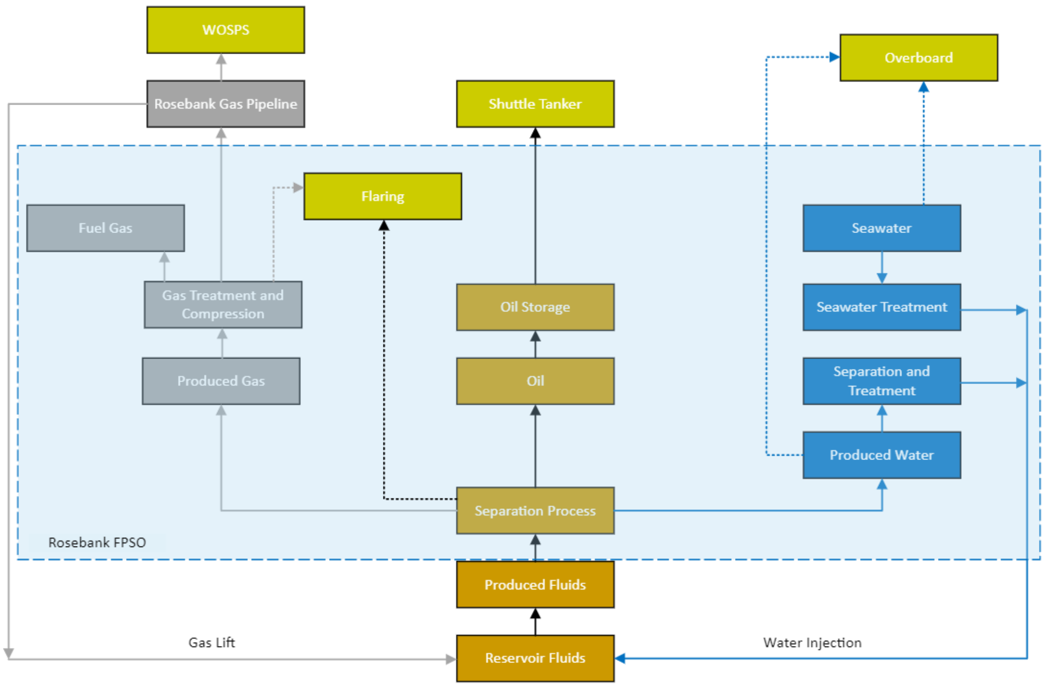


Figure 3-15 Diagram of the FPSO processing facilities

3.7.2 Moorings

The FPSO will be installed with twelve mooring lines positioned in three groups of four suction anchors and anchor chains (Figure 3-16). No impact piling will be required for the anchors. The FPSO mooring line suction anchors will be embedded to a depth of 19 m. No soil material discharge to the surrounding seabed is expected nor any significant disturbance of the soil outside the anchor footprint. The moorings will be connected to the geostationary FPSO turret, and the positions will be located on charts for information of mariners.

The mooring lines are composed a 50 m long top chain made of a 130 mm diameter studless chain, a 2,000 m long polyester rope and a 500 m long 130 mm diameter studless chain on the bottom. Between the polyester rope and the bottom chain there is a buoy with 20 tonnes buoyancy that prevents the polyester rope from hitting the seabed.

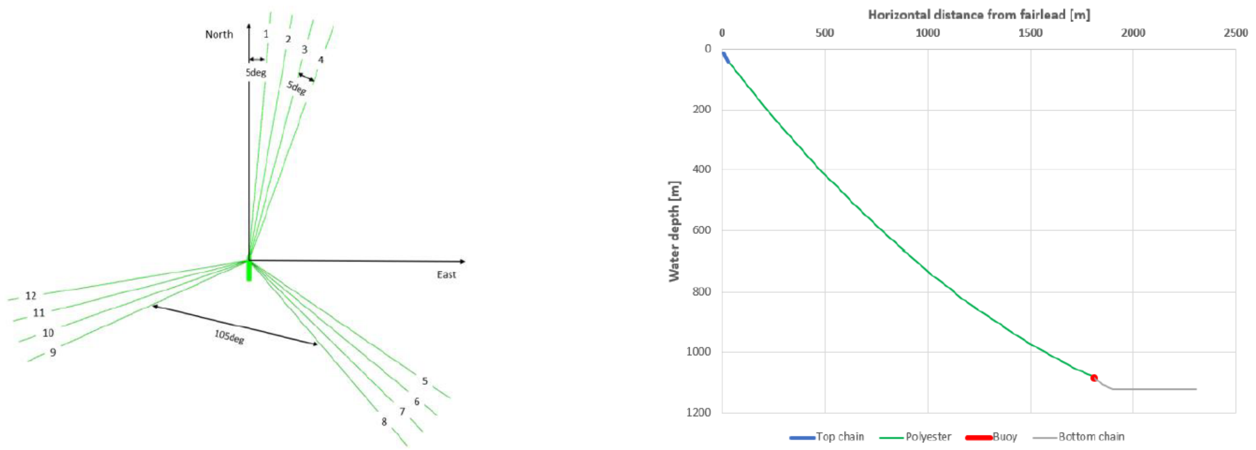


Figure 3-16 Diagram of the FPSO moorings configuration

3.7.3 Oil Processing

The FPSO topside inlet arrangement tie in the production risers from the turret and transfer the well stream to the topside separation system which consists of first, second and third stage separators and a coalescer as well as a test separator. The separation system is designed to separate the produced fluids into oil, gas and water and to deliver oil within the required specification. The test separator is used for well clean-up operations, start-up, pigging, well testing and calibration of subsea multiphase flow meters to avoid upsetting the process which can result in corrective activities and increased discharges or emissions (Figure 3-17).

The well stream from the production risers will be received in the production and/or test manifold in the turret. The well stream will be separated in the first stage separator. Oil will be heated and stabilised, and water content removed in the electrostatic coalescer before oil is sent to storage for offloading. The processing of the well fluids is as follows:

- The well production fluids from the production header enter the first stage separator. The first stage separator is a 3-phase separator that separates oil, gas and water. The first stage separator is designed for the total design rates and cater for a slug volume of 20 m^3 between normal liquid level and high liquid level. The crude oil from the first stage separator is routed to the second stage crude heaters. The temperature of the heater is adjusted so that the temperature of the inlet stream to third stage separator is constant for all cases. Second stage crude heaters are designed as shell and tube exchangers;
- The second stage separator is a 3-phase separator. The separated oil from the second stage separator is then routed to the third stage separator and electrostatic coalescer. Vapour from the second stage separator is sent to the LP Gas Compression System and produced water is sent to the Produced Water Treatment System;
- The third stage separator is a 2-phase separator, operating to ensure no vapor in downstream of the electrostatic coalescer. Flows from different sources, oil rejected from produced water hydrocyclones have been added to the oil flow from second stage separator to determine the design flow of the third stage separator; and
- Well test fluids from the test header enter the test separator via the test inlet heater for well testing. The test separator is a 3-phase separator that separates oil, gas and water.

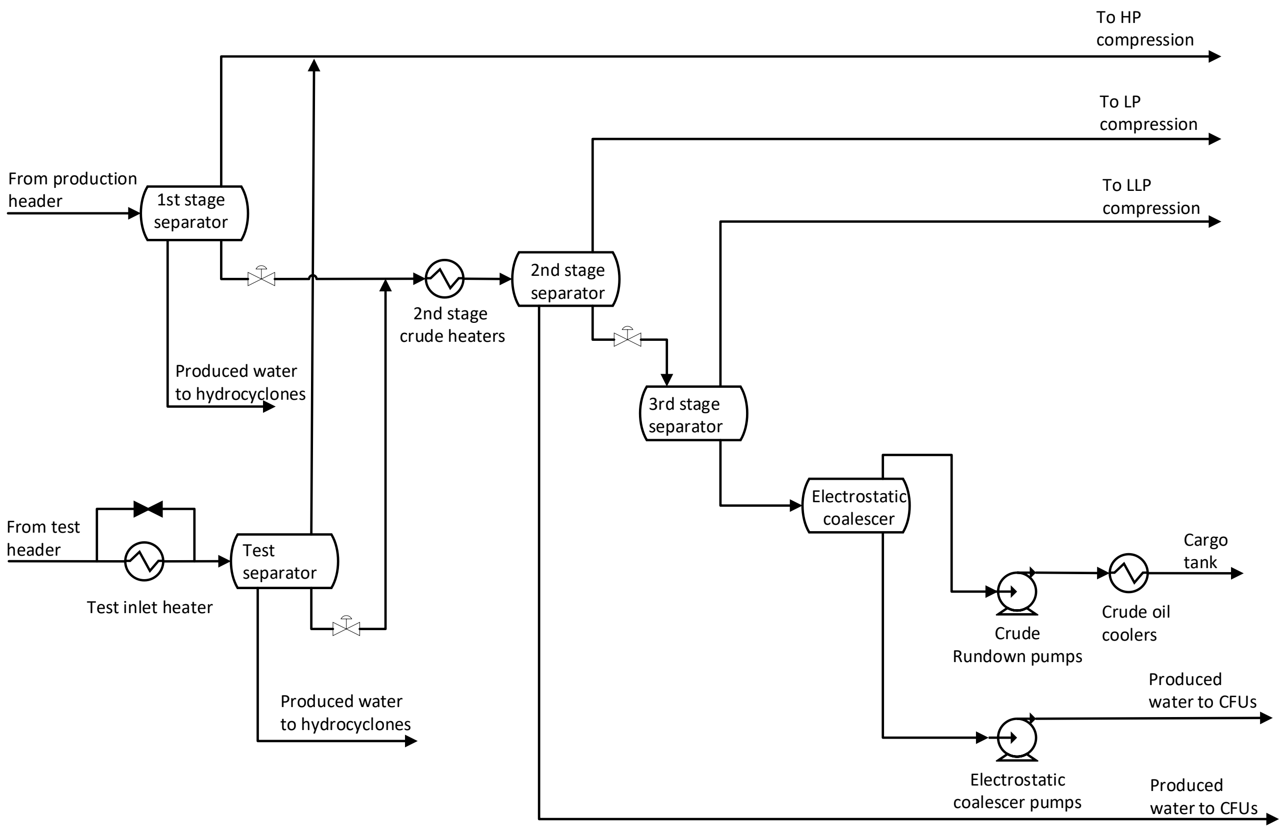


Figure 3-17 Diagram of the FPSO production separation process

3.7.4 Gas Processing

Gas will be treated for H_2S and mercury (if required), dehydrated, compressed and exported to WOSPS, utilised as fuel gas and injected in the wells for production support. Downhole gas lift is required in the producing wells to reduce the start-up time of wells with high water cut, to increase the production rates and to reduce slugging in the production flowlines. At the start of the field production gas will be imported from the WOSPS to serve as the gas lift for the initial wells.

Mercury removal will be via a mercury removal unit in the form of a fixed-bed absorbent. It will be designed for a 4 year bed life, depending on inlet concentration. Physical change out of the beds would occur as required according to that approximate timeline with no shut down facilities required

All processed gas, including export, lift and fuel gas, is dried in the gas dehydration system to the WOSPS maximum water content specification of 35 ppmV. The gas compression system on the FPSO consists of the low pressure (LP) and low pressure (LLP) compressor packages with associated coolers and scrubbers. The LLP and LP Compressors will require modification to accommodate the lower flow rates and the leaner Rosebank gas than that present on the field in which the FPSO currently operates. The gas from the first stage separator, the test separator and the LP compressor is compressed in three stages up to the final gas lift and/or gas export pressure (Figure 3-18).

Flash gas from the cargo storage tanks is routed to VOC recovery unit where it is commingled with gas from the third stage separator and compressed by LLP compression. Gas from second stage separator is mixed with the gas from LLP compression and is further compressed by LP compression before entering the HP gas compression. Gas from first stage separator, test separator and the decompressor train is compressed in 2 stage compression trains prior to third stage compression (consisting of a new gas lift compressor and a new gas export compressor).

Gas conditioning consists of gas cooling to reach the hydrocarbon dew point specification and water dew point reduction through a Tri Ethylene Glycol (TEG) contactor. In addition, a mercury removal unit will be installed upstream the third stage export gas compression stage to fulfil the gas export specification.

The gas lift and gas export compressors will be equipped with Variable Speed Drives, discharge pressures will be controlled by varying the compressor speeds. The flow split between the gas lift and the gas export will be by a new control valve on the inlet to the gas lift system. Dry gas is compressed in a dedicated gas lift compressor and cooled before it is sent subsea and distributed to the wells. New instrumentation for gas lift metering will also be installed.

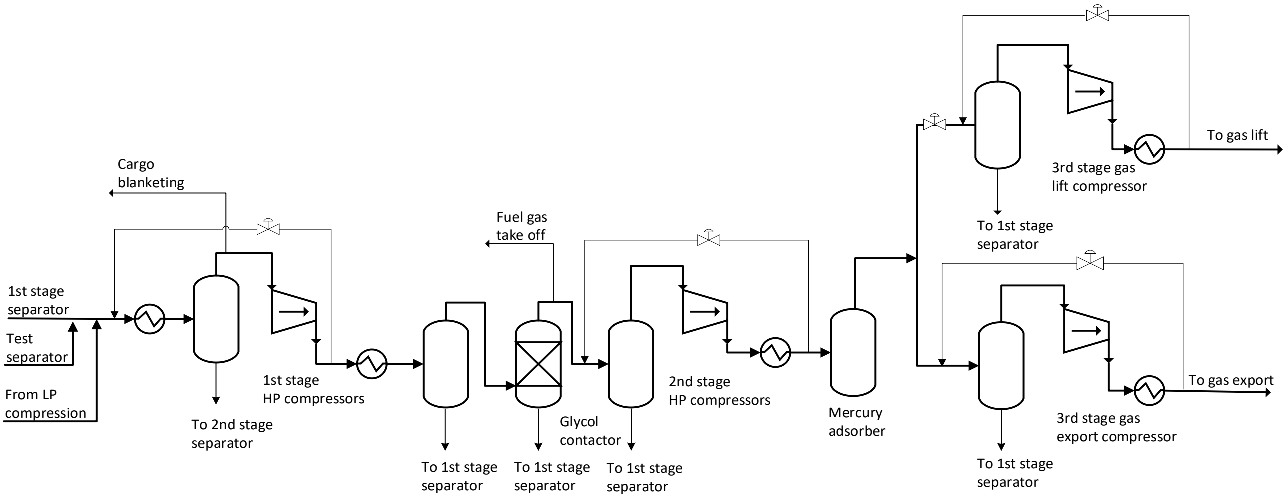


Figure 3-18 Diagram of the process gas management system

3.7.5 Water Management

Produced water is the result of the production of formation water from the reservoir. The produced water will be treated and reinjected into the reservoir with seawater that has been treated to produce low sulphate seawater in the Sulphate Removal Unit (SRU). Injection of non-treated seawater can introduce sulphur to the reservoir and contribute to souring by provision of a bacterial source. The resulting sour production will promote bacterial production and reservoir souring requiring further treatment before export or use as a fuel or lift gas. Seawater will be lifted on to the FPSO, where it will be filtered, passed through the SRU, and finally de-aerated to produce the low sulphate seawater. The SRU contains sulphate removal membranes through which the majority of the seawater will pass. The remainder of the seawater, along with any ions that were retained by the membrane, will be rejected and constitutes the hypersaline water for discharge via the caisson with excess low-sulphate seawater. The amount of excess low-sulphate seawater discharged will be dependent upon how much water is required to make up the total injection water volume at any one time. As more water is produced from the reservoir in field life as it matures then the amount of excess low-sulphate seawater required will decrease.

The combined seawater and produced water flow comprise the water injected to the reservoir required to maintain pressure and maximise production. Produced water may be discharged to sea if water injection is unavailable e.g. breakdown of a pump or the SRU, however the uptime of the combined water injection system is expected to be >95%. The produced water treatment system is required to remove oil and sand particles from the produced water stream to comply with the injection specification and the overboard discharge permitted levels in case of injection system unavailability.

The following activities and actions are the basis for water management at the Development:

- Great care will be taken to ensure only the required volumes of seawater are lifted;
- All produced water shall be re-injected into the reservoir for pressure support;
- Produced water shall be treated prior to injection to allow for fracture injection and to ensure reservoir containment of injected water;
- The backup solution in case of downtime of the water injection system is to discharge the produced water to sea following treatment;
- Sea water shall be treated for sulphate and oxygen removal prior to injection. In case of downtime of the SRU plant, sea water injection shall be stopped. No untreated sea water shall be injected into the reservoir; and
- Treated sea water and produced water will be mixed and injected through common subsea pipelines.

The water injection system consists of a seawater treatment system and common injection pumps for produced water and sea water (Figure 3-19). The produced water and treated seawater are injected for reservoir voidage replacement to maintain the reservoir pressure.

The produced water system on the FPSO will be subject to modification aiming to meet an oil in water concentration of between 15 mg/l and 30mg/l (permitted limit) (monthly average) prior to re-injection into the reservoir or in upset situations discharged to sea for a limited period. During the modification phase the fixed speed motors on the water injection pumps will be replaced with Variable Speed Drives. The average power saving is just over 700 kW per operating pump, so fitting Variable Speed Drives to the seawater injection pumps would save 1,400 kW life of field.

The produced water source includes the first and second stage separation and electrostatic coalescer. The combined water stream enters the hydrocyclones where the pressure drops along the inner contour of the liners creating the spin, thereby allowing gravitational oil/water separation. The bulk of the incoming oil is removed by the hydrocyclones, where the removed oil is directed back to third stage separator. The treated water is directed to the compact flotation units (CFU) for mechanical separation of liquids and gas.

The gasses which are removed from the CFUs are routed to the third stage separator whilst the water is routed to water injection primarily (> 95% of the time). The 95% uptime of the water injection system is derived from the Reliability Availability and Maintainability (RAM) analysis carried out based on produced water profiles. Recent operating experience of the water injection system in Knarr's current location complements the RAM analysis data as there has been strong operational performance in this area.

During production it is a credible scenario that there may be certain process upsets or outages (e.g. slugging, loss of deoiler chemical injection, reduced hydrocyclone efficiency caused by blockages etc.) where it is clear that the monthly average oil in water specification will be jeopardised if production continues.

Should water injection not be available produced water will be routed direct to an overboard dump caisson if it is within the permitted discharge specification However there is an option to divert produced water to the slop tanks and cargo tank 5 until these reach their capacities. The capacity utilising these two options is around 10,400 m^3 and would generally allow enough time to carry out short duration repairs on the water injection system. Routing to these tanks could also be done if the produced water was off spec.

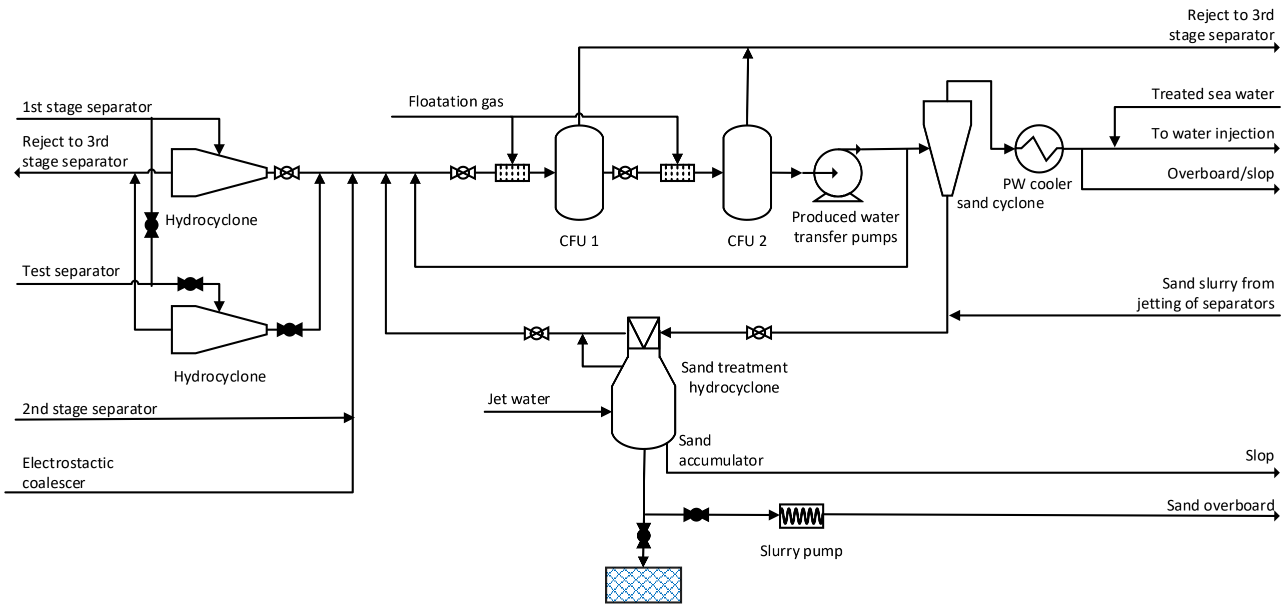


Figure 3-19 Diagram of the produced water management system

3.7.6 Sand Processing

The Rosebank production wells will be completed with a combination of open hole gravel pack (OHGP) completions for the deviated wells and stand-alone screens (SAS) for the horizontal wells. Neither completion type is expected to produce solids under normal producing conditions. Production wells will be equipped with an acoustic sand detector and one CEM (Corrosion Erosion Monitoring) to control sand production. The topside production flowlines will also include one acoustic detector with sand injection point and one CEM.

During the initial clean-up flow to the FPSO, elevated sand production is anticipated for a short period. During normal operations, minimum solids production is expected to be on average 9.4 Te/year during production, ranging from 1 Te in 2026 to 11 Te in 2033. During clean-up of the SAS, a sand production of 10 ppmw/well (weight of total fluid) and the majority of solids will be produced during the first 5 hours of the clean-up operation.

A sand treatment and removal system will be installed on the FPSO to manage any produced sand within the fluids produced from the Rosebank reservoir; these have been designed to handle the predicted sand quantities mentioned above. Sand removal facilities will be included in the first and second stage separators and the electrostatic heater. Sand will be removed as required as fluids pass through the vessel. The sand removed from the sources above will be transferred to a sand treatment hydrocyclone and collection chamber. As the sand enters the unit it passes through the hydrocyclone section with any oil/water rejected to the 1st stage CFU. The washed sand will pass through the hydrocyclone and collect in the base of the sand accumulator. The options for disposal of the sand is either to the sand skip or to overboard providing the sand has been cleaned up sufficiently. The final design has not been confirmed but it is expected that the washing of sand with Produced Water will continue until samples show that the sand particles contain ≤ 1% by weight of oil. At this point the sand slurry will be routed overboard. The washing and overboard disposal of sand is expected to be a batch process, which operates intermittently. Sand collected during the vessel cleaning will therefore be discharged periodically via the caisson along with the various water streams. (dependent on the nature of the failure) sand production will be managed within the capabilities of the topsides facilities by cutting back production or shut-in of the well in question pending intervention.

The maximum oil concentration limit for any oil on sand and/or scale discharge system that will be issued in any Permit is 10,000mg/kg (1% oil on sand). This Limit Value (LV) is a maximum value as suitable technology and sand cleaning systems/techniques are available to achieve oil on sand and/or scale concentrations significantly below this value. The Department's benchmark LV for oil concentrations of oil on sand and/or scale that may be discharged when considering Permit Application is in the range of 1,000-3,000 mg/kg as it is common for production installations to achieve such standards. Relevant Permits will be issued with LV to reflect the permit description of how the Permit Applicant will implement BAT and BEP to minimise oil concentration on the sand/scale that will be discharged.

3.7.7 Chemicals

Chemical injection will be required for the FPSO process and utilities facilities and for provision to the subsea production manifolds. The FPSO has separate tanks for chemical storage, each linked to a dedicated injection pump. Injection points are installed at various locations throughout the process systems where chemical treatment may be required.

The selection of specific production chemicals will be undertaken at a later stage of field development. The use and/or discharge of all production chemicals will be subject to risk assessment and permitting under the Offshore Chemicals Regulations. Equinor will ensure the chemicals selected for use at the Development will be registered for use under the Centre for Environment, Fisheries and Aquaculture (CEFAS) definitive ranked list of products for use in the UKCS. Equinor is committed to ensuring its environmental footprint is minimised and will aim to select the most environmentally friendly chemical products wherever possible (e.g. alternatives to chemicals listed as candidates for substitution).

Estimated production chemicals injection requirements are given in Table 3-15. Continuous downhole chemical treatment for scale inhibition is required for downhole gas lifted producer wells.

Table 3-15 Chemical injection requirements during production

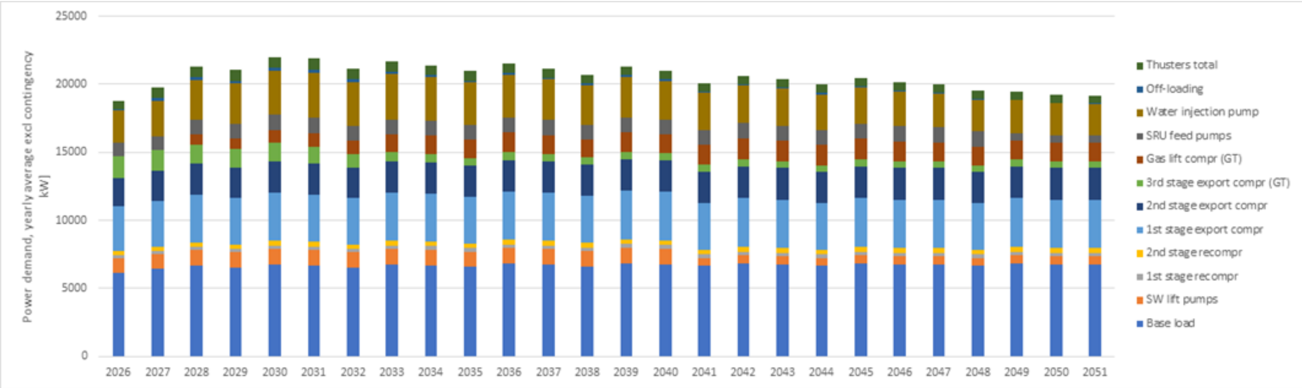
Chemical	Continuous/batch/intermittent	Total annual use (tonnes)
Methanol (for hydrate and SSSV equalisation)	Intermittent	750
Pour Point Depressant	Continuous or Intermittent	4,000
H_2S scavenger	Continuous or Intermittent	28
pH regulator	Continuous or Intermittent	16
Scale inhibitor	Continuous or Intermittent	570
Emulsion breaker	Continuous or Intermittent	500
Antifoam	Continuous or Intermittent	40
Flocculant	Continuous	54
Oxygen scavenger	Continuous	80
Biocide	Batch	130
Naphthenate Inhibitor	Continuous	60

The hydraulic system is an open loop system where the water based hydraulic fluid is discharged through check valves to sea. HW460R is the planned subsea hydraulic fluid with an estimated discharge of 1500 to 2000 litres per year per well. There may be a requirement for well interventions which would use scale squeeze and tracer chemicals during the life of the field. This will be on an intermittent basis and the use and discharge will be as required for the specific operation.

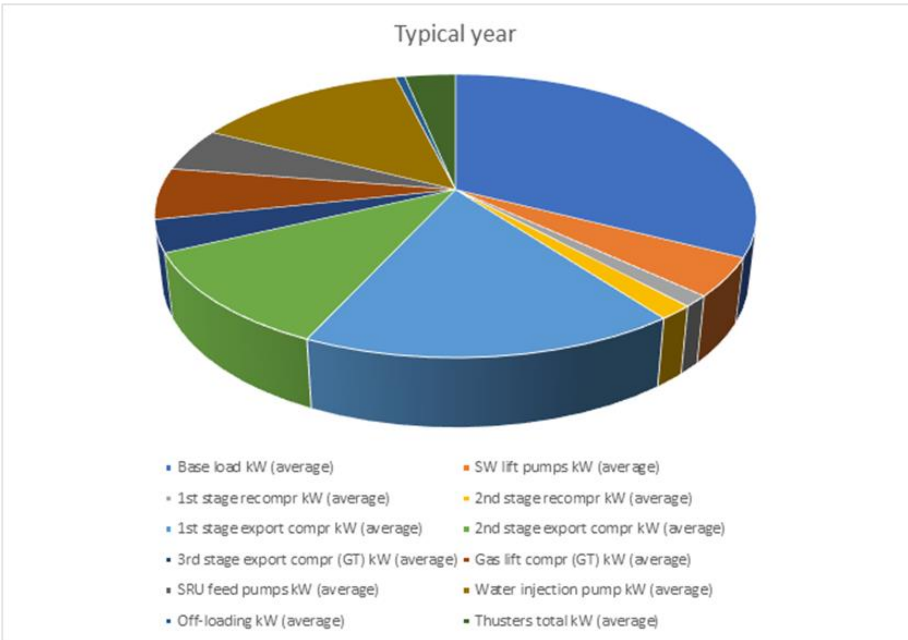
3.7.8 Utilities

3.7.8.1 Power Generation

Power is required for the operation of process systems and other vessel systems, including living quarters. Figure 3-20 A displays the estimated yearly average power demand for the life of field, highlighting the base load as well as key consumers, and Figure 3-20 B estimates the energy requirements for a typical year.



A



B

Figure 3-20 Estimated energy requirement for the range of services on the FPSO at Rosebank, A for life of field and B comparative for a typical year

The total power requirement for the life of field is expected to be relatively steady as per Figure 3-20 A. As the total duty will remain reasonably constant, there are only two normal operating scenarios considered, normal production operations and normal production plus offloading operation. It is estimated that offloading will increase power demand by around 1,545 kW. The highest users of power on the FPSO will be the baseload and the first stage export gas compressor, followed by the water injection pump and the second stage export gas compressor.

Main Power Mode

During normal production operations as well as during production plus offloading operations, power generation is supplied by a combination of the four main, 13.1MW, dual fuel (gas/diesel) turbine generators. Fuel gas is used as the main fuel, but the turbines are capable of dual fuel operation (i.e., fuel gas and diesel). There is the potential to import gas from WOSPS if the field becomes depleted of gas and it is still required for power generation, although this is a contingency.

The main intent of the operating philosophy is to minimise power usage whilst reducing the need for spinning reserve. As can be seen in Figure 3-20 A the estimated load during both normal production and production plus offloading modes, will allow power generation to be supplied from two turbines. If the power demand whilst operating with two turbines is deemed as being too high, then the philosophy will be to utilise a third turbine. The fourth turbine is only there as a backup for maintenance and will not be operated under normal operations.

The WHRUs have an almost constant duty of 14.3MW between 100% and 70% GTG loading and duty between 70 and 51% is assumed linear and estimated based on gas flowrate. As the peak heating requirements is anticipated to be between 18,000 - 20,000 kW, two turbines will be sufficient to provide the total heat demand for the FPSO.

To ensure supply is maintained where possible, load shedding shall be executed in the following levels:

- The first level, to be implemented following detection of an under-frequency condition, shall consist of step by step (if required) shedding of consumers according to a pre-set priority, which shall continue until the frequency returns to normal state; and
- The second level of load shedding, to be implemented following the loss (i.e. tripping) of an operating GTG (or tripping of HV switchboard bus tie breaker) shall consist of a general shedding of load blocks. The amount of load to be shed shall depend on the power which was previously provided by the source which was lost and the capability of the remaining turbines (if required).

Essential Power Mode

Upon failure of main power, the diesel engine driven essential 2.25 MW and 2.1 MW emergency generator supports the normal conditions of habitability and essential marine/process systems. For topsides, this includes the start-up loads for a turbine generator and some essential process and utility loads.

Emergency Power Mode

Emergency power mode shall be automatically initiated by a loss of power to the emergency switchboard. The diesel engine driven emergency generator shall start automatically and supply safety/emergency services as well as black start-up of the FPSO.

Emergency Power

Emergency power supply is independent of the main power supply and has black start capability. The emergency generator operates at standstill on automatic standby and shall be automatically initiated by a loss of power to the emergency switchboard. Emergency power is generated by a diesel driven generator capable of supplying the maximum emergency load as required for at least 18 hours.

The estimated diesel use on the FPSO (including small users and dual fuel turbines when run on diesel) is expected to be an average of approximately 3,750 tonnes of diesel per year. Power management systems will be provided which will ensure that the overall system operation is optimised such that the use of fuel will be minimised for best energy efficiency and lowest environmental emissions. The heat production during normal operation is ensured by the use of four WHRUs, fitted at the exhaust of the power generation turbines.

3.7.8.2 Preparation for FPSO Electrification

The most significant GHG emission reductions would be from a renewable energy source. As such, the FPSO will be fully prepared for electrification when leaving the yard. This means that the FPSO can be connected to the grid without any need for going off-station at Rosebank or executing any significant further modification work after start-up. As soon as the electrification is in place to provide power to the FPSO, Rosebank may be electrified.

The FPSO preparation for electrification scope will consist of the following modifications:

- Installation of a High Voltage Slip Ring (HVSR) on the turret Fluid Transfer System (FTS Swivel);
- Installation of a surge arrestor on the turret geo stationary section downstream of the HVSR to protect the HVSR from potential electrical surge;
- Cable routing from the HVSR to the E-House located on the M810 module which is port side aft on the FPSO;
- E-House will contain the electrical control cabinets and the new transformer to provide the power to the FPSO to replace the current GTG power generation systems; and
- HV electrode boilers installed on the poop deck to provide the process heat previously supplied by the WHRUs on the GT exhaust systems.

3.7.8.3 Flaring

The FPSO will be operated without routine continuous flaring. The Development philosophy is to reduce flaring wherever possible and maintain flare combustion efficiency to minimise emissions from the Development. The intention will be to start using the field gas as soon as possible and recover any gas in the separation process. Flaring will be reduced at well start up by using import gas from the WOSPS to speed up the start-up process. This method of start-up will limit the amount of gas to the flare to the well flowback and clean-up phase as far as possible.

The FPSO is designed with closed high- and low-pressure flare systems to service different parts of the plant at different pressures and retain as much gas as possible to reduce flaring emissions. In both systems, the received flows will enter a flare knock-out drum where any liquids in the stream are recovered. Gases will go from the knock-out drum on to a flare gas recovery compressor where hydrocarbon gases are recovered and fed into the compression system joining the rest of the gas flow for export and use in gas lift or power generation. The flaring of gas as waste is therefore eliminated on a routine basis.

3.7.8.4 Venting

During normal production operations the vent and flare systems are closed. Venting will be required for safe isolation of plant by allowing pressure release during maintenance operations. The vent system is provided for safe release of hydrocarbon / blanket gas fluids that are relieved from process equipment and/or from Pressure Safety Valves (PSVs), Blowdown Valves (BDVs), and Process Control Valves (PCVs)/PVs during start-up and/or process upset conditions. There is also a VOC recovery unit which prevents continuous flaring and reduces emissions during normal operation as it receives vapor from cargo tanks during production operation and also receives the vapor from flare system during offloading.

Shuttle tankers will have tanks empty of crude oil when they arrive at the FPSO, but the tanks will contain inert gas or a mixture of hydrocarbon gas and inert gas. This inert gas or mixture will be displaced (i.e. vented to the atmosphere) during offshore loading of crude oil from the FPSO to the shuttle tankers; this process will be managed as per the shuttle tanker's VOC Management Plan.

3.7.8.5 Fugitive Emissions

A methane action plan will be developed for the operational phase of the Development. This will include management of fugitive emissions, which are small leaks typically originating from valves and flanges which are not completely tight. Fugitive emissions occur essentially at random. Hence the mitigation approaches needed to deal with leaks and fugitives differ from the other emission categories, with the focus being on the detection and prevention of leaks, rather than the avoidance or configuration of processes that would release methane through normal operations. While the emissions from individual fugitive leakages are typically limited in magnitude, the total amount may represent a significant source of methane emissions.

An effective way of detecting and reducing fugitive emissions (i.e. those not typically identified with stationary gas detectors and/or through regular inspection rounds) is to carry-out regular Leak Detection and Repair (LDAR) programmes, which use specialised detection equipment to identify fugitive leakages. Handheld infrared (IR) cameras, used for optical gas imaging (OGI), are becoming the standard equipment for LDAR campaigns, as camera operators can survey many more potential leak sources in far less time than traditional "sniffing" methods which require detection equipment (e.g. Flame Ionisation Detection devices) to be placed within 1-2cm of a potential leak point. A specific remediation plan for fugitive emissions will be dependent on the findings of future surveys.

3.7.8.6 Drains

The Drainage System prevents any unintentional discharge to sea, and is composed of the following systems:

- Open Drain; and
- Closed Drain.

The drainage system prevents any unintentional discharge to sea and is composed of hazardous and non-hazardous open and hazardous closed drains. The hazardous and non-hazardous open drains are physically segregated to prevent any hazardous material migration from the hazardous areas to a non-hazardous area. Hazardous open drain has a dedicated open drain tank with the collected drains to this tank routed to the hull slop tank by electric motor driven pumps. Excessive flow to the hazardous and non-hazardous open drains from heavy rains can be routed overboard from the drain tank overflow line (which is valved and normally kept closed). Deluge water from non-hazardous drains is directly routed overboard through a module drain box.

Closed drains direct liquids from pressure vessels and equipment in the process area where the fluids are routed to a closed drain tank to permit maximum recovery of oil and contaminated water. Liquids in the closed drain tank are pumped to the second stage separator. The closed drain tank also can be drained to the slop tank if it is required.

3.7.8.7 Ballast System

The ballast system is designed to enable the FPSO to maintain trim, stability and hull integrity during normal and emergency operations. It is essential for maintaining or restoring vessel stability following marine events such as ship collision, reduction in stability, and structural failure. The ballast system on FPSO comprises the following:

- Seawater intakes (sea chests);
- Ballast pumps;

* Ballast water distribution ring main, including pipework and valves;
* Ballast tanks; and
* Ballast control system.

3.7.8.8 Slops Tanks and Oily Water Discharge

Slop tanks are provided based on one clean (starboard side) and one dirty tank (port side), with clean water decanting from port to starboard. An oil skimming pump is located in the port side slop tank, discharge from which is fed to offloading/transfer header to discharge oil into the cargo tank. In addition, two slop water treatment centrifuges are located on the main deck port side.

3.7.9 Oil Storage and Offloading

The FPSO double bottom and double-sided hull structure contains the cargo oil tanks that receive the stabilised oil from the process for storage until offloaded to the shuttle tankers. The offloading system comprises the following main components: cargo tanks, one electrical pump for each tank with a pump rate of 750 m^3/h, offloading header, metering unit, offloading hose reel and deck heaters. The FPSO's thrusters will be used to stabilise the heading during offloading operations. The offloading rate will be 4,500 m^3/h by running six cargo pumps at full capacity simultaneously. The cargo pumps will discharge the cargo oil through the stern offloading system. The crude oil will be offloaded through the 122 m long and 20" diameter offloading hose retained on the FPSO to a dynamically positioned shuttle tanker.

3.8 Gas Export

3.8.1 Pipeline Specifications

The gas export pipeline is approximately 85 km long and will be made of carbon steel. Table 3-16 shows other parameters of the gas export pipeline.

Table 3-16 Gas export pipeline parameters

Parameter	Value
Pipeline size (outside diameter)	273 mm
Wall thickness	15.9 mm
Design flowrate	1.5 MSm^3/d
Pipeline maximum allowable operating pressure (at 30 m above LAT)	235 barg
Pipeline design pressure (at 20 m above MSL)	258 bara

External corrosion control will be provided by anti-corrosion coatings over the entire length of the pipeline. The anti-corrosion coatings will be factory applied; typical coating is a 3-layer polypropylene. Cathodic protection by sacrificial anodes will also be employed (as they will also be used for the subsea structures). The anodes act as preferential sites for corrosion, thereby protecting the pipeline and extending the life of the pipeline. Each component of the pipeline system will be provided with suitable cathodic protection for the full design life of the system.

3.8.2 Seabed Preparation and Survey

Surveys commissioned at Rosebank (Chapter 3 Environmental Baseline) and experience from similar WoS projects suggest that areas of rock outcrops, hard soil conditions, boulder clay and boulders are to be expected at the seabed and trenching may not be technically feasible in many areas. The pipeline route surveys conducted in 2021 and 2022, and an earlier survey conducted in 2011, will identify seabed sensitivities and obstacles to inform the basis for seabed preparation and the routing design and installation method.

3.8.3 Infrastructure Installation

The gas export pipeline will be installed by a pipelay vessel capable of the method of reel lay. The reel lay method sends the pipeline from a reel mounted on a pipeline installation vessel. Instead of connecting each joint of pipeline at an offshore location, the pipeline is pre-assembled in a spool which is mounted on the deck of the reel vessel. Installation vessels will use DP to maintain position, therefore there will be no anchoring required for these vessels.

In UK waters, there is a ban on the use of all bottom-contacting mobile fishing gear at water depths greater than 800 m, implemented by The Common Fisheries Policy and Aquaculture (Amendment etc.) (EU Exit) Statutory Instrument (S.I.) 2019 No. 753. This applies to the Development and along the lengths of the gas export pipeline below this depth. There will be no specific overtrawlable protection installed over the pipeline and other structures below 800 m, however all infrastructure will be identified on maritime charts and routine marine traffic monitoring as detailed in the chapter on Interactions with Other Users of the Sea. All subsea structures in depths less than 800 m will be designed to be overtrawlable.

At water depths of less than 800 m, the intent is to minimise the impact on the seabed as much as possible by trenching and backfilling the gas export pipeline. Any issues e.g., boulders beneath the surface or upheaval buckling, encountered may require rock deposit creating an overtrawlable berm as protection laid on top of the pipeline (and, closer to the Clair tee, possibly also pre-lay rock carpet). It is estimated that installation of the gas export pipeline will take ~64 days, from installation vessel mobilisation to demobilisation, plus contingency for downtime due to bad weather. The installation activities will take place immediately following seabed preparation and it is planned to complete installation of the gas pipeline in one installation period (e.g., one summer).

3.8.4 Tie-in to Subsea Field Infrastructure

The gas export pipeline will require tie-in infrastructure at the Rosebank FPSO and the Clair Tee WOSPS connection point. A pipeline end termination (PLET) will be installed integral with the carbon steel rigid export flowline at the Rosebank field. The gas export flowline will be connected to a pipeline end manifold (PLEM) installed integral with the pipeline with a tee-off and pig launcher receiver (PLR) at the Clair Tee. There is an existing safety zone at the Clair WOSPS Tee. An in-line tee for intake of future third party gas will also be installed on the gas export line. The proposed approach to the WOSPS at the Clair end of the gas export route is shown in Figure 3-21.

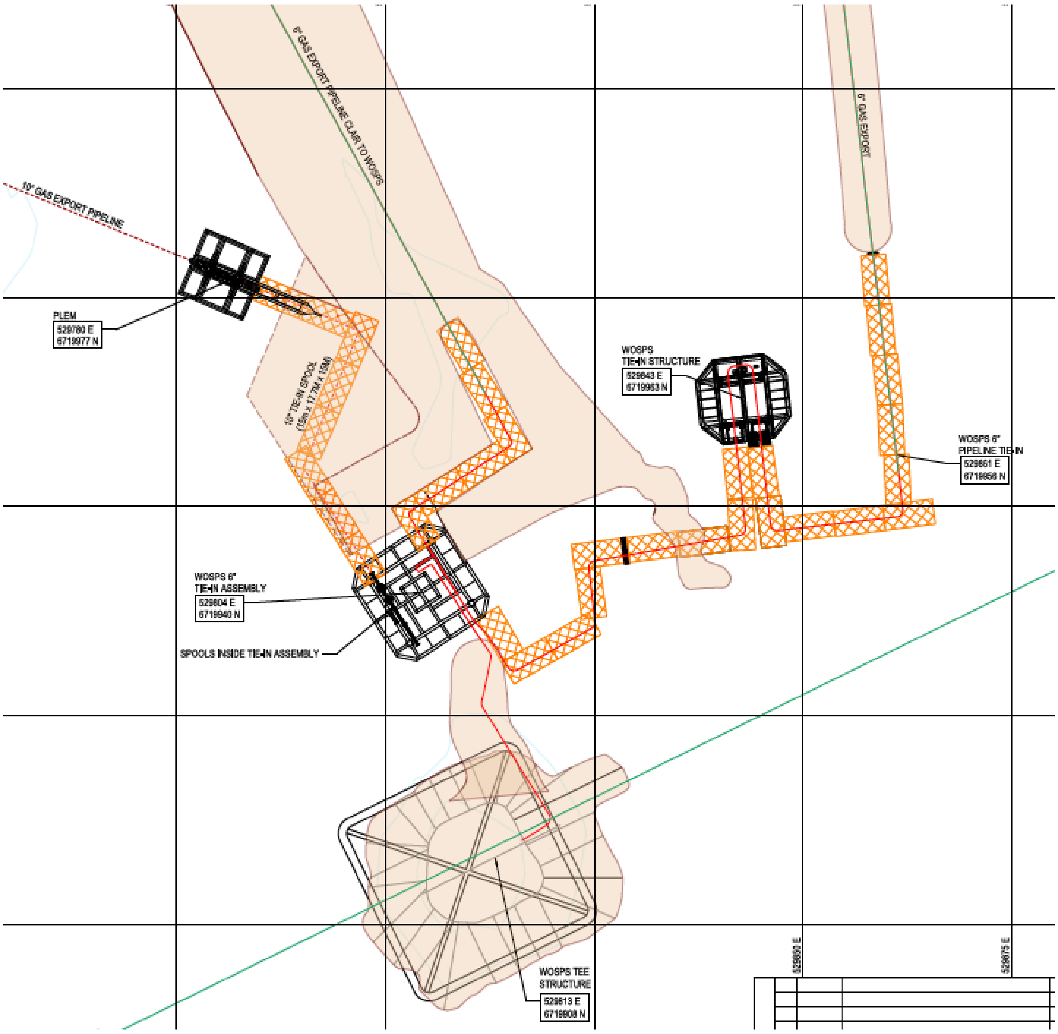


Figure 3-21 Gas export pipeline approach to the WOSPS at Clair

3.8.5 Protection and Stabilisation Material

Protection and stabilisation materials are required to both protect existing infrastructure on the seabed from damage as a result of infrastructure placement and also to ensure that the equipment placed on the seabed is stable and will not move under different conditions. The materials used are concrete mattresses and crushed rock. Bags of sand/grout are also used, the quantities to be determined as part of future detail. It may be possible to recover concrete mattresses at the end of the field life depending on future decommissioning requirements.

The section of gas export pipeline installed in water depths less than 800 m will require protection from trawl fishing gear. Where possible the pipeline will be trenched and buried where required. However, the presence of boulders may prevent trenching and, in this case, the pipeline will be surface laid and protected with deposits of rock overburden. Rock may also be used to correct critical pipeline freespans and for stabilisation.

The total pre-lay and post-lay rock estimation (Table 3-17) required for pipeline installation will be reviewed and updated further to data from the pipeline survey. Additional materials may be required during the life of field and are subject to statutory consenting processes.

Rock deposit within the Faroe Shetland Sponge Belt will be avoided as far as is practicable, although the impact assessment has assumed a worst case scenario. The valve structures on the Clair end of gas export pipeline will be protected with rock and are located in an existing subsea safety zone.

There are 24 infield infrastructure crossing points and 3 further crossing points along the gas export pipeline length. Concrete mattresses (approximately 3 m x 6 m x 0.3 m) are used to support the crossing and prevent damage. Figure 3-22 shows a schematic of a cable crossings arrangement. This arrangement could require up to six mattresses for each crossing depending on the angle at which the pipeline crosses and the height required to provide sufficient support, and the mattresses will be covered with rock.

Crossings in the infield area will be studied further as part of detailed engineering and additional concrete mattresses may be required for the infield area.

The rock placement vessel will survey the seabed as the rock placement installation progresses to determine the exact location of the rock material and to confirm that the design requirements have been met. The spread of rock placement will be restricted through the use of a fall pipe system held a few metres above the seabed to accurately place rock material.

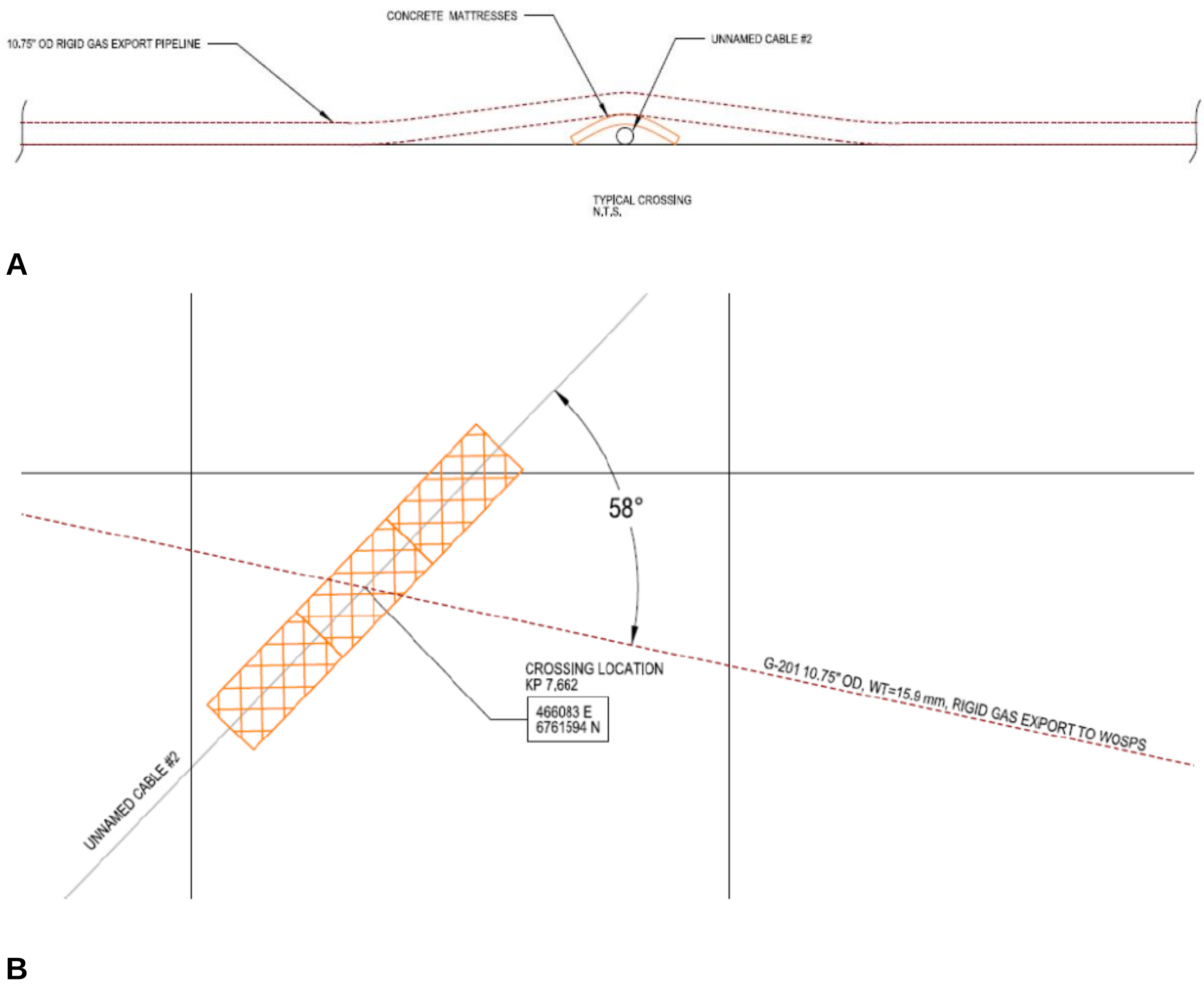


Figure 3-22 Typical cable crossing design (A) and the crossing location of the unnamed cable #2 (B)

Table 3-17 Worst-case protection and stabilisation materials estimates

Installation phase	Purpose of protection	Type of material (rock or concrete mattresses)	Volume of rock (m^3) /quantity of mattresses	Weight of rock/dimension of mattresses
Pre-lay	Protection at 24 infield cable crossings	Concrete mattresses	144	3 m x 6 m x 0.3 m
	Protection at 3 cable crossings along the Clair export pipeline	Concrete mattresses	18	3 m x 6 m x 0.3 m
Pre-lay and post-lay	Protection of flowlines approaching the Claire Tee tie-in	Concrete mattresses	8	3 m x 6 m x 0.3 m
	Rock to protect pipeline where trenching not possible. Some of this may be pre-lay rock carpet (closer to the Clair tee) in addition to burial and buckling mitigation and expansion control of gas export pipeline <800 m depth	Rock	400,000 m^3 (630,000 tonnes)	N/A

3.8.6 Pre-commissioning

Prior to first gas export being sent through the gas pipeline, a series of leak tests will be conducted. This series of tests is part of ‘pre-commissioning’ and the tests consist of flooding the pipeline with treated seawater, cleaning it with biocides and scavengers, gauging and hydrotesting the pipeline. Further leak testing when the pipeline is tied into the adjacent structures and then dewatering of the pipeline (treated seawater is removed from the pipeline so that gas can flow through).

The gas export line will be installed air filled which will be displaced by flooding with chemically treated fresh water (e.g., oxygen scavenger (to prevent oxygen induced corrosion), biocide (to prevent bacterial growth), corrosion inhibitor and dye (which would be visible in the water column if the gas pipeline leaked). A pig will be moved through the pipeline to detect any dents or defects in the pipeline surface that might have been caused during installation (called ‘gauging’) and to clean the inside of the pipeline. It is possible that the full volume of water in the gas pipeline (439 m^3) may be displaced to the marine environment over a period of one day during this pigging exercise. The pressure within the gas pipeline will then be slowly raised to help confirm that the pipeline structure is intact (hydrotesting/strength testing). Once the pressure has been raised to the intended pressure, it will be held for a period sufficient to determine that the pipeline demonstrates the required strength and integrity.

Following the pipeline testing the gas pipeline will be dewatered to ensure it is dry for gas transportation to WOSPS. A valve will be opened at one end of the pipeline and a series of pigs (a pig train) will be moved along the pipeline to force the treated seawater through the open valve at the other end of the pipeline. The pigs will be driven by hydrocarbon gas from the WOSPS line and up to a maximum of approximately 900 m^3 of treated seawater will be discharged from the FPSO. Hydrocarbon gas will be used for the gas export pipeline instead of nitrogen that is used for the infield lines, since the safety risk is substantially higher for such a comparatively longer line, and since vessel supply requirements would also be much greater than for hydrocarbon gas.

Following pipeline pre-commissioning, installation of structures and connexions at each end of the pipeline will commence.

3.9 Operation and Maintenance of Pipelines and Flowlines

Pipelines are subject to regular integrity inspections. Routine inspections check for lack of cover, free-spans and evidence of interaction with fishing equipment. External inspection will take place through a combination of ROV/AUV and towed sonar. The frequency of such maintenance will be determined by ongoing risk assessment. In terms of internal maintenance, the pipelines will be designed to accommodate intelligent pigging inspection if necessary, whereby a remote sensing pig will be conveyed through the pipeline to undertake checks on and confirm pipeline integrity and condition. The production lines are made from corrosion resistant material and hence will not be subject to corrosion inspection pigging. During production, as there is the potential for the produced fluids to form wax in the pipeline, pigging may be required to mitigate the build-up of wax in the infield pipelines. There shall be temperature measurements at the wellhead, downstream subsea choke and topside (upstream and downstream choke).

As a minimum, the FPSO hull, wells, and subsea equipment will be inspected once per year using an ROV.

Pigging frequency will be around every 3 to 6 months in the first year, extending to 18 months based on early findings. The gas lift lines, and gas export pipeline will be transporting dry gas and will not be subject to regular pigging in the operational phase.

Water injection lines are internally corrosion resistant and will not be subject to regular pigging in the operation phase.

3.10 Vessel and Rig Requirements

The vessels expected to be involved in the installation, commissioning and operation of the Development are described in Table 3-18. Working days shown below include a waiting on weather day contingency of an estimated 20%.

Table 3-18 Estimated number of days each will spend on site during development inclusive of waiting on weather

Operation	Type of transport	Number of days			
		2024	2025	2026	Annual LoF[15]
Drilling					
Drilling	Support Vessels	0	0	0	0
	Rig	0	299	283	439[16]
Transfer of drilling personnel (helicopters)	Helicopter	0	16	16	0
Drilling ERRV	ERRV	0	299	307	439[17]
Subsea installation					
Installation	Anchor handler (FPSO)	0	28	0	0
	Pipelay vessel	0	77	0	0
	Heavy lift	30	27	0	0
	Construction Support Vessel (CSV)	0	168	0	0
Tie-in operations	DSV	0	125	0	0
Seabed Intervention	Support vessel	0	0	73	0
Pre-commissioning activities	DSV	0	48	39	0
Subsea Commissioning	Support vessel	0	0	36	0
Riser Installation and pull-in	DSV	0	0	51	0
Installation of FPSO mooring lines	Anchor handler	0	57	0	0
FPSO tow to field*	Anchor handler	0	0	7	0
FPSO Mooring line hook-up	Anchor handler	0	0	34	0
Production					
Helicopter	Helicopter	0	0	374	374
ERRV presence	Support Vessel	0	0	365	365
Maintenance of subsea structures	Support Vessel	0	0	0	12
Transfer of supplies	Supply vessel	0	0	19	127
Decommissioning[18]					
Plug and Abandonment wells	Rig	0	0	0	28
Infrastructure removal	CSV	0	0	0	231

3.11 Decommissioning of the Rosebank Development

The main obligations for decommissioning offshore oil and gas operations are set out in OSPAR decision 98/3 (the "Decision 98/3") which specifically prohibits the dumping or leaving in place of installations in the marine

[15] Life of field.
[16] Second campaign.
[17] Second campaign.
[18] All vessels were considered to be used at the final year of the Development.

environment. OPRED (2018) guidance sets out current UK policy on decommissioning. The OSPAR provisions do not directly apply to pipelines and there are no international guidelines on the decommissioning of disused pipelines. However, pipeline and flowline decommissioning options will be assessed in accordance with of UK legislation and policy in place at the time of decommissioning and all necessary approvals obtained from the relevant regulator(s).

The following SURF decommissioning activities may be anticipated:

- The risers will be flushed, cleaned and plugged before disconnected from the turret and the top end transferred to an assisting vessel that lowers the risers to the seabed for later retrieval once the FPSO is taken off-station. Dynamic umbilical and power cable will follow similar sequence;
- Mooring lines will be disconnected from the turret and laid down on the seabed. The mooring lines are retrieved from the seabed and removed in a reverse sequence of the installation procedure once the FPSO will be taken off-station. The bottom chain will be cut at the mud line by an ROV. The suction anchors will be cut at the mud line and the top subsequently retrieved to the installation vessel;
- The complete subsea system will be cleaned and flushed to remove all hydrocarbons. A suitable assessment will be conducted to determine feasibility of removal of subsea structures in accordance with decommissioning regulatory requirements in place at the time;
- The wells will be cemented/plugged and cut at wellhead flush at the seabed. The wellhead area may be subject to rock placement; and
- Rigid flowlines (gas export and water injection) may either be removed or decommissioned *in situ* depending on the regulatory requirements for decommissioning in place at the time.

4 ENVIRONMENTAL BASELINE

4.1 Overview of the Rosebank Development Area

This chapter describes the baseline environment relevant to the Rosebank Development. The Rosebank Development area consists of the following areas as shown on Figure 1-1:

- The Rosebank field, where the oil and gas reserves are found and the FPSO and infield subsea infrastructure will be located, situated approximately 130 km west of Shetland in deep water of approximately 1,100 m in the Faroe-Shetland Channel; and
- The gas export pipeline route, which starts at the Rosebank field, ascends the eastern flank of the Faroe-Shetland Channel (termed a continental slope) onto the West Shetland Continental Shelf (from approximately 200 m depth) and ends at the Clair Tee at a water depth of approximately 140 m.

Given the ranges of water depth and distances from shore of the gas export pipeline route, the marine environment of the Rosebank Development area exhibits a wide variety of physical, chemical and human-use characteristics which are described in this chapter. This chapter considers the entire Rosebank Development area as well as the sensitivities of the adjacent coastlines. In view of the diversity of this area, the descriptions of several elements of the environment are presented in two subsections dealing with:

- Offshore areas in deep water on the eastern flank of the Faroe-Shetland Channel, covering the Rosebank field and the deeper parts of the gas export pipeline route (>200 m) up to the shelf break; and
- Offshore areas on the continental shelf (<200 m water depth), covering the shallower parts of the gas export pipeline route and, where relevant, inshore and coastal areas.

4.1.1 Supporting Studies

Since the discovery of the Rosebank field in 2004, a number of studies have been undertaken to gather information on the environmental and socio-economic sensitivities in the Rosebank Development area. These have been used in the development of the environmental baseline and are summarised in Table 4-1.

4.1.1.1 Seabed Environmental Surveys

Two types of survey have been conducted for the Rosebank Development: surveys using an ROV with a video camera and a manipulator arm enabling the collection of sediment samples and/or individual organisms, and ship-based remote sampling surveys using acoustic (sonar), photographic and sediment sampling devices.

The ROV surveys examined the seabed around various drilling sites during the exploration and appraisal phase of the Rosebank field and were all undertaken by the Scientific and Environmental ROV Partnership using Existing Industrial Technology (SERPENT) project based at the National Oceanography Centre (NOC), Southampton[19]. These surveys were localised in scale and provided some of the first high-quality images and specimens from these deep-water sites, as well as investigating the impacts of drilling in such areas.

Remote-sampling surveys of the Rosebank field and of the gas export pipeline route (including the currently proposed route to Clair and some of the alternative routes considered previously which provide some relevant data) collected data to map the seabed types and features present using acoustic survey techniques (high resolution

[19] SERPENT is a global project hosted by the DEEPSEAS group, within Ocean Biogeochemistry and Ecosystems (OBE) at the NOC. It is funded by a range of engineering, science and industry organisations including Rosebank's previous licence owner, Chevron North Sea Limited.

bathymetry and side scan sonar), and ground truth using cameras and sediment sampling devices (typically grabs or box cores). The locations of the sampling stations were established by experienced geophysicists and biologists in the field based on interpretation of the acoustic data, aligning with the 'intelligent survey design' specified in OPRED guidance (BEIS, 2021b). The objectives of the surveys were to map out the seabed types encountered, allocate habitat or biotope[20] names using either the UK or European classification systems, highlight and map any features (species or habitats/biotopes) that are sensitive or of particular conservation interest, and analyse sediment samples for physico-chemical characteristics and macrofaunal communities.

These surveys typically result in two environmental reports:

- A habitat assessment report, based largely on the acoustic and photographic data gathering, and presenting maps of bathymetry and seabed types, an account of the biotopes present on the basis of the seabed type and epifauna/megafauna (or their signs) visible, and highlighting any features of conservation interest (under European, OSPAR or UK/national regulation); and
- An environmental baseline report, in which an account of the sediment analyses for particle size, metals, hydrocarbon and macrofaunal content is given and interpreted.

Following a review of existing survey data in 2021, Equinor developed the scopes for new surveys to provide up-to-date environmental baseline data representative of the likely areas of impact from the Rosebank Development, both in the Rosebank field and along the gas export pipeline route. Subsequently, in April and May 2021, Akvaplan undertook environmental baseline surveys on behalf of Equinor at the Rosebank field. The results were compiled in two reports: an environmental baseline survey report, summarising the results of the seabed sampling (Akvaplan, 2022a) and a visual survey report, summarising the results of the seabed imagery taken at the Rosebank field (Akvaplan, 2022b). In April 2022, DNV undertook an environmental baseline survey along the gas export pipeline route for Equinor. The results will be compiled in two reports: an environmental baseline survey report (DNV, 2022a) and a habitat assessment report (DNV, 2022b). Details and maps of the sampling locations for all surveys relevant to the Rosebank Development area are provided in Section 4.2.7.1.

4.1.1.2 Other studies

Regional-scale studies that were used to inform the environmental baseline for the Rosebank Development include the following:

- The Atlantic Frontier Environmental Network (AFEN) was an innovative grouping of oil companies and UK Government departments set up to orchestrate sound management and regulation of oil and gas activities. Since 1995, several studies and research initiatives have been commissioned by AFEN to expand environmental knowledge of the area. Two widescale seabed surveys funded by AFEN were undertaken offshore to the north and west of Scotland (Bett, 1996; 1998). In 1996, 20,000 km^2 of seabed lying to the west of Shetland was mapped and sampled. The 1998 survey covered a further 10,000 km^2 of seabed. The results of both surveys were reported in AFEN (2000) and also summarised in AFEN (2001); and
- The United Kingdom Offshore Energy Strategic Environmental Assessment (OESEA) programme, referred to as OESEA3, builds on the work completed for the previous regional scale SEAs since 1999 (DECC, 2016). It aims to help inform licensing and leasing decisions by considering the environmental impacts of potential activities that could result from their implementation. Each SEA is supported by a series of

[20] A biotope is defined as the combination of an abiotic habitat and its associated community of species. It can be defined at a variety of scales and should be a regularly occurring association to justify its inclusion within a classification system. The latest UK marine biotope classification (version 15.03) is reported in JNCC (2015) and is fully incorporated into the marine component of the pan-European biotope classification known as the European Nature Information System (EUNIS).

specialist technical studies on issues relevant to the region being covered. As the individual SEA regions have been assessed in OESEA3, documents relating to the assessments have been made available for access by the industry and public on the internet. The Rosebank field and pipeline are located in the previous SEA region 4, which falls within the Regional Seas 8 (Scottish Continental Shelf) and 9 (Faroe-Shetland Channel), as described in OESEA3 (DECC, 2016).

Table 4-1 Supporting studies for the Rosebank Development

Study reference	Description and relevance
Metocean information	
Equinor (2022) Rosebank Field Metocean Design Basis.	Meteorological and oceanographic data gathering to inform the design basis for the Rosebank Development. Also informs the EIA.
Seabed environmental surveys	
Hartley Anderson (2003) ROV investigations of the seabed environment around well 204/17-1 pre and post drilling	Report of ROV observations of seabed sediments and fauna around an exploration well, including assessment of scale of impacts from cuttings discharges from top hole sections. An early study in the Faroe-Shetland Channel in nearby licence block, providing direct observations of seabed habitats and effects of drilling.
Hartley Anderson (2005) Seabed environmental investigations around exploration well 213/17-1z	Report of ROV observations and sampling around well 213/27 during drilling in July-August 2004, including assessment of impacts from cuttings discharges from top hole sections. An early study in the Rosebank field, providing direct observations of seabed habitats and effects of drilling.
Geolab (2007) Aberlour Environmental Seabed Survey, UK 2007.	Environmental survey in 2007 of the Aberlour prospect, UKCS block 213/28 in the Faroe Shetland Channel. Five stations were sampled. This report details the results of the macrofaunal analyses. Contributes to understanding of deepwater benthic macrofaunal communities in the Faroe-Shetland Channel.
SERPENT (2008) SERPENT Project; Rosebank visits 2007. Preliminary analysis of results	Preliminary report of investigations into extent of seabed disturbance by drill cuttings discharges on megafauna at Rosebank well 205/1-1 and 213/27-2 well locations. Contributes to understanding of the benthic megafauna in the Rosebank field and the potential effects from drilling.
SERPENT (2009a) Rosebank report including Cambo sediment analysis, June and July 2009	Report of seabed observations from an ROV around a Rosebank well site in Block 213/27 and the nearby Cambo well in Block 204/10a, sediment chemical analyses and mapping of extent of cuttings discharges. Contributes to understanding of the benthic megafauna in the Rosebank field and the potential effects from drilling.
SERPENT (2009b) Rosebank North visit report February to March 2009	Report of ROV visit to Rosebank North to collect high-definition photographs and samples of megafauna and to collect and analyse sediment samples. Contributes to understanding of benthic megafauna and seabed sediment characteristics in the Rosebank field.
Gardline (2009)	Environmental survey in 2008 of the proposed Stelkur and Sula drilling locations, in Faroes Block 6104/25. This report details the results of the seabed sampling investigations, including sediment particle size, metals, hydrocarbons and macrofaunal analyses. Contributes to understanding of the sedimentary environment in a nearby Faroese part of the Faroe-Shetland Channel.

Study reference	Description and relevance
Fugro (2011a) Environmental Baseline Survey - infield area	Environmental survey in 2011 of seabed over 162 km^2 in Rosebank field, as part of a geophysical and geotechnical programme. Station locations determined on the basis of acoustic (high resolution bathymetry and sidescan) returns. Benthic sediments at nine stations were photographed, and also sampled for sediment particle size, metals, hydrocarbons and macrofaunal analyses using a 0.25 m^2 box corer. Contributes to understanding of benthic habitats and species in the infield area.
Fugro (2011b) Environmental Baseline Surveys, Pipeline Routes	Environmental survey in 2011 of seabed along two export pipeline routes under consideration at the time, including a route to the Clair field, as part of a geophysical, geotechnical and environmental survey programme. Provides information on benthic species directly relevant to the current gas export pipeline route. In addition, an alternative route surveyed, to the deepwater Laggan field, provides information relevant to the deepwater parts of the Rosebank Development area.
Fugro (2012a) Habitat assessment report of the Rosebank gas pipeline corridor	Environmental survey in 2012 of the seabed along a gas pipeline route under consideration at the time. Acoustic survey (bathymetry and sidescan) together with video and stills photography and sediment sampling at 31 stations was undertaken along the route to describe and map the benthic habitats present. This report details the results of the habitat investigation. This was a substantially longer pipeline route than the current gas export pipeline route, extending from the Rosebank field around the south of Shetland to tie into the existing SIRGE pipeline at a point called Tee-2, south-east of Shetland. Although the deeper section of this pipeline route is directed further south than the present gas export pipeline, it follows a similar depth range up the continental slope and therefore provides useful information on the slope habitats.
Fugro (2012b) Environmental baseline report of the Rosebank gas pipeline corridor	Environmental survey in 2012 of the seabed along a gas pipeline route from the Rosebank field to Tee-2, as described above. Thirty-one stations were sampled along the route. This report details the results of the seabed sampling investigations, including sediment particle size, metals, hydrocarbons and macrofaunal analyses. Although the deeper section of this pipeline route is directed further south than the present gas export pipeline, it follows a similar depth range up the continental slope and therefore provides useful information on sediment physical and chemical characteristics and macrofaunal community structure at different depths on the slope.
Fugro (2014a) Habitat assessment report UKCS Quadrants 205, 206 and 213	Environmental survey in 2014 of the seabed in the Rosebank field and along a short deep-water gas pipeline route under consideration at the time, from the Rosebank field to the nearby Tormore manifold. Ten stations were sampled. This report details the results of the habitat assessment, undertaken on the basis of acoustic data interpretation for wide-scale mapping of seabed types, with ground truthing by video and still photography. Provides information on the seabed relevant to the Rosebank field area.
Fugro (2014b) Environmental Baseline Survey UKCS Quadrants 205, 206 and 213	Environmental survey in 2014 of the seabed in Rosebank field and along a short deep-water gas pipeline route under consideration at the time, from the Rosebank field to the nearby Tormore manifold as described above. This report details the results of the seabed sampling investigations, including sediment particle size, metals, hydrocarbons and macrofaunal analyses. Provides information on sediment physical, chemical and biological characteristics in the Rosebank field.
Fugro (2015a) Deep-sea Sponge Assessment. Re-analysis of survey data collected 11th May – 6th July 2012, and 1st – 16th August 2014.	Re-analysis of photographic survey data collected from stations at or adjacent to the 500 m isobath within the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA). Aim was to undertake a Deep-Sea Sponge Aggregation assessment of all photographs collected, using the more up to date criteria of Henry and Roberts (2014), at all stations where this feature might occur. Provides information on the presence of sponges in other parts of the NCMPA, which the current gas export pipeline route also crosses.

Study reference	Description and relevance
Akvaplan (2022a). Baseline Environmental Survey at Rosebank, 2021.	Environmental baseline survey carried out for Equinor in the Rosebank field from 6 April to 4 May 2021 including seabed sampling and a camera survey. This report summarises the results from the seabed sampling. Provides recent environmental survey data for the Rosebank field to inform the EIA.
Akvaplan (2022b). Visual survey with video-assisted multi sampler (VAMS) at Rosebank 2021.	Seabed environmental baseline survey carried out for Equinor in the Rosebank field as described above. This report summarises the results of the analysis of seabed imagery obtained from the VAMS. Provides recent environmental survey data for the Rosebank field to inform the EIA.
DNV (2022a). Environmental Baseline Survey report for gas export pipeline route to Clair.	Seabed environmental baseline survey carried out for Equinor along the gas export pipeline route. Samples for physico-chemical and macrofaunal analysis were obtained at 23 stations between the Rosebank field and the Clair Tee. Provides recent seabed sediment data for the gas export pipeline route to inform the EIA.
DNV (2022b). Habitat Assessment Report for gas export pipeline route to Clair.	Seabed habitat assessment carried out for Equinor along the gas export pipeline route as described above. A visual survey using an ROV was carried out to 50 m each side of each of the 23 sampling stations, focussing on identifying possible red listed or OSPAR type habitats and providing video footage and 2,515 still images of the seabed. Provides recent seabed habitat data for the gas export pipeline route to inform the EIA.
Fisheries and shipping assessments	
Brown and May Marine (2010) Commercial fisheries assessment for the Rosebank Development	An assessment of the commercial fishing activities at the Rosebank field and offshore areas to the shelf break (>200 m water depth). *Note: follow up work undertaken (see below).*
Xodus Group (2012) Rosebank to Tee-2 route: fishing intensity study	Fishing intensity study along the gas pipeline route from the Rosebank field to Tee-2 under consideration at the time. *Note: most up to date fisheries data have been used to inform the environmental description presented in this chapter of the ES.*
Anatec (2013) Collision risk assessment Rosebank FPSO	Assessment of the ship routeing data in the Rosebank field and the risks of collision. Contributes to an understanding of shipping use of the Rosebank field and informs the assessment of potential risks and impacts.
Xodus Group (2019) Rosebank Consent to Locate - Current, marine growth and wave monitoring buoys. Vessel Traffic Survey (VTS) and Collision Risk Assessment (CRA)	This report presents the results of a Vessel Traffic Survey and subsequent shipping Collision Risk Assessment undertaken on behalf of Equinor, to support an application to deploy four metocean moorings in UKCS Blocks 213/26, 205/1 and 205/2, in the Rosebank field. Contributes to an understanding of shipping use of the Rosebank field and informs the assessment of potential risks and impacts.

4.2 The Physical Environment

4.2.1 Meteorology

4.2.1.1 Faroe-Shetland Channel

The maritime climate of the Faroe-Shetland Channel is dominated by Atlantic weather systems, which in turn are influenced by a persistent regional pattern of high pressure over the Azores and low pressure over Iceland. This produces a sequence of secondary depressions which travel in an easterly or north-easterly direction, resulting in the passage of warm and cold fronts, changeable wind direction and frequent precipitation. Seasonal temperature variations are reduced by the influence of relatively warm surface water from the Atlantic Continental Slope Current (see Section 4.2.3), and the dominance of south-westerly winds. Although the sequence of depressions and anti-cyclonic ridges can produce winds from any direction, southerly to westerly winds are most frequent (Marshall, 1997; Scottish Government, 2011). The deep oceanic water west of Shetland is almost completely open to the prevailing weather from the west and south- west, with the result that the region is exposed to significantly stronger winds and sea conditions compared to other UK offshore areas.

There is a significant seasonal variation in wind speed; in winter winds of 8 m/s or greater are reported around 70% of the time, and in summer the same wind speeds are experienced 30% of the time. Fog may be experienced around 3-5% of the time in summer (April – September) and less than 2% of the time in winter (DECC, 2016). Monthly wind roses for the Rosebank field are shown in Figure 4-1 (Equinor, 2022). These correlate with the general picture for the west of Shetland region as a whole, i.e. that winds from the westerly to southerly quarters predominate and that wind strengths are highest over autumn and winter and lowest over the summer.

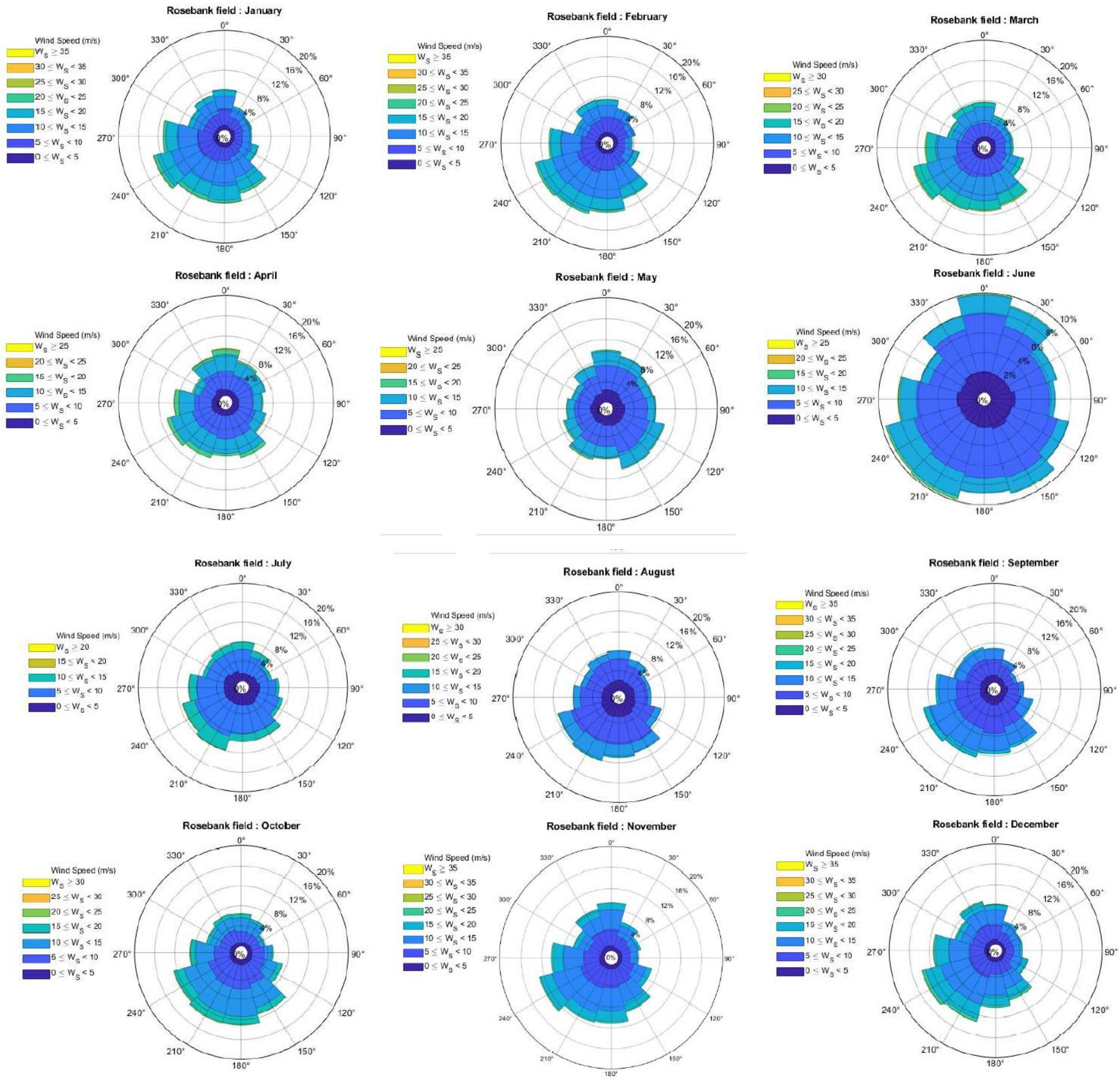


Figure 4-1 Monthly wind roses for the Rosebank field (Equinor, 2022)

4.2.1.2 Continental Shelf

On the West Shetland Continental Shelf, atmospheric weather and climate have considerable effects on marine conditions. The seasonal distribution of wind speed and direction in the area of the continental shelf are extremely variable. Winds occur from any direction; however, the predominant winds throughout the year are from the south-southwest and west, with winds from the northeast and east being less frequent (DTI, 2003a).

The predominant wind speeds throughout the year are from moderate to strong breeze (5.5 – 13.5 m/s) which have an overall frequency of approximately 50%. Between the months of October and March there are considerable seasonal variations in wind speed, with frequent strong winds above 13.5 m/s. During the summer months wind speeds decrease and are most commonly light or moderate breezes (2-8 m/s); calm conditions (up to 0.5 m/s) are rare (BP, 2010). Visibility within the area can vary considerably and is often poor during the predominant southwesterly winds.

4.2.2 Bathymetry

4.2.2.1 Faroe-Shetland Channel

The Faroe-Shetland Channel forms a narrow deep trough, orientated south-west to north-east, separating the Faroe Shelf from the West Shetland Continental Shelf to the east and the Wyville Thomson Ridge and several isolated banks to the south. The channel is wider and deeper to the northeast (190 km wide and 2 km deep) compared to the southwest (90 km wide and 1 km deep), where it turns to the northwest into the Faroe Bank Channel (DECC, 2016).

The Rosebank field is located on the continental slope[21] that forms the eastern flank of the Faroe-Shetland Channel in a water depth of approximately 1,100 m (Figure 1-4). The combined geophysical and environmental survey conducted by Fugro (2011a) found that the regional gradient of the seabed in the infield area to be typically less than 2º, although localised gradients of up to 22º were recorded associated with the flanks of sediment mounds and seabed depressions (see Section 4.2.7 for further discussion of seabed features). The water depth across the infield survey area ranged between 1,099 and 1,156 m LAT. Measured water depths at the sampling stations during the recent Rosebank field environmental survey ranged between 1,211 and 1,123 m (Akvaplan, 2022a).

The gas export pipeline route from the Rosebank FPSO location ascends the slope up to the shelf break (taken here to be 200 m) before continuing along the continental shelf[22] (Figure 1-4). Detailed bathymetry maps for the Rosebank field and the gas export route are available in Fugro (2011a, b).

4.2.2.2 Continental Shelf

The extensive West Shetland Continental Shelf is a shallow, near horizontal sea floor that extends west from the Shetland and Orkney coastlines to the continental shelf edge, roughly 60 km offshore, where the continental slope begins at depths of between 100 - 200 m (DTI, 2003b). The offshore parts of the West Shetland Continental Shelf are relatively flat, with the greatest seabed gradient located towards the shoreline. Water depth along the gas export pipeline route, from the shelf break to the Clair Tee-2 tie-in point, gently decreases from 200 m to around 120 m.

[21] Continental slope: the slope between the outer edge of a continental shelf and the deep ocean floor.

[22] Continental shelf: the area of seabed around a large land mass where the sea is relatively shallow compared with the open ocean.

4.2.3 Water Masses and Circulation

4.2.3.1 Faroe-Shetland Channel

The water current patterns in the Faroe-Shetland Channel are complex with various strong non-tidal currents interacting with relatively weak tidal flow. Five current systems exist in the area, distinguishable by geographical origin and vertical distribution in the water column as described in Table 4-2 and illustrated in Figure 4-2. The Faroe-Shetland Channel is a choke-point for the global thermohaline circulation since this is a region of significant inflow of warm Atlantic surface waters to the Norwegian Sea and towards the Arctic as well as of the return outflow of cold deep waters.

Table 4-2 Current systems in the Faroe-Shetland Channel

Current systems	Description
Surface layers: North Atlantic Water (NAW) and Modified North Atlantic Water (MNAW)	The surface layer is composed of North Atlantic Water (NAW) and Modified North Atlantic Water (MNAW). The NAW is warmer and more saline than the MNAW (Section 4.2.5 provides further information on salinity and temperature) and is located mostly towards the Scottish side of the Faroe-Shetland Channel at depths of up to 500 m (DECC, 2016). Circulation of water in the west of Shetland region is dominated by the northward flow of NAW from the Rockall Trough over the Wyville Thomson Ridge and along the slope before entering the North Sea via the Fair Isle Channel (between Orkney and Shetland) and round the north of Shetland (Figure 4-2). The MNAW flows clockwise round the Faroe Plateau before entering the Faroe-Shetland Channel from the north to link with the NAW flow, where it dominates the top 400 m of water, especially on the Faroese side. This MNAW flow from the north sets up a persistent and strong horizontal density gradient and velocity shear in these upper layers, resulting in eddies over the western/deeper slope. Current speed is low on the Faroese side at approximately 0.05 m/s but substantially higher on the Scottish side, reaching up to 0.2 m/s. The mean velocity of the shelf edge current is approximately 0.40 m/s towards the north-east, and 0.15 m/s towards the south-west. Measured near-bottom current velocities indicated peak currents of 0.75 m/s on the upper continental slope west of Shetland (DECC, 2016). The total flow rate of all water layers into the north Atlantic through the Faroe-Shetland Channel is 3.7 x 106 m^3/s.
Intermediate layer: East Icelandic and Arctic Intermediate Water (EIAIW)	The intermediate layer is made up of East Icelandic and Arctic Intermediate Water (EIAIW) which flows in from the north-east Faroe Plateau and mixes slightly with the MNAW. On the Faroese side of the Faroe-Shetland Channel, the EIAIW is found below the MNAW at a depth of approximately 300 to 600 m.
Bottom layers: Norwegian Sea Arctic Intermediate Water (NSAIW) and Norwegian Deep Sea Water (NDSW)	At depth, cold water from the Norwegian Sea flows to the south-west along the Faroe-Shetland Channel, turning to the north-west through the Faroe Bank Channel but periodically continuing southwards over the Wyville Thomson Ridge (Ellet, 1992; Chafik, 2012). The bottom layers are colder and less saline than the surface and intermediate waters and flow in the deepest parts of the channel (greater than 450 m). The bottom layer is itself made up of two layers; an upper layer of Norwegian Sea Arctic Intermediate Water (NSAIW) at a temperature of between -0.5°C and 0.5°C and a slightly deeper Norwegian Sea Deep Water (NSDW) at below -0.5°C. Total bottom-layer flow is approximately 1.9 x 106 m^3/s, but the current is highly variable in the Faroe-Shetland Channel. Maximum current speed is attained in the Faroe Bank due to funnelling, where the water mass may move at up to 1 m/s.

NAW is usually bounded on its western side by a frontal system, which separates it from cooler and slightly less saline water masses (MNAW and EIAIW) in the Faroe-Shetland Channel. The boundary layer between these two water masses is occasionally disturbed for a few hours by incursions of cold water (seabed surges) with accompanying strong currents (0.5 m/s). The cold-water surges are strongest near the 500 m contour. The boundary between the warm NAW and the colder channel water is not distinct and does not occur at a fixed depth.

In addition to the general water circulation pattern reported for the area, the west of Shetland area is characterised by a number of other sporadic water movement events. Events such as large-scale eddy currents along the continental shelf edge, seabed surges and storm-generated surges can all occur within the waters of the Faroe-Shetland Channel (Grant *et al*., 1995; Broadbridge and Toumi, 2015). Currents termed solibores[23] are a common occurrence within the Faroe-Shetland Channel (Hosegood and van Haren, 2004). The solibores move up the continental slope in a motion that can resuspend sediment and transport it up the continental slope, although the speed of these currents along the continental slope is not significantly different from normal current speeds (Hosegood and van Haren, 2004). Current meter records indicate that currents in the upper water column more frequently flow to the south-west than to the north-east, which is in direct contrast to the general north-east flow of currents nearer to shore (Equinor, 2022). As the Rosebank field is adjacent to the base of the slope near the centre of the Faroe Shetland Channel, the near-surface and near-seabed water layers both flow most regularly to the south-west.

4.2.3.2 Continental Shelf

Water currents patterns on the West Shetland Continental Shelf, similarly to that of the Faroe-Shetland Channel, are complex and varying, with multiple strong non-tidal currents interacting with relatively weak tidal flow. Due to the location of the west of Shetland continental slope and thus the North Atlantic Slope current, water movement within this area is largely to the northeast.

Surface tides in this region of the Northeast Atlantic are semi-diurnal, flooding from the west or the southwest towards the east or northeast and have minimal effect on the northeastern current. Mean surface water currents of 0.23 m/s and mean seabed currents of 0.16 m/s have been recorded at the Clair field (BP, 2010).

As discussed above, the North Atlantic Slope current is usually bounded on its western side by a frontal system which separates it from cooler and slightly less saline water masses in the Faroe-Shetland Channel. Infra-red satellite imagery reveals that frontal structures lie principally in a sweeping arc from the southern Faroes Shelf across the Faroe-Shetland Channel and along the West Shetland Slope. Their closest approach is at the west of Shetland shelf break, where it is thought the North Atlantic Slope Current can be displaced onto the shelf.

This is likely to result in stronger extreme currents than other areas on the West Shetland Continental Shelf. Storm generated currents have also been observed along the edge of the West Shetland Continental Shelf (DTI, 2003a). These currents are created when strong winds produce currents at the sea surface. When the wind ceases the currents still persist under their own momentum. Due to the Coriolis effect, the surface current moves with a clockwise rotation.

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[23] Currents which display properties of both turbulent internal bores (underwater waves which break upwards across shelf slopes, creating turbulent mixing with adjacent water masses) and nonlinear internal solitary waves.

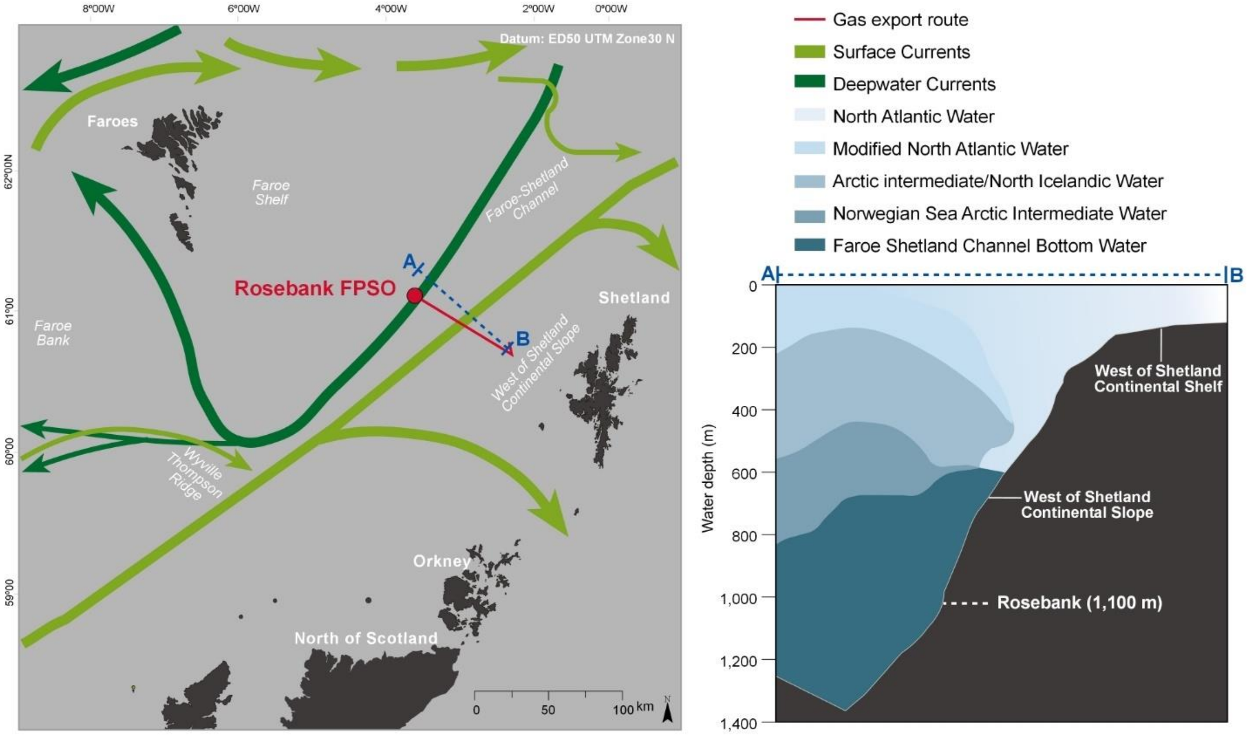


Figure 4-2 Water currents west of Shetland (DECC, 2016; Hansen and Østerhus, 2000; Turrell *et al.*, 1999 in AFEN, 2001)

4.2.4 Waves

The deep water over the West Shetland continental slope is exposed to a large fetch and strong winds, particularly from the west and southwest. These conditions generate a wave regime in the area which is more severe than that experienced in the northern North Sea. The area is also affected by long periods of ocean swells generated from Atlantic storms. For much of the west of Shetland region, including the Rosebank field and the gas export pipeline route, the annual mean significant wave height[24] ranges from 2.4 to 3.0 m, as mapped in Marine Scotland's National Marine Planning interactive (NMPi, 2022) tool and sourced from the ABmer Renewables Atlas (2008).

Significant wave height and direction data collected for the Rosebank field on a seasonal basis (Equinor, 2022) are shown in Figure 4-3. Wave direction appears relatively consistent through the year, travelling predominantly from southwest to northeast or west to east. Worst-case wave conditions are typically encountered during the winter months and into early spring. Significant wave heights of mean 4.1 m (and a maximum of 15.1 m) occur in January, whereas in July significant the mean wave height is 1.7 m (with a maximum of 6.3 m; Equinor, 2022).

The annual extreme significant wave height under a 1 in 100 year extreme storm scenario for the Rosebank field is 16.8 m with an associated spectral peak period of 18.6 s (Equinor, 2022). However, the estimated maximum 50-year wave height in the offshore area is approximately 32 m, with wave periods greater than 20 seconds (Grant *et al*., 1995 in DECC, 2016). These data indicate that wave directionality generally follows that of winds prevailing from the west to south and that the largest waves tend to occur in the winter months along with the strongest winds.

[24] Significant wave height (Hs) approximates to the mean wave height (trough to crest) of the highest third of the waves. The most common waves are lower than Hs. However, as this definition implies, the highest waves will be higher than the significant wave height, and the maximum wave height will be the highest of all.

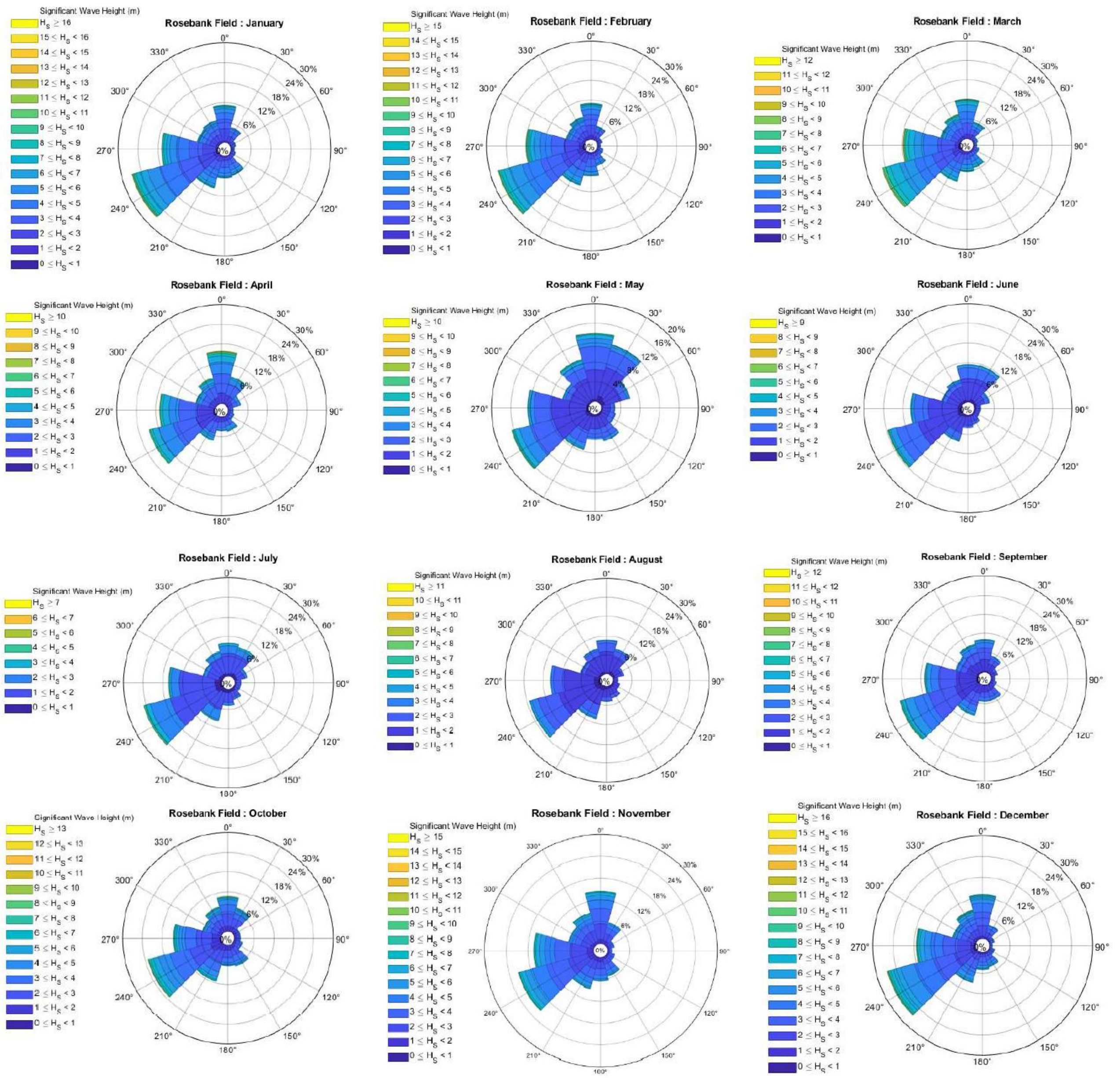


Figure 4-3 Seasonal wave roses for the Rosebank field (Equinor, 2022)[25]

4.2.5 Seawater Temperature and Salinity

The west of Shetland region in which the Rosebank Development is located lies mostly within OSPAR Region II, the Greater North Sea, which also includes the North Sea proper and its coasts. The most recent Quality Status Report (OSPAR, 2010a) states that sea surface temperatures in Region II had increased by 1 to 2°C over the previous 25 years. In open waters away from coastal influences, seasonal changes in sea surface salinity are comparatively small (OSPAR, 2000).

[25] Note: The length of rose "petals" indicates the relative frequency at which waves propagate towards different directional sectors in the intensity categories shown.

4.2.5.1 Faroe-Shetland Channel

Surface sea temperatures in the Faroe-Shetland Channel vary seasonally; minimum average sea surface temperatures of approximately 7.75°C occur in winter, increasing to 12.25°C during the summer (BODC, 1998). Temperature also varies with depth. For example, below the permanent thermocline found at depths of approximately 400 to 600 m (where the deep-water masses shown in Figure 4-2 interact), temperatures may drop below 0°C.

A seasonal thermocline may also form during the summer at a depth of approximately 50 m depending upon the local wave conditions, when the upper layers of water are heated, separating upper mixed layers from the deeper colder layers.

Sea surface salinity in the vicinity of the Faroe-Shetland Channel and the West Shetland Continental Shelf, including the Rosebank Development area, is typically between 35.2 and 35.5‰ (BODC, 1998; NMPi, 2022).

4.2.5.2 Continental Shelf

Over the West Shetland Continental shelf, variation in water depth and tidal influences results in changes in the structure of the water column during the year. Water column stratification occurs during the summer months when there is heating of the surface waters from the sun and less vertical mixing in the water column as a result of wind and tides. This gives rise to the formation of a seasonal thermocline, with a warmer surface water layer above cool bottom waters.

Surface sea temperatures on the West Shetland Continental Shelf also vary seasonally; minimum average sea surface temperatures of approximately 8.25°C occur in winter, increasing to 12.82°C during the summer (NMPi, 2022) with mean annual surface temperatures of approximately 10°C.

4.2.6 Water Quality

Scotland's open seas are generally little affected by land-based pollution, and of late contaminant levels continue to fall slowly (DECC, 2016).

Polycyclic aromatic hydrocarbons (PAH) concentrations in seawater vary widely, from 0.001 ng/l to 0.3 ng/l but can reach 8,500 ng/l in estuaries and coastal areas. A study by Webster *et al*. (2017) investigated the concentration of PAHs in environmental (water, fish, sediment, and deep water sponges) samples collected in 2014 and 2016 from the Faroe-Shetland Channel. Concentrations in all water samples were low (between 4.3 and 24.7ug/l) and typical of reported background concentrations.
The OSPAR (2000) Quality Status report gives an indication of the background reference concentration ranges for a limited number of metals in seawater: cadmium 5 to 25 ng/l, mercury 0.1 to 0.5 ng/l, lead 5 to 20 ng/l and copper 50 to 360 ng/l. It also states that for oceanic and offshore areas the reported concentrations are comparable to the background reference concentrations.

No water quality data are presented in the most recent Quality Status Report (OSPAR, 2010a), and the assessment in relation to seawater quality concentrates on measures in coastal areas around the North Sea to reduce inputs of hazardous substances (metals and persistent organic compounds), nutrients (particularly related to agricultural land run-off) and litter such as plastics. Eutrophication due to nutrient inputs is not regarded as an issue in the northern North Sea, as nutrient concentrations here are at background levels and most endemic plankton are unaffected by increased nutrient loading (DECC, 2016).

4.2.7 Seabed Sediments and Features

4.2.7.1 Descriptions of seabed surveys

Information on the seabed sediments, habitats and species within the Rosebank Development area has been obtained from:

- Regional studies including AFEN (Bett, 1996; 1998; AFEN, 2000; 2001), SERPENT survey programmes (SERPENT, 2008; 2009a, b, c) and DECC OESEA3 programme (DECC, 2016); and
- Surveys conducted for the Rosebank Development or related to the earlier exploration and appraisal drilling activities as shown in Table 4-1.

The key available seabed survey data relate to the following parts of the Rosebank Development area as summarised in Table 4-3 and Table 4-4 and illustrated in Figure 4-4 and Figure 4-5:

- The Rosebank field:
    - Surveys conducted specifically in the Rosebank infield area in 2010, 2011, 2012, 2014 and 2021; and
    - Surveys conducted along present and previously-considered gas export pipeline routes in 2010, 2012 and 2022, with some stations located in the infield area.
- The gas export pipeline route:
    - Surveys conducted for the gas export pipeline route to Clair Tee-2 in 2011 and 2022; and
    - Surveys conducted for previously-considered gas export pipeline routes in 2012 which provide useful information for the proximal parts of the route in 2012 and 2014.

The results of the environmental data review are included in the following sections. Methodology specific to the interpretation of seabed habitats and species of conservation importance is discussed in Section 4.3.2.

Table 4-3 Summary of key seabed surveys conducted in the Rosebank field area

Year of survey	Report references	Survey and sampling stations (see Figure 4-4 for locations)	Survey and sampling methods
2022	DNV (2022a, b)	29 Seven environmental stations (ENV01, ENV02, ENV08, ENV09, ENV10, ENV11 and ENV29_314-ENV29) providing up-to-date baseline data from the deeper parts of the gas export pipeline route corridor and a previously-considered route corridor south-west to the Cambo field, which provide further up-to-date baseline information for the Rosebank infield area.	Visual survey using ROV around each sampling station to a distance of 50 m. Box corer, van Veen grab and push coer for obtaining samples for sediment physico-chemical and macrofauna. Special attention paid to any OSPAR and Annex 1 habitats and species.
2021	Akvaplan (2022a, b)	19 environmental stations (ENV-01 to ENV-19) providing up-to-date baseline data representative of the likely area of impact from the Rosebank Development in the Rosebank field area.	Video Assisted Multi Sampler (VAMS) equipped with: • ROV for seabed photography (visual inspection for habitat types for a minimum of 3 minutes over an area of minimum 10 m radius); • Five grabs for obaining samples for sediment physico-chemical characteristics and macrofauna.
2014	Fugro (2014; 2015a, b, c)	Geophysical survey over three areas overlapping with and extending the area surveyed in 2011.	Geophysical: Autonomous underwater vehicle (AUV) collecting data using SSS, MBES, single-beam echosounder (SBES) and sub-bottom profiler.

