The Captain EOR Stage 2 Phase II Project

Environmental Statement

BEIS Reference No. ES/2022/007

August 2022

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<table>
<tr><td>Project Name</td><td colspan="2">Captain EOR Stage 2 Phase II Project.</td></tr>
<tr><td>Development Location</td><td colspan="2">Block 13/22a</td></tr>
<tr><td>Licence No</td><td colspan="2">P.324</td></tr>
<tr><td>OPRED Reference No</td><td colspan="2">ES/2022/007</td></tr>
<tr><td>Type of Project</td><td colspan="2">Enhanced Oil Recovery</td></tr>
<tr><td>Undertaker</td><td colspan="2">Ithaca Energy Limited, Hill of Rubislaw, Aberdeen, AB15 6XL.</td></tr>
<tr><td>Licensees/Owners</td><td colspan="2"><table><tr><th>Co-venturers</th><th>% Holding</th></tr><tr><td>Ithaca Energy</td><td>85</td></tr><tr><td>Dana Petroleum (E&P)</td><td>15</td></tr></table></td></tr>
<tr><td>Short Description</td><td colspan="2">Ithaca Energy are progressing the Captain field Enhanced Oil Recovery (EOR) strategy which was detailed in the original Field Development Plan. The Project involves the injection of a polymer into the reservoir to enhance recover of hydrocarbons. The EOR project has been split over a number of stages (including an initial pilot study and two further stages: Stage 1 and Stage 2). Stage 2 has been further split into two phases and this Environmental Statement covers the second of these phases. As part of the proposed Captain EOR Stage 2 Phase II Project, six new subsea polymer injection wells will be drilled across two new drill centres. Polymer injection flowlines and control umbilicals will be installed (jet trenched and buried) between the existing Captain Bridge Linked Platform (BLP) and the new wells. An additional production well will also be drilled. The proposed Captain EOR Stage 2 Phase II Project can be summarised as follows:
Drilling of six new polymer injection wells across two new drill centres;
Drilling of one new production well at an existing drill centre;
The installation and commissioning of the required subsea infrastructure;
Ongoing modifications to the three Captain installations; and
Increased production rates.</td></tr>
<tr><td>Key Dates</td><td colspan="2"><table><tr><th>Activities</th><th>Date</th></tr><tr><td>Drilling of wells</td><td>Q1 2023 – Q2 2024</td></tr><tr><td>Subsea installation</td><td>Q2-Q3 2023</td></tr><tr><td>First injection</td><td>Q1 2024</td></tr><tr><td>First production from new well</td><td>Q2 2024</td></tr></table></td></tr>
<tr><td>Significant Environmental Effects Identified</td><td colspan="2">The Environmental Statement (ES) assesses the worst-case impact of the project on the environment and is therefore very conservative. Even then applying the mitigation measures identified it is the conclusion of this ES that the current proposal for the proposed Captain EOR Stage 2 Phase II Project can be completed without causing any significant long term environmental impacts or cumulative or transboundary effects.</td></tr>
<tr><td>Statement Prepared by</td><td colspan="2">Ithaca Energy Limited and Genesis Energies</td></tr>
<tr><td>Company</td><td>Job Title</td><td>Relevant Qualifications/Experience</td></tr>
<tr><td>Ithaca Energy</td><td>[redacted]</td><td>[redacted]</td></tr>
<tr><td rowspan="2">Genesis Energies Ltd.</td><td>[redacted]</td><td>[redacted]</td></tr>
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NON-TECHNICAL SUMMARY

Background

The Captain field lies in UKCS Block 13/22a (Licence No. P.324) *c*. 145 km northeast of Aberdeen, in the Outer Moray Firth (Figure 1). The field is operated by Ithaca Energy (UK) Limited (Ithaca Energy) who has 85% interest equity, whilst Dana Petroleum (E&P) Limited holds a 15% non-operated working interest in the field.

Since early field life, production at the Captain field has been supported with water injection, whilst the original Field Development Plan (FDP) referenced an Enhanced Oil Recovery (EOR) strategy using the injection of polymers. After initial trials at the Captain field a staged EOR development approach was adopted in 2016. This Environmental Statement Report (ES) supports a number of the activities to be carried out as part of the second stage the EOR strategy, which is currently being progressed by Ithaca Energy.