Year of survey	Report references	Survey and sampling stations (see Figure 4-4 for locations)	Survey and sampling methods
		Six environmental stations (ENV01, 02, 03, 07, 08, 09, 10) and six video transects (TR01, 02, 07, 08, 09, 10) selected to provide good coverage of the survey areas. Video transects used to investigate specific features identified from geophysical data; drop-down camera locations positioned to ground-truth all the different sediment types identified from the geophysical data and identify the habitats and sediments present.	Environmental: drop-down camera for seabed photography; box-corer for obtaining samples for sediment physico-chemical characteristics and macrofauna.
2012	Fugro (2012a, b, c)	Geophysical survey over previously-considered Rosebank to Shefa cable route corridor and deep-water sections of previously-considered Rosebank to HT2 and Rosebank to Laggan gas export pipeline route corridors. One environmental station (RH30) in the Rosebank infield area and another (RH29) to the south-east in slightly shallower water, both representing general seabed conditions (areas of low reflectivity).	Geophysical: AUV collecting data using SSS, MBES, SBES and SBP. Environmental (along Rosebank to HT2 pipeline route corridor only): drop-down camera for ground-truthing seabed conditions; dual 0.1 m^2 van Veen grab for obtaining samples for sediment physico-chemical characteristics and macrofauna. Special attention was paid to any OSPAR List of Threatened and/or Declining Species and Habitats, Annex I habitats or other sensitive habitats previously recorded in the region such as Priority Marine Features (PMFs).
2010 and 2011	Fugro (2011a)	Geophysical survey over the entire Rosebank infield area (approximately 162 km^2), including the currently proposed location of the FPSO. Seven environmental stations (EBC101, 103, 105, 113, 310, 312, 313) selected to investigate the range of sediment types and features indicated by acoustic survey (mounds, a depression and possible sediment boundary).	Geophysical: multibeam echo sounder (MBES), side scan sonar (SSS), chirp sub-bottom profiler. Environmental: drop-down camera for seabed photography; box-corer for obtaining samples for sediment physico-chemical characteristics and macrofauna.
2010 and 2011	Fugro (2011b)	Geophysical survey and sampling at three environmental stations (ST202, 301 and 302) in the deeper parts of a gas export pipeline corridor from Rosebank to Clair and a previously-considered pipeline route from Rosebank to Laggan, selected to represent general seabed conditions (areas of low reflectivity).	Geophysical: AUV collecting data using MBES, SSS, chirp sub-bottom profiler. Environmental: deepwater camera system with digital stills and video for seabed photography; 0.25 m^2 box-corer for obtaining samples for sediment physico-chemical characteristics and macrofauna.

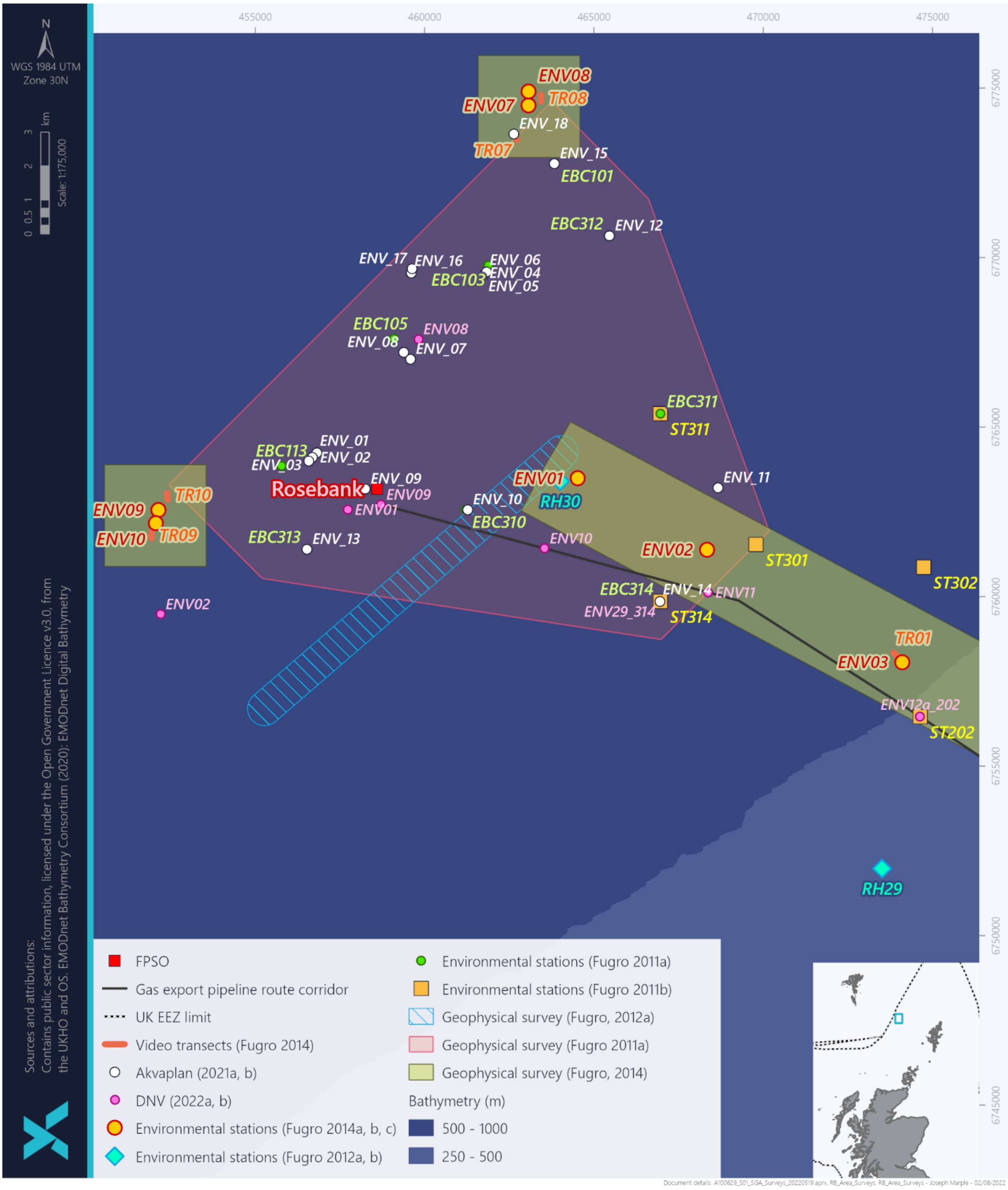


Figure 4-4 Environmental survey areas and stations in the Rosebank field

Table 4-4 Summary of seabed surveys on the gas export pipeline route and adjacent areas

Year of survey	Report references	Survey and sampling stations (see Figure 4-5 for locations)	Survey and sampling methods
2022	DNV (2022a, b)	22 environmental stations (ENV08-ENV29) distributed along the entire gas export pipeline route corridor, providing up-to-date and comparative baseline data representative of the likely area of impact from the Rosebank Development. Stations were selected to be representative of the depth variation and evenly spaced along the route (2-4 km apart), with final placement informed by previous geophysical survey data to investigate features of potential interest. Where relevant, stations surveyed by Fugro (2011b) were revisited.	Visual survey using ROV around each sampling station to a distance of 50 m. Box corer, van Veen grab and push corer for obtaining samples for sediment physico-chemical and macrofauna. Special attention paid to any OSPAR and Annex 1 habitats and species.
2014	Fugro, 2014, 2015a	Geophysical and environmental survey along a previously-considered gas export route from Rosebank to Tormore. Three environmental stations (ENV03, 04, 06) and several video transects selected to provide good coverage of the survey area and investigate specific features identified from geophysical data.	Geophysical: Autonomous underwater vehicle (AUV) collecting data using SSS, MBES, single-beam echosounder (SBES) and sub-bottom profiler. Environmental: drop-down camera for seabed photography; box-corer for obtaining samples for sediment physico-chemical characteristics and macrofauna.
2012	Fugro (2012b, c)	Geophysical and environmental surveys of previously-considered gas export pipeline corridors from Rosebank to HT2 (south-east of Shetland) and from Rosebank to Yell Sound (north of Shetland). Eight environmental stations on the Rosebank to HT2 route (RH23 to RH30) and two stations on the Laggan to Yell Sound route (LY11, LY12) are in the same depth range as the proposed gas export pipeline route and also cross the Faroe-Shetland Sponge Belt NCMPA. These stations do not lie within the expected impact area of the Rosebank Development but are considered here as they may inform the variation in seabed conditions in nearby areas. Stations are approximately equidistant along the route to represent general seabed conditions (areas of low reflectivity). *Note that shallower stations on these routes that fall within the mapped area have been greyed out as they are not considered relevant to the ES.*	Geophysical: SSS, MBES, SBES and SBP (using AUV for deeper parts of the route and conventional ship-based techniques for areas <250 m water depth). Environmental: drop-down camera for ground-truthing seabed conditions; dual 0.1 m^2 van Veen grab for obtaining samples for sediment physico-chemical characteristics and macrofauna. Special attention was paid to any OSPAR List of Threatened and/or Declining Species and Habitats, Annex I habitats or other sensitive habitats previously recorded in the region such as Priority Marine Features (PMFs).
2011	Fugro (2011b)	Geophysical survey along the entire Rosebank to Clair gas export pipeline route corridor and along a previously-considered gas export route to Laggan field. Environmental: • Thirteen stations (ST202, 204, 205 to 208, 212 on the continental shelf and 214, 215, 219, 222, 301 and 311 on the continental slope) approximately equidistant along the entire Rosebank to Clair gas export pipeline	Geophysical: MBES, SSS, SBP (using AUV at water depths >250 m and conventional equipment in shallower areas). Environmental: deepwater camera system with digital stills and video for seabed photography; 0.25 m^2 box-corer for obtaining samples for sediment physico-chemical characteristics and macrofauna.

Year of survey	Report references	Survey and sampling stations (see Figure 4-5 for locations)	Survey and sampling methods
		corridor, to represent general seabed conditions (areas of low reflectivity). • Six stations (ST303 to ST308) along a previously-considered gas export pipeline route to Laggan field, representing similar depth range to deeper parts of proposed gas export pipeline route.	

4.2.7.2 Faroe-Shetland Channel

As discussed in Section 4.1, the Rosebank field and the majority of the gas export pipeline route are located on the eastern flank of the Faroe-Shetland Channel, which forms the continental slope west of Shetland.

UKSeaMap 2021 provides a 100 m resolution habitat map which includes the Rosebank Development area (JNCC, 2021a). This describes the seabed within the Rosebank field and deeper parts of the gas pipeline route as deep sea mud and deep sea mixed substrata, with sediments becoming coarser further up the continental slope (Figure 4-6).

The slope of the Faroe-Shetland Channel comprises features related to slope instability, erosion and iceberg scouring (DECC, 2016). The channel is characterised by fine sandy and muddy sediments, with a variety of physical features including dense iceberg plough marks (relict glacial scarring features), sediment fans and down-slope channels along the shelf edges. Many of the features which characterise the present-day West Shetland continental slope were formed during the last glacial period. However, in deeper waters, there is evidence to suggest that along-slope currents were also active in moulding the present-day sediments and features (AFEN, 2001). The Faroe Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA) includes several features of conservation importance, including pilot whale diapirs which are series of seabed sediment mounds measuring 2 to 3 km across and rise over 70 m above the seafloor (DECC, 2016; see Section 4.4.1 for further information on the NCMPA). Figure 4-7 illustrates the seabed features recorded in the Rosebank Development area.

As water depths decrease up the continental slope, the seabed changes from the muddy sediments of the channel floor to sediments of more variable nature, disturbed by slope failure and mass flow (characterised by long wavelength sediment waves between 500 to 850 m depth), through to areas of potential iceberg plough marks with equally variable sediments towards the top of the slope (AFEN, 2001). Iceberg plough marks are very common along the outer shelf and upper slope area in water depths ranging from 200 to 500 m. Typical plough marks range from several tens to a few hundred metres wide. Regional surveys discovered coarse gravel and stones in the raised ridge areas around the plough mark edges and finer material that has since infilled the central grooves (AFEN, 2001).

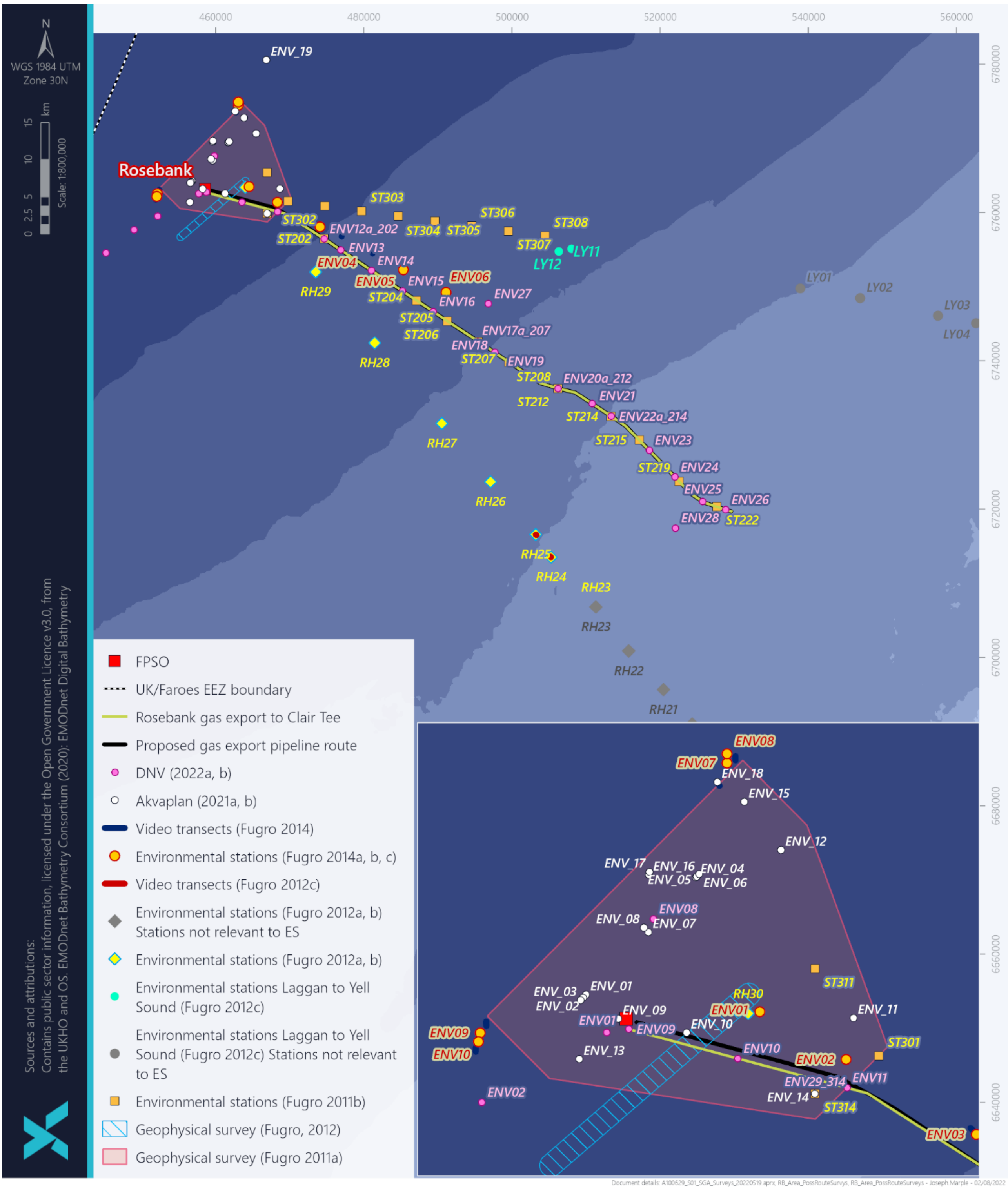


Figure 4-5 Environmental survey areas and stations along the gas export pipeline route and in nearby areas

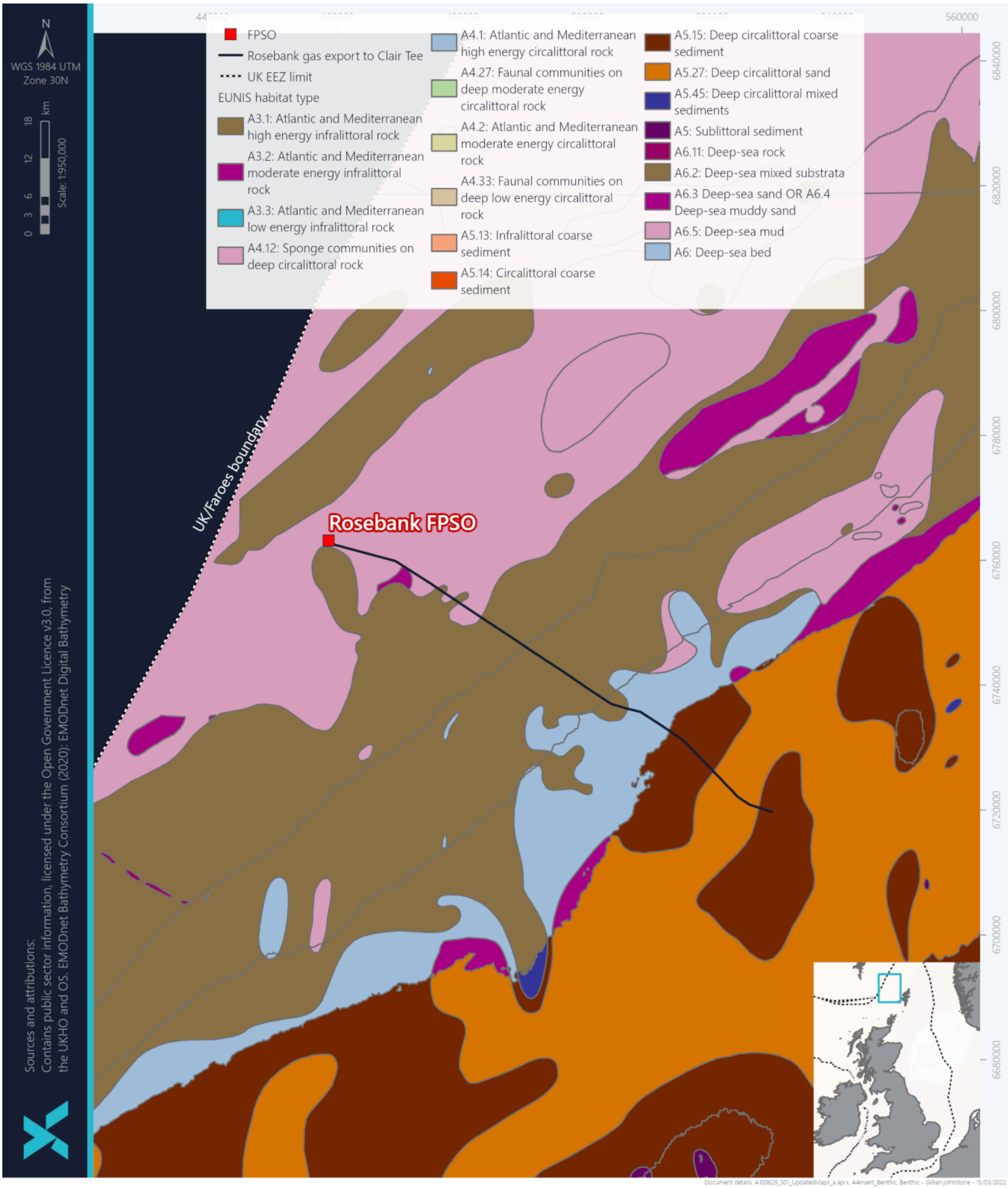


Figure 4-6 EUNIS seabed habitat classification in the region of the Rosebank Development (UKSeaMap, 2021)

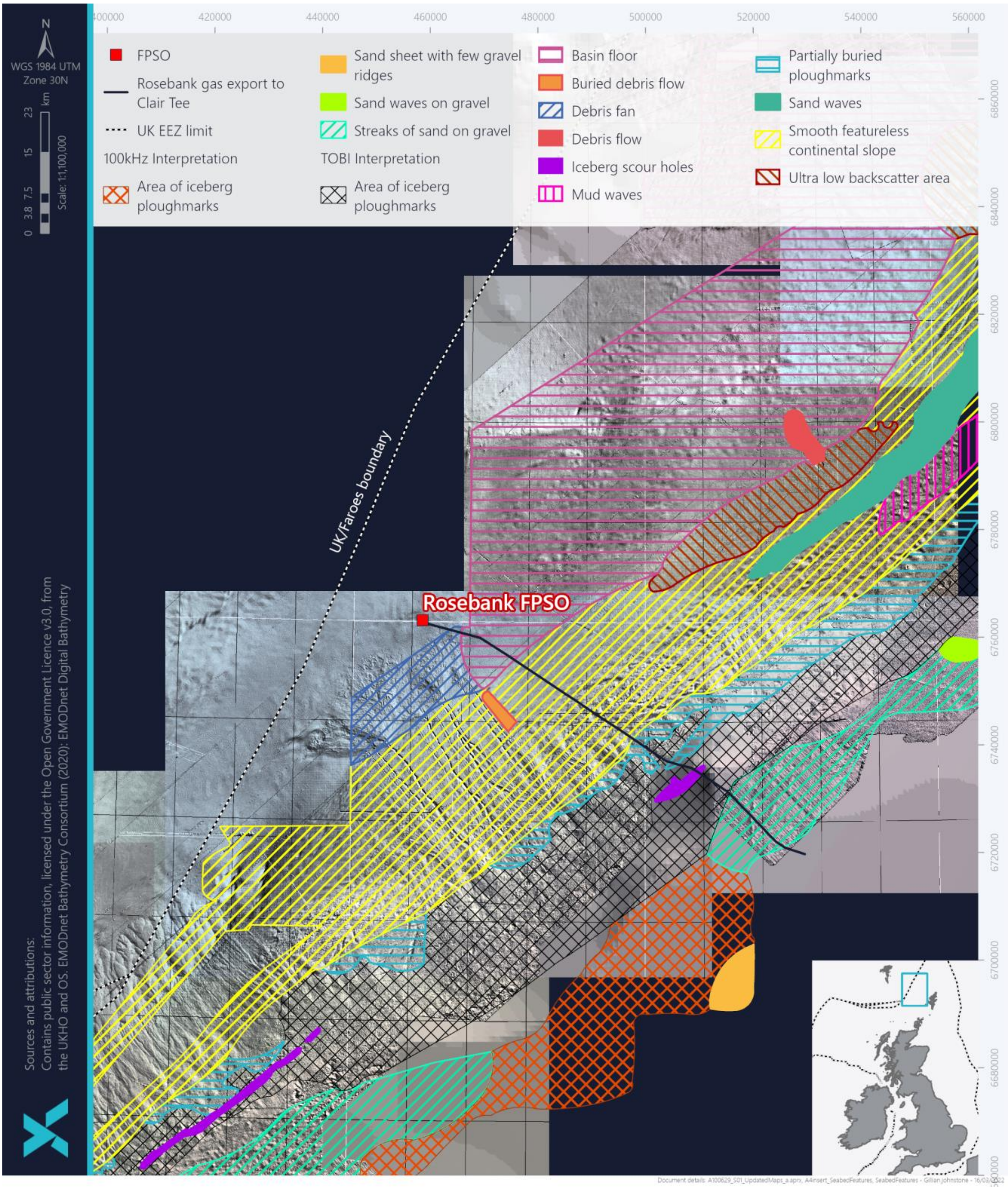


Figure 4-7 Seabed features in the Rosebank Development area

Side scan sonar data acquired in the Rosebank in-field area in 2011 (Figure 4-4) showed seabed sediments to comprise very soft, sandy clay (Fugro, 2011a). In the additional locations surveyed in 2014 (Figure 4-4), the seabed was interpreted as silty gravelly fine sand (Fugro, 2014a). In both surveys undertaken within the in-field area, numerous sonar contacts were observed and identified as boulders or glacial drop stones deposited from the base of ice sheets. Many of these sonar contacts had some degree of scour associated with them, to the extent that a considerable number of the contacts lay within well-defined small depressions (Fugro, 2011a, 2014a). Mounds were also observed, with diameters of up to 25 m and heights of 1 m. These are thought to have been formed by near-seabed currents and are not considered biogenic[26] in origin. These results are in agreement with the findings of earlier surveys and observations (AFEN, 2001; Hartley Anderson, 2003).

The early in-field remote sampling showed some variability in sediment composition but no discernible spatial trends (Fugro, 2011a). The majority of stations were described overall as very soft slightly or very sandy clay, generally dominated by silt and clay fractions (i.e. mud, or 'fines'), but also including significant sand and coarse fractions. Fines contents were relatively high and increased with water depth, ranging between 32% at Station EBC313 to 72% at Station EBC101 (Figure 4-4 shows the locations of these stations). The four in-field stations sampled in 2014 had sediment types described as gravelly muddy sand dominated by sandy fractions, although Station ENV10 was dominated by mud (Fugro, 2015a). Fines contents at these stations from 2014 ranged overall from 25% to 55% at Stations ENV7 to ENV10, all at similar depths of 1,108 to 1,160 m (Fugro, 2015a), and similar to values recorded at the closest station at a similar depth sampled in 2011 (46% at Station EBC310). The Rosebank to Tormore pipeline survey interpreted the seabed as silty gravelly fine sand, with numerous small depressions and mounds identified along the route (Fugro, 2015a).

The 2021 infield survey consisted of samples collected at 19 stations using a video-assisted multi sampler (VAMS) equipped with four 0.15 m^2 combi grabs and one 0.1 m^2 grab. Sediments sampled (see Table 4-3 and Figure 4-4) were classified as fine sand and silt with the fine sand proportion varying from 25.2% to 46.5% and the silt proportion ranging from 28.7% to 59.1% (Akvaplan, 2022a). Images taken at stations ENV-17 are provided in Figure 4-8, showing the typical sediment type that was observed across the Rosebank infield survey area (Akvaplan, 2022b). The stations across the Rosebank location had a relatively homogeneous substrate that was mainly dominated by soft sediment with some gravel and boulders. Since there was high homogeneity between the stations at Rosebank, all the stations were classified into the same EUNIS category: 'deep sea muddy sand'. The 2021 infield survey data confirmed the regional-scale information for west of Shetland, where the broad habitat type is categorised as deep sea mud and deep sea mixed substrata (EUNIS, Figure 4-6). These results were consistent with the sediment type observed during earlier surveys at the Rosebank field as described above and shown in Figure 4-9.

[26] Biogenic - created by or resulting from the activity of organisms.

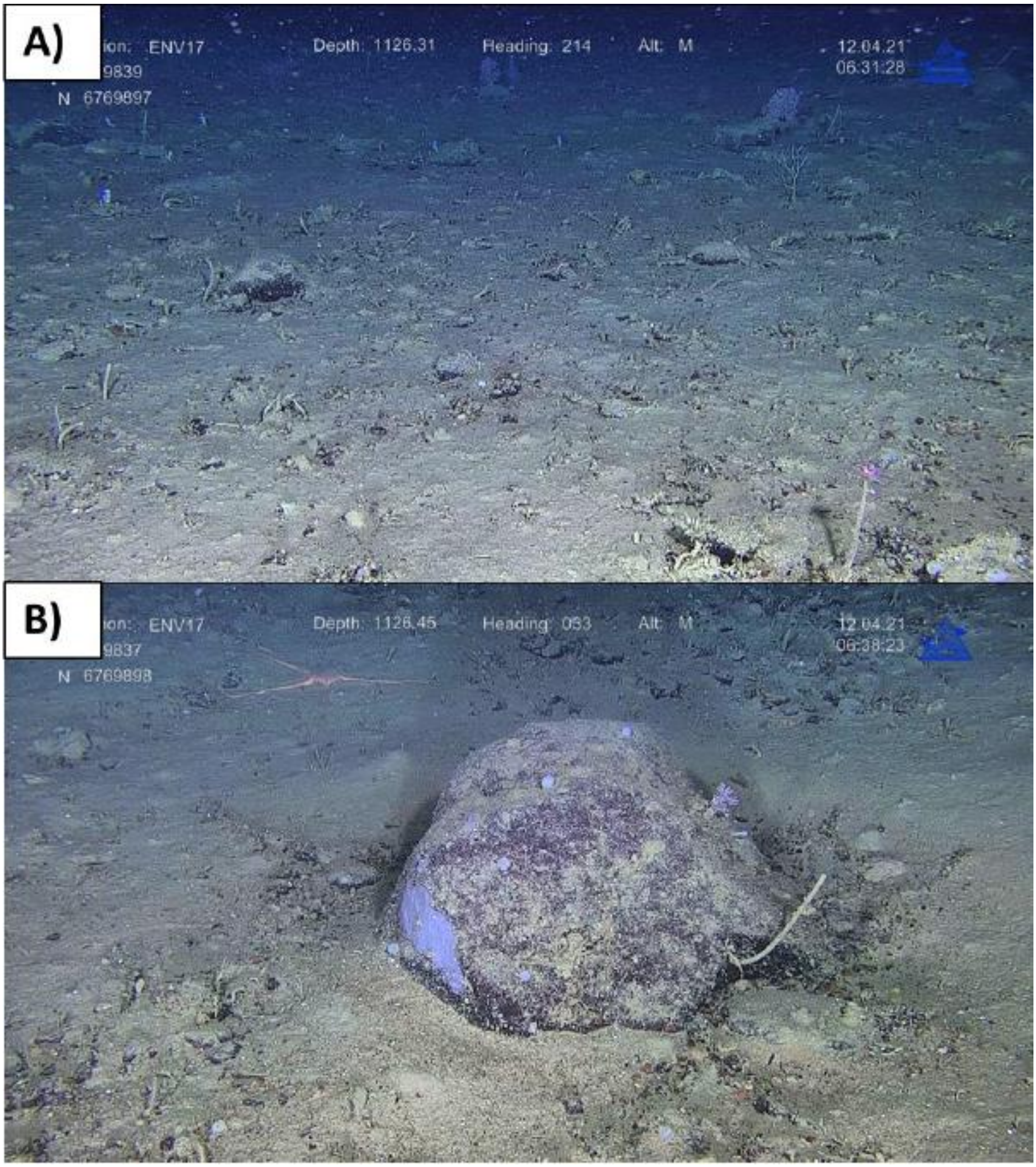


Figure 4-8 Typical sediments at the Rosebank field during the 2021 survey: A) muddy sand with gravel; B) boulders with encrusting organisms (taken at station ENV-17; Akvaplan, 2021b)

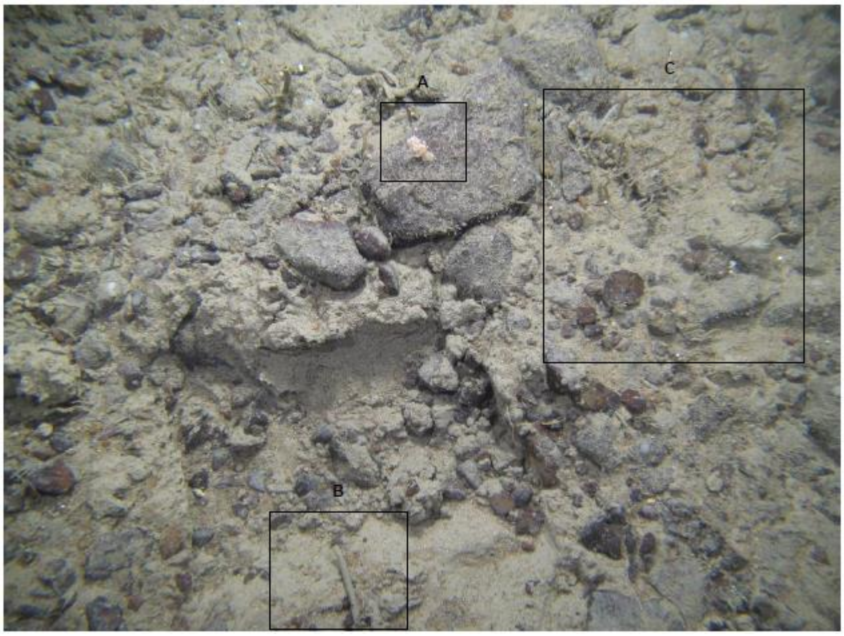


Photo no: 79
Easting: 461 309.61 mE
Northing: 6 762 792.65 mN
Depth: 1104 m

Sediment Description:

Silty clay with frequent pebbles and gravel, occasional cobbles and boulders

Fauna Description:

A: Soft coral (Anthozoa)

B: Worm tube

C: Faunal turf

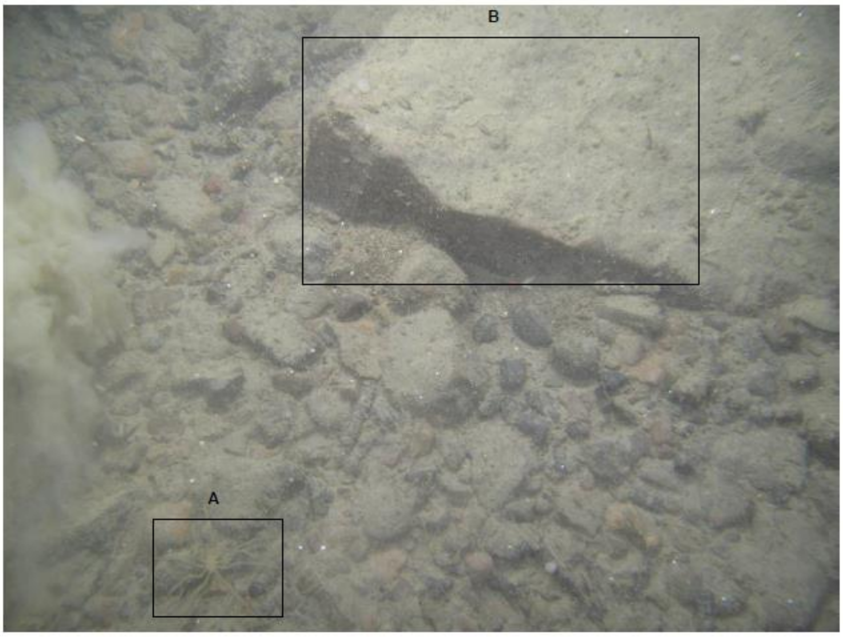


Photo no: 69
Easting: 456 636.84 mE
Northing: 6 761 619.54 mN
Depth: 1098 m

Sediment Description:

Silty clay with frequent pebbles and gravel, occasional cobbles and boulders

Fauna Description:

A: Sea spider (Pycnogonida)

B: Faunal turf

Figure 4-9 Images of typical seabed observed during the 2011 survey of the Rosebank field (Fugro, 2011a); images are from station EBC310 and likely to be representative of the potential area of impact of the subsea infrastructure.

A survey of the Sula and Stelkur prospects 15 km east of Rosebank found some variability between stations, with sediments described overall as gravelly muddy sand with sands dominating and fines contents varying between 16.6 – 44.1% (Gardline, 2009). Surveys conducted in blocks directly adjacent to Block 213/27 (which is the proposed location of the Rosebank FPSO) also showed predominantly soft sediments with the proportions of fine particles ranging from 21 – 63% at the Tranche 6 well location in Block 213/23, and 19–60% and 17-51% respectively at surveys in Blocks 213/23 and 213/28 in 2007 (OGUK, 2019).

The 2010 gas export pipeline route survey from Rosebank to Clair (Fugro, 2011b) showed that seabed sediments on the continental slope generally transitioned from sandy silts / clays in the deepest regions (depths greater than 770 m) through clayey fine to coarse sands (770 – 600 m) and sandy clay with a discontinuous veneer of sand (600 – 350 m) to fine to coarse, occasionally sands / gravelly sands in the shallower regions(350 – 200 m).

The 2022 gas export pipeline route survey (DNV, 2022a, b) followed the same route, with eighteen stations sampled in the infield area and on the continental slope up to the shelf break (stations on the continental shelf are discussed below in Section 4.2.7.2). Sediment samples were obtained using a box corer, van Veen grab or push corer, and observations were made of the seabed to a distance of 50 m around each station using an ROV. Some of the stations sampled by Fugro (2011b) were revisited (Table 4-5).

DNV (2022a, b) observed similar depth-related trends in the seabed to those recorded in the earlier survey. The sediment analysis results showed a general increase in silt/clay with increasing water depth, with levels of total organic carbon (TOC) and total nitrogen (TN) showed a corresponding general increase towards the deeper stations. There were, however, exceptions to this general trend, with some deeper stations showing elevated amounts of coarser material (Table 4-5 and Figure 4-10). The results corresponded well with those from the visual survey (DNV, 2022a), which showed a relatively high level of heterogeneity along the pipeline route, but with sediments becoming less coarse with increasing water depth. Interpreted classification of the seabed into EUNIS categories is included in Table 4-5 and discussed further in Section 4.3.2. The relatively high amounts of sand at the deeper stations indicates that the area is subject to relatively strong bottom current systems. Strong current patterns were experienced particularly at stations ENV 20a_212, ENV19, ENV 18, ENV 17a_207, ENV 27 situated on the slope with rapid changes in water depth of approximately 350 - 550 m. This area was also the most heterogeneous both with regards to faunal communities (Section 4.3.2) as well as sediment composition. Representative image examples from different water depths on the continental slope obtained during the 2022 survey are shown in Figure 4-11 with those obtained in 2011 from similar locations are shown in Figure 4-12.

Table 4-5 Key sediment characteristics and EUNIS habitat classification along the gas export pipeline route in descending water depth from the Rosebank field to the shelf break (>200 m depth) (DNV, 2022a, b)

Sampling station	Water depth (m)	Sediment classification	EUNIS classification (Level 3/Level 4)	Silt/clay (%)	Gravel (%)	TOC (%)	TN (mg/kg)
ENV08	1,110	Very fine sand	A6.5 Deep-sea mud/ A6.52 Communities of abyssal muds	39.07	5.17	0.48	460
ENV02	1,103	Silt and clay	A6.5 Deep-sea mud/ A6.52 Communities of abyssal muds	73.51	0.72	0.53	490
ENV10	1,102	Fine sand	A6.5 Deep-sea mud/ A6.52 Communities of abyssal muds	18.45	0.72	0.48	450
ENV01	1,101	Very fine sand	A6.5 Deep-sea mud/ A6.52 Communities of abyssal muds	37.00	1.18	0.31	710
ENV09	1,100	Very fine sand	A6.5 Deep-sea mud/ A6.52 Communities of abyssal muds	38.71	3.77	0.42	560

Sampling station	Water depth (m)	Sediment classification	EUNIS classification (Level 3/Level 4)	Silt/clay (%)	Gravel (%)	TOC (%)	TN (mg/kg)
ENV11	1,095	Silt and clay	A6.5 Deep-sea mud/ A6.52 Communities of abyssal muds	69.05	1.51	0.43	450
ENV29_314[1]	1,099	Very fine sand	A6.5 Deep-sea mud/ A6.52 Communities of abyssal muds	42.32	0.12	0.48	430
ENV12a_202[1]	991	Fine sand	A6.5 Deep-sea mud/ A6.52 Communities of abyssal muds	12.84	9.92	0.26	390
ENV13	920	Fine sand	A6.4 Deep-sea muddy sand/ No classification	29.75	1.55	0.35	390
ENV14	779	Fine sand	A6.4 Deep-sea muddy sand/ No classification	21.08	1.79	0.41	410
ENV15	689	Fine sand	A6.4 Deep-sea muddy sand/ No classification	15.06	2.91	0.43	420
ENV16	615	Fine sand	A6.2 Deep sea mixed substrata/ A6.21: Lag deposits	15.51	12.04	0.44	310
ENV27	556	Medium sand	A6.2 Deep sea mixed substrata/ A6.21: Lag deposits	5.44	10.12	0.52	300
ENV17a_207[1]	523	Fine sand	A6.2 Deep sea mixed substrata/ A6.21: Lag deposits	16.99	3.27	0.26	380
ENV18	493	Medium sand	A6.2 Deep sea mixed substrata/ A6.21: Lag deposits	6.30	2.75	0.39	360
ENV19	425	Medium sand	A6.2 Deep sea mixed substrata/ A6.21: Lag deposits	11.42	6.65	0.42	280
ENV20a_212[1]	352	Fine sand	A6.2 Deep sea mixed substrata/ A6.21: Lag deposits	8.77	2.58	0.35	250
ENV21	251	Medium sand	A5.1 Sublittoral coarse sediment/ A5.15: Deep circalittoral coarse sediment	0.72	12.72	0.22	170

[1] Station also sample by Fugro (2011).

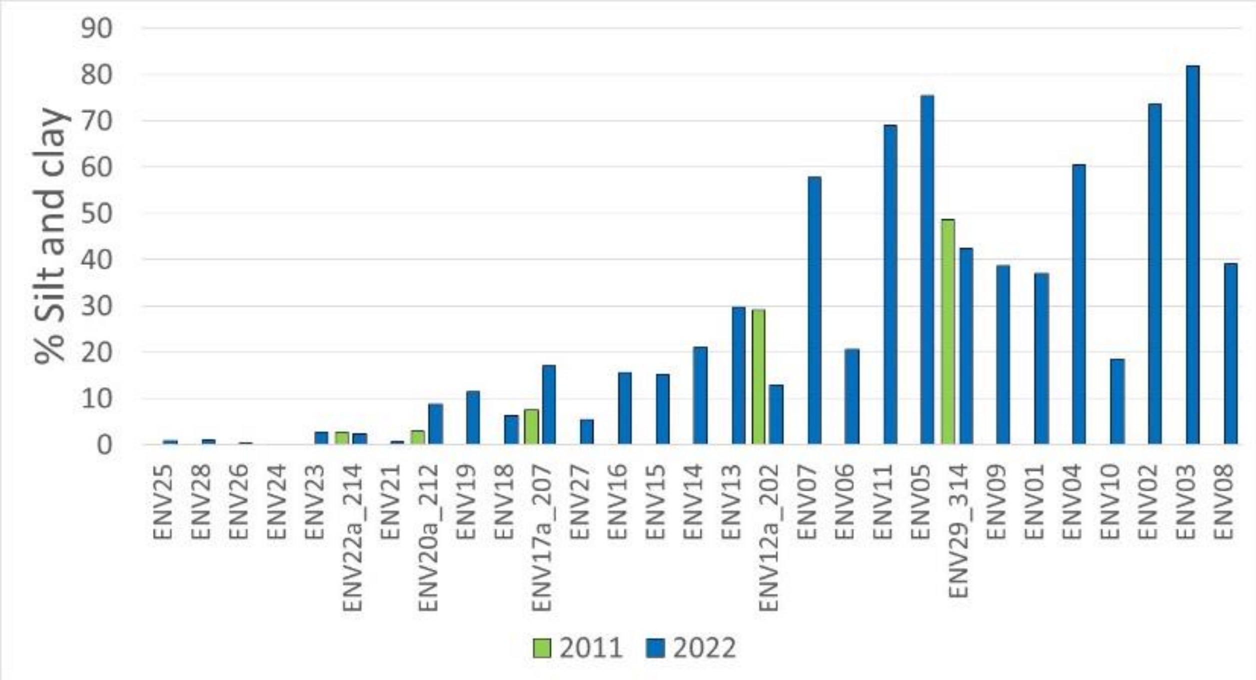


Figure 4-10 Proportions of silt/clay in sediments along the gas export pipeline route (stations arranged in order of increasing water depth) (DNV, 2022 b)*

*Note that the figure also includes stations ENV03, 04, 05, 06 and 07, situated on a previously-considered route from Rosebank to the Cambo field.

Station ENV12a_202; depth: 991 m; sediment description: sand/mud and parts of transect consisting mainly of gravel; fauna description: single occurrences of the soft coral *Gersemia.*

Station ENV14; depth 779 m; sediment description: muddy/sandy homogeneous sediment with a few boulders; fauna description: scattered to patchy occurrences of soft coral *Gersemia* and pycnogonids.

Station ENV27; depth 556 m; sediment description: heterogenous sediment consisting of areas of gravel, pebbles and sand; fauna description: scattered to no occurrences of hardbottom sponges.

Station ENV20a_212; depth 352 m; sediment description: sandy sediment with larger areas of gravel; fauna description: moderate number of species.

Figure 4-11 Representative images of the seabed at different depths along the gas export pipeline route (DNV, 2022a/b)

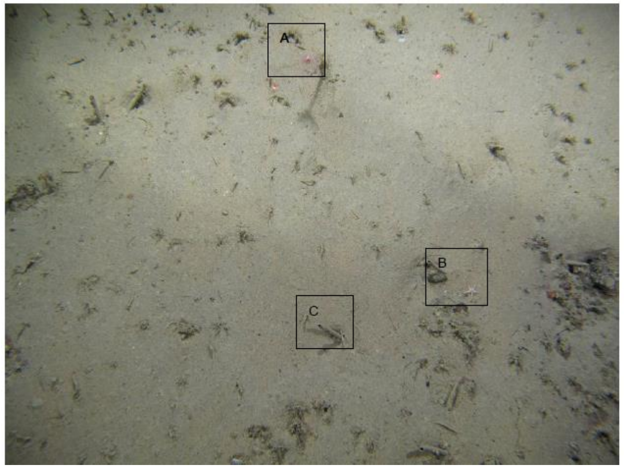


Photo no: 59
Easting: 474 726.5 mE
Northing: 6 756 677.1 mN
Depth: 991 m

Sediment Description:

Silty clay with pebbles

Fauna Description:

A: Anemone (Actiniaria)
B: Brittle star (Ophiuroidea)
C: Tube worm (Polychaeta)

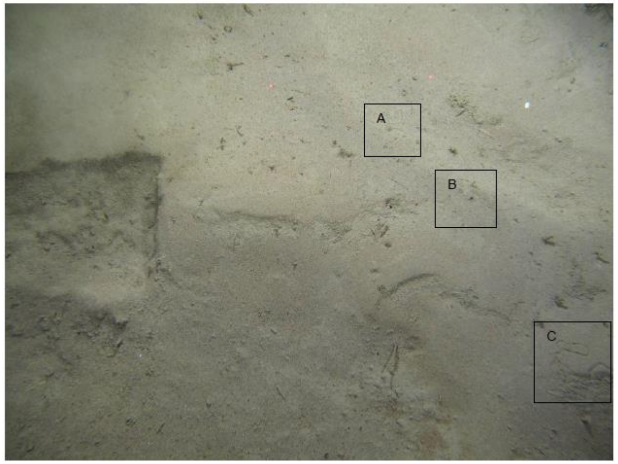


Photo no: 64
Easting: 483 044.3 mE
Northing: 6 751 128.1 mN
Depth: 729 m

Sediment Description:

Silty clay

Fauna Description:

A: Sea pen (*Virgularia Mirabilis*)
B: Bioturbation (burrow)
C: Bioturbation (tracks)

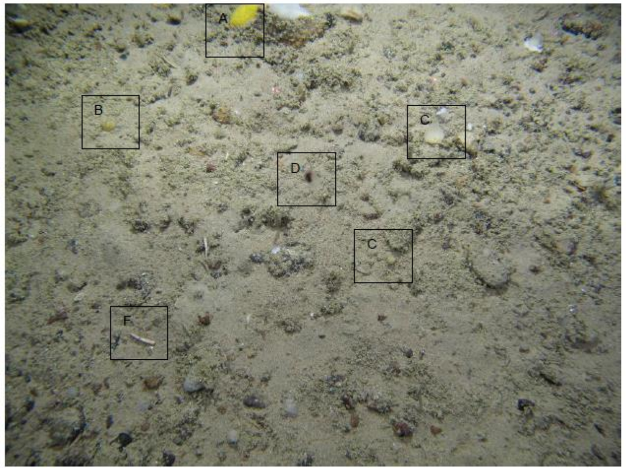


Photo no: 72
Easting: 491373.1 mE
Northing: 6 745 578.1 mN
Depth: 584 m

Sediment Description:

Silty sandy clay with gravel

Fauna Description:

A: Encrusting yellow sponge (Porifera)
B: Bivalve (Bivalia)
C: sponge (Porifera)
D: Krill (Euphausidae)
F: Tusk shell (Scaphopoda)

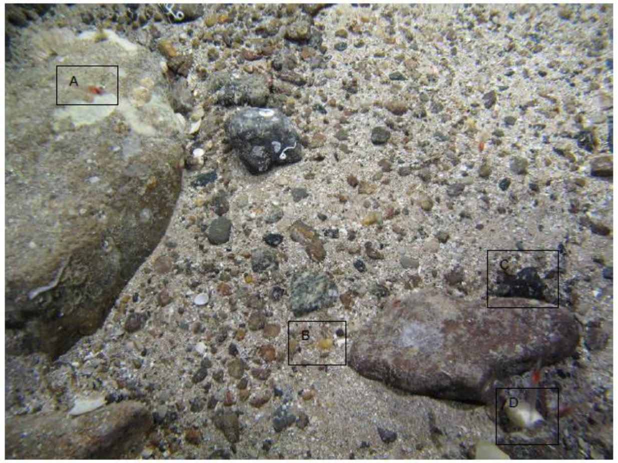


Photo no: 88
Easting: 506 299.0 mE
Northing: 6 736 502.2 mN
Depth: 351 m

Sediment Description:

Silty sand with shell fragments and pebbles

Fauna Description:

A: Krill (Euphausidae)
B: Bivalve (Bivalvia)
C: Sponge (Porifera)
D: Anemone (Anthrozoa)

Figure 4-12 Images of typical seabed observed at different depths on the continental slope along the Rosebank to Clair gas export pipeline route survey in 2010 (Fugro, 2011b). Station locations are shown in Figure 4-5.

Top left – Station 202, 991 m depth; top right – Station 204, 729 m depth; bottom left – Station 206, 584 m depth; bottom right – Station 212, 351 m depth

The NMPi (2022) indicates the presence of offshore subtidal sands and gravels, designated as Scottish Priority Marine Features (PMFs), within the Rosebank Development area. This aligns with the site-specific surveys undertaken, in which sediments sampled from the Rosebank field up to the shelf break were dominated by sand with variable proportions of silt/clay and gravel. Offshore subtidal sands and gravels are features of the Faroe-Shetland Sponge Belt NCMPA that is crossed by the Rosebank pipeline, as discussed in Section 4.4.1.

Offshore deep-sea muds, recorded in the Rosebank field and deeper parts of the gas export pipeline route, are also a PMF (NMPi, 2022).

4.2.7.3 Continental Shelf

The proposed gas export pipeline route to the Clair Tee would extend approximately 85 km up the continental slope and onto the West Shetland Continental Shelf to water depths of around 120 m. The portion of the pipeline route located within the Continental Shelf is approximately 22 km in length.

The seabed on the West Shetland Continental Shelf consists mainly of unconsolidated sediments ranging from boulders to sand and fine mud, though rocky outcrops are common, especially where bottom currents are strong or where there is a positive relief (Stoker *et al*., 1993). The sedimentary bedforms show considerable variability in grain size, with sand and gravelly sediments scattered throughout the shelf. These bedforms occur as sand streaks, sand ribbons and longitudinal sand patches aligned along-shelf or parallel to the coastline by tidal streams (Hartley Anderson, 2000). The superficial sediments are often only a few centimetres deep, overlying coarser material of glacial origin. On the shelf the finer sediments are transported away from areas of high hydraulic energy, leaving coarser gravelly sediments, and are deposited in lower-lying seabed areas, e.g. in depressions where the currents are weaker.

The Clair gas export pipeline route survey (Fugro, 2011b) found the seabed sediments on the shallowest part of the route to be coarse to gravelly sands at depths of 121-200 m (Stations 214 and 222; Figure 4-13). The recent Clair gas export pipeline route survey (DNV, 2022a, b) recorded medium to coarse sands in this area, with highly variable quantities of gravel and low levels of silt/clay (Table 4-6; Figure 4-14). Surveys conducted at the Clair field, close to the proposed gas export pipeline tie-in point, in 2000, 2010, 2012, 2013 showed proportion of fines (particles <63 µm) to be low (0 and 5%) at the vast majority of sampling stations. The EUNIS habitats assigned by DNV (2022a) included A5.15 Deep circalittoral coarse sediment and A5.27 Deep circalittoral sand. These findings are consistent with the UKSeaMap 2021 data (Figure 4-6) which provide broad scale habitat mapping of UK waters. The continental shelf section of the Rosebank Development area is described as A5.15 Deep circalittoral coarse sediment and A5.27 Deep circalittoral sand (JNCC, 2021a).

Table 4-6 Key sediment characteristics and EUNIS habitat classification along the gas export pipeline route on the continental shelf (<200 m depth) (DNV, 2022a/b)

Sampling station	Water depth (m)	Sediment classification	EUNIS classification (Level 3/Level 4)	Silt/clay (%)	Gravel (%)	TOC (%)	TN (mg/kg)
ENV22a-214	191	Medium sand	A5.1 Sublittoral coarse sediment / A5.15: Deep circalittoral coarse sediment	2.37	8.27	0.34	220
ENV23	165	Medium sand	A5.1 Sublittoral coarse sediment A5.15: Deep circalittoral coarse sediment	2.79	2.15	0.29	220

Sampling station	Water depth (m)	Sediment classification	EUNIS classification (Level 3/Level 4)	Silt/clay (%)	Gravel (%)	TOC (%)	TN (mg/kg)
ENV24	140	Coarse sand	A5.1 Sublittoral coarse sediment/ A5.15: Deep circalittoral coarse sediment	1.00	18.21	0.18	220
ENV26	133	Medium sand	A5.2 Sublittoral sand A5.27 Deep circalittoral sand	0.49	0.39	0.18	270
ENV28	127	Medium sand	A5.2 Sublittoral sand A5.27 Deep circalittoral sand	1.03	0.89	0.15	180
ENV25	126	Medium sand	A5.2 Sublittoral sand A5.27 Deep circalittoral sand	0.89	2.45	0.22	210

The seabed surveys did not identify possible Annex I habitat ‘submarine structures made by leaking gases’ features in the infield area or along the proposed gas export pipeline route. There are no known locations of such Methane Derived Authigenic Carbonate (MDAC) structures in the Faroe-Shetland Channel (NMPi, 2022)

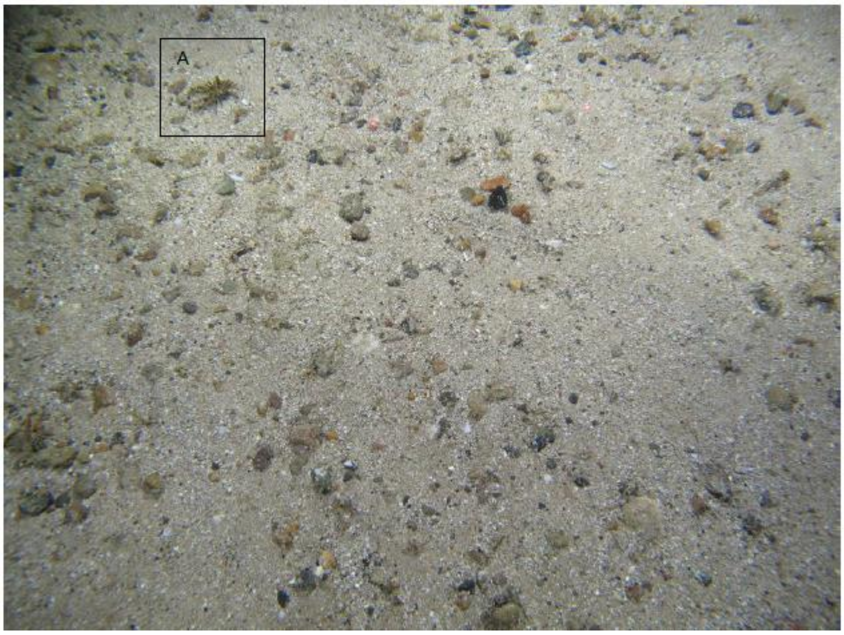


Photo no: 90
Easting: 513 483.0 mE
Northing: 6 732 742.0 mN
Depth: 172 m

Sediment Description:

Sand with shell fragments and pebbles

Fauna Description:

A:Bryozoa

Photo no: 99
Easting: 522 658.7 mE
Northing: 6 723 962.9 mN
Depth: 138 m

Sediment Description:

Silty sand with rare shell fragments

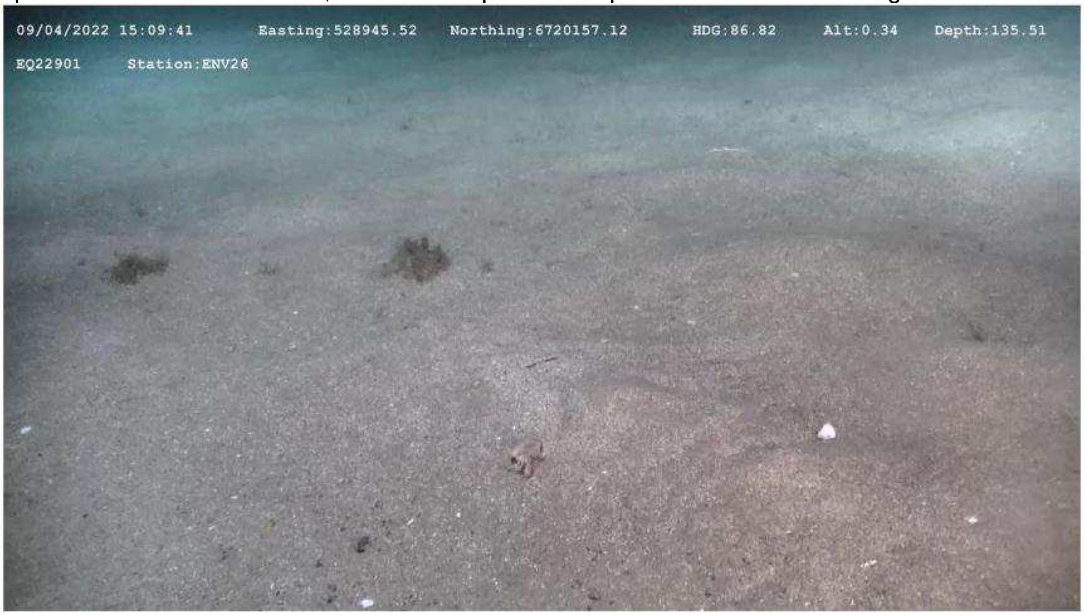
Fauna Description:

N/A

Figure 4-13 Seabed images from the West Shetland Continental Shelf from the Rosebank to Clair gas export pipeline route survey in 2010 (Fugro, 2011b). Station locations are shown in Figure 4-5.

Top – Station ST214, 172 m depth; bottom Station ST219, 138 m depth

Station ENV22a_214; depth 191 m; sediment description: sandy sediment with patches of pebbles and a few boulders; faunal description: few species and individuals registered.



Station ENV26; depth 133 m; sediment description: homogeneous sandy sediment with small patches of pebbles; faunal description: low abundance but relatively heterogenous macrofauna.

Figure 4-14 Seabed images from the West Shetland Continental Shelf from the Rosebank to Clair gas export pipeline route survey in 2022 (DNV, 2022a). Station locations are shown in Figure 4-5.

4.2.8 Sediment Chemistry

4.2.8.1 Faroe-Shetland Channel

Organic matter performs an important role in marine ecosystems, providing a source of food for benthic fauna, which may then be preyed upon by carnivores. Fugro (2011a) recorded a mean sediment total organic carbon (TOC) level of 0.39% in the Rosebank field, with similar results obtained in the infield survey in 2014 (TOC levels of 0.32 to 0.40% at Stations ENV07 to ENV10 at water depths of 1,108 to 1,160 m; Fugro, 2014b). The overall trend was for TOC values to increase with water depth. Values were lower than the regional mean level of 0.77% recorded in the area by AFEN (2000). During the 2021 survey in the Rosebank field, TOC ranged from 3.2 to 4.4 mg/kg (Akvaplan, 2022a).

Along the gas export pipeline route to Clare, Fugro (2011b) recorded TOC values ranging from 0.23 to 0.30% at those stations situated on the continental slope, while DNV (2022b) recorded TOC values ranging from 0.22 to 0.53% (
Table **4-5**, Table 4-6). Similarly low values, ranging from 0.22% at Station RH26 to 0.29% at Station RH29, were recorded in the deepwater section of the previously-considered pipeline route surveyed by Fugro (2012c).

Total hydrocarbon (THC) levels at all in-field stations sampled in 2010 were low, ranging between 0.6 and 1.3 µg/g (Fugro, 2011a) and were at similar levels at the four stations sampled in 2014 (0.7 to 1.3 µg/g; Fugro, 2014b). No significant anthropogenic contamination was recorded during these surveys, despite drilling activities having been conducted previously in the area.

The Rosebank infield survey conducted in 2021 reported more variable levels of THC in sediments, ranging from 1.3 µg/g (ENV-15) to 34.6 µg/g (ENV-18) (Akvaplan, 2022a). THC levels at Stations ENV-02 (27.2 µg/g) and ENV-18 were noticeably higher than at other stations. Evidence from gas chromatograms indicates that these higher levels are due to the presence of an elevated unresolved complex matrix (UTM), reflecting possible weathered hydrocarbon inputs.

Fugro (2011b) recorded low THC levels, ranging from 0.6 to 1.2 µg/g, along the gas export pipeline route from the Rosebank field to the shelf break. These levels were similar to those recorded in the Rosebank field in the 2010 survey and at other sites nearby and were considered as background concentrations for the region. Similarly low THC levels were recorded along the deeper parts of the route slightly further south: THC concentrations along the gas pipeline route from the Rosebank field to the shelf break (200 m) varied between 1.2 µg/g and 1.3 µg/g (Fugro, 2012c). DNV (2022b) recorded THC levels ranging from 3.0 to 7.3 µg/g along the gas export pipeline route from the Rosebank field to the shelf break. These levels are considered to be low and far from any threshold levels, e.g., 50 µg/g for THC cited by OGUK (2019). THC levels tended to increase with water depth and the amount of fines (silt/clay) in the sediments, as is expected due to the bonding affinity of THC to finer particles. The slightly higher levels recorded compared to the same area in 2011 may be due to differences in the solvent extraction techniques employed (DNV, 2022b). A mean concentration of 3.3 µg/g was recorded during the AFEN surveys in the area in 1996 and 1998, while the mean hydrocarbon concentration for the East Shetland Basin was 26.1 µg/g in 2002 and considered as a background concentration for the North Sea (DECC, 2016).

The results from sediment metals analyses in the early surveys for the Rosebank infield area (Fugro, 2011a, 2014b), along the gas export pipeline route to Clair (Fugro, 2011b) and a previously-considered route to the south (Fugro, 2012c) were indicative of background concentrations. The ranges of values recorded were consistent with those found during the regional surveys (AFEN, 2001; DTI, 2003) (See Table 4-7 for summary of results from Fugro, 2011a).

Levels of metals reported in the recent survey in the Rosebank field (Akvaplan, 2022a) are summarised in Table 4-7. The highest levels of barium, chromium, lead and zinc were found at Station ENV-08. There was, however, a significant difference in the metal content of the two replicates examined at Station ENV-08. Comparison with the results from Fugro (2011a) indicates that metals levels were lower than recorded in the earlier infield survey. However, this is most likely to be due to different analytical methodologies (complete digestion using hydrofluoric acid in 2011 and partial digestion using nitric acid in 2021), which means that the results are not directly comparable.

With respect to levels of metals along the portion of the gas export pipeline route from the Rosebank field to the shelf break, levels of metals recorded in the recent survey by DNV (2022b) are presented in Table 4-8. Levels were generally low and as expected for baseline samples. There was a general trend of increased concentrations with depth, as can be expected due to higher amounts of fine particles to which the metals can adhere. The levels of metals in the deeper stations in the Rosebank field area were very similar to those recorded in the same area by Akvaplan (2022b) in the 2021 infield survey. The levels of metals recorded along the gas export pipeline route by Fugro (2011b) were generally higher than in the recent survey, which is most likely to be due to different analytical methodologies as discussed above; however, similar depth/sediment-related trends were observed.

When assessing drilling-related contamination of the benthic environment, barium concentrations can be a key indicator of impact as barite (barium sulphate) is routinely used as a weighting agent in drilling fluids. Fugro (2011a) reported little variation in barium levels in the Rosebank field area, with concentrations ranging from 256 to 355 µg/g (stations EBC105 and EBC313, respectively). Similar results were recorded from the infield areas surveyed in 2014, with concentrations ranging between 300 and 350 µg/g (Fugro, 2014b). The mean regional barium concentration recorded during AFEN surveys was 333 µg/g (AFEN, 2000). Overall, Fugro (2011a, 2014b) determined that there was no evidence of anthropogenic contamination from the exploration and appraisal drilling activities that had been undertaken in the area.

Levels of barium recorded in the recent surveys (Table 4-7 and Table 4-8) are relatively low and do not indicate any clear disturbances from oil or gas activities in the area.

Table 4-7 Summary of sediment metal data in the Rosebank field (average values for two replicates at each station; Akvaplan, 2022a) and comparison with Fugro (2011a)

Element	Lowest		Highest		Mean concentrations in Fugro (2011a; µg/g)
	Concentration (µg/g)	Station	Concentration (µg/g) -	Station	
Arsenic	2.7	ENV-14	3.5	ENV-15	6.5
Barium	66.8	ENV-19	129	ENV08	294
Cadmium	0.035	ENV-19	0.077	ENV-17	0.3
Chromium	9.8	ENV-02	144	ENV-08	62.4
Copper	7.9	ENV-10	12.3	ENV-18	27.3
Lead	5.3	ENV-10	8.1	ENV-08	13.9
Mercury	<0.01	ENV-10	0.02	ENV-15	0.02
Zinc	19	ENV-02	603	ENV-08	81.4

Table 4-8 Summary of sediment metal data along the gas export pipeline route from the Rosebank field to the shelf break (DNV, 2022b)

Element	Lowest		Highest	
	Concentration (µg/g)	Station(s)	Concentration (µg/g) -	Station(s)
Arsenic	2.1	ENV14	4.6	ENV19
Barium	11.0	ENV21	150	ENV01
Cadmium	<0.03	ENV14, ENV15, ENV12a_202	0.1	ENV21 & ENV17a_207
Chromium	5.3	ENV21, ENV20a_212	20.0	ENV10
Copper	1.8	ENV21	20.0	ENV10
Lead	3.6	ENV20a_212	8.3	ENV10
Mercury	<0.01	All apart from ENV10 & ENV02	0.013	ENV10
Zinc	8.0	ENV20a_212	48.0	ENV10
Titanium	94	ENV21	970	ENV10

4.2.8.2 Continental Shelf

The sandy sediments of the continental shelf portion of the gas export pipeline route (Stations ST214 to ST202) contained very low levels of TOC, ranging from 0.21 to 1.8% (Fugro, 2011b) and 0.15 to 0.34% (DNV, 2022b; Table 4-6).

Levels of THC were also very low in this area, ranging from 0.4 to 0.8 µg/g (Fugro, 2011b) and 1.76 and 2.76 (DNV, 2022b), reflecting the sandy nature of the seabed with low levels of fine particles. Correlations between hydrocarbon levels and the proportion of fine material is typical of uncontaminated sediments.

Concentrations of all heavy and trace metals varied considerably over the entire gas export route survey area, the majority showing a positive correlation with the proportions of fines in the sediment. Levels on the continental shelf portion of the route were the lowest and deemed to represent background concentrations (Fugro, 2011b; DNV, 2022b). The results for the recent survey (water depths of 126-191 m) are summarised below (DNV, 2022b):

- Arsenic - 1.3-9.0 µg/g;
- Barium - 5.2-14.0 µg/g;
- Cadmium - <0.03-0.087 µg/g;
- Chromium – 3.7-11.0 µg/g;
- Copper – 0.7-2.2 µg/g;
- Mercury – all <0.01 µg/g detection limit;
- Lead – 1.5-5.3 µg/g;
- Titanium – 56-100 µg/g; and
- Zinc – 5.4-11.0 µg/g.

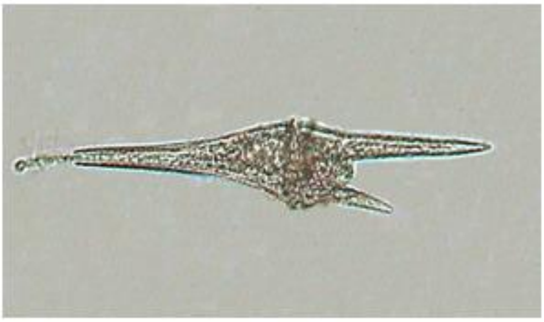
4.3 The Biological Environment

4.3.1 Plankton

Plankton are the diverse collection of organisms found in water which are largely reliant on ocean currents for movement. In the marine environment, they provide a crucial source of food to numerous organisms. Plankton can be divided into the following groups based on their functionality in the foodchain: phytoplankton (which are algae/plants) and zooplankton (animals). Phytoplankton communities of the area are dominated by microscopic single-celled plants called dinoflagellates, especially *Ceratium*, and diatoms, in particular *Chaetoceros* (Figure 4-15). Phytoplankton use sunlight to photosynthesise food and are therefore restricted to the upper photic (sunlit) layers of the ocean.

The most common group of organisms in the zooplankton community are the copepods (small, insect-like crustaceans which range from 0.5 mm to 6 mm). These are known to reach large concentrations, and they form the main food source for higher trophic levels. *C. finmarchicus* has historically dominated the zooplankton of the North Sea and is used as an indication of zooplankton abundance.

Doliolids are small marine animals of the Tunicata phylum, related to salps and pyrosomas. They are a form of gelatinous zooplankton and exist as free-floating filter feeders, preferring an appropriate density of phytoplankton (Johns and Wootton, 2004). Doliolids occur as visitors (invaded with warmer waters) from the open Northeast Atlantic Ocean and the Lusitanian stream. They survive only in offshore waters and are good indicators of offshore water movements.



The dinoflagellate *Ceratium* sp. Size range typically 300 to 500 µm. (photomicrograph by Minami Himemiya, 2007)

Chains of the diatom *Chaetoceros* sp. Chain length typically 0.5 to 1 mm. (photomicrograph by Richard A. Ingebrigtsen, University of Tromsø)

A copepod of the genus *Calanus*. Typically, up to 2 mm long. (photomicrograph by Russ Hopcroft, 2009)

Doliolids in the water column. Typically, up to 2 cm long. (photograph by Silke Baron, 2009)

Figure 4-15 Examples of planktonic organisms

4.3.1.1 Faroe-Shetland Channel

The Faroe–Shetland area is highly complex, where the upper 500 m of the water column has its origins in the Rockall Trough and poleward-flowing North Atlantic Current which is reflected in its plankton population and community structure. However, below 600 m depth in the Faroe-Shetland Channel and Faroe-Bank Channel, there is a counter-flow of cold, less saline water from the deep Norwegian Sea into the Atlantic. This water has its origins in the Arctic and temperatures decline to below 0ºC. Here, the plankton community is entirely different (Edwards *et al*, 2020).

The Faroe-Shetland Channel typically has lower phytoplankton biomass and a shorter productive season than waters more influenced by coastal processes (DECC, 2016). Phytoplankton productivity reaches its annual peak during May and is followed by a sharp decline in June (Heath *et al*., 2000), when nutrient supply becomes a severely limiting factor. The autumn phytoplankton bloom reaches its peak in mid-August; Gaard (1996) reports that 80% of related primary productivity is produced from May to August. This later bloom in the Faroe-Shetland Channel occurs following the development of a summer thermocline at approximately 20 to 50 m depth. Due to the nature of mixing water masses in this channel, the August bloom is more likely to continue into late autumn here than in other north Atlantic areas.

Zooplankton are scarce at depths below 600 m in the water column during the summer. However, in the winter abundance is high, when the zooplankton community of the area is dominated in terms of biomass and productivity by copepods (Figure 4-15), particularly *Calanus helgolandicus* and *Calanus finmarchicus* as well as, on a temporary basis, a number of meroplanktonic organisms (animals that only spend a part of their life cycle in the plankton, such as the larvae of fish and many benthic species). Zooplankton is not restricted to the photic upper layers of the water column and as a rule undergoes diurnal vertical migration, moving towards the surface to feed at night and sinking during daylight hours (Edwards *et al*, 2020).

Analysis of data provided by the Continuous Plankton Reader (CPR) surveys in the 10-year period between 1997 and 2007 shows a sharper spring increase in C. finmarchicus biomass in May in the northern North Sea compared to more southerly areas. This peak in numbers is 70% greater than seen in the central North Sea and 88% greater than the southern North Sea over the same period (SAHFOS, 2015). The increase is likely a reflection of the increased availability of nutrients and food (including phytoplankton) in spring. Beare *et al*. (2002) and FRS (2004) noted that the overall abundance of *C.finmarchicus* had declined dramatically over the previous 60 years; a decline attributed to changes in seawater temperature and salinity over that time period (Beare *et al*., 2002; FRS, 2004). *C. finmarchicus* has largely been replaced by boreal and temperate Atlantic and neritic (coastal water) species, and a relative increase in the populations of *C. helgolandicus* has occurred (DECC, 2009; Edwards *et al*., 2008; Baxter *et al*., 2011).

The oceanic waters that travel through the Faroe-Shetland Channel can often introduce warm/temperate oceanic species of plankton to the west of Shetland region, such as the copepods *Euchaeta hebes*, *Rhincalanus nasutus* and *Eucalanus elongatus*, and the gelatinous zooplankton forms including *doliolids* (Johns and Wootton, 2004).

Due to the depth of this region and the vertical distribution of the water masses, the composition of plankton communities will vary throughout the water column. Surface waters are dominated by *Acartia clausii* up to 160 m depth. The North Atlantic Oceanic Water is dominated by *Pseudocalanus elongatus* and *Munida* larvae reaching depths above 420 m, and associated with temperatures of 8-8.7°C. A third group is also found, dominated by *C. finmarchicus*, *Metridia lucens* and *Scolecithricella minor*. Between 430-510 m water depth, *Metridia longa*, *Calanus hyperboreus* and *Pleuromamma robusta* and *T. longicaudata* were identified. Finally, plankton found in the Norwegian Sea Deep Water include eight copepod species and two chaetognaths, dominated by *Spinocalanus abyssalis* and *Oncaea conifer* (DECC, 2016).

4.3.1.2 Continental Shelf

The West Shetland Continental Shelf region consists of transitional waters that are mixed during the winter months and stratified during summer. The plankton community within this area consists of cold-temperate boreal species and includes Atlantic and offshore species as well as some shelf species (DTI, 2003).

The West Shetland Continental Shelf is located within OESEA 4. This region is influenced by the warm waters of the continental shelf current and the currents entering the North Sea from the north-east Atlantic and the Norwegian Sea (JNCC, 2004). The phytoplankton community in these waters is dominated by the dinoflagellate genus Ceratium (mainly *C. fusus*, *C. furca* and *C. tripos*), with diatoms such as *Thalassiosira sp*. and *Chaetoceros sp*. also abundant. To the west of mainland Scotland, diatoms such as *Rhizosolenia sp*. and *Fragillariopsis sp*. and coccolithophores increase in abundance towards the shelf edge, while dinoflagellates such as *Protoperidinium*, *Gymnodinium* and *Scripsiella* are also abundant in late summer (DECC, 2016). During spring there is an increase in phytoplankton productivity known as the spring diatom bloom which reaches its peak in May and declines rapidly in June (Heath *et al*., 2000) and during august another phytoplankton bloom occurs, reaching its peak in mid-August before sharply declining (Gaard, 1996). The characteristics of this annual cycle is determined by local weather and oceanographic conditions and is crucial to the wider ecosystem as phytoplankton provide important feeding areas for most animal groups within the area including, zooplankton, cephalopods, pelagic fish, seabirds and cetaceans. The phytoplankton abundance also contributes to the vertical flux of biogenic detrital material on the seabed, although, this contribution has not been quantified (Johns and Wootton, 2003). Phytoplankton communities are not frequently subjected to anthropogenic pressures. However, significant changes in species have been recorded as a result of rising sea temperatures (DEFRA, 2010).

The zooplankton communities of the West Shetland Continental Shelf region are dominated in terms of biomass and productivity by calanoid copepods, particularly *Calanus sp.* (*finmarchicus* and *helgolandicus*), *Paracalanus sp*. and *Pseudocalanus sp*. Meroplanktonic echinoderm larvae and decapod larvae are also abundant. Other important taxa in the region include *Acartia sp*., *Evadne sp*., *Oithona sp*. and *Metridia lucens*. Commonly observed jellyfish species include *A. aurita* and *C. capillata* (Pikesley *et al*. 2014; DECC, 2016). In the spring and summer months, oceanic calanoid copepods, in particular *C. finmarchicus*, are likely to be more abundant and in the autumn *C. helgolandicus* is likely to be more dominant. Smaller, intermediate and neritic copepods such as *Pseudocalanus elongatus*, *Temora longicornis* and *Acartia clausi* are also abundant over the West Shetland Continental Shelf in the spring and summer months (Edwards and John, 1997; Madden *et al*., 1999). Marine Scotland Communications (2020) found that meroplankton are showing increasing trends in abundance throughout coastal and offshore waters in the UK. Additionally, in the northern North Sea, including Orkney and Shetland, diatoms are increasing (Marine Scotland Communications, 2020).

Zooplankton is an important food source for many fish species within the area such as herring, blue whiting and mackerel and therefore an important element in the recruitment of fish stocks over the continental shelf. Blue fin whale, sei whale and other cetaceans present in the area also rely heavily on krill (planktonic crustaceans). Certain species of bird also depend on planktonic crustaceans and other zooplankton during migratory routes, for example the Northern Fulmar and the European storm petrel (Hobson and Welch, 1992).

4.3.2 Seabed Fauna (benthos)

4.3.2.1 Overview

The biota living near, on, or in the seabed, is collectively termed benthos. The diversity and biomass of the benthos is dependent on a number of factors including substrata (e.g. sediment, rock), water depth, salinity, the local hydrodynamics and degree of organic enrichment (DECC, 2016).

Those species which burrow into the sediment or form tubes within it (benthic infauna) are normally studied by examining quantitative samples of sediment obtained by grab or corer. The focus is on those animals retained by a 0.5 mm or 1 mm sieve (termed the macrofauna). The species composition and diversity of the benthos or macrofauna found within sediments is commonly used as a biological indicator of sediment disturbance or contamination.

Species which live attached to stony or rocky substrates (epifauna) such as sponges or corals, and larger species which live on the seabed (megafauna) are normally studied using visual techniques such as stills and video photography.

The Rosebank surveys which inform this section, including maps of the sampling stations, are described in 4.1.1.1 and 4.2.7.1.

4.3.2.2 Faroe-Shetland Channel

4.3.2.2.1 Megafauna and epifauna

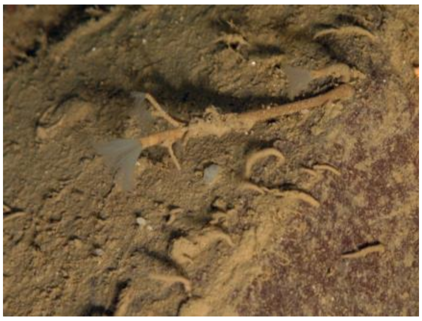
Survey investigations have confirmed that the distribution of seabed community types is strongly influenced by the nature of the seabed and the particular hydrographic conditions in the area (described in 4.2.3.1) and have highlighted some major patterns of distribution.

Environmental survey work within the Rosebank field (Fugro, 2011a, 2014) and along the gas export pipeline route (Fugro, 2011b) found a similar range of epifaunal forms to that seen during the AFEN survey of the eastern flank of the Faroe-Shetland Channel. On the channel floor, Bett (2000) and Texaco (2000) found a muddy seabed with sparsely distributed stones to which were attached stalked sea squirts, sponges, and soft corals, while the lower slope (>600 m) supported large polychaetes, brittlestars and sea spiders.

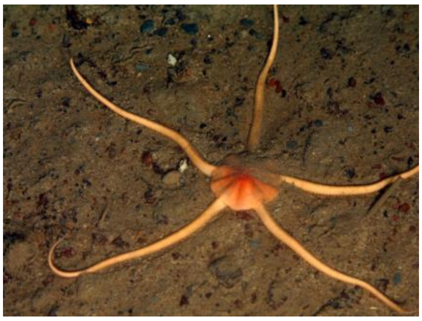
Fugro (2012b) found the Rosebank in-field area at approximately 1,100 m depth to be characterised by mobile species including large sea spiders and occasional scavenging amphipods, together with sedentary burrowing or attached forms such as the soft corals *Primnoa* and *Dendronephthya*, colonial hydroids, burrowing anemones, encrusting sponges and also the carnivorous club sponge *Chondrocladia gigantea*. Species similar to those found by the AFEN and Fugro survey work had also been observed and photographed by ROVs operating in the Rosebank field as part of the SERPENT programme in 2007, and some of these images are shown in Figure 4-16. The AFEN survey work identified an area of sandy sediments at depths of 900 m or more, supporting an abundant population of surface-dwelling acorn worms (Enteropneusts). Similar features were not observed on the gas pipeline route at similar depths during later surveys (Fugro, 2012b).

During the survey at the Rosebank field in 2021, 35 species were identified to the lowest possible taxonomic level (Figure 4-17). The most taxa-rich phylum was Cnidaria with 12 (35%) recorded taxa at the Rosebank field. Overall, the survey recorded little spatial variation in taxa richness. None of the species recorded form habitat types that are listed as threatened and/or declining according to OSPAR (Akvaplan, 2022b).

Some observations from the sea floor at Rosebank in 2021 are shown in Figure 4-18. Further recent imagery from the same area (Figure 4-19) is provided by the 2020 gas export pipeline route survey; the megafauna from depths greater than 690 m formed a distinct grouping in cluster analysis and was dominated by the soft coral Gersemia and sea spiders (Pycnogonida). Similar species can be observed from surveys conducted over ten years apart, including *Sabellid* polychaetes, soft corals, sponges, sea spiders, anemones and brittlestars.



Sabellid polychaete in tube on a boulder; feeding fan just being withdrawn into the tube.



Ophiuroid brittlestar on sediment (central disc approximately 25 mm diameter.

Sea spider *Colossendeis proboscidea* (leg span up to 400 mm).

Club sponge *Chondrocladia gigantea*.

Soft coral and tube-dwelling sabellid polychaetes on silty cobbles

Cerianthid burrowing anemone in sandy sediment.

Figure 4-16 Examples of megafauna or visible epifauna at approximately 1,100 m in the Rosebank field, Faroe-Shetland Channel, 2007 (SERPENT, 2008)

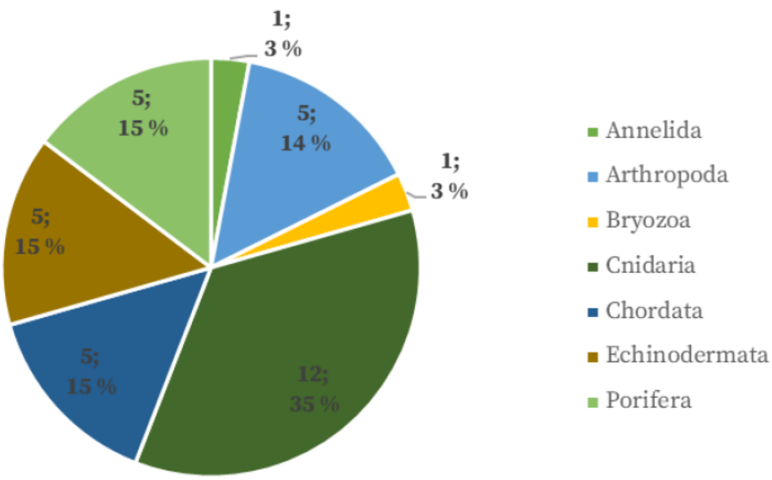


Figure 4-17 Taxonomic composition from visual survey conducted with an ROV at the Rosebank field in 2021 (Akvaplan, 2022b)

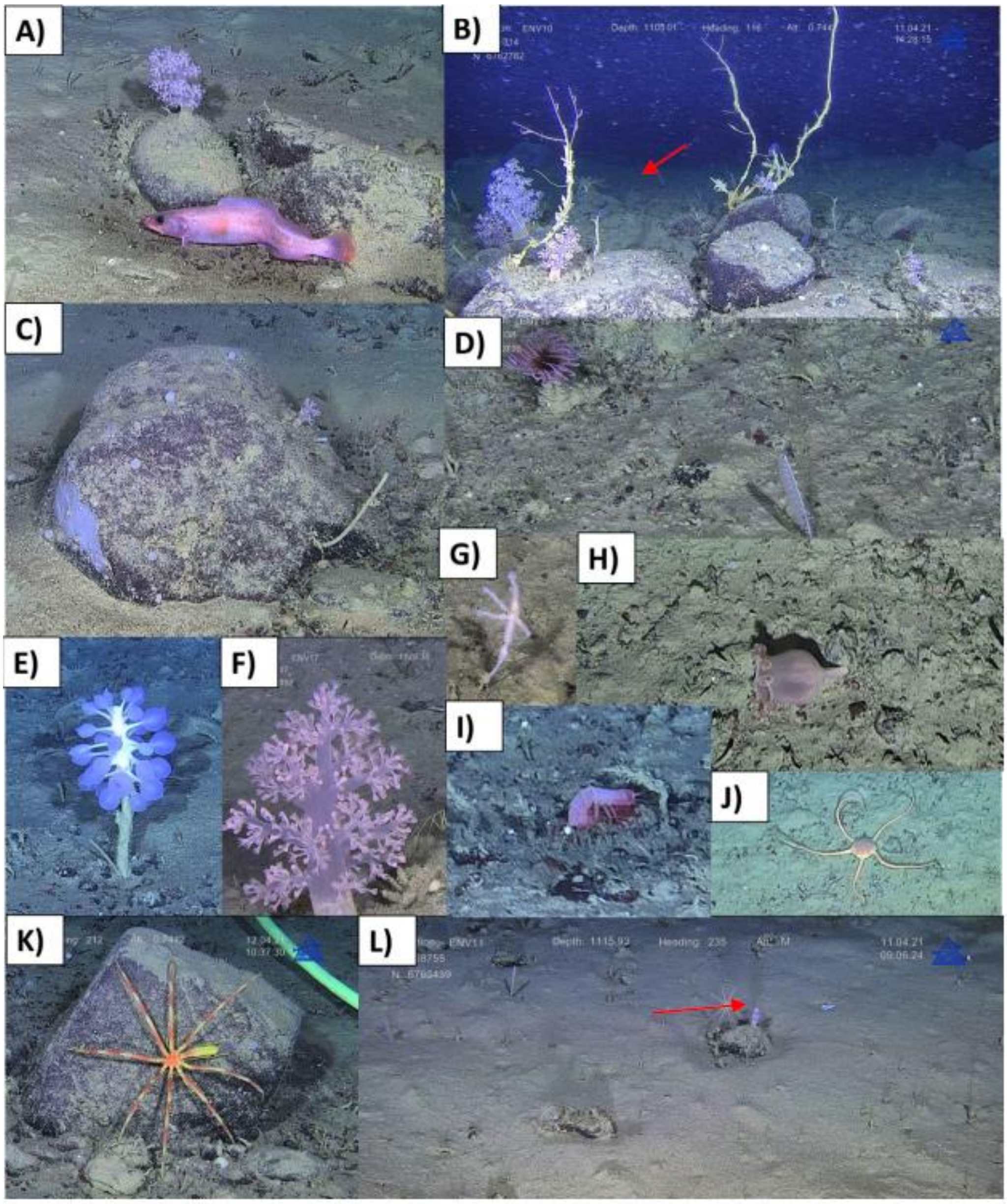


Figure 4-18 Conspicuous species and taxa that were registered at the Rosebank field during the baseline survey cruise in 2021 (Akvaplan, 2022b).

Key:

A) Soft coral in the family Nephtheidae, with what likely is a three-bearded rockling (*Gaidropsaurus ensis*) B) soft corals on rocks with long-branched hydroids or sponges, with Sabellid polychaetes (fanworms) attached on and beside it, with crinoids in the background (red arrow), C) rock with blue colonial mat on, likely Porifera for example Hymedesmia, some Bryozoa, soft corals and a *sabellid polychaete* (fanworm) in its tubes – extended radioles almost transparent but visible when enlarged D) sea anemone in the family Cerianthidae with a seapen (*Virgularia mirabilis*), E) carnivorous sponge (*Chodrocladia gigantea*), F) close-up image of soft coral (Nephtheidae), G) small sponge (*Asbestopluma furcata*), H) a Steuromedusae (*Lucernaria bathyphila*), I) amphipod (*Cleippides quadricuspis*) J) brittlestar (*Ophiopleura borealis*), K) sea spider (*Pycnogonidae*) and L) a crinoid likely within the genus *Bathycrinus* sp. (red arrow).

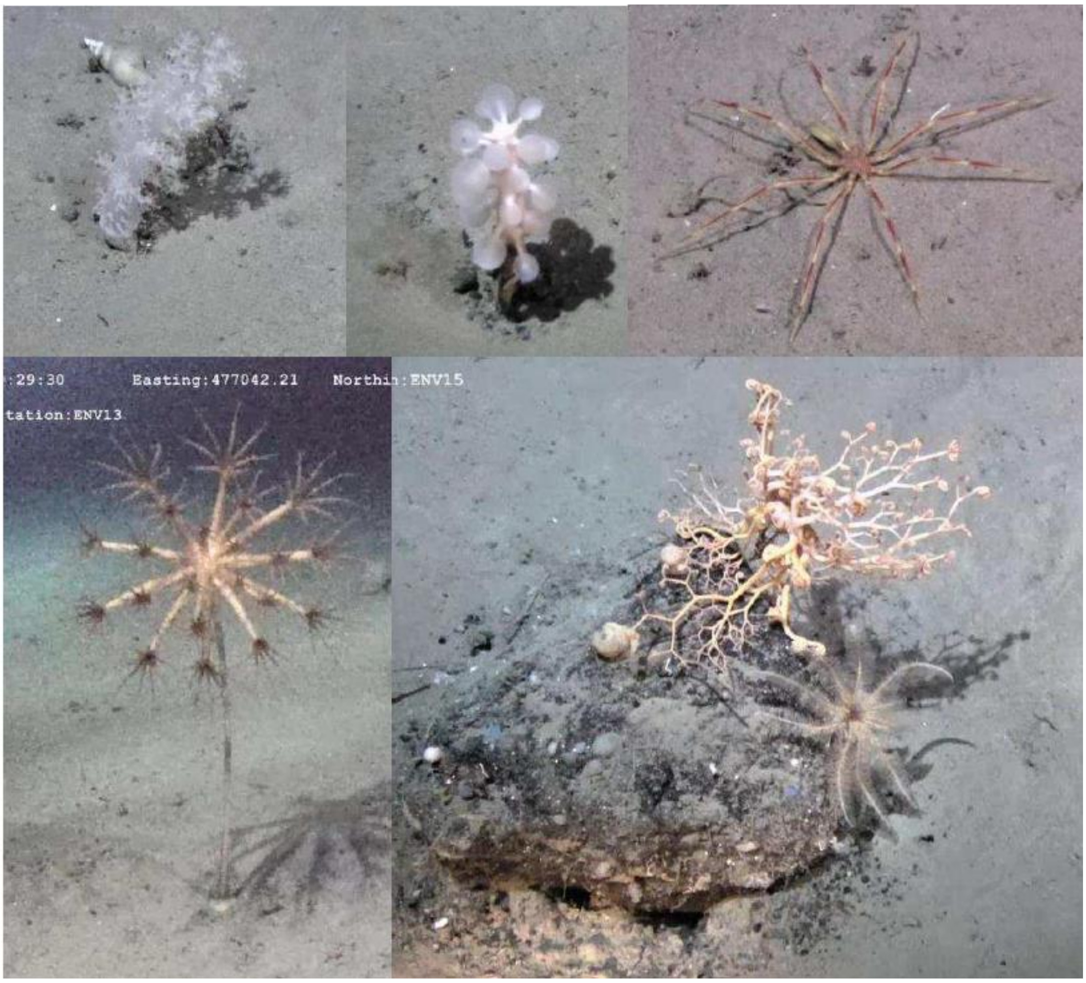


Figure 4-19 Image examples of seabed megafauna at deeper stations (>690 m) (DNV, 2022a).

Key:

From top left to bottom right: soft coral (*Gersemia* spp - ENV10). giant club sponge (*Chondrocladia gigantea* – ENV11), sea spider (*Colossendeis proboscidea* – ENV05), deepsea sea-pen (*Umbellula encrinus* - ENV13), basket star; gorgons head (*Gorgonocephalus caputmedusae* – ENV15)

The surveys conducted along the gas export pipeline route demonstrate the variation in megafauna and epifauna up the continental slope. The survey by DNV (2022a) along the entire gas export pipeline route has collected extensive photographic data to a distance of 50 m around each sampling station as illustrated in Figure 4-20 (station locations are shown in Figure 4-5). In addition to filming pre-defined transects, a target sonar was used to detect features of potential interest (reefs, objects etc); any such features within 50 m range of the sonar were inspected. A total of about 300 m of seabed was surveyed at each station.

All megafaunal species and habitat types encountered were recorded based on review of the video material and identification from stills photography. The abundance of each species was logged using the SACFOR scale developed by Hiscock (1996; available from https://mhc.jncc.gov.uk/media/1009/sacfor.pdf), which can be used to grade abundance on a six-point scale (Super-abundant, Abundant, Common, Frequent, Occasional and Rare) according to species' size and growth form. Seabed substrates and faunal types were classified following EUNIS (2019), OGUK (2019) and NOROG (2019). The identification of key habitats such as stony reefs and deep-sea sponge aggregations followed recommended practices for UK waters including those described by Irving (2009), Golding *et al.* (2020) and Henry and Roberts (2014).

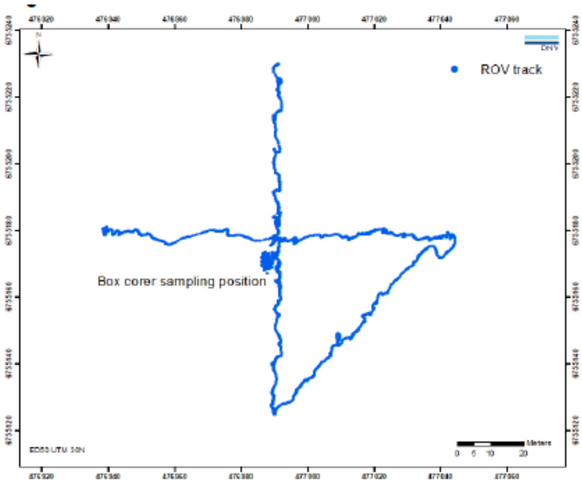


Figure 4-20 Example showing ROV track at each environmental station during the DNV (2022a) survey.

A total of 97 megafaunal/epifaunal taxa were recorded along the entire gas export pipeline route. Faunal composition changed substantially along the route as depth sediment type and environmental conditions changed; stations at similar depth intervals and with similar seabed current regimes and sediment composition showed highest similarity in faunal composition. The interpreted EUNIS categories for each station are given in Table 4-5 and Table 4-6 and illustrated below in Figure 4-21. Seabed currents are strongest at water depths of approximately 350-550 m (stations ENV 20a_212, ENV19, ENV 18, ENV 17a_207 and ENV 27), which also exhibited the most heterogeneous faunal communities. The relative composition of faunal groups at each station is shown in Figure 4-22. An increased relative contribution of sponge species within the Faroe-Shetland sponge belt MPA is apparent.

Multivariate analyses showed five main groupings of stations at the 25% similarity level as follows:

- All stations at depths >690 m – dominated by soft coral *Gersemia* and pycnogonids as discussed above and illustrated in Figure 4-19;
- ENV21 and ENV22a_214 – slope stations with low abundance and species richness;
- ENV28, ENV29 and ENV20a_212 – gravelly slope stations with cobbles/pebbles;
- ENV16, ENV17a_207, ENV18, ENV27 – slope stations with a richer sponge fauna; and
- ENV23 to ENV26 - shallow sandy stations on the continental shelf (discussed in Section 4.3.2.3).

At 60% similarity, two stations (ENV18 and ENV17a_207) with high abundances of sponges grouped together. These were considered to represent the OSPAR habitat type “Deep-sea sponge aggregations” and were located on the shallower part of the pipeline route that crosses the Faroe-Shetland Sponge Belt NCMPA (discussed further in the following subsection).

A small potential stony reef area was observed at one station (ENV14), but did not fulfil all criteria (size too small according to criteria established by JNCC) as discussed in Section 4.3.2.2.4. No other OSPAR habitat types, red listed species, ocean quahog, coral gardens or *Desmophyllum* reefs were encountered during the survey. Although there were significant differences in methodology, a general comparison with the 2011 survey (Fugro, 2011b) indicated that the faunal composition was relatively unchanged (DNV, 2022a).

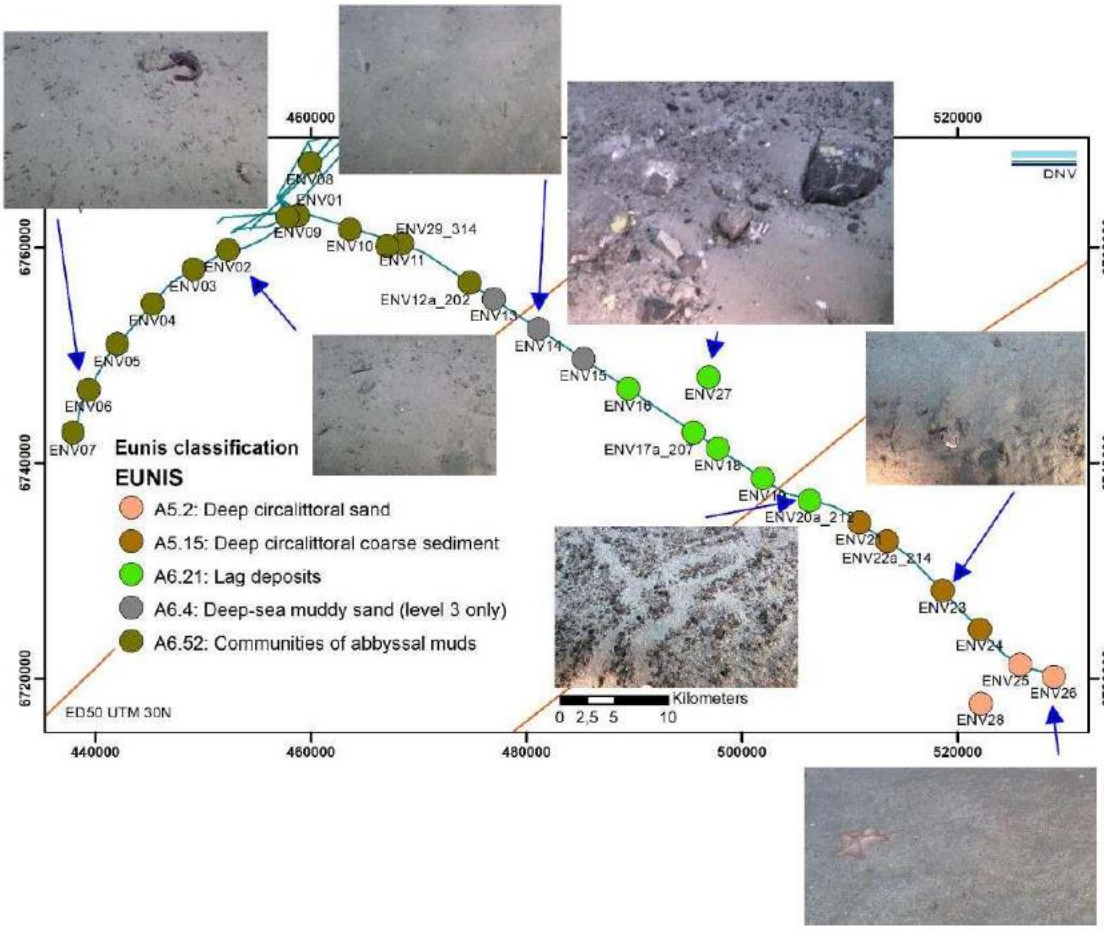


Figure 4-21 EUNIS classification (at level 4) and example images of typical seabed (DNV, 2022a)

Notes:

Brown lines show boundaries either side of the Faroe-Shetland Sponge Belt NCMPA. Stations ENV03, 04, 05, 06 and 07 lie outside of the proposed Rosebank Development area and are not directly relevant to the ES, although the findings do illustrate the homogeneity of the seabed and fauna along the depth contour in the Faroe-Shetland Channel.

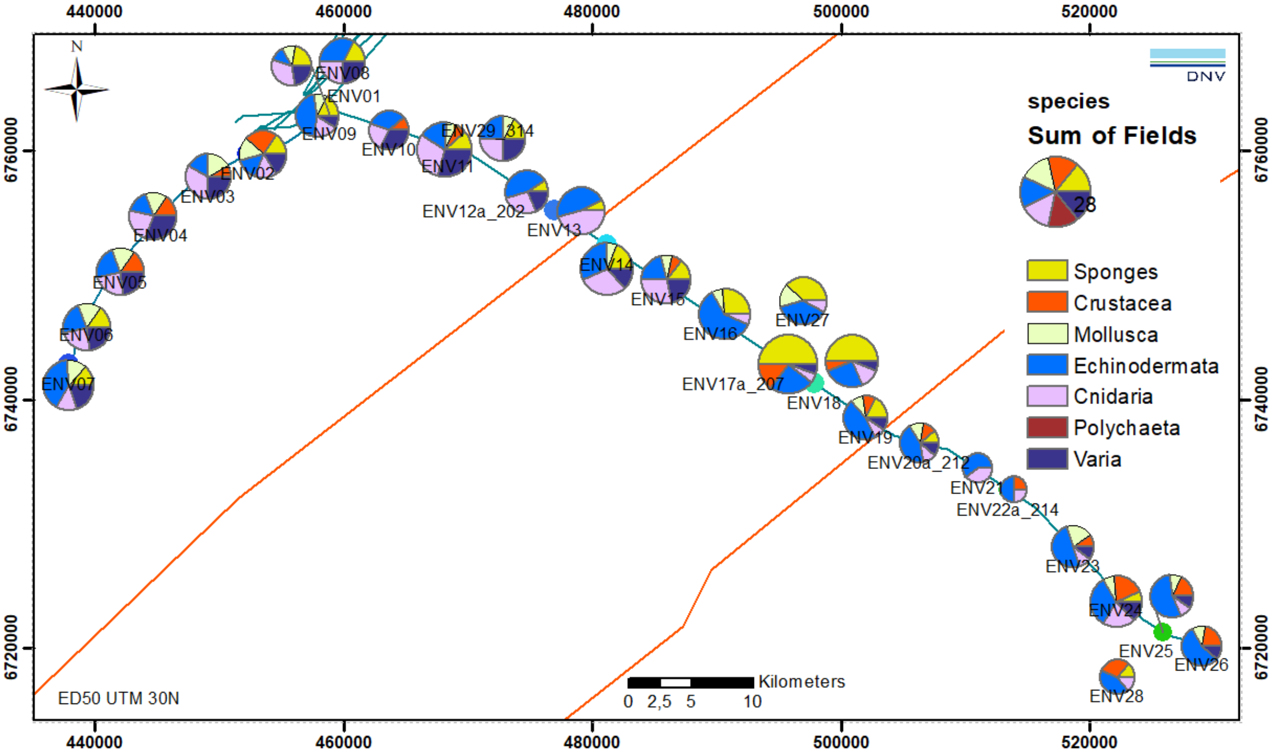


Figure 4-22 Composition of faunal types at each station; proportion of total number of species symbolised as pie charts (DNV, 2022a).