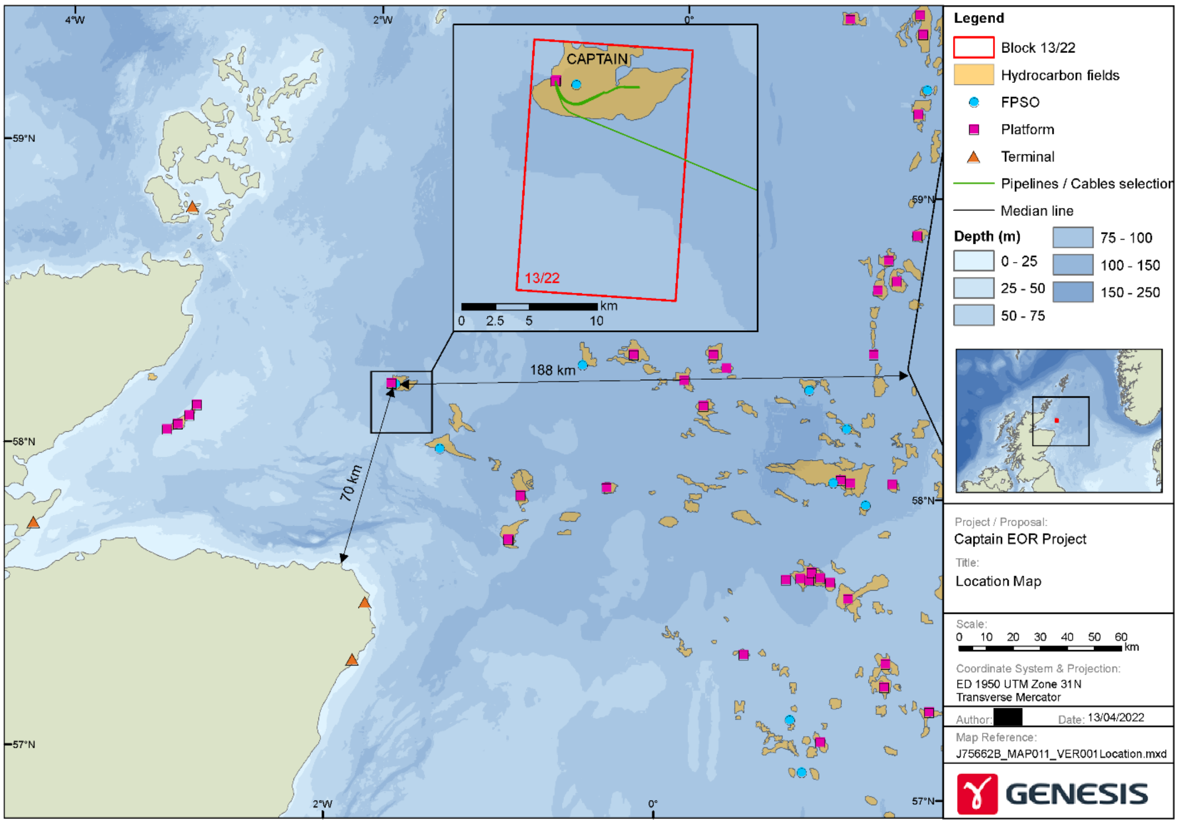


Figure 1: Location of Captain Field.

Overview of the Captain Field

The Captain field was discovered in 1977 and has been producing since 1997. The field was initially developed with a Wellhead Protection Platform (WPP) and the Captain Floating Production Storage and Offloading (FPSO) vessel. The WPP supports a self-contained drilling rig, personnel accommodation, helideck and all utility, ancillary and emergency systems.

In 2001 the second stage of the Captain Field Development was completed. This included the installation of a Bridge Linked Platform (BLP) bridge linked to the WPP. It is also connected to an 18-slot Unitised Template Manifold (UTM) at a subsea drill centre referred to as Area B. The Area B UTM is linked to the BLP by two production flowlines, injection and test flowlines and various communications and chemical umbilicals.

The third stage of the Captain Field Development was completed in 2006 and comprised the development of an additional drill centre referred to as Area C. Area C is tied back to the Area B UTM by means of one production flowline and several other lines for control and well fluids. Area A, Area B and Area C fluids flow to the BLP for processing then onto the FPSO via the WPP for further processing and storage.

Captain crude oil is offloaded from the FPSO vessel to a dynamically positioned shuttle tanker and transported to onward sales point. Captain gas is exported and imported via a subsea pipeline connecting to the Frigg U.K. gas transportation system and then on to the St Fergus gas terminal.

Figure 2 shows the layout of the Captain Field Development.

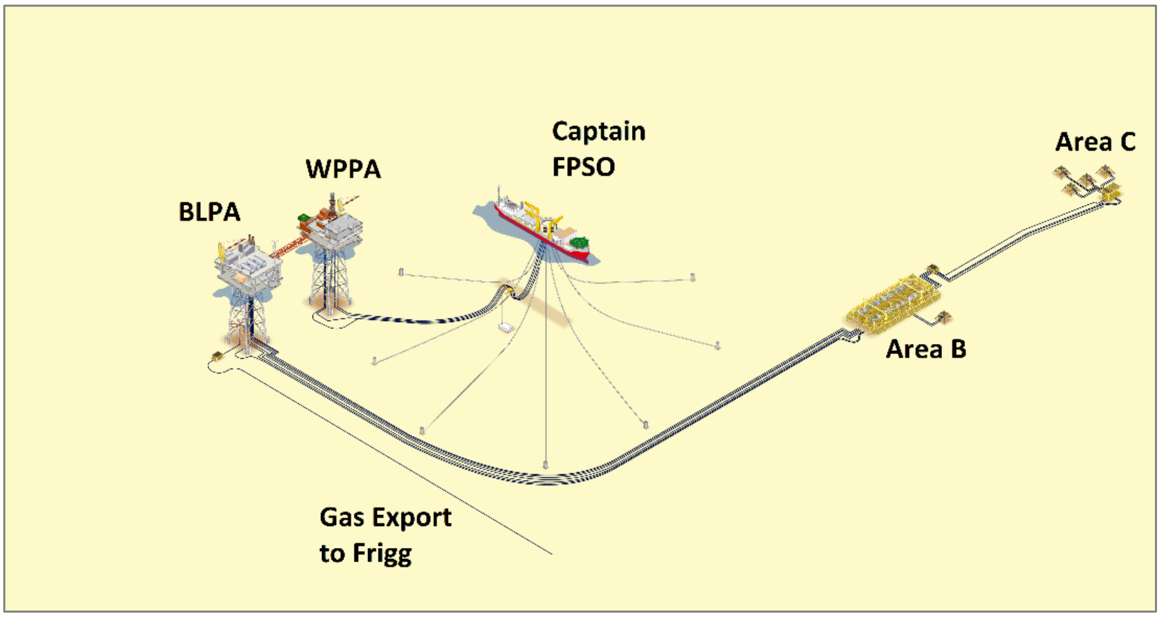


Figure 2: Indicative layout of the Captain Field Development.

Overview of the Captain Field Enhanced Oil Recovery Project

Since early field life, produced water has been injected at Captain to maintain reservoir pressure and provide reservoir sweep. Polymer solution injection was proposed in the original Captain FDP and the concept was included as part of the original facilities design to enable a field trial to take place. As part of a pilot EOR project, pilot polymer mixing and injection facilities were installed on the Captain FPSO and the WPP.

Following the pilot study, the Captain EOR Project was split into two further stages: Stage 1 and Stage 2. The second stage of the Captain EOR Project (the Captain EOR Stage 2 Project) includes some brownfield modifications across the three Captain installations (WPP/BLP/FPSO), as well as a significant expansion in the subsea area. The Captain EOR Stage 2 Project can be considered to be split into two phases (Phase I and Phase II) based on the schedule of activities and requirements under the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 (hereafter referred to as the 2020 Offshore EIA Regulations).

The ES details the activities associated with Stage 1 and with Stage 2 Phase I, whilst this summary focuses on the activities covered by the ES i.e. Captain EOR Stage 2 Phase II Project which includes:

- Drilling of six new polymer injection wells across two new drill centres (Area D and Area E);
- Drilling of one new production well at Area B (an existing drill centre);
- The installation and commissioning of the required subsea infrastructure;
- Ongoing modifications to the three Captain topsides; and
- Increased production rates.