Notes:
Brown lines show boundaries either side of the Faroe-Shetland Sponge Belt NCMPA.
Stations ENV03, 04, 05, 06 and 07 lie outside of the proposed Rosebank Development area and are not directly relevant to the ES, although the findings do illustrate the homogeneity of the seabed and fauna along the depth contour in the Faroe-Shetland Channel.

4.3.2.2.2 Deep-sea sponge aggregations

Deep-sea sponge occurrences were noted in the AFEN survey work. As outlined in OSPAR (2010b), deep-sea sponge aggregations (also known as 'ostebund' or 'cheese bottoms' by Faroese fishermen) are known to occur in water depths of 250 to 1,300 m, typically where the water temperature is higher than 4°C and where there is moderate current velocity. These aggregations may occur on soft or hard substrata, both on boulders/cobbles and on sediment. Deep-sea sponge aggregations are features of conservation importance in Scotland and have been designated as Scottish PMFs (Tyler-Walters, 2016). Sponge densities in these aggregations have been reported at between 4 and 5 per m^2 for glass sponges (a group of sponges typically living in deep water), whilst sponges from other groups have been reported at densities of between 0.5 and 1 per m^2 (OSPAR, 2010b). Surveys undertaken in 2007 confirmed a patchy presence of a structural sponge habitat (i.e. deep-sea sponge aggregations) between 400 and 600 m depth in the same region of the Faroe-Shetland Channel crossed by the gas export pipeline route (Howell *et al*., 2007). The Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (MPA) has been designated to protect these deep-sea sponge aggregations and is crossed by the proposed gas export pipeline (Figure 4-23).

Deep-sea sponge aggregations are characterised by a high diversity of species including branched, cup, lamellate, globose, erect and encrusting sponges; distinct species include bright blue and bright yellow encrusting sponge forms, large white erect sponges with multiple chimney-like structures, and Geodid species. Howell *et al*. (2007) commented that the distribution of sponges is patchy with some areas supporting dense growths of large sponges and other areas supporting less dense growths of small and encrusting forms. The latest JNCC published interpretation of sponge distribution in the Faroe-Shetland Channel area (JNCC, 2022; Taylor *et al.* (2019) shows aggregations centred around the 500 m isobaths, with records becoming scarcer as water depth becomes deeper and shallower (Figure 4-23), while analysis by Kazanidis *et al.* (2019) confirmed that sponge aggregations occurred within a narrow zone between 450 and 530 m depth, within relatively warm and saline water masses. A survey of the Faroe-Shetland Sponge belt MPA was conducted by Marine Scotland and the JNCC in August 2021, but results are not yet publicly available.

The survey conducted along the gas export pipeline route to Clair (Fugro, 2011b) did not include an analysis of sponge aggregations (there was no habitat assessment report), but several images from the survey in the relevant depth zone show a variety of sponge species.

At depths of 460 and 650 m along a previously-proposed gas export pipeline route, Fugro (2012b) found that the mixed sediments (poorly sorted very fine or medium sand) supported relatively diverse epifaunal communities including occasional sponges together with soft coral, pencil sea urchins and starfish. Sponges observed here included the chalice sponge *Phakellia ventilabrum* and glass, globose, branching and encrusting varieties, colonising occasional cobbles and boulders in mixed sediments. A quantitative assessment of photographic data was subsequently conducted within the depth range of known deep-sea sponge aggregations and reported by Fugro (2015a).

No deep-sea sponge aggregations were observed at the stations investigated in the Rosebank field in 2021 (Akvaplan, 2022b). A detailed assessment was conducted along the gas export pipeline route by DNV (2022a) to determine the presence of sponge aggregations by applying the OSPAR (2010) definition of deep-sea sponge aggregations based on density, habitat and ecological function. The survey methodology is described in Section 4.3.2.2.1. The video records of sponges were categorised into two groups: “soft bottom sponges” and “hard bottom sponges”. Since the survey lines during the visual mapping covered several kilometres of seabed, it was not practicable to count individual sponges in images or to calculate percentage coverage for the entire lengths of each line. Semi-quantitative density estimates were therefore used to provide an efficient assessment of spatial patterns on the seabed based on the following scale: “No sponges”, “single individual”, “scattered”, “common” and “high”. Soft bottom sponge cover above 10% cover (“high”) equals at least 0.5-1 sponge per m2, and thus can be regarded to comply with OSPAR (2010) habitat “deep-sea sponge aggregations” (DNV, 2022a).

Deep-sea sponge aggregations were recorded at two stations (ENV 18 and ENV 17a-207), located on the steep part of the slope at into the Faroe-Shetland Channel at depths of 490-525 m and within the Faroe-Shetland Sponge Belt MPA; image examples are shown in (Figure 4 24). These stations met criteria proposed by Henry and Roberts (2014) as follows:

- Density criteria - raw measurements of abundance/density that equal or exceed densities reported in the OSPAR definition (2010), which are generally between 0.5–24 sponges/m2; AND assessments of occurrence categorised as at least ‘frequent’ according to the Marine Nature Conservation Review’s SACFOR scale of abundance; AND using the multivariate similarity of percentages (SIMPER) metric to determine that sponges were truly characteristic of an assemblage; and
- Habitat criteria - habitat type characterised by one or a set of large (>5cm diameter) sponge species that may or may not dominate the community biomass (OSPAR 2010). Therefore, a sponge record that passes the habitat criterion if it could be determined that the assemblage could not be described as anything other than a potential deep-sea sponge aggregation i.e. not falling into any other habitat forming fauna types such as Desmpophyllum coral reefs.

The “ecological function criterion” proposed by Henry and Roberts (2014) could not be implemented with confidence. The somewhat increased megafaunal richness observed at these stations is likely associated with increased abundance of sponges at these fields but can also be ascribed to increased heterogeneity in general due to the amount of rocks and increased amounts of niches supporting other fauna.

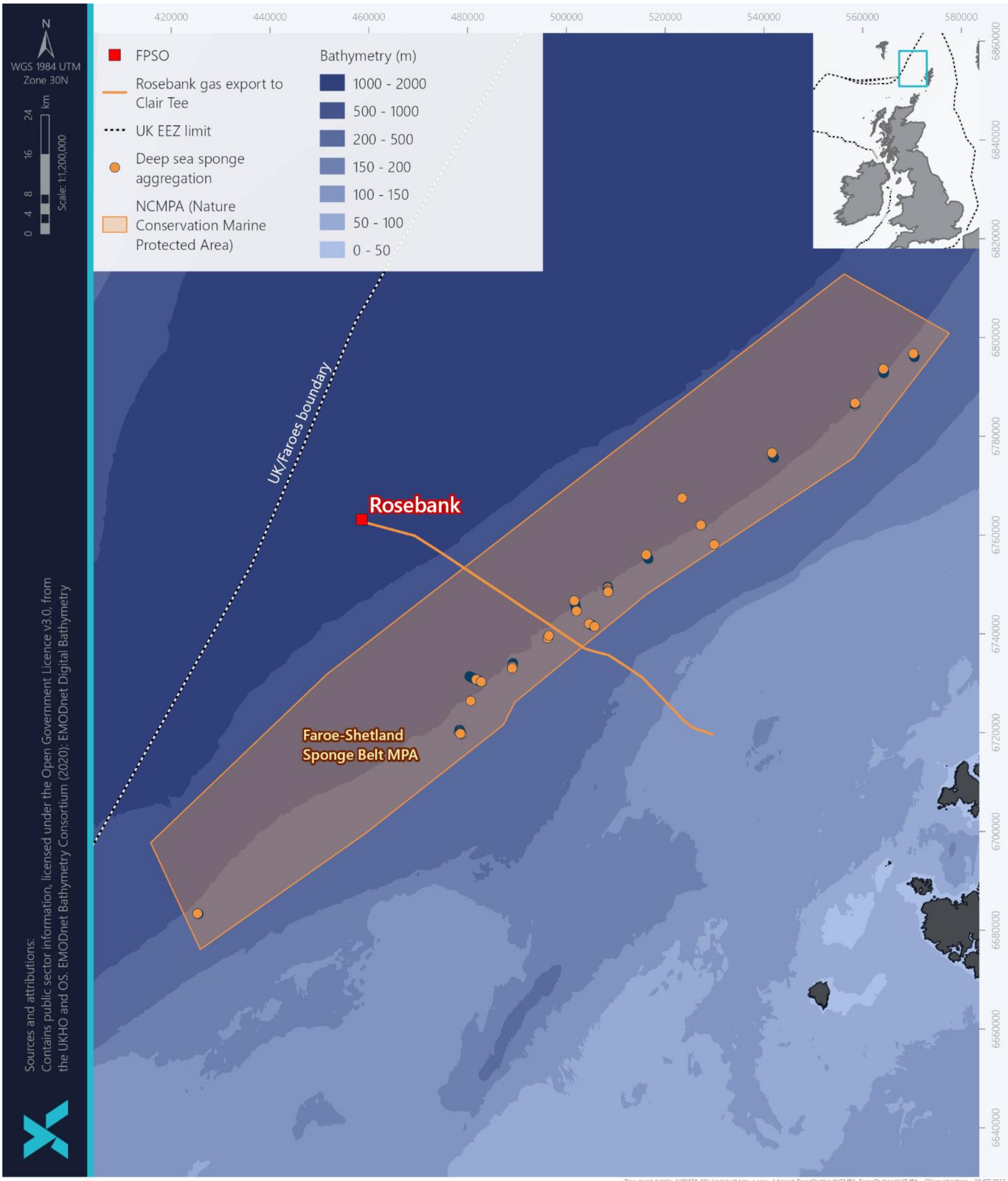


Figure 4-23 Deep-sea sponge aggregation point data in the Faroe-Shetland Sponge Belt NCMPA in relation to the Rosebank Development infrastructure (JNCC, 2022)

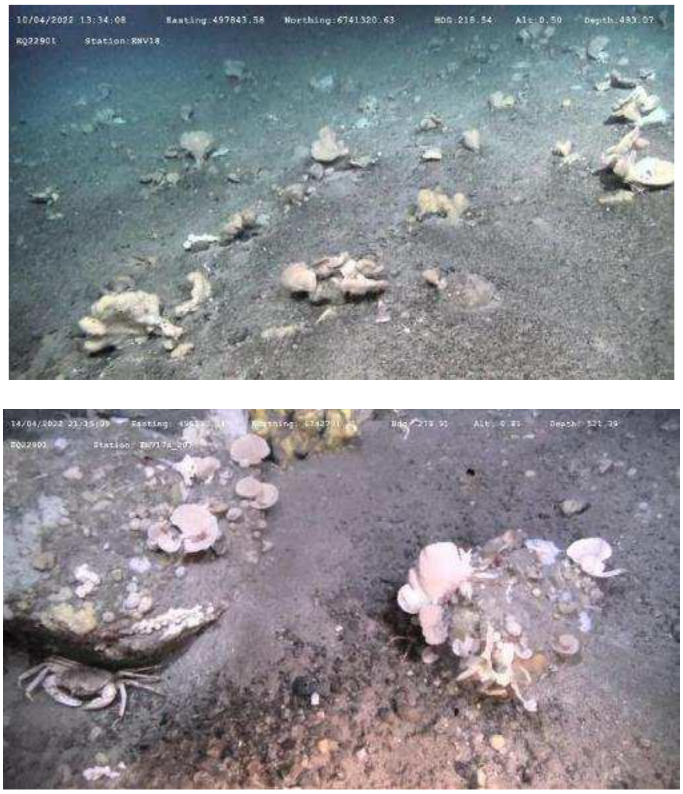


Figure 4-24 Image examples of deep-sea sponge aggregations at Station ENV18 (top) and ENV17a_207 (bottom) (DNV, 2022a)

Maps showing sponge distributions at stations ENV-18 and ENV-17a_207 are shown in Figure 4-25 and Figure 4-26 respectively.

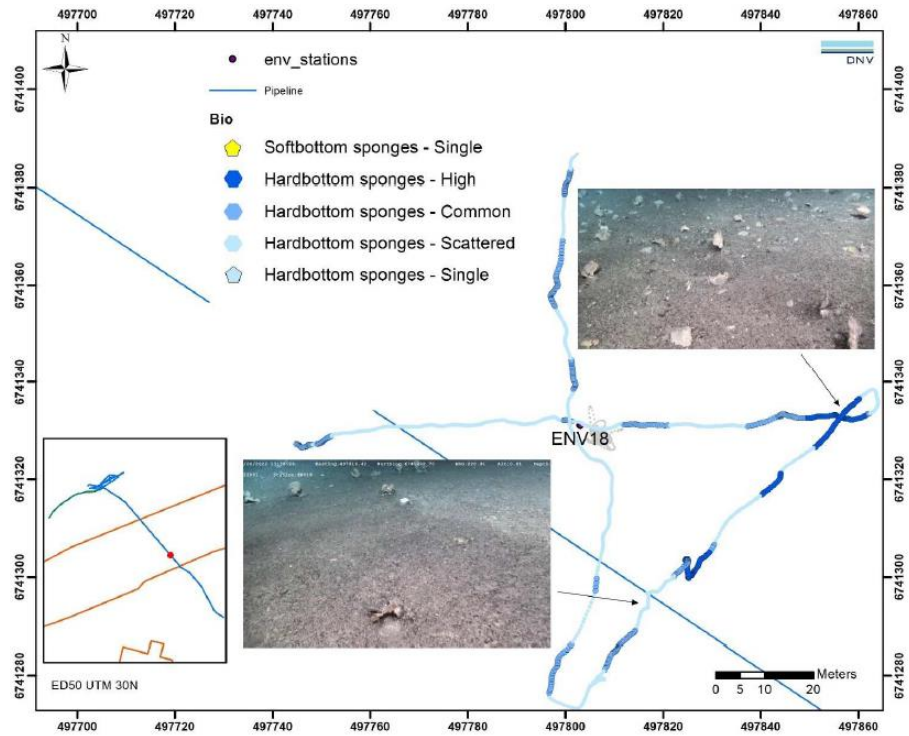


Figure 4-25 Records of sponges and density classification at Station ENV18

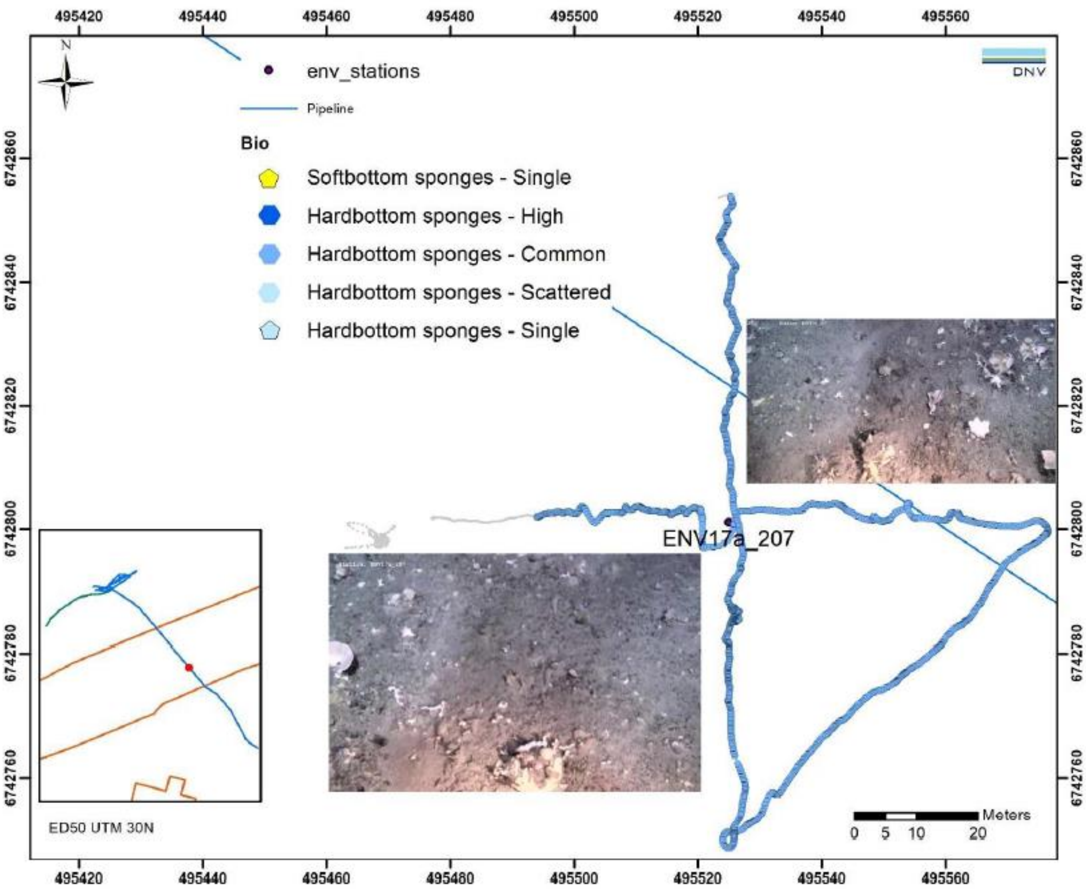


Figure 4-26 Records of sponges and density classification at Station ENV17a-207

4.3.2.2.3 Cold-water corals

The lattice-work structure of cold water reef-forming corals e.g. *Desmophyllum pertusum* (formerly known as *Lophelia pertusa*) have the potential to modify the seafloor by constructing impressive reef frameworks. Cold-water coral reefs qualify as 'reef' habitat under Annex I of the EU Habitats Directive and *Desmophyllum pertusum* reefs are also classified as OSPAR threatened/declining features or species (OSPAR, 2008); hence such habitats are a conservation priority. Cold-water coral reefs were designated as Scottish PMF in 2014 (Tyler-Walters, 2016).

The presence of cold water reef-forming corals in the deeper waters of the north-east Atlantic has received much public and research attention (e.g. Wilson, 1979; Frederiksen *et al*., 1992; Long *et al*., 1999; Bett, 2000). It is suggested that the depth distribution of *D. pertusum* in the Faroe-Shetland Channel is different to that in other areas of the north-east Atlantic, where it has been found to occur down to depths of more than 1,000 m. In the Faroe-Shetland Channel, Desmophyllum is found most frequently on the shelf and upper slope between approximately 200 to 400 m, and 250 to 450 m (Faroes slope). Desmophyllum does not generally thrive in water depths greater than 500 m. This limit in distribution corresponds with the depth at which there is a change from relatively warm Atlantic water to the cold Norwegian Sea bottom water.

The AFEN survey in 1996 found live and dead fragments of Desmophyllum in seabed samples at 250 to 350 m and at 550 m at one site (Bett, 2000). These locations were well to the north of the proposed gas pipeline route. No Desmophyllum was encountered during photographic work in this region by Howell *et al*. (2007) or the environmental sampling undertaken by Fugro in 2012 (Fugro, 2012a, 2012b). There are no known cold-water coral reefs in the vicinity of the Rosebank Development area (NMPi, 2022).

The visual survey conducted at the Rosebank field in 2021 (Akvaplan, 2022a) recorded a scattered distribution of soft corals belonging to the family Nephtheidae (cf. *Gersemia sp*.), but not in aggregations that could be considered as coral gardens as defined by OSPAR (2021). Note, however, that the precise definition of what density of corals constitutes a "garden" still is difficult to define (Bullimore, 2013). No coral gardens or *Desmophyllum* reefs were encountered during the DNV (2022a) gas export pipeline route survey.

4.3.2.2.4 Stony reefs

The EC Habitats Directive lists reefs under Annex I as habitats that should be maintained or restored. Reefs can be of three principal types; bedrock reef, stony reef and biogenic reefs. The term ‘rocky reef’ can be used to describe areas of either bedrock or stony (e.g. cobble and boulder) habitat. The NMPi indicates the potential presence of reefs, listed on the Annex I of the EC Habitats Directive, along the proposed gas export pipeline route.

All locations where bedrock or stones were observed along the gas export pipeline route were subject to a ‘reefiness’ assessment following current JNCC guidance (Golding *et al*, 2020) to determine if the habitats observed would constitute an Annex I rocky reef under the Habitats Directive (DNV, 2022a). At one station (ENV 14; Figure 4-27), a small rock outcrop was identified suspected of being classified as “low resemblance to Annex 1 stony reef” but did not fulfil all criteria set by JNCC due to its small size of less than 25m².

Figure 4-27 Image example of the small rock outcrop at Station ENV14 (DNV, 2022a)

Fugro (2012a, 2015a, b) assessed the ‘reefiness’ of the habitats observed using the methods then described by the JNCC for stony reefs (Irving, 2009). On the Rosebank to Tormore manifold route, three areas were assessed for ‘stony reef’ characteristics. All of the assessed areas were classified as ‘Not a reef’ due to a low level of faunal cover for two of the patches while the third patch was below the minimum area required (Fugro, 2015a, 2015b). Eight stations along the continental shelf section of the previously proposed gas pipeline route were assessed to have some level of reefiness. Four of these stations had one or more of the criteria scored as ‘low’ and were therefore considered unlikely to be considered as Annex I rocky reef. Of the remainder and of relevance to the Clair pipeline route, station 19, to the south-west of Shetland, m*et al*l criteria for high reefiness. The assessment covered a single feature of an estimated 250 m^2 of solid rock densely covered with epifauna including branching sponges and hydroids. Either side of this rock feature were areas of mixed sediment and cobble, of no reefiness potential.

4.3.2.2.5 Macrofauna

Within the Faroe-Shetland Channel, macrofaunal assemblages appear to be related to temperature range, as warmer Atlantic waters flow over cooler Arctic waters, limiting species distribution to specific depths (DECC, 2016). The continental slope plays a role in funnelling ocean currents and brings nutrients in the area, thus creating ideal conditions for the establishment of typical species of the area such as deep-sea sponges. Deep sea worms can tolerate cooler Arctic waters and therefore establish below 800 m in muddy sediments. In areas of iceberg plough marks, the heterogeneous habitat can result in significant local variation in macrofaunal composition and abundance, especially in the areas of coarse sediment (cobbles and boulders) (Hughes *et al*., 2003). DECC (2016) reported the presence of two sedimentary communities in the Faroe-Shetland Channel, namely offshore subtidal sands and gravels and cobbles and boulders, which were dominated by contrasting families of polychaete worms.

The wide-scale AFEN surveys provide an assessment of the community types present within the eastern flank of the Faroe-Shetland Channel. Over 1,000 infaunal species were found during the survey and about half of these could not be identified as known species (Bett, 2000). Overall, the infauna was dominated numerically by polychaetes and amphipods, with lesser contributions from crustaceans, molluscs and echinoderms. Biomass reached a peak between 300 and 400 m water depth and diversity reached a very marked peak at around 400 to 500 m (Bett, 1996; 2000). This diversity peak corresponds to the depth range of well-developed epifauna communities and with the maximum water temperature variations, and may represent an area of mixing between warm-water and cold-water faunas (Texaco, 2000).

The macrofauna at the Rosebank field sampled in 2011 (Fugro, 2011a) was abundant and diverse, and dominated numerically by polychaetes. The number of taxa recorded at in-field stations varied between 18 and 43 per 0.1 m^2 grab sample while total faunal abundance ranged between 53 to 161 individuals per 0.1 m^2. The most abundant species were the polychaetes *Paramphinome jeffreysii*, *Notoproctus sp*., *Notomastus sp*., *Proclea graffii*, *Glycera lapidum agg*., *Myriochele heeri* and *Samythella elongata*, together with the sipunculan worm *Nephasoma sp*., the sea cucumber *Myriotrochus sp.* and the tube-dwelling amphipod *Haploops vallifera*. Later in-field sampling in 2014 (Fugro, 2014b) found numbers of taxa of between 22 and 42 per 0.1 m^2 grab sample, total numbers of individuals ranging between 66 and 142 per sample, and a very similar range of dominant taxa.

The 2021 infield survey conducted at Rosebank by Akvaplan (2022a) recorded a total of 4577 individuals within 154 taxa (juveniles excluded). Polychaetes dominated the fauna, representing 65% of the total number of individuals and 42 % of the number of taxa recorded. The diversity index (H) was relatively high at all stations. The most dominant taxa were the polychaetes *Notoproctus sp*., *Galathowenia oculata*, *Paramphinome jeffreysii* and *Galathowenia fragilis* and the sipunculid *Nephasoma sp*. The polychaetes *Notoproctus sp.* and *G. oculata* were among the top 10 species at all stations and *Notoproctus sp*. was the most dominant at 16 of the 19 stations. The faunal similarity between the stations was high (dissimilarity less than 44 %), indicating a relatively uniform faunal composition in the area. A canonical correspondence analysis (CCA) was conducted on data from the 19 stations to assess associations between biological data (species abundances) and selected environmental covariates. The CCA results indicate that 87 % of the total variation in the benthos data can be explained by the environmental data. Among the environmental covariates, fines (silt/clay), gravel and TOC were statistically significant. Numerous traces of animal life in the sediment were observed, showing that there was a rich biological activity which is reflected in the results from the infaunal analyses conducted (Akvaplan, 2022b).

Earlier surveys in nearby areas suggest the macrofaunal communities at the Rosebank field are typical of the wider area. A survey conducted at the Aberlour field, located in Block 213/28, directly to the west of the Rosebank field, indicated that Polychaeta was the dominant class across the stations, with the dominant species being *Paramphinome jeffreysii*. The second most important species were *Golfingiidae sp*. (peanut worms or sipunculids). Another polychaete represented in high abundance in the sediment samples were *Notoproctus oculatus* (Geolab, 2007; OGUK, 2017d). These three species were also the most represented species at the Lochside field (located in Block 213/24) which was surveyed in 2007, although *N. oculatus* was dominating at that location. In 2000, the survey at the Tranche 6 Proposed Well (Block 213/24) identified the bivalve *Yoldiella sp*. as the dominant species, followed by the polychaetes *Cirratulus sp*., *P. jeffreysii*, *Myriochele oculata* and *N. oculatus* (OGUK, 2017d). A survey of the Sula and Stelkur prospects 15 km east of Rosebank also found the most abundant macrofaunal species to include the polychaetes *P. jeffreysii*, *Notoproctus sp*., *Notomastus sp*., *P. graffii*, *G. lapidum agg*. and the peanut worm *Nephasoma sp.* (Gardline, 2009).

The 2011 survey along the gas export pipeline route showed a moderate to highly diverse and abundant infaunal community. The most dominant phylum was Annelida, with the top three most abundant species being the polychaete worms *Paramphinome jeffreysii*, *Notoproctus* and *Chaetozone jubata*. Univariate analysis indicated a large variation in species richness and abundance of individuals throughout the survey area. This finding was supported by multivariate analysis which divided stations into eight statistically significant clusters. Clustering is likely to be driven by depth changes and/or changes in sediment type: those clusters at similar depths (and similar sediment types) had more statistically similar communities than those at different depths/sediment types. Significant correlations were identified between the macrofaunal community data and water depth and the sediment fine fraction. The communities recorded were similar in phyletic composition to communities previously sampled in the region, displaying a mix of taxa from the northern North Sea and those typically encountered further north in Arctic regions (Fugro, 2011b). The peak in diversity at between 400 and 500 m noted in the AFEN infaunal data by Bett (2000) described above appeared to be repeated in the data reported in and near the Rosebank Development area (Fugro, 2011, 2012b). Values for the Shannon-Weiner diversity function ‘H’ (a measure of species diversity in a community) in the in-field area ranged between 3.39 and 4.75 (Fugro, 2011), and ascending the slope towards the shelf edge peaked at 4.99 against a background deeper or shallower of 4.04 to 4.33 (Fugro, 2012b).

The 2022 environmental baseline survey along the gas export pipeline route (DNV, 2022b) exhibited marked depth-related trends in macrofaunal communities, with the lowest number of individuals recorded at the stations located on the continental shelf (discussed further in Section 4.3.2.3.2). At the stations located from the Rosebank field to the shelf break, the number of species sampled ranged from 15 to 60 and the number of individuals ranged from 126 to 464. In general, the number of species increased with water depth (maximum 60 species at station ENV11 at 1,095 m depth). However, it is noted that the lowest numbers of species were from Stations ENV17a_207, ENV18, ENV19, ENV20a_212 and ENV27 on the upper continental slope which were sampled by push corer operated by ROV and are not directly comparable to samples obtained by grab or box corer due to the smaller surface area sampled. Diversity H’ varied from 2.4 to 4.8 with no clear trends identified along the pipeline route, although diversity values would also have been affected by use of the push corer.

The deeper stations (>900 m) were dominated by the sipunculids Golfingiidae and Nephasoma and polychaetes *Paramphinome jeffreysii*, *Galathowenia oculata* and *Notoproctus* spp. Stations at depths of 700-550 m were dominated by polychaetes *Spiophanes kroeyerii* and S. *wigleyi*. The dominant species were more variable at depths of 250 – 550 m on the steep slope of the Faroe-Shetland channel, but include *S. kroeyeri* along with the polychaete Myriochele heeri and the anemone *Cerianthus lloydii*. The faunal composition at all stations was considered to be undisturbed and indicative of healthy benthic communities.

The ocean quahog Arctica islandica¸ a large marine bivalve mollusc, has been observed in the vicinity of the Development area, off the south-west coast of Shetland (NMPi, 2022). These species are considered of conservation importance in Scotland and designated as Scottish PMFs (Tyler-Walters, 2016). Ocean quahog is also a feature of the Faroe Shetland Sponge Belt NCMPA through which the Rosebank pipeline is routed. No specimens of ocean quahog (Arctica islandica) were identified in the sampled material (DNV, 2022b).

Multivariate analyses of the macrofaunal data grouped the stations into five main groups at 20% similarity, governed mostly by water depth and sediment grain size distribution. The grouping of stations was similar to that shown for megafauna in the visual survey, conducted at same stations (Section 4.3.2.2.1).

4.3.2.3 Continental Shelf

4.3.2.3.1 Megafauna and epifauna

In terms of epifauna, a photographic survey by Dyer *et al*. (1982, 1983) and trawl work by Basford *et al*. (1989) on the shelf to the west of Shetland found it to be characterised by northern species including starfish such as *Hippasteria phrygiana*, *Stichastrella rosea* and *Solaster endeca*, the anemones *Adamsia palliata* and *Actinauge richardi*, sponges such as *Phakellia sp*., the polychaete *Hyalinoecia tubicola*, the squat lobster *Munida rugosa* and sea urchins such as *Cidaris cidaris* and *Echinus sp*. Dyer *et al*. (1983) reported that the pencil urchin *C. cidaris* was most characteristic of the slope and shelf edge. Basford *et al*. (1989) found mixed sediments with a significant coarse element also supported the starfish *Asterias rubens*, *Porania pulvillus* and *Luidia ciliaris*, the large mobile anemone *Bolocera tuediae* and the bryozoan *Flustra foliacea*, the latter characteristic of high-energy mixed sediment areas with attendant sediment-scouring. In survey work at the Clair field and along the Clair pipeline route to Yell Sound (Hartley Anderson, 2000) it was also noted that the boulders and cobbles in mixed sediments on the outer continental shelf tended to be encrusted with bryozoans and the calcareous white tubes of serpulid polychaetes.

Environmental survey along the previously proposed Rosebank gas pipeline route (Fugro, 2012a, 2012b) reported similar epifaunal and infaunal communities across the shelf west of Shetland. Areas of predominantly sandy sediments tended to have a very sparse mobile epifauna of occasional starfish and hermit crabs. In contrast areas of mixed sediments incorporating pebble, cobble or boulder material together with areas where boulders and outcropping rock predominated had a greater variety of both mobile and attached species.

The methodology used to investigate the fauna in the 2022 survey is described in Section 4.3.2.2.1. DNV (2022a) identified the following biotopes on the West Shetland Continental Shelf where the gas export pipeline route will be located: A5.15 Deep circalittoral coarse sediment and A5.27 Deep circalittoral sand (see Figure 4-21 for example images). Multivariate analyses showed the fauna of the shallow sandy stations on the continental shelf to be distinct from that on the continental slope. Echinoderms were the most abundant phylum observed, with crustaceans also important at the shallowest stations (Figure 4-22). No OSPAR habitat types, red listed species, ocean quahog, coral gardens or Desmophyllum reefs were encountered on this part of the pipeline route.

4.3.2.3.2 Macrofauna

Dyer (1983) described a sparse epifauna from the West Shetland Continental Shelf dominated by northern species such as the asteroids *Hippasteria phrygiana*, *Stichastrella rosea* and *Solaster endeca*, the anthozoan *Adamsia palliata*, the polychaete *Hyalinoecia tubicola*, and the sponges *Tetilla* and *Phakellia*; the echinoid *Echinus tenuispinus*, asteroids *Pteraster militaris* and *Pontaster tenuispinus* and the anthozoan *Hormathia digitata* were also dominant in the deeper northern stations. Cranmer *et al*. (1984) extended this work and noted the presence, in small densities, of the anthozoan *Actinauge richardi* (common around Shetland), the squat lobster *Munida rugosa* and the zoantharian *Epizoanthus incrustatus* found in association with an anomuran crab (DECC, 2016).

A review by Eleftheriou (2003) outlines that the AFEN survey of 1996 found that the tube-building polychaete *Galathowenia oculata* was generally the most abundant species in sediments to the west of Shetland between 104 and 180 m. At shallower stations closer to the Clair field, the polychaetes *Aonides paucibranchiata*, *Hesionura elongata*, and *Protodorvillea kefersteini* were also amongst the more abundant species. Environmental survey work around the Clair field also reported macrofaunal communities dominated by *M. oculata* and *A. paucibranchiata*. '*H. elongata* and *P. kefersteini* in offshore coarse sand' is a biotope of the subtidal sands and gravels habitat, designated as a PMF, and has been recorded several kilometres south of the gas export pipeline route (at the closest point), to the south of Shetland (NMPi, 2022).

Shallower stations generally have coarser sand substrata, and supported a community dominated by *Prionospio (*Minuspio*) cirrifera*, together with a number of surface-dwelling species exploiting the greater habitat diversity of those sites which had more gravel (DECC, 2016).

On the portion of the gas export pipeline route located on the continental shelf, characterised by sandy sediments with very little silt/clay, DNV (2022b) recorded relatively low species richness (13 to 34 species) and abundance (18 to 119 individuals per sample). However, diversity H' on the shelf ranged showed a similar range (2.9 to 4.6) to that recorded on the deeper parts of the route (2.4 to 4.8). The macrofaunal community was considered to be undisturbed and was dominated by the crustacean *Ampelisca brevicornis* and polychaetes *Aonides paucibranchiata* and *Protodorvillea kefersteini*. No specimens of ocean quahog (*Arctica islandica*) were identified in the sampled material (DNV, 2022b).

4.3.3 Fish and Shellfish

4.3.3.1 Faroe-Shetland Channel

4.3.3.1.1 Species, migrations, spawning and nursery grounds

Due principally to the layered water masses in the Faroe-Shetland Channel and the marked lowering of water temperature below about 500 m (refer to Section 4.2.3), the fish communities present in the Faroe-Shetland Channel differ from those present in the warmer continental shelf and inshore waters west of Shetland.

With respect to migratory species, tagging studies have indicated that Atlantic salmon *Salmo salar* from the southwest UK and Ireland inhabit the surface waters and shelf edge current of the Faroe-Shetland Channel, during migrations northwards to the Norwegian Sea and the coastal waters of Greenland (Malcolm *et al*., 2010). Tagging studies re-captured 167 post-smolt salmon in five trawls in surface waters of the Faroe-Shetland Channel, where the densities caught indicated that post-smolt salmon form schools in the open sea (Shelton *et al*., 1997). Very little is known about the way in which the common eel *Anguilla anguilla* uses the waters to the west of Britain and Shetland in its migrations between UK rivers and the Sargasso Sea (Malcolm *et al*., 2010). However, the assumption is that juvenile stages arrive in waters west of Shetland and the Western Isles in September each year, being larvae when they reach west of the continental shelf and being slightly larger glass eels by the time they reach shelf waters (Tesch, 2003). Movement into the North Sea and around the east coast of the UK occurs via the Fair Isle current and via the inflow around the north of Shetland.

Table 4-9 shows the presence of spawning species or species which use the deeper parts of the Faroe-Shetland Channel (depths >500 m) in the Rosebank Development area as a nursery ground throughout the year. Species that may spawn or use nursery grounds on the upper slope and continental shelf are shown in Table 4 10. Figure 4-28 and Figure 4-29 and Figure 4 30 present this information visually in the context of the Rosebank field and the gas export pipeline route. As noted by Coull *et al*. (1998) spawning areas for most species are not rigidly fixed, and in addition fish may spawn earlier or later in the season in response to environmental cues.

There are no predicted spawning areas of high intensity which directly overlap with the Development (Figure 4-30). Norway pout *Trisopterus esmarkii* spawn to the west of Shetland, using deep waters between March and May and shelf waters between January and April (Coull *et al*., 1998). Norway pout is known to spawn in the section of the Rosebank Development area that is located within the Faroe-Shetland Channel, which comprises International Council for the Exploration of the Sea (ICES) rectangles 50E6 and 51E6 (Figure 4 30).

Blue whiting *Micromesistius poutassou* spawn in deep water areas to the west of Shetland from April through to June and may use the area around the Rosebank field as high intensity spawning ground in April and May (Ellis *et al*., 2012). Blue whiting are widely distributed in the north-east Atlantic, moving in shoals between 150 - 3,000 m water depths. They may pass through the Faroe Shetland Channel when migrating south to reach spawning grounds (DECC, 2016).

There are no benthic spawners such as sandeels and shellfish that are likely to spawn in the vicinity of ICES rectangles 51E6 and 50E6 (relevant to the Faroe-Shetland channel).

Mackerel *Scomber scombrus* use the continental shelf break as an important migration route and wintering area. Following spawning in deep waters to the west of Britain and Ireland, a large proportion of the adult western stock migrates north-east through the west of Shetland area along the shelf break between May and July, on route to summer feeding grounds in the northern North Sea and the Norwegian Sea. A return south-westerly migration of mackerel occurs between November and March at a depth of 100 to 200 m (Belikov *et al*., 1998; Reid *et al*., 1997).

Table 4-9 Spawning and nursing periods of fish species in the Faroe-Shetland Channel in the vicinity of the Rosebank Development (Coull *et al.*, 1998; Ellis *et al.*, 2012)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Blue whiting	N	N	N	S*/N	S*N	S/N	N	N	N	N	N	N
Ling	N	N	N	N	N	N	N	N	N	N	N	N
Mackerel	N	N	N	N	N	N	N	N	N	N	N	N
Norway pout	S/N	S*/N	S*/N	S/N	S/N	N	N	N	N	N	N	N

S	= Spawning period
S*	= Peak spawning
N	= Nursery
	= High nursery intensity as per Ellis *et al*., (2012)

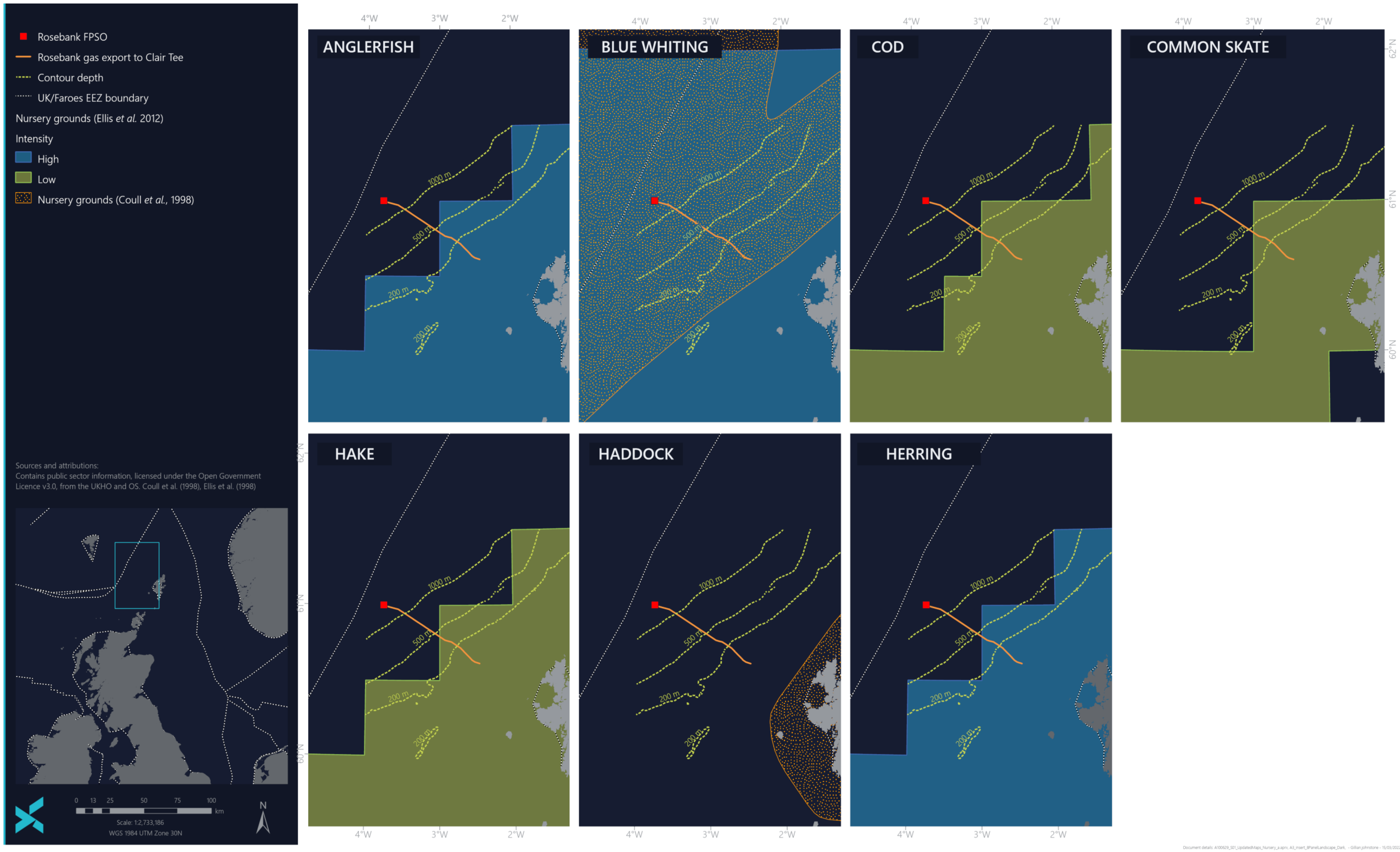


Figure 4-28 Fish nursery grounds (Aires *et al.*, 2014; Coull *et al.*, 1998; Ellis *et al.*, 2012)

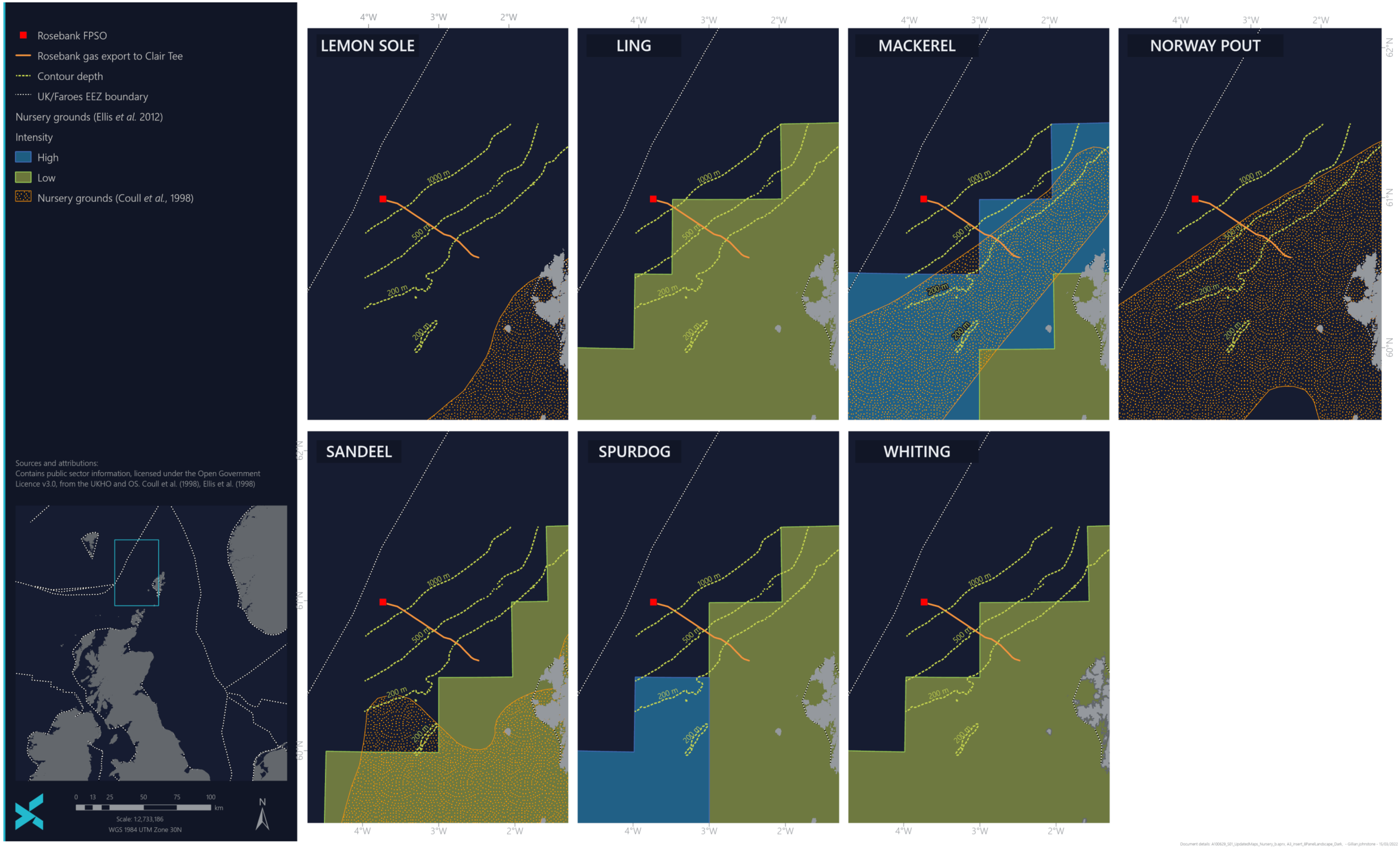


Figure 4-29 Fish nursery grounds (continued) (Aires *et al.*, 2014; Coull *et al.*, 1998; Ellis *et al.*, 2012)

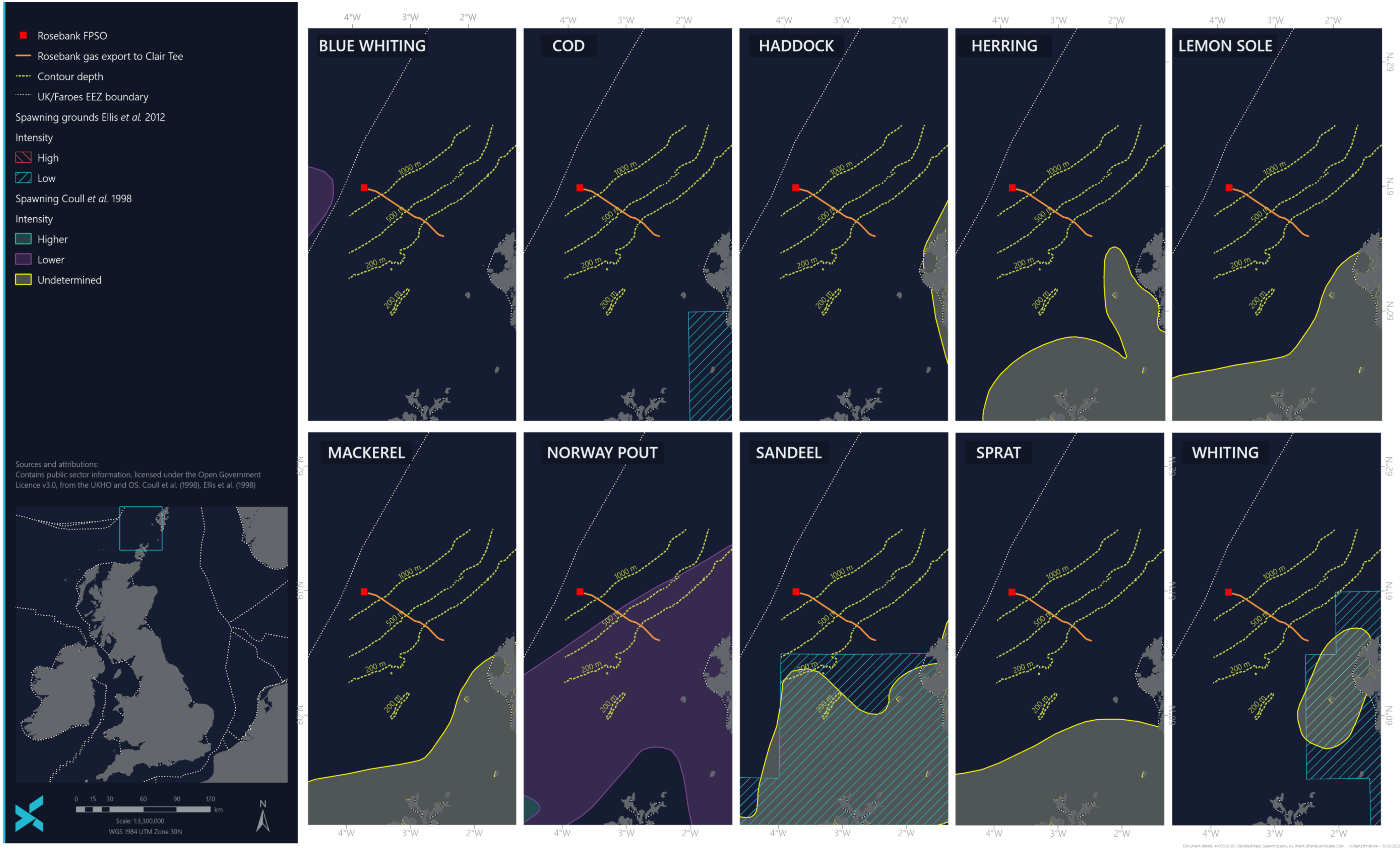


Figure 4-30 Fish spawning grounds (Coull *et al.*, 1998; Ellis *et al.*, 2012)

A review of juvenile fish data was undertaken by Aires *et al*. (2014) taking into account the findings of Ellis *et al*. (2012) and Coull *et al*. (1998), together with findings from the National and International Bottom Trawl Surveys, the Beam Trawl Survey, International Herring Larval Surveys and other standalone surveys. The findings summarise the probability of aggregations of juvenile (group 0) fish being present around the UKCS. Within the offshore Development area, there is a low probability of aggregations of juvenile fish (<1 year-old) amongst the species that are known to spawn and/or use the Rosebank Development area as nursery (Figure 4-29) (Aires *et al*., 2014).

Several of the fish species identified to be present in the wider offshore Rosebank Development area from the field to the shelf break, or to use the Rosebank Development area for spawning or as nursery, are regarded as Scottish Priority Marine Features (PMF). These include anglerfish *Lophius piscatorius*, blue whiting, herring *Clupea harengus*, mackerel, ling *Molva molva*, cod *Gadus morhua*, horse mackerel *Trachurus trachurus*, Norway pout and sandeel *Ammodytes marinus* (NatureScot, 2020).

Some species which may be found in the Development area are classified under additional international designations. Spurdog *Squalus acanthius* are listed as Vulnerable on the IUCN Red List and common eel are Critically Endangered (IUCN, 2022). The Atlantic salmon is listed on Annexes II and V of the EU Habitats Directive.

4.3.3.1.2 Deep-sea fish

There are relatively few data on the biology of deep-sea fish in the Faroe-Shetland Channel. As discussed above, the deep water fish fauna varies in relation to the depth of the water column. Surveys of the upper slope of the Faroe-Shetland Channel, from about 200 to 500 m depth have revealed a fauna resembling that of the upper continental slope to the west of the Hebrides, but with a higher abundance of redfish *Sebastes* species. The most abundant species observed included rabbitfish *Siganidae* species, Norway haddock *Sebastes norvegicus*, bluemouth *Helicolenus dactylopterus* and blue whiting (Gordon, 2003). The most important of these, in terms of abundance and commercial value is the blue whiting. Greenland halibut *Reinhardtius hippoglossoides* may also be present at these depths but is more common in deeper waters.

The fish fauna below 500 m is more similar to the cold Norwegian Sea than to the west of Scotland, because of the barrier presented by the Wyville-Thompson Ridge (Gordon, 2003). There is a relatively narrow transition zone where water temperature changes rapidly with depth. This zone hosts species such as Greenland halibut, roughhead grenadier *Macrourus berglax* and redfish (Gordon, 2003). Below the transition zone, there is a low fish biomass and an impoverished species abundance that is unique to the region (Gordon *et al*., 1994; Gordon, 2003). The dominant mesopelagic species (inhabiting waters between 200-1,000 m) along the west coast of the UK are thought to be the lantern-fish *Notoscopelus kroyeri* and the pearlside *Maurolicus muelleri* (DECC, 2016).

Limited surveys of the deeper areas, greater than 1,000 m, have revealed a cold water fauna that includes Greenland halibut, rockling and eelpout. Such species were observed during ROV surveys around well sites in the Rosebank field and included the Arctic rockling *Gaidropsarus argentatus*, various eelpout (*Lycodonus mirabilis*, *Lycodonus sp*., *Lycodes esmarkii* and *Lycodes sp*.) and a type of snailfish *Careproctus sp*. (SERPENT, 2009a, 2009b; Jones and Gates, 2010a).

4.3.3.1.3 Elasmobranchs (sharks, skates and rays)

A number of pelagic shark species are found in the waters around the British Isles, several of which occur in the Faroe-Shetland Channel. The porbeagle shark *Lamna nasus* occurs in the waters around Shetland and is thought to be present all year in deep-water off the Faroe Islands, and feeds on cephalopods and fish (Gordon, 2003). Blue sharks *Prinonace glauca* are known to follow the North Atlantic Drift through the Faroe-Shetland Channel towards the Norwegian Sea (Kohler *et al*., 2002). Thresher sharks *Alopias vulpinus* have also been recorded in these waters, but only in low numbers (Muus and Dahlstrøm, 1985).

The basking shark *Cetorhinus maximus* is a filter-feeding elasmobranch and the second largest fish species in the world, widely distributed throughout the waters of the UK west coast, including the Faroe-Shetland Channel. Basking shark sightings are most frequent between April and September (Chambers and Solandt, 2005; Witt *et al*., 2012) when they move inshore to feed.

Basking sharks species are now known move offshore in winter months to use deep-water areas off the shelf edge west of the British Isles, exploiting mesopelagic zooplankton populations, specifically calanoid copepods overwintering at depths down to 1,200 m (Sims *et al*., 2003; Gore *et al*., 2008). Basking sharks are listed as Scottish PMF (NatureScot, 2020).

Data on demersal elasmobranch species (i.e. those living on or close to the sea floor) are limited, but a study of deep-water fish stocks to the west of Scotland indicates the potential presence of deep-water sharks of the family Squalidae in the Faroe-Shetland Channel (Gordon and Hunter, 1994). Despite this, the colder waters of the region support fewer deep-water demersal shark species than the warmer waters to the south of the Wyville-Thompson Ridge (Gordon and Swann, 1997; Gordon, 2003). The velvet bellied shark *Etmopterus spinax* is probably the most abundant deep-water shark in upper slope waters down to about 500 m (Gordon and Hunter, 1994; Gordon, 2003). Leafscale gulper shark *Centrophorus squamosus* are also likely to be present in the deeper waters (DECC, 2016). In addition, blackmouth dogfish *Galeus melastomus* have been recorded in the Faroe-Shetland Channel down to 400 m (Gordon *et al*., 1994; Gordon, 2003). The Arctic skate *Amblyraja hyperborea* is one of the most abundant fish species in the deep-waters of the Faroe-Shetland Channel; it is found from about 600 m down to depths beyond 1,500 m (Fowler *et al*., 2004).

Elasmobranchs observed during ROV investigations around wells drilled in the Rosebank field in approximately 1,100 m included the thorny skate *Amblyraja radiata*, the Arctic skate and the ray *Dipturus linteus* (Jones and Gates, 2010b). Thornback ray were also observed in the wider Rosebank Development area during the 2014 survey (Fugro, 2014a).

4.3.3.2 Continental Shelf

4.3.3.2.1 Species, migrations, spawning and nursery grounds

The fish populations on the continental shelf southwest of Shetland are likely to include species of commercial importance including haddock *Melanogrammus aeglefinus*, cod, whiting *Merlangius merlangus*, saithe *Pollachius virens*, herring, ling, megrim *Lepidorhombus whiffiagonis*, lemon sole *Microstomus kitt*, Norway pout, mackerel and plaice *Pleuronectes platessa*. Continental slope species at their upper reaches could also be found towards the west of the continental shelf including ling, megrim *Lepidorhombus whiffiagonis*, ray species and sprat *Sprattus sprattus*, European hake *Merluccius merluccius*, pollock *Pollachius*, poor cod *Trisopterus minutus*, grey gurnard *Eutrigla gurnardus* and tub gurnard *Chelidonichthys lucerna* (Muus and Neilson, 1999; Robson, 1997). Other fish species that have been observed during past Rosebank surveys include dab *Limanda limanda* (Fugro, 2012a).

A large proportion of the adult western stock of mackerel migrates north along the West Shetland Continental Shelf break between May and July on route to feeding grounds in the northern North Sea and the Norwegian Sea. Between November and March they return on a southerly migration at a depth of 100 to 200 m. Coull *et al*. (1998) and Ellis *et al*. (2012) have identified a number of fish spawning and nursery areas on the continental shelf to the west of Shetland, in the Rosebank Development area which comprises ICES rectangle 50E7. Low intensity spawning grounds for Norway pout lie on the continental shelf and upper slope section of the pipeline route (Figure 4-30).

Several other species use the continental shelf area as spawning ground, but their spawning grounds do not appear to overlap with the Development (Figure 4-30). The timing of spawning for these species is included for information in Table 4-10. There are no benthic spawners such as sandeels and shellfish that are likely to spawn in the Development area. Though not recorded by Coull *et al*. (1998) and Ellis *et al*. (2012) (therefore not shown in Table 4-10), a more recent study by González-Irusta and Wright (2016) mapped cod spawning across the North Sea. The mapped areas show the Rosebank gas export pipeline route to pass through some 'occasional' cod spawning areas. Cod are a species known to aggregate over specific grounds to spawn and aggregate on a spawning arena where males hold small territories in a lek-like mating system. The seasonal site fidelity of cod means that some areas of the Rosebank Development will be used by the species for spawning. Cod spawning occurs in the late winter/early spring between January and April, with peak spawning in February and March (Coull *et al*., 1998; Ellis *et al*., 2012).

The following species are recorded as using the area as nursery grounds: anglerfish, blue whiting, cod, common skate *Dipturus batis*, European hake *Merluccius merluccius*, herring *Clupea harengus*, ling *Molva molva*, mackerel *Scomber scombrus*, Norway pout, spurdog *Squalus acanthias*, and whiting *Merlangius merlangus*. Of these species, anglerfish, blue whiting, herring, and mackerel use the area at a high intensity at points throughout the year. Although surveys have recorded juvenile horse mackerel *Trachurus trachurus* as being widespread throughout UK waters, there is no evidence to date of any spatially defined nursery grounds for this species (Ellis *et al*., 2012).

Table 4-10 Spawning and nursing periods of fish species on the continental shelf and upper slope in the vicinity of the Rosebank Development (Coull *et al.*, 1998; Ellis *et al.*, 2012)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anglerfish	N	N	N	N	N	N	N	N	N	N	N	N
Blue whiting	N	N	N	N	N	N	N	N	N	N	N	N
Cod	N	N	N	N	N	N	N	N	N	N	N	N
Common skate	N	N	N	N	N	N	N	N	N	N	N	N
European hake	N	N	N	N	N	N	N	N	N	N	N	N
Herring	N	N	N	N	N	N	N	N	N	N	N	N
Ling	N	N	N	N	N	N	N	N	N	N	N	N
Mackerel	N	N	N	N	N	N	N	N	N	N	N	N
Norway pout	SN	S*N	S*N	SN	N	N	N	N	N	N	N	N
Norway pout	SN	S*N	S*N	SN	N	N	N	N	N	N	N	N
Spurdog	N	N	N	N	N	N	N	N	N	N	N	N
Whiting	N	SN	SN	SN	SN	SN	N	N	N	N	N	N

Key:	S	Spawning period	S*	Peak spawning	N	Nursery	(blue)	High nursery intensity as per Ellis *et al.* (2012)

4.3.3.2.2 Elasmobranchs (sharks, skates and rays)

Basking sharks are frequently sighted on the continental shelf west and south of Shetland, in the coastal waters and around land masses. While the density of sightings in Shetland is considered low-moderate in comparison to some areas highly utilised by the species, Austin *et al*. (2019) concluded that the coastline of Shetland, and much of the Scottish coast, was considered highly suitable habitat for basking sharks. Basking sharks move inshore from the shelf edge in the summer months (April to September) to feed on zooplankton blooms particularly the calanoid copepods *Calanus finmarchicus* and *C. helgolandicus*. Hayes *et al*. (2018) observed breaching behaviour by basking sharks off the coast of Shetland and concluded that a lack of observational data in the region is likely more to be attributed to reduced sightings effort, not for any ecological reason. The study determined that the high number of sightings of sharks recorded during a relatively short time frame, in addition to breaching behaviour and presence of young individuals, suggest that the sea west of Shetland may be an important habitat for the basking shark (Hayes *et al*., 2018).

The porbeagle shark is distributed widely over the northern North Sea and the west of Scotland in summer months with the highest reported catches around the Shetland Islands (Gordon, 2003). None of the deep-water shark species occur in any numbers on the shelf area west or south of Shetland with the exception of the velvet-belly shark (Gordon, 2003).

The spurdog (a dogfish) occurs on the continental shelf mostly at depths between 10 m and 100 m, although it is occasionally caught in the deeper waters of the continental slope. Spurdog tend to aggregate in large shoals of the same size or sex. Tagging experiments in the 1960s indicated a winter migration from Scotland to Norway with a return migration in the summer (Gordon, 2003). Small elasmobranchs such as the dogfish species *Scyliorhinus canicula* and *S. stellaris* are also common in inshore waters of Shetland and the UK.

Ray species known from fish landing records to occur on the shelf and inshore waters around Shetland include the common skate *Dipturus batis*, the white skate *Raja alba*, the cuckoo ray *Leucoraja naevus*, spotted ray *Raja montagui* and thornback ray *Raja clavata* (DECC, 2016). The common skate is listed as Critically Endangered on the IUCN Red List (IUCN, 2022).

4.3.4 Cephalopods

Cephalopods are short-lived, carnivorous invertebrates with rapid growth rates that play an important role in marine food webs. Two superorders of the class Cephalopoda are found within the UK: the Decapodiformes (squid and cuttlefish) and the Octopodiformes (octopuses). Most cephalopods lack an external shell and are highly mobile predators.

Cephalopods are well represented in the region west of Shetland (Pierce *et al*., 2003). Collins *et al*. (2001) lists 29 species as occurring in waters ranging from 150 to 4,850 m in the northeast Atlantic. Although most of these species are not common and have not been the subject of a fishery, they may play an important role in the ecosystem and have an important ecological role as both predators and prey. For example, short-finned squid are known to contribute toward the diet of seabirds (Pierce *et al*., 2003) while bobtail squid are frequently recorded in the diet of porpoises. Many oceanic squid species occur in the diets of sperm whales *Physeter macrocephalus*, northern bottlenose whales *Hyperoodon ampullatus* and Cuvier’s beaked whales *Ziphius cavirostris* (Santos *et al*., 1999; 2001a, 2001b; 2002). The Faroe-Shetland Channel is a known habitat and migration route for whales many of which rely partly or exclusively on cephalopods for food.

4.3.4.1 Faroe-Shetland Channel

There are a number of deep-water squid likely to be present in the Faroe-Shetland Channel. The boreoatlantic armhook squid *Gonatus fabricii* is the most abundant and occurs at depths of between 350 to 1,200 m (Pierce *et al*., 2003). The cirrate octopuses (which include the cirroteuthids) are confined to deep water and are not actively fished. During their 2009 mission to Rosebank North, SERPENT (2009b) reported the presence of the deep-sea bentho-pelagic 'Dumbo' squid. Cirroteuthids caught from this area have predominantly been *Cirroteuthis muelleri* (Jones and Gates, 2010a).

In these deep waters, cephalopods are generally less well known, and none are of commercial importance. Collins *et al*. (2001) review records of deep-water benthic and bentho-pelagic cephalopods in the north-east Atlantic, based on specimens collected from commercial and research trawling. The squid *Neorossia caroli* (400 to 1,535 m), and *Rossia macrosoma* (205 to 515 m) were recorded in deep water. Three incirrate octopus genera were recorded in deep water: Benthoctopus and Bathypolypus were identified at depths of 250 to 2,700 m, and *Graneledone verrucosa* was caught at depths of 1,785 to 2,095 m. Cirrate octopods known from these deeper areas include *Opisthoteuthis massyae* (877 to 1,398 m) and *Cirroteuthis muelleri* (700 to 4,854 m). The deep-water cirrate octopuses *Bathypolypus arcticus* (spoonarm octopus), *Benthoctopus piscatorium* and *Graneledone verrucosa* are widespread throughout the deep, cool waters of the north Atlantic, down to depths of 2,500 m and have all been recorded in the Faroe-Shetland Channel. Little is known about the ecology of these predatory species.

4.3.4.2 Continental Shelf

On the continental shelf, the Sepiolidae family of bobtail squid are probably one of the most significant cephalopod groups (Pierce *et al*., 2003). Other frequently recorded species are the long-finned squids *Alloteuthis subulata* and *Loligo forbesii*; the short-finned squid *Todarodes sagittatus*; *Gonatus fabricii* and *Onychoteuthis banksii*; the bobtail squids *Rossia macrosoma* and *Sepietta oweniana*; and the octopus, *Eledone cirrhosa* (DECC, 2016). Example images of these species are given in Figure 4-31.

The European flying squid *T. sagittatus* has been known to form huge aggregations around the coasts of Scotland and Shetland in certain years, although by late December the squid have begun to migrate into deeper continental shelf water to over-winter and spawn at depths of between 70 and 800 m (Pierce *et al*., 2003). The similar *T. eblanae* (lesser flying squid), is also known to form large aggregations in the region, although the species rarely ventures into shallow or surface waters (Pierce *et al*., 2003).

Unidentified squid

Cirroteuthid squid in vicinity of well sites in the Rosebank field

Octopus, *Benthoctopus* sp. next to white sponge

Octopus, *Graneledone verrucosa*

Figure 4-31 Images and video screen grabs of cephalopods observed in the Rosebank field (SERPENT, 2009c)

4.3.5 Marine Mammals

4.3.5.1 Cetaceans – whales, dolphins and porpoises

The Faroe-Shetland Channel provides one of the few deep-water links between the north-eastern Atlantic and polar waters. The continental slope here plays an important role in funnelling ocean currents that bring valuable food and nutrients to the region, which support a wide diversity of life. The channel is believed to be a corridor for migrating marine mammals, including the fin whale ('razorback') and sperm whale (JNCC, 2020a). The Faroe-Shetland Channel and adjacent waters are regarded as important areas for cetaceans in a national and international context.

The regularly sighted whales in the region include blue whale *Balaenoptera musculus*, fin whale *B. physalus*, sei whale *B. borealis*, minke whale *B. acutorostrata*, humpback whale *Megaptera novaeangliae*, sperm whale *Physeter macrocephalus*, northern bottlenose whale *Hyperoodon ampullatus*, long-finned pilot whale *Globicephala melas* and the killer whale *Orcinus orca*. In addition, Risso's dolphin *Grampus griseus*, bottlenose dolphin *Tursiops truncatus*, white-beaked dolphin *Lagenorhynchus albirostris*, Atlantic white-sided dolphin *Lagenorhynchus acutus* and harbour porpoise *Phocoena phocoena* have all been regularly sighted in the waters to the west of Shetland and are therefore considered to be 'within their natural range'. A further eight species are occasionally sighted in the area (Table 4-11). There is increasing evidence that many of the species present here are breeding and rearing young (including white-beaked and Atlantic white-sided dolphins, common dolphins, humpback whales and probably blue and fin whales).

It is also likely that many of those species reported regularly in this area are feeding. In addition, several species make migrations through these waters (humpback whales and possibly blue and fin whales; Reid *et al*., 2003).

Table 4-11 details the seasonal occurrence of cetaceans in the eastern flank of the Faroe-Shetland Channel (as well as those found over the continental slope and up onto the continental shelf). The table gives an indication of the presence of species relative to the species population numbers rather than cetacean numbers overall. According to the review work by Reid *et al*. (2003), the most abundant cetacean in Rosebank Development area is the Atlantic white-sided dolphin. This confirms work by Skov *et al*. (2001). Other frequently sighted species include the northern sei, fin, sperm, killer and the long-finned pilot whales (Reid *et al*., 2003).

It is reported in Embling (2007) that dolphin species are detected in the northern waters of the north-east Atlantic later in the year and to that extent the Faroe-Shetland Channel could be considered a hotspot during the later months of the year. Additionally, long-finned pilot whales appear to move inshore around the Faroe Islands in years when sea surface temperature is highest, presumably due to the tracking of prey species (Zachariassen, 1993). Skov *et al*. (2001) report that cetaceans were seen frequently in the Wyville Thomson Ridge, the southern Faroe Bank Channel, the Faroe-Shetland Channel, the shelf break and banks to the east, and the south-east of the Faroe Islands.

During seismic survey work undertaken by previous licensees in the Rosebank field in August 2011, over 1,924 hours of visual observation were carried out (FrontierMEDEX, 2011) and 67 sightings of marine mammals were recorded. The species observed were long-finned pilot whale, sperm whale, humpback whale, minke whale, bottlenose dolphin, Atlantic white-sided dolphin, unidentified rorqual whale species, harbour porpoise and one unidentified dolphin species. The most frequently sighted species were long finned pilot and humpback whales (Figure 4-32). As part of this work, just over 1,971 hours of passive acoustic monitoring was also carried out during which 13 records of marine mammals were made. The species detected included long-finned pilot whales, Atlantic white-sided dolphins, three unidentified dolphins, three cetacean species and one mixed pod of long-finned pilot whales with an unidentified dolphin species.

More recent work by Waggitt *et al.* (2019) created cetacean distribution maps for 12 species in the North-East Atlantic using a newly developed species distribution model, overcoming issues with heterogeneous and uneven coverage. Of the species analysed, those predicted to have a medium to high density (animals per km^2 are relative to each species) in the Faroe-Shetland Channel were: long-finned pilot whale and sperm whale with a moderate abundance throughout the year; killer whale with a high abundance throughout the year; Risso’s dolphin with a high abundance in August and September, and white beaked dolphin and Atlantic white-sided dolphin with a high density from July to October.

In terms of conservation interest, the north Atlantic right whale is identified in the IUCN red list (IUCN, 2022) as a critically endangered species, the sei and blue whales as endangered and the sperm whale and fin whale are identified as vulnerable. The bottlenose dolphin, common dolphin, harbour porpoise, killer whale, long-finned pilot whale, Risso's dolphin, Atlantic white-sided dolphin, white-beaked dolphin, minke whale, fin whale and sperm whale are all listed in Annex IV of the Habitats Directive, whilst the bottlenose dolphin and harbour porpoise also feature in Annex II.

Humpback whale breaching

Long finned pilot whales; a mixed group containing adults, juveniles, and calves.

Figure 4-32 Images of cetaceans observed in the Rosebank field (FrontierMEDEX, 2011)

Table 4-11 Seasonal occurrence of cetaceans in the Faroe-Shetland Channel and continental slope and shelf (NMPi, 2022; Sea Around Us, 2008, Reid *et al.*, 2003, Taylor and Reid, 2001; Bloch *et al.*, 2000; Pollock *et al.*, 2000)

	Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Deep water species	Sperm whale												
		Rare. Sighted mainly in deep waters of Faroe-Shetland Channel and the Rockall Trough. Peak sightings occur in summer, acoustic data also indicates presence during winter.											
	Bottlenose whale												
		Very rare. Most sightings over the Wyville Thompson Ridge, Faroe Bank and Faroe-Shetland Channel. Sightings reported throughout the year in waters deeper than 1,000 m.											
	Killer whale												
		Found in inshore waters, over the continental shelf and in deep waters in every month of the year. Throughout May and June observations are predominantly along the continental slope.											
	Minke whale												
		Common. Most sightings along shelf break and deeper waters of the Faroe-Shetland Channel and Faroe Bank Channel. Higher densities in November-March.											
Continental slope and shelf species	Long-finned pilot whale												
		Uncommon. Sightings most often in waters less than 200 m and over Faroe Banks. Small proportion of species believed to overwinter.											
	White-beaked dolphin												
		Rare. Mainly concentrated in shelf waters all year round. Not reported in waters >200 m.											
	Atlantic white-sided dolphin												
		Common. Most numerous cetacean in area. All year round in deep waters of Faroe-Shetland Channel and the Faroe Bank Channel and regularly sighted in large pods.											
	Risso's dolphin												
		Rare in the west of Shetland region. Most sightings occur on the continental shelf in depths of less than 200 m.											

	Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Bottlenose dolphin												
		Uncommon in the west of Shetland region. Mostly recorded along the shelf ridge and over the Wyville Thompson Ridge.											
	Harbour porpoise												
		Uncommon. Rarely recorded in waters deeper than 500 m, found mainly around the continental shelf of the Faroe Islands throughout the year.											
Seasonal migrants	Blue whale												
		Very rare. Presence has been recorded in deep water around the Faroe Islands. Thought to migrate to northern latitudes during the summer but may overwinter in the north.											
	Fin whale												
		Most sightings are in the Faroe-Shetland Channel, along the shelf break and east of the Faroe Islands. Species believed to be both a seasonal migrant, summer resident and also spotted throughout the year. Peak sightings vary from year to year.											
	Sei whale												
		Sightings vary interannually, but higher in recent years. Mainly sighted in deep waters on the western side of the Faroe-Shetland Channel.											
	Humpback whale												
		Very rare. Few sightings along the shelf break. Migrate south-west through the region from November to March.											
Other rare species		Sowerby's and Cuvier's beaked whales, northern right whales, dwarf minke whales, narwhals, belugas, striped and common dolphins are occasionally sighted in the area also.											
No Data	**Cetacean sightings**			**Higher cetacean presence**				**Peak cetacean presence**					

More recently, the Small Cetaceans in European Atlantic waters and the North Sea (SCANS)-III survey results have been released. This programme consisted of ship-based and aircraft-based surveys over the European continental shelf carried out over a 6-week period in July and August 2016 (Hammond *et al*., 2021). It follows a series of cetacean surveys in European Atlantic waters initiated in 1994 with SCANS and continued in 2005-2007 with the SCANS-II surveys. Results consist of cetacean density estimates provided by blocks within which the Rosebank Development partially falls.

The Joint Cetacean Protocol (JCP) has been set up with the aim of delivering information on the distribution, abundance and population trends of cetacean species occurring in the North Sea and adjacent sea regions. The JCP Phase III analysis included datasets from 38 sources (including SCANS-III), totalling over 1.05 million km of survey effort between 1994 and 2010 from a variety of platforms (JNCC, 2017). The JCP Phase III analysis was conducted to synthesise these data sources to estimate spatial and temporal patterns of abundance for seven species of cetaceans (harbour porpoise, minke whales, bottlenose dolphins, common dolphins, Risso's dolphins, white-beaked dolphins and white-sided dolphins). Density estimates for the cetacean species observed in the Development area are presented in Table 4-12, according to both SCANS-III and the JCP Phase III analysis.

Table 4-12 Cetacean density (animals/km^2) estimates in the Development area (Hammond *et al.*, 2021, JNCC, 2017)

Species	SCANS III cetacean densities around Rosebank FPSO and along the pipeline lying on the continental slope (animals/km^2)	JCP cetacean densities at the Rosebank FPSO and along the pipeline lying on the continental slope (animals/km^2)
Harbour porpoise	0.152	0 - 0.001
Bottlenose dolphin	0.004	0 - 0.001
White-beaked dolphin	0.021	0 - 0.002
White-sided dolphin	No sighting	0.0011 - 0.002
Minke whale	0.010	0 - 0.002

= Low density
= Moderate density
= High density

The SCANS-III survey results show that harbour porpoise was the most abundant species recorded in the vicinity of the Development area, however the density of harbour porpoise in the Development area was low-moderate in comparison to other areas of the North Sea. White-beaked dolphin was the second most abundant species in the Rosebank Development area, but the density in the survey block is relatively low in comparison to the wider North Sea (Hammond *et al*., 2021). Other species for which sightings were recorded as part of SCANS-III included common dolphin, striped dolphin, Risso's dolphin, long-finned pilot whale, fin whale, sperm whale and all beaked whale species combined. However, there were not enough sightings in the survey blocks covering the Rosebank Development area to provide density estimates for these species (Hammond *et al*., 2021), suggesting the area is not heavily used by such species.

The Rosebank Development does not lie within any blocks within which Marine Scotland has identified a period of concern with regards to the potential adverse impacts on cetaceans from seismic surveys. Most blocks which are flagged as of concern are elsewhere on the continental shelf (OGA, 2019).

Based on current knowledge of their functional hearing, marine mammals are commonly classified into different hearing groups. The cetacean species most often sighted in the Development area are categorised, based on the hearing group frequency categories proposed by NMFS (2018), as:

- Low-frequency cetaceans (blue whale, fin whale, humpback whale, sei whale and minke whale);
- Mid-frequency cetaceans (sperm whale, northern bottlenose whale, long-finned pilot whale, killer whale, Risso's dolphin, bottlenose dolphin, white-beaked dolphin and Atlantic white-sided dolphin); and
- High-frequency cetaceans (harbour porpoise).

The estimated functional hearing ranges of these groups are provided in Section 10.1.2.1.

4.3.5.2 Pinnipeds

Seven species of pinniped have been identified in the northeast Atlantic (Atlantic walrus *Odobenus rosmarus*, bearded seal *Erignathus barbatus*, grey seal *Halichoerus grypus*, harbour seal *Phoca vitulina*, harp seal *Phoca groenlandica*, hooded seal *Cystophora cristata*, and ringed seal *Pusa hispida*; Sea Around Us, 2008, Bloch *et al*., 2000), but only three of these are likely to be encountered with any regularity in the vicinity of the Rosebank field: the grey, harbour and hooded seals.

McConnell *et al*. (1999) have shown that grey seals from British waters (from a population of 63,000 individuals, Hammond *et al*., 2003) migrate into Faroese waters, adding to the 2,000 individuals thought to make up the Faroe stock (Bloch *et al*., 2000). Grey seals, either foraging or migrating, are distributed across the Faroe shelf and slope area but generally are restricted to foraging in waters less than 500 m in depth, and most frequently in water depths of less than 200 m (Pollock *et al*., 2000). Grey seals are known to make trips of several hundred kilometres from one haul-out to another, including movements between Shetland and the Faroe Islands, and may therefore be encountered in the vicinity of the Rosebank Development area. However, these encounters are likely to be few and far between. Grey seals are listed on Annexes II and V of the Habitats Directive.

The distribution of grey seals at sea (the mean density of seals per 5 x 5 km grid square over the year on the basis of telemetry data spanning 1991 to 2016) is shown in Figure 4-33 (Russel *et al*., 2017). The at-sea usage takes into account that a proportion of animals are hauled out on the shore at any one time; this figure represents the estimated population of seals at sea only. Distribution data from Carter *et al*. (2020) suggests that 0-0.01% of the British Isles population of grey seals will be in the Rosebank field or along the pipeline routes at any one time; with the exception of some slight areas of increased distribution predicted along the continental shelf line (Carter *et al*., 2020). Grey seals travel mostly between 35 and 50 km of their haul-out sites to forage (Cox, 2012), but they are known to make trips of several hundred kilometres from one haul-out site to another, including movements between Shetland and the Faroe Islands (McConnell *et al*., 1999).

Harbour seals are numerous in Shetland waters and as a result are most abundant in inshore and coastal waters. They are recorded offshore, but rarely in waters deeper than 200 m (Pollock *et al*., 2000). The distribution of harbour seals at-sea is shown in Figure 4-34. Carter *et al*. (2020) predict up to 0.01% of the British Isles harbour seal population to be present in the Rosebank field or along the pipeline routes at any one time. Harbour seals are more closely associated with the coast and are less apparent in areas of deeper water (Carter *et al*., 2020). Tagging studies undertaken (e.g. Sharples *et al*., 2012) show that during the winter months harbour seals appear to spend more time in offshore waters, although they regularly returned to the inshore study area to haul-out. Female harbour seals travel further offshore, towards the shelf break than their male counterparts. Harbour seals generally remain close to their haul-out sites, within 10 to 25 km, and only very occasionally range further (100 to 150 km) (Cox, 2012).

Satellite tagging studies of hooded seals, both sub-adults and adults, from the West Ice breeding stock (whelping grounds east of Greenland) has shown that these mammals spend approximately 15% of the year in Faroese waters, mostly in May and autumn/winter (BP, 2001). With a population of West Ice hooded seals of approximately 250,000, the annual number of migrating hooded seals in the Faroe-Shetland Channel may be significant and could make this the most numerous seal species in Faroese waters on an annual basis (BP, 2001). Sightings have been recorded in the deep waters along the shelf break, submarine ridges or sea mounts where they make regular deep dives to 1,000 m or more (Pollock *et al*., 2000), but encounters are likely to be few and far between. Hooded seals are classified as vulnerable (IUCN, 2022) and included within Annex IV of the Habitats Directive.

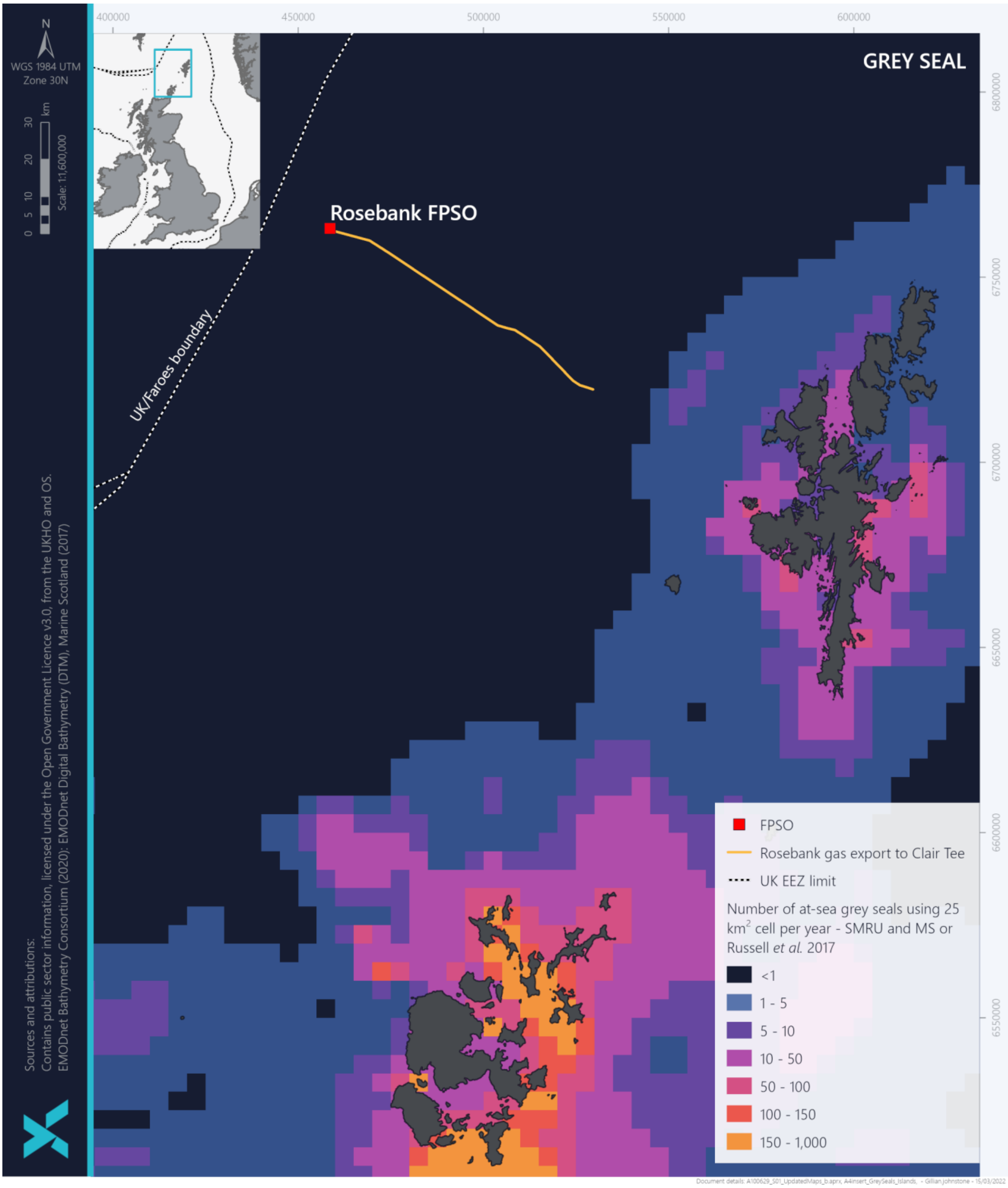


Figure 4-33 Estimated at-sea densities of grey seals around Shetland and Orkney (Russel *et al.*, 2017)

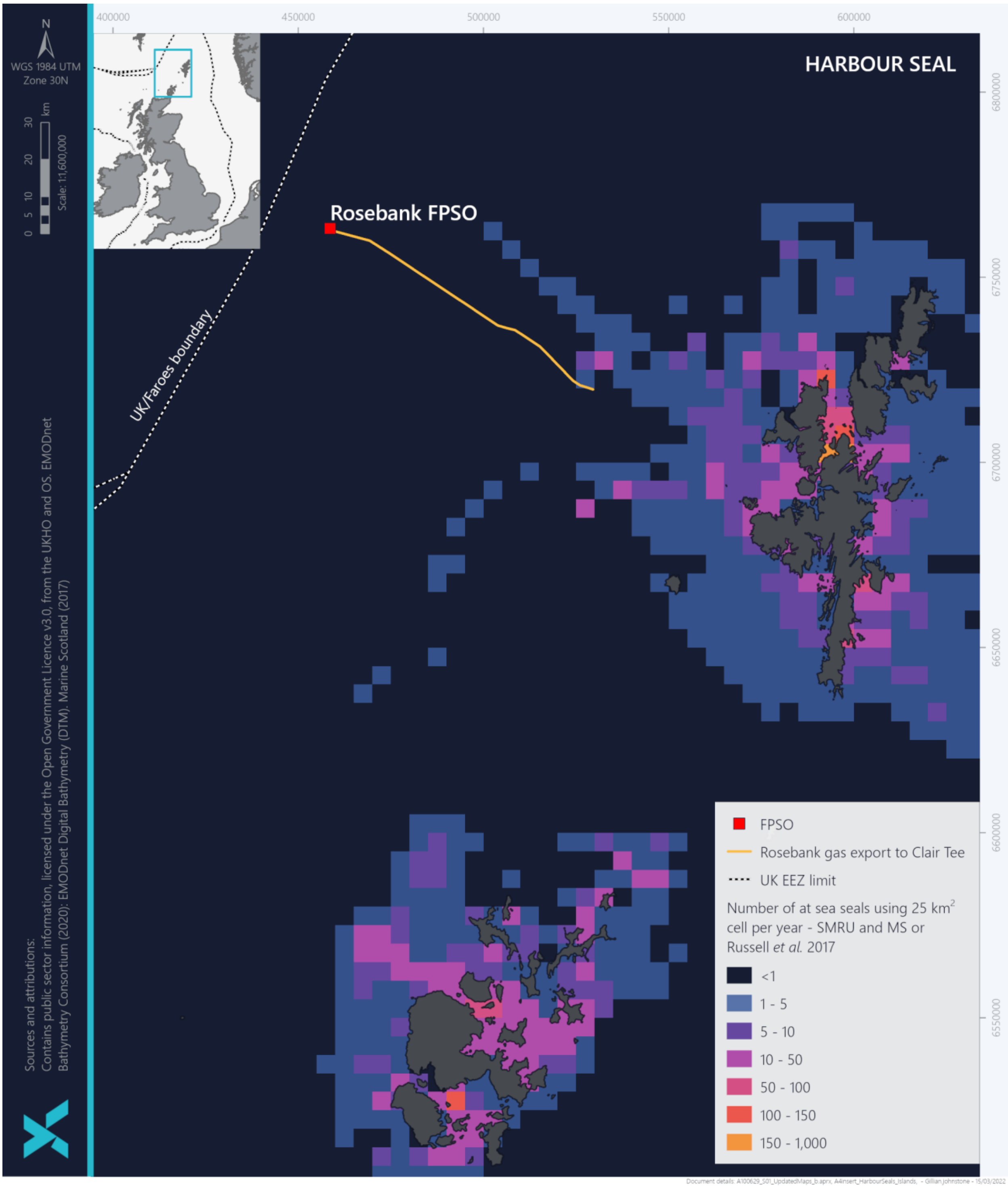


Figure 4-34 Estimated at-sea densities of harbour seals around Shetland and Orkney (Russel *et al.*, 2017)

4.3.6 Seabirds

4.3.6.1 Faroe-Shetland Channel and Continental Shelf

The Faroe Islands, Norway, Shetland and Orkney and their surrounding waters are of national and international importance for their breeding colonies of seabirds. Seabirds from these breeding colonies are likely to be the main source of seabirds found in offshore waters to the west of Shetland. The west of Shetland area is also visited by over-wintering and migratory birds from Norway, Iceland and the UK mainland (migratory birds are described in Section 4.3.6.2).

The JNCC has carried out surveys to assess the distribution and abundance of seabirds in the west of Shetland area since 1979, with the most intensive survey coverage occurring in 1994 (Pollock *et al*., 2000). The offshore distribution of seabirds varies both temporally and spatially through the year. During the breeding season seabirds will generally occur closer to their breeding colonies, where large concentrations may occur. Following breeding they leave their colonies and become more widely dispersed over offshore areas. The distance that seabirds will travel from their colonies for food varies greatly between species with black guillemots *Cepphus grylle* remaining within a few kilometres of the coast and northern gannet *Morus bassanus* foraging many hundreds of kilometres. Non-breeding seabirds may be found foraging further offshore than breeding birds.

Distribution and abundance

In the Faroe-Shetland Channel and up the continental slope and shelf (i.e. the area of the Rosebank field), the seabirds found are likely to originate mainly from major colonies in the Faroe Islands, Shetland and Orkney and breeding areas further afield such as Iceland and Norway. The offshore areas are too far for most seabirds to visit during the breeding season and seabirds are more likely to be found offshore in late summer and autumn on passage to wintering grounds, or in spring on route to breeding colonies. Although breeding season visits are likely to be few, the Faroe-Shetland Channel and continental shelf is within the foraging range for some of the highly pelagic species, such as northern fulmar Fulmarus glacialis, the most abundant seabird species in this area. High densities of fulmars are concentrated along the continental slope south of 60°N and around Shetland from January to April, prior to the breeding season. Some of the breeding fulmars found in this area may breed in the Faroese colonies, which hold in excess of 100,000 pairs.

Eight seabird species are thought to occur regularly over the deep waters west of Shetland throughout the year; these are the northern fulmar, northern gannet, black-legged kittiwake *Rissa tridactyla*, Atlantic puffin Frater*cula arctica*, great black-backed gull *Larus marinus*, common guillemot *Uria aalge*, herring gull *Larus argentatus* and razorbill *Alca torda*. The last named species is seen at low densities and is primarily found in waters less than 200 m deep, lacking the pelagic characteristics of the more abundant species seen in this offshore area. In addition, a further seven species occur primarily in the summer months; these are the European storm petrel *Hydrobates pelagicus*, lesser black-backed gull (*Larus fuscus*; moderate to high densities of which have been recorded along the shelf edge before the breeding season), Leach’s storm petrel *Oceanodroma leucorhoa*, Manx shearwater *Puffinus puffinus*, Arctic tern (*Sterna paradisaea*; more often a nearshore species), Arctic skua *Stercorarius parasiticus* and great skua *Stercorarius skua*. During the breeding season, great skuas are known to focus foraging activity in deeper waters on the edge of the Faroe-Shetland Channel towards the oceanic trench (Thaxter *et al*., 2011), whilst Leach’s storm petrels assume a mostly solitary foraging regime along the deep waters at the edge of the shelf (Kober *et al*., 2010). Three species have been seen in winter months only: the Iceland gull *Larus glaucoides*, glaucous gull *Larus hyperboreus* and the little auk *Alle alle*. Four migrant species have also been seen: the great shearwater *Puffinus gravis*, long-tailed skua *Stercorarius longicaudus*, Pomarine skua *Stercorarius pomarinus* and sooty shearwater *Puffinus griseus*.

Waggitt *et al*. (2019) modelled predicted densities of a select number of seabird species in both January and July across the North-East Atlantic. Results indicate the Faroe-Shetland Channel is an important feature for some seabird species. In particular, storm petrel, northern gannet and northern fulmar in summer are predicted to be found in comparatively high densities within the Channel compared to the surrounding areas. Of the species studied, northern fulmar are found in the highest densities within the Faroe-Shetland Channel, up to 3.1 animals per km^2 (Waggitt *et al*., 2019).

Seabirds observed during seismic survey work in the Rosebank field in August 2011 included northern gannet, roseate tern *Sterna dougalii*, Atlantic puffin, black guillemot, Pomarine skua, and long-tailed skua (FrontierMEDEX, 2011). Non-seabird species visiting the survey vessel included swallow *Hirundo rustica*, curlew *Numenius arquata*, wheatear *Oenanthe oenanthe*, spotted flycatcher *Muscicapa striata*, collared dove *Streptopelia*, pied wagtail *Montacilla alba*, Eurasian golden plover *Pluvialis apricaria*, merlin *Falco columbarius*, and peregrine falcon *Falco peregrinus*. Migrating greylag geese *Anser anser* and a second unidentified species of goose were also observed.

Several species of seabirds which may be present within the Rosebank field have experienced significant population declines for two or more decades. These include Arctic skua, northern fulmar and black-legged kittiwake, which suffered population declines of 70%, 33% and 29% respectively between 2000 and 2019. Data collected between 1985 and 2002 also suggest significant declines in herring gull populations, although recent census data is unavailable for this species. Populations of arctic tern, a species found in the Rosebank vicinity in summer, have fluctuated historically but most recently have declined by 5% (JNCC, 2021b).

Of the bird species that have been recorded over the shelf edge and in the Faroe-Shetland Channel, Eaton *et al*. (2009) classified two, the herring gull and Arctic skua, at a conservation status of red (severe decline in breeding population and/or range). In addition, 17 species have been classified at a conservation status of amber (moderate decline in breeding population or range): black guillemot, northern fulmar, black-legged kittiwake, Atlantic puffin, great black-backed gull, common guillemot, European storm petrel, northern gannet, lesser black-backed gull, Leach’s storm petrel, Manx shearwater, Arctic tern, Iceland gull, glaucous gull, sooty shearwater, great skua and razorbill. The criteria used to assess each conservation status draws upon information on global conservation status, historical population decline, recent population decline (number and geographical range), European conservation status, rarity, localised distribution and international importance of populations. Additionally, the black-legged kittiwake, lesser black-backed gull, and roseate tern are listed on the OSPAR List of Threatened and/or Declining Species and Habitats (OSPAR, 2021). The sooty shearwater and has been designated as Near Threatened on the IUCN Red List of Threatened Species (IUCN, 2022).

4.3.6.1.1 Vulnerability to surface oil in deeper waters

Seabirds are important indicators of environmental conditions. Seabird populations are particularly vulnerable to surface oil. The vulnerability of bird species to surface oil is dependent on a variety of factors including time spent on the water, total biogeographical population, reliance on the marine environment, and potential rate of population recovery. The JNCC has conducted a series of seabird surveys to assess the distribution and abundance of both onshore and offshore seabird populations. From these surveys the “offshore vulnerability index” has been compiled to assess the possible threat of surface oil to seabirds (JNCC, 1999).

The Seabird Oil Sensitivity Index (SOSI) (Webb *et al*., 2016) identifies sea areas where seabirds are likely to be most sensitive to oil pollution. It is an updated version of the Oil Vulnerability Index (JNCC, 1999) as it uses survey data collected between 1995 and 2015 and includes an improved method to calculate a single measure of seabird sensitivity to oil pollution. The survey area covers the UKCS and beyond. Seabird data were collected using boat-based, visual aerial, and digital video aerial survey techniques. These data were combined with individual species sensitivity index values, which consider several factors known to contribute towards the sensitivity of seabirds to oil pollution. Sensitivity factors include: foraging plasticity (ability to modify foraging behaviour and habitat selection in response to environmental change), adult survival rate, potential annual productivity, and the proportion of the total UK population to be impacted. Index values were then summed at each location to create a single measure of seabird sensitivity to oil pollution (Webb *et al*., 2016). Block/month combinations that were not provided with data have been populated with the SOSI using the indirect assessment method provided by JNCC (Webb *et al*., 2016).

Seabird sensitivity in the vicinity of the Development varies from low to very high (Figure 4-35, Figure 4-36, Table 4-13). The SOSI at the terminal point of the proposed pipeline where it ties into the Clair Tee (Block 206/13) is high in October and January and low the rest of the year. The SOSI further offshore within the Rosebank field on the border with Faroese waters ranges from low to extremely high, peaking in September.

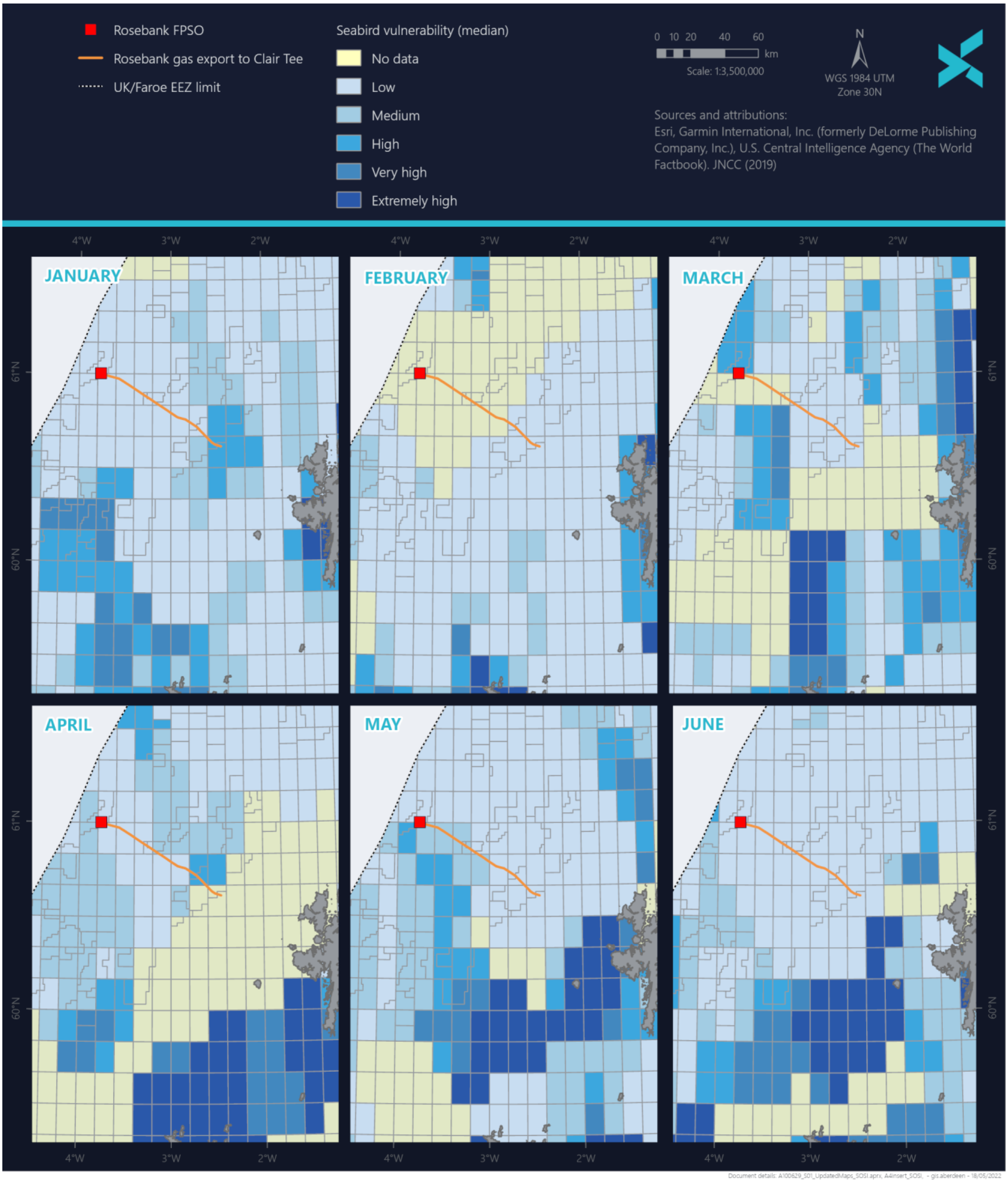


Figure 4-35 Seabird Oil Sensitivity Index (SOSI) in the Rosebank Development area

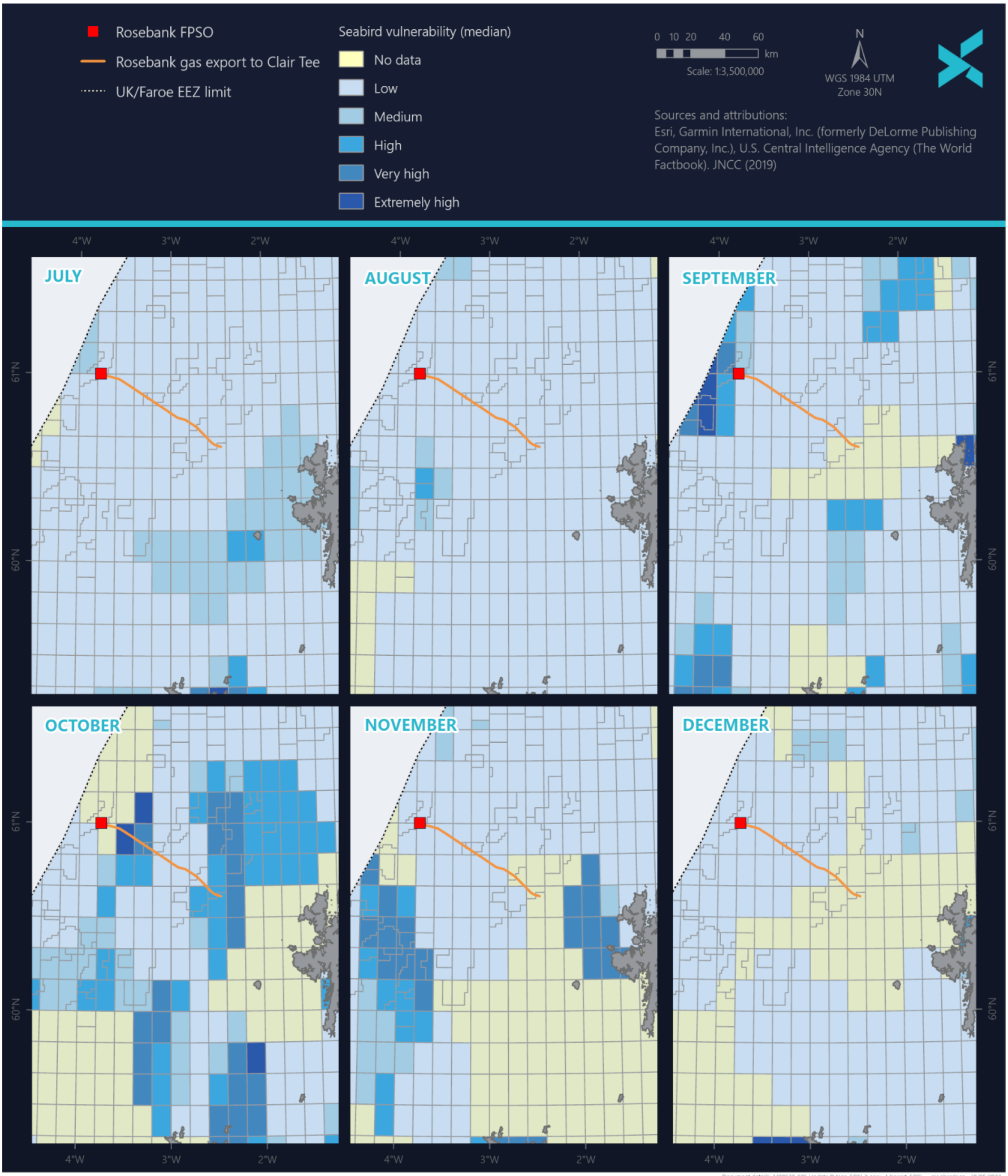


Figure 4-36 Seabird Oil Sensitivity Index (SOSI) in the Rosebank Development area (continued)

Table 4-13 Seabird oil sensitivity in the Rosebank Development area and adjacent UKCS Blocks (Webb *et al.*, 2016)

Block	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
212/30	5	5*	5*	5	5	3	4	5	1	5	5*	5
213/26	5	3*	3	4	5	5	4	5	2	2*	5	5
204/4	5	5*	5*	5	5	5	5*	5	1	5	5*	5
204/5	**5**	**5***	**5***	**5**	**4**	**4**	**5**	**5**	**1**	**5**	**5***	**5**
204/9	5	5	5	4	5	5	5*	5	2	5	2	5
205/6	5	5*	5	4	4	5	5	5	3	5	5	5
204/10	**5**	**5**	**4**	**4**	**5**	**4**	**5**	**5**	**1**	**5**	**5***	**5**
204/14	5	4	5	4	4	5	5	5	5	5	3	5
204/15	5	5	5	4	5	4	5	5	5	5	2	5
205/11	5	5	5	4	4	4	5	5	5	5	3	5
205/1	**5**	**5***	**4***	**4**	**3**	**5**	**5**	**5**	**3**	**5**	**5**	**5**
205/7	5	3*	3	4	3	5	5	5	5	4	5	5
213/28	5	5*	5	5	5	5	5	5	5	5*	5	5
205/2	**5**	**5***	**5***	**5**	**4**	**5**	**5**	**5**	**5**	**5***	**5**	**5**
205/8	5	3*	3	5	3	5	5	5	5	3	5	5
213/29	5	5*	5	5	5	5	5	5	5	1	5	5
205/3	**5**	**5***	**5***	**5**	**4**	**5**	**5**	**5**	**5**	**1**	**5**	**5**
205/9	5	2*	2	5	4	5	5	5	5	3	5	5
213/30	5	5*	5	4	5	5	5	5	5	5	5	5
205/4	**5**	**5***	**5***	**5**	**4**	**5**	**5**	**5**	**5**	**2**	**5**	**5**
214/26	5	5*	5	4	5	5	5	5	5	5	5	5
205/5	**5**	**5***	**5**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
206/1	5	5*	5	4	5	5	5	5	5	5	5	5
205/10	**5**	**5***	**5**	**5**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
205/14	5	2*	2	5	3	5	5	5	5	5	5	5
205/15	5	5	5	5	5	5	5	5	5	5	5	5*
206/11	5	5	5	4	5	5	5	5	5	5	5	5*
206/2	4	4*	5	4	5	5	5	5	5	5	5	5
206/6	**5**	**5***	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
206/3	4	5	5	4	5	5	5	5	5	2	5	4*
206/7	**5**	**5**	**5**	**3**	**5**	**5**	**5**	**5**	**5**	**5**	**5***	**5***
206/8	3	5	5	3	5	5	5	5	5	3	3*	3*
206/9	3	5	5*	5*	5	5	5	5	5	2	2*	3*
206/13	**3**	**5**	**5**	**5***	**5**	**5**	**5**	**5**	**3***	**3**	**3***	**3***
206/12	**4**	**5**	**5**	**5***	**5**	**5**	**5**	**5**	**3***	**3**	**5**	**4***
206/14	3	5	5*	5*	5	5	5	5	2*	2	2*	3*

Block	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
206/16	4	5	5*	5*	5	5	5	5	5*	5	5	4*
206/17	4	5	5*	5*	5	5	5	5	4*	4	5	4*
206/18	3	5	5*	5*	5	5	5	5	3*	3	3*	3*
206/19	4	5	5*	5*	5	1	5	5	2*	2	2*	4*
213/21	5	3*	3	5	5	5	4	5	3	3*	5	5
213/22	5	3*	3	5	5	5	5	5	4	4*	5	5
213/23	5	4*	4	5	5	5	5	5	5	5*	5	5
213/27	**5**	**3***	**3**	**5**	**5**	**5**	**5**	**5**	**4**	**4***	**5**	**5**
Key	Extremely high		Very high		High		Medium		Low		No data	
* in light of coverage gaps, an indirect assessment of SOSI has been made following the method described by the JNCC (Webb *et al.*, 2016)												

4.3.6.2 Migratory species

The food source of many land birds is seasonal with the result that many species (including passerines, near passerines, raptors and owls)[27] migrate, sometimes over vast distances. The waters around the British Isles are of key importance to many of these species during the spring and autumn migrations. Precise migratory routes are not well known, and it is currently thought that birds do not have preferred migratory corridors but instead exhibit broad movement across areas (Wernham *et al*., 2002). Migration can be temporally variable and flight heights will vary depending on the species and weather conditions; this can range from just above the water surface to several thousand metres (DECC, 2009). The importance of the UKCS may increase during periods of severe cold further east in continental Europe, when there may be influxes of waterfowl into the region. Coastal wetlands with saltmarsh or grazing marsh in close proximity to littoral areas act as the key feeding and roosting areas (DECC, 2009).