Figure 3 summarises the drilling and installation activities associated with the Captain EOR Stage 2 Phase II Project.

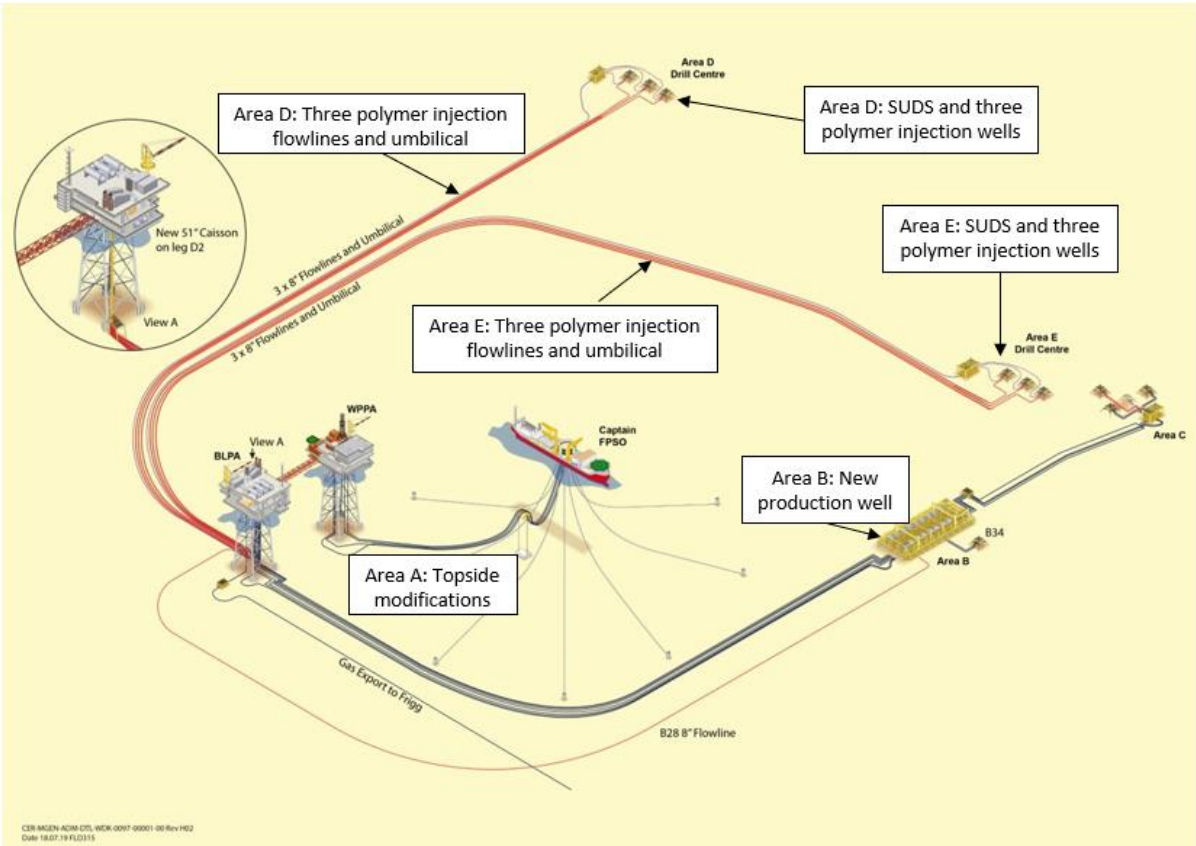


Figure 3: Representative schematic of the proposed Captain EOR Stage 2 Phase II Project activities.

Environmental Statement Scope

The scope of the Environmental Impact Assessment (EIA) and resultant (ES) includes the following activities:

- Drilling of the six polymer injection wells across two new drill centres (Area D and Area E)
- Drilling of one new production well at Area B (an existing drill centre);
- The installation and commissioning of the required subsea infrastructure;
- Modifications to the topsides of the BLP and the WPP platforms and the Captain FPSO and;
- Additional production (relative to operation without the Captain EOR Stage 2 Phase II project); and
- Decommissioning.