The Rosebank Development sits within the East Atlantic flyway, which links a discontinuous band of Arctic breeding grounds (stretching from Canada to central Siberia) with wintering grounds in Western Europe and West Africa (Figure 4-37; Wernham *et al*., 2002). In the autumn months, large numbers of birds from Arctic regions (such as Canada, Greenland and Iceland) move south along this flyway to Western Europe. DECC (2009) reports the presence of four migrant seabird species in the Faroe-Shetland Channel region, these being the great shearwater, long-tailed skua, pomarine skua and sooty shearwater. Non-seabird species migrate across the wider area and may pass across the Development area during spring and autumn migration. These include the greylag goose (*Anser anser*; late September/early November and mid-March/late April), pink-footed goose (*Anser brachyrhynchus*; September/October and mid-April) and the whooper swan (*Cygnus cygnus*; March/April and October/November). In addition, there are waders and waterfowl such as the bar-tailed godwit *Limosa lapponica*, dunlin *Calidris alpine*, oystercatcher *Haematopus ostralegus*, barnacle goose *Branta leucopsis*, lapwing *Vanellus vanellus*, red knot *Calidris canutus*, Slavonian grebe, grey plover *Pluvialis squatarola*, golden plover *Pluvialis apricaria*, tufted duck *Aythya fuligula*, red-throated diver, common redshank *Tringa totanus* and ruddy turnstone *Arenaria interpres*. Passerine species that will regularly cross the area include white wagtail *Motacilla alba*, redwing *Turdus iliacus*, meadow pipit *Anthus pratensis*, wheatear *Oenanthe* and snow bunting *Plectrophenax nivalis* (Wernham *et al*., 2002).

[27] Passerines are all 'perching birds', having feet adapted for perching. Near passerines are tree-dwelling birds related to passerines due to ecological similarities. Raptors are predatory 'birds of prey', such as eagles, hawks and kites.

4.3.6.3 Coastal breeding colonies

There are 24 seabird species that breed along the Scottish coastline (Scottish Government, 2011). The geography of the Northern Isles, northern coast of the Scottish mainland and Moray Firth is ideally suited for aggregations of breeding seabirds and many sites have been recognised for their international importance and been designated Special Protection Areas (SPAs). The Scottish Government has listed ten major seabird colonies in Scotland. These ten colonies are ranked on the total number of individual breeding birds in 1998-2002. Foula and Papa Stour are the seabird colonies closest to the Development. Recent research into the breeding season habitat use of kittiwake, guillemot, razorbill and European shag *Phalacrocorax aristotelis*, identified this colony, amongst others, as a hotspot for the species listed (Cleasby *et al*., 2020).

Breeding seabird colonies in the south and south-west coast of Shetland include: gannets, puffin and great skua (DECC, 2016).

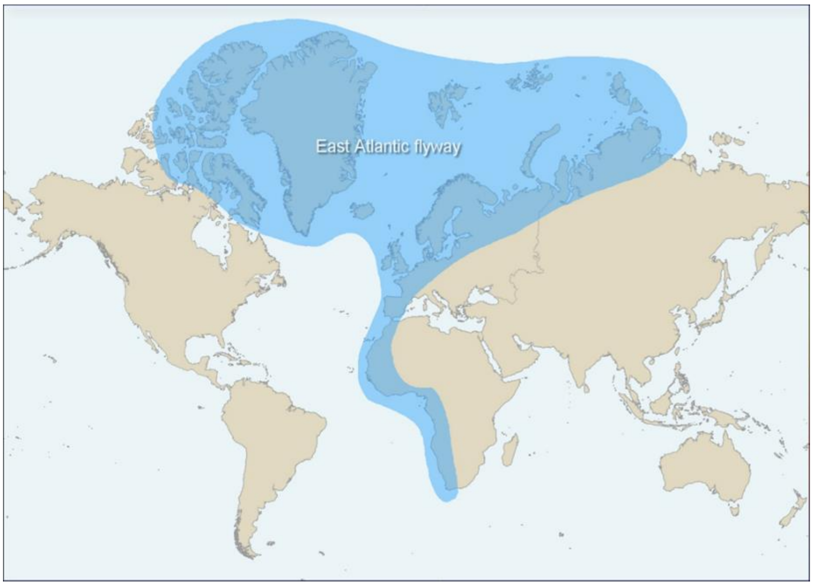


Figure 4-37 East Atlantic flyway

4.3.6.3.1 Coastal distribution and abundance

The offshore distribution of seabirds during the breeding season is closely linked to the breeding colonies on the coasts of the northern isles, including the internationally important Shetland breeding colonies of Hermaness, Saxa Vord and Valla Field, Ramna Stacks and Gruney, Foula and Papa Stour. Species associated with breeding colonies are found in relative high abundance in coastal waters. Available evidence suggests that numerous species are found around Shetland, including the northern fulmar, northern gannet, cormorant, European shag, Arctic skua, great skua, black-headed gull *Chroicocephalus ridibundus*, common gull *Larus canus*, lesser black-backed gull, herring gull, great black-backed gull, black-legged kittiwake, sandwich tern *Thalasseus sandvicensis*, common tern *Sterna hirundo*, Arctic tern, little tern *Sternula albifrons*, common guillemot, razorbill, black guillemot, Manx shearwater, little auk *Alle alle* and Leach's storm petrel (e.g. Pollock *et al*., 2000; NatureScot, 2015). The islands to the west, south and east of Shetland, including Foula, offer extensive and varied breeding habitats to such birds.

In contrast to the high importance of the area to seabirds, Shetland is not amongst the most important regions in the UK for wintering waterbirds. However, being on the major migratory flyway of the east Atlantic (detailed in Section

4.3.6.2), the estuaries of Shetland and the rest of this coastline are of some importance during spring and autumn migration, with many birds stopping and staging here as they move to and from wintering and breeding areas.

The Island of Foula is located approximately 54 km from the Development, at the nearest point. The island is important for a wide range of breeding seabirds and is designated as an SPA. As of 2020, an area of the surrounding marine area covering approximately 3,412 km^2 has been designated as the Seas off Foula SPA (JNCC, 2020b). At approximately 25 km from the Development, the Seas off Foula SPA is the closest SPA to the Development.

Foula is one of the few localities in Europe for Leach's petrel. The Foula SPA is designated for razorbill, red-throated diver, European shag, black-legged kittiwake, Leach's petrel, Atlantic puffin, great skua, common guillemot, Arctic skua, Arctic tern and northern fulmar. The Seas off Foula SPA complements the colony SPA, ensuring that the marine foraging habitat for great skuas, fulmars, gulls and auks which breed on the island is equally protected. The seabirds also feed further afield in the north Atlantic (JNCC, 2005). It is worth noting that the Foula SPA is also designated as generally holding important breeding seabird assemblages (NatureScot, 2015).

Of the bird species that have been recorded on the continental shelf south and west of Shetland, Eaton *et al*. (2009) classified eleven species at a conservation status of amber (moderate decline in breeding population or range). These are: northern fulmar, black-legged kittiwake, Atlantic puffin, common guillemot, European storm petrel, northern gannet, Arctic and little tern, great skua and razorbill. The criteria used to assess each conservation status drew upon information on global conservation status, historical population decline, recent population decline (number and geographical range), European conservation status, rarity, localised distribution and international importance of populations.

4.4 Conservation

Details of the protected sites to the west of Shetland are summarised in Figure 4-38 and the following sections.

4.4.1 Offshore Conservation

4.4.1.1 Offshore protected sites

The closest offshore conservation sites to the Rosebank Development are listed in Table 4-14. There are no SACs within 100 km of the Development.

Table 4-14 Offshore conservation sites west of Shetland within 100 km of the Development

Site	Designation(s)	Conservation interest
Seas off Foula	SPA	Migratory species: Great skua, northern fulmar, Arctic skua, common guillemot and Atlantic puffin.
North-East Faroe-Shetland Channel	NCMPA	Deep-sea sponge aggregations, offshore deep-sea muds, offshore subtidal sands and gravels, continental slope and a wide range of features representative of the West Shetland Margin Palaeo-depositional, Miller Slide and Pilot Whale Diapirs Key Geodiversity Areas.
Faroe-Shetland Sponge Belt	NCMPA	Deep-sea sponge aggregations, offshore subtidal sands and gravels, ocean quahog aggregations, continental slope, continental slope channels, iceberg plough marks, prograding wedges and slide deposits representative of the West Shetland Margin paleo-depositional system Key Geodiversity Area, and sand wave fields and sediment wave fields representative of the West Shetland Margin contourite deposits Key Geodiversity Area.
West Shetland Shelf	NCMPA	Offshore subtidal sands and gravels.
North-west Orkney	NCMPA	Sandeels and sand banks, sand wave fields and sediment wave fields representative of the Fair Isle Strait Marine Process Bedforms Key Geodiversity Area.

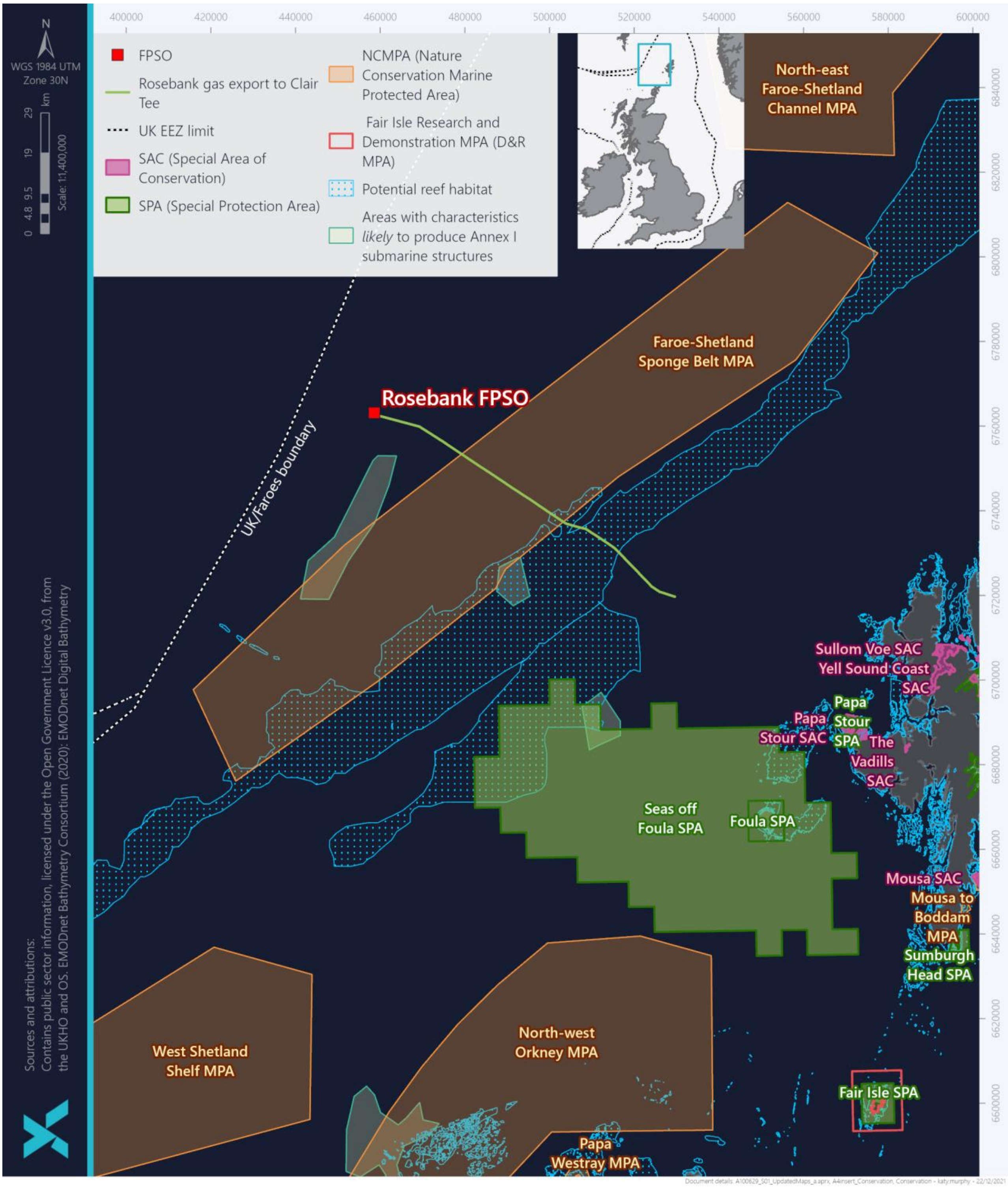


Figure 4-38 Offshore conservation west of Shetland

4.4.1.2 Habitats

Within the Greater North Sea, key habitats include deep-sea sponge aggregations, coral gardens, and sea pen and burrowing megafauna communities (OSPAR, 2015). No coral gardens or sea pen and burrowing megafauna communities have been observed during the extensive survey work undertaken around the Rosebank field and along the gas pipeline route.

An area along the upper continental slope has been identified as potentially containing Annex I reef (JNCC, 2016), although it should be noted that it is not necessarily the case that this whole area constitutes Annex I reefs, and further survey information is required to confirm presence or absence. With the exception of one station, all sampled locations have been dominated by silt and clay fractions (Fugro, 2012a). Based on the comprehensive survey coverage within the Rosebank Development area it is unlikely that rocky or stony reefs are present, as described in Section 4.2.7and 4.3.2.

The gas export pipeline route passes through the 500 m isobath within the Faroe-Shetland Sponge Belt; it is this isobath at which sponge aggregations are likely to be at their highest density in the area (e.g. JNCC, 2022; Kazanadis *et al*, 2019; Henry and Roberts, 2014). Deep-sea sponge aggregations were recorded at two stations located on the steep part of the slope into the Faroe-Shetland Channel at depths of 490-525 m and within the Faroe-Shetland Sponge Belt MPA as described in Section 4.3.2.2.2.

The habitat 'offshore subtidal sands and gravels', a designated PMF, is a feature of the Faroe-Shetland Sponge Belt NCMPA and covers a wide area of the northern North Sea and west of Shetland. FCS is where evidence suggests none of the features are being adversely affected. Current JNCC advice for the site states that the protected features of the site (detailed in Table 4-14) should be recovered to favourable condition, whereby evidence suggests that none of the features are being adversely affected.

4.4.1.3 Species

Four species of marine mammal listed in Annex II of the Habitats Directive are known to occur in UK waters: the grey seal, harbour seal, bottlenose dolphin and harbour porpoise. It is possible that the grey and harbour seals may occur in the Development area whilst the harbour porpoise is the only listed species likely to occur with any frequency in the vicinity of the Rosebank field and the gas pipeline route. Additionally, while potential calving grounds have been identified in the non-UK sector of the North Sea, no such areas are currently recognised and designated in UK waters.

Under the Conservation of Offshore Marine Habitats and Species Regulations 2017, it is an offence to deliberately disturb species listed on Annex IV of the Habitats Directive (species termed European Protected Species, EPS). All species of cetacean are listed on Annex IV. In addition, all cetaceans are listed in Annex II of the Convention on International Trade in Endangered Species, Appendix II of the Bern Convention Annex, and in Appendix IV of the EC Habitats Directive as species of European Community interest and in need of strict protection. They are also protected under Schedule 5 of the Wildlife and Countryside Act 1981.

European storm petrels, listed on Annex I of the Birds Directive, are widely distributed over the whole of the shelf break west of Shetland between May and November.

There are a number of PMF species including fish and marine mammal species identified to be present in the wider offshore Rosebank Development area from the field to the shelf break (NatureScot, 2020). These species include: anglerfish, blue whiting, herring, mackerel, ling, cod, horse mackerel, Norway pout, saithe, porbeagle shark, basking shark, Atlantic white-sided dolphin, fin whale, killer whale, minke whale, Risso’s dolphin, sperm whale, white beaked dolphin and grey seal. The species are all mobile and are known to occur in the wider west of Shetland region, in addition to the Rosebank Development area.

In conservation terms, the common thresher and porbeagle shark are considered Vulnerable and the basking shark is Endangered globally (IUCN, 2022), although no sharks or rays are listed in the Annexes to the Habitats Directive. In addition, the porbeagle and basking sharks are listed as PMFs (Tyler-Walters *et al*., 2016). Within 12 NM, the basking shark is protected under the Nature Conservation (Scotland) Act 2004, making it illegal to intentionally kill, injure or recklessly disturb or harass the species.

The basking shark is listed on Schedule 5 of the Wildlife and Countryside Act (1981), and aspects of legal protection for wildlife including the basking shark have been strengthened by the Nature Conservation (Scotland) Act 2004. Basking sharks are sighted, albeit in low numbers, in inshore waters of the continental shelf west and south of Shetland during the summer months (Witt *et al*., 2012).

Leatherback turtles are highly migratory species with a cosmopolitan distribution. The North Sea forms the northernmost extent of the northwest Atlantic distribution of this species and sightings of leatherbacks in UK waters are comparatively rare. However, leatherbacks have occasionally been caught as bycatch in Scottish waters (Pierpoint, 2000). They are considered to be Vulnerable globally and are listed on Annex IV of the Habitats Directive. In addition, loggerhead turtles are currently classified as Vulnerable, green turtle are Endangered, and the Kemp's Ridley and hawksbill turtles are classified as Critically Endangered (IUCN, 2022).

The PMF ocean quahog has been observed off the south-east and south-west coast of Shetland, thought the nearest ocean quahog record is over 100 km away from the Development (NMPi, 2022). Ocean quahog is also a feature of the Faroe Shetland Sponge Belt NCMPA through which the gas export pipeline route goes; however, the species has not been observed in the Development areas during either historic or more recent surveys.

4.4.2 Coastal Conservation

4.4.2.1 Coastal protected sites

The north coast of Scotland together with Shetland and Orkney includes many islands and skerries, and much of the coastal habitat is being designated as sites of national, European and international importance, including SPAs, SACs, National Nature Reserves (NNRs), Ramsar sites and SSSIs. Those closest to the Development area are shown in Figure 4-38 and listed in Table 4-15. There are no SACs within 100 km of the Development.

Table 4-15 Coastal conservation sites within 100 km of the Development

Site	Designation(s)	Conservation interest
Foula	SPA	Migratory species: Great skua, northern fulmar, Arctic skua, common guillemot and Atlantic puffin.
East Mainland Coast, Shetland	pSPA	Annex I species: Great northern diver, red-throated diver and Slavonian grebe. Migratory species: Common eider, long-tailed duck and red-breasted merganser.
Fetlar to Haroldswick	NCMPA	Biodiversity: Black guillemot, circalittoral sand and coarse sediment communities, horse mussel *Modiolus* beds, kelp and seaweed communities on sublittoral sediment, maerl beds and shallow tide-swept coarse sands with burrowing bivalves. Geodiversity: Marine geomorphology of the Scottish shelf seabed.

Site	Designation(s)	Conservation interest
Mousa to Boddam	NCMPA	Biodiversity: Sandeels. Geodiversity: Marine geomorphology of the Scottish shelf seabed.
East Sanday Coast	Ramsar	Biodiversity: Grey seal, otter, Arctic water flea. Geodiversity: Blanket bog with extensive pool systems.

Shetland has considerable lengths of cliff coastline, which support internationally and nationally important populations of breeding seabirds. In addition, shingle/rock and boulder shores on the western and northern coasts are important breeding sites for Arctic tern and ringed plover. The coastline has numerous wet and boggy areas which support approximately half of the British population of red-throated diver. Approximately 12% of the UK's harbour seal population occurs in Shetland and nationally important otter concentrations are present in Yell Sound to the north.

The west coast of Orkney is characterised by high cliffs and supports internationally important breeding seabirds. Grey seals are the most common seals in Orkney, which supports approximately 36% of the UK grey seal pup population (SCOS, 2018). Otters are also present in the coastal waters.

The Foula SPA and Seas off Foula, approximately 20 km south of Shetland have been designated for their importance to a wide range of breeding seabirds as habitat and foraging grounds respectively. Foula is one of only seven known nesting localities in Europe for Leach's petrel. The site has been designated for the breeding populations over 250,000 individual seabirds including Arctic tern, fulmar, great skua, guillemot, puffin, razor bill, red throated diver, Arctic skua, kittiwake and shag (NatureScot, 2015). See Section 4.3.6 for further details.

The Marine Scotland Act (2010), which applies to inshore waters (12 NM and inshore), grants powers to designate Nature Conservation MPAs in Scottish waters, as well as additional measures such as seal conservation, marine planning and enforcement. Under the Act the whole of Shetland has been designated a Seal Conservation Area, and the Mousa and Sanday SACs have been proposed as designated seal haul-outs for harbour seals under the same Act.

4.4.2.2 Habitats and species

During the gas pipeline route survey Fugro (2012a, 2012b) did not identify any coastal seabed habitat PMFs.

Of the mobile PMF species, there are a number of fish and marine mammal species known to occur within the wider region of the continental slope to the south and west of Shetland. However, none of these species are known to be particularly restricted to or important within the Rosebank Development area.

4.5 Other Sea Users

4.5.1 Fisheries

Fish and shellfish landings are reported in standard areas developed by the International Council for Exploration of the Sea (ICES), known as ICES statistical rectangles. Each statistical rectangle comprises an area of approximately 30 NM^2. The Rosebank Development area is located mostly within ICES statistical rectangles 50E6, with the Rosebank infield area located on the southern margin of rectangle 51E6 and the Rosebank to Clair Tee pipeline overlapping with ICES rectangle 50E6 and 50E7as shown in Figure 4-39. ICES rectangle 51E6 contains the UK/Faroes Median Line therefore recent fishing data for UK vessels and vessels landing at UK ports is limited for this rectangle. Marine Scotland landings data (2016 – 2020) have been analysed, which includes landings data for ICES rectangle 50E6 and 50E7. However, no data were available for ICES rectangle 51E6 in the Marine Scotland dataset. Landings data provide a comprehensive indicator of landings value and weight. These data encompass all UK vessels (irrespective of landing ports) and all foreign vessels landing into UK ports. The latest landings data (landings value and tonnage between 2016 and 2020) for the relevant ICES rectangles are provided in Table 4-16. Marine Scotland effort data (days fished for 2016 – 2020) has been analysed for the relevant ICES rectangles and is presented in Table 4-17, although no fishing effort was recorded in ICES rectangle 51E6 between 2016 – 2020 other than a disclosed value for March 2020.

Therefore, the data presented below relates mostly to ICES rectangles 50E6 and 50E7.

4.5.1.1 Fishing Effort

Vessel Monitoring System (VMS) data from 2015 – 2019 for vessels operating mobile fishing methods (Figure 4-39) and Marine Scotland fisheries effort statistics from 2016 to 2020 for ICES rectangles 50E6 and 50E7 indicate that fishing effort is highest within ICES rectangle 50E7, located within the shallower section of the Rosebank Development, overlapping with the Rosebank to Clair Tee pipeline route. Fishing effort in ICES rectangle 50E6 which overlaps with the deeper portion of the Rosebank to Clair Tee pipeline route is comparably lower than ICES rectangle 50E7.

The fishing effort data also indicate that effort in the vicinity of the Rosebank infield area (ICES rectangle 51E6) is low, with fishing effort generally increasing along the continental shelf and towards the Shetland coastline. A Vessel Traffic Survey and Collision Risk Assessment undertaken for the Consent to Locate for buoys within the Rosebank field showed fishing vessel tracks within 10 NM of the proposed buoy locations to be concentrated to the west of the field. Closer to the Rosebank field, fishing activity is more sporadic (Xodus Group, 2019).

Vessels within rectangle 50E6 only contributed 0.1% to the Scottish total fishing effort in 2020 (Scottish Government, 2022). Overall effort in the rectangle does not appear have a seasonal pattern; peaks in effort were sporadic and varied monthly between years. It is also difficult to make any conclusions regarding seasonality as fishing effort within this ICES rectangle was marked as disclosive for most months. Fishing effort in rectangle 50E7 also does not appear to follow any consistent seasonal patterns. Overall effort within rectangle 50E7 contributed 0.3% to the total annual Scottish fishing effort in 2020 (Scottish Government, 2020).

Fishing effort in ICES rectangle 50E6 was highest for trawls and hooks and lines between 2016 and 2020. Fishing effort by vessels > 10 m using demersal active gear ranged from 19 to 47 days between 2016 and 2020 and effort by pelagic vessels was disclosive within this time period. This indicates that the majority of trawl effort within ICES rectangle 50E6 is conducted by demersal trawls. Fishing effort by > 10 m vessels operating passive gear ranged from 20 to 75 days between 2016 and 2020, which is considered to be low when compared to other ICES rectangles in Scottish waters.

Effort in ICES rectangle 50E7 was highest for trawls between 2016 and 2020 with effort also recorded for hooks and lines and seine nets (Scottish Government, 2022). Demersal fishing effort in ICES rectangle 50E7 was comparatively higher than ICES rectangle 50E6, ranging from 125 days to 283 days between 2016 and 2020, however, this is still considered to be low when compared to all ICES rectangles in Scottish waters. Fishing effort by > 10 m vessels operating pelagic gear was recorded as disclosive between 2016 and 2020. Therefore, as per ICES rectangle 50E6, these data indicate that the majority of trawls operating within ICES rectangle 50E7 are demersal, with lower effort levels for pelagic trawls. Fishing effort by > 10 m vessels operating passive gear ranged from 24 to 127 days between 2016 and 2020. Effort levels for this fishing method were recorded as disclosive in 2017. Overall, the fishing effort by vessels operating passive gear is considered to be moderate compared to all ICES rectangles in Scottish waters (NMPi, 2022).

Recent VMS fishing intensity data across Scottish waters indicates that the primary fishing method in the Rosebank area is bottom trawling; between 2010 and 2020, > 2 weeks (336 hours) of fishing effort is associated with areas along the continental shelf through which the gas export pipeline will pass (NMPi, 2022). VMS data for UK vessels greater than 15 m in length operating mobile gear between 2016 and 2019 is shown in Figure 4-39 and indicates that mobile fishing within the Rosebank infield area is low, with higher levels of effort towards the east of the Rosebank to Clair Tee pipeline in ICES rectangle 50E7. Furthermore, according to VMS data, fishing activity by UK vessels (> 15 m) associated with oil and gas infrastructure (i.e. along pipelines) is negligible for dredges and Nephrops trawling in the Rosebank area. Demersal trawling activity between 2007 and 2015 was also relatively low along the pipelines with the exception of an area of increased intensity along the pipelines from Sullom Voe to Tormore, where the pipeline to Edradour is tied back (Figure 4-40). At this point along the pipeline between 60-100 VMS tracks associated with demersal trawls were identified per year between 2007 and 2015 (NMPi, 2022).

With regards to other vessel nationalities, Norwegian, French, German and Spanish demersal trawl vessels frequent the Rosebank area; in particular they concentrate effort along the continental shelf edge in waters between 100 m and 500 m, although vessel are reported to fish to depths of 800 m (Brown and May, 2010).

The eastern section of the Rosebank to Clair Tee pipeline, in water depths of 500m and less, sustains the highest recorded level of fishing activity of the whole Development area. Static gear, including long lining and gill netting, targeting demersal species, is deployed in the eastern portion of the buffer by Norwegian, French, UK and German vessels (Brown and May, 2010). Dutch and Danish vessels also utilise the area according to AIS data, however this is at a far lesser intensity than German, Norwegian and French vessels which cumulatively result in up to and over 1,000 hours of fishing effort along the Clair pipeline (Global Fishing Watch, 2022).

4.5.1.2 Catch Tonnage

Based on the most recent available Marine Scotland landings data, the catch in ICES rectangle 50E6 was dominated by demersal fishing catch, with landed weights which are considered to be moderate when compared to all ICES rectangles in Scotland (NMPi, 2022). Between 2016 and 2020, the catch for pelagic and shellfish fisheries was <1 tonne per annum (Table 4-16) (Scottish Government, 2021).

The catch in ICES rectangle 50E7 was markedly higher than ICES rectangle 50E6. Between 2016 and 2019, the catch was dominated by demersal fisheries. In 2019 and 2020, catch by pelagic fisheries was comparably higher compared to other years and this fishery was dominant. Overall, the demersal catch is considered to be high and the pelagic catch (2019 and 2020 only) is considered to be moderate when compared with all ICES rectangles in Scotland (NMPi, 2022). Shellfish catch was consistently low for this ICES rectangle between 2016 and 2020 (Scottish Government, 2021).

4.5.1.3 Landings Value

In ICES rectangle 50E6, demersal fish were dominant in terms of landings values, contributing to 99% of the landings values between 2016 and 2020. Hake, saithe, monkfish / anglerfish and ling contributed to 86% of the landings value in 2019 for this ICES rectangle. In 2020, Greenland halibut, hake, saithe and monkfish / anglerfish contributed to approximately 79% of the landings value for this ICES rectangle.

Demersal fish was dominant in terms of landings values in ICES rectangle 50E7 between 2016 and 2018. Pelagic fish dominated landings values in 2019 and 2020. Overall demersal fish accounted for 72% of the landings values for this ICES rectangle between 2016 and 2020. Mackerel was dominant in terms of landings values and together with saithe and monkfish / anglerfish accounted for 74% of landings values in 2019. In 2020, mackerel, monkfish / anglerfish, hake and saithe accounted for 79% of landings values (Scottish Government, 2021).

Table 4-16 Fisheries landings and effort data in the Rosebank Development area (Scottish Government, 2021)[28]

Species type	2020		2019		2018		2017		2016	
	Landed weight (tonnes)	Value (£)	Landed weight (tonnes)	Value (£)	Landed weight (tonnes)	Value (£)	Landed weight (tonnes)	Value (£)	Landed weight (tonnes)	Value (£)
ICES rectangle 51E6										
Demersal	-	-	-	-	-	-	-	-	-	-
Pelagic	-	-	-	-	-	-	-	-	-	-
Shellfish	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	-	-	-	-	-
ICES rectangle 50E6										
Demersal	688	603,746	418	730,089	478	829,495	273	601,976	373	838,740
Pelagic	<1	111	<1	18	1	455	1	592	-	-
Shellfish	<1	2,140	<1	2,246	<1	1,085	<1	1,847	<1	774
Total	**689**	**605,996**	**419**	**732,353**	**479**	**831,036**	**275**	**604,414**	**373**	**839,514**
ICES Rectangle 50E7										
Demersal	2,355	2,349,603	3,231	5,005,862	3,980	6,007,171	1,297	2,354,594	2,292	3,707,833
Pelagic	2,536	2,687,192	3,994	4,790,116	- <1	118	-	-	-	-
Shellfish	11	3,2314	14	56,208	9	34,998	**8**	29,752	4	12,927
Total	**4,902**	**5,069,109**	**7,239**	**9,852,186**	**3,989**	**6,042,287**	**1,306**	**2,384,347**	**2,295**	**3,720,760**

[28] Fishing effort data for ICES Rectangle 51E6 were unavailable for all years.

Table 4-17 Monthly breakdown of fishing effort (in days) in the Rosebank Development area between 2016 – 2020 (Scottish Government, 2020)[29]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
ICES rectangle 51E6													
2020	-	-	D	-	-	-	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-	-	-	-	-	-	-
ICES rectangle 50E6													
2020	18	D	D	D	D	D	D	22	17	D	10	5	
2019	13	D	D	D	D	D	-	D	25	31	D	D	69
2018	D	7	14	D	D	D	D	-	D	D	D	D	21
2017	-	D	D	D	D	D	D	-	D	-	14	15	29
2016	9	D	-	D	28	D	D	D	D	D	-	D	37
ICES rectangle 50E7													
2020	27	28	44	41	8	D	21	53	28	26	38	38	
2019	80	39	31	23	25	26	21	11	28	40	41	14	378
2018	17	53	35	21	36	27	31	23	19	20	37	51	370
2017	D	21	18	9	26	7	10	39	16	17	9	31	204
2016	16	6	25	38	44	43	11	D	13	19	9	D	225

[29] Fishing effort data for ICES Rectangle 51E6 was unavailable for almost all months in all years. Entries marked 'D' indicate data are Disclosive for privacy reasons (fewer than five fishing vessels involved).

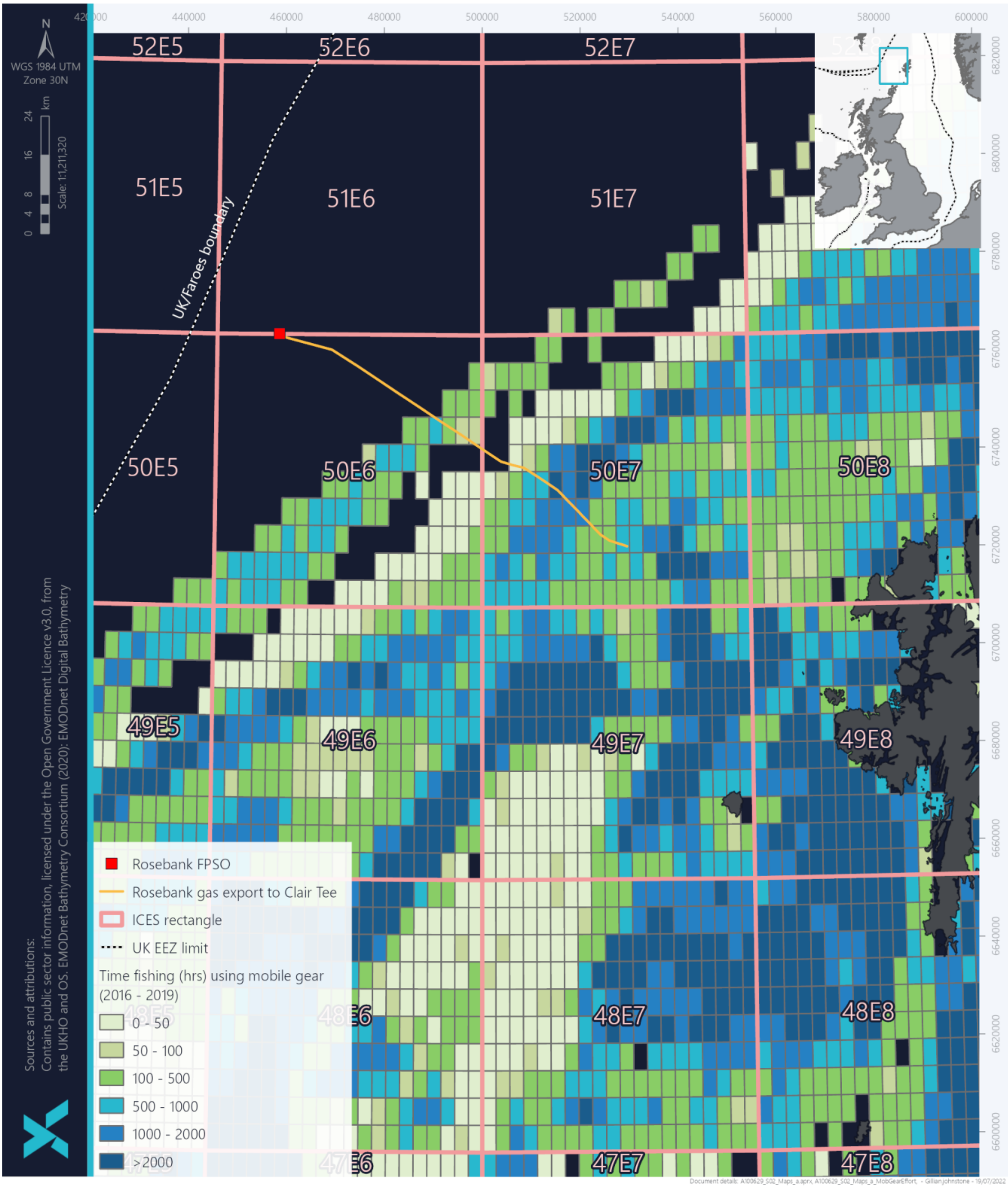


Figure 4-39 Annual average VMS effort (time fishing in hours) (2015 – 2019) (MMO, 2020)

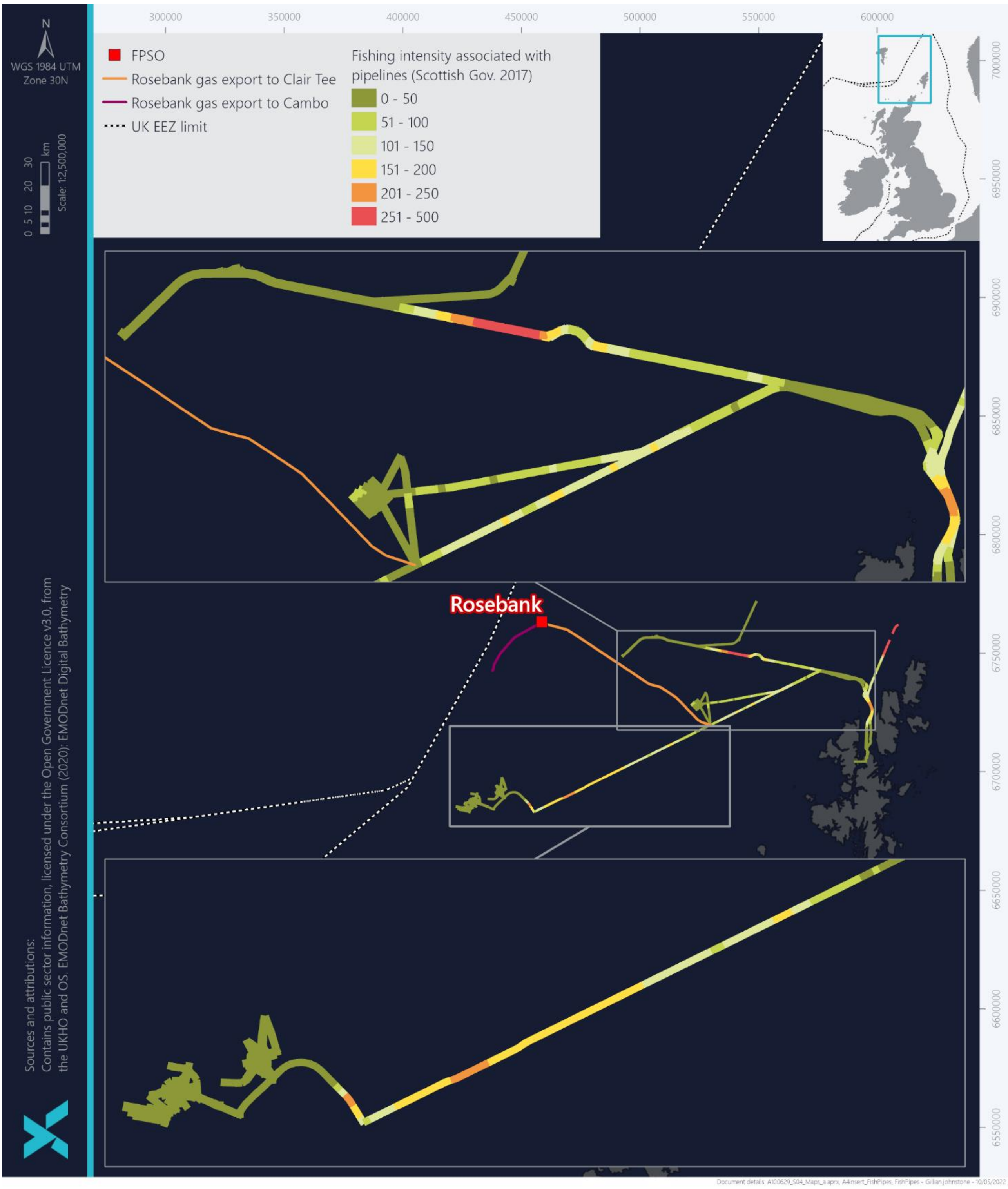


Figure 4-40 Fishing intensity associated with pipelines (Scottish Government, 2017)

4.5.2 Shipping

The shipping levels in the waters to the north-west of Scotland are relatively low when compared with parts of the English Channel and North Sea. The OGA reported levels of shipping activities around the Rosebank Development as being negligible to low (OGA, 2017).

4.5.2.1 Faroe-Shetland Channel

Commercial vessels in the area include those en route to/from Sullom Voe Terminal and vessels in transit across the Atlantic, such as supply vessels and shuttle tankers between Clair, Foinaven, Schiehallion and Sullom Voe and ferries and cruise liners between the Faroe Islands and Shetland or Denmark. The wide expanse of water combined with overall low vessel traffic results in low levels of vessel congestion. The most heavily used shipping routes in the region (Pentland Firth and Fair Isle Channel) are over 150 km to the south of the Rosebank field.

The Vessel Traffic Survey and Collision Risk Assessment undertaken for the series of monitoring buoys that have been deployed at the Rosebank field identified seven shipping lanes in the vicinity of the field (Xodus Group, 2019).

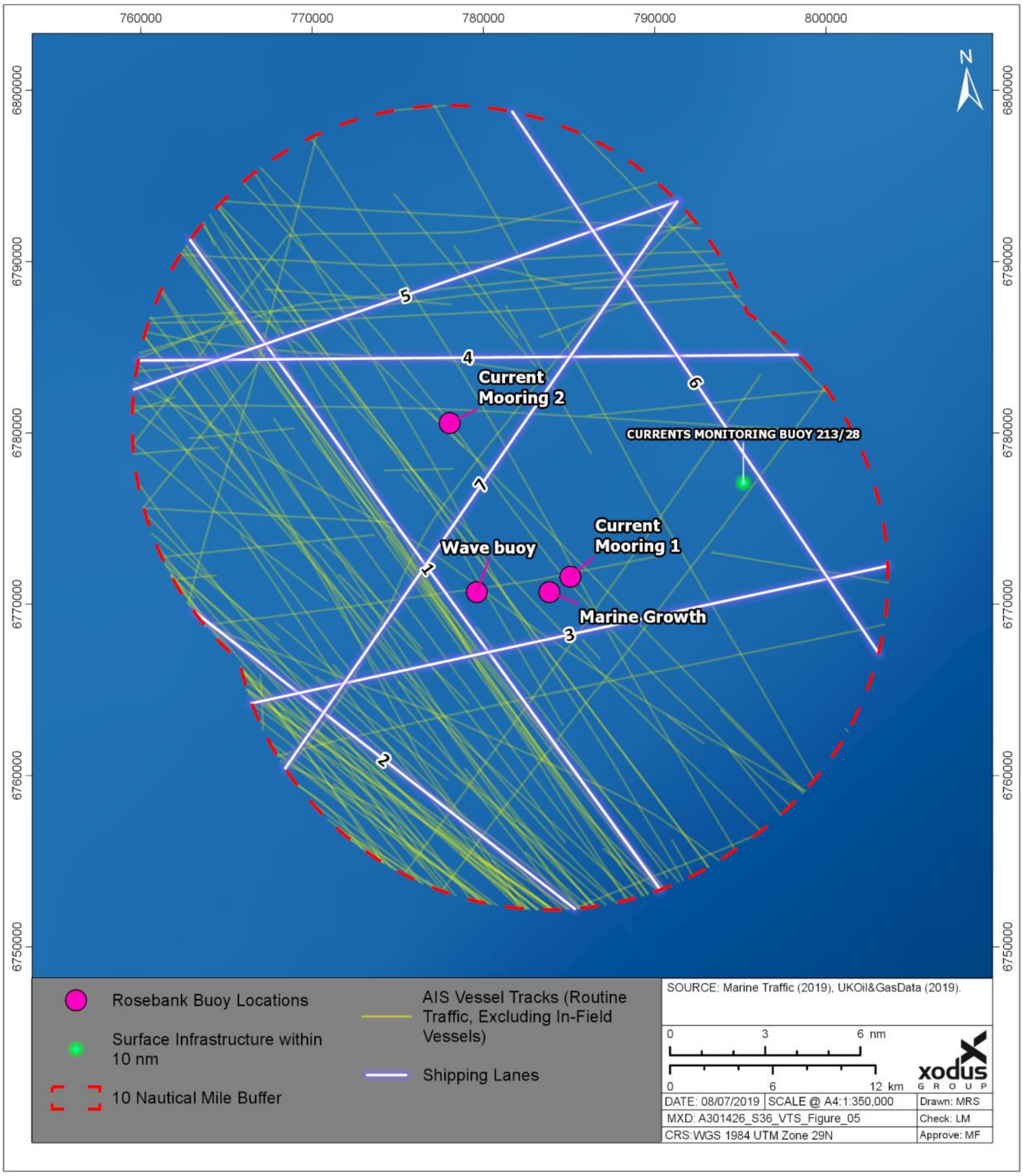


Figure 4-41 Centre lines of shipping lanes within the 10 nm study area (Xodus Group, 2019)

The most heavily-used lane was oriented northwest to southeast in the south of the Rosebank field and had the greatest number of annual cargo tracks at 47 tracks, which represents 50.5% of all cargo vessel tracks in the study area. The majority (77%) of those tracks were made by vessels in Dead Weight Tonnage (DWT) class 5,000 – 15,000 and the rest were all made by vessels in the smaller classes (Xodus Group, 2019).

The Xodus Group (2019) study area extended for 10 NM around the proposed buoy locations and contained a total of 344 routine tracks associated with 84 different vessels during the study period (May 2018 to May 2019), corresponding to an estimated 0.94 vessel transits per day. The majority of routine vessel tracks, accounting for 57% of all routine traffic, were associated with in-field traffic including safety and supply vessels (Xodus Group, 2019). AIS data from EMODnet supports this conclusion that areas of intense shipping activity correlate to the location of offshore facilities, with fishing vessels transiting northeast/southwest in the Faroe-Shetland Channel (EMODnet, 2022).

4.5.2.2 Continental Shelf

The vessel density on the continental shelf area of the Development remains low. According to the average weekly vessel traffic densities between 2013 and 2017, there are localised areas of moderate to high vessel density to the northeast of the Development, with vessel tracks radiating from the Clair and Clair Ridge platforms in UKCS Block 206/8. The majority of vessels within the continental shelf area are cargo vessels, centred around the Clair and Clair Ridge platforms, tanker vessels, travelling en route to/from Sullom Voe terminal and passing through the northwest of Shetland, and fishing vessels targeting the continental shelf (NMPi, 2022).

4.5.3 Submarine Cables

4.5.3.1 Faroe-Shetland Channel

A number of telecommunications cables cross the north Atlantic from the north of Scotland (Figure 4-42). The Rosebank to Clair Tee pipeline will cross the FARICE telecommunications cable.

4.5.3.2 Continental Shelf

In the continental shelf region, the Rosebank to Clair Tee pipeline route will cross the SHEFA-2 telecommunications cable towards the end of the pipeline route at Clair Tee (Figure 4-42).

4.5.4 Wrecks and Cultural Heritage

A number of wrecks have been identified to the west of Shetland (Figure 4-42), and undiscovered submarine archaeology is likely to consist of wrecks sites from World War I and World War II losses (DECC, 2016). AFEN identified approximately 112 large wrecks (> 60 m in length or > 1,000 gross tonne) within the SEA4 west of Shetland offshore area (Hartley Anderson, 2003).

4.5.4.1 Faroe-Shetland Channel

Towards the Faroe-Shetland Channel, the bathymetry becomes deeper, reducing the likelihood of peri-glacial settlement and therefore any associated artefactual remains (DECC, 2016). The wreck of the Bourbon Dolphin lies in Block 213/26, in water depths >1,000 m, approximately 12 km from the Rosebank infield area. During seismic survey work at the Rosebank field in 2010, the ROV discovered a World War I wreck, later identified as the Norwegian steamer Troldfos, lying just outside the field (RPS, 2012). Subsequent detailed survey work over the Development area (using acoustic and photographic methods) has identified no other wrecks, obstructions or items of cultural and historical significance (Fugro, 2011; 2012a, 2012b; 2014a; 2014b). There are no Historic Marine Protected Areas (HMPAs) in the vicinity of the Development area within the Faroe-Shetland Channel (NMPi, 2022).

4.5.4.2 Continental Shelf

There are two charted wrecks to the south of the Rosebank to Clair Tee pipeline route in the continental shelf region, in Blocks 206/6 and 205/10. The identify of these wrecks is not known. There are no HMPAs in the within the Continental shelf region (NMPi, 2022). There are three known wrecks towards the Shetland coastline around Foula Island, including Algier, Lord Kitchener (possibly) and HMS Oceanic. However, these are outwith the Development area (>20 km away from the nearest point at the Clair Tee).

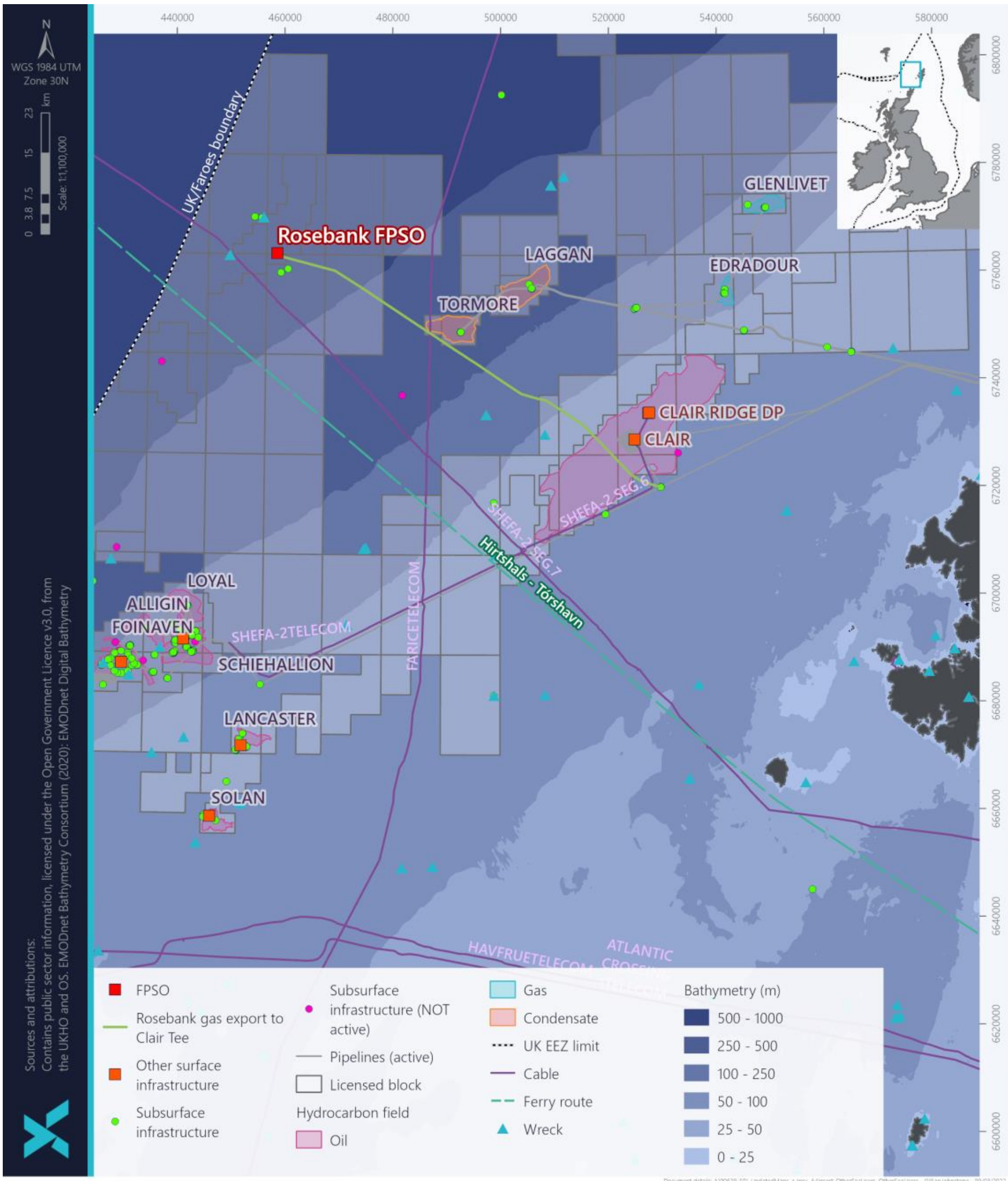


Figure 4-42 Submarine cables, oil and gas infrastructure and wrecks and obstructions (KIS-ORCA, 2021)

4.5.5 Oil and Gas Activities

4.5.5.1 Faroe-Shetland Channel and Continental Shelf

There is long history of oil and gas activity north and west of Shetland over the continental shelf and slope (i.e. in water depths right down to the Faroe-Shetland Channel), with the first exploration well being drilled in 1972. The first commercial discovery, the Clair field (150 m), was made in July 1977, following which exploration continued in the Faroe-Shetland Basin through the 1980s and early 1990s without significant success until the Foinaven (400 to 600 m) and Schiehallion (350 to 450 m) fields were discovered in 1992 and 1993 respectively. There are currently nine producing fields in the region, and any associated oil and gas infrastructure (subsea of surface) within 50 km of the Rosebank Development is listed in Table 4-18.

Table 4-18 Oil and gas infrastructure in the vicinity of the Rosebank Development area

Project name	Project owner	High level description	Project status (as of October 2021)	Distance and Direction from closest point of Rosebank Development
Clair	bp	The Clair field was the first commercial discovery to the north and west of Shetland. Clair Phase 1 includes a platform, a short gas pipeline to WOSPS and a 105 km oil pipeline from the platform to the Sullom Voe Terminal. The field produced first oil in 2005.	Operational	Approximately 10 km northeast of the Rosebank to Clair pipeline
Clair Ridge	bp	Further development of the Clair field. Project involved the installation of two platforms and two pipelines, gas and oil (6.5 km and 13.5 km) to tie into the WOSPS and Clair pipeline, to transport fluids to Sullom Voe Terminal. The pipelines were installed in 2012 and the platforms and subsea structures installed in 2013 and 2014. Construction was completed in 2016, with first oil achieved in 2018.	Operational	Approximately 5 km northeast of the Rosebank to Clair pipeline
Laggan–Tormore	TotalEnergies	Development of the Laggan and Tormore gas condensate fields. The production and export of condensate gas is achieved via subsea structures at Laggan and Tormore and two pipelines to the Shetland Gas Plant, next to the Sullom Voe Terminal. Following processing of condensate at Sullom Voe Terminal, gas is exported to Scotland mainland via a 225 km pipeline (the SIRGE pipeline system). Pipelines and subsea structures were installed, and further drilling of wells undertaken in 2015, with first production occurring in February 2016.	Operational	Approximately 5 km northeast of the Rosebank to Clair pipeline
Edradour	TotalEnergies	Gas condensate from the Edradour field is from one production well, exported via a 17 km pipeline to a tie-in on the Laggan-Tormore pipeline. There is an additional 35 km control umbilical installed subsea from the Laggan manifold to the Edradour manifold. Production commenced in August 2017.	Operational	Approximately 35 km northeast of the Rosebank to Clair pipeline
West of Shetland Pipeline (WOSPS)	bp	The WOSPS exports gas from the Greater Schiehallion, Foinaven and Clair fields to the Sullom Voe Oil Terminal.	Operational	The Clair Tee will tie in to WOSPS

Project name	Project owner	High level description	Project status (as of October 2021)	Distance and Direction from closest point of Rosebank Development
Cambo	Ithaca SP E&P Limited	SPE has previously submitted plans to develop the Cambo field but the project is currently on hold.	Planned	Approximately 34 km southwest of the Rosebank field

4.5.6 Offshore Renewables

4.5.6.1 Faroe – Shetland Channel and Continental Shelf

There are no active or proposed offshore wind farms in the vicinity of the Rosebank Development. The closest Sectoral Marine Plan (SMP) Option area is the NE1 site, located >100 km east of Rosebank, on the east coast of Shetland; a lease option area was not awarded for NE1, therefore there are presently no plans to develop a wind farm (NMPi, 2022).

The Rosebank Development is located within the Innovation and Targeted Oil and Gas (INTOG) area WoS-a. The Clair Tee is located within the INTOG area WoS-b and approximately the last 15 km of the pipeline passes through this area. The INTOG areas represent areas within which projects targeting oil and gas decarbonisation or which will generate >100 MW will be considered (Marine Scotland, 2021), although no such projects have yet been awarded.

4.5.7 Military Activities

4.5.7.1 Faroe – Shetland Channel and Continental Shelf

Chemical weapons and munitions dumping have occurred since the end of World War I. OSPAR began a project in 2004 to establish the extent of dumping. A total of 148 sites and 1,879 encounters were recorded since 2004, however none are located within or in the vicinity of the Development area (DECC, 2016).

A number of Blocks through which the gas pipeline routes pass are within Ministry of Defence (MoD) training ranges (OGA, 2019), including 205/2, 205/1, 205/3, 205/4, 205/5, 205/10 and 206/6 in the Faroe-Shetland Channel, and 206/7, 206/12 and 206/14 in the Continental shelf region. Although being situated in MOD training areas does not preclude development, the MoD must be notified at least twelve months in advance of the proposed siting of any installation, whether fixed to the seabed, resting on the seabed or floating, that is intended for drilling or acquiring hydrocarbons, or for fluid injection (OGA, 2019).

4.5.8 Coastal Economic Interests

The coastal waters of Shetland and Orkney are important regions for aquaculture developments. The west coast of Shetland, in particular, supports numerous active finfish and shellfish sites as well as shellfish waters protected areas (NMPi, 2022). Tourism is also an important contributor to the economies of the Shetland and Orkney. Around half of all visitors to Shetland visit for leisure purposes, with the majority of the tourism dependent upon an interest in the natural environment, such as the scenery and landscape including the dramatic coastline (Shetland Islands Council, 2020).

The FPSO will be located approximately 130 km west of Shetland. The closest part of the Development to the coastline is the gas export pipeline tie-in point to the Clair Tee, which lies on the seabed in deep water well over 20 km from Shetland.

4.5.9 Local Air Quality

Information on local air quality is provided as part of the assessment of atmosphere and climate in Chapter 9 Atmospherics and Climate.

4.6 Natural Disasters

This section aims to identify natural features of the environment in the Rosebank Development area that could pose a risk to the Development, including the possible effects of climate change, and particularly those events that could result in a hydrocarbon spill.
The Faroe-Shetland Channel and continental shelf areas can be exposed to significant weather conditions, with strong winds exceeding 14 m/s occurring through the year but most frequently during the winter months. The predominant wind speeds throughout the year being moderate to a strong breeze (5.5 to 13.9 m/s). Significant wind speeds recorded at the Lerwick Observatory show records as high as 95 knots (49 m/s) recorded in 1992 (Shetland Islands Council, 2011). These strong winds are associated with significant wave conditions. The 100-year extreme significant wave height for the Rosebank field being 17.7 m (see Section 4.2.4).

Historical records show that seismic activity in the North Sea is concentrated between the Fladen Ground and the waters offshore of Norway, and within the Dogger Bank area. An epicentre of small magnitude has been recorded on the continental slope to the west of Shetland (BGS, undated). It is considered that earthquakes with magnitude of 4 or higher may require special structural design and are of concern for oil and gas activities. In the North Sea, the expected frequency of occurrence for a magnitude 4 natural seismic event is approximately every two years and a magnitude 5 natural seismic event every 14 years. However, in the Rosebank field and the Regional Sea 9 area as a whole (the Faroe-Shetland Channel), seismic activity is largely absent, being mainly confined to the north of Shetland, towards the Møre Basin-Viking Graben area, where the highest recorded local magnitude is 3.1.

Slope instabilities generated by earthquakes have been recorded to the north-west of Shetland, however the seismicity and seismic hazard are low in this area. The Faroe-Shetland Channel displays landslides and debris flows, such as in the AFEN slide located 95 km north-west of Shetland where submarine mass movements occurred during the Holocene (DECC, 2016).

4.7 Environmental Conditions Without Implementation of the Development

This section aims to provide an outline of the likely evolution of the environment without implementation of the project as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge. This do-nothing or zero-alternative is not necessarily an actual alternative to the Development but forms a reference framework for the impact assessment evaluation. It is for comparative purposes i.e. how the environmental baseline might develop over the period of the Development in a scenario where the project does not go ahead.

Subsequent chapters describe the potential impacts to receptors from the Development in terms of physical footprint on the seabed, discharges to sea, emissions to atmosphere, and increased noise levels. The impact assessment qualitatively and quantitatively determines the extent of the impact of the Development on benthic habitats and species, fish and marine animals and mammals, seabirds and protected areas, and transboundary emissions to air.

It is considered that there are no significant effects from the Development which, either individually or in combination, would be sufficiently harmful to negatively affect the conservation objectives, population levels or ecological status of a relevant receptor. Much of the physical infrastructure will be removed once the Development lifetime is complete and discharges and emissions occurring during normal operations will cease with negligible or undetectable effects on environmental quality. The biggest risk from any offshore oil development is the potential for a large oil spill, however, there are stringent controls in place to prevent such an occurrence and such events are rare.

It is therefore considered that the likelihood of deviation from the natural changes from the baseline characterisation that might be expected over time without the Development is very low.

5 ENVIRONMENTAL IMPACT ASSESSMENT (EIA) METHODOLOGY

5.1 Overview

Offshore activities can involve a number of environmental interactions and impacts due, for example, to operational emissions and discharges and general disturbance. The objective of the EIA process is to incorporate environmental considerations into the Development planning, to ensure that Best Environmental Practice (BEP) is followed and, ultimately, to achieve a high standard of environmental performance and protection. The process also allows for concerns identified by stakeholders to be addressed. In addition, it ensures that the planned activities are compliant with legislative requirements and Equinor's HSE policy (Chapter 1 Introduction).

5.2 Identification of Environmental Impacts

An EIA is to be focused on the key issues related to the specific activities proposed. The impact assessment write-up should be proportionate to the scale of the development and to the environmental sensitivities of the development area. Equinor undertook an impact identification exercise to identify key environmental sensitivities, discussed sources of potential impact (including an environmental issue identification (ENVID) workshop) and identified those sources which required further assessment. The decision as to which issues required further assessment was based on the specific proposed activities and environmental sensitivities, a review of industry experience of EIA outcomes and on an assessment of wider stakeholder interest.

5.2.1 Issues Identified for assessment

The ENVID process, consultation and technical review phases resulted in the following issues being considered and agreed for assessment in the EIA:

- Seabed disturbance (Chapter 6), leading to changes in biodiversity
    - Disturbance to seabed species and habitats from the physical presence of subsea infrastructure – e.g., flowlines including the gas export pipeline, umbilicals, subsea templates, umbilical riser bases, anchors;
    - Direct loss of benthic species;
    - Direct loss of existing seabed habitat;
    - Introduction of novel habitat types; and
    - Wider indirect disturbance to the benthic environment through the suspension and re-settlement of sediments.
- Discharges to sea (Chapter 7)
    - Drilling discharges of drilling mud and cuttings, and drilling, cementing and completion chemicals into the water column and onto the seabed, pre-commissioning chemical discharges, operational discharges of high salinity brine from the Sulphate Removal Unit, cooling water, sand, and produced water potentially resulting in changes in water quality;
    - Localised and temporarily increased suspended solid concentrations; and
    - Impacts to organisms in the water column and to habitats and communities on the seabed.
- Interaction with other sea users (Chapter 8)
    - Physical presence of vessels and drilling rig during drilling, installation, commissioning, operation and decommissioning, and the long-term presence of the FPSO vessel and subsea infrastructure;
    - Interference with shipping and fishing activities that may occur in the area;

- Loss of access to the area for other vessels on a temporary or permanent basis; and
- Increased risk of vessel collisions through the presence of the drilling rig, FPSO and other vessels during drilling, subsea installation activities and operation.

- Atmospheric emissions and climate (Chapter 0)
  - Atmospheric emissions from fuel combustion by the drilling rig, the FPSO, vessels and helicopters, during drilling, installation, commissioning, and production resulting in release of GHGs including CO_2 and methane with potential global climate and local air quality issues.
- Underwater sound (Chapter 10)
  - Injury and disturbance to marine mammals and fish resulting in avoidance behaviours e.g., from the vertical seismic profiling, the use of drilling rig and vessel thrusters.
- Accidental events (Chapter 11)
  - Possible toxicity and smothering impacts to birds, other marine species (e.g., marine mammals) and habitats through the release of hydrocarbons from infrastructure or vessels.

5.2.2 Issues Scoped Out of Assessment

During the ENVID workshop and as the EIA developed, the following issues were reviewed and it was considered that the potential environmental impacts were negligible in EIA terms (therefore very unlikely to be significant) or would be regulated sufficiently robustly through existing agreements that no further project-specific assessment was necessary. For example, all routine vessel and drilling rig activities that are non-project specific will be subject to compliance with international maritime and/or UK specific legislation and compliance will be assured through the supply chain process and routine operational monitoring. The following were therefore scoped out of further assessment in the EIA:

- Ecology
  - Disturbance to ornithological features from drilling rig and vessels was scoped out as the activities are unlikely to produce a significant impact. Lighting on the drilling rig, vessels and FPSO will be reduced to levels required for safe and secure operations.
- Discharges to sea;
  - Routine vessel/FPSO discharges, including bilge water, blackwater production (i.e., sewage), grey water (i.e., from showers, laundry, hand and eye wash basins and drinking fountains) and food waste (macerated) disposal (vessels and drilling rig) – adherence by all vessels and drilling rigs to the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex I Prevention of Pollution by Oil, Annex V Prevention of Pollution by Garbage from Ships and Annex IV Prevention of Pollution by Sewage from Ships is required. No further project-specific controls are required, and no further assessment has therefore been undertaken; and
  - Ballast water, including non-native invasive species – scoped out as management of ballast water is a routine maritime activity and requires adherence to International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004. Furthermore, there are no planned, regular, international movements of vessels during the operational life of field.
- Direct loss of marine archaeological remains:
  - Scoped out since there were no wrecks identified during the seabed survey scope.
- Impact on seascape:
  - Scoped out as the limited vessel and drilling rig presence will be far enough offshore not to affect visual amenity.

- Waste
  - Routine waste management will be carried out by all the vessels and drilling rig and existing, effective management controls in place which require in compliance with International Convention for the Prevention of Pollution from Ships (MARPOL) Annex V Prevention of Pollution by Garbage from Ships (entered into force 31 December 1988). Waste was therefore scoped out of the EIA.
- Accidental events
  - Limited unplanned operational releases, such as resulting from an overfill of a tank into a bund was scoped out due to the highly limited volumes;
  - Natural disasters - it is considered that the implication of any natural disasters affecting the offshore region, such as an earthquake or extreme sea conditions (including tsunami), would most likely result in the accidental event scenarios described in Chapter 11; and
  - Disturbance to marine species in the Rosebank area from the physical presence of vessels or collision between vessel and animals was scoped out as the Rosebank field is in open sea and cetacean use is generally low (Chapter 4 Environment Baseline).
- Atmospheric and Climate
  - The use and discharge of halons and fluorinated greenhouse gases (GHGs) within the fire protection system and refrigerants was scoped out due existing, effective management controls in place and compliance required with legal requirements; and
  - It should also be noted that Scope 3 emissions are not within the remit of the EIA – the climate change assessment is therefore completed on the basis of the direct and indirect GHG emissions from construction and operation.
- Recreation and tourism.
  - Given the offshore location of the Development, there is no regular, intensive use of the area for recreational and tourism activities such as kayaking, yachting, diving or similar. Given the absence of these and other, similar activities, long-term restriction of access or amenity was therefore scoped out.

The impact identification process was kept under review throughout the EIA, with mitigation revised as understanding of the Development increased.

In addition, the consenting and approval process for installation of the fibre optic cable and infrastructure required for electrification of the FPSO do not form part of the Field Development Plan and are therefore not within the definition of the project covered by this EIA/ES.

5.3 Stakeholder Engagement and Consultation

Stakeholder consultation has been an integral aspect of the planning of the Development and integral to the EIA to provide stakeholders the opportunity to highlight their initial views and environmental concerns at an early stage of the EIA process. As the Development progresses through the design, execute, operation and decommissioning phases stakeholders will continue to be engaged on environmental issues. The consultation process included routine discussions with the regulator OPRED and NSTA to update them on the progress of the Development planning and seek advice on regulatory requirements.

Equinor carried out stakeholder engagement with both Statutory and Non-statutory consultees by letter. The letter included a description of the baseline environment of the project area, the proposed activities and scope of the EIA.

The letter was followed up with meetings called and arranged by Equinor. Details of meetings held are provided in Table 5-1.

Table 5-1 Details of meetings held with relevant stakeholders

Stakeholder	Engagement	Feedback Received
OPRED	31st March 2022	Yes, Comments in Appendix B
JNCC	17th March 2022	Yes, Comments in Appendix B
Marine Scotland	24th March 2022	Yes, Comments in Appendix B
Shetland Islands Council	Not requested	Yes, Comments in Appendix B
Scottish Fishermen's Federation	11th March 2022	Yes, Comments in Appendix B
Maritime and Coastguard Agency	Not requested	Yes, Comments in Appendix B
Ministry of Defence	Not requested	Yes, Comments in Appendix B
Shetland Fishermen	Not requested	Yes, Comments in Appendix B
UK Hydrographic Office	Not requested	Yes, Comments in Appendix B
NatureScot	Not requested	No response
Northern Lighthouse Board	Not requested	Yes, Comments in Appendix B
Scottish Pelagic Fishermen's Association	Not requested	No response
Faeroese Environment Agency	Not requested	No response
Faeroese Geological Survey	Not requested	No response

Overall, it was considered that the consultees were satisfied with the proposed approach to the EIA, with the key environmental issues and potential impacts that has been identified for assessment, and with the supporting studies that were proposed at that time to facilitate the assessment. The issues raised by the consultees have been considered and addressed during the EIA. A complete list of scoping comments and responses are provided in Appendix B.

5.4 Human Health

Human health impacts from routine and accidental events were considered during the EIA and were determined to largely require no further assessment within the EIA process, especially since activities are offshore and will be managed to meet industry requirements for safe operations. Chapter 0 describes possible local air quality issues associated with the Development.

5.5 Environmental Significance

The Project itself is considered an Annex I project with regards to the EIA Directive, and such projects are automatically subject to an EIA because their environmental effects of the proposed activities are assumed to be potentially significant. The decision process related to defining whether a development is likely to have this significant interaction with the environment is the core principle of the EIA process. The methods used for identifying and assessing impacts and potential effects should be transparent and verifiable.

The method presented here has been developed by reference to the Institute of Ecology and Environmental Management (IEEM) guidelines for marine impact assessment (IEEM, 2010), the Marine Life Information Network (MarLIN) species and ecosystem sensitivities guidelines (Tyler-Walters *et al*., 2001), and guidance provided by NatureScot (previously Scottish Natural Heritage (SNH), 2016) and by the Institute of Environmental Management and Assessment (IEMA) (IEMA, 2016).

The EIA provides an assessment of the environmental effects that may result from a development's impact on the receiving environment. The terms impact and effect have different definitions in an EIA and one drives the other. Impacts are defined as the changes resulting from an action (the proposed activities), and effects are defined as the consequences of those impacts.

In general, impacts are specific, measurable changes in the receiving environment (volume, time and/or area). Effects (the consequences of those impacts) consider the response of a receptor to an impact. The relationship between impacts and effects is not always so straightforward; for example, a secondary effect may result from both a direct and indirect impact on a single receptor. There may also be circumstances where a receptor is not sensitive to a particular impact and thus there will be no effect.

For each impact from the proposed activities, the assessment identifies a receptor's sensitivity and vulnerability to that effect and implements a systematic approach to understand the level of potential change. The process considers the following:

- Identification of receptor and impact (including duration, timing and nature of impact);
- Definition of sensitivity, vulnerability and value of receptor;
- Definition of magnitude and likelihood of impact; and
- Assessment of consequence of the impact on the receptor, considering the probability that it will occur, the spatial and temporal extent and the importance of the impact. If the assessment of consequence of impact is determined as moderate or major, it is considered a potentially significant impact.

Once the consequence of an effect has been assessed, it is possible to identify measures that can be taken to mitigate impacts through engineering decisions or execution of the Development. This process also identifies aspects of the Development that may require monitoring, such as a post-decommissioning survey upon completion of the works to inform inspection reports.

For some impacts, significance criteria are standard or numerically based. For others, for which no applicable limits, standards or guideline values exist, a qualitative approach is required. This involves assessing significance using professional judgement.

Despite the assessment of impact significance being a subjective process, a defined methodology has been used to make the assessment as objective as possible and consistent across different topics. The assessment process is summarised below. The terms and criteria associated with the impact assessment process are described and defined. Details of how these are combined to assess consequence and impact significance are then provided.

5.6 Baseline Characterisation and Receptor Identification

In order to make an assessment of potential impacts on the environment it was necessary to firstly characterise the different aspects of the environment that could potentially be affected (the baseline environment). The baseline environment has been described in Chapter 4 Environment Baseline and is based on regional studies combined with site-specific surveys.

Where data gaps and uncertainties remained (e.g., where there were no suitable options for filling data gaps), as part of the EIA process these have been documented and, as a precautionary approach, have been taken into consideration as part of the assessment of impact significance. Data gaps are noted within the written assessments where appropriate.

Identification of the potential receptors that could be affected by the Development (e.g., marine mammals, seabed species and habitats) is required in the EIA process. Receptor groups are identified within the individual impact assessments (Chapters 6 - 11).

5.6.1 Impact Definition

Determination of impact magnitude requires consideration of a range of key impact criteria including:

- Nature of impact, whether it will be positive or negative (beneficial or adverse);
- Type of impact, is it direct or indirect etc.;
- Duration over which the impact is likely to occur, i.e., days, weeks;
- Size and scale of impact, i.e., the geographical area;
- Seasonality of impact, i.e., is the impact expected to occur at any time of year or during specific times of the year, e.g., spring or summer; and
- Frequency of impact, i.e., how often is the impact expected to occur.

Each of these variables are expanded upon in the tables below and provide consistent definitions across all EIA topics. In each impact assessment, these terms are used in an assessment summary table to summarise the impact and are enlarged upon as necessary in any supporting text. With respect to the nature of the impacts described within each of the assessment chapters (Table 5-2), it should be noted that all impacts discussed in this ES are adverse, unless explicitly stated.

Table 5-2 Nature of Impact

Nature of impact	Definition
Beneficial	Advantageous or positive effect to a receptor (i.e., an improvement).
Adverse	Detrimental or negative effect to a receptor.

Table 5-3 Duration of Impact

Impact duration	Definition
Short term	Impacts that are predicted to last for a short duration (e.g., less than one year).
Temporary	Impacts that are predicted to last a limited period (e.g., a few years). For example, impacts that occur during the proposed activities and which do not extend beyond the main activity period for the works, or which, due to the timescale for mitigation, reinstatement or natural recovery, continue for only a limited time beyond completion of the anticipated activity.
Prolonged	Impacts that may, although not necessarily, commence during the main phase of the proposed activities and which continue through the monitoring and maintenance, but will eventually cease.
Permanent	Impacts that are predicted to cause a permanent, irreversible change.

Table 5-4 Geographical Extent of Impact

Extent of impact	Definition
Local	Impacts that are limited to the area surrounding the Development footprint and associated working areas. Alternatively, impacts that are restricted to a single habitat or biotope or community.
Regional	Impacts that are experienced beyond the local area to the wider region, as determined by habitat/ecosystem extent.
National	Impacts that affect nationally important receptors or protected areas, or which have consequences at a national level. This extent may refer to either Scotland or the UK depending on the context.
Transboundary	Impacts that could be experienced by neighbouring national administrative areas.
International	Impacts that affect areas protected by international conventions, European and internationally designated areas or internationally important populations of key receptors (e.g., birds, marine mammals).

Table 5-5 Frequency of Impact

Impact frequency	Definition
Continuous	Impacts that occur continuously or frequently.
Intermittent	Impacts that are occasional or occur only under a specific set of circumstances which occurs several times during the course of the Development. This definition also covers such impacts that occur on a planned or unplanned basis, and those described as 'periodic' impacts.

5.6.2 Impact Magnitude Criteria

Overall impact magnitude requires consideration of all impact parameters described above. Based on these parameters, magnitude can be assigned following the criteria outlined in Table 5-6. The resulting effect on the receptor is considered under vulnerability and is an evaluation based on professional judgement.

Table 5-6 Impact Magnitude Criteria

Magnitude	Criteria
Major	Extent of change: impact occurs over a large scale or spatial geographical extent and /or is long term or permanent in nature. Frequency/ intensity of impact: high frequency (occurring repeatedly or continuously for a long period of time) and/or at high intensity.
Moderate	Extent of change: impact occurs over a local to medium scale/spatial extent and/or has a short to medium-term duration.

Magnitude	Criteria
	Frequency/intensity of impact: medium to high frequency (occurring repeatedly or continuously for a moderate length of time) and/or at moderate intensity or occurring occasionally/intermittently for short periods of time but at a moderate to high intensity.
Minor	Extent of change: impact occurs on-site or is localised in scale/spatial extent and is of a temporary or short-term duration. Frequency/intensity of impact: low frequency (occurring occasionally/intermittently for short periods of time) and/or at low intensity.
Negligible	Extent of change: impact is highly localised and very short-term in nature (e.g., days/few weeks only).
Positive	An enhancement of some ecosystem or population parameter, ranging from negligible to major.
Notes: Magnitude of an impact is based on a variety of parameters. Definitions provided above are for guidance only and may not be appropriate for all impacts. For example, an impact may occur in a very localised area (minor to moderate) but at very high frequency/ intensity for a long period of time (major). In such cases expert judgement is used to determine the most appropriate magnitude ranking and this is explained through the narrative of the assessment.	

5.6.3 Impact Likelihood for Unplanned and Accidental Events

The likelihood of an impact occurring for unplanned/ accidental events is another factor that is considered in this impact assessment. This captures the probability that the impact will occur and also the probability that the receptor will be present. For some types of incident there are historical data available that allows a quantitative estimate of incident likelihood to be calculated; for other impacts, professional judgement must be used to resent a qualitative estimate. The quantitative and qualitative terms used to describe impact likelihood in the impact assessment chapters are defined in Table 5-7.

Table 5-7 Likelihood for Unplanned and Accidental Events

Likelihood	Qualitative definition
Likely	Event likely to occur more than once on the facility
Possible	Could occur within the lifetime of the development
Unlikely	Event could occur within lifetime of 10 similar developments. Has occurred at similar facilities.
Remote	Similar event has occurred somewhere in industry or similar industry but not likely to occur with current practices and procedures.
Extremely remote	Has never occurred within industry or similar industry but theoretically possible.

5.6.4 Receptor Definition

As part of the assessment of impact significance, the assessments have differentiated between receptor sensitivity, vulnerability and value. The sensitivity of a receptor is defined as the degree to which a receptor is affected by an impact and is a generic assessment based on factual information. Assessment of vulnerability, which is defined herein as the degree to which a receptor can or cannot cope with an adverse impact, is based on professional judgement taking into account a number of factors, including the previously assigned receptor sensitivity and impact magnitude, as well as other factors such as known population status or condition, distribution and abundance.

Example definitions for assessing the sensitivity of a receptor are provided in Table 5-8.

Table 5-8 Sensitivity of Receptor

Receptor sensitivity	Definition
Very high	Receptor with no capacity to accommodate a particular effect and no ability to recover or adapt.
High	Receptor with very low capacity to accommodate a particular effect with low ability to recover or adapt.
Medium	Receptor with low capacity to accommodate a particular effect with low ability to recover or adapt.
Low	Receptor has some tolerance to accommodate a particular effect or will be able to recover or adapt.
Negligible	Receptor is generally tolerant and can accommodate a particular effect without the need to recover or adapt.

Information on both impact magnitude and receptor sensitivity is required to be able to determine receptor vulnerability. These criteria, described in Table 5-5 and Table 5-7 respectively, are used to define receptor vulnerability as per Table 5-9.

Table 5-9 Vulnerability of Receptor

Receptor vulnerability	Definition
Very high	The impact will have a permanent effect on the behaviour or condition of a receptor such that the character, composition or attributes of the baseline, receptor population or functioning of a system will be permanently changed.
High	The impact will have a prolonged or extensive temporary effect on the behaviour or condition of a receptor resulting in long term or prolonged alteration in the character, composition or attributes of the baseline, receptor population or functioning of a system.
Medium	The impact will have a temporary effect on the behaviour or condition of a receptor such that the character, composition, or attributes of the baseline, receptor population or functioning of a system will either be partially changed post development or experience extensive temporary change.
Low	Impact is not likely to affect long term function of system or status of population. There will be no noticeable long-term effects above the level of natural variation in the area.
Negligible	Changes to baseline conditions, receptor population or functioning of a system will be imperceptible.

It is important to note that the above approach to assessing sensitivity/ vulnerability is not appropriate in all circumstances and in some instances professional judgement has been used in determining sensitivity. In some instances, it has also been necessary to take a precautionary approach where stakeholder concern exists with regard to a particular receptor. Where this is the case, this is detailed in the relevant impact assessment Chapters 6 - 11.

The value or importance of a receptor depends on a pre-defined judgement based on legislative requirements, guidance or policy. Where these may be absent, it is necessary to make an expert judgement on receptor value based on the perceived views of key stakeholders, experts and specialists. Examples of receptor value definitions are provided in Table 5-10.

Table 5-10 Value of Receptor

<table>
<tr><th>Value of receptor</th><th>Receptor type</th><th>Definition (example only – does not cover all receptors)</th></tr>
<tr><td rowspan="2">Very high</td><td>Environmental receptors</td><td>Receptor of very high importance or rarity, e.g., species that are globally threatened, e.g., IUCN Red List of Threatened Species (‘Red List’) including those listed as endangered or critically endangered and/ or a significant proportion of the international population (> 1%) is found within the Development site.</td></tr>
<tr><td>Cultural and socio-economic receptors</td><td>Receptor has no alternative to utilise an alternative area.
Receptor is entirely dependent on the Development area for all income/activities.
Receptor is the best known/only example to contribute to knowledge and understanding and/or outreach.</td></tr>
<tr><td rowspan="2">High</td><td>Environmental receptors</td><td>Receptor of high importance or rarity, such as species listed as near-threatened or vulnerable on the IUCN Red List.
Habitats and species protected under the European Union (EU)'s Habitats Directive.
Bird species protected under the EU Birds Directive.
Habitats and species (including birds) that are a qualifying interest of a SAC, SPA or Ramsar site and a significant proportion of the national population (>1%) is found within the Development site. Conservation interests (habitats and species) of Marine Protected Areas (MPAs), Heritage MPAs and Marine Conservation Zones (MCZ).</td></tr>
<tr><td>Cultural and socio-economic receptors</td><td>Receptors and sites of international cultural importance (e.g., United Nations Educational, Scientific and Cultural Organisation (UNESCO) World Heritage Sites (WHSs).
Receptor has little flexibility to utilise an alternative area.
Receptor generates the majority of income from the Development area.
Receptor is an above average example and/or has high potential to contribute to knowledge and understanding and/or outreach.</td></tr>
<tr><td rowspan="2">Medium</td><td>Environmental receptors</td><td>Receptor of least concern on the IUCN Red List, listed as a breeding species on Schedule 1 of the Wildlife and Countryside Act 1981, form a cited interest of a SSSI, are listed in the UK Biodiversity Action Plan or on the Birds of Conservation Concern (BOCC) ‘Red list’ and a significant proportion of the regional population (>1%) is found within the Development site.</td></tr>
<tr><td>Cultural and socio-economic receptors</td><td>Receptor has some flexibility to utilise an alternative area.
Receptor is active in the Development area and utilises it for up to half of its annual income/activities.
Receptor is average example and/or has moderate potential to contribute to knowledge and understanding and/or outreach.</td></tr>
<tr><td rowspan="2">Low</td><td>Environmental receptors</td><td>Any other species of conservation interest (e.g., BOCC Amber listed species).</td></tr>
<tr><td>Cultural and socio-economic receptors</td><td>Receptor has high flexibility to utilise an alternative area.
Receptor is active in the Development area and other areas and is reliant on Development area for some income/activities.
Receptor is below average example and/or has low potential to contribute to knowledge and understanding and/or outreach.</td></tr>
<tr><td rowspan="2">Negligible</td><td>Environmental receptors</td><td>Receptor of very low importance, such as those which are generally abundant around the UK and Ireland with no specific value or conservation concern.</td></tr>
<tr><td>Cultural and socio-economic receptors</td><td>Receptor is very active in other areas and not typically present in the Development area.</td></tr>
</table>

Value of receptor	Receptor type	Definition (example only – does not cover all receptors)
		Receptor does not generate any income/activities from the Development area. Receptor is poor example and/or has no potential to contribute to knowledge and understanding and/or outreach.

5.6.5 Consequence and Significance of Potential Impact

Having determined impact magnitude, and the sensitivity, vulnerability and value of the receptor, it is then necessary to evaluate impact significance. This involves:

- Determination of impact consequence based on a consideration of sensitivity, vulnerability and value of the receptor and impact magnitude;
- Assessment of impact significance (in accordance with EIA regulations) based on assessment consequence;
- Mitigation; and
- Residual impacts.

The assessment of activities and receptors is combined using expert judgement to arrive at a consequence for each effect, as shown in Table 5-11. The significance of impact is derived directly from the assigned effect consequence ranking.

In summary, this assessment methodology considers the impacts from the project (i.e. the activities we will undertake), taking various elements of those impacts (e.g. temporal scale) and assessing how those impacts may result in changes to the receptors (i.e. what effect the impact may have). Depending on the extent of the effect, which we call consequence, the impact can be considered either significant or not significant.

Table 5-11 Assessment of Effect Consequence

Assessment of effect consequence	Description (consideration of receptor sensitivity and value and impact magnitude)	Impact significance
Major consequence	Impacts are likely to be highly noticeable and have long-term effects, or permanently alter the character of the baseline and are likely to disrupt the function and status/value of the receptor population. They may have broader systemic consequences (e.g., to the wider ecosystem or industry). These impacts are a priority for mitigation in order to avoid or reduce the anticipated effects of the impact.	Significant
Moderate consequence	Impacts are likely to be noticeable and result in lasting changes to the character of the baseline and may cause hardship to, or degradation of, the receptor population, although the overall function and value of the baseline/receptor population is not disrupted. Such impacts are a priority for mitigation in order to avoid or reduce the anticipated effects of the impact.	Significant
Low consequence	Impacts are expected to comprise noticeable changes to baseline conditions, beyond natural variation, but are not expected to cause long-term degradation, hardship or impair the function and value of the receptor. However, such impacts may be of interest to stakeholders and/or represent a contentious issue during the decision-making process and should therefore be avoided or mitigated as far as reasonably practicable.	Not significant

Assessment of effect consequence	Description (consideration of receptor sensitivity and value and impact magnitude)	Impact significance
Negligible	Impacts are expected to be either indistinguishable from the baseline or within the natural level of variation. These impacts do not require mitigation and are not anticipated to be a stakeholder concern and/or a potentially contentious issue in the decision-making process.	Not significant
Positive	Impacts are expected to have a positive benefit or enhancement. These impacts do not require mitigation and are not anticipated to be a stakeholder concern and/or a potentially contentious issue in the decision-making process.	Not significant

Where significant impacts are identified (i.e., those ranked as being of moderate impact level or higher in Table 5-11), mitigation measures must be considered. The intention is that such measures should remove, reduce or manage the impacts to a point where the resulting residual significance is at an acceptable or insignificant level. Mitigation is also proposed in some instances to ensure impacts that are predicted to be not significant remain so. Appendix B provides detail on these commitments and how any mitigation measures identified during the impact assessment will be managed.

Residual impacts are those that remain once all options for removing, reducing or managing potentially significant impacts (i.e., all mitigation) have been taken into account.

5.7 Cumulative and In Combination Impact Assessment

The European Commission has defined cumulative impact as being those resulting "from incremental changes caused by other past, present or reasonably foreseeable actions together with the project" (European Commission, 1999). As outlined in studies by the European Commission (1999) and the United States Council on Environmental Quality (1997), identifying the cumulative impacts of a project involves:

- Considering the activities associated with the Development;
- Identifying potentially sensitive receptors/resources;
- Identifying the geographic and time boundaries of the cumulative impact assessment;
- Identifying past, present and future actions which may also impact the sensitive receptors/resources;
- Identifying impacts arising from the proposed activities; and
- Identifying which impacts on these resources are important from a cumulative impacts' perspective.

In-combination impacts result when the same receptor is affected in multiple different ways, for example fish experiencing effects from both sound and light. There is considerable uncertainty in the assessment of in-combination impacts but potential impacts will be identified and documented and any difficulties or uncertainties in undertaking the assessment recorded.

In relation to Habitats Regulations Assessment, assessment is required of whether the impacts of a development alone, or 'in-combination' with other projects or plans will result in likely significant effects. The requirement is codified within The Conservation of Habitats and Species Regulations 2017 (Regulation 63) and, beyond UK territorial waters (12 nautical miles), in The Conservation of Offshore Marine Habitats and Species Regulations 2017 (Regulation 28). In practice, such an 'in-combination' assessment is of greatest relevance when an impact pathway relating to a project would otherwise be screened out because it is considered not to result in likely significant effects. In an analogous process, the Marine and Coastal Access Act and The Marine (Scotland) Act require assessment of the potential for significant risk to achievement of the conservation objectives of MCZs and MPAs, part of which will require consideration of the potential for cumulative impact to occur.

To assist the assessment of cumulative and in-combination impacts, a review of existing developments (including oil and gas, cables and renewables) that could have the potential to interact with the Development was undertaken; the output of this review is reported in the Environment Baseline (Chapter 4). The impact assessment has considered these projects when defining the potential for cumulative and in combination impact.

5.8 Transboundary Impact Assessment

The impact assessment presented in Chapters 6 to 11 contains sections which identify the potential for, and where appropriate, assessment of transboundary impacts. The Development lies approximately 15 km from the UK/Faroes median line.

5.9 Habitat Regulations Assessment and Marine Conservation Zone Assessment

It is the responsibility of the Competent Authority (OPRED) to make an Appropriate Assessment of the implications of a plan, programme or in this case project, alone or in combination, on a Special Area of Conservation (SAC) or Special Protection Area (SPA) in view of the site's conservation objectives and the overall integrity of the site.

As part of the assessment of impacts on key receptors, for those receptors that are a qualifying feature of a site, relevant information on SACs or SPAs has also been provided. This information will then be used by the Competent Authority to determine the need for, and subsequently carry out (if required), an Appropriate Assessment of the Development.

In accordance with the Conservation of Offshore Marine Habitats and Species Regulations 2017 (for offshore areas, 12 – 200 nautical miles (NM)) and the Conservation of Habitats and Species Regulations 2017 (less than 12 NM), the impacts of a project on the integrity of a UK site are assessed and evaluated as part of the HRA process. In an analogous process, the Marine and Coastal Access Act and The Marine (Scotland) Act require assessment of the potential for significant risk to achievement of the conservation objectives of MCZs and MPAs.

The requirement to undertake the assessment lies with OPRED but the ES provides both qualitative and quantitative information to inform the assessment process and enable OPRED to determine whether a significant effect is likely and whether the proposed activities would have an adverse effect on the integrity of the relevant site.

5.10 Data Gaps and Uncertainties

The bank of published data for the environment to the west of Shetland has been supplemented by a site survey programme and studies undertaken on behalf of Equinor to collect Development specific environmental data, ensuring a robust baseline is available against which to assess impact. Where appropriate, studies have been commissioned to inform the impact assessment. Studies have included:

- Drill cuttings dispersion modelling, to assist in predicting the fate and impacts of WBM and cuttings discharged to the seabed and water column from the drilling process;
- Water discharge modelling to assist in impact assessment of the cooling water, brine from the Sulphur Removal Unit, sea water and produced water discharges;

- Oil spill modelling, to facilitate assessment of the impacts from worst case scenarios regarding accidental spills; and
- Noise propagation modelling to estimate underwater sound levels, impact zones for injury and disturbance to marine mammals (protected species) and potential mitigation strategies (as appropriate).

When evaluating and characterising potential impacts that could be associated with the Development, a variety of inputs are used, including baseline environmental data, modelling results, estimation of emissions and Development footprint. These inputs carry varying levels of uncertainty and conservatism and although the assessment conclude that potential impacts may occur, they are not stated as certain to occur (for example, there is some uncertainty in marine mammal response to certain sound emissions). To account for this uncertainty, worst case assumptions have been made in the assessments, and where key uncertainties exist they have been outlined within the impact assessment chapters.

6 SEABED IMPACTS

6.1 Introduction

This section describes potential impacts on seabed habitats and fauna arising from the physical presence of the Development and assesses the significance of these impacts. Chapter 2, Consideration of Alternatives, provides an overview of the selection process for the FPSO production facility, the well optimisation and drilling strategy, and the gas export pipeline from Rosebank FPSO to the Clair Tee, which, once in place, will have an impact on the seabed.

Potential impacts related to the physical presence of the Development relate to the following activities :

- Deployment of the FPSO suction pile anchors and mooring lines;
- Installation of the drilling templates;
- Installation of manifolds, Xmas Trees, Umbilical Riser Base (URB), Gas Riser Base (GRB) (which includes a subsea isolation valve (SSIV)), and in-line tees (ILT);
- Installation of infield flowlines and umbilicals;
- Installation of a 85 km Gas Export Pipeline (GEP) to Clair Tee;
- The use of materials for stabilisation and protection including rock deposits and concrete mattresses;
- Installation of a communications fibre optic cable[30].

The above activities have the potential to lead to changes in the seabed and potential negative impacts on the biota, including:

- Direct loss of benthic species;
- Direct loss of benthic habitat;
- Introduction of new hard substrate; and
- Wider indirect disturbance to the benthic environment through the suspension and re-settlement of sediments.

6.2 Regulatory Controls

In addition to the EIA regulations detailed in Chapter 1 Introduction, there are other requirements of UK legislation relevant to the assessment of seabed disturbance.

The following legislation is key in relation to seabed disturbance from the Development in terms of the potential impacts to the seabed and benthic habitats offshore:

- Marine (Scotland) Act 2010;
- Marine and Coastal Access Act (2009);
- Petroleum Act 1998;
- The Conservation of Offshore Marine Habitats and Species Regulations 2017;
- Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended).

[30] The fibre optic cable is not covered by the Field consents and is subject to a separate licensing process but is included here for assessment of cumulative impact on the seabed.

JNCC, NatureScot, and Marine Scotland have developed a list of 81 Priority Marine Features (PMFs) in Scotland's seas (Tyler-Walters *et al.*, 2016) to help guide policy decisions and support marine nature conservation. Many PMFs are protected by conservation legislation. Scottish Ministers adopted the list of habitats and species in 2014

6.3 Assumptions and Data Gaps

6.3.1 Assumptions

In addition to the environmental baseline surveys that have been carried out, a detailed geophysical and geotechnical investigation along the proposed Gas Export Pipeline route will be carried out. This high resolution topographical surveys will clearly identify seabed features such as boulders, seabed mounds and depressions, gullies and ridges, and debris. The location of these seabed features will inform the detailed pipeline protection engineering design and implementation strategy.

In order to evaluate the worst-case scenario associated with the physical presence of the Development infrastructure on the seabed, a number of assumptions have been made:

- The FPSO will be moored in place with 12 suction anchors and approximately 2,500 m of mooring line/chain. It is assumed for the impact assessment that approximately 500 m of chain per anchor will lie on the seabed and that the maximum lateral movement (swathe) of the mooring line caused by subsea currents is approximately 100 m at its widest point;
- It is assumed that the FPSO mooring lines may be wet stored on the seabed in a looped back arrangement around a temporary turning point for up to 13 months prior to installation creating an additional area of impact;
- Subsea rock installation (SRI) in deep water is technically complex with required tolerances challenging to achieve. Therefore, it is intended to avoid where possible SRI in deep water (>800 m depth). However, rock cover contingency for the ends of the rigid Water Injection rigid pipeline has been included in the assessment;
- The gas export pipeline (GEP) does not require protection from fishing trawl loads at water depth greater than 800 m and will be surface laid. However, SRI may be needed at these depths to stabilise the pipeline and for the purposes of the impact assessment a potential seabed impact corridor of 6 m width over a conservative estimate of pipeline length has been assumed;
- The GEP needs to be protected against fishing trawl pullover loads at water depth less than 800 m. The main protection method is expected to be trenching. Trench width is generally assumed to be 2 m but seabed conditions can prevent trenching. In this case, SRI will be required to create an over-trawlable berm to protect and stabilise the gas export pipeline. The width of the berm on the seabed is assumed to be 6 m and for the purposes of the impact assessment a worst case corridor width of 6 m along the pipeline at water depths <800 m has been applied;
- SRI is also used to rectify freespans and stabilise the pipeline in areas where there are seabed mounds and depressions;

- In addition, seabed sediments become coarser at shallower water depths (Chapter 4, Environmental Baseline) and areas of cobbles and boulders may be present on and beneath the seabed. The presence of boulders can restrict trenching and a worst case scenario assumption is that the 30 km GEP section approaching the Clair Tee will require a pre-lay rock carpet for seabed stabilisation in addition to rock cover. The assumed width of the pre-lay rock carpet is 12 m;

- A high case estimate is that a total of up to 400,000 m^3 (630,000 tonnes) of rock may be used; and
- There are several crossing points over existing infrastructure and infield products. These crossings require concrete mattress protection and it is assumed that up to six mattresses will be required per crossing (of standard dimensions 6 m x 3 m x 0.3 m.

Further detail on the specific values used in the calculations is given in the relevant sections below.

6.3.2 Data Gaps

Survey data of the area described in Chapter 4 Environment Baseline, is considered sufficient to enable a thorough assessment of the potential impacts resulting from the physical presence of the Development.

6.4 Discussion of Potential Impacts

The installation and physical presence of infrastructure needed for the Development will have an impact on the habitats and species present on the seabed.

The subsea infrastructure is listed in Table 6-1 below. The environmental impact assessments for the infield infrastructure and the Gas Export pipeline are considered in below.

Table 6-1 Summary of seabed infrastructure

Development activity	Structures being installed
FPSO	
Installation and presence of FPSO	12 suction pile anchors arranged in a 3 x 4 mooring line pattern 12 mooring lines (polyester / chain) of approximately 2,500 m length
Rosebank infield subsea infrastructure	
Installation and presence of subsea facilities	3 templates, each with 4 production slots 4 suction anchors per template 1 production manifold mounted on each template.
	5 water injection (WI) satellite wells foundations 1 Flow base structure on each WI well foundation

Development activity	Structures being installed
	4 suction anchors per foundation
	12 Xmas Trees
	1 Umbilical Riser Base (URB)
	1 Gas Riser Base (GRB) which includes the SSIV
	3 Water Injection rigid flowline Double In-Line Tees (DILT)
	1 Water Injection Pipeline End Module (PLEM) 1 Water Injection Pipeline End Termination (PLET)
	1 Gas Export PLET Rigid spool between PLET and GE riser
	1 Gas Export in-line tee
	15 infield flowlines comprising: 6 flexible production flowlines, 3 flexible gas lift flowlines, 5 flexible water injection flowlines and 1 rigid water injection flowline 6 Risers (2 production, 1 water injection, 1 gas export, 1 gas lift, 1 dynamic umbilical) 6 Riser Hold-down suction anchors 6 Riser Hold back suction anchors
	10 umbilicals: 1 dynamic umbilical, 3 interconnected production umbilicals, 5 water injection umbilicals and 1 SSIV control umbilical
	Protection associated with up to 24 in-field crossings – 6 concrete mattresses per crossing
Rosebank gas export pipeline installation	
Installation of Rosebank gas export pipeline and associated infrastructure, rock protection and mattresses	~85 km Gas Export Pipeline to Clair Tee at WOSPS Outside diameter 273 mm
	Pipeline protection and stabilisation: • Up to 400,000 m^3 (approximately 630,000 tonnes) of rock, including the PLEM to WOSPS tie-in assembly, Rosebank end of the pipeline, stabilisation of the Tee at KP6.3, stabilisation of the Clair spool (note this estimate also includes rock cover for the infield WI rigid pipeline)

Development activity	Structures being installed
	• Protection associated with flowlines on approach to the Clair Tee tie-in – 8 mattresses required
	• Protection associated with 3 crossings – 6 concrete mattresses per crossing • Unnamed cable crossing (~ KP7) • SHEFA-2 cable crossing (~ KP32) • FARICE cable crossing (~ KP83)
	1 Gas Export PLEM Rigid spool between PLEM and WOSPS

6.4.1 Summary of Benthic Sensitivities

Information on the seabed sediments, habitats and species within the Development area has been obtained from a number of regional and site-specific surveys; these are detailed in Chapter 4 Environment Baseline. Generally, the seabed across the Rosebank field consists of poorly sorted to very poorly sorted very fine sand and scattered pebbles, cobbles and boulders in a very thin layer overlying mud or clay deposits. Along the gas export pipeline, towards the continental shelf, sediments range from poorly sorted very fine sand at the deepest point to through to medium sand on the Shetland continental shelf slope, to poorly sorted coarse sand at the shelf break (DNV, 2022; Fugro, 2011b). Benthic megafauna and epifauna observed within the Rosebank field (Akvaplan, 2022a, 2022b; Fugro, 2011a, 2014a, 2014b) and along the gas pipeline route (Fugro, 2011b) comprises large polychaetes, brittlestars and sea spiders on the lower slope (>600 m) with sea squirts, sponges and soft corals attached to sparsely distributed stones within muddy sediments on the channel floor. Sedentary burrowing or attached species include the soft corals *Primnoa* and *Dendronephthya*, colonial hydroids, burrowing anemones, encrusting sponges and the carnivorous club sponge *Chondrocladia gigantea* (Fugro, 2011b). The mixed sediments (poorly sorted very fine or medium sand) further up the shelf slope supported relatively diverse epifaunal communities including occasional sponges together with soft coral, pencil sea urchins and star fish.

In addition to these communities, a number of potentially sensitive species have been identified within the general project region and, based on the available survey data, the presence of these sensitivities is assumed or discounted throughout the impact assessment as follows:

- The Rosebank gas export pipeline will pass through the Faroe-Shetland Sponge NCMPA, designated for the presence of deep sea sponge aggregations. Survey data and a deep sea sponge assessment carried out in the vicinity of the Development concluded that there were no examples areas of the EUNIS habitat 'deep-sea sponge aggregations' (A6.62) (Fugro, 2012a; Fugro, 2015a). The most recent survey effort (DNV, 2022) encountered sponge communities at two stations along the proposed GEP route (ENV 18 and ENV17a-20, between 490 m and 525 m depth), but densities of sponges were generally low to moderate and aggregations were generally spread over smaller areas. Generally, the deep-sea sponge occurrences within the Faroe-Shetland Sponge Belt NCMPA tend to occur between 460 m and 650 m depth (AFEN, 2000; Howell *et al*., 2007; OSPAR, 2010b; Henry and Roberts, 2014; see Chapter 4 Environment Baseline). The impact of gas export pipeline installation on the designated NCMPA is assessed;

- The NCMPA is also designated for the presence of ocean quahog aggregations; however, no record of the species was identified in any of the infield or pipeline route surveys indicating that these areas are unlikely to represent an important habitat for the species. Consequently, it is assumed that, while individual ocean quahog may be present within the project area, the species will not be found in large numbers constituting an aggregation and this species was not considered further in the assessment;
- Cold water reef-forming corals (e.g. *Desmophyllum pertusum*) are known to occur on the shelf and upper slopes of the Faroe-Shetland Channel, between 200 m and 400 m water depth. However, *D. pertusum* was not encountered during the photographic work in this region by Howell *et al*. (2007) or in previous surveys (Fugro, 2012a, 2012b). Additionally, the visual survey conducted at the Rosebank field in 2021 recorded a scattered distribution of soft corals; however, these did not form dense aggregations that could be considered as coral gardens. Therefore, the presence of cold water reef corals and soft coral aggregations has been ruled out throughout the Development area; and
- The closest area identified as being highly suitable for herring spawning is over 30 km from the project and the evidence suggests that herring do not use the Rosebank area for spawning (Chapter 4 Environment Baseline; Coull *et al*., 1998; Ellis *et al*., 2012). Spawning areas vary and are widespread in extent. Therefore, the potential impact on herring spawning habitat is addressed further.

6.4.2 Potential Seabed and Habitat Impacts, Including on Protected Sites

Physical disturbance during installation of these facilities has the potential to cause mortality or displacement of benthic species in the potential impact zone. The significance of direct habitat loss or mortality of sessile seabed organisms that cannot move away from the area of potential impact depends on the footprint of the area of disturbance, the level of tolerance of the affected habitat and species to direct disturbance, the conservation value of the affected habitat or species and the uniqueness of the affected habitats or species assemblages to the area.

In addition to the direct loss and/or disturbance of benthic habitats, seabed disturbance may also lead to indirect impacts such as the smothering of benthic species and habitats due to sediment suspension and re-settlement. Installation of subsea facilities including FPSO suction anchors and mooring lines, the gas export pipeline and associated infrastructure, rock protection and concrete mattresses, is likely to result in sediment suspension and re-settlement. In particular, rock placement operations can lead to increased levels of suspended solids in the water column, both from the presence of small amounts of fines in the imported rock material and from sediment plumes created as the rock material hits the seabed.

Exposure to higher-than-normal loads of suspended sediment can have the potential for negative impacts on adjacent habitats and species. The re-settlement of sediments can result in the smothering of epifaunal benthic species (Gubbay, 2003) with the degree of impact related to their ability to clear particles from their feeding and respiratory systems. However, infaunal communities are naturally habituated to sediment transport processes and are therefore less susceptible to the indirect impacts of increased sedimentation rates and in extreme cases can work their way back to the seabed surface (e.g. Neal and Avant, 2008).

Additionally, the physical presence of subsea infrastructure, rock protection and concrete mattresses provides a hard substrata available for colonisation by the epifauna present in the area.

These direct and indirect impacts are discussed in the following sections within the context of the Rosebank infield area and in relation to the gas export pipeline route.

Rosebank field

An estimate of the total area of seabed directly impacted by the installation of subsea infrastructure is presented in Table 6-2. There will be no seabed disturbance from the physical presence of the MODU, or installation vessels as all vessels will use DP to maintain station.

Table 6-2 Estimated area of seabed occupied by all the infield elements of the phased Development

Element	Assumptions	Footprint (m^2)	Footprint (km^2)
FPSO			
12 FPSO suction anchors and associated mooring chains and lines	Each suction anchor is a cylinder of up to 11m diameter which will be embedded to a depth of 30 m	1,140	0.0011
	50 m of mooring chain will be buried in the seabed and 500 m of chain will lie on the seabed, per anchor A maximum swathe of 50 m from the centre line of the mooring chain is assumed (per mooring chain)	300,000	0.3
	Pre-installation, the full length of the mooring lines (2,500 m) will be wet stored on the seabed A width of impact of 1 m has been assumed (per mooring line)	30,000	0.03
Subsea infrastructure			
3 drilling templates, which each include a manifold	3 templates, each of the dimensions 22 m x 20 m (this includes the suction anchors, production manifold and the Xmas Trees which are on top of the template)	1,320	0.00132
Water injection satellite foundations	5 foundations, each of the dimensions 14 m x 14 m (includes the suction anchors)	980	0.00098
Umbilical Riser Base	1 URB on mudmat of the dimensions 12 m x 12 m	144	0.00014
Gas riser base, which includes the SSIV	1 GRB on mudmat of the dimensions 9 m x 7 m (this includes the dimensions of the SSIV)	63	0.00006
Water injection rigid flowline in-line tees	3 water injection double in-line tees, each of the dimensions 6 m x 3 m	54	0.00005
1 water injection PLET	1 PLET dimensions 4 m x 3 m	12	0.000012
1 water injection PLEM	1 PLEM, dimensions 8 m x 3 m	24	0.000024
Gas export PLET	1 PLET dimensions 5 m x 3 m	15	0.000015
	I Rigid spool dimensions 60 m x 5 m	300	0.0003
Gas export pipeline in-line tee (KP6)	1 in-line tee dimensions 7 m x 3 m	21	0.000021
Riser mooring	6 riser hold-down anchors 6 riser hold-back anchors Cylinder 5 m diameter	235.5	0.00024

Element	Assumptions	Footprint (m^2)	Footprint (km^2)
Gas export PLEM	1 PLEM dimensions 7 m x 3 m	21	0.000021
	1 Rigid spool dimensions 45 m x 5 m	225	0.000225
Flowlines			
15 infield flowlines	6 surface laid flexible production flowlines, each with an outer diameter of 490 mm and a total combined length of 18,400 m	9,016	0.009012
	3 surface laid flexible gas lift flowlines, each with an outer diameter of 290 mm and a total combined length of 8,100 m	2,349	0.00235
	1 surface laid rigid water injection flowline with an outer diameter of 324 mm and a length of 15,000 m	4,860	0.00486
	5 surface laid flexible water injection flowlines, each with an outer diameter of 393 mm and a total combined length of 9,900 m	3,890	0.00389
10 umbilicals	1 surface laid dynamic umbilical with an outer diameter of 285 mm and a length of 1,700 m	485	0.0005
	3 interconnection production umbilicals with an outer diameter of 183 mm and a total combined length of 9,100 m	1,665	0.0017
	5 surface laid water injection umbilicals each with an outer diameter of 123 mm and a total combined length of 25,700 m	3,161	0.00316
	1 SSIV control umbilical with an outer diameter of 76 mm and length 1,500 m	114	0.0001
Stabilisation and protection			
Cable crossing protection	24-infield crossings to be protected using 6 mattresses each (total of 144 mattresses) The assumed dimensions of the concrete mattresses are 3.0 m x 6.0 m x 0.3 m	2,592	0.0026
Rigid water injection pipeline stability rock placement	Rock maybe required at each end of the water injection pipeline (some of which may therefore be deposited under the FPSO) The assumed width of the rock will be 6 m The berm will be 300 m at each pipeline end (2 ends, 600 m total)	3,600	0.0036
Total infield seabed footprint[31]		**366,277**	**0.366**

Direct impacts associated with activities within the Rosebank field

No areas of specific conservation interest have been observed in the Rosebank field. All of the habitats within the footprint of the offshore installations within the Rosebank field are typical of those in the west of Shetland region. No habitats have been identified that are unique to the Development area.

[31] Any discrepancies in totals are due to rounding throughout the table.

The total area of direct impact associated with the physical presence of infield infrastructure is estimated to be around 0.366 km^2 (Table 6-2). This represents a very small area when compared to the total area of seabed available throughout the Faroe-Shetland Channel and the presence of similar habitats within the vicinity of the Rosebank field and the wider Faroe-Shetland Channel.

There will also be an area of seabed that is abraded by the repetitive dragging of the FPSO and mooring lines throughout the Development life. This abrasion is likely to change and/or influence the nature of the seabed and the species present. However, this impact is localised and the total area is small (0.3 km^2) within the Rosebank field.

Indirect impacts from infield activities

To estimate the area likely to be influenced by potential sediment suspension and re-settlement around activities causing seabed disturbance, it has been assumed that this is likely to occur within the immediate vicinity of the direct disturbance. Although such potential disturbance will depend on the specific operation and the seabed conditions in the locality of that operation, for the purposes of estimating the potential impact zone it has been assumed that the area of potential disturbance will be twice that of the direct disturbance area. The assumption has been informed by the work of Rogers (1990), which presented work on sedimentation of reef habitats.

On this basis, the area where an indirect residual impact may occur resulting from activities within the Rosebank field is estimated as 0.732 km^2.

Exposure to sediment plumes from placement of infrastructure within the Rosebank field will be temporary whereas the plumes caused by the movement of the FPSO mooring lines on the seabed will occur repetitively throughout the life of the Development. It is reported that near-seabed concentrations of suspended particulate material on the west of Shetland continental slope are naturally high (DTI, 2003 and it is therefore considered that benthic species will be tolerant to some extent of sediment in the water column, and the potential impacts from sediment re-suspension are unlikely to be significant. In the event that losses of fauna were caused by increased sediment loads, the small areas involved and the presence of similar habitat in the immediate vicinity will aid direct re-colonisation of habitats by migration from nearby unaffected areas.

Gas export pipeline

The Gas Export Pipeline design is being matured in ongoing FEED studies with Marine Contractors. The Gas Export Pipeline shall be protected for potential trawl impact loads where water depth is limited to 800 m, and such protection will either be performed by burial in form of trenching, post-lay rock covering or a combination of these two methods. Initial trenching risk assessments, based on available seabed survey data, has highlighted the uncertainties around the possibilities of successfully performing trenching of the Gas Export Pipeline and as such the estimated volumes of rock to cover the untrenched sections are also uncertain. The worst case scenarios used for the impact assessment are described in the Assumptions section above.

Trenching may be carried out using either a pipeline plough or a jet trenching tool:

- A pipeline plough creates an open V shaped trench in the seabed and spoil heaps either side. Typically, rigid pipelines are post lay trenched i.e. the pipeline is laid on the seabed, picked up by the plough and passed through the equipment chassis during trenching. Backfilling is subsequently carried out using a mechanical backfill plough; and
- Jet trenching uses high pressure water to fluidise the sediments and the pre-laid pipeline sinks to the base of the trench. This method does not leave spoil heaps or require mechanical backfill.

Trenching by either of these methods is suitable for predominantly sandy clay sediments. The trenching method has not been finalised as the method selected will be based on detailed survey outputs and equipment availability. Boulders inhibit the use of the trenching equipment, and boulder clearance may be required prior to trenching. Boulder clearance is achieved through use of a grab or bumper bar.

However, the potential for the presence of major boulder fields along the planned Gas Export Pipeline Route may also affect the in-place design conditions for the pipeline. Where boulder density is too great an alternative to boulder removal and trenching is to surface lay the pipeline and cover it with rock. This could also require a pre-lay rock carpet to be installed in sections where boulder density prevents implementation of the clearance strategy.

Current FEED estimates range up to a maximum of 400,000 m^3 of rock to be installed along the Gas Export Pipeline route, in a combination of pre- and post-lay campaigns. These estimates are planned to be revised based on findings from the seabed survey campaign as described in the Assumptions section. Broadly, the pipeline route can be divided into three distinct sections, each with a different installation method (distances are rounded to nearest kilometre for clarity) (Table 6-3).

Table 6-3 Three broad areas along the gas export pipeline route

Section	Kilometre point (from FPSO)	Main installation method
1	KP0 – KP 22	Surface lay, no protection in water depth >800 m Rock stabilisation may be required to correct freespans
2	KP22 – KP55	Protection required, water depth < 800m Sandy clay sediments predominate Trenching with boulder removal
3	KP55 – KP 85	Protection required, water depth < 800m Potential for numerous boulders Post lay rock installation; and Potential need for pre-lay rock carpet

The gas export spool at Clair end and the gas export PLEM will also require protection against trawl pullover loads with concrete mattresses and/or rock cover.

Table 6-4 provides a description of the GEP infrastructure and a worst-case estimate of potential seabed impact. based on the assumptions described in Section 6.3 1. The worst case seabed impact area includes surface lay, trenching, post lay rock cover, pre-lay rock carpet, freespan mitigation and any materials required to rectify seabed depressions and mounds.

Table 6-4 Estimate of the area of seabed with the potential to be directly impacted by the gas export pipeline

Element	Parameters and Assumptions	Worst case Footprint (m^2)	Worst case Footprint (km^2)
KP0 – KP22 Water depth > 800m	Outside diameter of GEP is 273.1 mm Best case: surface laid, no protection or stabilisation materials required. Worst case: some rock cover required. Assume 8 km @ 6 m impact width and remaining 14 km surface laid.	48,000	0.048
KP22 – KP55 Water depth < 800m	Length of pipeline (in waters <800 m) 33 km The assumed width of the trench is 2 m Best case: trenched and buried, no rock cover required. Worst case: rock cover / over-trawlable berm required. Assume 6 m impact width	198,000	0.198
KP55 – KP85 Water depth < 800m	Length of pipeline in waters <800 m) is approximately 30 km Best case: trenched and buried with some rock cover Worst case: requires pre-lay rock carpet and post lay rock cover/over-trawlable berm installation. Assume 12 m impact width.	360,000	0.36
Cable crossing protection	3 crossings to be protected using 6 concrete mattresses each (total of 18 mattresses) The assumed dimensions of the concrete mattresses are 3.0 m x 6.0 m x 0.3 m	324	0.00032
Additional protection requirements	8 mattresses will be used for protection at the spool at Clair (post-lay) The assumed dimensions of the concrete mattresses are 3.0 m x 6.0 m x 0.3 m	144	0.00014
Total gas export pipeline route seabed footprint		**606,468**	**0.61**

Direct impacts associated with gas export pipeline installation

The area of seabed potentially impacted by installation of the 85 km GEP and associated protection and stabilisation materials is estimated, as a worst case, to be around 0.61 km^2. This is a maximum worst case, heavily influenced by the assumption of a pre-lay rock mattress throughout the last 30km section heading towards to Clair Tee. This section does not overlap with the Faroe-Shetland Sponge Belt NCMPA.

Around 0.518 km^2 of seabed in the section of the GEP installed in water depths deeper than 800 m (approximately KP0 to KP22) is estimated to be potentially impacted by installation of the GEP. Within the Rosebank field, seabed sediments comprise homogenous soft, sandy clay with occasional gravel and boulders. Along the initial section of the pipeline route, the sediment is classed as EUNIS A6.5 'Deep sea mud'. Along the pipeline route, as water depths decrease up the continental slope, the seabed changes from the muddy sediments of the channel floor to sediments more variable in nature. According to Tillin *et al*. (2010), as reported in the Scottish Government's Feature Activity Sensitivity Tool (FEAST) (Scottish Government, 2013), deep sea mud substrates have a high sensitivity to physical pressures, such as habitat loss or a change of substrate, as would occur through the installation of the pipeline. However, the confidence in this assessment is low owing to a lack of evidence to support this.

In water depths less than 800 m between KP22 and KP55, the seabed consists of highly variable unconsolidated sediment, ranging from boulders to sand and fine mud. Rocky outcrops are common, as are bedform features indicative of highly mobile regions e.g. sand ribbons etc. The EUNIS classification for this section of pipeline is A6.2 'Deep sea mixed substrata'. At this depth, it is expected the pipeline will be trenched and buried and that any boulders will be removed by grab or bumper bar prior to jet trenching. However, for the purposes of the impact assessment it has been assumed that boulder density and presence of boulder obstructions within trench depth could restrict trenching and as a worst case this section is covered with an overtrawlable rock berm with an estimated width of 6m resulting in a worst case impact area of 0.198 km^2. The Faroe-Shetland Sponge Belt NCMPA is located in this section of the pipeline and the potential impact on the NCMPA is discussed further below.

FEED studies have identified that the last 30 km of pipeline towards the Clair Tee between KP55 and KP85 are more likely to encounter seabed conditions that prevent use of the trenching tool and that boulders could occur at densities that make removal by grab technically infeasible. Seabed topography could also necessitate the installation of pre-lay rock carpet in some sections. It is considered unlikely that this would be installed, however, for the impact assessment, it was considered that the assumption resulting in the largest area of potentially impacted seabed should be presented. Deep sea mixed sediments are thought to be highly sensitive to physical changes (Tillin *et al*., 2010; Scottish Government, 2013).

The immediate effect of pipeline installation, whether by trenching or surface-lay and rock cover is mortality and injury of benthic and epibenthic fauna that cannot move away from the activities and disturbance of motile fauna. The introduction of new substrate in the form of rock deposits results in the creation the material, the ongoing effect will be the change of an area of softer habitat to a hard substrate, and a related change in the types of organisms that can use the habitat; new habitat will be created for species groups such as encrusting sponges and anemones.

Indirect impact associated with gas export pipeline installation

As for the infield seabed infrastructure, it is precautionary to assume that there will be sediment disturbance from pipeline installation activities over a wider area caused by suspension and re-settlement of sediments. As per the infield seabed infrastructure discussion, this area can be assumed to be around twice that directly impacted. The potential impact area for the pipeline (Table 6-4) already has conservatism built into the estimate, but as a worst case for overall impact based on any change to existing seabed conditions the estimate could be increased to $1.2km^2$.

Information on the tolerance of some of the specific biotopes on the slope and shelf areas to the west and south of Shetland to disturbance is unknown. However, Tyler-Walters *et al.* (2004) report such information for a number of similar biotopes. Generally, tolerance of increased sedimentation is thought to be intermediate whilst sensitivity to disturbance is generally low. The shelf and slope areas are energetic environments subject to regular sediment scour, and species will have some degree of tolerance of elevated sediment levels (Chapter 4 Environment Baseline). Where sedimentation might impact negatively on species and habitats, consequences are likely to be short-lived since most of the smaller sedentary species (such as polychaete worms) have short lifecycles and recruitment of new individuals from outside the narrow corridor of disturbance will be rapid given the prevalence of similar undisturbed habitat in the immediate vicinity.

Direct Impact of GEP installation on the Faroe-Shetland Sponge Belt NCMPA

The gas export pipeline passes through the Faroe-Shetland Sponge Belt NCMPA. In addition to deep-sea sponge aggregations, there are a number of other protected features included within this NCMPA. Based on information from FEAST (Scottish Government, 2013), these protected features are all considered to be under pressure from the following activities associated with oil and gas developments:

- Physical change (to another seabed type);
- Physical removal (extraction of substratum); and
- Sub-surface abrasion/penetration.

The key protected features of the NCMPA, and their corresponding sensitivity to the pressures listed above, are provided in Table 6-5.

Table 6-5 Key features of Faroe-Shetland Sponge Belt NCMPA and relative sensitivity to pressures from oil and gas activities (Scottish Government, 2013)

NCMPA feature	Sensitivity
Deep-sea sponge aggregations	Sensitive to high
• Offshore subtidal sands and gravels including: • Deep-sea sands; • Continental shelf sands; • Continental shelf coarse sediments; • Continental shelf mixed sediments; • Deep-sea sands; and • Deep-sea mixed sediments.	Medium to high

NCMPA feature	Sensitivity
Ocean quahog *Arctica islandica*	High
Continental slope	Low
Continental slope channels, iceberg plough marks, prograding wedges and slide deposits representative of the West Shetland Margin paleo-depositional system Key Geodiversity Area	Low for prograding wedges, otherwise medium (abrasion/penetration) to high (change and physical removal) for the other features
Sand wave fields and sediment wave fields representative of the West Shetland Margin contourite deposits Key Geodiversity Area	Low (abrasion/penetration) to medium (change and physical removal) for sand wave fields and high for sediment wave fields

Ocean quahog were not identified to be present along the gas pipeline route from the survey work undertaken and were ruled out of further assessment (Section 6.4.1).

Iceberg plough marks have been recorded along the section of the gas pipeline route that passes through the NCMPA. FEAST (Scottish Government, 2013) concluded that that iceberg plough marks, comprising ridges of unconsolidated boulders and cobbles, are relict features which have no resilience and are highly sensitive to both physical change and removal. They also have medium sensitivity to abrasion/penetration. However, the gas pipeline does not pass through the area of ploughmarks (Chapter 4 Environment Baseline) and hence there is no potential for any impact on the feature.

Offshore subtidal sands and gravels are assessed as having medium to high sensitivity to physical change, removal and abrasion/penetration and variations of these sediment types have been observed along the gas pipeline route within the Faroe-Shetland Sponge Belt NCMPA. The area of impact associated with GEP installation is considered to be very small compared to the wider extent of this habitat.

Most verified records of deep-sea sponge aggregations come from the West Shetland Slope in the Faroe-Shetland Channel with records of other occurrences along the Wyville Thomson Ridge, Hatton and Rockall Banks, in the Hatton-Rockall Basin, on seamounts in the Rockall Trough and along the Hebrides continental shelf (JNCC, 2014). These records were obtained in 2010 from a number of sources including NatureScot, JNCC, Mapping European Seabed Habitats, Marine Life Information Network (MarLIN) and Archive of Marine Species and Habitats Data (DASSH). These records are also consistent with observations on the distribution of deep-sea sponge aggregations made by AFEN (2000), Howell *et al.* (2007), OSPAR (2010b) and Henry and Roberts (2014). (JNCC, 2014). The aggregations in the Faroe-Shetland Channel, including the West Shetland Slope, conform to the description boreal ostur (Klitgaard and Tendal, 2004, in ICES, 2010) which is dominated by large geodiids, globose and encrusting species such as the yellow *Aplysilla sulfurea* and occurs around the Faroe Islands, Norway, Sweden, parts of the western Barents Sea and south of Iceland, and rarely occurring at temperatures lower than 3°C (OSPAR, 2010b).

The records collated by JNCC (2014) indicate that deep-sea sponge aggregations are mainly centred along the 500 m bathymetric contour of the eastern flank of the channel (Chapter 4 Environment Baseline). The level of confidence in the available data is variable throughout NCMPA; confidence is higher in the centre and north of the site, comparatively less certainty is attributed to aggregations on the margins of the site due to slightly lower overall abundance of sponges in these areas.

Surveys of the Rosebank gas export pipeline route have recorded the presence of sponge communities potentially resembling the OSPAR habitat ‘deep sea sponge communities’ within the NCMPA. Fugro (2012b) observed epifaunal communities with sponges (possible ‘deep-sea sponge aggregations’) on the continental slope a two sampling stations located at 460 and 650 m water depth (sampling stations 27 and 28 respectively; Chapter 4 Environment Baseline), although assessment of the fauna present at these stations using the criteria of Henry and Roberts (2014) concluded that no deep-sea sponge aggregations were present (Fugro, 2015a).

Potential sponge communities were encountered at two stations during most recent surveys (ENV 18a and ENV 17a-207; Chapter 4 Environment Baseline), but densities of sponges were generally low to moderate and aggregations were generally spread over smaller areas (DNV, 2022).

Designation of the Faroe-Shetland Sponge Belt NCMPA was one of the key actions taken by the Scottish Government under OSPAR to improve protection of deep-sea sponge assemblages. As noted by ICES (2009, in OSPAR, 2010b), deep-sea sponge aggregations are considered to be very sensitive to the effects of demersal trawling and sensitive to the localised effects of oil and gas developments. The Scottish Government’s Feature Activity Sensitivity Tool (FEAST) (Scottish Government, 2013) developed for determining potential management requirements for NCMPAs, provides further information on the sensitivity of deep-sea sponge assemblages to various human induced impacts. In terms of impacts associated with installation of the gas pipeline, based on information from FEAST (Scottish Government, 2013) deep-sea assemblages are considered to have high sensitivity to physical changes to the seabed and direct damage, displacement and disturbance from direct physical impact on the sponges (mainly trawling but also other activity such as installation of a gas pipeline).

Work has been done surrounding the impact of oil and gas activities on sponges. At an individual level, exposure to sediments generated by drilling activity leads to sponges halting feeding activity, diminished metabolism and increased cellular instability (Vad *et al*., 2018; Vad *et al*., 2021). Additional to exposure to sediment resuspension and sedimentation, the chemical components of drill cuttings (e.g. heavy metals) are also harmful to individual sponges (Vad *et al*., 2018; Vad *et al*., 2021). Within the Faroe-Shetland Channel, drilling was found to cause smothering of benthic megafauna (including sponges) on the seafloor in a radius of 50–120 m around the drilling site (Jones *et al*., 2006, cited in Kazanidis *et al*., 2019).

Common to both general installation field development activities and drilling is the generation of sediment resuspension which can ultimately lead to a change in benthic community distribution. Subsea cable installation resulted in 100% mortality of glass sponges directly within the area of installation and up to 15% mortality within 1.5 m of the cable (Jones *et al*., 2012, cited in Vad *et al*., 2018). Similar effects would be expected of pipeline installation (OSPAR, 2010a, cited in Vad *et al*., 2018).

Data from experiments on trawling impacts to deep-sea sponge communities in the Gulf of Alaska (ICES, 2009 in OSPAR, 2010b) have indicated that the re-colonisation of damaged habitat is likely to be very slow with recovery taking decades rather than years. Principally this is thought to be due to the slow growth rates of deep water sponge species, but also infrequent reproduction rates. Klitgaard and Tendal (2004, in ICES, 2010) suggest that the dominant species in deep-sea sponge aggregations are slow growing and take at least several decades to reach the sizes commonly encountered. On this basis it is unlikely that new sponge communities will develop on areas of installed rock substrata in the short or medium term. Instead, a community succession is likely to take place over time in which the available space will be readily used by the mobile species but where the variety of other encrusting and attached species such as sponges evolving most slowly of all.

Approximately 29 km of the gas pipeline will pass through the NCMPA with 19 km of pipeline located in waters shallower than 800 m and requiring protection via trenching and/or rock cover. The worst case impact assessment assumes that potentially all 19 km of the pipeline installed in the NCMPA located in water depth <800m will be covered in rock to create an over-trawlable berm. Approximately 15 km of pipeline will pass through the 460 m to 650 m depth band within the NCMPA. This scenario is estimated to result in an estimated direct loss of habitat of 0.114 km^2 (Table 6-6) which represents 0.002% of the total area of the Faroe-Shetland Sponge Belt NCMPA (which has an area of 5,278 km^2).

Sponge density within the Faroe-Shetland Channel has been previously reported as 0.001 to 0.818 individuals/m^2, which is consistent with densities across much of the North Atlantic (Axelsson, 2003; Henry and Roberts, 2014, cited in Kazanidis *et al*., 2019). More recently, Kazanidis *et al*. (2019) investigated the composition and density of sponge communities within and outside of the NCMPA. They reported that, when averaging across all types of sponges, the density was 0.28 individuals/m^2. They found that densities were highest in a very narrow depth range, and were also correlated with sediment type; the highest densities were recorded where cobbles/cobble with boulders were the dominant substrate (Kazanidis *et al*., 2019). The relationship between fauna and substrate type within the confines of the Faroe-Shetland Channel were also observed by Vad *et al*. (2020). Given the nature of the seabed along the proposed pipeline route, the frequently gravelly seabed lends itself to the presence of sponges.

Using the Kazanidis *et al*. (2019) estimate of sponges within the NCMPA being, on average, at densities of 0.28 individuals/m^2, it is inevitable that the installation of the pipeline within the known sponge belt (460 m to 650 m) depth band will result in the mortality of a number of individual sponges when considering the predicted area of impact (Table 6-6).

However, this is a highly conservative estimate presenting an absolute worst-case scenario and assuming that high quality sponge aggregations are present. Survey data indicates that the sponge aggregations in this area are patchy in distribution (Chapter 4 Environment Baseline) and the high quality sponge habitat for which the site is designated has not been observed (Fugro, 2015a, DNV, 2022). It is very unlikely that rock placement within the NCMPA will be required as initial data suggests that the sediments are amenable to trenching. In this case it is estimated that the area of impact in the NCMPA from pipeline protection will be around 0.038 km^2 corresponding to less than 0.001% of the total area of the NCMPA.

Table 6-6 Estimate of the area of seabed within the NCMPA directly impacted by pipeline protection activity in water depth < 800m and between water depths 650 m and 460 m

Assumptions	Within the NCMPA		Within the 460 – 650 m water depth	
	Footprint (m^2)	Footprint (km^2)	Footprint (m^2)	Footprint (km^2)
Best case trench and bury: • All 19 km of pipeline within the NCMPA will be trenched and buried; • Assumed trench width of 2 m; and • All 15 km of pipeline between 650 m and 450 m will be trenched and buried.	38,000	0.03800	30,000	0.03000
Worst-case rock placement: • All 19 km of pipeline within the NCMPA will be covered in rock; • All 15 km of pipeline between 650 m and 450 m will be covered in rock; and • Assumed rock berm width of 6 m.	114,000	0.11400	90,000	0.09000
Total seabed footprint (assuming trenching possible)		0.038 (<0.001% of NCMPA)		0.030 (<0.001% of NCMPA)
Total seabed footprint (assuming worst-case rock placement)		0.114 (0.002% of NCMPA)		0.090 (0.002% of NCMPA)

Considering the overall direct effect on habitats and species over the whole Development area against the wider occurrence of similar habitats and species across the west of Shetland continental shelf and slope and the Faroe-Shetland Channel, it is not expected that the loss of habitat and fauna would compromise the integrity or viability of the habitats encountered. While mortality of individual sponges will be caused by the installation of the pipeline within the NCMPA, overall, it is unlikely that mortality will occur at a level which will have an impact on the wider community composition. This applies to Faroe-Shetland Sponge Belt NCMPA and its conservation objectives, which include conservation of the deep-sea sponge aggregations in a favourable condition, where favourable condition is defined as where evidence indicates none of the attributes are being adversely affected. Considering the above, there is no significant risk to the conservation objectives of the NCMPAs being achieved.

Indirect Impact of GEP Installation on the NCMPA

As before, an assessment of indirect impact considers the effect of sediment suspension and re-settlement on the identified receptor, in this case, deep sea sponges in the NCMPA, over an area twice the direct impact estimate i.e.0.228 km^2.

There is limited information available on the sensitivity of deep-sea sponges to increased turbidity and smothering. Hiscock (2008) described the encrusting sponge *Halichondria panicea* as not sensitive to increased suspended sediment, and moderately sensitive to smothering, but having good recovery potential.

OSPAR (2010b) also suggests that sponges have good potential to survive light accumulations of sediment, but also that sponges are particularly vulnerable to, and unlikely to survive, repeated heavy sediment accumulations. The FEAST database suggests that deep-sea sponge aggregations are highly sensitive to both heavy siltation and light siltation on the basis that smothering can damage sponges by clogging their complex filtering apparatus which they use to feed (Hogg *et al.,* 2010 in Scottish Government, 2013). Therefore, on a precautionary or conservative basis, it is assumed unlikely that individuals smothered by re-suspended sediments will recover. However, the area of the Faroe-Shetland Sponge Belt NCMPA that is likely to be affected is very small in comparison to the wider availability of this habitat.

6.5 Cumulative and Transboundary Impacts

With regards to the potential for cumulative impacts associated with the Development, Chapter 4 Environment Baseline lists all nearby currently operational and planned oil and gas developments within 50 km of the nearest point of the Development (either within the field or along the gas export pipeline). Most developments in the area are currently operational with the exception of the planned Cambo Development (approximately 34 km southwest of the Rosebank field).

DECC (2016) identifies that the sources of cumulative physical disturbance to the seabed associated with oil and gas activities include drilling rigs, wellhead placement and recovery, subsea template and manifold installation and piling, umbilical and pipeline installation and trenching and decommissioning of infrastructure. Of these, pipelay is considered to account for the largest spatial extent. The Development will result in a predicted direct total disturbance of approximately 0.975 km^2, with an indirect impact approximately twice that of the direct area, attributed to the suspension and resettlement of sediments in the immediate vicinity of the subsea installation activities (described in Table 6-1). The majority of this impact is considered to be short-term disturbance and this area of seabed is small relative to the available similar habitat in the vicinity of the Development and in the wider area.

Although there is potential that the activities associated with the non-Rosebank infrastructure listed in Chapter 4 Environment Baseline could have similar impacts, these will all be non-overlapping, both spatially and temporally. Given these activities are distributed across a large area of the west of Shetland continental slope and shelf, their overall cumulative footprint as a proportion of the habitats and species present across the wider area will remain small, reducing the potential for any significant cumulative impacts. There are no other known planned developments in the area which could coincide with the Rosebank activities, the nearest being the proposed Cambo Development. It is very unlikely that the potential impacts from installation of seabed infrastructure at either Development would interact with each other and result in a cumulative impact in addition to the potential impacts described above. All suspended sediment impacts will affect areas of seabed immediately adjacent to the activities. There will be no overlap between Rosebank and Cambo areas of impacts. The Cambo Development has been paused, so timelines are not known.

As part of the Development, a fibre optic cable will be installed from the Rosebank FPSO to the SHEFA-2 telecommunications cable. However, as described in Chapter 1 Introduction, this will be subject to a separate consenting process via a Marine License application. The cable is therefore not within scope of this ES (which refers to the activities forming part of the Development consent under the Petroleum Act 1998). however, it is considered here in the context of cumulative impacts to the seabed. A number of possible route options are currently being assessed. The distance from the FPSO to the Shefa 2 branch is approximately 6.5km, therefore assuming a 2 m wide installation trench along its length, will impact an additional area of 0.01 km^2. Overall, this small additional area is not anticipated to generate an impact beyond what is already expected as a result of the proposed Rosebank activities. In addition, the fibre optic cable will not cross any protected sites, or encounter any known protected features.

Given the relatively small area of seabed affected by the Development and the limited number of other developments within the NCMPA, there is expected to be no cumulative impact upon the NCMPA. Considering the above, there is no significant risk to the conservation objectives of the NCMPAs being achieved.

The Offshore Energy Strategic Environmental Assessment (OESEA) for UKCS waters (DECC, 2009) states that seabed impacts from installation and physical present of subsea infrastructure and pipelines on the UKCS are unlikely to result in transboundary effects Given the distance of the Development to the UK/Faroe boundary line (approximately 15 km), transboundary impacts to the seabed are very unlikely.

6.6 Decommissioning

Decommissioning may involve the removal of subsea infrastructure where this is technically and economically feasible and environmentally beneficial. Where subsea infrastructure is removed, it is expected that pre-installation and operational conditions could be re-established over time through sediment redistribution, and migration and recolonisation of the area by species from the surrounding environment.

Any potential impacts as a result of decommissioning operations are likely to be localised and transient. DTI (2003) note that recovery is likely be rapid and any potential impacts from decommissioning of seabed infrastructure are likely to be similar in magnitude to those experienced during installation and hence not considered significant.

6.7 Management and Mitigation

Various surveys of the Development area and proposed gas export pipeline route have been undertaken (Chapter 4, Environmental Baseline). A specific geotechnical seabed survey will be carried out along the gas export pipeline route (planned Q2 2022) which will inform detailed planning and design of the pipeline and requirements for stabilisation and protection materials.

Equinor will apply the following mitigation measures to the Development to reduce, where possible, potential impacts on benthic habitats and species:

- The use of 4 slot drilling templates are a compact layout and minimise the seabed footprint;
- The proposed gas export pipeline route will take the most direct / shortest route to the Clair Tee subject to seabed conditions encountered;
- The use of rock cover / pre-lay will be minimised as much as possible through the implementation of a detailed GEP installation plan based on the high resolution seabed topography data;
- Trenching will be the preferred pipeline protection method in water depth < 800m;
- The use of concrete mattresses at cable crossing points will be optimised;
- All flowlines, umbilicals and jumpers installed in the Rosebank field as part of the Development will be surface laid to avoid the need for trenching;
- The installation of all the subsea facilities will exclusively employ DP vessels;
- Planning for the use of suction pile anchors will include consideration of minimising impact on the seabed;
- Dropped objects will be treated according to industry standards, with procedures in place to record the location of any lost material and to recover significant objects where practicable. A dropped object risk assessment will be carried out initially. Installation and simultaneous operations (SIMOPS) procedures will be in place to reduce the potential for dropped objects and training and awareness will be provided to installation contractors;
- All lifting equipment will be tested and certified prior to the commencement of activities. Lift planning will be undertaken to manage risks during lifting activities, including the consideration of prevailing environmental conditions and the use of specialist equipment where appropriate; and
- Dropped object surveys will be carried out at appropriate points through the Development life-cycle (including following the completion of drilling activities).

6.8 Residual Impacts

6.8.1 In-field Subsea Infrastructure

The seabed surrounding the Development is typical of the Faroe-Shetland Channel and consists of deep sea mud and deep sea mixed substrata. There was no evidence of protected species or habitats in the in-field area, therefore the sensitivity of these receptors is low.

The area of direct impact associated with the activities in the Rosebank field is estimated to be approximately 0.366 km^2. Apart from the very small area abraded by the dragging of the FPSO and mooring lines, all the other operations resulting in localised loss, change and disturbance of seabed habitat will occur during installation. Some of these changes will be permanent e.g. rock placement on the seabed.

The extent of the identified impacts is highly localised and therefore magnitude of impact is considered low. Comparing the small area of seabed habitat impacted alongside the large area of similar seabed habitat available for colonisation within the wider Faroe-Shetland Channel, sensitivity and vulnerability are low, as is value of receptor. Considering these together, and as per Chapter 5 EIA Method, the consequence of effects is assessed as low and there will be no significant impact on the seabed.

6.8.2 Gas Export Pipeline Route

Seabed habitat on parts of the pipeline route is designated for a number of features, notably the presence of 'deep sea sponge aggregations'. The potential presence of deep-sea sponge aggregations classifies the area as a NCMPA and the value of this habitat is considered high. Sponge aggregations are slow growing, and therefore considered both sensitive and vulnerable to impacts. Data collected from the most recent pipeline route surveys identified sponge aggregations at two stations within the 460 – 650 m depth band (DNV, 2022).

An anticipated worst-case area of 0.61 km^2 will be impacted by the installation of the gas export pipeline within the NCMPA, based on the worst case assumption that all of the pipeline at depths less than 800 m within the NCMPA will require rock protection. This area equates to 0.002% of the NCMPA designated area therefore, in the context of the wider habitat available in the NCMPA, the magnitude of impact is considered low.

Comparing the small area of seabed habitat impacted alongside the large area of similar seabed habitat available for colonisation within the wider Faroe-Shetland Channel, sensitivity and vulnerability are low. For much of the seabed on which activity will take place, value is low, except within the NCMPA where value is high. Considering these together, and as per Chapter 5 EIA Method, the consequence of effects is assessed as low and there will be no significant impact on the seabed.

7 DISCHARGES TO SEA

7.1 Introduction

This chapter details the assessment of the discharges to sea associated with the drilling, commissioning, and operational stages of the Development. Potential impacts from drilling discharges (cuttings, drilling mud and cement) are discussed in Section 7.5.1 and aqueous discharges during the installation and commissioning and the operational phases of the Development are discussed in Sections 7.6.

Equinor is committed to continual improvement in the reduction of aqueous discharges to sea. Extensive use has been made of mathematical modelling in order to investigate the potential environmental impacts on the receiving environment. Key design features of the Rosebank FPSO, such as re-injection of produced water and its associated chemicals, have been implemented to reduce of discharges to sea.

7.2 Regulatory Controls

The key regulatory controls that relate to the Development activities are:

- Offshore Chemicals Regulations 2002 (as amended) (OCR): The OSPAR Decision relating to the Harmonised Mandatory Control System for the use and discharge of offshore chemicals is implemented on the UKCS by BEIS under the OCR. Under these Regulations, operators using or discharging chemicals in connection with offshore activities need to apply to BEIS for a chemical permit to cover both their use and discharge;
- Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended) (OPPC): The OPPC Regulations were introduced to meet the OSPAR goal of reducing discharges of oil to the marine environment from the offshore oil and gas industry. The Regulations require a permit to be in place prior to the discharge of any oil to sea and any unpermitted discharges to be formally reported to BEIS. During drilling operations, the Regulations will apply where any drill cuttings contain reservoir hydrocarbons, or during well clean-up if there are discharges of oil in water;
- Merchant Shipping (Prevention of Oil Pollution) Regulations 1996 (as amended): The Regulations implement MARPOL Annex 1 in the UK and controls oily discharges from any vessel activity including machinery space drainage. The Regulations require all vessels to have in place a UK or International Oil Pollution Prevention Certificate to demonstrate compliance; and
- The Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008: The Regulations control sewage treatment and discharge and applies to offshore installations and vessels. The main requirement is that all discharges are monitored and recorded.

7.3 Assumptions and Data Gaps

7.3.1 Assumptions

- As a potential worst case scenario for the assessment of impact from the discharge of drill cuttings, the drill cuttings modelling assumes that two wells are drilled from the same template in each Phase to represent the maximum possible number of wells (four) to be drilled from a single template location;
- Aqueous discharges refer to the produced water discharges. Produced water is the naturally occurring water that comes out of the wells along with the oil and gas and is separated from the hydrocarbons in the production process. It is usually more saline than seawater and may contain residues of chemicals that

have been used downhole in the well to manage well fluid properties. There are various operating scenarios which influence the specific nature of aqueous discharges. The normal disposal route for treated produced water is re-injection into the Rosebank reservoir via PWRI for pressure support. The design specification of operational availability of at least 95% has been used to calculate the total annual produced water volume that may be discharged overboard, when the PWRI system is unavailable as described in Section 3.7.5; and

- The types of chemicals have been assumed for the purposes of the environmental impact assessment, final chemical selection will be subject to a specific risk assessment and permit application under the OCR as described above.

7.3.2 Data Gaps

It is considered that the information available has been sufficient to undertake a thorough and accurate assessment of the potential impacts resulting from the discharges to sea resulting from the Development.

7.4 Characterisation of Receiving Environment

The discharges considered in this section will all take place at the Rosebank field, approximately 130.5 km from the nearest landfall in Shetland and in water depths of approximately 1,100 m. Some of the discharges will take place close to the sea surface, while others will take place at or near the seabed. Their fate and behaviour will be influenced by the water column characteristics and prevailing water currents as described in Chapter 4 Environmental Baseline.

7.4.1 Potential Receptors - Drilling Discharges

Particulate discharges to sea during the drilling phase of the Development include drilling muds and cuttings, and cement. These discharges may lead to potential impacts to the seabed or water column through the following mechanisms:

- Deposition of cuttings on the seabed predominantly as a result of drilling tophole (riserless) sections;
- Deposition of cement on the seabed from cementing tophole casings; and
- Increased suspended solids in the water column from caisson discharge.

Settlement of particulates on the seabed can result in changes to the physical and chemical nature of the seabed habitat, smother benthic organisms and impair their feeding and respiratory systems. The potential impacts on plankton populations from drilling discharges in the water column are also considered. A description of the benthic species and zooplankton communities likely to be present around the drilling templates are presented in Chapter 4 Environmental Baseline. These impacts are assessed in Section 7.5.

7.4.2 Potential Receptors – Aqueous Discharges

Produced water discharges will mix with seawater and be dispersed by local currents. Potential impacts on water quality could affect plankton drifting in the water column that come into contact with the discharge plume. It is unlikely that fish or marine mammal species will be directly impacted by produced water discharges to sea due to their ability to avoid the discharge. Discharges due to installation of subsea infrastructure include chemicals used in pipeline flooding and cleaning, and installation and commissioning of the manifold, spools and umbilical. These impacts are assessed in Section 7.6.

7.5 Drilling Discharges

The drilling programme will be carried out in two phases as described in Chapter 3 Project Description. Initially four production wells plus three water injection wells in Phase 1 with, based on current assumptions, up to a further three producing wells and two water injection wells in Phase 2. Drilling of the Phase 1 wells is expected to take place between April 2025 and August 2026. The requirement and timing for the second phase wells will not be known until the field has been in production for sufficient time to allow for analysis of the dynamic data. It has been assumed for the purposes of this impact assessment that the second phase wells will be drilled four to five years after Phase 1. All the production wells will be drilled from the three fixed four well-slot templates, located along the structural crest of the field.

7.5.1 Drilling Discharges Impact Assessment

For the production wells, the tophole well sections will be drilled riserless using seawater and sweeps to remove cuttings and keep the well bore clean. These cuttings will be discharged at the seabed. Subsequent sections will be drilled with a marine riser in place and the drilling fluids and cuttings will be circulated back to the drilling rig and discharged to sea via the discharge caisson.

7.5.1.1 Drilling Programme

Table 7-1 presents the drilling programme for the Rosebank wells, and Table 7-2 presents quantities of drilling mud components and drill cuttings.

Table 7-1 Drilling programme data for the Development[32]

Well section	**1**	**2**	**3**	**4**	**5**
Diameter (inches, ")	42	26	17.5	12.25	8.5
Length (m)	90	478	1,162	461	949
Discharge type	Continuous		Cuttings – continuous Mud – batch at end		
Drilling rate (m/hr)	30	30	40	5	20
Discharge location	Seabed - Drilled Riserless		0.35 m ID caisson 12 m above sea level[33] Mud discharge – Batch 270 m^3/hr		
Discharge orientation	Vertically upwards from seabed		Vertically downwards from rig		

[32] Based on drilling information from well DP3.
[33] Modelling was carried out with discharges from the sea surface.

Table 7-2 Mass of drilling components and cuttings

Component	Modelled discharges per section				
	1	**2**	**3**	**4**	**5**
Cuttings (Te)	191	382	420	82	82
MUD/Fluid name	seawater and sweeps	seawater and sweeps	WBM	WBM	WBM
Barite (Te)	0	21	0	19	32
Bentonite (Te)	25	0	0	0	0
Non PLONOR chemicals (e.g. defoamer)	25 kg	250 kg	750 kg	350 kg	150 kg
Total mud[34] (Te)	675	1,460	3,567	1,387	2,367

Particulates in the discharge (cuttings, barite and bentonite) were set up using the model default values, which includes information on their potential non-toxic impact on the water column and seabed. Toxic effects are also considered, with toxicity values in the in the modelling assuming that the CEFAS template toxicity value represented the whole product. This is a conservative approach, as the component contributing to the template toxicity value may only represent a small component of the total product composition and the majority of the components have negligible toxicity to marine organisms.

The metals attached to barite were set up according to Table 7-3.

Table 7-3 Concentration of metals attached to barite

Metal	Parts per million
Cadmium (Cd)	0.26
Mercury (Hg)	1.63
Lead (Pb)	76.61
Zinc (Zn)	260.00
Chromium (Cr)	5.59
Copper (Cu)	27.55

7.5.1.2 Cementing

Steel casings will be installed in the well during the drilling operation to provide structural strength and isolate unstable formations and formation fluids. The casings will be cemented in place to form an effective seal between the casing and the rock formation. When the upper (riserless tophole) well sections are cemented, excess cement is pumped to guarantee an effective seal and some of this excess cement will be discharged directly to the seabed. Once the riser is installed, the cement is recirculated back to drilling rig. There are discharges of cement from the drilling rig when the cement unit is cleaned between each cementing operation. However, it is anticipated that the majority of the cement will be mixed and used as required, and as a result discharges should be limited to discharges made during pit cleaning between cement batch mixes.

[34] This includes PLONOR substances, added substances and water. PLONOR substances are those on the OSPAR List of Substances/Preparations Used and Discharged Offshore which are considered to Pose Little Or No Risk to the environment.

7.5.2 Behaviour of Drill Cuttings at Sea

7.5.2.1 SERPENT project

Studies conducted over the past decade have investigated drill cuttings and their observable impacts during drilling in the deep waters of the Faroe-Shetland Channel. For example, the SERPENT Project has conducted ROV surveys before, during and after drilling operations in this area, including at the Rosebank field. Figure 7.1 shows an example of a typical conical accumulation from upper section drilling at a single exploration well (204/17-1) approximately 84 km south-west of the proposed Rosebank FPSO location in approximately 985 m of water. Pre and post-drilling ROV surveys showed the impact of drill cuttings on the seabed at 30 m and 50 m from this well. After completion of the drilling there was a thin covering of drill cuttings 30 m south-west of the well and only minimal disturbance to the seabed 50 m south-west of the well (Figure 7.2; Hartley Anderson, 2003). The reference sandbag is visible in all the images, together with a covering of cuttings evident in the image from 30 m south-west of the well.

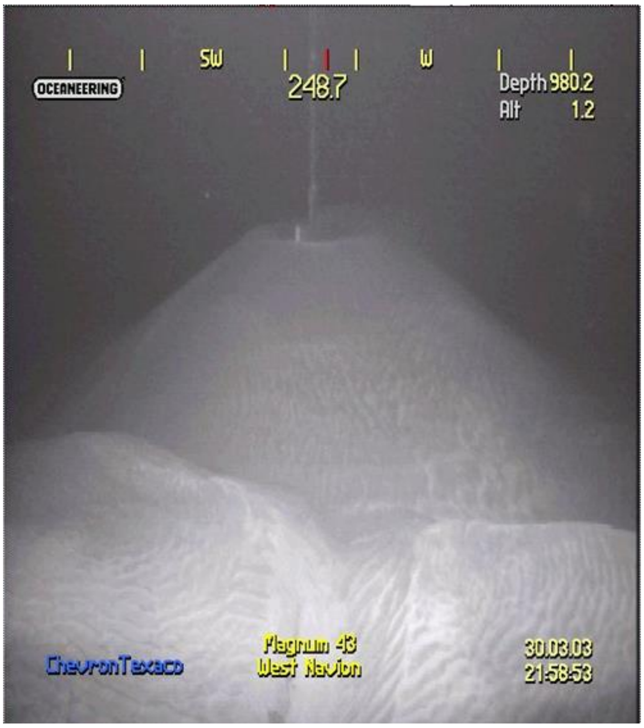
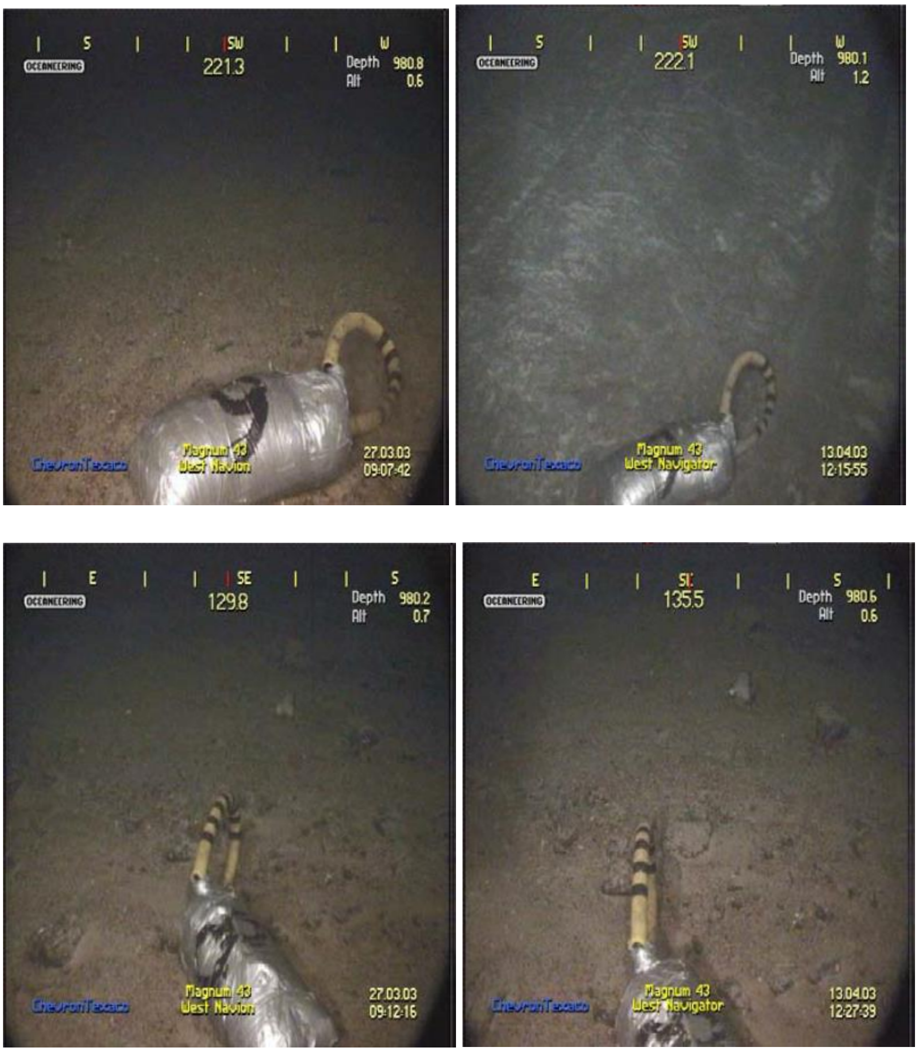


Figure 7.1 Well 204/17-1 conductor and drill string during upper section drilling showing cuttings accumulation and a rippled surface indicative of strong water currents (Hartley Anderson, 2003). The conductor shown is 36" in diameter, the cuttings accumulation is 2 to 2.5 m in height and the base diameter is approximately 3 to 3.5 m

Analysis of ROV video data obtained following drilling of exploration and appraisal wells in the Rosebank field indicates that accumulations of cuttings may cover an area ranging from 40 m to beyond 120 m from the drilling location, oriented according to prevailing currents in the region. Partial disturbance (5 to 95% coverage of seabed with cuttings) was observed over an area of seabed extending between approximately 10 and 40 m beyond the area completely covered (Gates, 2008; Roterman & Jones, 2009). Figure 7.3 shows the observations of cuttings spread from the Rosebank 205/1 well.

Location | Pre-drilling | Post-drilling



30 m south-west

50 m south-west

Figure 7.2 Comparison of pre (left) and post (right) drilling seabed sediment 30 m and 50 m south-west of well 204/17-1 (Hartley Anderson, 2003)

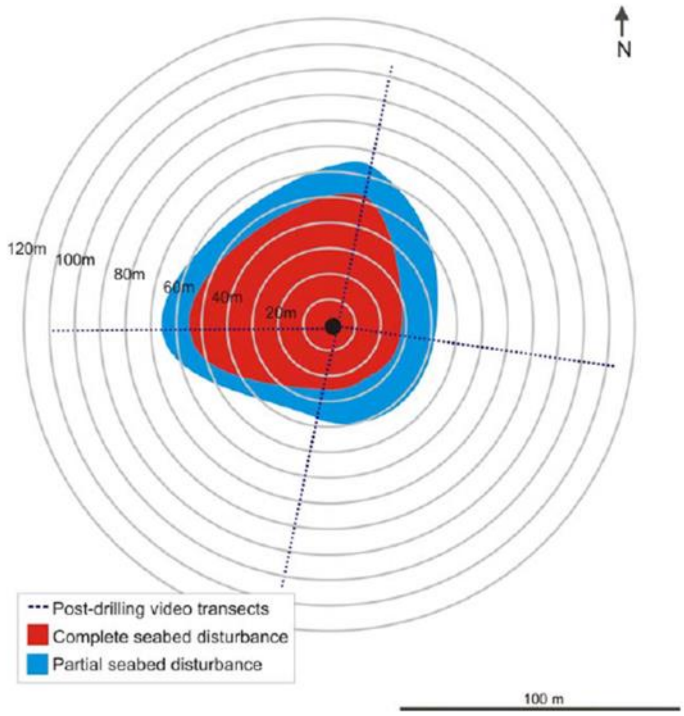


Figure 7.3 Extent of visible drill cuttings observed at Rosebank 205/1 well (Gates, 2008)

7.5.2.2 Drilling Discharge Modelling Overview

An assessment of the potential impacts of the drilling programme was conducted using the ParTrack module within SINTEF's Dose-Related Risk and Effect Assessment Model (DREAM) (included in Marine Environmental Modelling Workbench (MEMW) version 12.1.0). This model was used to assess the dispersion and potential environmental impact of the drilling discharges from up to four wells that will be drilled from the same drilling template. The parameters used to undertake the modelling are briefly described here to provide some context to the findings and their relevance to the realistic drilling scenario. Whilst the results of modelling cannot be directly substituted for observed impacts occurring during a real situation (due to model limitations and differences in data resolution), modelling is a useful tool to help assess the risk of potential impacts and to inform project decision-making.

Modelling was undertaken to determine worst-case scenarios to represent the largest discharge volume at a single template location for the Development. The information provided from well template D (well DP3) was chosen for this assessment, as the only template with the drilling of two wells planned during the first phase of the Development. The scenario modelled assumes a much larger discharge volume at one template location (i.e., four wells) than is the case with the planned Development drilling programme (maximum three wells per template) and the modelling output therefore presents a maximum worst-case scenario for the current Development.

The following considerations were included in the modelling process:

- The 42" and 26" sections are drilled riserless with seawater and bentonite sweeps and the cuttings are discharged directly to the seabed; and
- The 17.5", 12.25" and the 8.5" sections are drilled with a marine riser in place and the WBM mud and drilling cuttings are discharged via a caisson assumed to be at sea surface.

7.5.2.3 Environmental Impact Factor

The Environmental Impact Factor (EIF) is a relative measure of the risk to the biota in the marine environment. It is calculated using the PEC/PNEC approach, where the predicted environmental concentration (PEC) of a contaminant is divided by the predicted no effect concentration (PNEC); the highest concentration at which no environmental effect is predicted. A ratio of >1 indicates there may be an environmental effect.

The PNEC values within the ParTrack model are the estimated highest concentrations at which toxic effects are not expected. The PNEC values for each substance have been defined by laboratory tests. These have been divided by an assessment factor to produce a value that is considered to be protective of all but the most sensitive 5% of species. This approach is internationally accepted in the regulatory assessment of chemicals. SINTEF have adapted this methodology by using experimental data to calculate pseudo-PNECs for non-toxic stressors such as burial, sediment grain size change and oxygen depletion.

The PEC for each contaminant is determined within the model using a number of calculations to simulate the behaviour of contaminants in the water column. Processes including dilution, partitioning, degradation and deposition into the sediment are simulated in order to generate a PEC for each contaminant over time. EIFs for the sediment compartment are more complex, they incorporate the toxicity of the contaminants as well as processes such as oxygen depletion, change in median grain size and burial effects.

Within the model the entire water volume in the modelled area is split into compartments measuring 100 m x 100 m x 10 m (0.0001 km^3). Each compartment where the PEC/PNEC ratio is >1 contributes a value of 1 to the water EIF. Sediment EIFs are calculated based on area rather than volume. The sediment is divided into compartments measuring 100 m x 100 m (1 hectare or 0.01 km^2). Each compartment where the PEC/PNEC ratio is >1 contributes a value of 1 to the sediment EIF. The EIFs generated for the drilling discharge modelling are discussed in the following sections.

7.5.2.4 Modelling Results for Drilling Discharges

A time series showing the developing risk to the water column from two wells during drilling is shown in Figure 7-4 and presents the discharge from two wells, drilled sequentially at the same template. This represents the worst-case water column impact for either Phase 1 or 2 of the drilling programme as two wells are the maximum number that will be drilled sequentially at any template during either phase.

The lateral extent of the section of the water column predicted to have an impact risk on more than 5% of the species present extends to a maximum of 2.6 km to the north of the release sites and 2.0 km east. As is usually predicted with drilling programmes the water column impact is very transitory, with most of the risk in the water column during the time of drilling between days 1 and 31. The risk is shown to dissipate rapidly after falling below 1% by day 20.5 and zero by day 21. Figure 7-5 displays the water column risk along transect A-B. This shows that the water column risk is predicted to occur from the seabed where the top-hole sections are being discharged and from the sea surface where the discharge occurs for the remaining sections and the release of the batch mud. The DREAM model has used a compressed timescale for the drilling activity however in the current drilling programme the wells will be drilled sequentially, over a longer period. Thus, there are likely to be four more discrete spatial separated transient impacts through the drilling programme.

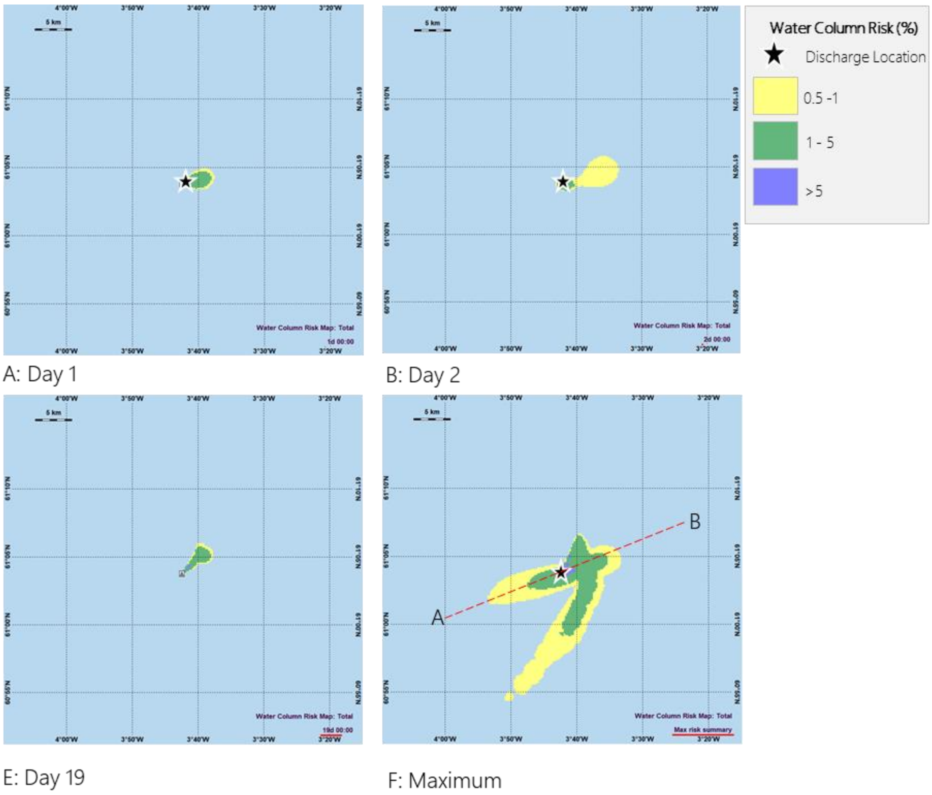


Figure 7-4 Development of water column risk (%) due to particulate material discharged during drilling over time

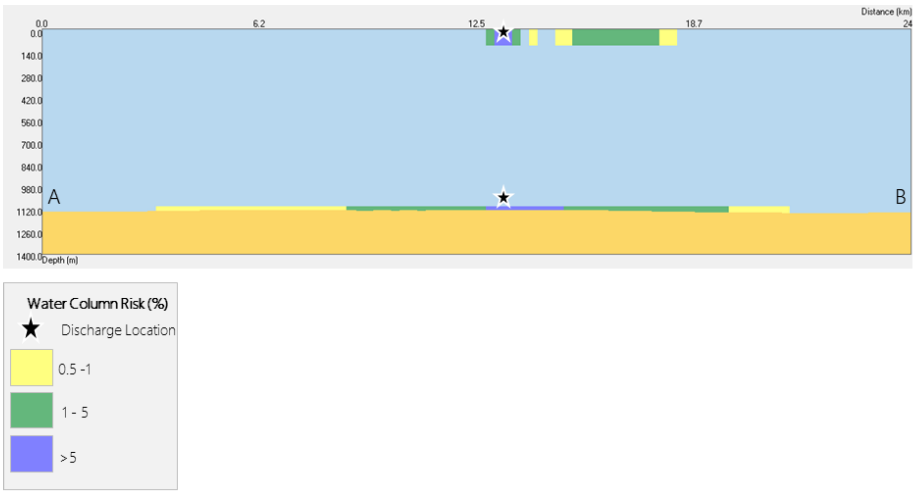


Figure 7-5 Water Column Risk Along Transect A-B Shown in Figure 7-4

The development of the water column risk as described by the EIF values is presented in Figure 7-6. This shows three peaks in EIF corresponding to the drilling of the well top-holes and the batch discharge of mud at the end of drilling. The maximum computed EIF was 839.9, shown in Figure 7-7 which returns to zero by day 21. The two well section top-hole discharges and the batch mud discharge contain barite, bentonite and the defoamer NF-6. The bentonite followed by barite components are shown to result in the largest contribution to water column EIF as a result of particle stress.

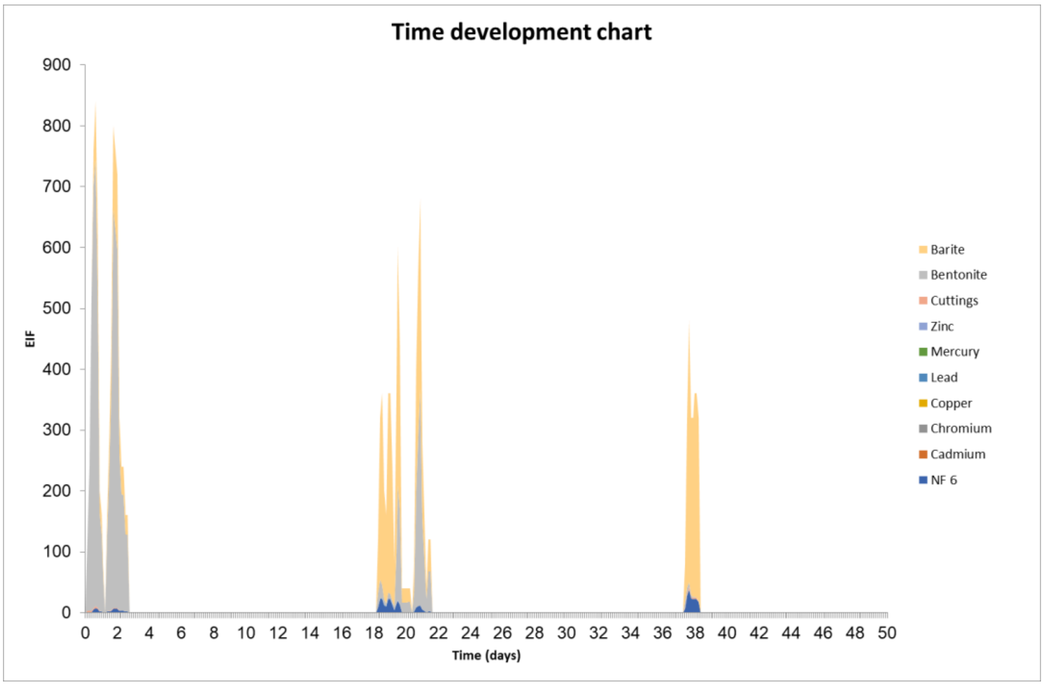


Figure 7-6 Development of the water column EIF during drilling

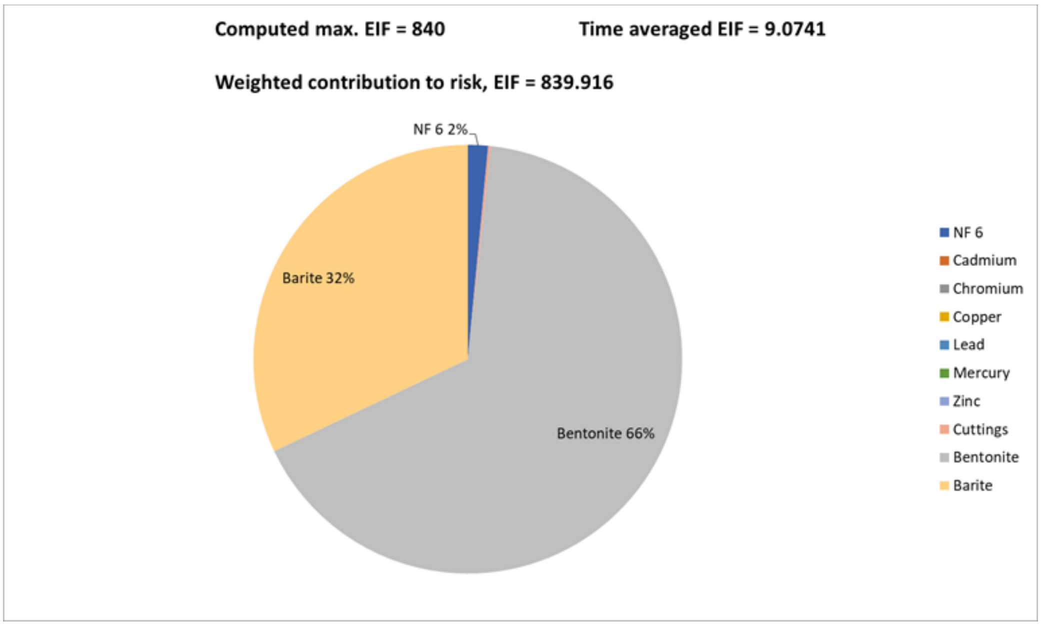


Figure 7-7 Contribution to maximum water column EIF

The modelled thickness of the deposited drilling mud from drilling two wells sequentially at the same template is presented in Figure 7-8 (in plan) and Figure 7-9 and Figure 7-10 (in section view). This represents the worst-case deposition of mud and cuttings during the Phase 1 drilling programme. The two wells are predicted to produce overlapping cuttings piles with a maximum thickness of 4.95 m from the primary cuttings pile closest to the template. There is a large overlap predicted for the joined cuttings piles as all wells are drilled on a fixed-slot template with a separation of 3 m. The predicted thickness rapidly decreases to less than 1 mm within 110 m. This is a relatively short distance and is because the cuttings from the top sections of the well are discharged directly to the seabed The thickest area of the mud and cuttings pile is predicted to be predominantly formed to the immediate south-west (4.95 m thickness) and north-east (2.21 m) of the template. The direction of the wider-scale deposition of sediment is dominated by prevailing currents at levels that are not easily detectable in the environment. Therefore, any potential seabed impacts are likely to remain localised.

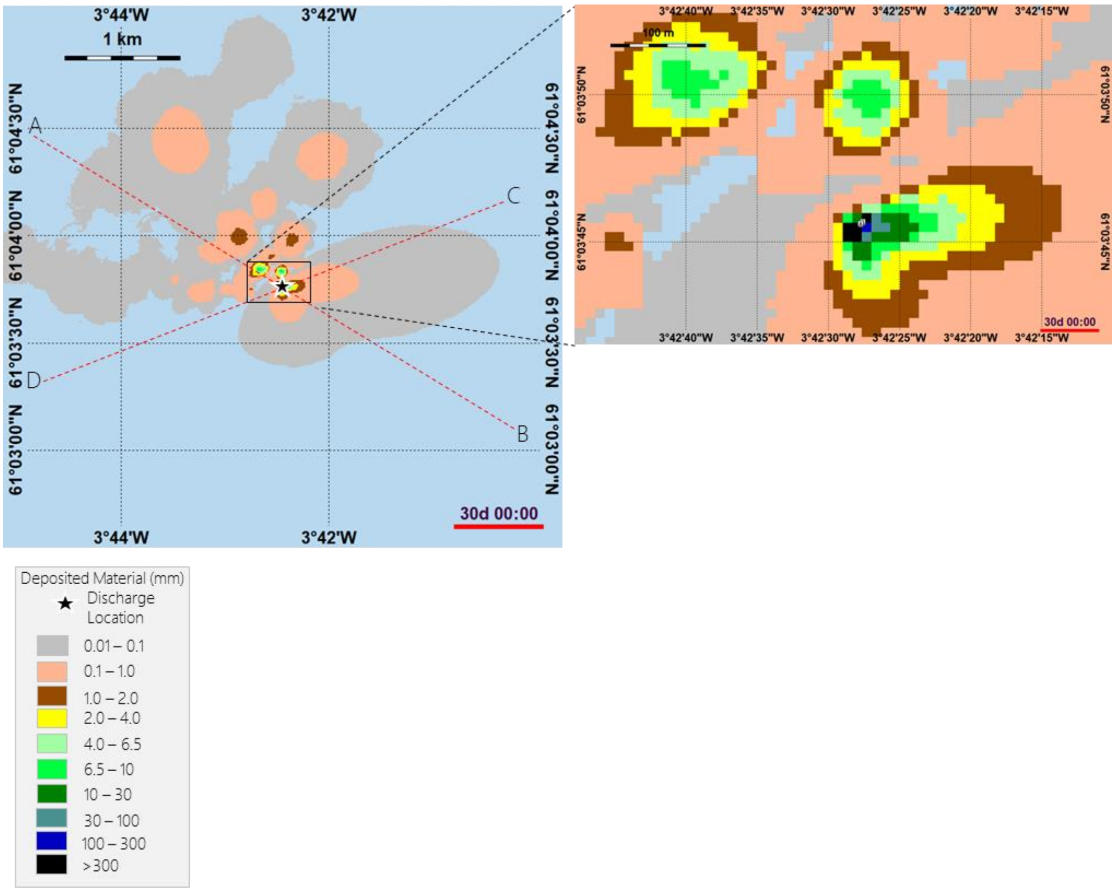


Figure 7-8 Modelled Accumulation on the seabed

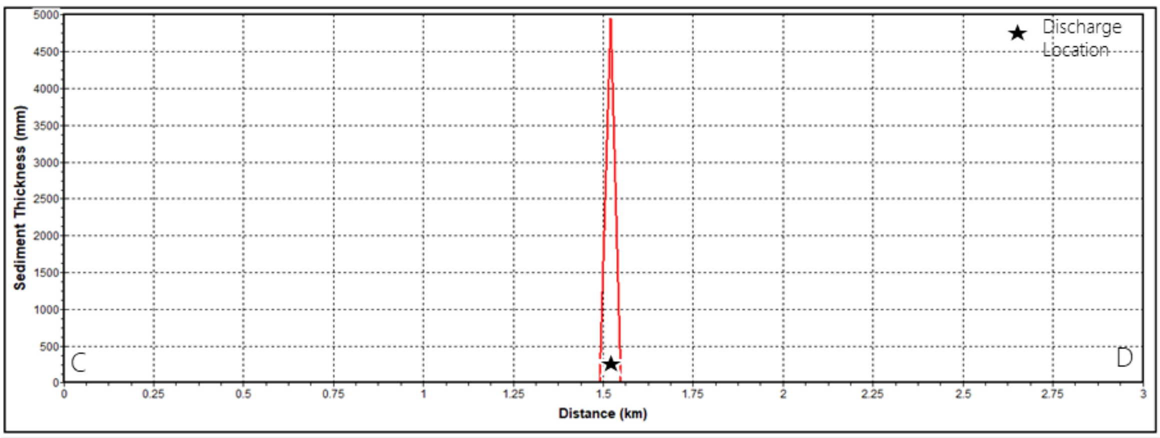


Figure 7-9 Sediment thickness on the seabed along transect A-B

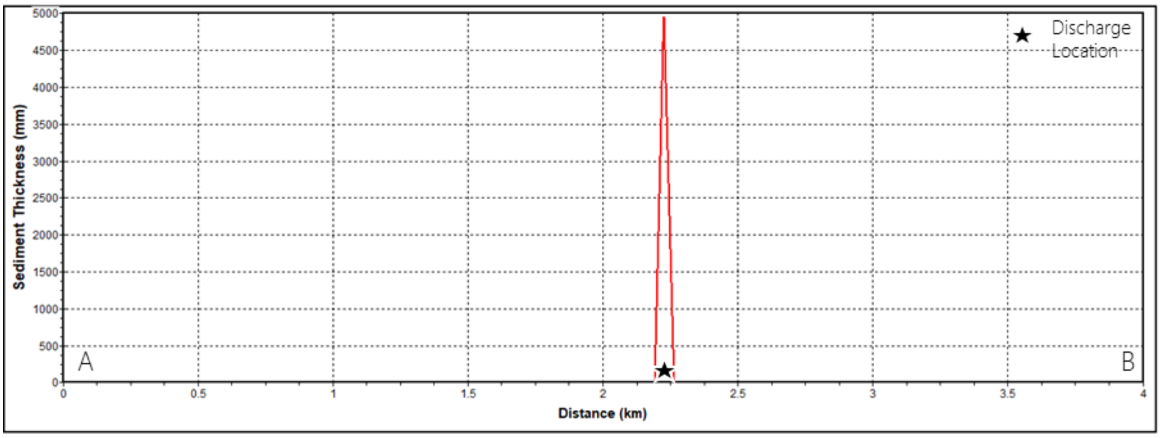


Figure 7-10 Sediment thickness on the seabed along transect C-D

Drill cuttings dispersion modelling also allowed estimating the total area of seabed impacted by drill cuttings deposition. It shows, that while the drill cuttings dispersed over a wide area, only a small area is impacted by a thickness greater than 1 mm. Drill cuttings deposited with a thickness greater than 1 mm are shown to deposit over a total 0.08 km^2 area, whilst cuttings over the 10 mm contour are predicted to deposit over a 0.003 km^2 area. No EIF is predicted from the sediments deposited due to the small area covered by the pile and the lack of non-PLONOR chemicals used in the mud.

In order to understand the potential seabed deposition from drilling two additional wells at the same template during the Phase 2 development drilling a further simulation was conducted. The modelled thickness of the deposited drilling mud from the drilling of four wells drilled sequentially in pairs at the same template is presented in Figure 7-11 (in plan view) and Figure 7-12 and Figure 7-13 (in section view). The four wells are predicted to produce several adjoining cuttings piles with a maximum thickness of 7.438 m from the primary cuttings pile closest to the discharge points. As with the previous 2-well simulation there is a large overlap predicted for the joined cuttings piles due to the 3 m slot spacing in the template. The predicted thickness rapidly decreases with increasing distance from the discharge point, such that it decreases to less than 1 mm within 110 m, as it did in the 2-well scenario. The thickest area of the mud and cuttings pile is predicted to be predominantly formed to the immediate south-west and north-east of the four wells. The direction of the wider-scale deposition of sediment is dominated by prevailing currents at levels that are not easily detectable in the environment. Therefore, any potential seabed impacts are likely to remain localised.

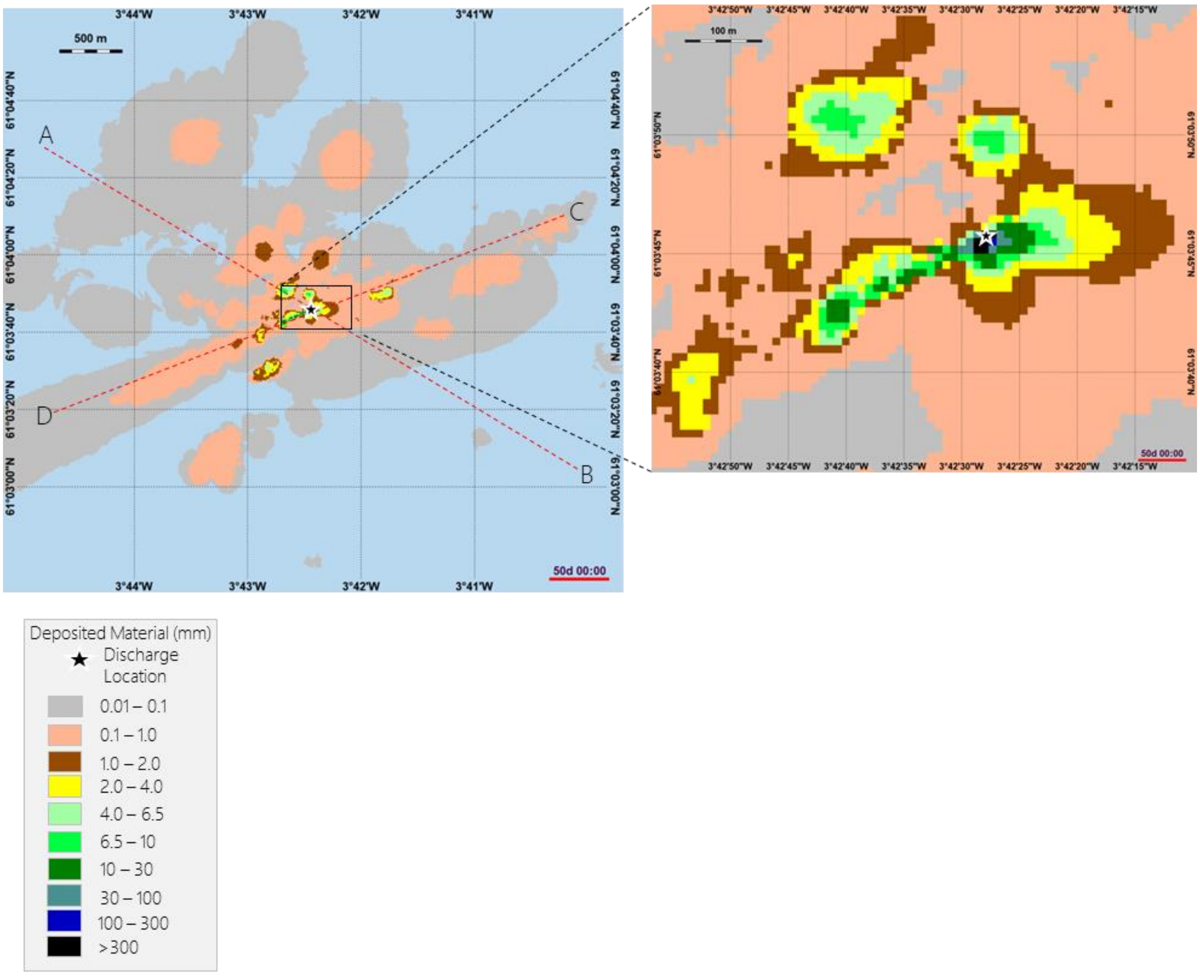


Figure 7-11 Modelled cuttings accumulation on the seabed

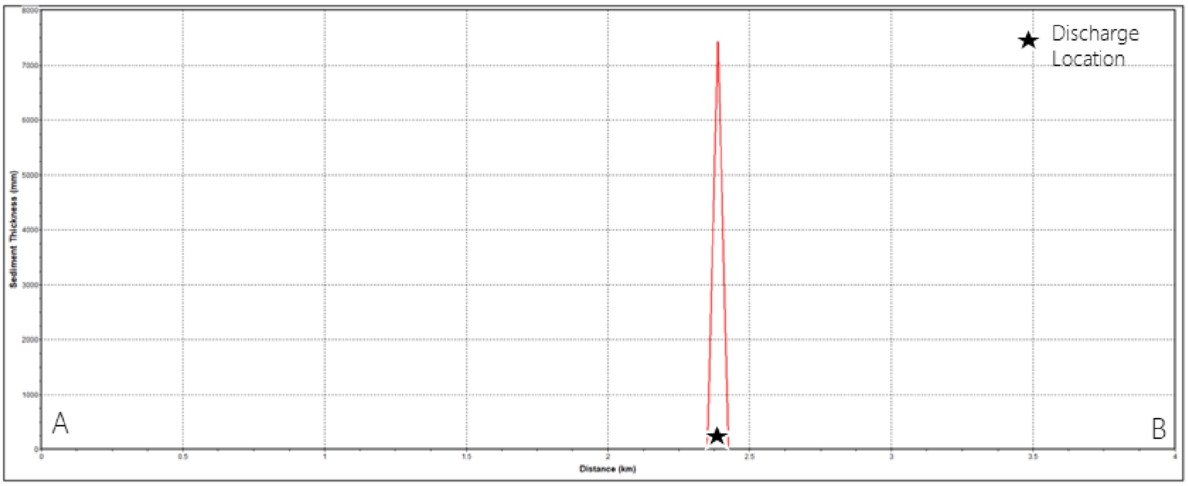


Figure 7-12 Sediment thickness on the seabed along transect A-B

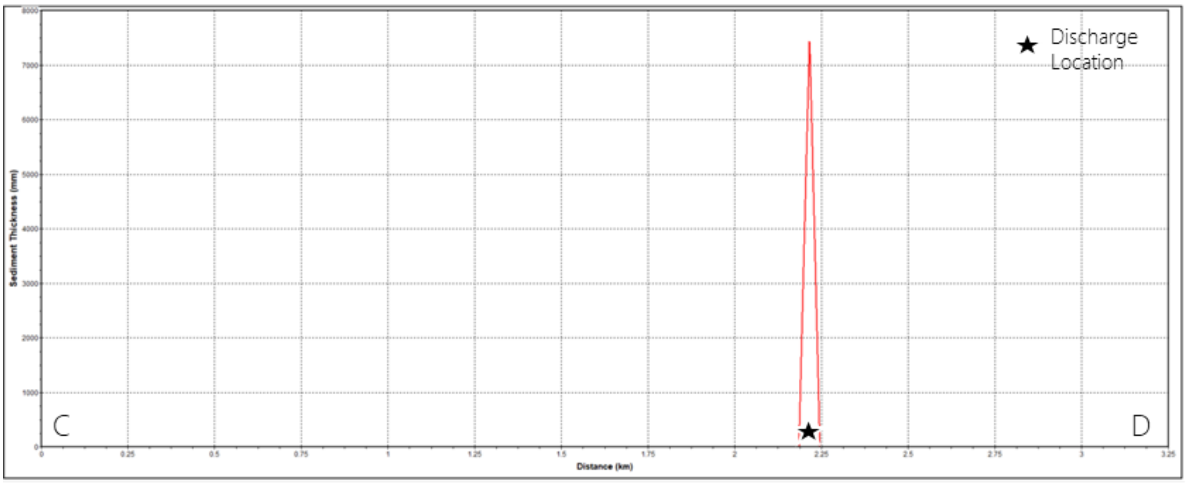


Figure 7-13 Sediment thickness on the seabed along transect C-D

Drill cuttings dispersion modelling also allowed estimating the total area of seabed impacted by drill cuttings deposition. It shows, that while the drill cuttings dispersed over a wide area, only a small area is predicted to accumulate a mud and cuttings thickness greater than 1 mm; 1 mm or greater deposit occurred over a total 0.18 km^2 area, whilst these deposit within a 0.006 km^2 area at the 10 mm thickness contour. Thus the four well scenario results in about twice the area of impact as the 2-well scenario. As with the 2-well scenario the mud used contains predominantly PLONOR chemicals and the depositional area is relatively small which results in no EIF being predicted for the seabed in the 4-well scenario.

7.5.2.5 Management and Mitigation for Drilling Discharges

Mitigation measures will be applied to the drilling of the Development wells to limit, where practicable, the potential environmental impacts of discharges to sea (many of these were included in the modelling presented above), including:

- Returns from cementing of the riserless tophole well section casings are monitored on the drilling rig via ROV footage to minimise the quantity of excess cement discharged to the seabed;
- Once the riser is installed, cuttings and drilling muds are returned to the drilling rig and WBM is recovered and re-used as far as practicable to reduce discharges (with a single batch discharge of mud occurring after drilling has finished);
- Whilst it is not intended to use LTOBM it is included as a contingency. Cuttings contaminated with LTOBM will be skipped and shipped to shore for treatment and disposal;
- A chemical risk assessment under the Offshore Chemical Regulations 2002 (as amended) (OCR) is carried out for all chemicals used and discharged during drilling operations;
- A product selection process is in place to identify alternatives to chemicals carrying substitution notifications where possible;
- Chemicals will used in accordance with the conditions contained in the permit issued under the OCR; and
- An assurance process shall be in place to the ensure the drilling rig complies with all relevant guidelines and legislation.

7.5.2.6 Assessment of Impacts to the Water Column from Drilling Discharges

The modelled scenario assumes as a worst-case that the maximum possible number of wells (four) would be drilled from a single template location. There are currently no more than three wells planned to be drilled from any single template location. Batch drilling will be used, meaning that the equivalent diameter sections of each well will be drilled sequentially, rather than completing a whole well at a time.

Water column residual impacts from drilling discharges relate to both the physical and chemical effects predominantly experienced by planktonic species. Considering the relatively limited volume over which the water column is predicted to be affected by particle stress, the residual impact from drilling activity is likely to be temporary and short term and is not considered to represent a significant residual impact to the water column

As the suspended particulates from the lower well sections in the model are spatially restricted in the lower water column it is unlikely that there will be any significant residual impact on zooplankton feeding, as these will generally be located higher in the water column. Discharges occurring at or near the sea surface have the potential to extend over a much larger area than those occurring at the seabed, as demonstrated by the results of the modelling.

Considering the characteristics of the potential impact, the water column receptor species and the nature of the drilling operations (batch), and as per Chapter 5 EIA Methodology, the overall consequence is considered negligible and there the impact is not significant.

7.5.2.7 Assessment of Impacts to Seabed from Drilling Discharges

Cuttings deposition on the seabed can have both physical and chemical impacts on seabed communities, with smothering the most likely mechanism for impact. Where cuttings settle on the seabed then losses of fauna are likely to occur. Mortality and community composition change is therefore likely at the well location due to discharge of drill cuttings from the riserless upper well sections. However, considering the relatively limited area over which benthic habitats and species have the potential to be impacted, drilling activity at the Rosebank field is not likely to represent a significant residual impact to benthic species.

In terms of features of conservation interest, the drilling locations are not located within any protected areas and no other protected habitats and species have been identified within the potential impact zones of the drilling discharges.

The worst case has been modelled, which potentially overestimates the seabed area affected. The 12 wells will be split between 3 templates (7 production wells) and 5 single well injectors outwith 1 km of each of the drilling template locations. The deposition of cuttings from each drilling location is expected to be effectively discrete with no detectable overlap in potential environmental impact.

The Strategic Environmental Assessment (SEA) undertaken for the area within which the Rosebank field is located (DTI, 2003) indicated that surface hole cuttings mounds in all but the deepest parts of the area will be dispersed, typically over a time scale of 1 to 10 years, mainly through re-suspension and bedload transport due to tidal, storm and surge induced currents. Local accumulation of cuttings, except in the very near vicinity of wellheads, is not expected to be detectable due to near-bed current velocities and sediment mobility in the area (Wynn *et al*., 2002).

The drilling discharge modelling results have been used to assess the residual seabed impacts. Considering the characteristics of the potential impact, the benthic receptor species and the potential for recovery in the medium term, the consequence of the potential impact due to cuttings deposition to the seabed is considered minor and not significant.

7.6 Aqueous Discharges

7.6.1 Overview

Aqueous discharges are expected to occur in during installation, commissioning and operation of the Rosebank Development. All aqueous discharges have the potential to impact water column receptors the extent of which depends on many factors. Sensitivity of the receptor organisms (which can vary widely between species), the nature of the chemicals used and the concentration of the chemicals and hydrocarbons in the discharge stream are all included as factors that could impact water column receptors. Most studies on produced water toxicity and dispersion have concluded that the necessary dilution to achieve a No Effect Concentration (NEC) would be reached at <10 to 100 m, and usually less than 500 m from the discharge point (IOGP, 1994; OLF, 1998; Riddle *et al.,* 2001; Berry and Wells, 2004; DECC, 2016).

Plankton abundance is influenced strongly by the physical environment and variables such as water temperature, current velocity, stratification in the water column, and nutrient concentration. As a result, they are particularly vulnerable to the introduction of chemicals and hydrocarbons to the water column. Plankton may be exposed to these contaminants through passive diffusion, active uptake, or through eating contaminated prey. As plankton spend most of their lives in the water column, they will be exposed to those contaminants that remain in solution (Sheahan *et al.,* 2001). Produced water can affect recruitment in calanoid copepods (Hay *et al.,* 1988), with lowered fecundity and increased offspring mortality reported for some plankton, as outcomes of hydrocarbon contamination (Van Beusekom & Diel-Christiansen, 1993). Strømgren *et al.* (1995) found that acute toxicity in the diatom Skeletonema spp. was only likely in individuals in the immediate vicinity of the source of produced water, where concentrations of contaminants are highest.

The OSPAR (2010b) Quality Status Report (QSR) noted that water column monitoring to determine possible effects from PAHs and other chemicals such as alkyl phenols discharged with produced water has been carried out to a limited extent in the OSPAR area. Monitoring with caged mussels in the Netherlands and Norwegian sectors of the North Sea has shown that mussels exposed to produced water discharges may accumulate PAH and show biological responses up to 1,000 m from the discharge. Concentrations of PAHs and alkyl phenols and measured biological responses in wild fish such as cod and haddock caught in the vicinity of offshore installations from Norwegian waters in 2002 and 2005 showed a mixed pattern mostly with no increased concentrations, but some elevated biological responses suggesting past exposure. Exposure of cod sperm cells to environmentally relevant concentrations (100, 200, 500 ppm) of produced water from the Hibernia platform, Newfoundland, did not result in a strong toxicity to the cells (only subtle changes were observed) or a significant change in fertilisation rate (Hamoutene *et al.,* 2010 in DECC, 2016).

Bakke *et al.* (2013) reviewed research on the biological effects of offshore produced water discharges, with focus on Norwegian waters. Produced water discharges are a continuous source of contaminants to continental shelf ecosystems, and alkylphenols and PAH were found to accumulate in cod and mussels caged near the discharge points, but these compounds are rapidly metabolised in cod. Such compounds may affect reproductive functions, and various chemical, biochemical and genetic biomarkers, but Bakke *et al.* (2013) concluded that the risk of widespread impact from such operational discharges is low. These discharges are likely to be rapidly dispersed in the turbulent offshore environment meaning that the consequence of effect, as per Chapter 5 EIA Methodology, would be negligible and the impact therefore not significant.

7.6.2 Installation and Commissioning

Following their installation onto the seabed, seawater dosed with chemicals will be used to protect the gas pipeline, subsea infrastructure and risers prior to commissioning. The associated discharges to sea expected during the pre-commissioning and commissioning operations are quantified and the impact assessed. The measures being taken to improve chemical use and reduce the potential impacts on the receiving environment from installation and commissioning discharges are also presented in this section.

7.6.2.1 Potential Impacts

There will not be one single discharge event or location during the installation and commissioning activities. A series of discrete discharges throughout the different stages of the subsea programme will be carried out for different reasons such as protection of equipment, testing for integrity and preparation for gas containment. There will therefore be three types of operations in relation to installation and commissioning activities that will result in discharges of inhibited seawater to sea:

- Flooding/gauge pigging;
- Hydrotesting (discharge of water when the pressure is reduced); and
- Dewatering (discharge of all water in the gas pipeline).

After the gas export pipeline has been installed on the seabed, a series of pre-commissioning operations will be conducted as described in Chapter 3 Project Description. The pipeline will first be flooded with seawater, then checked and cleaned using pigs. It will then be hydrotested (pressurised with seawater beyond the operating pressure for a short period) to conduct gas pipeline strength and leak tests. Before start-up, the gas pipeline must be dewatered (emptied of water used for flooding and hydrotest). The seawater used to flood and hydrotest the gas export pipeline will be chemically treated to prevent internal corrosion or bacterial growth in the gas pipeline.

The dewatering of the gas export line will be carried out by importing gas from WOSPS and using this to propel a six-pig train through the pipeline. The fluid will be propelled to the FPSO and received in a temporary pig receiver to be routed into the process. The fluid will be managed within this system for injection downhole as water injection or discharged to sea if the specification is acceptable. The gas pipeline will subsequently be treated and dried using pig trains carrying slugs of freshwater followed by slugs of mono-ethylene glycol (MEG), prevents hydrate formation in the gas pipeline.

No pigging is planned to be required for the water injection system due to the internal plastic liner in the flowline. Flushing with fresh water treated with dye will be performed after tie-in and prior to start of water injection to ensure integrity of the water injection flowlines. The use and discharge of the dye will be covered by an approved chemical permit.

Following installation, the in-field flowlines, risers and umbilicals will be flooded with seawater and hydrotested to check their integrity. The seawater used will be treated with chemicals to prevent corrosion and bacterial formation. Prior to commissioning, these structures will be dewatered.

When the risers are connected to the FPSO, the small volume of inhibited seawater in most of the risers and flowlines will be discharged to sea. Some discharge will also occur during connection of the flowlines to the manifolds. The inhibited seawater in the water injection risers and flowlines will be injected into the well and will not be discharged to sea.

Discharge of the chemicals used in pipeline / flowline operations are fully risk assessed in a chemical permit.

7.6.2.2 Management and Mitigation

All chemical use and discharge will be risk assessed and included on an approved chemical permit issued under the OCR prior to the operations before the activity takes place. The selection of chemicals will be made in accordance with Equinor policies and in compliance with relevant permit requirements. Once engineering details and chemical requirements are known, and prior to the commencement of operations, Equinor will submit the relevant permit applications, supported by appropriate detailed chemical risk assessments, to OPRED under the OCR in order to obtain approval prior to chemical use and discharge.

7.6.2.3 Overall Assessment of Residual Impact from Installation and Commissioning Discharges

There will be several discharges of inhibited seawater during installation and commissioning of infrastructure. The discharges will be predominantly from around the flowlines and risers, some at the sea surface and some at the seabed and be spatially and temporally separated. The modelled behaviour of the discharges from pipeline / flowline commissioning operations indicates that discharges to sea are rapidly dispersed and diluted. There are mitigation measures in place with regard to chemical selection and all discharges are risk assessed in the chemical permit. As per Chapter 5 EIA Methodology, the consequence of the residual impact is considered negligible and the impact therefore not significant.

7.6.3 Operational

7.6.3.1 Potential Impacts

There are four discharges that will occur during the operational phase of the Rosebank Development. All four discharges are required for the production of hydrocarbons through the FPSO.

The Hypersaline Water from Seawater Treatment

Seawater undergoes a sulphate removal process in the SRU prior to injection into the reservoir to prevent reservoir souring. Under normal operation of the SRU there will be reject streams from the SRU which will form a single hypersaline stream, which will be discharged overboard from the FPSO. A scale inhibitor and biocide may be added to the injection water upstream of the SRU and so will be present in the SRU reject stream; an antifoam may also be added but this will occur downstream of the SRU to go into the reservoir, and therefore will not be present in the SRU reject stream.

Discharges of the hypersaline water can potentially impact plankton, including the larvae of fish and invertebrates, by causing a drop in osmotic pressure[35] (breaking the osmotic equilibrium between planktonic organisms and seawater), and hence potentially causing negative impacts in primary and secondary production and mortality in larvae (Palomar & Losada, 2011). However, such potential impacts are usually only associated with very large discharges of hypersaline water into coastal areas, e.g. associated with desalination plants.

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[35] Osmosis is the physical process in which any solvent moves across a selectively permeable membrane (permeable to the solvent, but not the solute) separating two solutions of different concentrations. Osmotic pressure is the main cause of support in many plants, providing the primary means by which water is transported into and out of cells. When a cell is submerged in water, the water molecules pass through the cell membrane from an area of low solute concentration to high solute concentration.

Produced Water Discharges

Produced water may contain residues of reservoir hydrocarbons (oil), dissolved organic and inorganic compounds present in the geological formation and chemicals added during the production process. Examples of the types of chemicals which may be used on the FPSO include defoamer, demulsifier, wax inhibitor, biocide, reverse emulsion breaker, scale inhibitor and oxygen scavenger. The produced water treatment system is designed to remove the majority of residual hydrocarbons and substances held in the oil phase. The treatment system is not expected to have any impact on any chemicals or naturally occurring substances which have dissolved in the water phase.

Produced water from the wells is expected to increase steadily during the life of the field to a peak of around 12,360 Sm^3 per day in later production, as detailed in Chapter 3 Project Description. The produced water processing capacity for the Rosebank FPSO is 14,785 Sm^3/sd (93 kbpd) therefore, there is ample capacity to meet this requirement.