This document provides details of the EIA that has been undertaken to support Ithaca Energy and their Co-Venturer's application for consent to undertake the proposed project. This process includes a public consultation followed by a comprehensive review by various bodies including the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED).

In line with the 2020 Offshore EIA Regulations, the EIA sets out to describe and evaluate the impacts of any emissions to air, discharges to sea, seabed disturbance, underwater noise, waste production and resource use resulting from the proposed development on a range of receptors including flora, fauna, water, air, climate, and material assets. In addition, the potential interactions with other users of the sea are considered. These aspects are considered for planned activities and unplanned (i.e. accidental) events.

Option Selection

The ES details the options considered for the following facets of the Captain EOR Stage 2 Phase II Project:

- Use polymer injection or continue with produced water/water injection;
- Type of polymer;
- Number and location of the polymer injection wells;
- Type of well;
- Number of flowlines and method of installation;
- Use of piled or gravity based Subsea Umbilical Distribution Structures (SUDS) at each drill centre.

In the absence of the new polymer injection wells there will be a reduction in the recovery factor from the field, whilst the type of polymer being used has been chosen based on its ability to provide high solution viscosity, while maintaining good injectivity in the injection wells.

Determining the optimal injection well number and spacing is a function of: (1) the polymer viscosity required to meet the optimal displacement ratio; (2) the reservoir thickness and properties; (3) oil saturation at that location; and (4) the desired phasing of oil production. Taking these factors into account, it was determined that six polymer injection wells across two drill centres is the optimal approach.

As jet trenching and burying of lines has been successful across the Captain field, this approach has been selected for the installation of the flowlines and umbilicals. Based on previous reports of fishing gear interacting with subsea infrastructure within existing 500 m exclusion zones at the field it was determine that the SUDS should be piled to minimise impact of any future interactions that may occur.

Captain Stage 2 Phase II Development Project

The infrastructure to be installed as part of the proposed Captain EOR Stage 2 Phase II Project is summarised in Table 1.

Table 1: Subsea infrastructure associated with the proposed Captain EOR Stage 2 Phase II Project.

Item No.	Description
1	Seven Xmas trees: one each for the polymer injection wells and one for the new production well which will be located within the existing UTM at Area B.
2	Two piled SUDS, one at Area D and one at Area E, plus one gravity based SUDS at the BLP riser base location.
3	Three 6.6" (internal diameter) polymer injection flowlines from the BLP to Area D: *c*. 4,728 m in length with an external diameter of 228 mm.
4	A 4,709 m EH umbilical (110 mm outer diameter) from the BLP to Area D.
5	Three 6.6" (internal diameter) polymer injection flowlines from the BLP to Area E: *c*. 5,718 m in length with an external diameter of 228 mm.
6	A 5,757 m EH umbilical (110 mm outer diameter) from the BLP to Area E.
7	A 326 m EH riser umbilical (203 mm outer umbilical) from BLP topsides to the Riser base SUDS structure.
8	Three EH umbilical jumpers at Area D laid between the SUDS and the three wells: each one measuring 80 m.
9	Three EH umbilical jumpers at Area E laid between the SUDS and the three wells: each one measuring 80 m.

Schedule of Activities

The activities associated with the drilling, installation and commissioning of the Captain Field are scheduled to take place in 2023 and 2024 as shown in Table 2.

Table 2: Indicative schedule for the proposed Captain EOR Stage 2 Phase II activities.

Activity	2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Drilling of the polymer injection wells at Area D, and Area E and the production well at Area B	■	■	■	■	■	■		
Installation of subsea infrastructure		■	■					
First injection at Area D					■			
First injection at Area E					■			
First oil from new production well at Area B						■		

Baseline Environment

The Captain Field is situated in Block 13/22 c. 145 km north-east of Aberdeen and c. 188 km from the UK/Norway median line. The Field is situated in a water depth of approximately 105 m.

A number of environmental surveys have been commissioned at the Captain field, with sampling locations illustrated in Figure 4. The data from these surveys has been used to inform the impact assessment. The information available from these surveys was deemed sufficient to inform the impact assessment carried out in support of this ES.

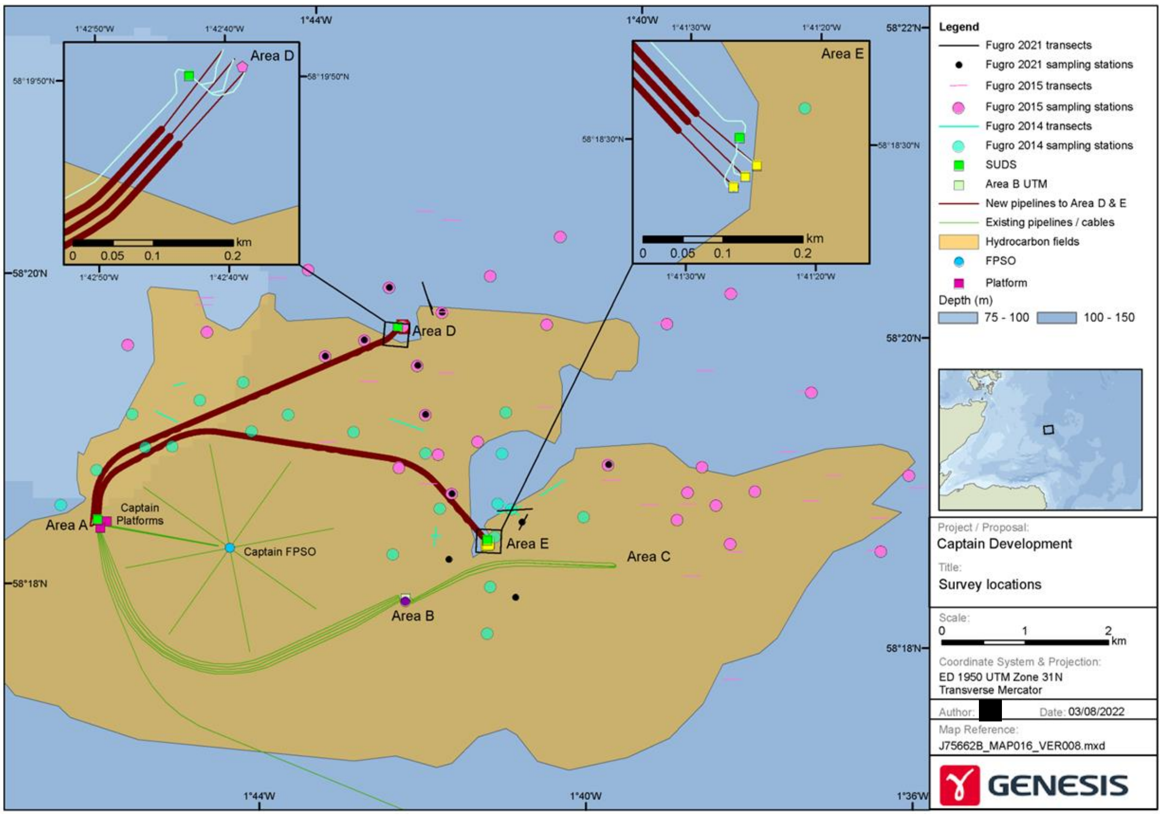


Figure 4: Extent of environment surveys used to support this ES.

The main sediment type over the survey area as sandy mud/muddy sand, which is classified as the EUNIS biotope complex 'Deep circalittoral mud' (A5.37). Small, localised areas of high reflectivity were also observed and interpreted to comprise sandy mud with pebbles, cobbles, and boulders and to be representative of 'Deep circalittoral mixed sediments'. The 'Deep circalittoral mud' observed across the Captain field is considered to be representative of the Priority Marine Feature (PMF) broad habitat 'Burrowed mud' and 'Offshore deep-sea muds' and the priority habitat 'Mud habitats in deep water'. It is recognised that these habitats are widely distributed within the North Sea. The area is also considered representative of the OSPAR listed threatened and/or declining habitat 'sea pen and burrowing megafauna communities' habitat. The Annex II species, *Arctica islandica* was also found to occur in the area.