Produced water will be treated to meet, as a minimum, the statutory monthly average oil in water concentration limit of 30mg/l as a minimum. The produced water treatment system is designed to reduce the oil content in the produced water to a target concentration of around 15mg/l (monthly average).

As detailed in Chapter 3 Project Description, the base case is that the produced water will be treated and then combined with seawater from the SRU and then re-used for water injection purposes to provide reservoir pressure support.

The produced water system is designed to meet regulatory requirements as a minimum. During periods of WIP downtime, the treated produced water may be discharged overboard although there is a potential option for produced water to be routed to and stored in hull tanks for later processing and disposal overboard within the required specification as described in chapter 3.7.5.

Produced Sand Discharges

When oil is produced from reservoirs, small particles and sand grains are dislodged and carried along with the flow. The production of the particles (sand) can cause erosion in flowlines and other equipment and therefore needs to be removed and managed. As sand is expected to be produced with the Rosebank reservoir fluids, the wells have been designed to help reduce the production of sand.

Sand is likely to accumulate in the first and second stage production separators and the electrostatic heater. This sand will be removed periodically and is stored prior to being cleaned of oil. The proposed sand cleaning process is described in Section 3.7.6. Project Description. The sand is cleaned to meet a minimum 1% oil on sand content although it is expected that the application of BAT will achieve a lower concentration. An appropriate sampling and analysis regime will be in place. The cleaned sand will either be skipped or shipped or discharged overboard via caisson.

Operation and Well Maintenance

Workovers and interventions will be planned for in the well and subsea infrastructure during the life of the field. There is therefore the potential for scale squeeze and well intervention chemicals including acid stimulation to be used and discharged during operations on an *ad hoc* basis. The discharges will be small in volume and transient throughout the life of the Development and due to the nature of the discharges, are expected to rapidly dispersed in the turbulent offshore environment with no significant impact to species in the water column.

7.6.3.2 Management and Mitigation

The selection of chemicals will be made in accordance with Equinor policies and in compliance with relevant permit requirements. Once the final chemical requirements are known, and prior to the commencement of operations, Equinor will submit the relevant permit applications, supported by appropriate detailed chemical risk assessments, to OPRED under the OCR in order to obtain approval prior to chemical use and discharge. Equinor, in conjunction with its chemical suppliers, regularly investigates alternative technologies which may reduce the requirement for production chemical use. In addition, Equinor is committed to trialling chemicals which have more environmentally acceptable components and which are not listed for substitution.

Produced Water

The produced water system is designed to reduce the oil content in the produced water to a target of 15 mg/l oil-in-water (OIW) or less (monthly average). If regulatory OIW requirements for overboard discharge cannot be met (i.e. >30 mg/l monthly average or >100 mg/l at any time) for the short time that the WIPs are unavailable, the procedure will be to use temporary storage in the slop tanks in the hull and then, if necessary, to restrict or shut-in production until the injection water is brought back into line with re-injection or overboard discharge requirements.

Hypersaline Discharge

Maintenance will be carried out on the SRU to ensure the equipment will be functioning optimally and the discharge will be within the specifications of the unit.

Produced Sand

The following mitigation measures will be applied to the Development to reduce potential impacts of produced sand on the marine environment:

- Sandface completion techniques will be used in the completions of the producing wells to help reduce the production of sand at source;
- Sand treatment and disposal will be based on BAT and industry standards; and
- Produced sand will only be discharged overboard when the residual level of oil following cleaning is less than permitted.

7.6.3.3 Residual Impacts

During routine operations the FPSO there may be a combination of discharges that would occur simultaneously. The following scenarios have been identified as potential simultaneous discharges:

1. During Normal operations when the WIP is operational hypersaline water from the SRU and cooling water will be discharged vertically downwards from a 1.21 metre diameter seawater dump caisson – this discharge may also include a batch discharge of sand for a period of up to 4 hours;
2. During Normal operations when the WIP and the SRU are not operational, produced water and cooling water will be discharged vertically downwards from a 1.21 metre diameter seawater dump caisson or the 0.723 metre diameter produced water dump caisson; and
3. In addition, there is a theoretical possibility that the hypersaline reject stream from the SRU, excess treated seawater from the SRU, cooling water and produced water are discharged simultaneously. Although it is unlikely that the WIPs are down, the SRU is still running and PW is discharged to sea, this scenario represents the largest combined water volume which may be discharged.

The mixing and dilution of the different discharge streams in the three scenarios above were modelled to assess the behaviour of the mixtures of aqueous discharges under the typical water currents for the FPSO location. A sediment release scenario was also run to assess whether the solid waste, discharged from the Rosebank FPSO, would have any detrimental environmental effects

Modelling

The MixZon Inc. CORMIX GTS v12.0GTS model was used to investigate the behaviour of the discharge and maximum dilution at the edge of the mixing zone (nominally 500 m) for the diffuser under varying current conditions. CORMIX is a comprehensive software system for the analysis, and design of outfall mixing zones resulting from the discharge of aqueous effluents, which can be applied to a variety of water bodies. It contains various simulation systems to model hydrodynamic inputs and outputs and is designed to analyse water quality criteria within mixing zones; it is used to assess whether water quality criteria will be met at set distances from the discharge point.

The CORMIX model uses the density and flow rate of the effluent and ambient environment, together with the geometry of the discharge port, to estimate the movement and dilution of the discharge in the receiving environment and provide a detailed output of plume behaviour. Interpretation of CORMIX modelling results requires assessment of the output in terms of both duration and extent of the discharge.

A summary of the parameters used to configure the model is shown in Table 7-4.

Table 7-4 Model parameters

Medium	Parameter	Value		
Effluent discharge	Location	Rosebank FPSO		
	Flow	Scenario 1	Scenario 2	Scenario 3
		HSW: 4,832 m^3/d CW: 1,500 m^3/h	CW: 1,500 m^3/h PW: 14,785 m^3/d	PW: 14,785 m^3/d TSW: 7,550 m^3/d HSW: 2,416 m^3/d
	Density[36]	Scenario 1	Scenario 2	Scenario 3
		1,025 kg/m^3	1,014 kg/m^3	1,016.2 kg/m^3
	Orientation	Down		
	Bearing (compass)	240°		
	Temperature of liquid discharge	21 to 25 °C		
	Internal diameter	Seawater dump caisson: 1.21 m Produced water dump caisson: 0.723 m		
Environmental conditions	Depths for discharge point	18.6 m at maximum draft 11.3 m at minimum draft		
	Current speed	Variable based on project metocean data (as per report ROS-OFFG-TEC-BOD-ETC-0000-00203-01)		
	Seawater density	1,027 kg/m^3		
	Average water depth	1,100 m (modelled at 1,000 m)		

[36] The actual salinity of the discharges will not be available until the end of design and density is used as a surrogate in the model.

The variables adjusted in the model include: discharge composition and densities, local current speeds, number and size of the discharge caissons and effluent flow. Different discharge depths were also considered due to the capacity for the vessels position, relative to the level of the ocean's surface, to change.

Modelling Results

The three water discharge scenarios all involved discharge streams that had a lower density than the ambient seawater. All aqueous discharges are predicted to initially travel downwards from the mouth of the discharge caisson (discharge port) whilst being displaced sideways by the current. The discharge streams centreline reaches a depth of no more than 7.2 m below the discharge port and are therefore only present in the top 20 to 30 m of the average 1,000 m Rosebank location water column. After reaching maximum depth the buoyancy of the discharge streams become the driving factor in the dispersion as they rise whilst being moved sideways, eventually spreading out when it reaches the sea surface. The results of the three scenarios are detailed.

Scenario 1: Normal operation, hypersaline water and cooling water discharged.

The aqueous discharge was predicted to travel downwards from the mouth of the discharge caisson (discharge port) while being displaced by the current. The centre line of the discharge stream reaches a depth of no more than 3.0 m. The model predicted that at 100 m away from the discharge point, for current speeds of between 0.1 and 0.2 m/s, the buoyancy of the discharge would be the driving factor of dispersion. At increasing current speeds the current and routine water mixing processes will dominate: at 0.3 m/s the ambient current would be strong enough to deflect the jet phase whereas at current speeds of 0.5 m/s to 1.1 m/s, the dispersion at 100 m would be driven by plume nearfield mixing.

Scenario 2: Produced water discharge may occur intermittently during WIP down time and when the SRU is not operating. These batch discharges of produced water will be discharged with cooling water alone.

The aqueous discharge was predicted to travel downwards from the mouth of the discharge caisson while being displaced by the current. The discharge stream centreline reaches a depth of no more than 5.9 m. When discharging from both the larger and smaller caisson, the buoyancy of the discharge was predicted to be the dispersion driver for current speed of 0.1 to 0.6 m/s, (100 m from the discharge point). Routine water mixing was predicted to be the main driving factor in dispersion for the higher current speeds of 0.7 to 1.1 m/s.

Scenario 3: The discharge consists of the reject hypersaline stream and excess treated seawater from the SRU, cooling water and produced water. It is however unlikely that when the WIPs are down, the SRU is still running, and produced water is discharged to sea.

The aqueous discharge was predicted to travel downwards from the mouth of the discharge caisson while being displaced by the current. The discharge stream centreline reaches a depth of no more than 7.9 m. The model predicted that, 100 m away from a discharge from the larger caisson, the buoyancy of the discharge would be the driving factor in dispersion for current speeds of 0.1 to 0.6 m/s and for 0.1 to 0.4 m/s from the smaller caisson The routine water mixing processes are the main dispersion factor for current speeds of 0.7 to 1.1 m/s for large and 0.6 to 1.1 m/s for the small caisson size.

Sand release scenario: The sediment model was run with high salinity and cooling water discharges, in current speeds of 0.1 to 1.1 m/s in 0.1 m/s increments and was run conservatively, with 100 % of the composition being attributed to sand. Due to the small size of the discharge (1.2 tonne in four hours) the discharge volume was increased 12.5 times to be able to run the model and estimate the fate of the discharged sand. The discharge plume is buoyant and the sand particles would be expected to exit the plume and settle through the water column. The water depth is in excess of 1,000 m and therefore any produced sand is expected to be widely dispersed in the water column, without causing a significant increase in particle loading or discernible deposition pattern on the seabed. Both the modelled increased discharge volume and the 12.5 times smaller actual intermittent batch discharge would therefore not be expected to have anything other than a negligible consequence on the marine environment, and therefore would be not significant.

7.6.3.4 Overall Assessment of the Residual Impact from Operational Discharges

Given the small difference in density between the ambient seawater and the dilution of the discharges at 500 m, it is expected that the discharges of hypersaline water from the Rosebank FPSO will be rapidly dispersed in the turbulent offshore environment. Typical dilutions from the modelling are in the range 249 to 117 fold at 500 m depending upon the draft of the vessel at the time of discharge, the discharge port used and the density of the discharge stream. Comparison of the intermittent and short duration produced water discharges with the generic whole effluent at step 3 of the UK RBA guidance 2021[37] is not appropriate as the generic dilution factors are not considered to be relevant for this discharge stream. Sand discharged with any produced water would be rapidly dispersed.

Given the above, the consequence of the operational discharges is considered negligible and the impact therefore not significant.

7.7 Potential Cumulative and Transboundary Impacts

Impacts to the seabed and water column include the effects from discharges from drilling discharges, pipeline commissioning, well intervention discharges and operational discharges. These discharges will be transient. Discharges from drilling will be spatially highly restricted. Residual hydrocarbons and chemicals associated with these are expected to disperse rapidly through the water column therefore no cumulative impacts are expected from other activities occurring in the area, such as other oil and gas activities, commercial fisheries or shipping.

Pipeline dewatering operations during commissioning are expected to cause a small and short-lived plume which could potentially contain residual levels of some of the chemical(s) used during the installation of the pipeline. However, exposure of organisms in the water column to toxicity will be short-term and spatially limited and no impact to the benthic environment is expected.

The limited quantity of chemicals discharged during the life of the Development and the use of appropriate management and mitigation measures reduces the likelihood of any measurable cumulative impacts to the benthic environment. Additionally, dilution of the releases during the field life will likely be rapid and the potential impacts will be transient in nature. Considering this, no significant cumulative impacts will occur.

Considering the Development lies approximately 15 km from the UK/Faroes median line, no transboundary impacts are expected.

[37] The United Kingdom Risk-Based Approach Programme. A risk-based approach to the management of produced water discharges from offshore installations. Version 3.1

8 OTHER SEA USERS

8.1 Introduction

This section addresses potential impacts on other sea users in the vicinity of the Development area (UKCS Blocks 204/5, 204/10, 205/1, 205/2, 205/3, 205/4, 205/5, 205/10, 206/6, 206/7, 206/12, 206/13, and 213/27) (Chapter 1 Introduction). The other sea users considered within this section include commercial fisheries, offshore renewables, oil and gas activities, telecommunications cables and commercial shipping. Aquaculture sites and tourism and recreation are largely constrained to coastal locations, and the Development is not considered to be in an area of high value for these users, as described in Chapter 4 Environmental Baseline. These other sea users are considered to be beyond a distance at which an interaction with the Development activities is likely. Impacts relating to accidental events, including shoreline oiling on aquaculture sites are discussed in Chapter 11 Accidental Events and are not considered within this chapter.

The drilling operations, installation and presence of subsea facilities in the Development infield area and the gas export pipeline, together with associated tie-in structures and pipeline protection, in the form of concrete mattresses and rock protection, all have the potential to interact with sea users by obstructing or excluding other sea users through the following pathways:

- By precluding their use due to the establishment of one 500 m radius safety zone implemented around the MODU during drilling operations and maintained around the FPSO for the life of the field;
- By increasing the vessel collision risk associated with the increasing vessel traffic in the Development area; and
- By introducing snagging points for fishing gear through the presence of the gas export pipeline and subsea facilities on the seabed and in the water column and through the potential introduction of dropped objects.

Based on the information presented in Chapter 3 Project Description, Table 8-1 presents the key activities that have potential to impact on other sea users.

Table 8-1 Summary of activities with the potential for interaction with other sea users

Phase of development	Potential for interaction
Drilling	Presence of MODU and support vessels
Installation of subsea facilities	Presence of installation and support vessels Wet storage of mooring lines on the seabed
Installation of gas export pipeline and associated infrastructure	Presence of installation (pipelay) vessel and support vessels
Installation of FPSO	Presence of installation vessels, FPSO and support vessels
Operation of Development infield facilities	Presence of FPSO, support vessels, intervention vessels (including Heavy Well Intervention Vessel (HWIV) and MODU) and subsea facilities
Operation of gas export pipeline and associated infrastructure	Presence of gas export pipeline, associated infrastructure and pipeline protection

8.2 Regulatory Controls

Regulatory frameworks guide management measures in the mitigation of impacts to other sea users from the Development. Please note that specific management and mitigation measures are included in Section 8.4. The following legislation is key in relation to the assessment of interactions with other sea users:

- Marine and Coastal Access Act (MCAA) 2009: The MCAA 2009 provides for navigational safety and risk management in UK waters. Section 77 of the MCAA 2009 excludes oil and gas activities that relate to oil and gas exploration and production for which a licence under Part 4 of the Energy Act 2008 is required (see below);
- Energy Act 2008 Part 4A Consent to Locate: Consents to Locate (CtL) under Part 4A of the Energy Act 2008 will be sought as required. The granting of a CtL allows the installation of an offshore structure or the carrying out of offshore operations providing they are undertaken in accordance with the consent conditions. A Vessel Traffic Survey (VTS) report, collision risk assessment with associated collision risk management measures will support the CtL applications, alongside information on any proposed aids to navigation and any other navigational mitigation measures;
- International Regulations for the Prevention of Collisions at Sea 1972 (COLREGS): These regulations contain provisions to prevent vessel collision that vessels must abide by; and
- Petroleum Act 1987: The Petroleum Act 1987 governs the establishment of offshore safety zones, including statutory safety zone, established to protect the asset as well as other sea users. A 500 m surface safety zone is established automatically around surface installations.

In addition to the above, under Part 5, Chapter 7 of The Common Fisheries Policy and Aquaculture (Amendment etc.) (EU Exit) Statutory Instrument (S.I.) 2019 No. 753 there is a ban on the use of all bottom-contacting mobile gear below 800 m depth across all UK waters. This applies to the Development and along the lengths of the pipeline below this depth. As such, there will be no specific overtrawlable protection installed around wellheads and other structures within the field as it is assumed no fishing gears will come into contact with the seabed at this depth. Part 5, Chapter 7 of The Common Fisheries Policy and Aquaculture (Amendment etc.) (EU Exit) Statutory Instrument (S.I.) 2019 No. 753 also implements restrictions on fishing between 400 m and 800 m where Vulnerable Marine Ecosystems (VMEs) are present or are likely to occur. While the sponge habitats within the Faroe-Shetland Sponge Belt NCMPA would constitute a VME, restrictions are not equivalent to a ban and therefore it is assumed demersal fishing will occur to a depth of 800 m. All in-field flowlines will be surface laid. Thus, overtrawlable protection will only be utilised as part of the Development at depths less than 800 m.

8.3 Discussion of Potential Impacts - Interaction with Other Sea Users

8.3.1 Commercial Fisheries

As described in Chapter 4 Environmental Baseline most fishing activity in the Rosebank Development takes place in shallower waters across the continental shelf and towards the Shetland coastline, where the southern sections of the gas export pipeline will be located. Very low effort levels and catch tonnage are recorded in the Faroe-Shetland Channel, where the Rosebank infield area will be located. Based on the information presented within Chapter 4 Environmental Baseline, the fishing effort in the vicinity of the Development is dominated by demersal trawls, with effort also recorded by hooks and lines and seine nets. It is acknowledged that fishing patterns may change over the lifetime of the Rosebank Development. The nature of this change is uncertain, however, it could be expected that colder water species may move to deeper, colder waters. Impacts on the physical and biological environment may also affect human activities in the marine environment. For instance, any impacts on fish stocks will indirectly impact commercial fishing activity, potentially reducing the abundance of species or altering species composition. However, determining the causal factors for these changes is difficult when other factors also influence fish stocks (Pinnegar *et al*., 2020). Nevertheless, it is generally considered that the assessment provided here would be applicable for future changes in fishing patterns.

The Development has the potential to interact with commercial fishing vessels through the:

- Presence of MODU, FPSO, installation, support vessels and intervention vessels resulting in increased vessel traffic and collision risk;
- Exclusion of fishing vessels from areas of sea and seabed that could be used for fishing activities;
- Introduction of snagging points, such as the mooring lines and anchors associated with the FPSO, the gas export pipeline (especially if free spans occur), the subsea facilities; and
- Potential for any dropped objects.

A description of these potential impacts is provided in the sections below. The risks relating to vessel collision risk are considered to be analogous to those for other vessel types. Therefore, the assessment of this impact has been included in Section 8.3.1.5 to avoid duplication.

8.3.1.1 Temporary and Permanent Exclusion

The following sections provide a summary of the potential temporary and permanent exclusion associated with the various phases of the Development. A summary of the assessment of these impacts is then provided.

Drilling operations

As described above, a temporary safety zone with a radius of 500 m will be applied around the MODU whilst it is on site at each well location in order to minimise the risk of collision with the installation and prevent loss of fishing gear. Therefore, whilst the MODU is on site, fishing activity will be excluded from the safety zone, i.e., an area of 0.8 km^2. Wells will be drilled sequentially, and it is therefore expected that only one safety zone in place at any one time. Other installation and support vessels involved in drilling activities will be covered by the safety zone that will be in place around the MODU.

Installation of subsea facilities

The FPSO mooring anchors and chains will also be wet stored on the seabed temporarily whilst awaiting connection to the FPSO. Safety zones will not be implemented around the risers and mooring anchors and chains when they are wet stored. An Emergency Response and Rescue Vessel (ERRV) will be present and the details of the wet storage will be communicated through relevant channels (e.g. Kingfisher bulletin). Although there will be no statutory restrictions on fishing activity within this area, it is acknowledged that the presence of these structures on the seabed and in the water column could pose a safety risk to fishing vessels. Thus, access to fishing may be restricted during this time due to the potential safety risk posed by structures within the water column and unprotected on the seabed. The presence of installation and support vessels may also temporarily displace vessels, although this would be limited to the immediate vicinity of the vessels and on a temporary basis only.

Installation of gas export pipeline and associated infrastructure

The presence of installation vessels for the gas export pipeline may temporarily displace fishing vessels. This would be in the immediate vicinity of the installation vessels that will be travelling along the proposed gas export pipeline route. Therefore, the nature of displacement will be transient and highly localised.

Installation of FPSO

Once the FPSO is on site, a 500 m safety zone will be applied, excluding fishing vessels from a 0.8 km^2 area. The safety zone around the FPSO will extend from the extremities of the centre of the turret. Installation vessels will be on site to connect the risers and mooring lines to the FPSO. The presence of vessels may temporarily displace fishing activities; however, it is expected that the installation vessels will be covered by the 500 m safety zone.

Operation of Development infield facilities

Throughout the life of the Development, fishing vessels will not be able to enter the safety zone around the FPSO. The 12 mooring anchors and chains for the FPSO will extend out to approximately 2 km from the FPSO and will be outside the safety zone, meaning there may also be a permanent loss or restriction of access to this area during operation.

Operation of gas export pipeline and associated infrastructure

No safety zone will be implemented along the gas export pipeline, with the exception of those already in place for Clair Tee Once the installation and support vessels have moved out of the area, there will be no statutory restrictions on fishing in the vicinity of the gas export pipeline for the lifetime of the Development. Sections of the pipeline requiring remediation works may remain temporarily unprotected; these will be monitored by guard vessels that will remain on site until remediation works start.

Summary of assessment

Fishing effort in the Development infield area, which encompasses the areas of exclusion or restricted access associated with the MODU, FPSO, mooring lines and anchors and risers, is low. Any exclusion during the drilling operations, the installation of subsea infield facilities and the installation of the FPSO will be spatially limited and there will be no significant impact from temporary or permanent exclusion in this area. Furthermore, as demersal trawling is prohibited within water depths greater than 800 m in Scotland, these exclusions are relevant only to vessels operating other types of gear (e.g. pelagic trawlers which sometimes fish close to the seabed, see Section 8.3.1.2).

Fishing effort is higher along the Rosebank gas export pipeline to Clair Tee, as described in Chapter 4 Environmental Baseline. However, any restricted or loss of access to fishing grounds will mostly be temporary in nature during installation (lasting approximately 64 days plus waiting on weather time) and within the immediate vicinity of the pipeline installation vessels only, representing a very small area of the available fishing grounds in the area. During the operation of the gas export pipeline, at depths greater than 800 m, the pipeline will be trenched and backfilled where possible to minimise any loss of fishing grounds. Where this is not possible, an overtrawlable berm will be laid atop of the pipeline. Considering this, once operational, no exclusion of fishing activities is expected in relation to the gas export pipeline.

8.3.1.2 Snagging Risk

Fishing gear, such as nets, can become trapped on subsea equipment, resulting in loss of fishing gear or potentially posing a threat to the safety of the fishing vessel and the crew, or damage the asset, potentially resulting in oil spills to sea (the impact of which is discussed in Chapter 11 Accidental Events). Snagging of fishing gear can occur where structures are laid or fixed on the seabed, such as the in-field subsea infrastructure, in association with structures in the water column (e.g. risers and mooring lines) and along the gas export pipeline (e.g. protrusions from the gas export pipeline (e.g., joint ties), where debris has accumulated against the gas export pipeline, or where a gap exists underneath the gas export pipeline (free span)). Free spans occur where there are areas of hard or uneven seabed, or where strong currents have caused scour beneath the gas export pipeline. Fishing gear can also snag on or be damaged by collision with subsea structures such as gas export pipeline tees. Snagging should not occur within the safety zone around the FPSO; however, subsea structures outwith this zone may pose a snagging risk. Additional snagging risks may arise from the mooring lines which extend outwith the safety zone around the FPSO.

Installation vessels and the MODU will use dynamic positioning (DP) to maintain position, and therefore, there will be no anchoring required for these vessels, with no potential for anchor mounds to present a snagging risk following the well drilling and pipeline installation works.

Operation of Development infield facilities

Fishing effort within the Development area is low and VMS data indicates that there is no demersal trawling over the Development infield area, as result of the prohibition of bottom trawling in depths greater than 800 m. Thus, any snagging risks associated with this area are expected to be minimal. Water depths at the Development infield area exceed 800 m out to 21.2 km southeast of the FPSO. This will likely limit snagging risk by demersal trawlers associated with the risers and the FPSO mooring lines and suction pile anchors. There may be snagging risks for pelagic trawlers associated with the presence of mooring lines (composed of chain and polyester rope) and risers which are suspended in the water column, as their gear may become entangled in these structures. However, adequate charting, including the FPSO any moorings and the gas export pipeline, and communication with the fishing industry, through standard communication channels (such as Kingfisher) will reduce any potential snagging risk. An ERRV standby vessel will also be on location.

Operation of gas export pipeline and associated infrastructure

It is expected that the greatest snagging risk would occur along the eastern section of the Rosebank to Clair Tee pipeline, as soon as water depths are less than 800 m, approximately 21 km distance from the FPSO. This section of the pipeline is associated with moderate levels of demersal trawling activity. As described in Chapter 2.1 Project Description, at water depths of less than 800 m, the pipeline will be either trenched and backfilled or surface laid with an overtrawlable protection laid on top of the pipeline. The valve structures at the connection point on WOSPS at Clair Tee will also be located within an existing permanent safety zone, which already prohibits fishing activity within this area, minimising any potential snagging risk.

Trenching will be conducted immediately after pipe lay so guard vessels will not be required. Trenching berms could be formed by cohesive clay sediments, which are most likely to generate resistance to fishing gear (Rouse *et al*., 2020). The sediments in the Development infield area are classified as fine sand and silt and sediments along the gas export pipeline ranged from were classified as mud and sand to sand with patches of pebbles and boulders (DNV, 2022). The muddy sediments along the gas export pipeline, predominantly located towards the Development infield area may consist of clay sediments. [HOLD – awaiting survey data along pipeline route to be analysed]. Berms formed in clay sediments are likely to persist for longer, while features formed in sand are expected to be re-worked by the currents more quickly. Notably, the stations interpreted as mud are mostly located at depths greater than 800 m, and therefore, as a result of the prohibition of bottom trawling in this area, present a limited snagging risk. Sandy sediments are expected to provide little resistance to demersal towed gear which is likely to be able to pull through the sediment and wash out.

There is the potential for free spans on the gas export pipeline to arise, presenting a snagging risk to demersal fishing gear. A final survey will be undertaken of the infrastructure prior to the installation vessels leaving the field to confirm location and as-built status. Regular pipeline route inspection surveys will be undertaken to assess pipeline conditions, including free spans, and subsequently rectify accordingly.

Summary of assessment

Overall, considering the low levels of fishing effort throughout the Development area combined with the management procedures and mitigations proposed, such as adequate charting of infrastructure, the risk of snagging is considered to be low. Furthermore, Rouse *et al*., (2020) showed that the frequency of snagging events resulting in financial loss, vessel abandonment and/or crew injury or fatality in the North Sea drastically declined (by 98.6%) between 1989 and 2016 and is more likely to occur with older assets. This decline is most likely related to improved Global Positioning Systems (GPS) and communication / data sharing (Rouse *et al*., 2020). No local information on potential the snagging events occurring in the vicinity of the Development has been acquired, as there is limited infrastructure in the region. As described in Chapter 4 Environmental Baseline, demersal trawling along pipelines in the vicinity of the Rosebank Development is low, with the exception of an area of higher effort along the pipelines between Sullom

Voe and Tormore. The relatively low demersal trawling effort along nearby pipelines further indicates that the snagging risk associated with the Development will be low.

8.3.1.3 Dropped Objects

There is also the potential for objects to be lost overboard during installation activities. This debris, termed 'dropped objects', can provide uncharted obstacles that have the potential to damage fishing nets and fishing catch through snagging. Dropped objects of significant size or hazard potential (which would normally be recovered) are not expected to pose a serious hazard to fishing activity in the deep waters west of Shetland, again due to the lack of fishing activity and the prohibition of bottom trawling at depths greater than 800 m. Any dropped object with the potential to pose a significant hazard to other users will also be reported through the (Petroleum Operations Notice) PON 2 reporting process.

8.3.1.4 Shipping - Including Vessels Associated with Nearby Assets

Compared to shipping levels in the English Channel and the North Sea, shipping levels in the north - west of Scotland are relatively low and reported shipping activity in the vicinity of the Development is negligible to low (OGA, 2017). The most likely vessels to be affected by the Development, detailed in Chapter 4 Environmental Baseline, would be commercial vessels that transport to and from Sullom Voe Terminal and transit vessels that cross the Atlantic Ocean. The results of a VTS for the Development area, undertaken in 2019 for the Rosebank Metocean buoys indicate that vessel traffic within the vicinity of the Development infield area is low, although there are some shipping lanes present, which is primarily used by cargo, tankers and other shipping vessels. There were also supply and safety vessel tracks within the Development area which are associated with oil and gas activities (Xodus Group, 2019). As noted in Chapter 4 Environmental Baseline, there are several oil and gas assets within the vicinity of the Development, including nine producing fields in the region. AIS data available through EMODnet indicates that the areas of higher shipping activity are associated with offshore facilities (EMODnet, 2022). The Innovation and Targeted Oil and Gas (INTOG) search areas WoS-a and WoS-b also overlap with the Development infield and gas export pipeline, respectively.

The Development has the potential to interact with commercial shipping and vessels associated with nearby oil and gas activities through the:

- Presence of MODU, FPSO, installation and support vessels resulting in increased vessel traffic and collision risk; and
- Exclusion of vessels from areas of sea, resulting in increases in steaming times.

As the impacts to shipping, oil and gas activities and offshore renewables are considered to be similar in nature, the impacts to these receptors are discussed together in the sections below.

8.3.1.5 Increased Vessel Traffic and Collision Risk

The presence of installation and support vessels will result in an increase in the level of vessel activity, especially during the drilling operations and installation of subsea facilities and the gas export pipeline. Increased vessel presence may interfere with other shipping activities and increase the risk of vessel collision. Details of vessel requirements during each stage of the Development are provided in Chapter 3 Project Description.

Drilling operations, installation of subsea facilities and installation of FPSO

The greatest increase in vessel presence in the Development infield area will be during drilling operations and installation of subsea infrastructure. However, any discernible increase in vessel presence in the area will be temporary in nature. The temporary 500 m safety zone in operation around the MODU will minimise the potential for collision risk between the MODU and third-party vessels.

During the installation phase of the project unconnected risers and moorings may be temporarily exposed. In these instances, an ERRV will be on site to monitor the traffic and the collision risk is expected to be minimal.

Installation of gas export pipeline and associated infrastructure

During pipeline installation, vessel presence will be temporary and limited to the duration of the pipeline installation works (approximately 64 days plus waiting on weather time). The vessels will be moving along the pipeline route, and therefore, will not be in any one area for any significant length of time. Notifications to other sea users through Kingfisher will be issued to communicate the location of the works.

Operation of Development infield facilities

Following successful installation, vessels will be required as part of routine operations and maintenance, although vessel traffic will be considerably lower than during installation. Once operational, there is expected to be approximately 500 offloads during the life of field. During the first 5 years, an offload is expected every 7-10 days with this declining over the lifetime of the field. During offload, an in-field ERRV will be on location. Well interventions may also be carried out by a MODU or HWIV, which will temporarily increase vessel presence in the Development infield area.

Operation of gas export pipeline and associated infrastructure

Prior to first gas being exported, flooding, cleaning, gauging, hydrotesting, leak testing and de-watering of the gas export pipeline is planned, using a support vessel over 20 days. This will temporarily increase vessel traffic in the region. The gas export pipeline will be subject to routine inspections and maintenance. However, any increased vessel traffic will be temporary.

Summary of assessment

There is ample sea space for vessels to route any vessels associated with the Development and a low volume of vessel traffic in the area. Combined with the temporary nature of any increased vessel traffic during drilling and installation and the limited vessel requirements during operation, increased vessel traffic will not have a significant impact on other sea users.

8.3.1.6 Temporary and Permanent Exclusion

The nature of the temporary and permanent exclusion through the various phases of the Development are described in Section 8.3.1.1 in relation to commercial fisheries and is only summarised below to avoid duplication.

Drilling operations, installation of subsea facilities and installation of FPSO

During the drilling works, vessels will be temporarily excluded from the 500 m temporary safety zone applied around the MODU. The safety zone around the MODU will be in place from the day the MODU is in place to the day it leaves the field. Access for shipping may also be obstructed as a result of the wet storage of the mooring lines during installation.

Installation of the gas export pipeline and associated infrastructure

The presence of installation vessels for the gas export pipeline may temporarily displace vessels, in the immediate vicinity of the installation works. The installation vessels will be travelling along the proposed gas export pipeline route, so the nature of any displacement will be transient and highly localised.

Operation of the Development infield facilities

During operation, vessels will be permanently excluded from the 500 m safety zone applied around the FPSO, and vessels may be required to route around mooring lines and risers as they may act as an obstruction to vessel traffic.

Operation of gas export pipeline and associated infrastructure

No safety zone will be implemented along the gas export pipeline, and therefore, any obstruction to vessels will be associated with vessels undertaking maintenance, which will be intermittent and on a temporary basis.

Summary of assessment

Vessel traffic within the Development area is low and given the small area that will be excluded and the limited infrastructure in the region, this assessment considers there to be sufficient sea-space for vessels to avoid the Development without significant alterations to routes.

8.3.2 Telecommunication Cables

The Rosebank gas export pipeline to Clair crosses the SHEFA-2 telecommunications cable, an unnamed cable and the FARICE telecommunications cable.

At crossing points with cable infrastructure, there is the possibility of disruption or damage to the third-party asset. Crossing arrangements will consist of concrete mattresses to protect the pipeline and the third-party assets, as described in Chapter 2.1 Project Description.

8.4 Management and Mitigation – Interactions with Other Sea Users

Design

- The gas export pipeline, associated subsea facilities and rock protection will be designed to be overtrawlable in water depths shallower than 800 m (where the greatest concentration of fishing occurs); and
- Where practicable, gas export pipeline routing will be refined during Detailed Design to reduce the potential for free spans, which may pose a potential risk of snagging fishing gear. Unavoidable spans that present a potential hazard to fishing will be rectified (e.g., by rock placement).

Planning, Assessments and Procedures

- Lift planning will be undertaken to manage risks during lifting activities, including the consideration of prevailing environmental conditions and the use of specialist equipment where appropriate. Lifting equipment will be tested and certified as per UK regulations;
- Crossing and proximity agreements will be in place with operators of any crossed pipelines or cables prior to installation;
- A dropped object protocol will be developed to reduce the risk of dropped objects from installation vessels;

- Procedures will be put in place to make sure that the location of any lost material is recorded and that significant objects are recovered where practicable, including by carrying out dropped object surveys at appropriate points through the Project life cycle;
- Training and awareness will be provided to installation contractor, and that there is a need to promote good housekeeping aboard installation vessels to minimise drops;
- A dropped objects risk assessment will be carried out with a suite of appropriate control measures;
- A VTS, CRA and collision risk management plan will be prepared to support the CtL applications; and
- A Simultaneous Operations (SIMOPS) plan will be developed if another activity is taken place at the location at the same time.

Marking and Communication of Presence

- The FPSO will be equipped with Aids to Navigation as per the BEIS Standard Marking Schedule for Offshore Installations and vessels will be marked and lit as per the International Regulations for the Prevention of Collisions at Sea 1972 (COLREGS);
- Information on the location of subsea infrastructure, FPSO suction pile anchors and mooring chains, vessel operations, and the timeline for any works associated with the Development will be communicated to other sea users via the United Kingdom Hydrographic Office (UKHO), FishSafe, Maritime and Coastguard Agency (MCA), Kingfisher, Notices to Mariners and Radio Navigation Warnings. These notifications will be provided with advanced notice to ensure they are distributed to other sea users in advance of any works. The UKHO and MCA will be notified at least 48 hours in advance of the commencement of works and Kingfisher and local operators will be informed with at least two weeks notice;
- The FPSO will have vessel tracking systems linked to the control room in addition to an attending ERRV which will monitor and communicate with vessels engaged in fishing in close proximity to any hazard;
- The Equinor Marine Operations centre will remotely monitor vessel traffic around the field;
- A temporary safety zone of 500 m will be implemented around the MODU whilst on location; and
- A permanent safety zones of 500 m will be implemented around the FPSO.

Fisheries Consultation and Liaison

- Consultation will be undertaken with relevant authorities and organisations with the aim of reducing potential interference resulting from Project activities as far as practicable. Consultation has already taken place with the Scottish Fishermen's Federation to inform the ES;
- Equinor will continue to engage with the fishing industry throughout the lifetime of the field through standard communications channels; and
- A fisheries representative may be onboard the pipelay vessel during relevant parts of the installation of the gas export pipeline, recognising that fishing activity is low in deep water and therefore a fisheries liaison officer may not be required in certain areas.

Vessel Use

- During installation the number of vessels and length of time they are required on site will be reduced as far as practicable through careful planning of the installation activities; and
- An ERRV will be present in the Development infield area during drilling and installation to protect subsea facilities, infield flowlines and risers and ensure safety of fishing and other vessels operating near the area. A separate ERRV will be on site at the FPSO during operation.

Monitoring and Maintenance

- Dropped object surveys will be carried out at appropriate points through the project life cycle (including following the completion of drilling activities) and reported to OPRED; and
- Regular maintenance and gas export pipeline route inspection surveys based on the condition will be undertaken, checking for lack of cover, free-spans and evidence of interaction with fishing equipment will be carried out. Once the results of the initial inspection surveys are available the frequency of these surveys will be reviewed by the Integrity Management team and Pipeline Technical Authority within Equinor, and also by the relevant assurance body.

8.5 Cumulative and Transboundary Impacts

The Development will be the first oil field in the Faroe-Shetland Channel. The nearest surface infrastructure to the Rosebank FPSO include BP's Clair and Clair Ridge platforms, which are located along the continental shelf and approximately 70 – 75 km southeast of the Development infield area and the Glen Lyon and Foinaven FPSOs, approximately 75 km southwest of the Development infield area. Siccar Point Energy, now part of Ithaca SP E&P Limited, submitted an environmental statement in 2021 for the drilling of eight new wells and the installation of an FPSO and gas export pipeline at the Cambo field, which would be located approximately 34 km southwest from the Development infield area. Offshore development activities were due to commence in 2021. However, in December 2021, the company announced that the original timescales of the Cambo project were not achievable and that the development is postponed until the next steps can be evaluated (OPRED, 2022). It is possible that the Development construction activities may overlap with those of the Cambo oil field and as such there may be an increase in vessel activity in the area resulting in an increase in collision risk or an increase in the number of simultaneous or sequential safety zones. This could lead to fishing vessels in the region being excluded from two nearby areas simultaneously. However, given the low levels of fishing effort recorded in the vicinity of the Development and the Cambo development, and the temporary nature of the installation activities, it has been assessed that there it is not likely that there would be a significant cumulative impact on the local commercial fisheries and shipping activity. There are also not anticipated to be any overlapping safety zones (either simultaneously or sequentially) with other developments.

There are also several pipelines in the vicinity of the Rosebank gas export to Clair Tee associated with nearby oil and gas developments, and the Rosebank gas export pipeline to Clair Tee crosses telecommunication cables, including FARICE Telecom, an unnamed cable and SHEFA-2. The nearby oil and gas assets include the aforementioned Clair and Clair Ridge platforms, which are located 10 and 5 km from the gas export pipeline, respectively. In addition to the subsea infrastructure associated with the Laggan-Tormore fields, are approximately 5 km northeast of the gas export pipeline and the West of Shetland Pipeline (WOSPS). The Rosebank gas export pipeline will tie into at the Clair Tee junction on the WOSPS pipeline. In relation to the potential for cumulative impacts from the presence of seabed infrastructure, the measures which are to be put in place will allow the gas export pipeline and other infrastructure to be over-trawlable, and thus reduce snagging risks. Given that the gas export pipeline is to be installed in an area where there is limited other seabed infrastructure (other than the WOSPS), it has been assessed that the gas export pipeline is unlikely to lead to a cumulative impact that is any greater than the non-significant impact identified in this assessment.

Other developments will also utilise vessels which have the potential to act cumulatively in increasing vessel collision risk. As mentioned in Chapter 4 Environment Baseline, shipping and general vessel traffic is considered low in the area, with localised areas of higher shipping activity around the Clair and Clair Ridge platforms. As the Development is located within the open sea and increased vessel traffic will be temporary, limited to the installation, and maintenance and decommissioning activities, it should not act in combination with any other existing projects to increase collision risk.

In the future, decommissioning of nearby installations could also generate increased vessel presence. With regards to immediate activities, which are temporally limited, there are not likely to be any cumulative impacts associated with the Development. Given the small potential for snagging risks to arise and dropped objects to occur, it is considered that the chance for cumulative impact relating to these hazards is negligible.

The Rosebank FPSO is located 17 km away from the UK-Faroe boundary line. As such this area is expected to experience above average levels of fishing by non-UK vessels when compared to coastal locations around the UKCS. The SFF has been consulted on the importance of the Development area for non-UK fleets and will continue to be consulted with to understand the most appropriate communication channels to notify non-UK vessels of the works.

The area which will be lost to fisheries represents a small fraction of the total sea available for both fisheries and shipping. Furthermore, non-UK fishing vessels will be made aware of the Development through adequate charting of infrastructure. Vessel tracking systems will be in place at the FPSO control centre and will be able to monitor fishing activity and communicate with vessels engaging in fishing in proximity to subsea hazards, assuming that all such vessels are suitably fitted with tracking systems. An attending ERRV will also monitor and warn any vessel which looks likely to be fishing in close proximity to any subsea hazard.

On this basis it is considered that there will be no significant cumulative and transboundary impact on other sea users.

8.6 Decommissioning

Any potential impacts as a result of decommissioning operations (e.g., removal of the Development subsea infrastructure) will occur in the area that experienced disruption / obstruction during drilling, installation operations and within the operation and maintenance phase.

The majority of the potential impacts and the suggested mitigation and management relating to physical presence of the Development will be the same as has been described for installation. It is anticipated that infrastructure will either be fully or partially removed. If not all of the infrastructure is removed at decommissioning, then there are likely to be fewer activities/vessels present to cause physical presence impacts compared to the drilling and installation phases of the Development. The majority of potential impacts will be of a similar or lesser magnitude than the effects already described above. Any infrastructure left *in situ* or rock placement made, will be surveyed for potential snagging risks and mitigated accordingly. Prior to the end of field life, there may be changes to the statutory decommissioning requirements as well as advances in technology and knowledge. Equinor will aim to utilise recognised industry standard environmental practice during all decommissioning operations in line with the legislation and guidance in place at the time of decommissioning.

8.7 Residual impacts – Interactions with Other Sea Users

Commercial fisheries

Interactions between fishing vessels and installation and support vessels within the Development infield area both during installation and operation are unlikely to be a significant issue due to the low frequency of fishing activity within the area as described in Chapter 4 Environment Baseline and summarised in Section 8.3.1. In addition, the number of fishing vessels passing through the area (i.e., not fishing) is also very low (Anatec, 2013) and therefore any additional vessels related to the Development are unlikely to cause significant interference or displacement of vessels.

Fishing activity varies from very low at the Development infield area to its highest level along the shelf edge to the west of Shetland, relevant to the gas export pipeline. The suction pile anchors and lines for the FPSO moorings and for the risers will be outside the FPSO 500 m safety zone and therefore fishing activity will have the potential to interact with these structures. However, these are located in water depths of greater than 800 m where bottom trawling is prohibited. Gear snagging on subsea infrastructure and the FPSO moorings is therefore not expected and the subsea infrastructure in this area will not require any additional protection.

The sensitivity of fisheries to the Development is considered to be low, as the fishing industry has the ability to tolerate the change. Furthermore, the levels of activity across the Development where permanent exclusion will occur is low and no permanent exclusion is expected across the Development gas export pipeline to Clair Tee where fishing effort is higher. The vulnerability of commercial fisheries is considered to be low as the area of permanent exclusion is small in the context of available fishing area. The value of the receptor is considered to be medium as the effort in the area is considered to range from low to moderate across the Development, however the installation forms a small part of a much larger area available for fishers i.e., there is flexibility to utilise other areas. The magnitude of the impact is considered to be minor as any impact will be localised and largely of a short-term nature. Consequence is therefore low, and impact not significant.

Shipping – including vessels associated with nearby assets

The area experiences low vessel traffic so the risk of collision due to Development vessel presence is low. Shipping is also capable of accommodating short-term interference and therefore sensitivity is low. Vulnerability is also considered low as even though behaviour may have to change short-term, it is considered the Development will not cause any long-term changes to shipping within the area, as there is considered to be sufficient sea space for vessels to avoid the Development without significant alterations to routes. The value of shipping is considered low given the level of activity in the area. The magnitude is also considered to be minor as the Development drilling, installation and commissioning activities are temporary in duration and so limited in extent. The operational phase of the Development will be much less likely to impact shipping in the region. Consequence is therefore low, and impact not significant.

Although the Development will be located within relatively close proximity to a number of oil and gas developments, vessel activities associated with these developments should be able to tolerate the small area of exclusion associated with the MODU, FPSO, subsea infrastructure and increased vessel activity. However, the nature of oil and gas developments is considered relatively sensitive thus the overall sensitivity is considered medium. There are not thought to be any long-term impacts on oil and gas developments in the area, beyond the 500 m safety zone around the FPSO and any associated obstruction from the mooring lines and risers, and therefore, the vulnerability is considered low. The value of the receptor is considered low given the distance between the existing oil and gas activities and the Development will not impact the operational functionality of the industry. The magnitude of the impact to oil and gas developments from the Development is minor given the temporary and short-term nature of the disruption. Consequence is therefore low, and impact not significant.

There is no existing offshore renewable infrastructure in the vicinity of the Development. However, the Development is located within the INTOG area WoS-a and WoS-b, representing an area targeting oil and gas decarbonisation or for generating offshore wind projects of > 100 MW. Offshore renewables are considered to have the same sensitivity, vulnerability, value and magnitude as oil and gas developments.

Telecommunication Cables

The gas export pipeline route crosses telecommunications cables. However, telecommunications cables are considered to be highly tolerant of a small area of temporary exclusion associated with the installation works and increased vessel activity, as typically, only infrequent access to these assets is required. Furthermore, cable and pipeline crossings are common in the North Sea, and therefore, sensitivity is considered to be low. There are not thought to be any long-term impacts on telecommunications cables in the area. Any crossings with the telecommunications cable will also be in agreement with the relevant asset operator. Therefore, vulnerability is low. Given the proximity of the telecommunications cable and the gas export pipeline, the value is considered to be medium. The magnitude of the impact from the Development is minor given the temporary and short-term nature of the disruption. Consequence is therefore low, and impact not significant.

9 ATMOSPHERICS AND CLIMATE

9.1 Introduction

This chapter addresses the environmental impacts associated with emissions to atmosphere during the installation and operation of the drilling and production facilities and subsea infrastructure. These include emissions resulting from fuel consumption by the FPSO (e.g. for power generation) and the MODU during drilling activities, subsea infrastructure installation, flaring and venting[38], and transport fuel (e.g. for installation vessels, supply vessels and helicopters).

A number of gases are emitted to the air during production operations. The assessment considers the following gases: carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_x), nitrous oxide (N_2O), sulphur dioxide (SO_2), methane (CH_4), and non-methane Volatile Organic Compounds (nmVOC).

This chapter quantifies the emissions anticipated as a result of installation activities and subsequent operations in the field and assesses the potential impacts of the quantified emissions.

A list of the activities at the Development that will result in emissions to atmosphere is presented in Table 9-1, and the sources of atmospheric emissions and their potential impacts are presented in Table 9-2.

Table 9-1 List of the planned activities at the Development contributing to atmospheric emissions

Operation	Activity	Source of emissions
Drilling and completions	Power generation for drilling rig operation	Combustion of diesel for power generation on drilling rig
	Support vessels i.e. supply and emergency response and rescue vessel (ERRV), and helicopters	Transport fuels
Installation and commissioning of the FPSO, subsea infrastructure and gas export pipeline	Anchor handler vessel (FPSO), pipelay vessel, heavy lift vessel, construction support vessel and ROV support vessels.	Transport fuels
	Support Vessels i.e. supply and helicopters	Transport fuels
Commissioning	De watering of gas export pipeline	Non routine flaring
Well clean-up	Well clean-up back to the FPSO with reduced setpoint in test separator	Non routine flaring
FPSO operations	Power Generation for production operations	Routine: Combustion of fuel gas in dual fuel turbines. Non-routine: Combustion of diesel in dual fuel turbines and emergency generators and fire pumps.

[38] There will be no routine flaring and venting on the FPSO. See Chapter 2 Consideration of Alternatives chapter for more information.

Operation	Activity	Source of emissions
	Hydrocarbon Processing	Non-routine flaring (only for de-pressurisation during plant upsets)
	Hydrocarbon Processing	Venting (pressure release during maintenance, start-up and process upsets)
	Hydrocarbon Storage	Vapour from the FPSO storage tanks. will be normally mitigated by a VOC recovery unit, but some limited venting may occur during abnormal operating conditions such as equipment downtime.
	Tanker Loading	Vented NMVOCs and methane from the transfer of crude oil from FPSO to shuttle tankers
	Support vessels - i.e., ERRV, supply, maintenance, well intervention vessels and helicopters	Transport fuels

Quantification of gaseous emissions used for the impact assessment was based on engineering estimates of fuel consumption and generic emission factors (UK Environmental and Emissions Monitoring System (EEMS) [39]. For the climate change impact assessment, the global warming potentials (GWP) used to convert gaseous emissions to their carbon dioxide equivalent (CO_2e) were those defined in the IPCC Sixth Assessment Report, AR6 and AR5 (based on a 100-year horizon).

Table 9-2 Environmental effects of emissions and 100 year GWP (where relevant)

Gaseous emission	Environmental effects	100 year GWP factor
Carbon dioxide	Contribute to climate change	**1**
Methane	Regional-level air quality deterioration through low-level ozone production, which can be detrimental to health and can potentially impact vegetation, crops and ecosystems Contribute to the global GHG emission load and climate change	**29.87**
Nitrous oxide	Contribute to climate change	**273**
Carbon monoxide (CO)	Has an indirect effect on climate change	**1.6**
Sulphur oxides (SO_x)	Precursor to acid deposition	**n/a**
Nitrogen oxides (NO_x)	Precursor to acid deposition Forms ozone in the presence of sunlight	**n/a**
Non-methane volatile organic compounds (NMVOCs)	Reacts with NOx in the atmosphere to form ozone in the lower atmosphere, further contributing to the global GHG emission load and climate change	**5.6**

[39] EEMS Atmospheric Emissions Calculations (OGUK, 2008).

In addition, the concentration of local air quality emissions was compared with the requirements of the UK Air Quality Standards (AQS) to assess the potential magnitude of impact on human health and environmental receptors. These results are presented in Section 9.4.

Initiatives that are discussed in this chapter, or already embedded within the operating function of the FPSO, are summarised in Figure 9-1.

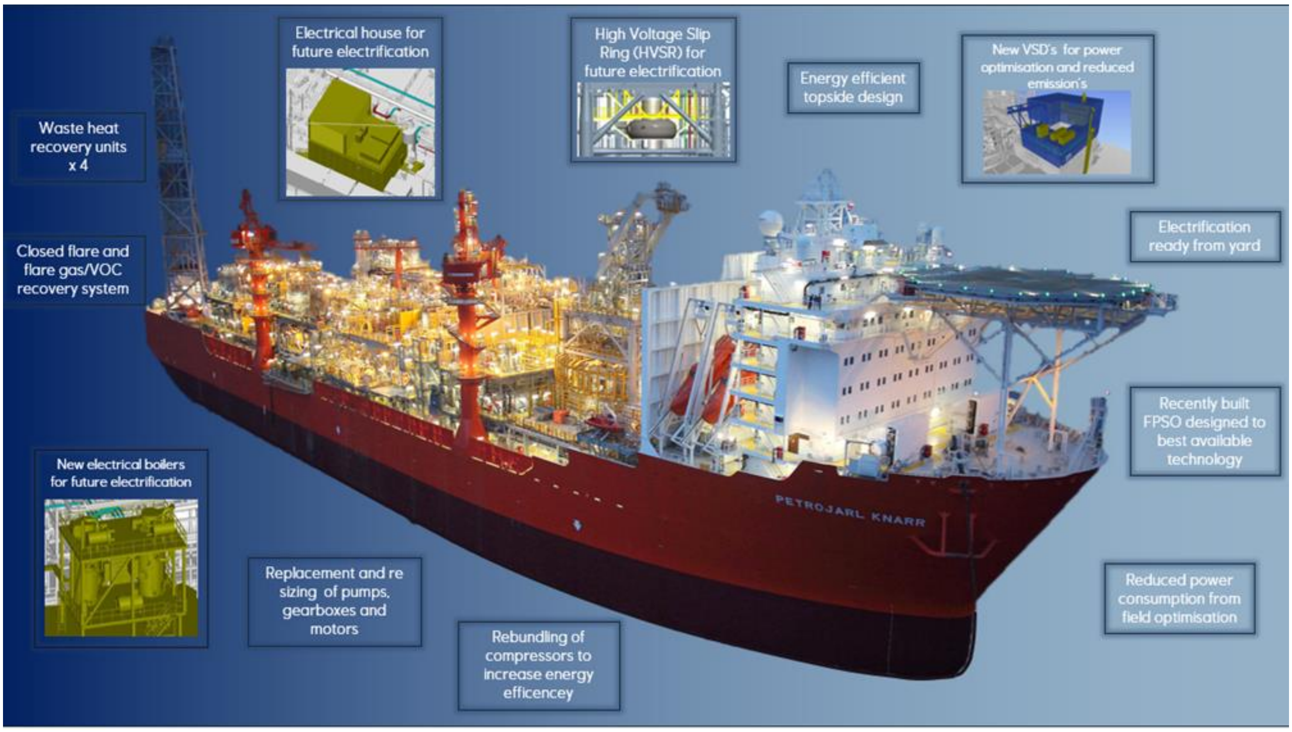

Figure 9-1 FPSO net zero initiatives

9.2 Regulatory Controls

9.2.1 Environmental Regulations

Atmospheric emissions from combustion activities from offshore oil and gas operations on the UKCS are controlled by specific regulations. Emissions to atmosphere must be monitored and reported, and, in the case, of the Emissions Trading Scheme (ETS), verified and submitted to the UK ETS Registry. Relevant legislative controls for offshore combustion equipment includes:

- The Offshore Combustion Installations (Pollution Prevention and Control) Regulations 2013 (as amended);
- The Greenhouse Gas Emissions Trading Scheme Order 2020; and
- Energy Savings Opportunity Scheme Regulations 2014 (as amended).

9.2.2 Licensing Obligations

The NSTA issued (June 2021) consolidated and updated guidance on flaring and venting, which sets out their approach to driving reductions in the emissions, through clear principles, using the NSTA consenting regime and stewardship activity. The consent requirements to conduct flaring and venting are set out in the Energy Act 1976, as well as the applicable offshore production license (granted under the Petroleum Act (1998)).

The NSTA Stewardship Expectations (SE) are designed to give operators and licensees clarity on expected behaviours and good practices. SE11 issued in March 2021 focuses on the following areas:

- Creating a culture of GHG emissions reduction within the UKCS;
- Ensuring that GHG emissions reduction is considered throughout the entire oil and gas lifecycle; and
- Collaboration between all relevant parties to support and progress potential energy integration developments (such as electrification, carbon capture and storage and hydrogen).

In addition, flaring and venting is consented through the Petroleum Act 1998.

9.2.3 Equinor Climate Ambitions

Equinor supports the Paris Agreement and has set a clear ambition to reach net zero by 2050. This includes an ambition to reduce net group-wide operated emissions by 50% by 2030, consistent with the goals of the Paris Agreement and a 1.5 degree pathway, along with eliminating routine flaring and achieving a near zero methane intensity within operational control by 2030. Equinor is developing the Rosebank field in alignment with these ambitions and SE11, and reducing the carbon intensity of the Development through the application of BAT. The Rosebank field is part of the balanced pathway to net zero and in line with the North Sea Transition Deal (for example, as outlined in Section 2, relevant concepts and technologies that can be implemented to create the net zero basin that the Deal calls for have been thoroughly evaluated and adopted where appropriate), and, as presented later in this assessment, aligned with the UK Carbon Budget.

9.3 Description and Quantification of Atmospheric Emissions and Abatements

The quantification of emissions in this section of the ES are based on engineering assumptions regarding fuel consumption and generic emission factors and therefore should be used only as an indication of potential order of magnitude of potential impact. The atmospheric emissions from fuel combustion have been assessed for the scope of drilling, installation, operations and maintenance for the life of the field.

9.3.1 Assumptions and Exclusions

The following assumptions have been made when calculating and presenting the atmospheric emissions:

- The environmental impact of Scope 1 and 2 GHG emissions have been included. Scope 3 GHG emissions for logistical services (helicopters and vessels excluding shuttle tankers) have also been included;
- The EIA Guidance (OPRED 2020) states that the overall predicted impact should be based on the worst-case scenario in terms of environmental impact. Therefore, the atmospheric emissions impact assessment for power generation assumes that the FPSO will be powered by fuel gas with diesel as back up over the life of the field (assumed 25 years for the purposes of the ES) from first oil, planned 2026;
- The aspiration is to electrify the FPSO once a low carbon power source is available;
- The FPSO will operate with a closed flare i.e. zero routine flaring. However, reasonable worst-case scenarios of non-routine and safety flaring events have been included in the calculation of emissions; and
- The Institute of Petroleum (IP) (2000) have a database with different types of vessels and the estimated daily fuel use depending on the number of days in port working, in port not working, days in transit, working,

and days waiting on weather. This estimated daily fuel use per vessel type has been applied to the number of each type of vessel to produce an estimated total fuel use per vessel type. The estimated emissions of each pollutant gas in tonnes were calculated using conversion factors[40]. Combustion gases other than CO_2 were then converted into their CO_2e using the applicable GWP (as per Table 9-2) to generate the estimated tCO_2e per transport type over the life of the field (shown in the right hand column of the tables in the following sections).

9.3.2 Quantification of emissions during Drilling and Well Completion

Drilling and completion operations will require a MODU, specifically a 6th generation (or greater) DP semi-submersible MODU due to the Development location and conditions. It is estimated that the MODU will consume approximately (maximum) 45 tonnes of diesel per day. The total number of operational days is currently estimated to 851 days to drill and complete 12 wells in Phase 1 and 2), this accounts for 38,295 tonnes of diesel being used for power generation aboard the MODU for all drilling and completion operations[41]. A further allowance of 20% has been made for waiting on weather.

In addition to fuel use by the MODU, there will be support vessels (supply, inspection/maintenance and repair (IMR), well intervention and ERRV) and helicopter flights which also consume fuel and emit atmospheric pollutants (Scope 3). Table 9-3 presents the estimated emissions from drilling activities: MODU, support vessels, and helicopters based on total fuel consumption.

The effect of these emissions are considered alongside other emissions from the Development in Section 9.5.

Table 9-3 Estimated emissions from drilling and well completion

Operation	Type of transport	Total atmospheric emissions (tonnes)							CO_2e for life of field (Tonnes)
		CO_2	CO	NOx	N_2O	SOx	CH_4	NMVOC	
Drilling and completions	Support vessels	48,571	238	861	2	0	1	35	49,794
	Rig	98,219	481	1,741	5	1	2	71	100,692
	Helicopter	1,133	3	0	0	0	0	1	1,165

9.3.3 Drilling and Well Completion/Reservoir Abatements

As described in Chapter 2 Consideration of Alternatives, the following optimisation opportunities of the selected reservoir drainage strategy and well design were identified that will result in emissions reductions due to energy efficiencies, while reducing the volume of produced water as far as possible and maximising oil produced, thus reducing carbon intensity:

- Optimisation of the well design by simplification included reducing the number of wells required. This reduced the total meters drilled by ~40% and reduced the total drilling duration by ~50%. Approximately 45% reduction in drilling related GHG emissions have been achieved due to the optimisation activities during screening and selection of concept since the asset was taken over by Equinor;

[40] Defra, EEMS, Atmospheric Emissions Calculations (OGUK, 2008) and IPCC (2021).
[41] Calculations are a simple “vessel days x daily fuel usage (taken from IP2000) x emission factor (BEIS)” or similar.

- The drilling strategy utilises vertical/deviated and horizontal wells: Vertical/deviated wells maximise the likelihood of successfully drilling the wells while horizontal wells have a longer reach, allowing hydrocarbon production from larger areas and are associated with a lower water production. This strategy allowed the Development to reduce the well count from fifteen to twelve wells (Phase 1 & 2) whilst maintaining the hydrocarbon production levels. A low well count and inclusion of horizontal wells also results in significantly less produced water to be re-injected and less gas lift than the alternative solutions;
- Drilling rigs suitable for working in WoS typically have large storage capacity allowing the rig to be autonomous for longer periods of time and hence optimisation of support vessel frequency and capacity can be optimised. Batching also minimises logistic requirements due to the repetition of work across multiple wells i.e., same people and equipment required therefore reducing mobilisation/demobilization per well;
- To reduce idle rig time and plan for parallel operations with marine operations a SIMOPS plan will be in place. In the drive towards supporting the UK's net zero target, the drilling priorities include a stepwise implementation of new digital solutions such as automated drilling to reduce people on the rig, the number of drilling days and optimise energy efficiency on all rigs;
- A move from 5½ to 7-inch tubing in the water injection wells significantly reduces the frictional pressure losses in the well. The topside injection pump pressure is reduced, and the CO_2 emissions associated with water injection is reduced by approx. 25%;
- Selection of a phased development concept will allow for later wells to be located based on reservoir learnings from the first drilling campaign. This will allow for better placement and greater energy efficiency in the wells in the second drilling campaign, which target more oil relative to produced water with lower water injection and gas lift requirements. In addition, the inclusion of inflow control valves on the injector wells will promote efficient placement of injected water to optimise sweep and reduce energy inefficiency associated with any misplaced water injection;
- In the drive towards zero emission operations, priorities include a stepwise implementation of new digital solutions such as automated drilling to reduce the number of drilling days and optimise energy efficiency on all rigs;
- GHG emission reduction targets against an agreed baseline will be included in contracts to incentivise contractors to support investments in low carbon solutions. Rig contractors will be expected to have a system for energy management assuring a continuous, systematic and target oriented evaluation of measures that can be implemented to achieve an optimal energy efficient operation;
- Optimising energy efficiency and GHG emission reduction will be part of the evaluation criteria for rig tendering; and
- Technical emission reducing initiatives that will be evaluated in the rig tendering process may include requirements for:
    - An optimised power management system;
    - Exhaust heat recovery;
    - Demonstrable optimization of equipment e.g. heat tracing, utilities, hydraulic power unit;
    - Use of low sulphur diesel (<0.1% S content);
    - A Shipboard Energy Efficiency Management Plan describing how fuel consumption is minimised during transit (economical speed);
    - Green Dynamic Positioning; and
    - Planning mobilisations to minimise frequency.

9.3.4 Quantification of Emissions during Installation Works

This section presents the emissions estimates for installation of the SPS (Subsea Production Systems), SURF (Subsea Umbilical, Risers and Flowlines), towing the FPSO to location and installation of the Gas Export pipeline.

The subsea installation phase will require a fleet of specialist vessels (pipelay vessel, heavy lift vessel, anchor handling vessel, ROV support vessel) as well as general support vessels.

Installation of the SPS/SURF is expected to take ~811 days. A number of different vessels have been considered to do this including support (~353 days), pipeline (~64 days), DSV (~219 days) and heavy lift (~47 days) vessels, which consume approximately 25, 30, 18 and 30 tonnes of diesel per day respectively. A further allowance of 20% has been made for waiting on weather.

The installation and hook up of the FPSO moorings including the FPSO tow to field will also be undertaken using an ROV support vessel and take an estimated ~82 days to complete. These operations will also require support vessels consuming an estimated 2044 tonnes of diesel. A further allowance of 20% has been made for waiting on weather.

Table 9-4 presents the estimated emissions and associated GWP from these operations.

The effect of these emissions are considered alongside other emissions from the Development in Section 9.5.

Table 9-4 Estimated emissions and associated GWP from installation works

Operation	Type of transport	Total atmospheric emissions (tonnes)							CO_2e for life of field (tonnes)
		CO_2	CO	NOx	N_2O	SOx	CH_4	NMVOC	
Subsea Installation	Pipelay vessel	7,410	36	131	0	0	0	5	7,596
	Heavy lift	5,448	27	97	0	0	0	4	5,585
	Anchor handler (FPSO) and support vessels	32,382	159	574	2	0	1	24	33,197
	ROV support vessels	15,175	74	269	1	0	0	11	15,557

9.3.5 Installation Works Abatements

As described in Chapter 2 Alternatives, the following improvement opportunity has been identified:

- The location of the FPSO was moved from the centre of the Rosebank field to a more southerly field location and a single flow loop to connect all subsea templates was selected, instead of using two. This optimised subsea layout reduced the number of structures requiring installation, reducing installation vessel time. It was estimated that using this simplified subsea layout would result in a 40% reduction in flowline lengths and a 40% reduction in vessel days, further contributing to reducing the carbon footprint of the Development; and
- Minimising the vessel time required to install subsea equipment by executing the installation during the summer period when the sea state is likely to be conducive to offshore operations and there will be minimal waiting-on-weather standby periods.

Additional logistics related opportunities to reduce emissions during the installation phase were identified and are discussed in the Facilities and Production Operations section.

9.3.6 Quantification of Emissions during Production Operations

During production the FPSO will produce emissions to atmosphere from the combustion of produced gas and diesel as fuel for power generation and from flaring during emergency or safety related events. As the FPSO will be brought to location electrification ready, the following assessment provides information for two scenarios: firstly, the worst case that the FPSO generates its own power from the dual fuel turbines over the life of the field, and secondly, emissions should full PfS become available.

Assuming no electrification, to establish a worst case, the estimated fuel gas and diesel demand at the FPSO for the life of the field is shown in Table 9-5 (based on current plans for well production and shutdowns). With the exception of the first year, diesel consumption is expected to be consistent throughout the life of field. There is higher diesel consumption in the first year because the turbines will use diesel until the wells are on-line and sufficient fuel gas is available. For the emissions calculations an estimated has bene made from operational data from the FPSO between 2016 and 2020. Until gas break through may use diesel but can go on import gas for any occasion when not exporting gas to reduce diesel consumption, Diesel will be used only during TAR, or during a trip which affects gas import. During unplanned shut downs gas import will be used to minimise diesel usage.

Table 9-5 presents estimated emissions from production operations assuming no electrification over life of field (worst case scenario). The effect of these emissions are considered alongside other emissions from the Development in Section 9.5.

Table 9-5 Estimated emissions from fuel gas diesel and flare at the FPSO for life of field (excluding electrification)[42]

Year	LoF usage (t)	CO_2	CO	NOx	N_2O	SOx	CH_4	VOC	tCO_2e
Diesel fuel	96,539	308,923	89	1,303	21	386	3	28	315,117
Fuel gas	1,398,525	3,999,782	4,196	8,531	308	18	1,287	50	4,129,114
Flaring	29,270	81,956	196	35	2	0	527	59	98,945

The production phase (including operations and maintenance) will require the assistance of support vessels as well as a helicopter service for crew transport as described in Table 9-6. Where relevant, a further allowance of 20% has been made for waiting on weather.

[42] The Rosebank Development engineering team developed a spreadsheet for calculating the total carbon dioxide emissions from the turbines and flaring. This spreadsheet was used to estimate emissions based on the high production case including fuel consumption assumed for turnarounds, etc and 5% contingency for process power demand, and flaring from initial well clean-up. Generally, over the life of field, well clean-up will be conducted using the closed flare system, although the initial wells (before full plant start up) will be cleaned up to flare as the closed flare system will not be fully operational at this time. Flaring will be minimised and the required Flare Consent will be in place. Each production well is expected to be worked over up to two times over life of field, with hydrocarbon emissions directed to the closed flare gas recovery system.

Table 9-6 Estimated emissions from logistics operations during the production phase

Operation	Type of transport	Atmospheric emissions for life of field (Tonnes)							CO_2e for life of field (tonnes)
		CO_2	CO	NOx	N_2O	SOx	CH_4	NMVOC	
Production	Helicopter	30,663	81	1	2	4	1	23	31,533
	Support vessel (ERRV)	780,661	3,823	13,841	37	5	12	567	800,316
	Supply vessel	15,385	75	273	1	0	0	11	15,772

Worst-case Scenario: Accounting for Emissions from Dual Fuel Turbines over Life of Field

This worst-case scenario assumes that the FPSO generates its own power from dual fuel turbines over the life of the field. Table 9-5 presents the estimated emissions and associated GWP of the emissions from power generation.

Emissions from use of the turbines are expected to include CO_2, CO, NO_X, N_2O, SO_X, CH_4 and NMVOCs. The turbines employ Best Available Technique (BAT) Dry Low Emission (DLE) technology, resulting in low NO_x emissions. Fuel gas is used as the main fuel, but the turbines are capable of dual fuel operation (i.e., fuel gas and diesel). Knarr has a fully functioning Predictive Emission Monitoring System (PEMS), that gives full visibility both on and offshore to the DLE Gas Turbine exhaust emissions of NOx and CO_2.

During normal production operations as well as during production plus offloading operations, power generation is supplied by a combination of the four main,13.1MW, dual fuel (gas/diesel) turbine generators. The main intent of the operating philosophy is to minimise power usage whilst reducing the need for spinning reserve. As can be seen in Figure 3-20, in Section 3.7.8.1, the load is estimated to remain steady throughout the life of field as the duty required on all of the equipment will be constant. Therefore, the estimated load during both normal production and production plus offloading modes, should allow power generation to be supplied from two turbines. If the power demand whilst operating with two turbines is deemed as being too high, then the philosophy will be to utilise a third turbine. This is an N+1 configuration; N supplies the defined power output requirement to provide the defined load and another turbine (N+1) is a common design concept which allows for maintenance and overhaul with no loss of generation capacity. The fourth turbine is only there as a backup for maintenance and will not be operated under normal operations.

Flaring

There are no plans to conduct routine flaring, in alignment with the Hydrocarbons BREF (Best Available Techniques (BAT) Reference document), and the NSTA's offshore flaring and venting guidance[43], and Equinor's internal climate ambitions which aim to eliminate unnecessary or wasteful flaring and venting of gas. The FPSO is designed with closed high- and low-pressure flare systems to service different parts of the plant at different pressures and retain as much gas as possible to reduce flaring emissions. Occasional flaring may occur during process upsets, maintenance, or emergency situations.

Diesel Use

The power generation turbines will occasionally be run on diesel when fuel gas is not available or recovery from shut down requires re-start on liquid fuel. Other diesel consumers include the emergency power generators and firewater

[43] NSTA Flare and Vent Guidance, 2021.

pump drives. There are no routine users of diesel during normal production operations e.g. cranes are electrified. A total life of field diesel consumption figure has been determined assuming that the turbines run on diesel one day per month with higher consumption in the first year when not all the wells are on line.

9.3.7 Production Operations Abatements

A third-party BAT assessment of Rosebank's power and heat generation was undertaken and concluded that the FPSO current single (open) cycle gas turbines and WHRUs comprised BAT as described below.

The existing single (open) cycle system was compared against a combined cycle system. The potential energy efficiency gain of replacing the system to a combined cycle system was considered too low in an overall assessment based on environmental benefit, technical feasiblity and cost. The current turbines employ Dry Low Emissions (DLE) technology (SoloNOx nozzles) to reduce NOx generation from the turbines. The basic principle of operation in the DLE technology is close control of the flame temperature to a reduce NOx emissions to as low as 25 ppmv (measured on dry off gas, 15% O2). The DLE technology does not require additional chemicals or energy, compared to a turbine without a low NOx solution. By incorporating lean pre-mix combustors in the turbine, DLE systems allow for reduced NOx emissions without the use of steam or water suppressors, and without increasing CO emissions. DLE provides the best environmental performance compared to other techniques, so is considered BAT.

The WHRUs are fitted at the turbine exhausts. The waste heat from the turbine exhausts is used to provide the required heat production for the FPSO. Other alternatives for heat production include fired heaters, which utilise direct combustion or liquid fuel, and electric heaters, which would be powered from main generation. Both fired heaters and electric heaters will increase fuel consumption and hence also the CO_2 emissions. As the WHRU system makes use of waste heat from the turbine exhausts, it neither uses fuel directly nor does it create additional emissions. As WHRUs provide the best environmental performance when compared to other alternatives, it is considered BAT.

Energy efficiency measures have also been planned and the required modifications will be carried out in the shipyard before the FPSO is towed out to location. Examples of energy saving measures requiring technical modification are listed in Table 9-7.

Table 9-7 Examples of energy saving measures requiring technical modification

Equipment	Modification / replacement
Pump operating configurations	Optimise to fit new operating points
Water injection pumps	Replace motors (optimised size). Install variable speed drive to enable operating point optimization.
LLP Compressor	Replace compressor bundle.
LLP liquid Return pumps	Replace pump (optimised size)
LP Compressor	Replace motor (optimised operation).
1st Stage HP compressors	Replace compressor gearboxes (optimised operation). Replace motors (under evaluation).
2nd Stage HP Compressors	Replace existing impeller bundles with new bundles
3rd Stage HP Compressors	New VSD gas lift compressor and new VSD gas export compressor to be installed (optimised individual operation of gas lift and gas export)

9.3.8 Carbon Intensity of Production

As described in Chapter 2 Alternatives, it was determined that the redeployment of the FPSO significantly reduced GHG emissions compared to fabrication and transport of a new FPSO. An additional factor favouring the redeployment option was that the FPSO was already designed to support future electrification of the field; Equinor is undertaking further work to ensure that it will be electrification-ready prior to arriving at the Rosebank field. In support of the UK's net zero target, Equinor is planning to utilise a low carbon power source for the Rosebank field once the field is electrified.

The NSTA expects operators to demonstrate a firm commitment to reducing GHG emissions throughout the lifecycle of the project. One approach is electrification of offshore oil and gas production installations (BEIS, 2021). Equinor have the aspiration to electrify the Development as soon as the technology is qualified and matured, and necessary regulatory consents are in place, as described in Chapter 2 Consideration of Alternatives. Prior to electrification, the base case presented in this chapter is that the FPSO will generate its own power from dual fuel gas turbines which will generally run on produced fuel gas.

Potential future carbon intensity values for the Development were made to account for the improvements in carbon intensity that are expected with efficient gas turbines and process optimisation, and ultimately full electrification. These values were compared to the NSTA 2020 average UK upstream oil and gas carbon intensity overall benchmark of 20 kg CO_2/boe and the benchmark for an FPSO less than 10 years old of 16kgCO_2 /boe. The NSTA industry averages are based on a combination of measured and estimated GHG emissions and reported production data. The carbon intensity estimation presented for the Development uses GHG emissions data associated with high recovery to estimate potential GHG emissions and production data based to the average production figures to derive both a predicted carbon intensity from the gas turbine base case and from future electrification. This to ensure a degree of conservatism in the predicted carbon intensity figures for the Development.

The carbon intensity comparison is presented in Figure 9-2. The first reduction of 4 kgCO_2/boe is between overall UKCS Offshore Carbon intensity and UK average for FPSO <10 years. The next reduction is showing a reduction of 4 kgCO_2/boe between UK average for FPSO <10 years and this Rosebank FPSO project. The last reduction of 9 kgCO_2/boe is showing the effect of electrification from shore for the Rosebank FPSO. The full power from shore Rosebank CO_2 intensity includes Scope 2 emission estimates from imported electricity and, for the purposes of potential emissions reduction estimation, power from shore is assumed to be available in 2030.

The intensity for the Development in the base case, defined as efficient gas turbines and optimised operations, is estimated to be approximately 12 kg CO_2/boe. The carbon intensity of the Development with full electrification is estimated to be approximately 3 kg CO_2/boe. The figures presented are indicative only as it is difficult to accurately quantify potential emission reductions from operational optimisation and a number of assumptions have been made with regard to power requirements, diesel consumption and flaring. A key variable that affects the intensity calculation is the level of production. The estimates of future predicted carbon intensity, therefore, are based on an expected oil production profile (i.e. oil export) and electricity loads from the high oil case. Estimated annual emissions are the sum of the gas turbines with an allowance for occasional diesel consumption, safety flaring evaluation and drilling rig fuel consumption. Emissions are highest early in field life when drilling is underway and relative to production. Emissions decrease over time due to lower production rates and reduced power demand on the turbines. The electrification case also includes assumed Scope 2 emissions. The CO_2 emissions intensity estimates are therefore based on the high oil (worst) case, but the production profile used to estimate the associated intensity is the expected oil production profile.

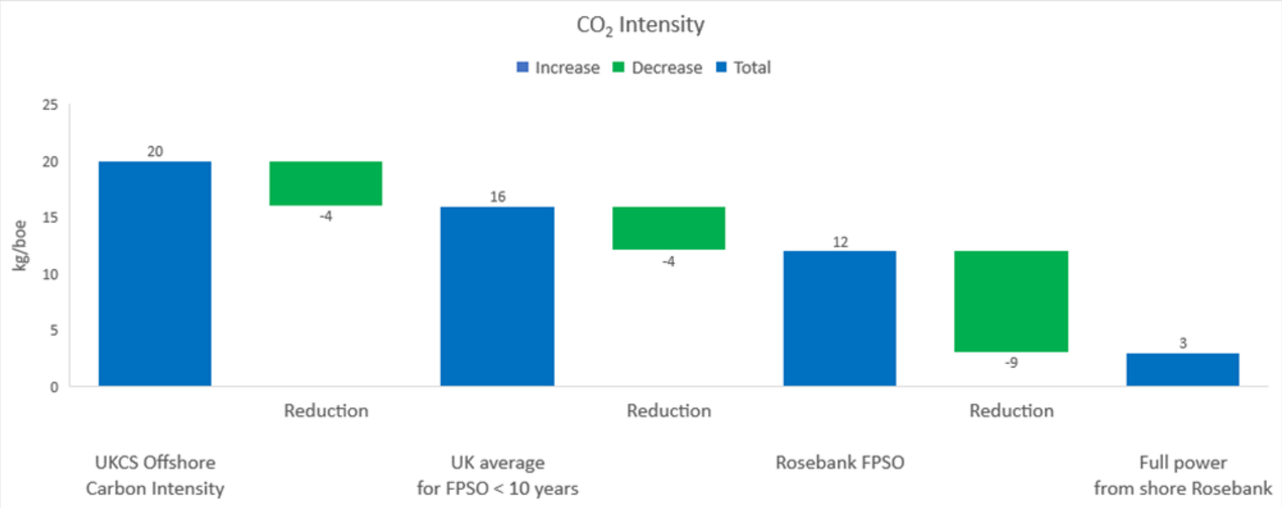

Figure 9-2 Carbon intensity improvements

Equinor will continue to mature electrification options for the FPSO for implementation with manageable technology, execution and timeline risks. Equinor will also keep regulators regularly updated on progression of the electrification scope.

Even without electrification the power generation and energy use philosophy for the FPSO is considered BAT (as discussed in Section 2.5.7.1) and the following additional abatement opportunities during production opportunities have been identified:

- The FPSO was designed to minimise GHG emissions by means of a vapour recovery system and a flare gas recovery system. This vapour recovery system recovers VOCs from several systems including the crude oil storage, the tri-ethylene glycol system, and the produced water treatment system;
- The Development shall not have continuous routine flaring or venting of gas associated with production;
- Heat recovery from turbine exhaust gases will be used to heat the processing plant;
- Power generation at the FPSO (pre-electrification operations) is considered BAT as per the Large Combustion Plants BREF. A third-party BAT assessment of Rosebank's power and heat generation has been completed and it concludes that current single (open) cycle gas turbines and waste heat recovery units are considered BAT;
- Whist the FPSO already had a modern, energy efficient topside design, significant modification / replacement of equipment will be carried out in order to further improve energy efficiency and thereby reduce the energy consumption. Modifications/replacements include replacement of pumps, gearboxes and motors, re-bundling of compressors and changing from direct online drives to variable frequency drives for sea water injection and 3rd stage gas compression. The measures are estimated to reduce average yearly GHG emissions by approximately 6,500 tonnes;
- The planned gas export via the WOSPS was selected in part because it offered higher production efficiency at the Development and is the shortest feasible route, minimising the potential environmental impact of the installation. Applying the shortest feasible route also implies lower embodied carbon in the fabrication of the infrastructure;
- During the operation phase, Rosebank will work to reduce the GHG emissions both onshore and offshore and support the UK's net zero target. An important element of this work will be optimising the operation of the power turbines and auxiliary systems. Generator output varies with ambient temperature and other factors but Rosebank will operate the fewest number of gas turbines required in order to minimise GHG emissions;

- During life of field, opportunities will be continuously evaluated and considered to reduce the requirement for flaring and ensure compliance with the aim of zero routine flaring (see Chapter 2 Alternatives for further details); and
- Minimising the methane fugitive emissions through innovation and adoption of best practice; for example, leak detection and repair programmes will be implemented to reduce fugitive emissions, techniques such as optical gas imaging cameras will be assessed, and the flare gas recovery system and the vapour recovery system will reduce methane emissions from the FPSO. Equinor is also part of the North Sea methane monitoring group tackling the challenge of methane emissions from North Sea assets by increasing the accuracy of emissions estimates via monitoring of emissions using drones and sensors. Monitoring of flare combustion efficiency is an area of focus for Equinor who are screening the market for suitable technologies / services that would give flare combustion efficiency calculations. The tracking of flare unlit periods is now a regulatory requirement under the NSTA flare & vent guidance (NSTA, 2021) and so is tracked as part of Equinor compliance.

In addition to the logistics optimisation measures described above as part of production operations, Equinor will also seek to streamline logistics associated with installation, commissioning and decommissioning through careful planning, to reduce the time required for vessels and helicopters, and thus reduce the carbon footprint. Additional logistics related opportunities to reduce emissions during routine operations have also been identified by Equinor, including, but not limited to:

- Optilift™ technology to improve cargo handling and reduce vessel time;
- Forming a cross industry vessel and helicopter sharing group with other fields;
- Direct flights to the field without a fixed wing travel segment;
- Use of hybrid vessels with shore side plug in points;
- Possible use of bioethanol fuels or alternative vessel fuels; and
- More efficient helicopters, with lower carbon emissions than traditional heavy category helicopters.

9.3.9 Summary of Abatement Approach

Equinor has assessed the impact of the Development on climate and the UK's net zero target, and has embedded the identification, assessment, and minimisation of GHG emissions in the project management process. The most significant reductions have been achieved via integrated optimization across subsurface, drilling and well, and facilities.

As described above, a third-party BAT assessment of Rosebank's power and heat generation was undertaken and concluded that the systems in place for power generation and emissions reduction were indicative of techniques described as BAT in the Large Combustion Plant BAT Reference Document (BREF). For example, single (open) cycle gas turbines with DLE technology and waste heat recovery units are considered BAT. Similarly, there are no plans to conduct routine flaring. This is in alignment with the BAT Guidance Document on upstream hydrocarbon exploration and production and, as detailed further in Section 1.3, the aspirations of various important agreements and publications, including the Energy White Paper and the UK's Net Zero Strategy. It is also consistent with other key drivers of future oil and gas development, such as the World Bank's Zero Routine Flaring initiative.

Equinor will work to minimise emissions generated by production by ensuring emissions reduction reviews, including 3rd Party contractors where appropriate, are part of further detailed design, installation process and through operations and maintenance on the Rosebank installation. Several optimisation plans are described in Chapter 2 Consideration of Alternatives, and their relevance with respect to minimising atmospheric emissions is discussed in the sections above. The mitigation measures described will be managed and delivered within the framework of

Equinor´s Safety and Environmental Management System, as described in Chapter 12 Environmental Management System.

9.4 Local Air Quality Emissions Inventory and Assessment

Background air quality at the FPSO will be influenced by nearby sources of emissions. These were identified as:

- The Scottish Highlands due to the prevailing wind direction;
- Shetland due to it being the closest onshore location to the FPSO;
- The Glen Lyon FPSO, located 73.7 km away from the Rosebank FPSO; and
- Transient shipping and aviation traffic.

These sources are relatively remote, thus their associated background levels are expected to be reduced at the Development´s location. Additionally, the prevailing wind at the FPSO is predominately from the southwest with a resultant vector of 224 degrees. As such, the FPSO is neither downwind nor upwind of any nearby sources during prevailing wind conditions.

To determine the levels of background pollutants; public domain information was reviewed as follows:

- Carbon Monoxide:
  - Background CO concentrations in the Scottish Highlands and Shetland are expected to arise predominantly from road transport in urban areas due to the incomplete combustion of fuel. Ambient CO concentrations have been well within the UK Air Quality Standards (AQS) for a number of years. Therefore, the Scottish Highlands and Shetland do not have CO monitoring sites (Defra, 2020). However, it is predicted that any background level CO will disperse to negligible levels upon reaching the FPSO; and
  - Transient shipping and aviation traffic are not expected to generate a significant contribution to CO background levels at the FPSO.
- Nitrogen Dioxide:
  - Background NO_2 concentrations in the Scottish Highlands and Shetland are predicted to be <5 $\mu g/m^3$ (Ricardo-AEA, 2013);
  - NO_2 emissions from Glen Lyon FPSO are expected to cause localised background levels at source but disperse to negligible levels upon reaching the FPSO; and
  - Transient shipping and aviation traffic are not expected to make a significant contribution to NO_2 background levels at the FPSO.
- Sulphur Dioxide:
  - Background SO_2 concentrations in the Scottish Highlands are expected to arise only from solid fuel domestic heating and small combustion plants. The Highland Council (2011) reported SO_2 background concentrations to be insignificant in 2005 and expected them not to increase;
  - Similarly, the Shetland Islands Council (2011a) considered SO_2 levels to be generally low on Shetland;
  - SO_2 emissions from Glen Lyon FPSO are predicted to disperse to negligible levels upon reaching the FPSO; and
  - Transient shipping and aviation traffic are not expected to make a significant contribution to SO_2 background levels, particularly as shipping fuels used will meet MARPOL low sulphur limits.

For these reasons, CO, NO_2 and SO_2 background concentrations at the Rosebank FPSO are considered negligible and are excluded from the modelling.

9.4.1 FPSO Operations (Air Quality)

As described above, power generation from dual fuel DLE turbines at the FPSO is considered BAT as per the Large Combustion Plants BREF. A third-party BAT assessment of power and heat generation techniques has been completed and it concludes that current single (open) cycle gas turbines and waste heat recovery units are considered BAT.

In order to assess the worst-case scenario, the air dispersion modelling scenario assumed that:

- Dual fuel turbines would be the Solar Titan 130, each ISO rated for 13.1 MW with dry low NOX technologies, ensuring 25 ppmv of NO_X emissions (measured on dry off gas, 15% O_2);
- The turbines would operate in 3 out of 4 mode (3oo4) at 80% load as a worst-case (normal operations is 2 no. turbines); and
- During normal operations fuel gas would be used, whilst start up and blowdown events diesel would be used and flaring will occur for a short period.

FPSO air emissions were modelled for both short-term and long-term average concentrations, to compare with UK onshore AQS, as shown in Table 9-8 and set out in the Air Quality Standard (Scotland) Regulations 2010. The scenarios considered were:

- Scenario 1 – Maximum emissions from normal operations, without flaring
  - Scenario 1 involved three (of four) turbines running at 80% load on gas, without flaring.
- Scenario 2 – Maximum emissions from abnormal operating conditions, without flaring
  - Scenario 2 involved three (of four) turbines running 80% load on diesel, without flaring.
- Scenario 3 – Maximum emissions from abnormal operating conditions, with flaring
  - Scenario 3 involved two (of four) turbines running at 80% load on diesel, with flaring (note: some of the heavy power users, such as compression, will not be in operation in this abnormal operating conditions scenario. As demand is reduced, fewer turbines are required to be running).

The modelling study assessed potential emissions from the project under worst-case operating scenarios. As a conservative approach was taken, it is likely that modelled concentrations reflect an overestimation of the potential impacts. The results from each scenario were compared against the AQS as a benchmark. Table 9-8 summarises the maximum estimated worst-case concentration from the modelling (Scenario 3) against each AQS. It illustrates the maximum concentration at any point in the model´s offshore grid.

Table 9-8 Maximum concentrations of air quality pollutants from FPSO operational combustion activities based on Scenario 3

Emission	Reference period	Air quality standard limit value (µg/m^3)	Maximum predicted concentration (µg/m^3)	Percentage of limit value (>100% indicates exceedance) (%)
CO	CO 8-hour rolling average (100.00%ile)	10,000	0.2	2.1
	Annual average	40,000	<<0.1	<<0.1
NO_2	1-hour average (99.79%ile)	200	<<0.1	<<0.1
	Annual average	40	<<0.1	<<0.1
SO_2	1-hour average (99.73%ile)	350	0.3	<<0.1
	24-hour average (99.18%ile)	125	0.1	0.1
	15-minute average (99.9%ile)	266	0.4	0.1
	Annual average	20	<<0.1	<<0.1

For comparison, maximum predicted concentration for Scenarios 1 and 2 were <<0.01 µg/m^3 in all cases except one (the exception being for the 15-minute average for SO_2 in Scenario 2 where it was 0.1 µg/m^3) and the percentage of limit value was <<0.01% in all cases.

In air quality terminology, percentiles are commonly used to help define where short-term (hourly or 15 minute) AQS values will be exceeded. For example, for NO_2, the hourly mean value of 200 µg/m^3 must not be exceeded more than 18 times a year. This means that 18 exceedances are acceptable, whereas 19 are not. This can be expressed as a percentile by considering the total number of hourly periods in a year (i.e. 8760 - 18/8760 x 100) which gives the 99.79th percentile. Therefore, the gas concentrations at the 99.79th percentile must be below 200 µg/m^3 for compliance with the AQS.

The results indicate that all estimated concentrations following modelling of worst-case scenarios are substantially below AQSs, and no emission concentration modelled to be greater than 2.1% of AQS. Modelled concentrations of all gases at the nearest landfall receptor (Shetland) were negligible.

Emergency blowdown flaring modelling showed no significant additional impact on air quality. These short duration infrequent emissions are therefore unlikely to significantly add to the emissions from the power generation scenarios.

9.4.2 Vessel, Helicopter and Drilling Rig (Air Quality)

In addition to the emissions from the FPSO discussed above, several other sources of air emissions are expected as a result of the vessels, drilling and completion operations, and helicopters that will be necessary as part of the Development. Each vessel and helicopter will be powered by combustion engines resulting in emissions of CO_2, CO, NO_X, N_2O, SO_X, CH_4, and NMVOC, as well as particulate emissions. The estimated emissions for these activities are shown in Table 9-3, Table 9-4 and Table 9-6.

Environmental receptors such as flora and fauna present in the vicinity of the Development are expected to be mobile and/or sparsely distributed and therefore not highly sensitive to vessel and helicopter emissions. Air quality impacts from vessel and helicopter emissions are further mitigated by the open and dispersive nature of the local environment, meaning that emissions are likely to disperse rapidly to the extent they are not expected to be detectable above current background levels.

9.4.3 Protected Sites

The Scottish Marine Plan seeks to ensure that oil and gas developments consider key environmental risks including the impacts of releases to atmosphere. Atmospheric emissions associated with the Rosebank Development will not occur within any Special Area of Conservation (SAC), Special Protection Area (SPA) or Nature Conservation Marine Protected Area (NCMPA) with the exception of limited gas export pipelay installation within the Faroe-Shetland Sponge Belt NCMPA.

The atmospheric emissions are expected to represent a very small percentage of UK emissions and cumulative impact from the Development is not expected with regards to potential impact on protected sites. As such there are no significant effects expected within SACs and SPAs, and hence no impact on their conservation objectives or integrity. This assessment also concludes that there is no potential for atmospheric emissions to interact with protected features of an NCMPA, and therefore the Development does not present a risk to the conservation objectives of any NCMPA.

Other protected sites such as Ramsar sites and Sites of Special Scientific Interest (SSSI) are coastal sites with the closest ones being located around the Shetland Islands, 130 km from the Rosebank field. Atmospheric emissions from the Development will not cause an exceedance in air quality at any coastal sites. Any elevated concentrations offshore will be short-lived and hardly detectable beyond a short distance from the FPSO (due to the dispersive nature of the offshore environment).

9.4.4 Summary

As described above, the Development will include several sources of atmospheric emissions. The main pollutants with the potential to contribute to impacts are described in Table 9-2. Modelling described in Section 9.4 indicates that the Development will not lead to an exceedance of AQS values. There are no air quality issues identified in the vicinity and the impact will only affect a small area of the atmosphere in the immediate vicinity of the Development given the transient nature of shipping and aviation traffic in the vicinity, and the limited oil and gas infrastructure in the WoS region, significant cumulative impacts on local air quality are not expected. The Rosebank field lies approximately 15 km from the UK/Faroes median line, but 180 km from the Faroe Islands themselves. Modelled concentrations of all gases at the nearest landfall receptor (Shetland) were negligible, thus, the potential for transboundary impacts on sensitive receptors is considered negligible and the impact is not significant.

9.5 Cumulative, In-combination and Transboundary Impacts

9.5.1 Comparison with the UK Carbon Budget

All developments with GHG emissions have the potential to result in a cumulative effect on the global climate and additional GHG emissions beyond those accounted for in the UK carbon budget may affect the UK's ability to reach net zero. As operator, Equinor is actively working with a broad range of stakeholders in Scotland, the UK and Europe to ensure that Rosebank is developed in line with the NSTD, UK net zero targets and Equinor net zero ambitions. The UK carbon budget is based on NSTA production scenarios that include emissions from producing oil and gas developments alongside production under consideration, including the Rosebank Development.

Table 9-9 presents the Offshore Development's net CO_2e emissions against UK carbon budgets; this brings together the emissions described for each phase of the development in Table 9-3 to Table 9-6. During the 2023 - 2027 carbon accounting period, emissions associated with pre-construction and construction phases of the Development and initial electricity generation are assumed to occur from the Development. As carbon budgets are not yet determined past 2037, it is not possible to quantify the percentage of the Development's CO_2e emissions between 2038 and 2051 (the estimated end date for the operational phase of the Development). However, it is clear that the Development will contribute only a very small percentage of the UK's available carbon budget regardless of the accounting period being considered.

Table 9-9 Development net CO_2e emissions against UK carbon budget (Committee on Climate Change, 2020)

Emission item	Carbon accounting period		
	2023 to 2027	2028 to 2032	2033 to 2037
UK carbon budget for period (tonnes CO_2e)	1,950,000,000	1,765,000,000	965,000,000
Offshore Development emissions for period (tonnes CO_2e)	702,276	1,028,419	1,108,686
Development CO_2e emissions as a % of UK budget	0.04%	0.06%	0.11%

9.5.2 Comparison with NSTA regional data

The NSTA publishes offshore oil and gas emissions data and these have been used as a baseline against which to compare the emissions from the Development. The estimated cumulative increase is worst case as it does not take into consideration:

- Future provision of power to the FPSO from a renewable energy source;
- That new oil and gas projects coming on-stream will be required to operate according to Stewardship Expectation 11 – Net Zero; and
- The commitments made by the offshore oil and gas industry under the North Sea Transition Deal.

Table 9-10 NSTA UKCS offshore CO_2 emissions and estimated impact of Rosebank (NSTA, 2020).

Period	Total UKCS CO_2 (Mt)	Average
2017	12.6	12.6
2018	12.7	
2019	13.1	
2020	11.9	
Rosebank (annual estimate and %age)	0.2	1.6%

The average annual offshore CO_2 emissions from the combined offshore oil and gas sector from the last 4 years of data is 12.6 Mt CO_2 (Table 9-10). The Development´s annual operational emissions are estimated between approximately 106 and 220 kt CO_2 per year over the 25-year period of production (excluding future electrification). The lowest number is estimated towards end of field life when production has significantly declined, and the high estimate is based on high production and emissions from the Phase 2 drilling campaign within the first 5 years. The average CO_2 emissions over field life is estimated to be approximately 165 kt CO_2. This equates to 1.6% of the annual sector emissions (Table 9-10).

9.5.3 Conclusion

The Institute of Environmental Management and Assessment (2022)[44] states that "The crux of significance is not whether a project emits GHG emissions, nor even the magnitude of GHG emissions alone, but whether it contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero by 2050." From the comparison against the UK Carbon Budget, it is clear that the Development will contribute only a very small percentage of the UK's available carbon budget regardless of the accounting period being considered. With respect to the comparison with emissions over the previous 4 years from the offshore oil and gas sector specifically, the magnitude of the emissions from the Development is such that the Development coming online would represent a negligible change (Table 9-11).

Table 9-11 Criteria for magnitude of change

Change	Description of change
Beneficial	> 3 % decrease in the most recent 4-year average of the offshore oil and gas sector emission value
Negligible	+/- 3 % change to the most recent 4-year average of the offshore oil and gas sector emission value
Small increase	Between 3 and 30% increase in the most recent 4-year average of the offshore oil and gas sector emission value
Large increase	Greater than 30% increase in the most recent 4-year average of the offshore oil and gas sector emission value

Note: In the absence of specific guidance, a standard technical methodology of four criteria (beneficial projects, negligible, small and large) has been adopted. The lower limit of 3% is the level below which there is a 95% chance that any change may be due to uncertainty in the data. Any value above 3% can therefore be classed as a statistically real change and not an artifact of the data quality. The 30% criteria for a large impact was selected at a 10-fold increase above the uncertainly limit in order to provide a gradation point for the descriptions of magnitude.

[44] Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance.

As per the impact assessment methodology described in Section 5, this magnitude of change is combined with the sensitivity, vulnerability and value of the receiving environment (high or very high) to derive an overall consequence of effect. Following the definitions in Table 5-11, consequence is defined as low, and the impact of emissions from the Development is determined to be not significant.

10 UNDERWATER NOISE

10.1 Introduction

Underwater sound is generated by natural sources such as rain, breaking waves and marine life, such as whales, dolphins and fish; contributing to ambient sound. Man's use of the marine environment adds additional sound from numerous sources including shipping, oil and gas exploration and production, aircraft and military activity. In this assessment, sound is used as a term for anything that an individual animal can hear. The term noise is reserved herein for anthropogenic sound that may have some form of potential impact (for example, it may affect behaviour). Whilst all 'noise' is also 'sound', not all 'sound' will be considered 'noise' unless it is from an anthropogenic source and may potentially elicit a response.

Many species found in the marine environment (including seabirds, fish and marine mammals) use sound to understand their surroundings and communicate with members of their own species. Some species, particularly cetaceans (whales, dolphins and porpoises), also use sound to build up an image of their environment and to detect prey and predators through echolocation.

10.1.1 Underwater Sound and Assessment Metrics

Sound is transmitted through liquids as longitudinal waves, or compression waves. These are waves of alternating pressure deviations from the equilibrium pressure, causing local regions of compression and rarefaction. Sound pressure (p) is therefore the average variation in pressure caused by the sound. By convention, sound levels are expressed in decibels (dB) relative to a fixed reference pressure commonly 1 micropascal (µPa) for underwater measurements, as measurements typically cover a very wide range of pressure values.

10.1.1.1 Peak Sound Pressure Level (SPL)

The Peak Sound Pressure (SPL), or zero-to-peak (0-Peak) sound pressure, is the maximum sound pressure during a stated time interval. A peak sound pressure may arise from a positive or negative sound pressure, and the unit is the pascal (Pa). This quantity is typically useful as a metric for a pulsed waveform, though it may also be used to describe a periodic waveform.

10.1.1.2 Root Mean Square (RMS) sound pressure

The Root Mean Square (RMS) Sound Pressure Level (SPLrms) is the mean square pressure level measured over a given time interval. Therefore, it represents a measure of the average sound pressure level over the time. The RMS sound pressure is expressed in pascals (Pa).

When the SPLrms is used to quantify a transient sound source the time period over which the measurements are averaged must be given, as the SPLrms value will vary with the averaging time period.

10.1.1.3 Sound Exposure Level (SEL)

The Sound Exposure Level (SEL) is the time integral of the square pressure over a time window long enough to include the entire pressure pulse. The SEL is therefore the sum of the acoustic energy over a measurement period, and effectively takes account of both the level of sound and the duration over which the sound is present in the environment.

10.1.1.4 Pulse Duration

The pulse duration is the time during which a specified percentage of sound energy in the signal occurs. In the calculation, sound exposure may be used as a proxy for energy. The pulse duration is expressed in units of second(s).

10.1.2 Marine Mammal Impact Criteria

Underwater sound has the potential to affect marine life in different ways depending on its sound level and characteristics. Richardson *et al*. (1995) defined four zones of sound influence which vary with distance from the source and level. These are:

- The zone of audibility: this is the area within which the animal is able to detect the sound. Audibility itself does not implicitly mean that the sound will have an effect on the marine mammal;
- The zone of responsiveness: this is defined as the area within which the animal responds either behaviourally or physiologically. The zone of responsiveness is usually smaller than the zone of audibility because, audibility does not necessarily evoke a reaction;
- The zone of masking: This is defined as the area within which sound can interfere with detection of other sounds such as communication or echolocation clicks. This zone is very hard to estimate due to a paucity of data relating to how marine mammals detect sound in relation to masking levels (for example, humans are able to hear tones well below the numeric value of the overall sound level); and
- The zone of hearing loss, discomfort, and injury: this is the area where the sound level is high enough to cause tissue damage to auditory or other systems. This can be classified as either a temporary threshold shift (TTS) or permanent threshold shift (PTS). At even closer ranges, and for very high intensity sound sources (e.g. underwater explosions), physical trauma or even death are possible.

For this assessment, the zones of injury in terms of PTS and disturbance (i.e. responsiveness) are of concern. To determine the potential spatial range of injury and disturbance, a review has been undertaken of available evidence, including international guidance and scientific literature. The following sections summarise the relevant thresholds for onset of effects and describe the evidence base used to derive them.

10.1.2.1 Injury (Physiological Damage)

The Joint Nature Conservation Committee (JNCC, 2010) recommends using the injury criteria proposed by Southall *et al.* (2007), which are based on a combination of linear (i.e. un-weighted) peak pressure levels and mammal hearing weighted (M-weighted) sound exposure level (SEL).

In 2018, the U.S. National Marine Fisheries Service (NMFS) provided details of the acoustic thresholds at which individual marine mammals are predicted to experience changes in their hearing sensitivity for acute, incidental exposure to all underwater anthropogenic sound sources (NMFS, 2018). These new thresholds reflect new/updated scientific information that has demonstrated differences between the marine mammal hearing groups first categorised in Southall *et al.*(2007).
Southall *et al.* revaluated their proposed injury criteria in light of the scientific advances and as a result revised sound exposure criterion to predict the onset of auditory effects in marine mammals were published (Southall *et al.,* 2019). The only significant difference between Southall *et al.* (2019) and NMFS (2018) is the re-categorisation of mid-frequency and high frequency groups to High Frequency (HF) and Very High Frequency (VHF) respectively i.e. very

high frequency for greater clarity. This report retains the categorisation used in NMFS guidance, namely, Mid-Frequency (MF) and HF.

The hearing weighting functions used in NMFS are designed to represent the bandwidths of each group within which acoustic exposures may have auditory effects. This study uses the NMFS (2018) hearing group frequency categories:

- Low-Frequency (LF) cetaceans — i.e. marine mammal species such as baleen whales with an estimated functional hearing range between 7 Hz and 35 kHz;
- Mid-Frequency (MF) cetaceans — i.e. marine mammal species such as dolphins, toothed whales, beaked whales and bottlenose whales with an estimated functional hearing range between 150 Hz and 160 kHz;
- High-Frequency (HF) cetaceans — i.e. marine mammal species such as true porpoises (including harbour porpoise), river dolphins and *Cephalorhynchus* with an estimated functional hearing range between 275 Hz and 160 kHz; and
- Pinnipeds in Water (PW) — i.e. a suborder of carnivorous aquatic mammals that includes seals, walruses and other similar animals having finlike flippers with an estimated functional hearing range between 50 Hz and 86 kHz (for underwater).

These are presented graphically in Figure 10-1. Note this figure includes sirenians and otariid pinnipeds for completeness, but these taxa are not included in this assessment.

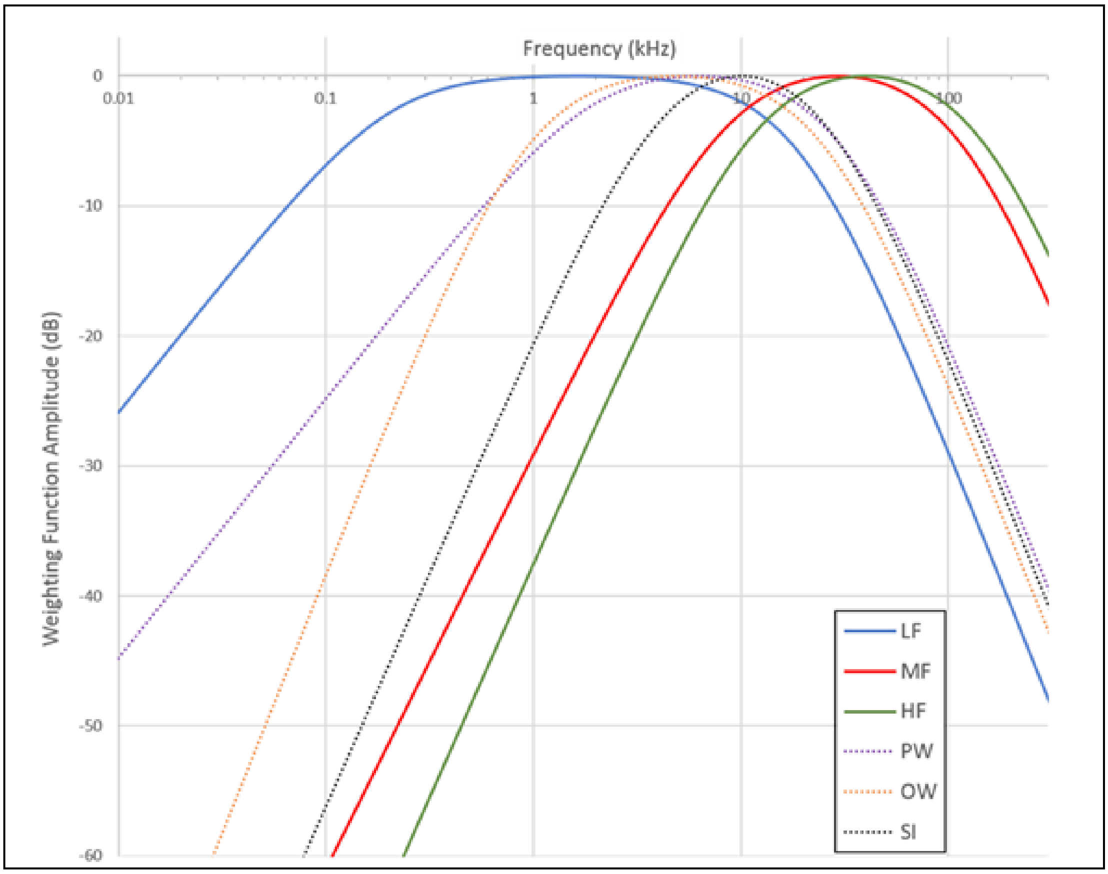

Figure 10-1 Auditory weighting functions for pinnipeds and cetaceans (NMFS, 2018)

10.1.2.2 Disturbance

The JNCC guidance (JNCC, 2010) proposes that a disturbance offence may occur when there is a risk of a significant group of animals incurring sustained or chronic disruption of behaviour or when a significant group of animals are displaced from an area, with subsequent redistribution being significantly different from that occurring due to natural variation.

There is an intra-hearing group category as well as intra-species variability in behavioural response. Therefore, this assessment adopts a simplified approach in the absence of further scientific information and uses the NMFS Level B harassment threshold of 160 dB re 1 μPa (root mean square (rms)) for impulsive sound.

Level B Harassment is defined as having the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild. This is similar to the JNCC (2008) description of non-trivial disturbance and has therefore been adopted as the basis for onset of behavioural change in this assessment.

It is important to understand that exposure to sound levels in excess of the behavioural change threshold stated above does not necessarily imply that the sound will result in significant disturbance as defined in the legislation. As noted previously, it is also necessary to assess the likelihood that the sensitive receptors will be exposed to that sound and whether the numbers exposed are likely to be significant at the population level.

10.1.2.3 Criteria Summary

The PTS criteria adopted within the study were those presented in NMFS (2018) for impulsive sound. These have been reproduced in Table 10-1.

Table 10-1 Permanent threshold shift (PTS) onset thresholds for marine mammals exposed to non-impulsive noise. SEL thresholds in dB re 1 μPa^{2}s (NMFS, 2018)

Marine mammal group	Type of sound	PTS threshold criteria	
		SPL$_{peak}$, dB re 1 μpa (unweighted)	Cumulative SEL[45], dB re 1 μpa^{2}s (weighted)
LF Cetaceans	Single or multiple pulses e.g. impulsive	219	183
	Non-impulsive e.g. continuous sound	-	199
MF Cetaceans	Single or multiple pulses e.g. impulsive	230	185
	Non-impulsive e.g. continuous sound	-	198
HF Cetaceans	Single or multiple pulses e.g. impulsive	202	155
	Non-impulsive e.g. continuous sound	-	173
Phocid Pinnipeds (underwater)	Single or multiple pulses e.g. impulsive	218	185
	Non-impulsive e.g. continuous sound	-	201

[45] The accumulation period is 24-hours.

Marine mammal group	Type of sound	PTS threshold criteria	
		SPL_{peak}, dB re 1 µpa (unweighted)	Cumulative SEL[45], dB re 1 µpa^{2}s (weighted)
Behaviour change (disturbance)	Single or multiple pulses e.g. impulsive	SPL_{rms} > 160 dB re 1µPa	
	Non-impulsive e.g. continuous sound	SPL_{rms} > 120 dB re 1µPa	

10.2 Regulatory Controls

In terms of the potential effects from underwater noise associated with the Development, the important legislative drivers are those that enact The EU Habitats Directive into UK and Scottish law. These regulations include the following:

- Conservation of Offshore Marine Habitats and Species Regulations 2017;
- Offshore Petroleum Activities (Conservation Habitats) Regulations 2001 (as amended); and
- Conservation (Natural Habitats, &c.) Regulations 1994 (as amended in Scotland).

The regulations above make it an offence to:

- Deliberately capture, injure or kill any wild animal of a European Protected Species (EPS); or
- Deliberately disturb wild animals of a EPS in such a way as to:
    - Impair their ability to migrate, hibernate, survive, breed, or rear or nurture their young; or
    - Significantly affect the local distribution or abundance of the species to which they belong.

According to the Regulations, an assessment of the potential to injure and disturb such species must be undertaken for any operations that may emit noise. The assessment should determine:

- The extent to which injury or disturbance may occur (or indeed if it will occur); and
- Whether a EPS licence to conduct the operations is necessary.

EPS are animals (but not birds) listed on Annex IV of the Habitats Directive whose natural range includes Great Britain. All whales and dolphins are designated as EPS. The information presented in Chapter 4 Environment Baseline shows that such species likely to be found in the Development area include the harbour porpoise, bottlenose dolphin, white-beaked dolphin, white-sided dolphin and minke whale. There are no fish species listed as EPS that are likely to occur in the Development area (Chapter 4 Environment Baseline); note, however, that basking sharks (occasionally sighted on the continental shelf) are given a similar level of protection as EPS by the Wildlife and Countryside Act 1981, which prohibits killing, injury or disturbance of any individuals. Atlantic salmon inhabit the surface waters and shelf edge waters of the Faroe-Shetland Channel during northwards migrations, but this species is only afforded protection (by the Habitats Regulations) in freshwater.

According to the regulations detailed at the start of this section, a project's applicant must assess if the noise-emitting operations described in this chapter have the potential to cause injury or disturbance to any species designated as a EPS. If injury or disturbance is considered likely, Equinor will be required to apply for a EPS licence. The process involves a two-stage approach to risk assessment. The first step (a Stage I EPS risk assessment) requires an assessment of the likelihood of injury or disturbance, where alternatives and mitigation measures are taken into account. The Stage I EPS risk assessment consists of two main components:

- Determination of the likelihood of an injury; and
- Determination of the likelihood of disturbance.

This requires a review of:

- The duration and frequency of the activity;
- The intensity and frequency of sound and extent of the area where injury and disturbance thresholds could be exceeded, taking into consideration species-specific sensitivities;
- The interaction with other concurrent, preceding or subsequent activities in the area (potential cumulative impacts);
- The Southall *et al*. (2007) thresholds for injury and behavioural responses, and other relevant published studies; and
- Whether the local abundance or distribution could be significantly affected.

If the Stage I EPS risk assessment concludes that an offence of either form is still likely, and the applicant determines that there are no other available options or methods, the EPS licence assessment process (a Stage II EPS licence assessment) must be initiated. The requirement for a EPS licence is considered further in Section 10.8. Importantly for this assessment, it must be considered that the definition of the potential for significance disturbance differs inshore and offshore, in that inshore disturbance of an individual EPS would be considered an offence whilst in offshore waters it is disturbance of a significant group of animals that would be considered an offence.

10.3 Assumptions and Data Gaps

10.3.1 Assumptions and Studies

In order to assess the worst-case scenario of underwater noise generated by the Development, key assumptions have been made regarding the following:

- The thresholds used to understand potential disturbance ranges are those at which the onset of possible disturbance could occur. In reality, estimated ranges will likely be lower, since not all animals will be disturbed at those larger estimated ranges; and
- Where environmental parameters are likely to be variable in time or space, the underwater noise modelling has made use of the worst-case values. For example, a sea state of zero has been assumed since it results in the greatest propagation of noise compared to other sea states, whilst a conservative marine mammal swim speed of 1.5 m/s has been used since it will result in animals receiving a greater amount of noise.

10.3.2 Data Gaps

Noise propagation models which define noise impact criteria are limited by the available data used to inform the model's metrics. At present, there are no direct measures of PTS in marine mammals. Noise-modelling work has so far been generally based on measured TTS responses. Data on TTS thresholds have been extrapolated to determine PTS values using auditory weighting functions (AWF). There is some discourse within the scientific community as which extrapolation metric is most appropriate for each hearing group (i.e. high-frequency, mid-frequency, and low-frequency cetaceans, and the true- and eared-seals). However, this remains the best methodology for determining hearing thresholds in marine mammals given current data limitations.

10.4 Description of Potential Impacts

10.4.1 Definition of Potential Sound Sources

There are a number of vessels associated with surveys, drilling, subsea installation, intervention activities and production for the Development which are detailed further in Chapter 2.1 Project Description.

Development activities related to underwater noise emissions that were identified in the ENVID Workshop as having potential significant effects before application of mitigation measures were:

- Conventional vertical seismic profiling (VSP) surveys;
- Thruster operations during drilling operations and the operation of FPSO;
- Use of acoustic beacons to maintain position during drilling operations; and
- Use of helicopters during drilling operations and the operation of FPSO.

The noise emission from construction activities e.g. trenching or rock placement, are usually dwarfed by the noise emission from the vessels themselves (DECC, 2011). The vessels associated with the seismic survey, drilling, subsea installation and production for the Development may cause very localised changes in distribution of marine mammals and fish (i.e. in the immediate vicinity of the vessel e.g. De Robertis and Handegard, 2013, Erbe *et al*., 2019) but the limited temporal scale of vessel use means these small-scale changes will not result in population level effects and so will not be significant impacts. Of the activities listed above, only the use of seismic sources (VSP) are considered to have the potential to affect the hearing of sensitive marine species because they form the greatest sound source in both power (i.e. pressure levels) and in character (i.e. as an impulsive sound). For this reason, seismic activities are considered to constitute the worst-case activities and form the focus of this assessment. Seismic survey activities (e.g. 3D or 4D surveys) that may be required over the life of the Development will be planned and consented according to regulations in place at the time. The assessment below considers the potential for the contingency VSP activities during planned drilling activities to significantly impact upon receptors.

10.4.2 Methodology of Proposed Seismic Survey

10.4.2.1 Approach

The underwater sound assessment was conducted using the Xposure model, a set of proprietary tools developed for common sound sources (e.g. piling, surveys). This modelling tool is based on an extended version of the semi-empirical model developed by Marsh & Schulkin (1962). The sound propagation model uses several concepts including:

- Refractive cycle, or skip distance;
- Geometric divergence;
- Deflection of energy into the bottom at high angles by scattering from the sea surface;
- A simplified Rayleigh two-fluid model of the bottom for sand or mud sediments; and
- Absorption of sound energy by molecules in the water.

The following inputs are required within the model:

- Third-octave band source sound level data;
- Discreet range (distance from source to receiver);
- Water column depth and sediment layer depth;
- Sediment type (sand/mud);
- Sea state; and
- Source directivity characteristics.

The Marsh & Schulkin model is based on a combination of acoustic theory and empirical data from around 100,000 measurements and has been found to provide good predictions.

As well as calculating the un-weighted RMS and peak sound pressure levels at various distances from the source, it is also necessary to calculate the SEL for a mammal using the relevant auditory weightings described earlier, taking into account the number of pulses to which it is exposed. For operation of the survey source, the SEL sound data for a single pulse was utilised, along with the maximum number of pulses expected to be received by marine mammals in order to calculate cumulative exposure. Two conditions were modelled:

- A marine mammal staying stationary in relation to a stationary source array[46]; and
- A marine mammal moving away from a stationary source array at a constant speed of 1.5 m/s.

Both cases were modelled for a range of start distances (initial or closest distance between the animal and vessel) in order to calculate cumulative exposure for the scenarios. In each case, the pulses to which the mammal is exposed in closest proximity to the vessel dominate the sound exposure. This is due to the logarithmic nature of sound energy summation.

It should be noted that the sound exposure calculations are based on the simplistic assumption that the source is active continuously over a 24-hour period, being activated at the same interval. In the real-world the situation is more complex with the device not activated during turns for example. However, the SEL calculations do not take any breaks in activity into account and therefore the activation period is assumed to be consecutive and therefore worst case. However, the potential for recovery is not accounted for in the multiple pulse sound criteria described in NMFS (2018) and so as far as the SEL calculation is concerned breaks in activity are not considered in the assessment.

10.4.2.2 Model Inputs

Source data for seismic array has been based on data supplied by Equinor for the 750 in^3 Sercel G-Guns (3-gun device). The data used in the calculations are summarised in Table 10-2.

Table 10-2 Input data for modelling

Model/type	TI sleeve gun mini air gun
Total energy source volume (in^3)	750 (3 x 250 in^3)
Number of airguns in array	3
Deployment method	Rig deployed
Source depth (m, below sea level)	5

[46] This is referred to as the baseline case, as it is considered that marine mammals will not move away from the source without being impacted upon by the received sound level.

Model/type	TI sleeve gun mini air gun
Shot interval (seconds)	ca. 200 shots over ca. 4 hours (ca. 72 seconds)
Zero to peak pressure level; bar m	7.52
Peak to peak pressure level; bar m	12.2
Maximum survey time per 24 hours	5 hours
Water depth (m)	1100
Sediment type	Sand

For this study, the source sound levels were based on a combination of those provided in the data sheet for the seismic energy source, supplemented by measured sound data from Breitzke *et al.* (2008), Tolstoy *et al.* (2009) and Richardson *et al.* (1995), to produce low- and mid-frequency data. The low- and mid-frequency data has been extrapolated to derive the third-octave frequency spectra at higher frequencies based on the gradient of the power spectral density and third-octave band plots.

The SEL represents the total energy of an event or number of events normalised to a standardised one second interval. This allows a comparison of the total energy of different sounds lasting for different time periods. As a pressure pulse from a source array propagates towards the receiver, the duration of the pulse increases. Thus, the relationship between the peak SPL and the SEL changes with distance. The SEL was calculated based on the RMS SPL normalised to a one second time interval. The single pulse SEL values have been combined for each pulse as part of the various cumulative SEL modelling scenarios.

It is important to note that the RMS SPL will depend upon the integration window used or, in other words, the measurement time for the rms. Using a longer duration measurement would result in a lower RMS SPL than using a shorter one.

10.4.2.3 Summary of Results

The radii of the potential injury zones and behavioural change zone for the different modelled situations are summarised based on a comparison of the calculated sound level against the criteria described in Section 10.4. Injury zones are presented relative to the leading edge of the array for the main shooting operations (see Table 10-3).

Table 10-3 Estimate of Injury and Disturbance Ranges from Seismic Activities (750 in^3)7

Situation	Radius of effect, m			
	Low-frequency cetacean	Mid-frequency cetacean	High-frequency cetacean	Pinnipeds
Peak pressure (SPL) physiological damage	15 m	4 m	109 m	17 m
Peak pressure (SPL) physiological damage + soft start	5 m	2 m	34 m	5 m
SEL of a static mammal and static vessel	816 m	184 m	2,234 m	339 m

Situation	Radius of effect, m			
	Low-frequency cetacean	**Mid-frequency cetacean**	**High-frequency cetacean**	**Pinnipeds**
SEL of vessel passing static mammal + soft start	763 m	174 m	2,145 m	321 m
SEL of mammal swimming away from a static vessel	62 m	15 m	407 m	24 m
SEL of mammal swimming away from a static vessel + soft start	18 m	5 m	111 m	8 m
RMS behavioural change	1,630 m			

The distances presented reflect the start point of the mammal relative to the source when the source first starts up. The mammal would then move away source so the distance between the mammal and the source would increase over time.

The potential ranges presented for injury and disturbance should not be interpreted as a hard and fast contour 'line' within which a significant impact will occur. The contour provides a conservative distance estimate at which sound levels will decrease to below SEL threshold values for PTS., which in reality is probabilistic; a combination of a range of variables; exposure dependency in PTS onset, individual variations in hearing, uncertainties regarding behavioural response and swim speed / direction.

10.4.2.4 Peak Pressure

The results show that cetaceans avoid being exposed to a level of peak SPL exceeding the NMFS (2018) criteria if they are beyond 109 m from the source array, pinnipeds beyond 17 m. This assumes no soft start. With a soft start period set at 20 minutes, cetaceans are not exposed above the guideline limits at distances of 34 m or more, with pinnipeds at 5 m; a reduction of two-thirds over the unmitigated case.

The peak pressure levels for the base case and soft start conditions is represented graphically in Figure 10-2.

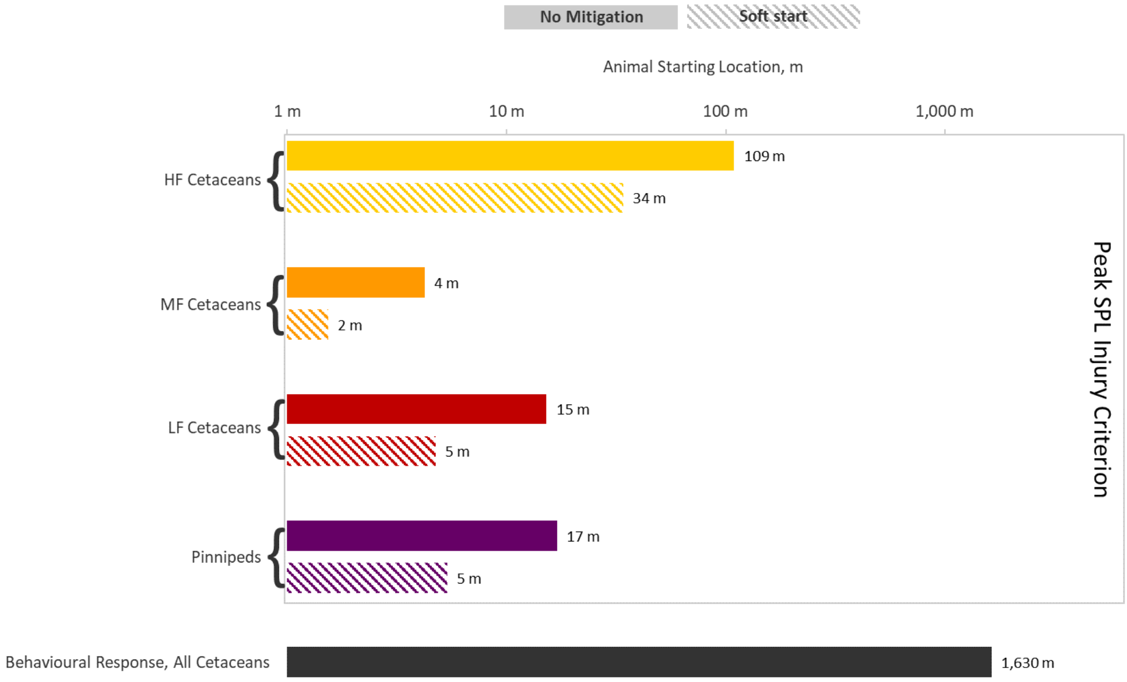

Figure 10-2 Modelled Peak pressure levels for base case and soft start conditions

10.4.2.5 Cumulative Weighted SEL

The sound exposure level for; i) a marine mammal staying stationary in relation to a stationary source array and ii) a marine mammal moving away from a stationary source array at a constant speed of 1.5 m/s is shown Figure 10-3.

The assumption that the mammal would stay stationary during a period of survey activity is considered to be unrealistic. A more realistic assumption is that, upon hearing the onset of source activity, the mammal would move away from the sound source, hence the first pulse would provide the highest 'dose' of sound, with each subsequent pulse contributing less to their exposure as they move away from the source. Swim speeds of the species most likely to be observed in the area have been shown to be up to 5 m/s e.g. a cruising minke whale swims at a speed of 3.25 m/s (Cooper *et al*., 2008) and harbour porpoise up to 4.3 m/s (Otani *et al*., 2000). Further, SNH (now known as NatureScot) (2015) has provided standard parameter values for various mammals which include mean swimming speeds. For example, for harbour porpoises the mean speed is 1.4 m/s (Westgate *et al*., 1995); harbour seal / grey seals 1.8 m/s (Thompson, 2015); minke whale 2.1 m/s (Williams, 2009). Therefore, to take a representative approach, the predicted exposures of marine mammals moving away from the sound source have been calculated using a mean swim speed of 1.5 m/s.

This section will therefore consider a marine mammal moving away at a 180-degree angle from a static vessel source array at a constant speed of 1.5 m/s.

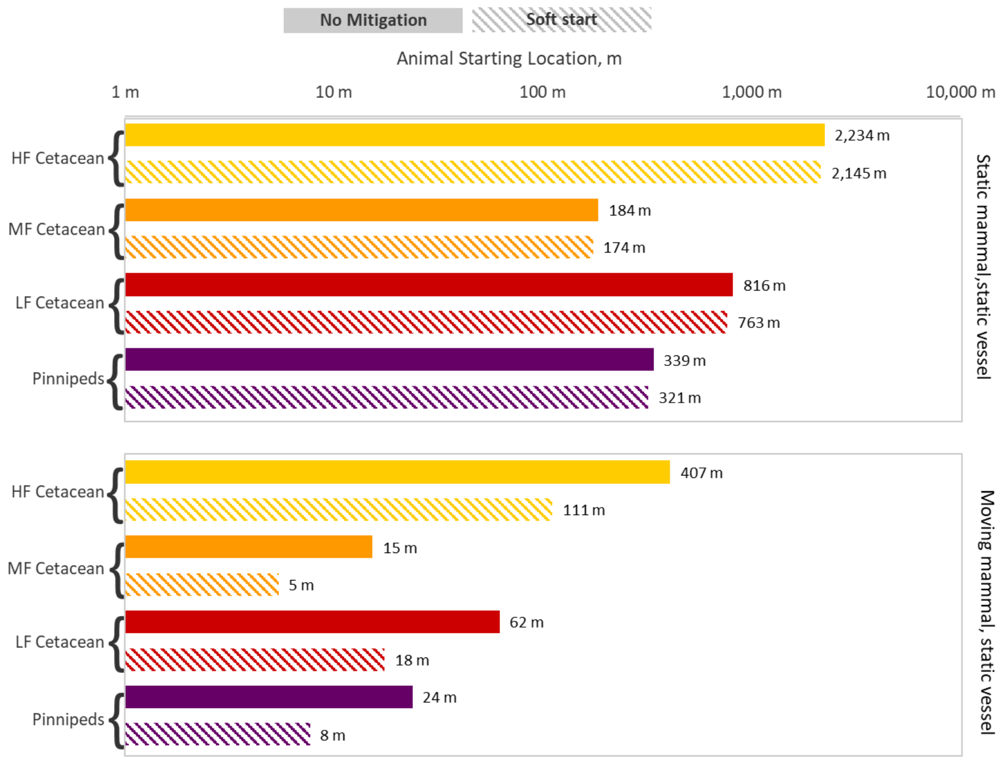

Figure 10-3 Modelled Start Distances Resulting in Exceedance of Guideline SEL Criteria for Onset of Injury to Marine Mammals

The benefit of the soft start operations will be greater at shorter ranges from the source than if the mammal starts further away from the source array. This is because at short distances the sound level is higher and falls away at a faster rate, so an animal swimming at a constant speed will see a larger relative reduction in sound if it starts closer to the source. Care should also be taken in interpreting the results close to the source due to near-field effects for the larger source arrays.

The mitigation measures outlined in the JNCC guidelines (JNCC 2017) aim to protect marine mammals from the injury due to survey activities by encouraging vessels to be aware of animals that might be in the area and by increasing sound emissions gradually to give animals the opportunity to move away. With a soft start procedure implemented, the overall radius of potential injury in terms of PTS has been reduced significantly as illustrated in the figures above. For example, Figure 10-3 suggests that the predicted impact distance during the use of the Sercel G-Guns for HF cetaceans (e.g. harbour porpoise the most sensitive hearing category) is reduced from 407 m to 111 m under soft start conditions for a mammal swimming away from the static source. For a static HF cetacean, the distances would be 2,145 m without the use of a soft start although the condition that the animal would be stationary is considered unrealistic.

10.4.2.6 Behavioural Effects

The behavioural impact assessment was also conducted using the Level B harassment threshold of 160 dB re 1 μPa (rms) proposed by NMFS (2018). As a worst-case the results presented corresponds to a static marine mammal. This resulted in a predicted radial distance of approximately 1,630 m for all marine mammal hearing groups which equate to areas of 8.35 km^2.

Behavioural changes such as moving away from an area for short periods, reduced surfacing time or echolocation clicks, vocalisation changes and separation of mothers from offspring for short periods, do not necessarily imply that detrimental effects will result for the animals involved. Similarly, the masking of communication signals may also occur without any detrimental effects for the animals involved. In addition, the pulses will be intermittent rather than a continuous sound, which will reduce the period over which sound is experienced and allow animals to echolocate and communicate between pulses. Some whales are known to continue calling in the presence of pulses since the vocalisations can be heard between pulses (e.g. Greene & McLennan, 2000, Madsen *et al*., 2002). It is therefore considered that the zone of behavioural change will not be a zone from which animals are necessarily excluded, but rather one in which normal behaviour might be affected across a range of potential responses, from a simple noticing of the sound to a startle response and return to normal behaviour, through to exclusion from an area. The fact that an animal is within this area does not necessarily mean that disturbance will occur. Mitigation of the potential effects of anthropogenic sound on cetaceans focuses on reducing near field injuries, and risk assessments assume that the animals move away from loud sources of sound. While this is supported by various studies, observations also show a decline in response to airgun sound during the seismic survey. The findings of Thompson *et al*. (2013) suggest that broader-scale exclusion from preferred habitats is unlikely. Instead, individual's fitness and demographic consequences are likely to be subtle and indirect, highlighting the need to develop frameworks to assess the population consequences of sub-lethal changes in foraging energetics of animals occurring within affected sites.

It is possible to calculate the number of animals likely to experience some sort of behavioural impact using local density and population estimates. Density estimates from the area covering the North Sea are not well understood for many cetacean species but estimates from SCANS-III (detailed in Hammond *et al*., 2021) provide regional density estimates for some of the species most regularly found in vicinity of the survey.

To assess how the number of animals that could potentially be affected might constitute a non-trivial disturbance offence, it is important to understand what proportion of the population this number represents and what the duration of an effect may be. Temporarily affecting a small proportion of a population would be highly unlikely to result in population level effects, thus not considered as qualifying as a non-trivial disturbance. In contrast, affecting a large proportion of a population may be considered non-trivial disturbance. Determining this proportion is not a simple task since it is not clear how northeast Atlantic marine mammal populations act at a local level. For example, minke whales are likely to make use of the entire northeast Atlantic, so the population can be viewed as one, whilst other species, such as bottlenose dolphins, may display more local fidelity and be viewed as a series of sub-populations.

The Statutory Nature Conservation Bodies (SNCBs) (Hammond *et al.,* 2021; JNCC, 2010; IAMMWG, 2021) note that marine mammals of almost all species found in UK waters are part of larger biological populations whose range extends into the waters of other States and/or the High Seas. To obtain the best conservation outcomes for many species, it is necessary to consider the division of populations into smaller management units. This requires an understanding of the geographical range of populations and sub-populations, to provide advice on effects at the most appropriate spatial scale. The output of the SNCB exercise investigating how marine mammal populations may act is the determination of Marine Mammal Management Units (MMMU) for species including harbour porpoise, bottlenose dolphin, Atlantic white-sided dolphin, minke whale and white-beaked dolphin. These MMMUs and associated population estimates can be interpreted in the context of the potential disturbance zones to consider the potential for a significant impact to occur.

Bottlenose dolphin, harbour porpoise, minke whale and white-beaked dolphin have been recorded within the Development area. The number of individual cetaceans potentially affected by the proposed operations are detailed in Table 10-4.

The percentage of populations that may be affected are very small/low. Therefore, the proposed operations would be largely undetectable against natural variation and would have no significant effect at the population level.

Two species of seals inhabit UK waters: grey seal and harbour seal. According to the seal density maps provided in NMPi (2022), harbour and grey seal densities in the proposed survey area are 0-1 individuals per 25 km^2 and 0-1 per 25 km^2 respectively. As with cetaceans, the number of individuals likely to be affected is very small and, therefore, would be largely undetectable against natural variation and would have no significant effect at the population level. Due to the relatively low densities, an assessment was not undertaken for seals within the Development area. The information provided indicates that there is a very low likelihood of injury or non-trivial disturbance as a result of the proposed survey operations.

The information provided indicates that there is a very low likelihood of injury or non-trivial disturbance to cetaceans as a result of the proposed survey (Table 10-4). These values are based on a single pulse of the Sercel G-Guns (i.e. disturbance within 1,630 m) and not for the entire survey area. Whilst the latter will provide larger predicted numbers of animals affected, the sound emitted from the source will dissipate relatively very quickly and there will be no accumulation of the sound levels. Therefore, whilst animals may move away from the sound source, they are likely to be able to return to the area following the passing of the survey vessel. Hence, it was considered that the single pulse approach represented a realistic case.

Table 10-4 Estimated Number Of Cetaceans Experiencing Behavioural Changes Based on a Single Pulse of the Innomar source (Hammond *et al*., 2021; IAMMWGG, 2021)

Species*	Scans-III density estimates per km^2	Maximum number of animals predicted to be in the behavioural change impact zone at any one time (density x behavioural change area) **	Management unit (MU) / biogeographical population estimate	Percentage of reference population potentially affected (%)
Bottlenose dolphin	0.0037	8.10446E-07	0	<<0.001
Harbour porpoise	0.152	3.3294E-05	227,298	<<0.001
Minke whale	0.0095	2.08088E-06	23,528	<<0.001
White-beaked dolphin	0.021	4.59983E-06	15,895	<<0.001

*Note: Density estimates have been reported for SCANS-III Survey Block R

**The worst-case predicted behavioural change impact zone is 0.09 km^2 for a single pulse from the Innomar source

10.4.2.7 Fish

For fish, the most relevant criteria are considered to be those contained in the Sound Exposure Guidelines for Fishes and Sea Turtles (Popper *et al.*, 2014). The guidelines set out criteria for injury due to different sources of noise including those from seismic survey activities. The criteria for the different types of sources include a range of indices including SEL, rms and peak sound pressure levels. Where insufficient data exist to determine a quantitative guideline value, the risk is categorised in relative terms as “high”, “moderate” or “low” at three distances from the source: “near” (i.e. in the tens of metres), “intermediate” (i.e. in the hundreds of metres) or “far” (i.e. in the thousands of metres). It should be noted that these qualitative criteria cannot differentiate between exposures to different noise levels and therefore all sources of noise, no matter how noisy, would theoretically elicit the same assessment result.

The criteria presented for seismic surveys using airguns are reproduced in Table 10-5.

Table 10-5 Criteria for Onset of Injury to Fish due to Seismic Activities (Popper *et al*., 2014)

Type of animal	Parameter	Mortality and potential mortal injury	Impairment		Behavioural response
			Recoverable injury	TTS	
Fish: no swim bladder (particle motion detection)	Peak, dB re 1 µPa SEL_{cum} dB re 1 µPa ^{2} ·s	>213 >219	>213 >216	- >>186	(Near) High (Intermediate) Mod (Far) Low
Fish: where swim bladder is not involved in hearing (particle motion detection)	Peak, dB re 1 µPa SEL_{cum} dB re 1 µPa ^{2} ·s	>207 >210	>207 >203	- >>186	(Near) High (Intermediate) Mod (Far) Low
Fish: where swim bladder is involved in hearing (primarily pressure detection)	Peak, dB re 1 µPa SEL_{cum} dB re 1 µPa ^{2} ·s.	>207 207	>207 203	- 186	(Near) High (Intermediate) Mod (Far) Low
Eggs and larvae	Peak, dB re 1 µPa SEL_{cum} dB re 1 µPa ^{2} ·s.	>207 >210	(Near) Mod (Intermediate) Low (Far) Low	(Near) Mod (Intermediate) Low (Far) Low	(Near) Mod (Intermediate) Low (Far) Low

While specific modelling of fish has not been carried out, the radius of injury for the different types of fish due to seismic survey operations is presented in Table 10-6. The assessment does not include the effect of soft start partly due to the fact that eggs and larvae cannot move away from the source once the source has started up and therefore the benefit cannot be realised.

Table 10-6 Assessment on Fish from Sercel G-Guns

Type of animal	Parameter	Mortality and potential mortal injury	Impairment		Behavioural response
			Recoverable injury	TTS	
Fish: no swim bladder (particle motion detection)	Peak, dB re 1 µPa SEL_{cum} dB re 1 µPa $^{2}\cdot$s.	16 m 20 m	16 m 28 m	- 849 m	(Near) High (Intermediate) Mod. (Far) Low
Fish: where swim bladder is not involved in hearing (particle motion detection)	Peak, dB re 1 µPa SEL_{cum} dB re 1 µPa $^{2}\cdot$s.	22 m 28 m	22 m 128 m	- 849 m	(Near) High (Intermediate) Mod. (Far) Low
Fish: where swim bladder is involved in hearing (primarily pressure detection)	Peak, dB re 1 µPa SEL_{cum} dB re 1 µPa $^{2}\cdot$s.	22 m 80 m	22 m 128 m	- 849 m	(Near) High (Intermediate) Mod. (Far) Low
Eggs and larvae	Peak, dB re 1 µPa SEL_{cum} dB re 1 µPa $^{2}\cdot$s.	22 m 28 m	(Near) Mod (Intermediate) Low (Far) Low	(Near) Mod (Intermediate) Low (Far) Low	(Near) Mod (Intermediate) Low (Far) Low

The radius of potential injury from 750 in^{3} Sercel G-Gun Array source using the Popper *et al.* (2014) criteria is relatively small and range between 80 m for mortal injury to 128 m for temporary threshold shifts depending on the type of hearing mechanism of the fish.

Adult fish not in the immediate vicinity of the sound generating activity are generally able to move away and avoid the likelihood of physical injury. However, larvae are not highly mobile and are therefore more likely to incur injuries from the sound energy, including damage to their hearing, kidneys, hearts and swim bladders. Damage from shock to eggs and developing embryos consist of deformation and compression of the membrane, spiral curling of the embryo, displacement of the embryo, and disruption of the vitelline membrane. Although, such effects are unlikely to happen outside of the immediate vicinity of the geophysical survey (> 10 m). Popper *et al.* (2014) recognises the need for more data to help determine the effects of anthropogenic sound on eggs and larvae.

In terms of disturbance (or behavioural response) the effects from geophysical survey operations are presented in qualitative terms rather than quantitatively. Based on these qualitative criteria, there is a high level of risk of disturbance up to ‘tens of metres’ from the moving device, moderate at distances of 100s of metres (except for fish with swim bladders were the risk remains high) and low beyond this (i.e. ‘far’). For eggs and larvae, the risk is moderate close to the centre of activity (tens of metres) and low beyond this point.

Wardle *et al.* (2001), Mosbech *et al.* (2000) and Wardle *et al.* (1998) state that the potential disturbance zone for fish from intermittent sources like seismic survey sound sources may extend to hundreds of metres or a few kilometres, although these references relate to airgun sources. Whilst estimates of fish populations are generally not available, it is likely that many millions of individuals make up most species' populations (e.g. Mood & Brooke, 2010). The movement of fish tens or hundreds of metres away from the potential injury or disturbance impact zones would not constitute a large-scale movement by individuals of a species and is unlikely to result in population level changes. Similarly, fish outside the impact area finding the sound levels too high to enter would be unlikely to result in population level effects.

In summary, using the approach adopted by Popper *et al.* (2014), the area of behavioural change will extend beyond 10 m from the source, but the risk of disturbance will be moderate and is unlikely to be significant beyond 1 km. Given the fact that the operations will be constantly moving and the relatively short period of activity no habituation to the sound is likely.

10.5 Management and Mitigation

10.5.1 Overview

The underwater sound assessment and calculations has predicted that the use of soft start procedures will reduce the overall impact of the survey operations on marine mammals.

The JNCC guidelines for minimising the risk of disturbance and injury to marine mammals from geophysical surveys (JNCC, 2017) are summarised below. Compliance with these guidelines is considered to constitute best practice and will in most cases, reduce the risk of deliberate injury to marine mammals to negligible levels. Whilst the guidelines don't deal with disturbance directly it is considered that the mitigation measures as recommended will also assist in reducing the potential for disturbance.

10.5.2 Marine Mammal Observer (MMO) and Passive Acoustic Monitoring (PAM)

MMOs on board the vessel from which the VSP will be deployed (in this case, the drilling rig) will monitor for the presence of marine mammals, during the pre-source start search, soft-start and survey, and will recommend delays in the commencement of source activity should any marine mammals be detected within the 500 m mitigation zone. Dedicated PAM operators may also be required to cover the hours of darkness and during periods when day-time conditions are not conducive for visual surveys (e.g. fog or increased sea states). The survey contractor will be providing a team to cover 24-hour observations/PAM during the survey.

10.5.3 Pre-Source Start Search & Mitigation Zone

All observations (MMO or PAM) will be undertaken during a pre7-shooting search of 60 minutes prior to the commencement of the seismic sources. This will involve a visual (during daylight hours) and/or acoustic assessment (during hours of darkness/reduced visibility) to determine if any marine mammals are present within the 500 m mitigation zone from the centre of the device deployed. If marine mammals are detected in the mitigation zone during the pre-shooting search, then operations must be delayed until their passage. Either way there should be a minimum of a 20-minute delay from the time of the last sighting within the mitigation zone and the commencement of the soft-start and/or start of operations, to allow animals unavailable for detection to leave the area.

10.5.4 Soft-Start

There should be a soft start conducted every time prior to survey operations. Regardless of duration, where possible power should be built up gradually, in uniform stages from a low energy start-up. Surveys should be planned to avoid unnecessary time at operational power before commencement of an acquisition line and to time operations to commence data collection as soon as possible once full operational power is achieved.

10.5.5 Reporting

All recordings of marine mammals will be made using JNCC Standard Forms. At the end of the survey, a monitoring report detailing the marine mammals recorded, methods used to detect them, and details of any problems encountered will be submitted to the JNCC. The report will also include feedback on how successful the mitigation measures were. This requirement will be communicated to the MMO at survey start up meetings and at crew change. If the MMO has any queries on the application of the guidelines during the survey they will contact the JNCC for advice.

10.6 Cumulative and Transboundary Impacts

In theory, any activity that regularly emits underwater noise has the potential to act cumulatively with the Development to negatively effect marine mammals and fish in the west of Shetland area. The west of Shetland is well-developed in terms of the oil and gas industry and the Development area is within an area already used for oil and gas development (DECC, 2016). Surface infrastructure within 25 km of the Development includes BP's Clair and Clair Ridge platforms, approximately 5 and 10 km east of the Rosebank gas export pipeline to Clair Tee, respectively. There are also several pipelines in the vicinity of the Rosebank gas export to Clair Tee associated with nearby oil and gas assets and the Rosebank gas export pipeline to Clair Tee crosses telecommunication cables. However, given that the noise source with the highest likelihood of affecting receptors has been determined to be from rig deployed seismic surveys, the possibility of a cumulative impact from pre-existing infrastructure and vessels is considered to be negligible.

Siccar Point Energy, now part of Ithaca SP E&P Limited, submitted an ES in 2019 for the drilling of eight new wells and the installation of an FPSO and gas export pipeline at the Cambo field. In December 2021, the company announced that the original timescales of the Cambo project were not achievable and that the development is postponed until the next steps can be evaluated (OPRED, 2022). It is possible that the Development construction activities may overlap with those of the proposed Cambo oil field and as such there may be in increase in underwater noise emissions.

However, cetacean and fish populations are free-ranging and long-distance movement is likely to be frequent. Any animal experiencing a significant impact from one activity is likely to belong to a much wider ranging population and there is the potential for that same animal to subsequently come into contact with noise from other activities. However, injury and disturbance impacts resulting from the Development are not expected to be significant, and significant cumulative impact from the unlikely scenario of an animal encountering noise emissions from multiple activities within a short period of time will therefore not occur.

The restricted areas of potential impact mean that, considering the Development is 15 km from the UK/Faroes median line, sound emissions capable of potentially causing injury or disturbance (which are 2.2 km maximum) are unlikely to be received directly by marine mammals or fish across median lines. However, an animal experiencing a significant impact in UK waters would likely belong to a much wider ranging population and such potential impact could qualify as a transboundary impact. Despite this, any injury or disturbance resulting from the Development is expected to be not significant and potential transboundary impacts will therefore also be not significant.

10.7 Decommissioning

Any potential impact that decommissioning operations may have through sound emissions will occur in an area that experienced noise emissions during the Development operations. In general, activities are likely to be similar in nature to those required for installation (e.g. vessel use) and will generate similar noise emissions. However, should wells be abandoned, it is possible that wellheads will be cut off below the seabed; these cutting activities would result in sound emissions. Such sound emissions would be of short-term duration only and would be conducted in line with any relevant mitigation measures. Given the impact from the installation and operation are considered to be not significant, the potential impact from decommissioning is also considered to be not significant.

It is worth noting that if all the Development infrastructure is not removed at decommissioning, then there are likely to be less activities/vessels which could potentially generate underwater noise, compared to the drilling and installation phases of the Development.

10.8 Protected Sites

The assessment of potential impacts presented in this chapter has, where appropriate, taken account of protected sites. This section provides specific information on the potential impacts on conservation objectives and site integrity of relevant sites.

As described in Chapter 4 Environmental Baseline, there are four species of marine mammal listed on Annex II of the Habitats Directive that are known to occur in UK waters, all of which are qualifying features of SACs. Table 10-7 identifies whether any of the pinnipeds, harbour porpoise or bottlenose dolphin recorded in the development area have the potential to be part of an SAC population on the basis of the foraging distances of each of the qualifying features, and actual distance of the SACs designated for these species from the Development area. An assessment of the potential for a Likely Significant Effect (LSE) on a protected site is then made. As can be seen, the assessment considers there to be no potential for underwater noise emissions to interact with species listed as protected features of an SAC. Given no LSE on any SAC, it is not necessary to consider the conservation objectives or integrity of any sites in further detail. Some SACs that have been designated for marine mammals have also been designated as Sites of Special Scientific Interest (SSSI) for the same feature. These are indicated in Table 10-7, however since no LSE are expected on the SACs it is also considered that there will be no potential for damage to the protected features of the SSSI.

This assessment considers there to be very limited potential for underwater noise emissions to interact with marine mammal species listed as protected features of any NCMPA due to the distance of these from the Development area. Whilst some Risso's dolphins from the proposed Northeast Lewis NCMPA may be found within the Development area, they are likely to be in shallower waters on the continental shelf where the pipeline installation is the main activity. As this is planned to take place over one summer window and the vessels will be moving along the pipeline route rather than being in one location for the whole duration, it is considered that the interaction with this species will be limited. As such, there is no significant risk to the conservation objectives of the NCMPAs being achieved (either directly from the Development or cumulatively with other projects).

Under the Marine Scotland Act (2010), the whole of Shetland has been designated a Seal Conservation Area. Given that no activities will occur in the nearshore, there is expected to be no impact on the Seal Conservation Zone with respect to underwater noise emissions.

Table 10-7 shows the distances from the Development to the nearest protected sites.

Table 10-7 Conclusions on the potential for LSE from the Development

Species	Identified as present in area?	Closest sites to development area and designation	Foraging range of qualifying features	Distance from Development area	Potential for likely significant effect?
Bottlenose dolphin	No	Moray Firth SAC	Mainly coastal distribution (east coast Scotland)	320 km from Rosebank FPSO[47]	No – Development area beyond foraging range for bottlenose dolphin from Moray Firth SAC (especially since this population is restricted largely to within the 20 m depth contour and to the Scottish east coast). The Development is not expected to injure any bottlenose dolphins or exclude any of this species from the Development area, so there is no cumulative impact expected with other projects.
Harbour porpoise	Yes, but rarely recorded in waters deeper than 200 m.	Inner Hebrides and the Minches / Southern North Sea SAC	Mainly coastal distribution	320 km / >450 km from Rosebank FPSO	No – the Rosebank FPSO is not located within the management unit area for the Inner Hebrides and the Minches SAC. For the Southern North Sea SAC, despite being in water depth within their foraging ability and although the North Sea harbour porpoise management unit includes the continental shelf waters around Shetland, the temporally restricted nature of noise means it has a highly limited potential for interaction between the Development and animals from this site. The Development is not expected to injure any harbour porpoises or exclude any of this species from the Development area, so there is no cumulative impact expected with other projects.

[47] Distances are given from the Rosebank FPSO as a central point for noise sources.

Species	Identified as present in area?	Closest sites to development area and designation	Foraging range of qualifying features	Distance from Development area	Potential for likely significant effect?
Harbour seal	Yes, but infrequently and in very small numbers	Yell Sound Coast SAC	Approximately 50 km from haul outs	160 km Rosebank FPSO	No – outwith the foraging range and although there is known travel between this site and Shetland (SMRU Ltd, 2011), the temporally restricted nature of the noise emissions means highly limited potential for interaction between the Development and animals from this site. The Development is not expected to injure any harbour seals or exclude any of this species from the Development area, so there is no cumulative impact expected with other projects.
		Mousa SAC (and SSSI)		180 km from Rosebank FPSO	No – despite being in water depth within their foraging ability and although travel is known between Shetland and Orkney (SMRU Ltd, 2011), the temporally restricted nature of emissions means there is a highly limited potential for interaction between the Development and animals from this site. The Development is not expected to injure any harbour seals or exclude any of this species from the Development area, so there is no cumulative impact expected with other projects.
		Sanday SAC		200 km from Rosebank FPSO	No – outwith the foraging range and although there is known travel between this site and Shetland (SMU Ltd, 2011), the temporally restricted nature of the noise emissions during pipelay means there is a highly limited potential for interaction between the Development and animals from this site. The Development is not expected to injure any harbour seals or exclude any of this species from the Development area, so there is no cumulative impact expected with other projects.
Grey seal	Yes, but infrequently and in very	Faray and Holm of Faray SAC (and SSSI)	Up to 200 km from haul outs	200 km from Rosebank FPSO	No – although travel between these sites and Orkney and Shetland is known (SMRU Ltd, 2011), the Development area is at the very edge

Species	Identified as present in area?	Closest sites to development area and designation	Foraging range of qualifying features	Distance from Development area	Potential for likely significant effect?
	small numbers	North Rona SAC		240 km from Rosebank FPSO	of foraging extent and any animals found in the site would be in very low numbers and found very infrequently. The Development is not expected to injure any grey seals or exclude any of this species from the Development area, so there is no cumulative impact expected with other projects.
		Monach Islands SAC		440 km from Rosebank FPSO	No – although travel between this site and Orkney and Shetland is known (SMRU Ltd, 2011), the Development area is considered outwith their foraging extent and there is very limited scope for interaction. The Development is not expected to injure any grey seals or exclude any of this species from the Development area, so there is no cumulative impact expected with other projects.

10.9 EPS Risk Assessment

For any EPS, the Offshore Marine Conservation (Natural habitats &c.) Regulations 2007 (as amended) make it an offence to deliberately or recklessly capture, kill, injure, harass or disturb any such animal. Whilst the injury offence is related to acts against one or more animals, the disturbance offence is related to disturbance of a significant group of EPS. An EPS licence is required for any activity that might result in injury to, or disturbance of, an EPS. There is considered to be no potential for significant impact to EPS in terms of injury or disturbance during the Development. As such, an EPS licence is considered unnecessary.

10.10 Residual Impacts

The information below presents the anticipated impact as a result of the underwater noise generated as part of the Development following the implementation of mitigation measures outlined in Section 10.5.

Considering the information available on the species and species groups that will use the wider deep water and shelf areas in which the Development will see activity, it is considered that there is some tolerance to accommodate the anticipated noise emissions, with an ability to adapt or recover. As such, sensitivity is defined as low. It is recognised that whilst there may be temporary effects on behaviours of these species groups (as demonstrated by the modelling and subsequent assessment of impact above), there is not expected to be a change as a result of the proposed activities in the long term functioning or status of any populations to which they belong and vulnerability for all groups is low. Cetaceans and pinnipeds are Annex II species and protected under the EU Habitats Directive and their value is considered to be high for the assessment. For fish species, value is defined as low from an ecological perspective, as designated protection is not the same as for cetaceans and pinnipeds. Finally, as demonstrated by the noise modelling, the extent of change will be localised in scale and time, and in many cases of very limited frequency. Consequently, magnitude is defined as minor for all species.

Considering all of the above, including that there will be no discernible effects on protected sites with marine mammal features and that mitigation will be adopted to address any potential concerns, the consequence of underwater noise emissions is ranked as low. As such, the impact of the noise emitted by the Development will be not significant.

11 ACCIDENTAL EVENTS

11.1 Introduction

The risk of accidental hydrocarbon and chemical releases is inherent in all offshore oil and gas activities. This section assesses the potential impact significance of an oil spill and outlines the preventative and response measures that are in place to reduce the likelihood of such a spill occurring.

The effect of any accidental hydrocarbon or chemical release will be determined by the location of the release, characteristics and weathering properties of the released material, the direction of travel and whether environmental sensitivities lie in the path of the release. These environmental sensitivities will have spatial and temporal variations. Therefore, the risk of any accidental release having a significant impact on the environment considers both the probability of occurrence against the consequence of that hydrocarbon or chemical spill reaching an environmentally sensitive area and the environmental sensitivities present at that time.

11.2 Regulatory Controls

The key regulatory drivers associated with the prevention of oil spills, and response measures in the event of a spill are summarised in the following section.

The Offshore Safety Directive 2013/30/EU. On 10th June 2013 the EU adopted a Directive on safety of offshore oil and gas operations (Directive 2013/30/EU of the European Parliament and of the Council of 12 June 2013 on safety of offshore oil and gas operations, amending Directive 2004/35/EC). In recognition of the risks relating to major offshore oil and gas accidents, the objective of the Directive is to reduce as far as possible the occurrence of major accidents and to limit their consequences; thereby protecting the marine environmental and coastal economies from pollution, establishing requirements for safe offshore operations, ensuring effective response mechanisms, and limiting disruptions to indigenous energy production. Many of the Directive's requirements are implemented the Offshore Installations (Offshore Safety Directive) (Safety Case) Regulations 2015 (OSCR 2015) and the Health & Safety Executive (HSE and OPRED (part of the Department of Business Energy and Industrial Strategy (BEIS) have formed a partnership to establish the Competent Authority for regulating offshore major accident hazards and potential environmental consequences.

An MA is defined by the Safety Case Regulations 2015 as:

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), and for the purposes of determining whether an event constitutes a major accident under paragraph (a), (b) or (e), an installation that is normally unattended is to be treated as if it were attended.

The definition of Major Accident Hazard (MAH) is therefore any hazard that has the potential to cause a MA as per the OSCR 2015 definition and the definition of Major Environmental Incident (MEI) by the Safety Case Regulations 2015 is "an incident which results, or is likely to result, in significant adverse effects on the environment in accordance with Environmental Liability Directive 2004/35/EC of the European Parliament and of the Council on environmental liability with regard to the prevention and remedying of environmental damage".

The Environmental Liability Directive 2004/35/EC defines environmental damage to three criteria:

1. Protected habitats or species which has significant adverse effects on them reaching or maintaining favourable conservation status (i.e. designated sites under habitats and birds' directives).
2. Water damage
    a. significant adverse effects on the ecological potential of water bodies under Water Framework Directive (i.e. non-designated WFD waterbodies or length of coastline); and, or
    b. significant adverse effects on environmental status of marine waters under Marine Strategy Framework Directive (i.e. non-designated MSFD regional seas).
3. Land damage (not relevant to this assessment).

The International Convention on Oil Pollution, Preparedness, Response and Cooperation (OPRC), which has been ratified by the UK, requires the UK Government to ensure that operators have a formally approved Oil Pollution Emergency Plan (OPEP), outlining emergency response procedures, in place for each offshore operation or agreed grouping of facilities. This is enacted through The Merchant Shipping (OPRC) Regulations 1998 (as amended).

The Offshore Installations (Emergency Pollution Control) Regulations 2002 give the Government power to intervene in the event of an incident involving an offshore installation where there is, or may be, a risk of significant pollution, or where an operator has failed to implement proper control and preventative measures. These regulations apply to accidental hydrocarbon releases.

11.3 Sources of Hydrocarbon Spills

Large oil spills are rare but the risk of an oil spill is one of the main environmental issues associated with the offshore oil and gas industry and the environmental consequences of spilled oil at sea can be serious if large volumes are involved, with seabirds and coastlines noticeably affected. It is therefore important that operators consider the risks of an oil spill from planned operations in order to put in place appropriate prevention and response measures.

11.3.1 Sources

The following is a list of potential oil spill scenarios associated with the Development:

- Uncontrolled well blowout;
- Loss of FPSO inventory;
- Loss of liquid hydrocarbon inventory from infield flowline or riser; and
- Diesel spillage from FPSO, support or supply vessel, or MODU.

The above scenarios are discussed individually in the following sections, along with the potential risk of accidental spills of chemicals used in the drilling and production processes. Failure of the gas export pipeline resulting in a subsea gas release is very unlikely to result in a MEI and was therefore not considered further.

11.3.1.1 Well Blowouts

A surface blowout is defined as an uncontrolled flow of formation hydrocarbons from the reservoir to the surface which occurs because of loss of the primary and secondary well controls i.e. oil flowing due to a loss of control and containment. A blowout beneath the seabed may occur if the downhole pressure exceeds the fracture pressure of a formation and hydrocarbons flow into the weaker formation (this will not result in a release to the marine environment).

Primary well control is the process which maintains a hydrostatic pressure in the wellbore which is greater than the pressure of the hydrocarbons in the formation being drilled, but less than the formation fracture pressure. If the formation pressure is greater than the pressure of the drilling fluid in the wellbore (i.e. mud hydrostatic) the well will flow, and the hydrocarbons will enter the wellbore. If the primary well control fails this flow may be stopped by closing the Blowout Preventer (BOP), which is the initial stage of secondary well control. Secondary well control is completed by circulating out and displacing the wellbore with a high-density fluid to shut in the well. If the primary and secondary well controls fail, then a blowout may occur.

A uncontrolled and unmitigated well blow out scenario is considered to result in the largest, i.e. worst case, volume of oil to sea. The potential from an uncontrolled and ongoing well blow out scenario has therefore been assessed. Oil spill modelling has been undertaken using the Oil Spill Contingency and Response (OSCAR) model developed by Sintef and the results are presented and effects discussed in Section 11.5; in summary, beaching volumes ranged from 35,610 – 169,306 m^3 depending on season.

11.3.1.2 Loss of FPSO Inventory

Loss of the entire FPSO inventory is a highly unlikely event that has never occurred in the North Sea. Whilst collisions between vessels and fixed installations (including FPSOs) do occur from time to time, these are low energy events and the design features of FPSO (e.g. tank and hull design) are intended to prevent loss of containment occurring as the result of collisions. Whilst there is potential for loss of inventory during offloading, operational procedures with respect to maintenance and inspection of hoses and offloading activities minimise the quantities of oil that may be lost generally to less than 0.1 tonnes. However, in order to assess worst case, a scenario involving complete loss of inventory is modelled for the assessment. In summary, beaching volumes ranged from 418 – 81,371 m^3 depending on season.

11.3.1.3 Loss of Inventory from Infield Flowline or Riser

Scenarios of mooring or anchoring failure in floating installations, such as FPSOs, also have the potential to result in oil released. Commonly, after experiencing loss of mooring or anchoring, the likely cause of loss of containment would be a release from the risers and flowlines further to a loss of station. This is also a risk for the drilling rig if DP fails while the marine riser is in place.

In recent years, scenarios of loss of containment associated with loss of mooring events were experienced by Banff and Gryphon FPSOs in 2011 in adverse weather conditions. In all cases, the spills were of just under 2 tonnes of crude oil as a result of releases from the risers further to the loss of station. The volumes in this type of event are covered in the worst case loss of FPSO inventory modelling and not considered further in the impact assessment.

11.3.1.4 Diesel Spillage from FPSO, Support or Supply Vessel, or MODU

The FPSO will have diesel storage capacity and potential diesel spills may occur as a result of overfilling of tanks, incorrect line-up of valves, and hose failure during bunkering. Diesel will also be used on the MODU for power generation during planned drilling operations. The worst case diesel spill scenario would be the complete loss of inventory from the fuel tanks (modelling for which suggested beaching volumes ranging from 8.6 – 19.1 m^3 depending on season. However, the loss of diesel inventory is small compared to the worst case well blow out / loss of FPSO inventory scenarios and is not considered further in this assessment.

11.3.1.5 Chemical Release

Chemical spills may occur during chemical transfer, chemical/mud handling, or mechanical failure. The fate of any chemical entering the water column is dependent upon how physicochemical properties influence its partitioning between seawater and its susceptibility to degradation (DTI, 2001). Given the high energy marine environment of the west of Shetland area, chemical spills are expected to disperse in the offshore marine environment with a possible localised and transient effect on plankton or fish eggs/larvae, depending on the season.

As discussed in the Project Description (Chapter 3), there will be a number of chemicals used in the drilling and production phases of the Rosebank Development which present and potential spill risk. All chemicals will be certified for use offshore in accordance with UK Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) requirements.

Equinor will work with its chemical suppliers to ensure that process chemicals are monitored and managed to minimise use without compromising technical performance. Furthermore, Equinor recognises that some offshore chemicals are hazardous to the marine environment and carry a “substitution warning” under the OSPAR Harmonised Mandatory Control Scheme (HMCS) and will select, wherever possible, chemical products without a substitution warning. Equinor will work with its chemical suppliers to investigate the replacement of undesirable components and consider the use of alternatives where substance replacement not currently technically possible.
Detailed information on chemical use and discharge will be provided in the relevant chemical permit prior to the commencement of operations. Containment and handling procedures will be in place to prevent chemical spills as described in Section 11.6.

Taking the above mitigation measures into account along with probability of a spill occurring and with the highly dispersive marine environment of the West of Shetland, it is considered that the use of chemicals will not result in a significant impact to the marine environment.

11.3.2 Probability of a well blow out

The IOGP published data sheet (IOGP, 2019) presents frequencies of blowouts and well release incidents applicable to operations in the North Sea. For drilling and well operations in the North Sea, frequencies are presented for equipment meeting the North Sea standard where the operation is performed with a BOP installed and a two barrier principle is followed. The well blow out frequencies for the planned drilling operations are very low (Table 11-1).

Table 11-1 Well blow out frequencies for North Sea offshore operations as applied to the Development (IOGP, 2019)

Operation	Category	Frequency average well (per well drilled)
Development drilling, deep, normal Wells	Blowout	3.9×10^{-5}
Water injection wells	Blowout	9.2×10^{-6}
Total of 12 wells (7 development, 5 water injection)	Blowout (subsea) assuming conservative subsea fraction of 1	$[7 \times (3.9 \times 10^{-5})] + [5 \times (9.2 \times 10^{-6})]$ $= 3.19 \times 10^{-4}$

11.3.3 Behaviour of Hydrocarbons at Sea

When oil is spilled into the marine environment, it becomes subject to a number of natural "weathering" processes which quickly changes its character and distribution. Weathering effects include evaporation, influenced by ambient temperature and air movement; spreading, dependent on the viscosity of the oil and sea temperature; dissolution, where some light aromatic components of the oil are soluble; dispersion, wave action breaks up the oil into droplets which are mixed into the water column with concentrations highest in the vicinity of the spill; emulsification, seawater droplets are incorporated with oil to form a water-in-oil emulsion with a volume much greater than the original volume of oil spilled; sedimentation, oil binds to suspended solids in the water column which are then deposited on the seabed; and, biodegradation, when marine bacteria metabolise hydrocarbons with the time taken mainly dependent on surface area and bacteria density.

Therefore, the potential significance of an accidental hydrocarbon release depends on a wide variety of factors, which include:

- Release volume;
- Physical and chemical properties of the oil;
- Location of spill and metocean conditions (wind direction and speed, wave action and currents) affecting the direction of travel and spreading;
- Weathering profile of the hydrocarbon type, i.e. tendency of the oil to evaporate, disperse, and emulsify;
- The environmental sensitivities (environmental receptors) present in the path of the slick (these may change temporally);
- Likelihood of beaching and shoreline types; and
- Presence or absence of socio-economic receptors.

11.3.3 Oil Spill Modelling

The Oil Spill Contingency and Response (OSCAR) model has been developed by Sintef to model the fate of accidentally release hydrocarbons at sea. OSCAR is a stochastic (probability) model and is created by overlaying multiple computer simulations of hypothetical oil spills based on different wind and weather records. The model indicates how often oil may be observed at a particular location in all of the individual modelled events and presents this as a probability of exposure. Stochastic modelling does not represent what a single spill would look like or the area it would potentially affect. However, this type of modelling is useful for environmental risk assessment because it presents a summary of a large number of simulations based on historical wind and sea current data. This type of model generates a statistical output covering the potential geographical distribution of oil (extent of drift) and travel times. The area presented on the map shows sea and coastal locations that can reasonably be predicted to potentially be affected by an oil spill. When the outputs of the model are combined with environmental receptor characterisation at sea and on the shoreline, a qualitative estimate of potential environmental impact as a function of oil exposure and receptor sensitivity can be derived.

The sensitivity of an environmental receptor is assessed by considering the ability of the identified receptor to both tolerate exposure to, and recovery from, spilled oil. For example, the qualitative assessment takes into account species sensitivity at an individual and population effect level, the holding capacity of a particular shoreline type, or the socio-economic impacts of a spill on resources.

The extent of a hydrocarbon spill on the sea surface presents a risk to marine life, especially seabirds. When a spill reaches the shore is also a major consideration due to the sensitivity of coastlines and the near shore marine environment to oil spills. To provide information on when an oil spill might (i) beach, or (ii) cross a marine median line into non UK waters oil spill modelling was conducted in accordance with latest guidance (BEIS Sept 2021b[48]) using the OSCAR model. The two worst-case release scenarios modelled were:

1. Instantaneous loss of the entire FPSO crude cargo; and
2. Well blowout using the highest unconstrained well flowrate (8,000 m^3/day) for 112 days (this is the estimated time taken to drill a relief well).

These models were run for each season and on the basis that there was no intervention by any third-party to respond to the released oil and, as such, represent a worst-case scenario. The model results are displayed to a surface oil thickness of 0.3µm in accordance with OPRED oil spill modelling guidance. The accidental release scenarios volumes for the oil spill modelling are detailed in Table 11-2 (note: FPSO actual cargo capacity is 127,500 m^3, lower than the release scenario modelled).

Table 11-2 Summary of accidental release scenarios modelled for the Development

Scenario number	Scenario description	Hydrocarbon type	Release volume (m^3)	Modelled depth of release	Model type
1	Instantaneous loss of FPSO crude cargo	Rosebank crude	187,313	Surface	Stochastic
2	Well blowout using the highest unconstrained well flowrate for 112 days (estimated time taken to drill a relief well).	Rosebank crude	896,000	Seabed	Stochastic

The well blow out scenario parameters (8,000 m^3/day continuous flow rate for 112 days) is very conservative. It is more realistic to expected that the well flow rate would decline over a matter of days and that a relief well could be drilled in a quicker time. However, for the purposes of the assessment a worst case set of scenario parameters was selected for the oil spill model.

[48] Guidance Notes for Preparing Oil Pollution Emergency Plans. For Offshore Oil and Gas Installations and Relevant Oil Handling Facilities BEIS Sept 2021.

The stochastic model presents a large number of individual simulations to present an area that corresponds to the likelihood that oil thickness on the sea surface will be at least 0.3 um by combining all the simulations on to a single map. It does not represent a single oil spill trajectory. A single oil spill can be individually modelled in a deterministic simulation to support response planning in a particular set of circumstances. Mitigation and response measures can be incorporated into the deterministic model to illustrate the effect of planned interventions which is often presented as a set of time series maps over a number of days/weeks. For this reason, deterministic modelling is used for planning the response to a specific incident scenario whereas the stochastic representation provides an overview of probable scenarios for the purpose of environmental risk assessment.

11.3.4 Scenario 1: Instantaneous Loss of Rosebank FPSO Crude Inventory

The results of the FPSO inventory loss oil spill modelling are presented below. The modelling outputs provide a range of probability (lowest to highest) and time taken (minimum to maximum) to reach the median line or the coastline. The highest probability and minimum arrival time, i.e. the worst case, generated by the model, are presented below (Table 11-3) and probability plots for surface oiling and arrival time are displayed in Figure 11-1 and Figure 11-2.

(Note: N/A means that model did not predict surface oil at these locations at that time of year).

Table 11-3 Loss of FPSO inventory oil spill modelling results summary

Feature	Highest probability of surface oil reaching a median line and minimum arrival time by season			
	Dec - Feb	Mar - May	Jun - Aug	Sep - Nov
Median Line				
Norway	85.5%	94.5%	83.6%	60%
	6 days 16 hours	6 days 22 hours	6 days 1 hour	7 days 7 hours
Faroe Islands	59.1%	80%	83.6%	63.6%
	4 hours	7 hours	9 hours	6 hours
Iceland	N/A	N/A	0.9%	N/A
	N/A	N/A	40 days 18 hours	N/A
Landfall - UK				
Shetland	3.6%	14.5%	17.3%	10.9%
	7 days 7 hours	4 days 13 hours	6 days 1 hour	4 days
Orkney	0.9%	2.7%	0.9%	0.9%
	39 days 2 hours	18 days 16 hours	36 days 22 hours	39 days 15 hours
Highland	N/A	1.8%	N/A	N/A
	N/A	28 days 15 hours	N/A	N/A
Aberdeenshire	N/A	0.9%	N/A	N/A
	N/A	43 days 13 hours	N/A	N/A
Moray	N/A	0.9%	N/A	N/A
	N/A	45 days 10 hours	N/A	N/A
Landfall - International				
Norway	0.9%	0.9%	6.4%	9.1%
	26 days 5 hours	28 days 19 hours	25 days 15 hours	19 days 20 hours
Faroe Islands	9.1%	16.4%	35.5%	6.4%
	20 days 16 hours	9 days 16 hours	6 days 14 hours	10 days19 hours

Feature	Highest probability of surface oil reaching a median line and minimum arrival time by season			
	Dec - Feb	Mar - May	Jun - Aug	Sep - Nov
Beached volumes				
Maximum volume of beached emulsion in any single run (m^3)	2,850.0	81,370.7	8,489.9	417.6

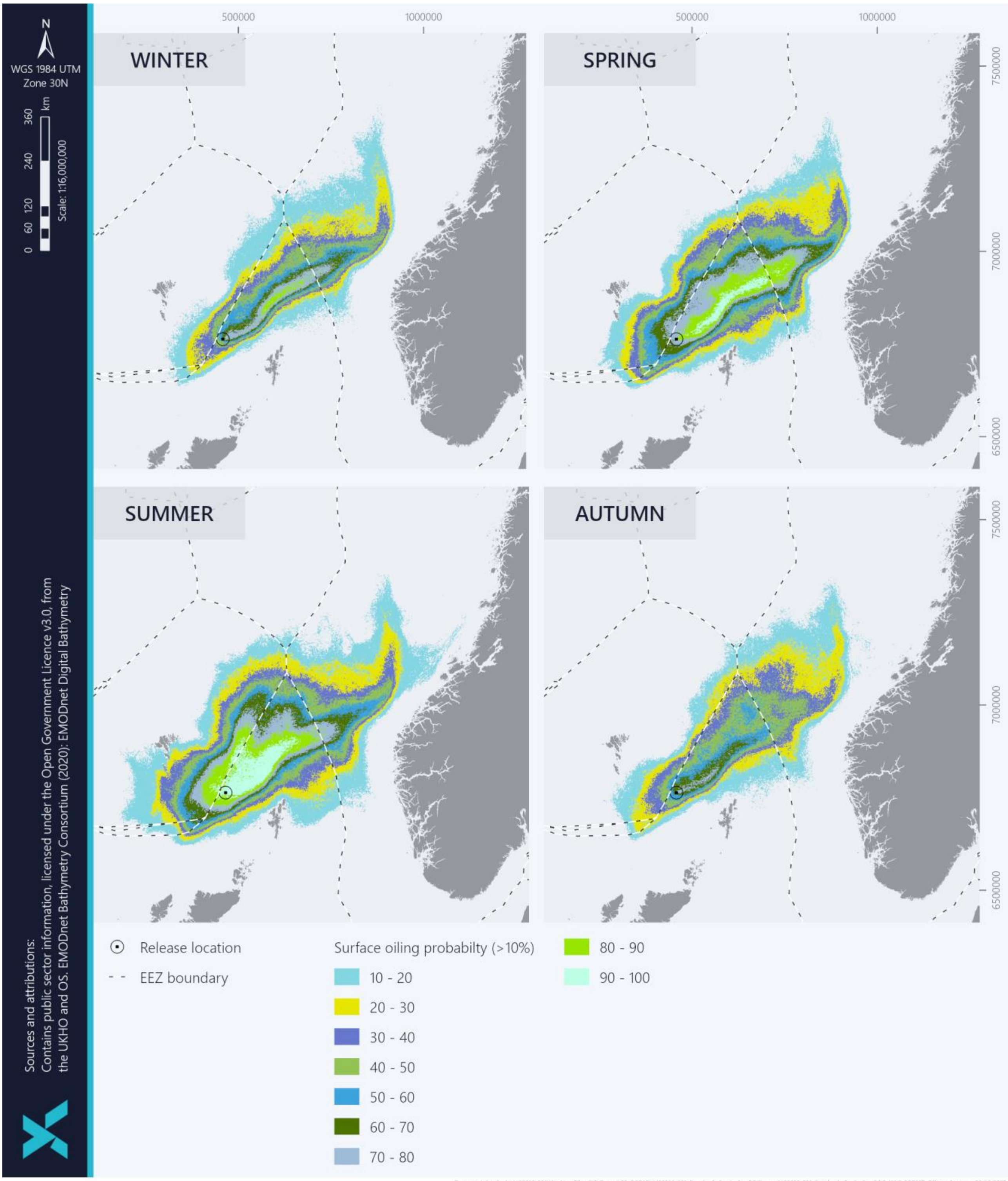

Figure 11-1 Scenario 1: Crude release – Maximum probability of surface oiling (above 0.3 µm thickness)

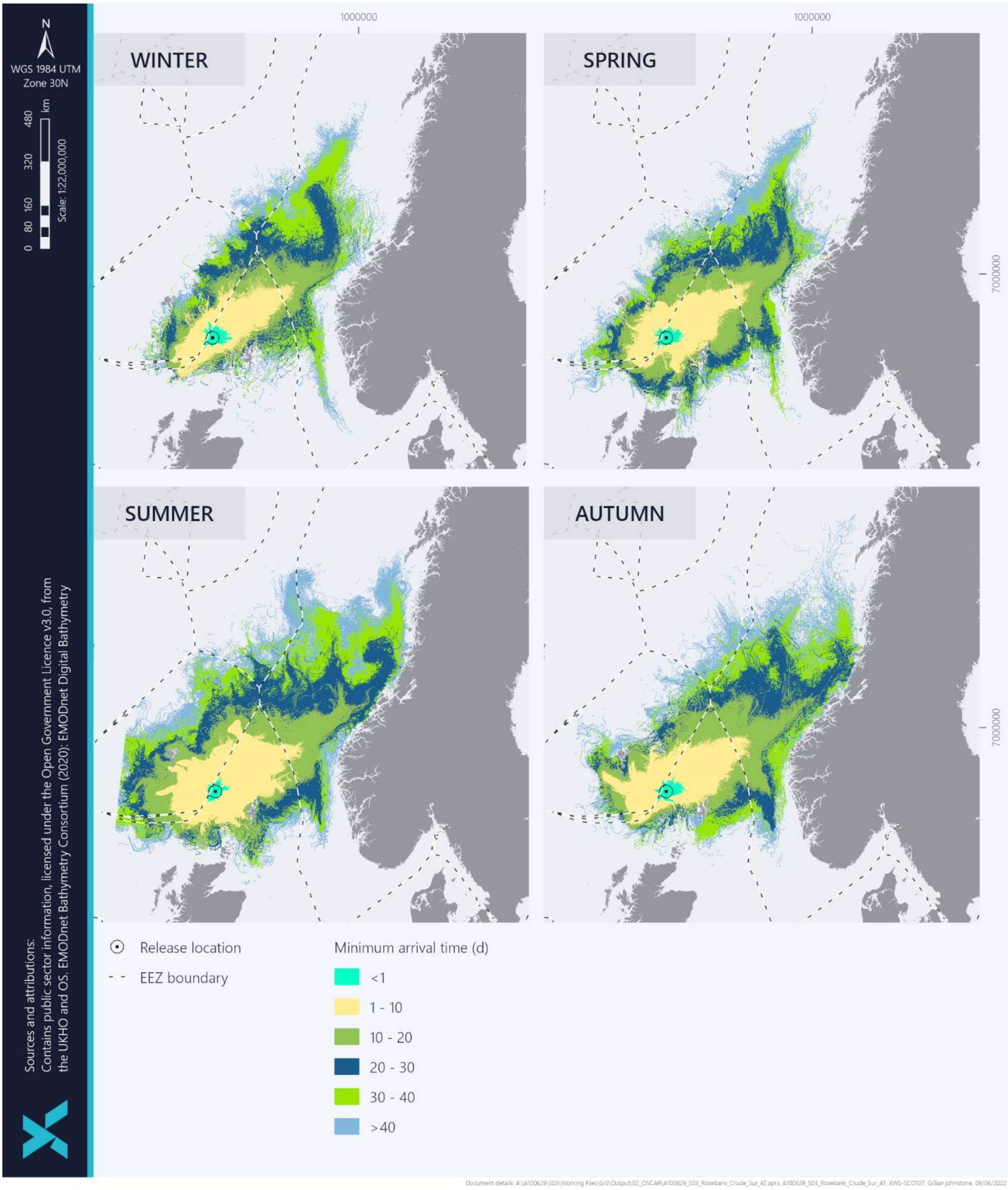

Figure 11-2 Scenario 1: Crude release – Estimated arrival time

11.3.5 Scenario 2: Well Blowout for 112 days (maximum estimated time taken to drill a relief well)

The results (highest probability and minimum arrival time to median line or coastline) of the worst case flow rate uncontrolled well blow out oil spill modelling are presented in Table 11-4. For worst case to be presented, the highest well volume has been assumed to flow at a constant rate (no decline) over the maximum number of days expected to drill a relief well. Probability and minimum arrival time plots for Scenario 2 are displayed in Figure 11-3 and Figure 11-4.

Table 11-4 Well blowout modelling results

Feature	Highest probability and minimum arrival time by season			
	Dec - Feb	Mar – May	Jun - Aug	Sep - Nov
Median Line				
Norway	100%	100%	100%	100%
	4 days 12 hours	5 days 1 hour	6 days 6 hours	4 days 22 hours
Faroe Islands	100%	100%	100%	100%
	9 hours	10 hours	13 hours	10 hours
Iceland	19.1%	50.9%	23.6%	14.5%
	59 days 13 hours	50 days 12 hours	38 days 9 hours	53 days 4 hours
Jan Mayen	48.2%	33.6%	25.5%	36.4%
	78 days 21 hours	68 days 5 hours	54 days 3 hours	60 days 6 hours
Denmark	20.9%	11.8%	6.4%	6.4%
	62 days 4 hours	43 days 16 hours	92 days 6 hours	75 days 17 hours
Sweden	10%	9.1%	2.7%	4.5%
	73 days 8 hours	89 day 2 hours	103 days	83 days 1 hours
Eire	0.9%	10%	0.9%	N/A
	121 days 9 hours	57 days 1 hour	53 days	N/A
Germany	8.2%	7.3%	N/A	2.7%
	94 days	64 days 8 hours	N/A	129 days 16 hours
Netherlands	3.6%	2.7%	N/A	0.9%
	112 days 14 hours	70 days 11 hours	N/A	123 days 21 hours
Greenland	N/A	N/A	N/A	1.8%
	N/A	N/A	N/A	117 days 15 hours
Landfall – UK				
Shetland Islands	92.7%	99.1%	95.5%	88.2%
	3 days	4 days 9 hours	5 days 14 hours	3 days 20 hours
Orkney Islands	41.8%	59.1%	33.6%	36.4%
	6 days 4 hours	10 days	8 days 19 hours	9 days 4 hours
Highland	17.3%	20%	9.1%	20%
	33 days 1 hour	21 days 15 hours	23 days 6 hours	15 days 22 hours
Moray	16.4%	15.5%	0.9%	2.7%
	60 days 8hours	31 days 2 hours	136 days 14 hours	94 days 11 hours
Aberdeenshire	14.5%	14.5%	1.8%	4.5%
	23 days 14 hours	30 days 12 hours	92 days 5 hours	40 days 19 hours
East Lothian	6.4%	3.6%	0.9%	0.9%
	100 days 1 hour	78 days14 hours	137 days 4 hours	132 days 23 hours
Angus	5.5%	2.7%	N/A	0.9%

Feature	Highest probability and minimum arrival time by season			
	Dec - Feb	Mar – May	Jun - Aug	Sep - Nov
	103 days 11 hours	78 days 11 hours	N/A	104 days9 hours
Fife	5.5%	3.6%	N/A	0.9%
	99 days 7 hours	78 days 3 hours	N/A	120 days 13 hours
Scottish Borders	1.8%	1.8%	N/A	0.9%
	97 days 16 hours	86 days	N/A	121 days 16 hours
Northumberland	1.8%	0.9%	0.9%	0.9%
	99 days	74 days 17 hours	127 days 8 hours	93 days 1 hour
Landfall – International				
Faroe Islands	54.5%	83.6%	93.6%	60%
	7 days 17 hours	6 days 12 hours	6 days 3 hours	4 days 14 hours
Norway	50%	34.5%	49.1%	37.3%
	16 days 22 hours	13 days 2 hours	20 days 18 hours	17 days 12 hours
Iceland	0.9%	4.5%	4.5%	8.2%
	117 days 14 hours	104 days 17 hours	88 days 3 hours	82 days 11 hours
Denmark	8.2%	4.5%	3.6%	6.4%
	39 days 19 hours	77 days 6 hours	103 days 21 hours	51 days 4 hours
Sweden	3.6%	5.5%	2.7%	1.8%
	76 days 10 hours	100 days 23 hours	119 days 5 hours	98 days 15 hours
Germany	1.8%	3.6%	N/A	N/A
	117 days 4 hours	87 days 15 hours	N/A	N/A
Netherlands	1.8%	0.9%	N/A	N/A
	115 days 3 hours	106 days 12 hours	N/A	N/A
Beached volumes				
Maximum volume of beached emulsion in any single run (m^3)	99,348	169,306	104,839	35,610

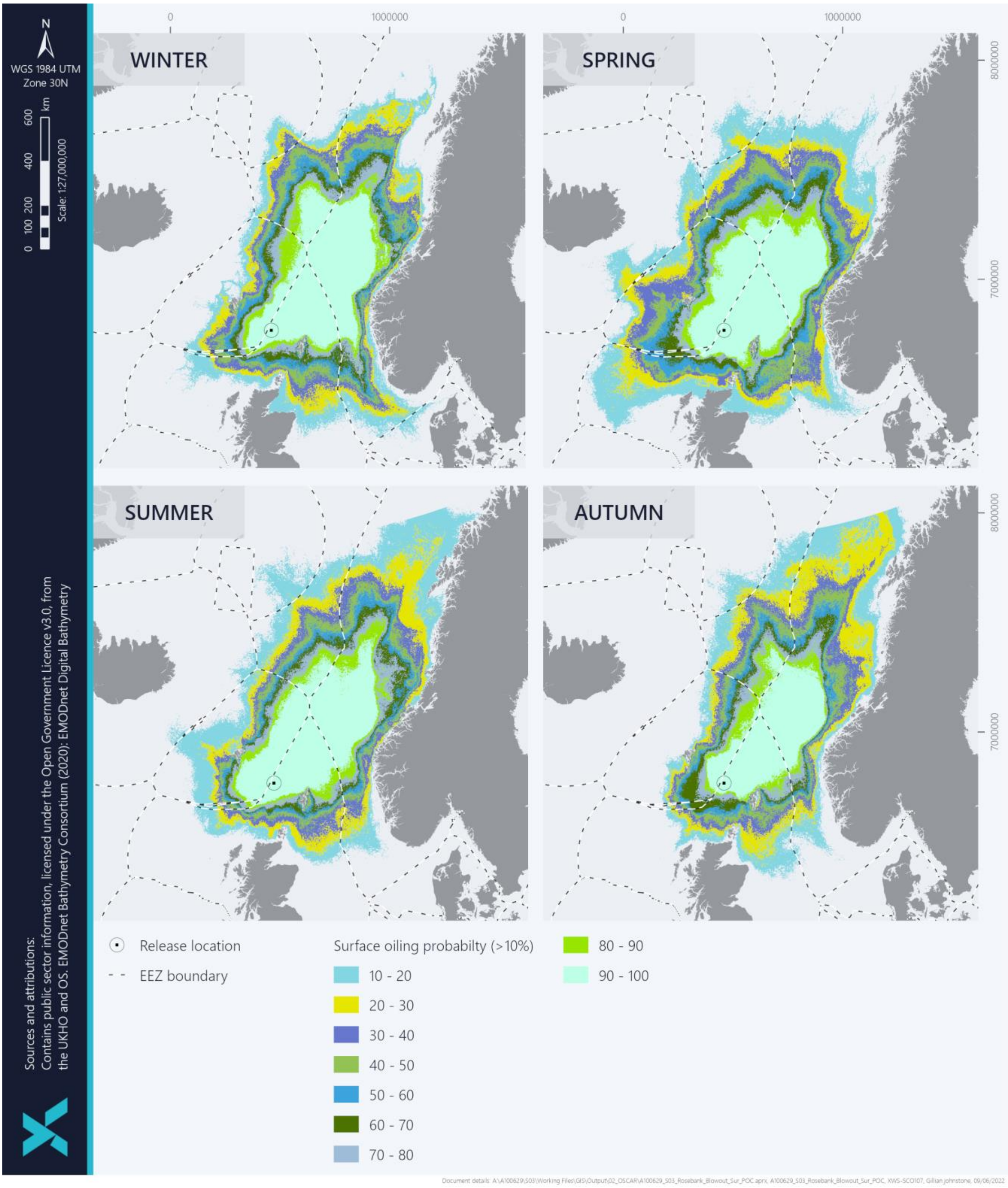

Figure 11-3 Scenario 2: Well blowout - Probability of surface oiling (above 0.3 µm thickness) that is above 10%

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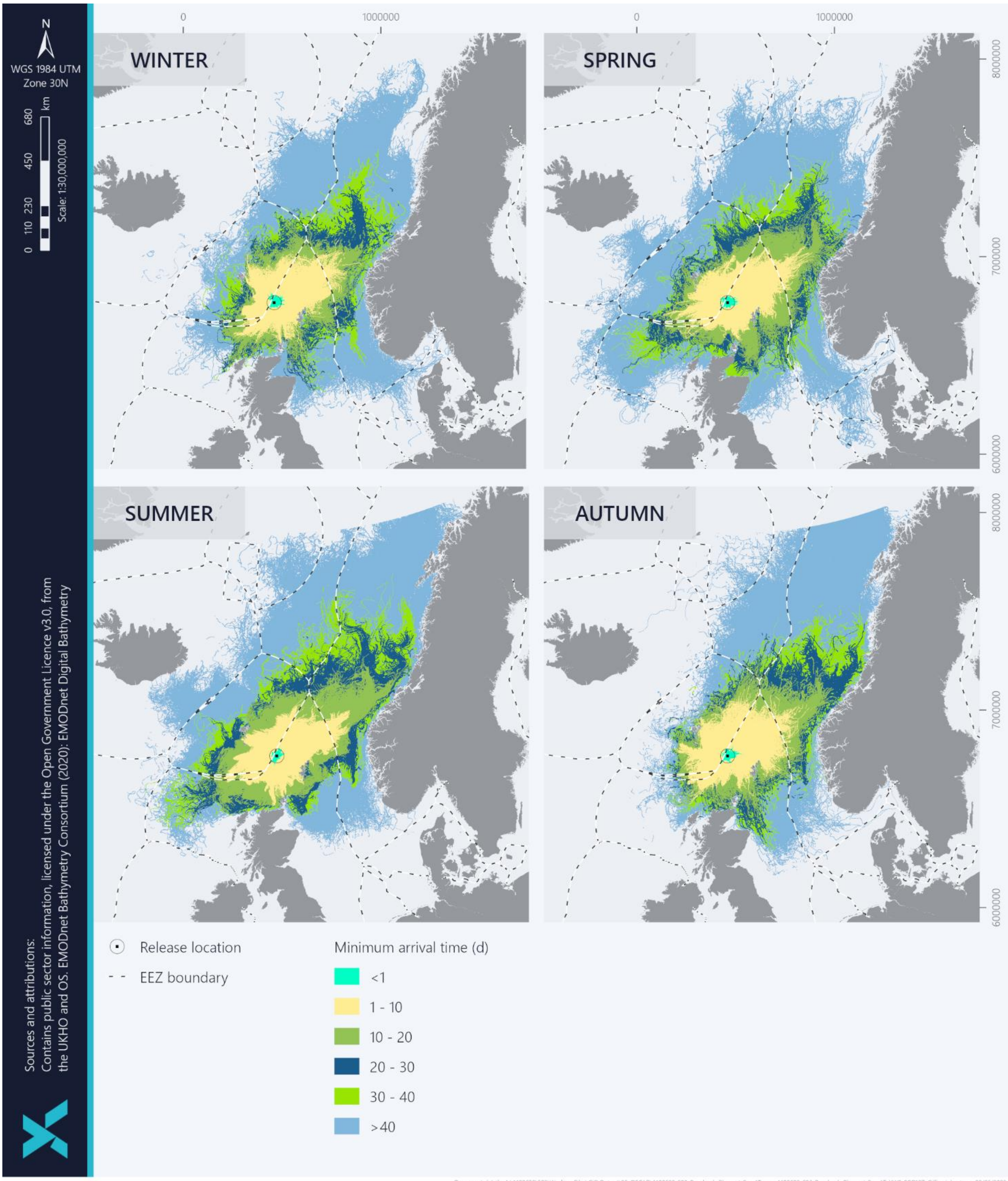

Figure 11-4 Scenario 2: Well blowout – Estimated arrival time

11.4 Potential Environmental Effects

The oil spill modelling for the worst case scenario of a well blow out predicts that oil will reach shorelines and a large area would be affected by sea surface oiling. A general summary of expected changes which could result from an oil spill and the effects on marine receptors is provided below. The following assessment considers the potential for a low probability, high consequence blowout event to result in a worst case oil spill scenario. In this assessment, to enable a worst case assessment, it is assumed that no response or clean-up activities are implemented to mitigate the spill, noting in reality that this would not be the case.

11.4.1 Plankton

Plankton are relatively sensitive to hydrocarbon exposure, particularly when exposed via small droplets and soluble components in the water column. However, it is expected that plankton communities return to normal densities and community composition once oil in water concentrations have reduced. The ability to recover quickly is due to short generation times and the production of large numbers of eggs and juveniles, distribution over large areas and high refreshment rates of the water column.

The sensitivity and vulnerability of planktonic species to an oil spill are considered Low as populations are large and widespread. However, the potential magnitude of effect is considered Major and overall consequence Moderate.

11.4.2 Benthos

The seabed habitats and communities in the location of the Development are described in detail in Chapter 4. It is considered that a sub-surface well blow out would rise quickly to the sea surface and the main effects on benthic species and habitats would be detected if the oil spill reached shallow waters at the shoreline.

Although it is unlikely for significant oil concentrations to be found on the seabed at offshore locations, the effect of oil spills on seabed dwelling species and their habitats is likely if the spill reaches shallow waters and shorelines. In this case, animals that live on the seabed or burrowing creatures that siphon water for feeding or irrigation are vulnerable to the effects of a spill. A spill reaching a coastline is likely to affect filter feeding bivalves living in the shallow sediments and if a significant number are lost, it may take some time for populations to recover, especially for long lived bi-valve species. Oil spills on shorelines and coastal habitats are discussed further below.

The sensitivity of benthic species is considered moderate as it is related to the extent of shoreline oiling and the vulnerability is considered high. The magnitude of the impact is major and overall consequence is moderate.

11.4.3 Fish

The likelihood of fish or shellfish being exposed to water soluble hydrocarbons or dispersed oil droplets depends on the depth of water in which they live. It is unlikely that dispersed oil will affect fish populations in deep water as demersal species will be below the depths that elevated concentrations of oil are likely to reach. And pelagic fish tend to avoid surface waters and are very mobile and therefore their exposure is expected to be very limited.

Fish eggs and larvae are expected to be more vulnerable to oil spills than adult fish as they may be floating at the surface where contact w oil is much more likely. However, extensive spawning grounds and high reproduction rates mean that population levels are unlikely to be affected.

The sensitivity and vulnerability of fish populations to a sub-surface well blow out is considered to be moderate and the magnitude of impact is major due to the large volume of water potentially affected and overall consequence is moderate.

11.4.4 Coastal Environments

The implications for a shoreline are related to the volume of any hydrocarbon beaching, the composition of the beached hydrocarbons, and the type of beach.

Coastal environmental sensitivities to spills include nearshore breeding seabird populations, shore birds, over wintering diver and duck species, marine mammals, aquaculture operations and sub-littoral and coastal habitats, some of which are designated as protected sites.

Intertidal areas of the coast show varying degrees of sensitivity to spills. For example, high energy rock, boulder or cliff coastlines tend to have lower sensitivity to hydrocarbon pollution because oil is rapidly broken up and dispersed by wave action, with any beached oil remaining on the surface of rocks and being exposed to further weathering. Much of the north and east coast of mainland Scotland (and Shetland and Orkney) is predominantly rocky shoreline so the effect of beached oil may be less severe than for sedimentary coastlines.

Sheltered, low energy shorelines tend to have a relatively greater sensitivity because oil does not tend to be broken up by wave action and it can be mixed into the sediment, shingle or cobbles where it is not exposed to weathering and therefore can persist for longer.

Mudflats and sandflat habitats (Annex I habitat) are particularly vulnerable to oil because oil is not broken up by wave action and it can be mixed into the sediment, shingle or cobbles where it is not exposed to weathering and therefore persists for longer. The Sanday SAC is designated for the protection of mudflats and sandflats and the model shows that it could be affected by beached oil (Table 11-5).

Hence the sensitivity of the coastline is considered high and the magnitude of impact is major and the overall consequence is major.

11.4.5 Protected Sites

Coastal sites most likely have the potential to be affected because of oiling are estuaries, mud and sandflats and dune features, although dunes are unlikely to be oiled[49]. These habitats are also more likely to be negatively affected by hydrocarbon contamination than sea cliff habitats. Habitats most likely to be negatively affected by hydrocarbon contamination are exposed reefs and affected species are those that feed and/or breed in areas where hydrocarbons beach.

The probabilities of sea surface oiling and arrival on the shoreline derived from the stochastic oil spill modelling (see Section 0) were examined to identify protected sites at risk of hydrocarbon contamination. A threshold probability of 40% for surface oiling at the protected site was selected as the criteria for likely significant effect.

The protected sites included in the assessment were SACs (including cSACs), SPAs (including pSPAs) and NCMPAs. The modelling for the worst case oil spill scenario (well blowout) predicted there to be at least a 40%

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[49] Dune systems commonly have a significant component of their area that is inland and away from the extreme high water spring line. However, the part of the dune system that is bordering the littoral zone does have the potential to become oiled, particularly during storm events on spring tides.

probability of receiving oil at 29 sites, although this does not necessarily mean that the qualifying features of the sites will be affected (e.g. some of the sites are designated for features that would be unlikely to receive any oil such as those in the benthic environment). The sites likely to be most affected are those designated for seabird species or marine mammals as they are most likely to be present at the sea surface where the oil is predicted to be found. These sites are presented in Table 11-5, and the effect of hydrocarbon interaction with the features of designation are discussed below.

Table 11-5 Protected sites where surface oiling from a well blowout at Rosebank is predicted to enter the site at a surface contamination probability >40%

Site	Primary designation/features
Hermaness, Saxa Vord and Valla Field SPA Maximum probability of surface oiling (%): 99.1	Annex I Species that are primary reason for selection: • Red-throated diver *Gavia stellata*
Noss SPA Maximum probability of surface oiling (%): 76.4	Annex I Species that are primary reason for selection: • Great skua *Catharacta skua* • Guillemot *Uria aalge* • Gannet *Morus bassanus*
Bluemull and Colgrave Sounds SPA Maximum probability of surface oiling (%): 59.1	Annex I Species that are primary reason for selection: • Red-throated diver
East Mainland Coast, Shetland SPA Maximum probability of surface oiling (%): 84.5	Annex I Species that are primary reason for selection • Great northern diver *Gavia immer* • Red-throated diver • Slavonian grebe *Podiceps auritus*
Foula SPA Maximum probability of surface oiling (%): 93.6 Seas Off Foula SPA Maximum probability of surface oiling (%): 100	Annex I Species that are primary reason for selection (Foula SPA): • Arctic tern *Sterna paradisaea* • Leach's Storm-petrel *Oceanodroma leucorhoa* • Red-throated diver Annex I Species that are primary reason for selection (Seas off Foula SPA): • Great skua *Catharacta skua* • Guillemot
Fetlar SPA Maximum probability of surface oiling (%): 97.3 Fetlar to Haroldswick NCMPA Maximum probability of surface oiling (%): 96.4	Annex I Species that are primary reason for selection (Fetlar SPA): • Arctic tern • Red-necked phalarope *Phalaropus lobatus* Annex I Species that are primary reason for selection (Fetlar to Haroldswick NCMPA): • Black guillemot *Cepphus grylle*
Sumburgh Head SPA Maximum probability of surface oiling (%): 80	Annex I Species that are primary reason for selection: • Arctic tern
Mousa SAC Maximum probability of surface oiling (%): 56.4	Annex II species that are a primary reason for selection: • Harbour seal *Phoca vitulina*
Fair Isle SPA Maximum probability of surface oiling (%): 87.3	Annex I Species that are primary reason for selection: • Arctic tern

Site	Primary designation/features
Papa Stour SPA Maximum probability of surface oiling (%): 89.1	Annex I Species that are primary reason for selection: • Arctic tern
Yell Sound Coast SAC Maximum probability of surface oiling (%): 52.3	Annex II species that are a primary reason for selection: • Otter *Lutra lutra* • Harbour seal *Phoca vitulina*
Sanday SAC Maximum probability of surface oiling (%): 50.9	Annex I habitats that are primary reason for selection: • Reefs Annex I habitats present as a qualifying feature • Sandbanks which are slightly covered by sea water all the time • Mudflats and sandflats not covered by seawater at low tide Annex II species that are a primary reason for selection: • Harbour seal *Phoca vitulina*
Sule Skerry and Sule Stack SPA Maximum probability of surface oiling (%): 40	Annex I Species that are primary reason for selection: • Guillemot *Uria aalge* • Gannet *Morus bassanus* • Leach's petrel *Oceanodroma leucorhoa*
East Sanday Coast SPA Maximum probability of surface oiling (%): 50.9	Annex I Species that are primary reason for selection: • Bar-tailed godwit *Limosa lapponica* • Purple sandpiper *Calidris maritima*

In addition to the sites listed in the table above, there are a further 13 protected sites that could receive oil under a worst-cast well blowout (>40% probability) which are designated for features that are less sensitive to oil on the sea surface, such as those of benthic or geological nature. These are listed below in Table 11-6.

Table 11-6 Protected sites with features that are not likely to be affected because of hydrocarbon contamination from a well blowout at Rosebank (>40% probability of surface contamination)

Site	Primary designation/features
Wyville Thomson Ridge NCMPA Maximum probability of surface oiling (%): 79.1	Annex I habitats that are primary reason for selection: • Reefs
Mousa to Boddam NCMPA Maximum probability of surface oiling (%): 59.1	Protected geomorphological features: • Marine Geomorphology of the Scottish Shelf Seabed Protected species: • Sandeels
West Shetland Shelf NCMPA Maximum probability of surface oiling (%): 78.2	Protected habitats and geomorphological features: • Offshore subtidal sands and gravels
Central Fladen NCMPA (Offshore) Probability of surface oiling (%): 60	Protected habitats and geomorphological features: • Burrowed mud (seapens and burrowing megafauna and tall seapen components) • Sub-glacial tunnel valley representative of the Fladen Deeps Key Geodiversity Area
North-east Faroe-Shetland Channel NCMPA Maximum probability of surface oiling (%): 100	Protected habitats and geomorphological features: • Offshore deep sea muds • Offshore subtidal sands and gravels Protected species:

Site	Primary designation/features
	• Deep-sea sponge aggregations
Pobie Bank Reef SAC Maximum probability of surface oiling (%): 100	Annex I habitats that are primary reason for selection: • Reefs
Darwin Mounds SAC Maximum probability of surface oiling (%): 67.3	Annex I habitats that are primary reason for selection: • Reefs
Faroe-Shetland Sponge Belt NCMPA Maximum probability of surface oiling (%): 100	Protected habitats and geomorphological features: • Offshore deep sea muds • Offshore subtidal sands and gravels Protected species: • Deep-sea sponge aggregations
North-west Orkney NCMPA Maximum probability of surface oiling (%): 92.3	Protected geomorphological features: • Sandbanks, sand wave fields and sediment wave fields Protected species: • Sandeels
Papa Stour SAC Maximum probability of surface oiling (%): 89.1	Annex I habitats that are primary reason for selection: • Reefs • Submerged or partially submerged sea caves
Braemar Pockmarks SAC Maximum probability of surface oiling (%): 51.2	Annex I Habitats that are primary reason for selection: • Submarine structures made by leaking gases
West of Scotland NCMPA Maximum probability of surface oiling (%): 65.5	Protected habitats and geomorphological features: • Offshore deep sea muds • Offshore subtidal sands and gravels Protected species: • Deep-sea sponge aggregations
Papa Westray NCMPA Maximum probability of surface oiling (%): 55.5	Protected geomorphological features: • Marine Geomorphology of the Scottish Shelf Seabed

The sensitivity, vulnerability and value of coastal protected sites are all considered to be High and the magnitude of potential effect is Major. Hence the overall assessment of potential consequence of a large oil spill on protected sites is Major.

11.4.6 Marine Mammals

Marine mammals have the potential to encounter surface oil in the event of a release. Cetaceans are present in the vicinity of the Development area (Environment Baseline Chapter 4). In the event of a release, the potential effect will depend on the encounter rate of the species with the oil and their feeding habits, the overall health of individuals before exposure, and the characteristics of the hydrocarbons. Whilst these species are highly mobile and often undertake lengthy migrations, a strong attraction to specific areas for breeding or feeding may override any tendency cetaceans have to avoid hydrocarbon contaminated areas. It is thought unlikely that a population of cetaceans in the open sea would be affected by a spill in the long-term (Aubin, 1990), although in contrast to seabirds, there is relatively little evidence of direct mortality associated with oil spills (Geraci & St. Aubin, 1990; Hammond *et al*. 2002).

Seals are widespread in the North Sea and come ashore to breed and pup (see Environment Baseline Chapter 4). There are a number of seal haul-out sites along the coast of Shetland. Seal pups are susceptible to external oil contamination (Ekker *et al*., 1992) because they are born without any blubber and rely on their prenatal fur and metabolic activity for thermal balance. The pups remain in breeding colonies until they are weaned and, unlike adults or juveniles, would be unable to leave an affected area in the nearshore.

The Sanday, Mousa, and Yell Sound Coasts SACs are predicted to receive surface oil contamination (Table 11-5) and surface oiling is considered to present a potential for significant adverse impact to marine mammals found at these protected sites.

Otters are found on Shetland and often live along the coast. Hydrocarbons can be toxic to otters when ingested, and ingestion has been found to lower haemoglobin levels. Otters affected by oiling have been found to dive less often and hence prey capture rate decreases (Ben-David *et al.* 2000).

As marine mammals are protected species, their sensitivity and value are considered high whilst the magnitude of impact is considered major and the consequence of effect is assessed as major.

11.4.7 Seabirds

Seabirds are affected by sea surface oiling. Should oil become incorporated into the feathers, there is an increased chance of mortality, since functioning plumage is essential to flight, waterproofing and heat insulation. Some groups of seabirds are more vulnerable than others due to their particular behaviours. Guillemots, which spend much of their time on the sea surface and typically dive to avoid danger, are particularly sensitive to oil slicks. This is most true in the post-breeding period because the male parents accompany their flightless young in swimming offshore from the breeding colonies. This generally occurs in late spring and early summer. Gannets may also be more sensitive due to their diving behaviour which causes them to repeatedly pass through any sea surface hydrocarbon layer.

Species that nest on cliffs and cliff tops are unlikely to have their nesting sites directly adversely affected by an accidental hydrocarbon release, although following the Sea Empress incident, gannets were observed collecting contaminated nesting material (Santillo *et al*., 1998).

Sheltered habitats that encourage wading or resting on calm water may see losses of birds in the event of sea surface oiling due to the greater likelihood that large accumulations of birds will be exposed.

The magnitude of any impact will depend on the number of birds present, the percentage of the population present, their vulnerability to spilled hydrocarbons, and their recovery rates from oil pollution. The JNCC has produced a Seabird Oil Sensitivity Index (SOSI) which identifies the) seasonal vulnerability of seabirds to oil pollution, derived from JNCC block-specific data. In the immediate vicinity of the Development, seabird sensitivity to oil releases ranges from low to extremely high (see Environment Baseline Chapter 4 for further detail).

Specific recovery rates will vary by species and with the total biogeographical population, which influences the potential for population recovery following an incident. Population recovery depends on factors including:

- Mortality rate of the breeding population;
- Number of juveniles lost (affecting recruitment rates in following years);
- Rates of reproduction of individual species;
- Loss of feeding grounds and prey species; and
- Sub-lethal effects which may affect reproductive success.

Many of the SPAs along the east coast of the UK support similar protected bird species and therefore, each population could be expected to be able to recover through recruitment events from nearby sites within a single breeding season. However, potential recovery rates will vary depending on the species affected, recovery of feeding grounds, the extent of change in food source availability and the extent of population loss (see Piatt *et. al.,* 1990; Boersma *et.al.,* 1995).

Seabirds that rest and breed within SPA boundaries commonly feed in waters outside the site boundary, meaning that hydrocarbon releases may affect protected site features without directly entering the site. There are twelve SPAs listed in Table 11-5 with a >40% probability of surface oiling.

It is therefore concluded that there is a potential for surface oil contamination to result in significant adverse effects to protected bird species and their high sensitivity (SOSI) and potential major magnitude of effect results in an overall consequence of effect is major.

11.4.8 Socio-economic Receptors

Shellfish production is an important economic activity in Scotland. The Shellfish Farming Production Survey (Scottish Government, 2020b) states that in 2018, the total value at first sale for all species was calculated at approximately £7.9 million, a decrease of 17% from the £9.5 million estimated in 2018. Production was dominated by mussel and Pacific oyster in terms of value and tonnage. Mussel production decreased by 3% and Pacific oyster production increased by 14% during 2019, although small quantities of scallop, queen scallop (queen) and native oyster were also produced (Scottish Government, 2020b). An increase for finfish production was also recorded between 2018 and 2019, where total production was 156,025 tonnes in 2018 and 203,881 tonnes in 2019 (Scottish Government, 2020c).

The model predicts potential surface oiling on the coastlines of Shetland and Orkney which support shellfish protection areas and aquaculture sites such as Bluemull Sound and Ronas Voe in Shetland and Papa Sound in Orkney. Potential taint and associated health effect may result in the closure of aquaculture sites and fishing grounds for a prolonged period.

Other socio-economic receptors can be affected by beached oil, such as tourism and recreation and coastal industries.

The sensitivity of socio-economic receptors is considered high and magnitude of impact is considered major. The overall consequence of effect is considered major.

11.5 Major Environmental Incident (MEI) Assessment

11.5.1 MEI Summary

Under the Offshore Safety Directive (2013/30/EC) and the implementing UK regulations, the Offshore Installations (Offshore Safety Directive) (Safety Case) Regulations 2015 (OSCR), operators are required to identify in their well notifications where any Major Accident Hazards (MAHs) associated with the operations has the potential to cause a Major Environmental Incident (MEI). A MEI is defined by the OSCR as an incident which results, or is likely to result, in significant adverse effects on the environment in accordance with the Environmental Liability Directive (2004/35/EC) (refer to Section 11.2).

The well blowout scenario is considered to represent the worst-case oil spill scenario as indicated by the probability modelling. Loss of FPSO inventory also presents a risk to the marine environment and both oil spill scenarios have the potential to lead to a MEI.

11.5.2 Assessment Methodology

Environmental vulnerability to oil spills is both a function of the magnitude of the event and the sensitivity of environmental receptors to such events. The EIA Methodology described in Chapter 5 can be applied to the receptors which are likely to be affected by a large oil spill and the conclusions of the assessment are presented in the relevant sections above. The significance of the impact is summarised as the overall consequence determination.

11.5.3 Surface Oiling

The areas predicted to be affected by surface oiling from a worst case well blowout oil spill scenario with a probability of at least 40% were compared with the presence of receptors likely to affected by surface oiling. The overall sensitivity of seabirds and marine mammals should they encounter surface oiling is described in Chapter 4 Environmental Baseline and above. The protected sites for which bird and marine mammal species populations are a designated feature and have a greater than 40% probability of being affected by surface oiling from the worst case well blowout scenario are listed in Table 11-5. Loss of FPSO inventory would also result in surface oiling which would affect seabirds in the spill trajectory. The consequence of the effect based on the likelihood of surface oiling at protected sites designated for these species is considered to be major.

11.5.4 Oil on Shorelines

The vulnerability of different types of coastline types to oiling is discussed above. In addition, a number of protected sites listed in Table 11-5 have been designated for the presence of coastal or shallow water habitats which may be vulnerable to oiling. The sites predicted to receive the highest quantity of oil from the worst case scenario modelled are Foula SPA, Fair Isle SPA, East Sanday Coast SPA, and Hermaness, Saxa Vord and Valla Field SPA. The model for loss of FPSO inventory indicated a much lower probability of coastal oiling, but the consequence of the effect is considered to be major regardless of this.

11.5.5 Conclusion of MEI Assessment

The environmental impacts from both the worst case oil spill scenario of an ongoing and uncontrolled well blow out scenario and the loss of FPSO inventory scenario have been identified and assessed for the UKCS using the EIA methodology of consequence and probability to qualitatively assess the level of risk. This has determined whether there is potential for significant damage to protected species or habitats (listed under the Annex I of the Birds Directive and/or Annex I, II and IV species listed under the Habitats Directive). The MEI assessment concluded that the worst case well blow out scenario presented in the oil spill model could lead to degradation of a qualifying feature of a protected site (SPA, SAC, NCMPA) as a result of surface oiling or oil reaching the coastline and hence the well blow out oil spill scenario is considered to be a MEI. The loss of FPSO inventory has the potential to adversely affect seabirds and the model indicates a low probability that the oil might reach the shoreline, therefore a precautionary conclusion is drawn that the impacts from this oil spill scenario also have the potential to constitute an MEI.

11.6 Management and Mitigation

The regulatory mechanisms described in Section 11.2 require operators to ensure that appropriate controls are in place to either reduce the probability of failure of a control resulting in a release or reduce the consequences in the event of a release. For example, this will include appropriate well control and blowout preventers These measures will all be documented in the installation safety case under the Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015. These regulations stipulate that safety and environment critical elements

(SECEs) performance standards with verification, equipment inspection, maintenance routines and management of operations will be in place during the operations.

As measures are being developed in accordance with requirements of legislation and of Equinor's own corporate demands, consistent with the principles of BAT and BEP, this ES does not present a list of all mitigation that will be in place through the life of the Development. However, a number of commitments to mitigation have been made as part of this impact assessment, and they are reflected as follows:

- Well blow out
    - Risk assessment and appropriate emergency response procedures will be implemented;
    - Specific procedures regarding conducting activities in the harsh environment of the wider west of Shetland region will be in place;
    - Drilling rig will be appropriately certified;
    - The drilling rig shall have an approved safety case with all SECEs verified by an independent verification body and managed through a recognised maintenance management system;
    - The BOP will have fully redundant control systems; and
    - Weather forecasts will be monitored so that oil-based mud in the riser can be removed to the drilling rig prior to riser unlatch.
- FPSO loss of inventory
    - The FPSO will be of a double-hull design, meaning oil cargo tanks are not on the outside, thus limiting risk of spill;
    - A mandatory 500 m safety zone will be in place;
    - There will be agreed approach procedures to the FPSO by supply and safety vessels, informed by appropriate collision risk assessments;
    - Operational restrictions will be in place for visiting vessels in bad weather; and
    - A robust maintenance and inspection programme linked into the critical elements and associated verification scheme.
- Tanker offloading
    - Tanker offloading procedures will be in place;
    - Shuttle tankers will be required to be DP2-classed as a minimum; and
    - Metocean conditions may limit offloading; where production storage limits are reached, production could be curtailed until export can resume. Tanker offloading procedures will be in place to limit the risk of spills.

- Spill from infield flowlines and risers
    - Dropped object risk assessments will be carried out for all lift activities;
    - Procedures will be put in place to record the location of any lost material and to recover significant objects where practicable; and
    - Simultaneous operations (SIMOPS) procedures will be in place.

11.7 Cumulative and Transboundary Impacts

Existing hydrocarbon release risks in the North Sea are associated primarily with oil and gas industry activities as well as other marine industries such as merchant shipping and fishing. As indicated by historical data, the likelihood of one major accidental release occurring is remote or extremely remote, limiting the cumulative impact from the Rosebank Development and other existing installations. An OPEP and Temporary Operations OPEP (TOOPEP) will be in place, outlining the response measures to be implemented in the event of any accidental release.

Worst-case scenario modelling indicates a 93.6% probability of hydrocarbons crossing a median line (UK/Faroese), with the potential to reach Norwegian, Danish, Swedish, German, Dutch, Icelandic, Greenland, Jan Mayen and Irish waters. Therefore, consultation by the Competent Authority under the Espoo Convention is likely to be required. The Espoo Convention requires notification and consultation only for projects likely to have a significant adverse effect across boundaries. In the event that a release crosses the median line, Equinor can confirm that there are relevant processes and procedures in place to liaise with member states.

The risk of an accidental hydrocarbon release being a significant transboundary impact, particularly from UKCS operations, is recognised by the UK Government and other governments around the North Sea. Agreements are in existence for dealing with international releases with states bordering the UK (e.g. Bonn Agreement). These agreements would operate within the framework of the National Contingency Plans (NCPs) and are oriented towards major releases. This becomes operational when agreement to the request for its implementation is reached. Responsibility for implementing joint action with neighbouring states rests with the Action Co-ordinating Authority (ACA) of the country on whose side of the median line a spill originated. The UK's ACA is the Counter Pollution Branch of the Maritime Coastguard Agency. In the event of a major accidental release, which would likely have the potential to drift into Norwegian waters, the Norwegian/British oil spill response (NORBRIT) plan would be activated. As the oil is most likely to drift into Faroese waters, it should be noted that a local agreement of mutual support exists between the UK and Faroe Islands and remains extant. Many other countries which have the potential to receive oil across a median line are members of the EU and therefore the European Maritime Safety Agency (EMSA) would be consulted in this instance. EMSA provides operational services to Member States including a network of stand-by oil spill response vessels, satellite imagery, pollution response experts and information service for chemical spills at sea. Additional engagement mechanisms with countries not covered by this arrangement, such as Iceland, will be defined prior to activities with potential for a significant transboundary movement of hydrocarbon are initiated.

11.8 Residual Impact of Hydrocarbon Release

Although the consequences of a large oil spill are severe, the probability of such an event occurring is low due to the preventative measures in place. In the unlikely event of an oil spill, oil spill response plans are required to be prepared and the regulatory mechanisms ensure that appropriate response and mitigation actions are fully implemented.

Applying the assessment methodology outlined in Chapter 5 EIA Methodology, the receptor sensitivity for most groups has been designated as high. Furthermore, it is anticipated that some features, particularly on the shoreline, could exhibit high value as some protected sites contain habitats and species protected under the EU Habitats Directive, and the value has been assigned as such. The worst-case release assessment determined that, although highly unlikely, a potential spill could have a long-term effect on the populations of the receptors, but with eventual recovery. Therefore, as per Chapter 5 EIA Methodology, vulnerability was designated as high.

Applying the impact assessment methodology described in Chapter 5 EIA Methodology assigns a designation of "high" to the sensitivity of receptors such as seabirds and protected sites along the coastline. A precautionary assessment would indicate that a large potential spill could have a long-term effect on the populations seabirds but with eventual recovery. Therefore, as per Chapter 5 EIA Methodology, vulnerability was designated as high.

Following Chapter 5 EIA Methodology, the potential magnitude of the release is expected to be moderate, as although the potential release is expected to extend across a large area of UKCS and across median lines, the likelihood of the release happening is remote.

In summary, a hydrocarbon release, should it occur, could result in a change in receptors. However, for this type of accidental event, it is especially important to assess the likelihood of the impact occurring. A release of this nature can be considered to result in a major consequence; however it is also considered a remote probability. Given the mitigation measures that are in place (Section 11.6) and the remote likelihood of the release happening, the impact is therefore considered not significant.

12 EQUINOR ENVIRONMENTAL MANAGEMENT SYSTEM (EMS)

12.1 Leadership

Equinor has developed a management system to ensure safe and efficient execution of activities whilst reducing costs. The objectives of the Equinor's management system include:

- Contributing to safe, reliable and efficient operations and enable Equinor to comply with external and internal requirements;
- Helping to incorporate Equinor's values, people and leadership principles into all activities;
- Supporting Equinor's business performance through high-quality decision-making, fast and precise execution, and continuous learning; and
- Ensuring that Equinor's commitment to preventing harm to the environment and to achieve outstanding natural resource efficiency in business activities, which sees actively limiting of greenhouse gas emissions from activities, is adopted across the business.

The governing documentation in Equinor's management system are structured in Fundamentals, Requirements and Recommendations, as shown in Figure 12-1. There are three layers of the management system hierarchy. The Fundamentals are documented in the Equinor Book[50] which provides a common framework for the way Equinor works and describes the most important requirements for the whole company by setting standards for Equinor's behaviour, performance and leadership.

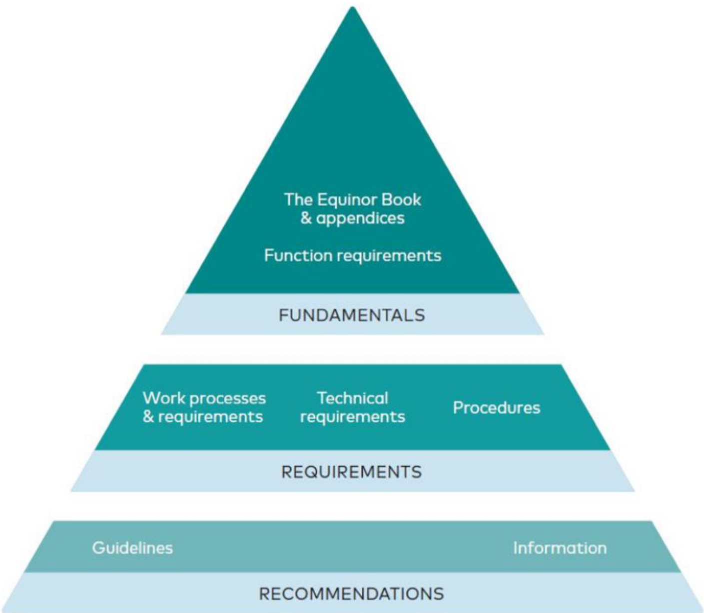

Figure 12-1 Management system hierarchy

Functional requirements are used to manage risks and to ensure safe and efficient operations. The Requirement documents describe what Equinor needs to comply with when performing tasks. Each business area is responsible for establishing and implementing governing documentation that is designed to fit its business and operational context.

[50] https://www.equinor.com/en/about-us.html

Recommendations support people when performing tasks and enable compliance with Fundamentals or Requirements. They describe suggestions or proposals for the best course of action and are based on the collective learning and experience of the company. Recommendations are documented in Guidelines or integrated into Equinor's governing documentation.

The main tool used by Equinor personnel to implement the Management System is the Architecture of Integrated Information Systems (ARIS). ARIS models and documents workflows and allows the user to locate and access documents in a structured manner. An overview of the structure of the Equinor management system is shown in Figure 12-2. It includes the Equinor Book, the corporate management and planning processes, and the process and function areas.

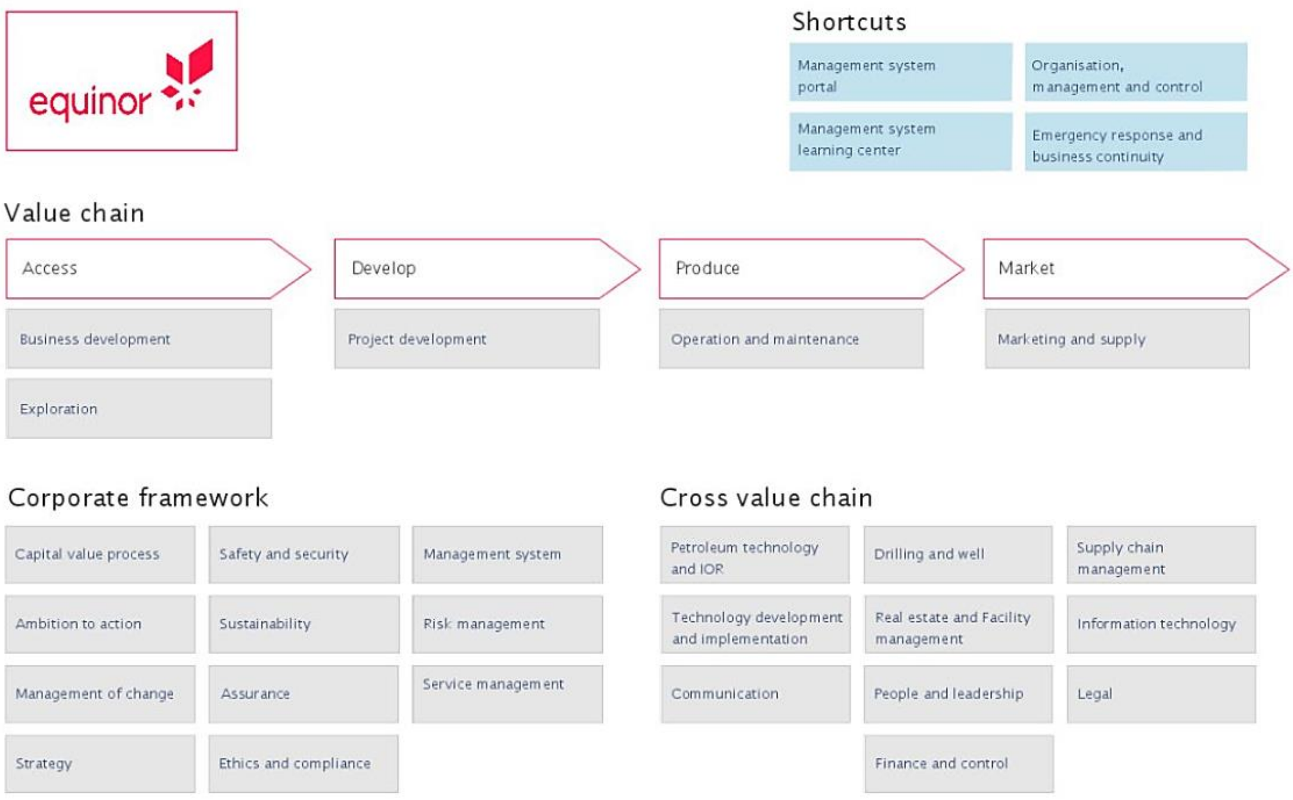

Figure 12-2 Equinor management system

The Management System Fundamentals of the Corporate Framework ensures Equinor has one structured management system that meets the objectives stated in the Equinor Book. It includes the following scopes:

- Management system framework;
- Framework for development and implementation of governing documentation;
- Mechanisms for management of change (MoC);
- Assurance framework; and
- Mechanisms for management system improvement.

Equinor is focused on delivery of sustainability and detailed requirements under the HSE policy are encompassed in the following non-negotiable sustainability fundamentals in the Corporate Framework:

1. Management of sustainability performance shall be an integrated part of governance, strategies, business planning, risk and performance management and decision-making processes.
2. We shall systematically identify, analyse and manage our significant sustainability aspects to achieve continual improvement in a verifiable, efficient and effective manner.
3. We shall implement measures according to the mitigating hierarchy: avoid, minimise, remediate/compensate for or offset adverse sustainability-related impacts, and enhance positive impacts, in accordance with good international practices and principles.
4. We shall respect human rights in accordance with our human rights policy.
5. We shall drive change in support of a net zero society and a reduced net carbon intensity for Equinor.
6. We shall work systematically to optimise energy efficiency, minimise energy demand and reduce greenhouse gas emissions from our activities.
7. All Equinor operated oil and gas assets shall work systematically to reduce all flaring and to eliminate routine flaring, in order to fulfil our commitment to zero routine flaring by 2030. In our partner-operated assets we shall work actively to help achieve the same objective.
8. We shall establish, implement and maintain tools and practices to manage chemicals, waste and discharges in a safe and sustainable manner.
9. We shall establish, implement and maintain practices for managing direct impacts from our operations on biodiversity.
10. We shall ensure that our activities do not have a significant negative direct impact on the freshwater resources in the areas we operate.
11. We shall contribute to social and economic development in the societies and communities we operate in.
12. We shall conduct meaningful engagement with potentially affected stakeholders and let their views inform our actions, decisions and follow-up.
13. Distinct sustainability competencies and technologies shall be available and suitable for the scope and complexity of Equinor's business activities.
14. Our sustainability reporting shall be open, accurate, clear, reliable and consistent, reflecting material topics and impacts and in accordance with relevant requirements and reporting frameworks.

The above sustainability fundamentals are in alignment with achievement of the UK Net Zero emissions targets, the OGUK 2035 Roadmap, and the OGA (2020) (Stewardship Expectations 11: Net Zero). The scope of the sustainability fundamentals reflects the level of ambition of Equinor to influence decarbonisation of the industry and support the energy transition. Indeed, the introduction to this ES (Chapter 1 Introduction) outlines how the Rosebank Development aligns with the North Sea Transition Deal, UK Net Zero Strategy, ambitions of the Energy White Paper and the relevant carbon budgets.

All the Fundamentals are supported by a variety of requirement documents which outline the operational obligations, including risk, audit and assurance, crisis and emergency response, performance and reporting, training and competence and management of change. Policies, objectives and targets, fundamentals, and processes to be followed are cascaded through the business within the annual planning cycle and HSE plans specific to the activities. The OGA Net Zero Stewardship Expectations 11: Net Zero are embedded throughout the Equinor management system as they are in alignment with the Equinor corporate strategy for Energy Transition[51].

[51] https://www.equinor.com/en/news/20220419-presents-first-energy-transition-plan-shareholders.html

12.2 Safety and Environmental Management System

The management system covering environmental elements is embedded within the overall Safety and Environment Management System. The elements of the EMS have been verified as aligned with the requirements of ISO 14001:2015 and the EMS is subject to external third-party audit every two years.

It is the aim of Equinor to ensure best environmental practices and procedures are followed and that continual improvement in environmental performance is always maintained. The Rosebank field will be operated by Equinor according to the Equinor Group's management system, as modified to reflect UK conditions and regulations, and specific operational best industry practices.

All Equinor projects, concepts and technical developments are subject to environmental risk assessment though their key development stages up to and including cessation of production and decommissioning. The method used to identify and handle environmental aspects has been verified and aligned with the ISO 14001 process where an environmental aspect is formally defined as an "element of an organisation's activities, products or services that can interact with the environment" and a significant aspect is one which "has or can have a significant environmental impact".

When identifying environmental risks, the aspects and impacts register differentiates between normal and abnormal (including emergency) operating conditions. The influence that Equinor has extends beyond those impacts directly associated with its activities to those associated with its suppliers, contractors and clients. The FPSO that has been selected for the Development is currently operated by Altera Infrastructure LP ('Altera'), which will follow its own environmental management system and manage its own contractors up to point of handover to Equinor. All contractors for drilling and operating the wells, flowlines and risers will be managed by Equinor. The Equinor contractor management system is described in Section 12.4 and will be used to manage all contractors, including Altera.

Equinor's ambition is to be an industry leader in safety, and the management system works to continuously improve the safety standard and to control the risk of Major Accident Hazards (MAH) and Major Environmental Impacts (MEI) as a result of Equinor's operations. Equinor Oil Spill Response Procedures will be applied during all operations. Emergency Response Bridging Documents are prepared for all offshore activities involving contractor facilities and vessels. Management System Interfacing and procedural precedence is defined in contract documents, and for high-risk activities is further clarified by preparation of Management System Interface documents. These documents clearly define the interfaces and establishes the agreed arrangements including responsibilities, systems, procedures and practices, for managing HSE during contracted works.

All employees, suppliers, and contractors of Equinor undergo training on environmental issues. This may include one or more of the following:

- Induction training;
- Applicable environmental awareness training modules:
- Safety management course (for supervisory and managerial employees);
- Incident investigation training (as required); and
- Risk assessment training.

Environmental objectives and targets are used for setting goals for continuous improvement in performance as part of Equinor's Safety and Environmental Management System. Equinor views environmental management as an ongoing active process and will continue to facilitate continuous improvement beyond implementation of mitigation measures identified in this ES. The performance of the management system is regularly tested through an assurance process that includes a self-assessment, verification or internal independent assessment of high impact risks and independent audit. The Equinor Audit Management System is used for planning and follow-up of audits, verifications and external supervisory activities. Mitigation measures relevant to the Development will be documented to ensure appropriate execution and management. The delivery of the commitments made in this ES will be subject to assurance activities in line with the corporate requirements.

12.3 Environmental Monitoring

Monitoring is an important activity for ensuring performance against both the environmental regulatory requirements and the objectives and targets specifically designed for the Development (as outlined in the commitments register). Monitoring also enables the gathering of information to track overall environmental performance. There are a number of inter-related drivers for such monitoring:

- Statutory requirements for compliance with environmental consents and regulatory governmental requirements;
- To track performance against Equinor Corporate or Project expectations and targets;
- Fulfil Equinor's internal and external non-mandatory reporting requirements; and
- The validation of predictions made during the EIA process.

All planned and permitted environmental emissions, discharges and waste will be reported via the UK Environmental Emissions Monitoring System (EEMS) either annually or as required by specific environmental permits. Equinor's internal, corporate, environmental reporting is managed via an internal database. Equinor also submits an annual OSPAR environmental report to the UK Regulator[52] demonstrating responsible management of the existing UK operated assets.

12.4 Interface with Contractors

Management of contractors is an essential activity to ensure compliance with regulatory requirements and company policy. Clarification of primacy and procedural interfaces, including management of environmental aspects, is key to the management of contractors and ultimately environmental risks and impacts. The objectives of the Equinor contractor management processes are applicable to all phases of the Rosebank Development to ensure that:

- All contractors apply HSE policies and standards that are compatible with Equinor policy (Figure 12-2 and the HSE policy shown in Chapter 1 Introduction);
- All contractors' personnel are competent to perform their tasks;
- HSE responsibilities of both contractor and Equinor are clearly defined and embedded within contracts; and
- Each contractor has a formal hazard management process to minimise HSE risk.

Equinor recognises its suppliers' own competency management systems, monitors how effective their systems are, and encourages continuous improvement. It is the responsibility of all contractors to ensure that their employees have the minimum competence requirements equal to or above Equinor's own standards. Assessment of contractor performance is conducted via internal and independent audits throughout the contract life.

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[52] https://www.gov.uk/guidance/oil-and-gas-ospar-ems-recommendation#ems-public-statements

The Rosebank Supply Chain Action Plan incorporates opportunities to share supply chain and logistics synergies to reduce GHG emissions by implementing net zero emissions reduction as an important part of tender evaluation. In addition, incentive structures to reward the supply chain for making emission reduction choices for the benefit of the company will be introduced. Embedding 'low carbon thinking' mechanisms into how the supply chain interacts with and delivers for the company, including mission statements and training, will be highlighted in the tender documents. Furthermore, supply chain agreements will include requirements for the measurement and reporting of relevant carbon emissions, as well as carbon targets to be achieved, and for decarbonisation innovation to be at the forefront of the supplied service.

The Rosebank team will deliver the commitments made in this ES through the application of Equinor's structured management system and, in doing so, fully support the UK energy transition.

13 CONCLUSIONS

The Development underwent a Concept Screening phase, which embedded technical, economic, and environmental considerations into the Project Design. The BAT / BEP principles were used to ensure the optimal environmental design was chosen. The selected Concept was then subject to a Scoping Consultation to obtain the views and environmental concerns of stakeholders to be addressed during the EIA. The scope and focus of the EIA were refined through an impact identification exercise, including an ENVID workshop. This process identified issues requiring further assessment based on the proposed activities, the known environmental sensitivities, industry experience and stakeholder concerns. The EIA was conducted in line with the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020, as well as other relevant legislation and associated guidance as detailed in Section 1.9.

Potentially significant impacts that were highlighted during the impact identification exercise were fully assessed in Chapters 6 to 11. Conclusions regarding significance of impacts were as follows:

- Seabed impacts – not significant based on the small seabed area affected and the extent of similar habitat available;
- Discharges to sea – not significant based on the low sensitivity / exposure of receptors (water column) and the limited area of habitat affected (seabed);
- Other sea users – not significant based on the low sensitivity of all assessed receptors;
- Atmospherics and climate – not significant based on: (a) modelling concluding that emissions will not affect air quality in the local or wider area, and (b) the expected emissions from the Development comprising a negligible proportion of annual emissions from the UK offshore oil and gas sector;
- Underwater noise – not significant based on the low sensitivity of all assessed receptors, the small area and short time period over which the impact will occur, and the mitigation measures that will be enacted; and
- Accidental events – not significant based on the remote likelihood of a worst-case release occurring, and the prevention and mitigation measures that will be implemented.

The EIA Regulations require a description of aspects of the project (mitigations) that are intended to avoid, prevent, reduce or offset likely significant adverse effects and how they are to be delivered. Mitigation measures were actively considered during the project design as detailed in Chapters 6 to 11 and summarised in the Commitments Register (Appendix C). The Commitments Register will be managed within Equinor's Safety and Environmental Management System.

In conclusion, the EIA described in this ES demonstrates that, with the proposed mitigation measures in place, the Rosebank Development is not expected to have a significant effect on the environment. Environmental effects will be managed, monitored and minimised through adherence to the Equinor Safety and Environmental Management System and regulatory compliance.

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Appendix A – Alignment Between the Development and the Scottish National Marine Plan

Objective / policy	Development details
General policies	
GEN 1: There is a presumption in favour of sustainable development and use of the marine environment when consistent with the policies and objectives of this Plan.	The Development and this ES has been developed with consideration of the policies and objectives within the Scottish National Marine Plan.
GEN 2: Sustainable development and use which provides economic benefit to Scottish communities is encouraged when consistent with the objectives and policies of this Plan.	The Development and this ES has been developed with consideration of the policies and objectives within the Scottish National Marine Plan. The Development will support local and UK employment during construction, operation and decommissioning phases. In addition, the Development will provide new pipeline infrastructure that may facilitate future developments in the area, i.e. there is also potential longer-term economic benefit.
GEN 3: Sustainable development and use which provides social benefits is encouraged when consistent with the objectives and policies of this Plan.	The Development and this ES has been developed with consideration of the policies and objectives within the Scottish National Marine Plan. The Development will support local and UK employment during construction, operation and decommissioning phases. In addition, the development of Rosebank materially improves the UK's production and energy security outlook. Expressed in terms of oil self-sufficiency, from first oil in 2026 through to 2050. The development will play an important role in establishing the infrastructure necessary for the electrification of the West of Shetland oil and gas operations. It also represents an opportunity to train and develop the local oil and gas supply chain, and in the process develop transferable skills in the manufacturing sector required for the growth of the offshore wind sector.
GEN 4: Proposals which enable coexistence with other development sectors and activities within the Scottish marine area are encouraged in planning and decision making processes, when consistent with policies and objectives of this Plan.	The Project will coexist with other marine developments, without long-term exclusion or detriment to other developments in the Project area. This is outlined in Chapter 8, Other Sea Users.
GEN 5: Marine planners and decision makers must act in the way best calculated to mitigate, and adapt to, climate change.	The impact of the Development on global climate change is outlined in Chapter 9, Atmospherics and Climate, which describes how Equinor has embedded the identification, assessment, and minimisation of GHG emissions in the project management process. Power generation at the FPSO is considered BAT according to third-party assessment. Furthermore, there are no plans to conduct routine flaring, in alignment with the NSTA's offshore flaring and venting regime, and the Licensees are committed to take a proactive role to deliver electrification of the FPSO.
GEN 6: Development and use of the marine environment should protect and, where appropriate, enhance heritage assets in a manner proportionate to their significance.	The Project is not anticipated to impact on any marine heritage features. Therefore, no loss of marine archaeological remains is expected to result from the Development.
GEN 9: Development and use of the marine environment must: (a) Comply with legal requirements for protected areas and protected species.	The Development is not expected to have any significant impacts on any protected sites or species, as outlined within the impact assessment chapters. Where necessary, mitigation measures have been proposed to reduce potential impacts.

Objective / policy	Development details
(b) Not result in significant impact on the national status of Priority Marine Features. (c) Protect and, where appropriate, enhance the health of the marine area.	The Development will comply with all legal requirements for protected sites and species.
GEN 10: Opportunities to reduce the introduction of invasive non-native species to a minimum or proactively improve the practice of existing activity should be taken when decisions are being made.	There are no planned major international movement of vessels for the Development resulting in introduction of non-native species from beyond the West of Shetland area.
GEN 11: Developers, users and those accessing the marine environment must take measures to address marine litter where appropriate. Reduction of litter must be taken into account by decision makers.	As outlined in Chapter 6, Seabed Impacts, a dropped objects procedure will be developed and adhered to. Personnel will also be trained to minimise the potential for dropped objects. The FPSO once on station will adhere to the MARPOL requirements regarding management of garbage.
GEN 12: Developments and activities should not result in a deterioration of the quality of waters to which the Water Framework Directive, Marine Strategy Framework Directive or other related Directives apply.	Equinor will make every effort to minimise discharges to sea. The potential impact of any operational discharges is assessed in Chapter 7.
GEN 13: 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.	The potential impact from underwater noise generated from the Development is assessed in Chapter 10. The assessment concluded that no significant adverse effects were expected.
GEN 14: 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.	The potential impact of the Development on air quality is considered in Chapter 9. No significant effects on local air quality are anticipated.
GEN 17: All marine interests will be treated with fairness and in a transparent manner when decisions are being made in the marine environment.	This ES presents an assessment of the potential impacts from the Development across a range of receptors.
GEN 18: Early and effective engagement should be undertaken with the general public and all interested stakeholders to facilitate planning and consenting processes.	Equinor has engaged with statutory and non-statutory consultees and will continue to do so through the life of the Development.
GEN 19: Decision making in the marine environment will be based on sound scientific and socio–economic evidence.	This ES presents an assessment of the potential impacts from the Development across a range of receptors using scientific and socio-economic evidence.
GEN 21: Cumulative impacts affecting the ecosystem of the marine plan area should be addressed in decision making and plan implementation.	Cumulative impacts are assessed within each assessment chapter.
Oil and gas	
Oil and Gas – Objective 1: Maximise the recovery of reserves through a focus on industry-led innovation, enhancing the skills base and supply chain growth.	Rosebank is one of the largest undeveloped resources in the UK with an estimated 300mn recoverable bbls. With the North Sea in decline, oil imports are forecast to increase even with the anticipated developments such as Rosebank coming onstream. Without Rosebank, using NSTA demand and production forecasts, imports would increase further. Rosebank is estimated to support a significant number of UK-based jobs, particularly at its peak in Q3 2025 (including direct, indirect, and induced jobs), but also over the full life of the field, including decommissioning. Employment levels will be driven by the season and stage of the development resulting in considerable variability through to 2031. Multiple workstreams will provide material employment through the supply chain in areas such as fabrication of equipment, well drilling and completions, and installation of subsea infrastructure. The skills development that will

Objective / policy	Development details
	take place in the Rosebank workforce will not only help the UK strengthen the skills base for oil and gas, but also retain talent in the UK, ready for the expected demand in the coming years for offshore renewables sector workers. Equinor already works with a significant number of suppliers in the UK, and through Rosebank will increase this number. A supplier day was held in Summer 2022 to encourage local content on the project. With UK suppliers looking to diversify into renewables over the coming years, projects like Rosebank can enable them to sustain their workforce and skills so that the UK has a healthy supplier base in years to come, as the energy transition progresses. Equinor is one of the leading companies in offshore electrification technologies, helping adopt an industry approach to innovations needed to decarbonise the sector, and is working with partners and industry peers to develop collaborative solutions.
Oil and Gas – Objective 2: An industry which delivers high-level risk management across all its operations and that it is especially vigilant in more testing current and future environments.	Equinor has developed a management system to ensure safe and efficient execution of activities. The objectives of the Equinor's management system include: • Contributing to safe, reliable and efficient operations and enable Equinor to comply with external and internal requirements; and • Ensuring that Equinor's commitment to preventing harm to the environment and to achieve outstanding natural resource efficiency in business activities, which sees actively limiting of GHG from activities, is adopted across the business. Future processes and procedures shall take into account the harsh and challenging weather west of Shetland.
Oil and Gas – Objective 3: Continued technical development of enhanced oil recovery and exploration, according to the principles of BAT and BEP.	The Development will deploy up-to-date and innovative technology, aligned with the principles of BAT and BEP. For example, as described in Chapter 9, Atmospherics and Climate, a third-party assessment concluded that the FPSO´s gas turbines and waste heat recovery units are BAT.
Oil and Gas – Objective 4: Where possible, to work with emerging sectors to transfer the experience, skills and knowledge built up in the oil and gas industry to allow other sectors to benefit and reduce their environmental impact.	The Development will draw on experienced engineers, environmental specialists and other groups that are not necessarily limited to oil and gas experience throughout the Development lifetime. As described in Section 1.5, Equinor is also taking a proactive role in West of Shetland work groups, for example the Net Zero Technology Centre, providing mentoring, and networking opportunities, including connecting innovative technology with potential projects for piloting and testing.
Policy – OIL & GAS 1: The Scottish Government will work with BEIS, the NSTA 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 BAT and BEP. Consideration will be given to key environmental risks including the impacts of releases to atmosphere, oil and chemical contamination and habitat change.	BAT has been used as a key tool in developing the Development design. The potentially significant environmental impacts from drilling, installation, flaring activities, accidental release and habitat change have been considered within the EIA. For example, as described in Chapter 9, Atmospherics And Climate, a third-party assessment concluded that the FPSO´s gas turbines and waste heat recovery units are BAT.
Policy – OIL & GAS 2: 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,	Section 3.11 of the ES provides and overview of the expected approach to Decommissioning. Equinor will review decommissioning best practice closer to the point at which the Development area will be decommissioned. Full consideration will

Objective / policy	Development details
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.	be given to available decommissioning options, including reuse and removal. However, the design of the new installed infrastructure at Rosebank will take into account considerations for its potential removal at end of field life.
Policy – OIL & GAS 4: All oil and gas platforms will be subject to 9 NM consultation zones in line with Civil Aviation Authority guidance.	There are no existing offshore installations within 9 NM of the planned Rosebank installation. However, Equinor will engage as necessary with any relevant future developments that may be proposed within 9 NM of the Development area to ensure all helicopter flight routes remain free of obstacles.
Policy – OIL & GAS 5: 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.	The Rosebank field will be developed in a way that there will not be a significant impact on the physical, biological and socio-economic environment. This demonstrates an appropriate siting within the West of Shetland area. For example, the reuse FPSO is designed for harsh weather environment application and the subsea infrastructure, risers and moorings has been designed to withstand extreme weather conditions. With respect to future climate, the life of field is estimated up to 2051, whilst design considerations have accounted for 100 year extreme weather events. In this context, the development is also appropriately designed for the location for which it is proposed.
Policy – OIL & GAS 6: 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 NCP and the Offshore Safety Directive.	Potential environmental impacts have been reviewed as part of this EIA and relevant mitigation measures developed. The Equinor response strategy to accidental hydrocarbon release will be developed with due reference to the NCP, as further described in Chapter 11, Accidental Events.

Appendix B – Response to Comments Received from Stakeholders During Meetings as Described in Chapter 5 EIA Methodology

Stakeholder	Stakeholder comment	Equinor response
Shetland Islands Council	The Shetland Islands Marine Region includes all territorial waters seaward of the mean high water of the spring tide (MHWS), out to 12 nautical miles. From the development proposals referred to in your letter, it appears that all works will lie outwith this area. If this is the case there will be no requirements for a Works Licence from the council, which is required for all marine works (other than aquaculture) within 12NM.	All activities lie outside of the 12 nm limit, no further action taken.
Shetland Islands Council	The Shetland Islands Regional Marine Plan (2021 Amended Version) is currently with Scottish Ministers awaiting adoption. This is due to be adopted in late Spring 2022. Whilst the development proposals may be outwith the marine region, the plan contains information and data that may be useful for the purposes of the EIA. It can be viewed at: https://www.shetland.uhi.ac.uk/research/marine-spatial-planning/shetland-islands-regional-marine-plan/	All activities lie outside of the 12 nm limit, no further action taken.
Shetland Islands Council	The National Marine Plan covers the management of offshore waters (out to 200NM) and should therefore be referred to in the context of this development proposal. This can be viewed at: https://www.gov.scot/publications/scotlands-national-marine-plan/	The plan is referred to in Chapter 1.
Shetland Islands Council	Helpful data can also be found at on the National Marine Plan Interactive. https://marinescotland.atkinsgeospatial.com/nmpi/	NMPI has been used to inform the Environmental Baseline presented in Chapter 4.
Shetland Islands Council	We note that the letter states that: Any future onshore or offshore works, including cables, for electrification will be covered by a separate consenting process. It is recommended that you contact the Council once this proposals have developed so we can inform you of any requirements for Works Licences and planning consents for land-based works.	Noted.
Shetland Fishermen	Our membership are not concerned by the development of the Rosebank field. It is their view that the preferred route would be the option to tie into the WOSPS via the Pipeline End Manifold (PLEM).	Noted - further information on option selection is provided in Chapter 2.
UK Hydrographic Office	The UKHO has no comment on this, however we would ask that you keep us informed as this develops. We will eventually require: • The final as-laid position of any installations (stating horizontal datum used) • ID of any relevant features • Details of aids to navigation present during the works • Details of any chains and anchors and mooring buoys • Maximum height of infrastructure above seabed and height of FPSO above sea level (stating vertical datum used) • Water depth at position of installation (stating vertical datum used)	Noted.
OPRED	We would be grateful if you could provide us with a copy of any comments from stakeholders when received, in addition to any comments you have received directly from stakeholders OPRED wish to highlight the following key aspects which should be considered as you prepare the ES.	Comments are provided within this appendix.
OPRED	You should familiarise yourself with the requirements of the Offshore Oil and Gas Exploration, Production, Unloading and	Noted.

Stakeholder	Stakeholder comment	Equinor response
	Storage (Environmental Impact Assessment) Regulations 2020, including the requirements set out in Schedule 6 and the requirements of the Department's EIA Guidance which was updated in July. 2021 and ensure that the ES fulfils the requirements set out in the regulation and guidance. In addition, other issues which we request you give consideration to. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005109/The_Offshore_Oil_and_Gas_Exploration__Production__Unloading_and_Storage__Environmental_Impact_Assessment__Regulations_2020_-_A_Guide__July_2021.pdf As you have identified proposals which will exceed the Schedule 1 thresholds will require to be supported by ES.	
OPRED	Equinor will be applying to OGA for a Development and Production consent, can you confirm if this consent will cover phase 1 only or phase 1 and 2- as per our discussion the ES should assess the impacts of the project sought under the relevant consent(s), however it may be useful to describe the wider development to set context.	This ES and the FDP covers both phase 1 and phase 2 activities.
OPRED	We would highlight that the ES should clearly describe the main alternatives (in terms of project design, technology, location, size and scale) for the proposed project which have been considered, the advantages/disadvantages of each option and associated environmental implications, and summarise which option was selected and why (safety, environment, technical feasibility etc.), this is particularly important where a number of options for a project have been identified and progressed to some extent. While we note that some of this information was captured in the Concept Select Report to the OGA, any relevant information should be included in the ES.	This is detailed in Chapter 2.
OPRED	Reference is made to future electrification of the project being outwith the scope of this ES, the ES should explain the timeline for electrification noting that first oil will not be until 2026, can electrification be achieved prior to first oil? Describe the technical challenges and progress in addressing these challenges and any uncertainties.	Decision making is detailed in Chapter 2 and project timeline in Chapter 3.
OPRED	Consideration should be given to potential decommissioning requirements and how these have influenced the options selected.	Chapter 2 notes where decommissioning has influenced key decisions, whilst Chapter 3 outlines the proposed decommissioning strategy at this time.
OPRED	You will be aware of the Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015 (SCR 2015) transposed the requirements of the OSD, and came into force on 19 July 2015. The primary aim of SCR 2015 is to address major accident hazards and reduce the associated risks to the health and safety of the workforce employed on offshore installations or in connected activities. However, SCR 2015 also aims to increase the protection of the marine environment and coastal economies against pollution and to ensure appropriate response mechanisms are in place in the event of such an incident. There is already a requirement to assess worst-case oil spill scenarios resulting from major accidents in an EIA, summarising the likely fate and impact of potential releases. ESs should also give due consideration to the potential for operations to result in Major Environmental Incidents (MEI) as defined under OSDR. In most cases, the worst-case scenario relating to the identified major accident	This is considered in Chapter 11.

Stakeholder	Stakeholder comment	Equinor response
	hazards will equate to the worst-case potential release assessed under the EIA process. The assessment in the EIA will therefore be relevant and will additionally confirm whether there is likely to be a significant impact that would constitute a MEI.	
OPRED	It is not clear whether the proposed pipeline and fibre optic cable will require to have protection installed, the ES should consider the potential for impacts on the seabed from installation including any protection	Protection requirements for the pipeline are described in Chapter 3 and the impact assessed in Chapter 6. The fibre optic cable is not in scope, as outlined in Chapter 1.
OPRED	Consideration should be given to the proposed operations in the context of the relevant Marine Plans- see https://www.gov.scot/publications/scotlands-national-marine-plan/. In addition you may wish to familiarise yourself with the Department's own Guidance on Consideration on Marine Plans in Environmental Submissions https://www.gov.uk/guidance/oil-and-gas-offshore-environmental-legislation#the-marine-and-coastal-access-act-2009	The plan is referred to in Chapter 1.
OPRED	You should ensure that consideration is given for any potential impacts on Designated sites and Marine Protected Areas http://jncc.defra.gov.uk/page-6895 this includes the potential for any cumulative or in combination effects. Particular consideration should be given to any potential impacts on Annex I habitats or priority species in the vicinity.	Protected areas are described in Chapter 4 and considered within the impact assessment chapters as relevant (Chapters 6 - 11).
OPRED	OPRED confirms that we would not expect a separate Habitat Regulations Assessment document or Appendix to be submitted, any information relevant to consideration of the proposals under the Habitats Regulations should be contained within the ES itself. Sufficient information should be provided to enable OPRED to undertake (if required) an assessment under the Habitats Regulations of the development's potential impact on protected sites (SPAs and SACs) and any assessment required under the MCAA of potential impacts on Marine Protected Areas.	Information related to HRA is provided in Chapter 4 and within the impact assessment chapters as relevant (Chapters 6 - 11).
OPRED	Noting the increased focus on Net Zero, the ES should set out how the development will help deliver the requirements and commitments which relate to the oil and gas industry as set out in key strategy and policy documents such as:- The North Sea Transition Deal The UK Net Zero Strategy The Energy White Paper Relevant carbon budgets	This is covered in Chapter 1 and Chapter 2.
OPRED	Reduction of emissions from power generation through project design (e.g. opportunities for electrification, selection of installation for power generation optimisation, operating philosophy to reduce emissions)	This is covered in Chapters 1 - 3 and Chapter 9.
OPRED	Reduction of emissions from flaring and or venting (for example will the FPSO be ale to operate without the need for routine flaring?)	This is covered in Chapters 1 - 3 and Chapter 9.
OPRED	Installation emissions and MODU/vessel use emissions reduction including through project design.	This is covered in Chapters 1 - 3 and Chapter 9.
OPRED	Calculation of emissions should be based on a worst case (high production) throughout the consented life of the field (as defined by the EIA project and applied for in any associated consent), this will be particularly relevant to our consideration	This is covered in Chapter 3 and Chapter 9.

Stakeholder	Stakeholder comment	Equinor response
	of relevant environmental protection objectives under Schedule 6 (5 (d)).	
Ministry of Defence	After further investigation I can confirm the MoD has no objection to this activity at the locations specified.	Noted.
Scottish Fishermen's Federation	The deep water location of the Rosebank field should mean that the impact on fisheries from the main elements of the project should be limited.	Noted.
Scottish Fishermen's Federation	Proposed pipeline route to Clair will have an impact as it crosses shallow water depths where fishing is more common. The proposed route to Cambo would have less impact as it remains in deep water.	As described in Chapter 2, the Cambo option is not under consideration, as the Cambo project has been placed on pause.
Scottish Fishermen's Federation	Industry standards for rock protection should be followed, includes a 1 in 3 gradient to the slope of the berm and using a 50 – 70mm individual rock size. The Laggan Tormore development is an example of a nearby development which required a lot of rock placement, it has caused some issues closer to shore. Larger fishing vessels in offshore areas should not have issued with properly installed rock berms.	Chapter 3 describes the proposed use of rock. The impact of this pipeline protection is covered in Chapter 6 (seabed impact) and Chapter 8 (other sea users).
Scottish Fishermen's Federation	The ban on trawling below 800 m only applies to demersal trawlers, pelagic trawlers can still fish below 800m and will sometimes fish close to the seabed. So if structures are not over trawlable then other mitigations need to be present.	Chapter 3 describes the proposed protection for the pipeline, and Chapter 8 covers the potential impact on other sea users.
Scottish Fishermen's Federation	It is understood that here may be a restriction on trawling in the Rosebank area due to the presence of unnamed cables.	Noted.
Scottish Fishermen's Federation	Backfilling method for trenched section of export pipeline?	Chapter 3 describes the proposed trenching method for the pipeline, and Chapter 8 covers the potential impact on other sea users.
Scottish Fishermen's Federation	If mooring lines extend outside safety zones it's important to have clear information on the locations of the mooring lines provided in asset data cards and by the ERRV.	Chapter 3 describes the location of safety zones, and Chapter 8 covers the potential impact on other sea users.
Scottish Fishermen's Federation	SFF How will you ensure that foreign fishing vessels are aware of the ongoing work and any obstructions?	Information on notifications that Equinor will provide is given in Chapter 8.
Scottish Fishermen's Federation	Consulted by Chevron during their ownership of the project, are there many project staff still remaining from the Chevron Team?	A number of former Chevron personnel are working on project across various technical disciplines.
Marine Scotland	Impacts on designated conservation areas and habitats of conservation concern will be assessed by the Joint Nature Conservation Committee (JNCC) who are statutory consultees for such a development. Avoiding a gas export route which transects the above designated conservation area would be the preferred MSS option, as this is the best way of ensuring no impacts on protected areas. In the event that no alternatives to this are identified, MSS advise robust justification is provided in the ES which considers all alternative options. MSS advise a calculation of the size of the impact area in relation to the protected area, and an assessment of the overlap between the activities and the known location of features within the MPA using this link	Chapter 2 explains the decision-making behind the proposed route, which does pass through a protected sites. Chapter 3 describes in detail the proposed infrastructure, and Chapter 6 describes the potential impact on the seabed and relevant protected sites.

Stakeholder	Stakeholder comment	Equinor response
	(https://marine.gov.scot/information/deep-sea-sponge-aggregations). Potential impacts must be clearly stated and the significance of those impacts fully assessed.	
Marine Scotland	It appears that some elements associated with the proposed gas export pipeline, such as the future tie in point at KP7 and the Pipeline End Manifold (PLEM) at KP84 may be located outwith any 500 m safety zone. Are the Gas Riser Base (GRB) and Umbilical Riser Base (URB) structures located within the 500 m safety zone of the FPSO (or the swing circle)? MSS advise that such elements should be carefully designed, with input from fishing representative organisations such as the Scottish Fishermen's Federation (SFF) to ensure these do not pose a hazard to other sea users.	Chapter 3 describes the location of safety zones, and Chapter 8 covers the potential impact on other sea users.
Marine Scotland	MSS welcome the operator is engaging with other operators in the West of Shetland on electrification options for this development and that the FPSO is designed to facilitate future electrification.	Noted.
Marine Scotland	The proposal includes a number of satellite wells for water injection. Organising the wells in this manner inevitably requires more pipelines on the seabed. MSS would like to understand if extended reach drilling techniques have been considered to allow the satellite wells to be drilled from the existing drill centres, with a view to minimising the number of pipelines required, potential protective materials required and the number of safety zones. MSS advise that the location of any newly established safety zones are clearly shown in a figure. There is no mention of how the pipeline and fibre optic cable are to be installed or what protective materials may be required for the development. MSS advise that protective materials are minimised as far as possible and that impacts associated with all protective materials should be fully assessed taking account of the ability to decommission these in the future. MSS advise that accurate worst case assessments of protective material requirements are used.	Chapter 2 explains the drilling strategy, and the limitations on what reach can be achieved from the surface locations. Chapter 3 provides details on the safety zones (note, only one is proposed, at the FPSO, and so no figure is provided). Chapter 6 assesses the impact of material on the seabed, noting that whilst the installation of the fibre optic cable installation is outwith the scope of the ES, it has been considered as part of the cumulative seabed impact assessment.
Marine Scotland	Export of gas to the WOSPS was considered previously in the development of the Rosebank field (ES ref D/4218/201), but it is understood that WOSPS operates as a sour gas export route with high levels of CO_2. In the previous ES, sweet gas was to be exported to the SIRGE pipeline system. Is it now expected that the gas will be sour as a result of water injection and is this known in advance? What happens if it the gas fails to meet the WOSPS specification? Will the risk of a gas leak from the proposed gas export pipeline also be considered in the accidental events section?	Chapter 3 provides clarification on the requirement to use the Clair gas to dewater the export line for start-up (Section 3.6) and the design to meet the specifications of the WOSPS pipeline (Section 3.7). Chapter 10 does not include a leak from the gas export line as this is not considered a MEI. I chapter 3.7.1 it is explained that the H_2S content for export will be 2.3ppmv
Marine Scotland	The proposed export route is to tanker oil from the development, which is likely to carry an inherently higher risk of an accidental event, particularly given the environmental conditions experienced at this exposed location. In the event that offloading is disrupted by weather, will production be curtailed / shut in? Will this risk be accounted for in the accidental events section?	There will be procedures limiting the weather conditions under which oil offloading can be carried out, limiting the risk in such conditions. Note that the specific spill risk from tankers once they have left the field is outwith the scope of the EIA, and tanker owners will be required to have procedures in place to manage travelling in poor weather conditions.

Stakeholder	Stakeholder comment	Equinor response
Marine Scotland	Does the technology used in the drilling of the wells represent the Best Available Technology (BAT)?	The ES contains text on drilling optimisation (Chapter 2) and energy efficiency through batch operations (Chapter 9). Reference to the Hydrocarbon BAT document states that discharge of WBM cuttings and skip and ship of OBM cuttings are acceptable BAT options, and that the operator should have in place appropriate measures to prevent and mitigate oil spills from drilling activities (which Equinor can confirm).
Marine Scotland	Does the sediment type at the site lend itself to alternative technologies for the conductor sections that would reduce the amount of cuttings and discharge of cement to the seabed?	The sediment type at the site lends itself to other conductor installation methodologies e.g. conductor jetting which would minimise the amount of cuttings and discharge of cement to the seabed, however due the risk of encountering boulders and verticality constraint requirement for installing such conductors through a template structure excludes such technologies. The preferred installation method is to drill and cement the conductor.
Marine Scotland	It is noted that cement discharges are not listed in the activities that may result in potential environmental impacts and MSS advise that any impacts from cement discharges are assessed.	Cement use is detailed in Chapter 3 and assessed in Chapter 7.
Marine Scotland	MSS welcome that new environmental survey data will be collected in support of the development and advise that any environmental sampling is representative of the likely impact area.	Noted.
Marine Scotland	MSS advise that the physical aspects of the environment at this location are fully described and that the ES considers the different water masses present in the Faroe-Shetland channel and describes the water temperatures likely to be experienced at these depths.	Information on water masses is presented in Chapter 4.
Marine Scotland	As the field is located in deeper waters, the scoping report correctly identifies the limited number of demersal spawning species in the area. MSS advise that the ES discusses the presence of elasmobranchs and deep water species in this area, in addition to commercial species. MSS acknowledge that information on deep water species is limited and advise reference to the Strategic Environmental Assessment OESEA3 and Appendix 1a.4 (https://www.gov.uk/government/consultations/uk-offshore-energy-strategic-environmental-assessment-3-oesea3).	Deep water species and elasmobranchs are covered in Chapter 4, with reference to OSEA 3 as relevant.
Marine Scotland	MSS advise reference to the following paper (José M. González-Irusta, Peter J. Wright; Spawning grounds of Atlantic cod (Gadus morhua) in the North Sea, ICES Journal of Marine Science, Volume 73, Issue 2, 1 February 2016, Pages 304–315, https://doi.org/10.1093/icesjms/fsv180) which provides an update to the cod spawning areas and describes parts of the proposed gas export route (to Clair) as an 'occasional' cod	González-Irusta *et al*. (2016) has been used to inform the baseline presented in Chapter 4 and the seabed impact assessment in Chapter 6.

Stakeholder	Stakeholder comment	Equinor response
	spawning area. Cod are a species known to aggregate over specific grounds to spawn and aggregate on a spawning arena where males hold small territories in a lek-like mating system. This aggregative behaviour together with seasonal site fidelity makes cod, especially vulnerable to anthropogenic impacts. Potential impacts on cod spawning should be specifically addressed.	
Marine Scotland	Pipeline installation methods are not discussed in the scoping report and MSS advise that the ES considers the potential for upheaval buckling and free spans forming as a result of the mobility of sediments in this area. Likewise, if pipelines are to be trenched or protected with rock, the ES should consider what impact clay or rock berms may have on other sea users.	Pipeline installation methods are described in Chapter 3 and impacts, including from clay berms, assessed in Chapter 6 (seabed) and Chapter 8 (other sea users).
Marine Scotland	MSS have a general preference for fully trenched and buried pipelines and cables where technically feasible. The assessment of potential impacts on fisheries should acknowledge that fishing patterns may also change within the 25 year life of the development, particularly as species move into deeper, colder waters in response to climate changes predicted.	A note on future fishing activity has been included in Chapter 8 (other sea users).
Marine Scotland	MSS advise that the ES takes account of foreign fishing activity in this area, particularly of long-liners which it is understood operate in these deeper waters. Landings and effort by non-UK vessels is not represented in the Scottish Government ICES data sets. MSS advise that fishing representative organisations such as the SFF should be consulted on the importance of the area to foreign fleets and to advise on appropriate notification channels to ensure such vessels are made aware of any potential hazards associated with the development.	SFF have been consulted, and foreign fishing activity has been described for the area in Chapter 4.
Marine Scotland	The moorings associated with an FPSO in this depth of water are likely to be of significant length. It is not clear if moorings will be constructed from chain or fibre rope at this stage. MSS advise that fibre ropes may not be detected by sonar on-board fishing vessels and may therefore pose a particular hazard to fishing activity in the area. MSS advise that this aspect is discussed in the ES to ensure the FPSO moorings do not pose a hazard to other sea users. Further discussion with fishing representative bodies such as the SFF is advised on this aspect.	Chapter 3 states that the mooring lines are chains and polyester rope and infrastructure will be charted. The potential impact is considered in Chapter 8.
Marine Scotland	There is no mention of cumulative impacts in the scoping report and MSS advise that potential cumulative impacts are fully assessed.	Cumulative impact has been considered in each of the impact assessment chapters (Chapters 6 - 11).
Marine Scotland	Decommissioning should be fully considered in the ES. MSS advise that the ES should demonstrate the ability to remove infrastructure and any protective material should this be the policy in place at the time, or the preferred outcome of a comparative assessment process. MSS advise that the ES also considers the impact this project may have on decommissioning timescales and requirements of other developments connected or impacted by this development.	Chapter 2 notes where decommissioning has influenced key decisions, whilst Chapter 3 outlines the proposed decommissioning strategy at this time.
Marine Scotland	MSS advise that the chosen options for the various elements of the project are fully justified and it is demonstrated that these represent Best Available Technology (BAT) and Best Environmental Practice (BEP) and take account of decommissioning.	Chapter 2 explains the decision-making behind the Development.
Marine Scotland	Details of how other adjacent pipelines and cables are laid is advised in support of the chosen installation methods.	This is addressed in Section 3.8.2.

Stakeholder	Stakeholder comment	Equinor response
Marine Scotland	MSS understand that production pipelines will be ‘piggable’ but would like to understand whether there are any specific constraints with the produced hydrocarbons that require specific management.	There is a high potential for wax formation, and Chapter 2 explains how this has been addressed in decision-making.
Marine Scotland	Depending on the gas export route option, MSS also advise that consideration is given to the expected field life of the third party infrastructure that this development will tie into.	Equinor confirm that the Clair life of field was taken into account in this decision-making.
Marine Scotland	An upfront description of the surveys used in support of the development should be provided. This should include detail of the methods used and justification for the location of sampling stations.	This is presented in Chapter 4.
Marine Scotland	A local scale bathymetry map for the development area is advised, highlighting any significant seabed features.	Broad scale bathymetry is presented in Figure 1-4, and seabed features are charted and described in Chapter 4.
Marine Scotland	The physical characteristics of the environment at the location should be fully described and include, for example, information on currents, wind speed, wave height / power, temperature and salinity. The MS MAPS National Marine Plan interactive (NMPi): https://marinescotland.atkinsgeospatial.com/nmpi/ is a useful source of information.	These physical characteristics have been described in Chapter 4, with reference to NMPi where appropriate.
Marine Scotland	MSS has recently added new spatial layers to the Marine Scotland MAPS National Marine Plan interactive (NMPi) showing predicted seabed habitats (https://marine.gov.scot/maps/68) and sediment types (http://marine.gov.scot/maps/745) which are advised, to provide additional regional context. These spatial layers may be viewed on the Marine Scotland MAPS National Marine Plan interactive (NMPi) web site : https://marinescotland.atkinsgeospatial.com/nmpi/.	Seabed habitats are described in Chapter 4, with reference to NMPi where appropriate.
Marine Scotland	MSS advise that good quality, high resolution images of the local sediment / benthic community, are included in the ES. These should ideally be labelled with a description of the features and fauna observed, provide some scale and be linked to a location on the map.	Images are presented in Chapter 4.
Marine Scotland	A summary of any particle size analysis and contaminant analysis of sediments should be provided.	This is described in Chapter 4.
Marine Scotland	Plankton: MSS advise that ES includes baseline data on plankton and considers any potential impacts on plankton. Useful information is available in the Strategic Environmental Assessment (OESEA3) (https://www.gov.uk/government/consultations/uk-offshore-energy-strategic-environmental-assessment-3-oesea3) and Appendix 1a.1.	This is described in Chapter 4.
Marine Scotland	MSS advise that a biotope classification is assigned for the area in accordance with the EUNIS / JNCC indices.	Information on broad scale habitat classification, as well as classification based on site surveys, is provided in Chapter 4.
Marine Scotland	Where species of conservation concern or species indicative of habitats of conservation concern are identified, it is advised that the abundance of animals is discussed in accordance with the SACFOR abundance scale (https://mhc.jncc.gov.uk/media/1009/sacfor.pdf).	Information on species and habitats is provided in Chapter 4, including an assessment of the most recent survey data using the SACFOR scale.

Stakeholder	Stakeholder comment	Equinor response
Marine Scotland	MSS advise that *Lophelia pertusa* should now be regarded as *Desmophyllum pertusum*.	This has been captured as relevant.
Marine Scotland	The Marine Scotland MAPS National Marine Plan interactive (NMPi) now contains useful layers showing the known locations of species and habitats of conservation importance. MSS advise this is represented visually. More details may be obtained from the 'healthy and biologically diverse' sections at the following web address: http://marine.gov.scot/themes/healthy-and-biologically-diverse and on NMPi here: https://marinescotland.atkinsgeospatial.com/nmpi/.	Figures in the Chapter 4 show the location of species and features of conservation concern in relation to Rosebank.
Marine Scotland	A basic assessment of the spawning habits and preferred habitats of the main species identified, as compared to the conditions experienced locally, may highlight additional mitigation opportunities.	The presence of fish spawning/nursery areas is covered in Chapter 4. An assessment on impacts associated with the Development on the seabed in relation to fish spawning is included in Chapter 6.
Marine Scotland	Reference to the following report is advised, which provides a modelled spatial representation of the probability of presence of 0 age group fish (fish in the first year of their life) and the probability of aggregations of 0 age group fish. It is recommended these data are presented visually in conjunction with the Coull *et al.* (1998) and Ellis *et al.* (2012) nursery maps, as there are certain limitations with the data (please see here for full report - (https://data.marine.gov.scot/dataset/updating-fisheries-sensitivity-maps-british-waters) (DOI: 10.7489/1555-1). The report should be cited as; Aires, C., González-Irusta, J.M., Watret, R (2014) Scottish Marine and Freshwater Science Report, Vol 5 No 10, Updating Fisheries Sensitivity Maps in British Waters. Further details are available here: (http://marine.gov.scot/node/12828).	These reports are referenced as relevant in Chapter 4.
Marine Scotland	Scottish Natural Heritage (now NatureScot), The Joint Nature Conservation Committee and Marine Scotland have developed a priority list of marine habitats and species in Scotland's seas, known as Priority Marine Features (PMF's), which should referred to in the ES. This list will help deliver Marine Scotland's vision for marine nature conservation outlined in the Marine Nature Conservation Strategy (https://www.webarchive.org.uk/wayback/archive/20160107013417mp_/http://www.gov.scot/Resource/Doc/295194/0115590.pdf). A list of PMF's was adopted on 24th July 2014 and contains habitats and species considered to be of conservation importance in Scotland's seas. A list of all PMF's in Scotland's seas and further information may be obtained here: https://www.nature.scot/professional-advice/safeguarding-protected-areas-and-species/priority-marine-features-scotlands-seas	The presence of PMFs is described in Chapter 4.
Marine Scotland	New aggregated VMS fishing effort data sets for 2010 - 2020 are now available on the National Marine Plan Maps interactive web site (NMPi). The data are split into three groups of fishing method: bottom trawls, dredges and crustaceans caught by bottom trawl (i.e. Nephrops). Further information may be obtained here http://marine.gov.scot/node/12832. Map layers showing average annual fishing effort (mW fishing hours) in the Greater North Sea Ecoregion during 2015–2018 are also available via EMODNET. Data are split by gear type: beam trawls, bottom otter trawls, bottom seines, dredges, pelagic trawls and seines	The data has been described in Chapter 4 and a figure of mobile fishing effort (from VMS) has been included using the newest available data.

Stakeholder	Stakeholder comment	Equinor response
	and static gears. Further information is available here: https://www.emodnet-humanactivities.eu/view-data.php.	
Marine Scotland	MSS also advise visual representation of the recently added nine new spatial layers to the National Marine Plan interactive (NMPi) showing changes over the last five years of published statistics for: 1. tonnage for demersal, pelagic and shellfish species; 2. value (£) for demersal, pelagic and shellfish species; 3. effort (days) (by UK vessels >10m length) for demersal active (bottom trawls, dredges etc.); pelagic active (pelagic trawls, purse seines etc.); and passive (pots/creels, gillnets etc.).	The most recent, relevant commercial fisheries statistics have been presented in Chapter 4.
Marine Scotland	Tabulated fisheries statistics are advised in addition to any graphics provided.	Tables have been provided in Chapter 4.
Marine Scotland	The following paper highlights a number of fisheries incidents with oil and gas infrastructure in this area for which claims were submitted to the Fishing Compensation Fund "Rouse, S., Hayes, P., and Wilding, T. A. Commercial fisheries losses arising from interactions with offshore pipelines and other oil and gas infrastructure and activities. – ICES Journal of Marine Science, doi:10.1093/icesjms/fsy116". It is advised that finer scale information regarding specific losses in the location of the development are available from the Environment Manager at Oil and Gas UK and it may be useful to take these into account.	The Rouse *et al*. paper has been referenced as part of the snagging assessment in Chapter 8.
Marine Scotland	MSS has recently added new spatial layers to the Marine Scotland MAPS National Marine Plan interactive (NMPi) showing the intensity of mobile fishing associated with oil and gas pipelines and cables in the UK for 2007 - 2015. Further information and shape files containing the data may be found here: https://data.marine.gov.scot/dataset/uk-fishing-intensity-associated-oil-and-gas-pipelines-2007-2015-0	This information has been used as part of the written assessment in Chapter 4.
Marine Scotland	A minor error is noted in section 3.5 of the scoping report where the proportion of pelagic fish landed in ICES rectangle 50E7 in 2020 is described as 53% of the landed weight and 52% of the value. It is advised these figures are the wrong way round and this should be 53% of the value and 52% of the landed weight.	Noted.
Marine Scotland	The EMODNET Human Activities data portal now contains useful up to date shipping information based on the Automatic Identification System (AIS). Further information is available here: https://www.emodnet-humanactivities.eu/view-data.php.	Shipping information from the EMODnet source has been referenced within Chapter 4, along side data from project-specific studies.
Marine Scotland	MSS advise that the location of existing oil and gas infrastructure and previously drilled wells in the area is shown. The Oil and Gas Authority quadrant maps may be useful: (https://data-ogauthority.opendata.arcgis.com/pages/pdf-maps).	A figure of oil and gas infrastructure is provided in Chapter 4.
Marine Scotland	MSS advise that the Sectoral Marine Plan for Offshore Wind Energy 2020 areas (http://marine.gov.scot/information/sectoral-marine-plan-offshore-wind-energy-plan-options), the Sectoral Marine Plan for Offshore Wind Innovation and Targeted Oil and Gas Decarbonisation (INTOG) areas (https://marine.gov.scot/information/sectoral-marine-plan-offshore-wind-innovation-and-targeted-oil-and-gas-decarbonisation) and the ScotWind option agreement offer	Scotwind Plan Option areas and those awarded have been considered, in addition to INTOG areas, within Chapter 4.

Stakeholder	Stakeholder comment	Equinor response
	areas as of February 2022 (http://marine.gov.scot/node/15039) are taken into account.	
Marine Scotland	Other sea users: Where there is potential for shoreline oiling on the Scottish coastline as a result of an accidental event scenario, MSS advise that impacts on aquaculture and Shellfish Water Protected Areas are considered. The following information sources are advised: o The National Marine Plan interactive (https://marinescotland.atkinsgeospatial.com/nmpi/); o Shellfish Water Protected Areas (https://www.gov.scot/policies/water/protected-waters/); o Scotland's Aquaculture website (http://aquaculture.scotland.gov.uk/map/map.aspx); o The Scottish Shellfish Farm Production survey 2020 (https://www.gov.scot/publications/scottish-shellfish-farm-production-survey-2020/) (These statistics are usually published in May each year); o The Scottish Finfish Farm Production survey 2020 (https://www.gov.scot/publications/scottish-fish-farm-production-survey-2020/) (These statistics are usually published in September each year).	Consideration to sites of aquaculture interest has been given in Chapter 11.
Marine Scotland	MSS advise that the ES includes a detailed assessment of how the proposal is aligned with the policies and objectives of the Scotland's National Marine Plan (https://www.gov.scot/publications/scotlands-national-marine-plan/?msclkid=88c6a548a69d11ec8bd2d29e22d47d07). The assessment should take account of the applicable general policies as outlined in Chapter 4 of the plan and the sector specific policies and objectives as outlined in Chapter 9.	The Marine Plan has been considered during development of the Project and the EIA, and an assessment of alignment is presented in Appendix A.
Marine Scotland	MSS welcome that modelling work will be conducted to demonstrate the impact areas associated with drilling the wells. MSS would like to highlight that impact areas associated with disturbance of sediments during pipeline installation should also be considered and that modelling work may be useful in demonstrating this.	The impact assessment (Chapter 6) has considered sediment disturbance during installation activities. During development of the EIA, sediment dispersion modelling was not considered necessary, as existing literature was determined to be sufficient to support a robust assessment.
Marine Scotland	When discussing potential impacts on species or habitats of conservation concern, MSS advise that the Feature Activity Sensitivity Tool – FEAST (http://www.marine.scotland.gov.uk/feast/) and MARLIN sensitivity reviews (https://www.marlin.ac.uk/sensitivity/sensitivity_rationale) are referred to.	The FEAST tool and MarLIN have been used to support the seabed impact assessment (Chapter 6).
Norther Lighthouse Board	NLB will provide lighting and marking recommendations later in the consenting process, but it would be in line with the Standard Marking Schedule for Offshore Installations.	Noted.
Maritime and Coastguard agency	The MCA would expect the Environmental Statement to include a chapter on shipping and navigation (impact on other users)	This has been provided in Chapter 8.
Maritime and Coastguard agency	We note the development is for four production and three water injection wells in the first phase, and up to five additional wells in the second phase. The subsea wells will tie back to a Floating Production Storage and Offloading facility (FPSO) via the installation of new risers, flowlines and umbilicals. Oil will	Noted.

Stakeholder	Stakeholder comment	Equinor response
	be exported from the FPSO using tankers and gas will be exported via a new offshore gas export pipeline to tie into the existing West of Shetlands Pipeline System (WOSPS). Two gas export pipeline route options are under consideration: New offshore pipeline from Rosebank to tie into WOSPS via the Clair Tee (base case); and New offshore pipeline from Rosebank to the Cambo field, to tie into the planned Cambo pipeline to tie into WOSPS via the Pipeline End Manifold (PLEM).	
Maritime and Coastguard agency	The MCA would have no significant concerns to raise on this occasion on the understanding that a Risk Assessment (Shipping and Navigation) and Collision Risk Management Measures are in place for the Consent to Locate. This is to minimize the risk of ship collision and to define the guarding role of the ERRV whilst on location. The MCA would expect the standard conditions as set out below for this development. The conditions used may vary but should be based on the Navigational Risk Assessment, along with any other mitigation measures in respect of pipeline trenching, mattressing and over-trawlability protection required:	Noted.
Maritime and Coastguard agency	a) The UK Hydrographic Office (UKHO) and the Maritime Coastguard Agency (MCA) must be informed at least 48 hours in advance of the commencement of the Works.	Noted.
Maritime and Coastguard agency	b) Kingfisher Information Services and local operators must be informed at least two weeks in advance of the date of commencement of the Works. If determination of the application is made within two weeks prior to of the commencement of the Works, Kingfisher Information Services and Local Operators must be notified immediately following issue of the consent.	Noted.
Maritime and Coastguard agency	Communications with other bodies in relation to the consent conditions should be addressed to: United Kingdom Hydrographic Office Email to navwarnings@ukho.gov.uk, and copy offshore.energy@ukho.gov.uk or fax to +44 (0)1823 322352, marked for the attention of the Navigation Warnings Section. Maritime and Coastguard Agency Email to Oilandgas@hmcg.gov.uk, oelo@mcga.gov.uk and navigationsafety@mcga.gov.uk, or fax to +44 (0)2380 329204, marked for the attention of the Navigation Safety Branch General Lighthouse Authorities Trinity House (England, Wales and the Channel Islands) email to navigation@trinityhouse.co.uk, or telephone +44 (0)20 7481 6900, for the attention of the Navigation Directorate. Northern Lighthouse Board (Scotland and the Isle of Man) email to navigation@nlb.org.uk, or fax to +44 (0)131 220 0235, marked for the attention of the Navigation Department. Commissioner of Irish Lights (Northern Ireland and Republic of Ireland) email to info@cil.ie or fax to +353 (0)1271 5566. Kingfisher Information Services The Kingfisher Bulletin is online and works notices can be submitted and managed via a users' account at www.kingfisherbulletin.org. Alternatively email kingfisher@seafish.co.uk, or fax to +44 (0)1482 223310, marked for the attention of the Kingfisher Bulletin.	Noted.
Maritime and Coastguard agency	Local operators are defined as operators of vessels who regularly use the vessel routes identified within the Vessel Traffic Survey Report which is required to be produced, and submitted, as part of the Consent to Locate application	Noted.

Stakeholder	Stakeholder comment	Equinor response
	process. Local operators should be informed via local notifications (also known as Local Notice to Mariners).	
Maritime and Coastguard agency	Local Notifications, which can be sent via email should include the start date, duration, nature of activity including an image on a nautical chart, details of precautions, the potential impact on shipping and contact details. All local notifications should be sent to the UK Hydrographic Office the responsible authority for charting, who will decide whether navigation warnings and/or Admiralty Notices to Mariners are also required. These local notifications should also be sent to MCA at oilandgas@hmcg.gov.uk.	Noted.
Maritime and Coastguard agency	An Oil Pollution Emergency Plan and Emergency Response Procedure to be in place.	Noted.
Joint Nature Conservation Council	Preference would be for the shorter of the two gas export route options, particularly as it avoids the Faroe Shetland Sponge Belt Marine Protected Area (MPA)	Chapter 2 outlines the rationale behind the decision to route the pipeline to the west of Shetland pipeline system.
Joint Nature Conservation Council	Equinor have included all relevant habitats and species of concern in the scope of the EIA.	Noted.
Joint Nature Conservation Council	Update to Stony reef Assessment Guidance issued in 2020, should be referred to within the EIA.	Reference is made in Chapter 4.
Joint Nature Conservation Council	Report from joint JNCC and Marine Scotland survey of the MPA that took place in August 2021 will be published soon.	Noted, but the report does seem to have been available prior to finalisation of this document.
Joint Nature Conservation Council	Question on the addition of new survey data in the EIA mentioned in the scoping letter.	The scope of the survey is described in Chapter 4, alongside the results.
Joint Nature Conservation Council	Regarding the output from the survey in the EIA, a statement should be included on the presence or non-presence of the infaunal bivalve Arctica islandica for which the MPA is known to be a habitat The survey should also attempt to quantify the number of deep-sea sponges and sponge aggregations identified, rather than express these in terms of the density of sponges identified GK shared a paper which he co-authored which may be a useful reference for the EIA: Distribution of Deep-Sea Sponge Aggregations in an Area of Multisectoral Activities and Changing Oceanic Conditions	Specific results regarding this species is presented in Chapter 4.
Joint Nature Conservation Council	How likely is it that the FPSO will be powered by gas turbines for the life of field?	The proposed strategy for power provision on the FPSO is described in Chapter 3 and assessed in Chapter 9.
Joint Nature Conservation Council	Are Equinor aware of the ongoing Offshore Transmission Network Review?	Yes, Equinor is taking part in this review through involvement in the West of Shetland Operators Electrification working group (discussed further in Chapter 1).

Stakeholder	Stakeholder comment	Equinor response
Joint Nature Conservation Council	JNCC's general advice regarding construction within the MPA is to minimise the impact on the seabed as much as possible.	The seabed footprint is described and assessed in Chapter 6; the broad principle to reduce seabed footprint as far as is feasible when balanced against technical and other issues has been taken.

Appendix C – Commitments Register

Note: Only non-regulatory comments have been included.

Issue	Mitigation or management action
Chapter 6 - Seabed impacts	
Seabed disturbance	The MODU will use DP to maintain station.
Seabed disturbance	Subsea templates will be a compact layout, thereby limiting seabed footprint.
Seabed disturbance	All flowlines, umbilicals and jumpers will be surface laid to avoid the need for trenching.
Seabed disturbance	The installation of all subsea facilities will exclusively employ DP vessels.
Seabed disturbance	A suction pile anchor plan will be in place for the FPSO to minimise impacts on the seabed.
Seabed disturbance	The use of rock cover / pre-lay will be minimised as much as possible through the implementation of a detailed GEP installation plan further to obtaining high resolution seabed topography data.
Seabed disturbance	The use of concrete mattresses at cable crossing points will be optimised.
Seabed disturbance	All flowlines, umbilicals and jumpers installed in the Rosebank field as part of the Development will be surface laid to avoid the need for trenching.
Seabed disturbance	Dropped objects will be treated according to industry standards, with procedures in place to record the location of any lost material and to recover significant objects where practicable. A dropped object risk assessment will be carried out initially. Installation and SIMOPS procedures will be in place to reduce the potential for dropped objects and training and awareness will be provided to installation contractors.
Seabed disturbance	To minimise the risk of dropped objects, all lifting equipment will be tested and certified to LOLER 1989 regulations prior to the commencement of activities. Lift planning will be undertaken to manage risks during lifting activities, including the consideration of prevailing environmental conditions and the use of specialist equipment where appropriate.
Seabed disturbance	Dropped object surveys will be carried out at appropriate points through the Development lifecycle (including following the completion of drilling activities).
Seabed disturbance	Decommissioning of subsea infrastructure will be in accordance with future decommissioning guidelines and industry best practice in place at that time.
Chapter 7 – Discharges to sea	
Drilling	Returns from cementing of the riserless tophole well section casings are monitored on the drilling rig via ROV footage to minimise the quantity of excess cement discharged to the seabed
Drilling	An assurance process shall be in place to the ensure the drilling rig complies with all relevant guidelines and legislation.
Produced water	All produced water and associated chemicals will be re-injected unless there is a process upset that requires discharge to sea. All discharges of produced water will be in accordance with the required overboard discharge limits.
Chemical selection	Selection of chemicals will be made in accordance with Equinor policies which aim to minimise the environmental impact. Equinor, in conjunction with its chemical suppliers, will regularly investigate alternative technologies which may reduce the requirement for production chemical use.

Produced water	The produced water system will be designed to reduce the oil content in the produced water to the minimum regulatory requirement.
Sand	Sandface completion techniques will be used in the completions of the producing wells to help reduce the production of sand at source.
Sand	Sand treatment and disposal will be based on BAT and industry standards.
Sand	Produced sand will only be discharged overboard when the residual level of oil following cleaning is less than permitted.
Chapter 8 – Other sea users	
Increased vessel traffic and collision risk	Safety zones will not be implemented around the risers and mooring anchors and chains when they are wet stored, but an Emergency Response and Rescue Vessel (ERRV) will be present and the details of the wet storage will be communicated through relevant channels (e.g. Kingfisher bulletin).
Temporary and long-term exclusion	No safety zone will be implemented along the gas export pipeline, with the exception of those already in place for Clair Tee. Once the installation and support vessels have moved out of the area, there will be no statutory restrictions on fishing in the vicinity of the gas export pipeline for the lifetime of the Development.
Temporary and long-term exclusion and snagging risk	The gas export pipeline will be trenched and backfilled where possible to minimise any loss of fishing grounds. Where this is not possible, an over-trawlable berm will be laid atop of the pipeline. Considering this, once operational, no exclusion of fishing activities is expected in relation to the gas export pipeline.
Snagging Risk	Installation vessels and the MODU will use DP to maintain position, and therefore, there will be no anchoring required for these vessels, with no potential for anchor mounds to present a snagging risk following the well drilling and pipeline installation works.
Snagging Risk	Adequate charting, including the FPSO any moorings and the gas export pipeline, and communication with the fishing industry, through standard communication channels (such as Kingfisher) will reduce any potential snagging risk. An ERRV standby vessel will also be on location.
Snagging Risk	The valve structures at the connection point on WOSPS at Clair Tee will be located within an existing permanent safety zone, which already prohibits fishing activity within this area, minimising any potential snagging risk.
Snagging Risk	A final survey will be undertaken of the infrastructure prior to the installation vessels leaving the field to confirm location and as-built status.
Increased vessel traffic and collision risk	During the installation phase of the project, unconnected risers and moorings may be temporarily exposed. In these instances, an ERRV will be on site to monitor the traffic and the collision risk is expected to be minimal.
Increased vessel traffic and collision risk	Installation of gas export pipeline and associated infrastructure - notifications to other sea users through Kingfisher will be issued to communicate the location of the works.
Damage to third-party assets	Crossing arrangements will consist of concrete mattresses to prevent damage to third-party assets.
Damage to third-party assets	Crossing and proximity agreements will be in place with operators of any crossed pipelines or cables prior to installation.
Snagging Risk	Where practicable, gas export pipeline routing will be refined during Detailed Design to reduce the potential for free spans, which may pose a potential risk of snagging fishing gear. Unavoidable spans that present a potential hazard to fishing will be rectified (e.g., by rock placement).
Dropped objects	Lift planning will be undertaken to manage risks during lifting activities, including the consideration of prevailing environmental conditions and the use of specialist equipment where appropriate.

Dropped objects	A dropped object protocol will be developed to reduce the risk of dropped objects from installation vessels.
Dropped objects	Procedures will be put in place to make sure that the location of any lost material is recorded and that significant objects are recovered where practicable, including by carrying out dropped object surveys at appropriate points through the Project life cycle.
Dropped objects	Training and awareness will be provided to installation contractor, and that there is a need to promote good housekeeping aboard installation vessels to minimise drops.
Dropped objects	A dropped objects risk assessment will be carried out with a suite of appropriate control measures.
Increased vessel traffic and collision risk	A VTS, CRA and collision risk management plan will be prepared to support the CtL applications.
Increased vessel traffic and collision risk	A SIMOPS plan will be developed if another activity is taken place at the location at the same time.
Increased vessel traffic and collision risk	The FPSO will be equipped with Aids to Navigation as per the BEIS Standard Marking Schedule for Offshore Installations.
Increased vessel traffic and collision risk	Information on the location of subsea infrastructure, FPSO suction pile anchors and mooring chains, vessel operations, and the timeline for any works associated with the Development will be communicated to other sea users via the United Kingdom Hydrographic Office (UKHO), FishSafe, Maritime and Coastguard Agency (MCA), Kingfisher, Notices to Mariners and Radio Navigation Warnings. These notifications will be provided with advanced notice to ensure they are distributed to other sea users in advance of any works. The UKHO and MCA will be notified at least 48 hours in advance of the commencement of works and Kingfisher and local operators will be informed with at least two weeks' notice.
Increased vessel traffic and collision risk	The FPSO will have vessel-tracking systems linked to the control room.
Increased vessel traffic and collision risk	The Equinor Marine Operations centre will remotely monitor vessel traffic around the field.
Increased vessel traffic and collision risk	A temporary safety zone of 500 m will be implemented around the MODU whilst on location.
Increased vessel traffic and collision risk	A permanent safety zone of 500 m will be implemented around the FPSO.
Interaction with fishing activity	Fisheries consultation will be undertaken with relevant authorities and organisations with the aim of reducing potential interference impacts resulting from Project activities as far as practicable.
Interaction with fishing activity	Equinor will continue to engage with the fishing industry throughout the lifetime of the field through standard communications channels.
Interaction with fishing activity	A fisheries representative may be onboard the pipelay vessel during relevant parts of the installation of the gas export pipeline, recognising that fishing activity is low in deep water and therefore a fisheries liaison officer may not be required in certain areas.
Increased vessel traffic and collision risk	During installation, the number of vessels and length of time they are required on site will be reduced as far as practicable through careful planning of the installation activities.
Increased vessel traffic and collision risk	An ERRV will be present in the Development infield area during drilling and installation to protect subsea facilities, infield flowlines and risers and ensure safety of fishing and other vessels operating near the area. A separate ERRV will be on site at the FPSO during operation. However During extreme weather there may be a need for the ERRV to seek shelter in calmer waters.

Snagging Risk	Regular maintenance and gas export pipeline route inspection surveys based on the condition-based maintenance strategy will be undertaken, checking for lack of cover, free-spans and evidence of interaction with fishing equipment will be carried out. Once the results of the initial inspection surveys are available the frequency of these surveys will be reviewed by the Integrity Management team and Pipeline Technical Authority within Equinor, and by the relevant assurance body.
Snagging Risk	During decommissioning, any infrastructure left *in situ* or rock placement made, will be surveyed for potential snagging risks and mitigated accordingly.
Chapter 9 – Atmospherics and climate	
Atmospheric Emissions	The installation will be during the summer period, when the sea state is likely to be conducive to offshore operations, with minimal waiting-on-weather standby periods, hence minimising the vessel time required to install subsea equipment.
Atmospheric Emissions	Equinor will undertake further work to ensure that the FPSO will be electrification-ready prior to arriving at the Rosebank field.
Atmospheric Emissions	Equinor will continue to mature electrification options for the FPSO for implementation with manageable technology, execution and timeline risks. Equinor will also keep regulators regularly updated on progression of the electrification scope.
Atmospheric Emissions	The FPSO will be equipped with a vapour recovery system and a flare gas recovery system.
Atmospheric Emissions	The Development will not have continuous routine flaring or venting of gas associated with production.
Atmospheric Emissions	Heat recovery from turbine exhaust gases will be used to heat the processing plant, enhancing energy efficiency.
Atmospheric Emissions	Significant modification / replacement of equipment on the FPSO will be carried out in order to further improve energy efficiency and thereby reduce the energy consumption.
Atmospheric Emissions	The gas export pipeline route will be the shortest feasible route, which implies lower embodied carbon in the fabrication of the infrastructure.
Atmospheric Emissions	During the operation phase, Rosebank will operate the fewest number of gas turbines required in order to minimise GHG emissions.
Atmospheric Emissions	During life of field, opportunities will be continuously evaluated and considered to reduce the requirement for flaring and ensure compliance with the aim of zero routine flaring.
Atmospheric Emissions	Minimising methane fugitive emissions through innovation and adoption of best practice will be implemented to reduce fugitive emissions.
Atmospheric Emissions	Evaluation criteria for vessel tendering will assess: (a) if all vessels will use low sulphur diesel (<0.1% sulphur content); (b) if each vessel has a Shipboard Energy Efficiency Management Plan; (c) the application of Green DP or economical speeds when operationally appropriate; and (d) the potential to minimise the number of mobilisations or demobilisations to the extent practicable.
Atmospheric Emissions	Equinor will also seek to streamline logistics associated with installation, commissioning and decommissioning through careful planning, to reduce the time required for vessels and helicopters, and thus reduce the carbon footprint.
Chapter 10 – Underwater noise	
VSP Design	Survey equipment will be designed to produce a downward focused sound source, with sound levels reducing with horizontal distance.
Marine Mammals	MMOs on board the vessel from which the VSP will be deployed (in this case, the drilling rig) will monitor for the presence of marine mammals, during the pre-source start search,

	soft-start and survey, and will recommend delays in the commencement of source activity should any marine mammals be detected within the 500 m mitigation zone.
Marine Mammals	If applicable, dedicated PAM operators will cover hours of darkness and periods when daytime conditions are not conducive for visual surveys (e.g. fog or increased sea states). The survey contractor will be providing a team to cover 24-hour observations/PAM during the survey.
Marine Mammals	All observations (MMO or PAM) will be undertaken during a pre-shooting search of 60 minutes prior to the commencement of the seismic sources. This will involve a visual (during daylight hours) and/or acoustic assessment (during hours of darkness/reduced visibility) to determine if any marine mammals are present within the 500 m mitigation zone from the centre of the device deployed. If marine mammals are detected in the mitigation zone during the pre-shooting search, then operations must be delayed until their passage. Either way there will be a minimum of a 20-minute delay from the time of the last sighting within the mitigation zone and the commencement of the soft-start and/or start of operations, to allow animals unavailable for detection to leave the area.
Marine Mammals	A soft start will be conducted every time prior to survey operations. Regardless of duration, where possible, power will be built up gradually, in uniform stages from a low energy start-up.
Marine Mammals	Surveys will be planned to avoid unnecessary firing at operational power before commencement of an acquisition line and to time operations to commence data collection as soon as possible once full operational power is achieved.
Marine Mammals	All recordings of marine mammals will be made using JNCC Standard Forms. At the end of the survey, a monitoring report detailing the marine mammals recorded, methods used to detect them, and details of any problems encountered will be submitted to the JNCC. The report will also include feedback on how successful the mitigation measures were. This requirement will be communicated to the MMO at survey start up meetings and at crew change. If the MMO has any queries on the application of the guidelines during the survey, they will contact the JNCC for advice.
Chapter 11 – Accidental events	
Well blow out	Risk assessment and appropriate emergency response procedures will be implemented.
Well blow out	Specific procedures regarding conducting activities in the harsh environment of the wider west of Shetland region will be in place.
Well blow out	The drilling rig will be appropriately certified.
Well blow out	The drilling rig will have an approved safety case with all SECEs verified by an independent verification body and managed through a recognised maintenance management system.
Well blow out	The BOP will have fully redundant control systems.
Well blow out	Weather forecasts will be monitored so that oil-based mud in the riser can be removed to the drilling rig prior to riser unlatch.
FPSO loss of inventory	The FPSO will be of a double-hull design, meaning oil cargo tanks are not on the outside and, thus limiting risk of spill.
FPSO loss of inventory	A mandatory 500 m safety zone will be in place
FPSO loss of inventory	There will be agreed approach procedures to the FPSO by supply and safety vessels, informed by appropriate collision risk assessments.
FPSO loss of inventory	Operational restrictions will be in place for visiting vessels in bad weather.

FPSO loss of inventory	A robust maintenance and inspection programme will be in place, linked to the critical elements and associated verification scheme.
Tanker offloading	Shuttle tankers will be required to be DP2-classed as a minimum.
Tanker offloading	Metocean conditions may limit offloading; where production storage limits are reached, production could be curtailed until export can resume.
Tanker offloading	Tanker offloading procedures will be in place to limit the risk of spills.
Tanker offloading	Equinor will consider the use of infrared cameras as an early warning of oil on the sea surface.
Spill from infield flowlines and risers	Dropped object risk assessments will be carried out for all lift activities.
Spill from infield flowlines and risers	Procedures will be put in place to record the location of any lost material and to recover significant objects where practicable.
Spill from infield flowlines and risers	SIMOPS procedures will be in place.

Acronyms

AC	Alternating Current
ACA	Action Co-Ordinating Authority
AFEN	Atlantic Frontier Environmental Network
AIS	Automatic Identification System
ALARP	As Low as Reasonably Practical
API	American Petroleum Institute
AQS	Air Quality Standards
ARIS	Architecture Of Integrated Information Systems
AUV	Autonomous Underwater Vehicle
AWF	Auditory Weighting Function
BAT	Best Available Techniques
BEIS	Business Energy And Industrial Strategy
BEP	Best Environmental Practice
BGS	British Geological Survey
BOCC	Birds Of Conservation Concern
BODC	British Oceanographic Data Centre
BOP	Blowout Preventer
BREF	Best Available Technique Reference Document
CAPEX	Capital Expenditure
CCC	Climate Change Committee
CCS	Carbon Capture And Storage
CCUS	Carbon Capture Usage And Storage
CEFAS	Centre For Environment, Fisheries And Aquaculture
CEM	Corrosion Erosion Monitoring
CFU	Compact Flotation Units
CHOP	Cased Hole-Oriented Perforation
CO	Carbon Monoxide
COLREGS	International Regulations For The Prevention Of Collisions At Sea 1972
CORMIX	Cornell Mixing Zone Expert System
CPR	Continuous Plankton Reader
CRA	Collision Risk Assessment
CSV	Construction Support Vessel
DASSH	The Archive For Marine Species And Habitats Data
DC	Direct Current
DECC	Department For Energy And Climate Change
DEFRA	Department for Environment, Food and Rural Affairs
DG	Decision Gate
DLE	Dry Low Emission
DNV	Det Norske Veritas
DP	Dynamically Positioned
DREAM	Dose-Related Risk And Effect Assessment Model
DSV	Diving Support Vessel
DTI	Department of Trade and Industry
DWT	Dead Weight Tonnage
EC	European Commission

EEMS	UK Environmental And Emissions Monitoring System
EIA	Environmental Impact Assessment
EIAIW	East Icelandic And Arctic Intermediate Water
EIF	Environmental Impact Factor
EMS	Environmental Management System
EMSA	European Maritime Safety Agency
ENVID	Environmental Issues Identification
EOSPS	East of Shetland Pipeline System
EPS	European Protected Species
ERRV	Emergency Response And Rescue Vessel
ES	Environmental Statement
ESOS	Energy Savings Opportunity Scheme Regulations
ETH	Electrical Trace Heating
ETS	Emissions Trading Scheme
ETSWAP	Emissions Trading Scheme Workflow Automation Project
EU	European Union
EUNIS	European Nature Information System
FDP	Field Development Plan
FEAST	Feature Activity Sensitivity Tool
FEED	Front End Engineering And Design
FID	Final Investment Decision
FLAGS	Far North Liquids and Associated Gas System
FPSO	Floating Production, Storage And Offloading Unit
FPU	Floating Production Units
FRS	Fisheries Research Service
FTS	Fluid Transfer System
FUKA	Frigg UK Pipeline
GEP	Gas Export Pipeline
GES	Good Environmental Status
GHG	Greenhouse Gas
GIS	Gas Insulated Switchgear
GLA	Greater Laggan Area
GOR	Gas Oil Ration
GPS	Global Positioning Systems
GRB	Gas Riser Base
GT	Gas Turbine
GTG	Gas Turbine Generator
GWP	Global Warming Potentials
HC	Hydrocarbon
HF	High Frequency
HMCS	Harmonised Mandatory Control Scheme
HP	High Pressure
HRA	Habitat Regulations Assessment
HS	Significant Wave Height
HSE	Health, Safety And Environment
HV	High Voltage
HVAC	High Voltage AC
HVDC	High Voltage DC

HVSR	High Voltage Slip
HWIV	Heavy Well Intervention Vessel
ICES	International Council For The Exploration Of The Sea
ICUN	International Union For Conservation Of Nature
ID	Internal Diameter
IEEM	Institute Of Ecology And Environmental Management
IEMA	Institute Of Environmental Management And Assessment
ILT	In-Line Tees
IMR	Inspection/Maintenance And Repair
INTOG	Innovation And Targeted Oil And Gas Decarbonisation
IOGP	International Association Of Oil & Gas Producers
IOR	Improved Oil Recovery
IP	Institute Of Petroleum
IPCC	Intergovernmental Panel On Climate Change
IR	Handheld Infrared
ISO	International Organization For Standardization
JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee
KIS-ORCA	Kingfisher Information Service - Offshore Renewable & Cable Awareness
LAT	Lowest Astronomical Tide
LDAR	Leak Detection And Repair
LF	Low-Frequency
LLP	Low Low Pressure
LNG	Liquefied Natural Gas
LOHC	Liquid Organic Hydrogen Carrier
LP	Low Pressure
LQHC	Liquid Organic Hydrogen Carrier
LSE	Likely Significant Effects
LTOBM	Low Toxicity Oil-Based Mud
LV	Limit Value
LWD	Logging While Drilling
LWIV	Well Intervention Vessel
MAH	Major Accident Hazard
MARPOL	International Convention For The Prevention Of Pollution From Ships
MBES	Multibeam Echo Sounder
MCA	Maritime And Coastguard Agency
MCAA	Marine And Coastal Access Act
MDAC	Methane Derived Authigenic Carbonate
MEG	Mono-Ethylene Glycol
MEI	Major Environmental Incident
MEMW	Marine Environmental Modelling Workbench
MER	Maximising Economic Recovery
MF	Mid-Frequency
MMMU	Marine Mammal Management Units
MMO	Marine Mammal Observer
MNAW	Modified North Atlantic Water
MOD	Ministry Of Defence
MODU	Mobile Offshore Drilling Unit

MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
MSL	Mean Sea Level
MU	Management Unit
MUSD	Million United States Dollars
MVDC	Medium Voltage DC
MW	Megawatt
NAW	North Atlantic Water
NCMPA	Nature Conservation Marine Protected Area
NCS	Norwegian Continental Shelf
NDC	Nationally Determined Contribution
NDSW	Norwegian Deep Sea Water
NEC	No Effect Concentration
NLGP	Northern Leg Gas Pipeline
NM	Nautical Miles
NMFS	National Marine Fisheries Service
NMVOC	Non-Methane Volatile Organic Compounds
NOC	National Oceanography Centre
NORBRIT	Norwegian/British Oil Spill Response
NOX	Nitrogen Oxides
NPT	Non-Productive Time
NPV	Net Present Value
NSAIW	Norwegian Sea Arctic Intermediate Water
NSDW	Norwegian Sea Deep Water
NSTA	North Sea Transition Authority
NUI	Normally Unmanned Installation
NZTC	Net Zero Technology Centre
OBM	Oil Based Mud
OCNS	Offshore Chemical Notification Scheme
OCR	Offshore Chemicals Regulations (
OESEA	Offshore Energy Strategic Environmental Assessment
OEUK	Offshore Energy Uk
OGA	Oil and Gas Authority
OGI	Optical Gas Imaging
OGUK	Oil & Gas Uk United Kingdom
OHGP	Open Hole Gravel Pack
OIW	Oil-In-Water
OLF	Source
OPEP	Oil Pollution Emergency Plan
OPEX	Operating Expenses
OPPC	Oil Pollution Prevention And Control
OPRC	Oil Pollution, Preparedness, Response And Cooperation
OPRED	Offshore Petroleum Regulator For Environment And Decommissioning
ORION	Opportunity Renewables Integration Offshore Networks
OSCAR	Oil Spill Contingency And Response
OSCR	Offshore Installations (Offshore Safety Directive) (Safety Case) Regulations 2015
OSPAR	Convention For The Protection Of The Marine Environment Of The North-East Atlantic
PAH	Polycyclic Aromatic Hydrocarbons

PAM	Passive Acoustic Monitoring
PEC	Predicted Environmental Concentration
PEMS	Predictive Emission Monitoring System
PETS	Portal Environmental Tracking System
PLEM	Pipeline End Manifold
PLET	Pipeline End Termination
PLR	Pig Launcher Receiver
PMF	Priority Marine Features
PNEC	Predicted No-Effect Concentration
PON	Petroleum Operations Notice
PPC	Pollution Prevention And Control
PTS	Permanent Threshold Shift
PW	Pinnipeds In Water
PWRI	Produced Water Reinjection
QSR	Quality Status Report
RAM	Reliability Availability And Maintainability
REACH	Registration, Evaluation, Authorisation And Restriction Of Chemicals
RL	Received Level
RMS	Root Mean Square
ROV	Remotely Operated Vehicle
RSA	Radioactive Substances Act
SAC	Special Area Of Conservation
SACFOR	Superabundant, Abundant, Common, Frequent, Occasional And Rare
SAHFOS	Source
SAS	Stand-Alone Screens
SBES	Single-Beam Echosounder
SBP	Sub-botom Profiler
SCANS	Small Cetaceans In European Atlantic Waters And The North Sea
SCOS	Special Committee on Seals
SE	Stewardship Expectations
SEA	Strategic Environmental Assessment
SEEMP	Shipboard Energy Efficiency Management Plan
SEGAL	Shell-Esso Gas and Liquids
SEL	Sound Exposure Level
SERPENT	Scientific And Environmental ROV Partnership Using Existing Industrial Technology
SFF	Scottish Fishermen's Federation
SGP	Shetland Gas Plant
SIC	Shetland Islands Council
SIMOPS	Simultaneous Operations
SIRGE	Shetland Islands Regional Gas Export System
SMP	Sectoral Marine Plan
SMRU	Source
SMU	Source
SNCB	Statutory Nature Conservation Bodies
SNH	Scottish Natural Heritage
SOPEP	Shipboard Oil Pollution Emergency Plan
SOSI	Seabird Oil Sensitivity Index
SOX	Sulphur Oxides

SPA	Special Protection Area
SPE	Siccar Point Energy
SPL	Peak Sound Pressure Level
SRU	Sulphate Removal Unit
SSE	Scottish And Southern Electricity
SSEN	Scottish And Southern Electricity Networks
SSIV	Subsea Isolation Valve
SSS	Side Scan Sonar
SSSI	Sites Of Special Scientific Interest
SSSV	Subsurface Safety Valve
SURF	Subsea, Umbilical, Riser And Flowline
SVT	Sullom Voe Terminal
TCC	Thermomechanical Cuttings Cleaner
TEG	Tri Ethylene Glycol
THC	Total Hydrocarbon
TLP	Tension Leg Platform
TOC	Total Organic Carbon
TOOPEP	Temporary Operations
TTS	Temporary Threshold Shift
UK	United Kingdom
UKCS	UK Continental Shelf
UKHO	United Kingdom Hydrographic Office
UNESCO	United Nations Educational, Scientific And Cultural Organisation
UNFCCC	United Nations Framework Convention On Climate Change
URB	Umbilical Riser Base
UTM	Unresolved Complex Matrix
VAMS	Video Assisted Multi Sampler
VHF	Very High Frequency
VME	Vulnerable Marine Ecosystems
VMS	Vessel Monitoring System
VOC	Volatile Organic Compounds
VSP	Vertical Seismic Profiling
VTS	Vessel Traffic Survey
WAG	Water Alternating Gas
WBM	Water Based Mud
WFD	Water Framework Directive
WHRU	Waste Heat Recovery Units
WIP	Water Injection Pumps
WOSPS	West of Shetland Pipeline System
XOVER	Crossover