Spawning and nursery grounds for fish species including anglerfish, blue whiting, cod, European hake, haddock, herring, lemon sole, ling, mackerel, *Nephrops*, Norway pout, sandeel, spotted ray, sprat, spurdog and whiting have been identified in the area.

A number of seabirds are known to occur in the area including northern gannet, great skua, razorbill, northern fulmar, black legged kittiwake, guillemot etc. Based on the Seabird Oil Sensitivity Index (SOSI) the sensitivity of seabirds to surface oil pollution is generally medium throughout the year within Block 13/22a, but it is recorded as either High or Very High in December, February and March.

The most abundant cetacean species in the Captain Field area is the Atlantic white-beaked dolphin. Other species known to occur there include the harbour porpoise, killer whale and the minke whale.

For management purposes the International Council for the Exploration of the Sea (ICES) collates fisheries information for area units termed ICES rectangles. The importance of an area to the fishing industry is assessed by measuring the fishing effort within each ICES rectangle. The proposed project area is located within ICES rectangle 45E8. UK commercial fishing effort within this rectangle varies throughout the year and is considered to be moderate with an average fishing effort of 779 days in 2020 which constitutes 0.7% of the overall UK fishing effort in days.

Shipping in the area is considered low and there are no military exercise areas in the vicinity of the field.

Environmental Impact Assessment

In order to determine the impact that the proposed Captain EOR Stage 2 Phase II Project may have on the environment an ENVironmental and socio-economic impact IDentification (ENVID) was undertaken following a structured methodology. The purpose of the ENVID was to identify the significance of the environmental and socio-economic risks associated with the planned activities and any possible unplanned events and to identify appropriate mitigation measures, controls and safeguards to minimise this risk.

For each of the planned activities an environmental and/or socio-economic impact significance is assigned for the relevant aspects (e.g. emissions to air, discharges to sea, underwater noise etc.) by taking into account the sensitivity of the receptors and the magnitude of the effect.

For unplanned events the environmental and/or socio-economic significance of risk ranking also takes into account the likelihood of the event occurring. A summary of the key findings of the ENVID and supporting impact assessment is presented here.

Physical Presence

The physical presence of the project vessels, the drilling rig and the subsea infrastructure has the potential to be a navigational hazard, to restrict fishing operations in the area and / or to cause disturbance to wildlife. However, taking account of the mitigation measures outlined in Table 3, which includes early consultation with the Scottish Fisheries Federation (SFF), and notification to other users of the sea regarding the project's activities, the socio-economic impact significance is considered low and is therefore acceptable when managed within the mitigation measures described.

Emissions to Air

Gaseous emissions can contribute to global atmospheric concentrations of greenhouse gases, regional acid loads and ozone depletion. The main greenhouse gases are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) all of which will be produced during the drilling, installation, commissioning and operational phases of the proposed Captain EOR Stage 2 Phase II Project.

It is anticipated that, as a worst-case scenario, the average annual CO_2 emissions associated with the drilling rig and the drilling and installation vessels represents *c*. 0.4 % of the annual total UK shipping emissions (UK figures for 2019).

In the context of UKCS oil and gas production, the Captain field with the proposed project offers relatively low GHG emission per barrel of oil equivalent. In addition, the proposed project lowers the forecasted GHG intensities at the Captain field relative to the estimated intensities in the absence of the proposed project.

A range of mitigation measures to minimise emissions to air is proposed, as outlined in Table 3. These include optimisation of vessel use, vessel assurance and compliance with UK legislation. When compared against other emission sources on the UKCS and taking the mitigation measures into consideration, the overall risk from emissions to air resulting from the proposed project is considered low and is therefore acceptable when managed within the mitigation measures described.

Discharges to Sea

There will be a number of planned discharges to sea associated with the proposed project. Planned and permitted discharges to sea during drilling include mud and entrained drill cuttings and seawater with bentonite sweeps, cement and associated chemicals.

Planned and permitted discharges to sea during the installation and commissioning phase are primarily associated with testing the pipelines and infrastructure. All associated chemicals will be risk assessed and permitted in accordance with the Offshore Chemicals Regulations 2002 (as amended).

The BLP platform operates 100% Produced Water (PW) reinjection such that there will be no PW discharges to sea. Following implementation of the proposed project, the field will continue to inject all produced water.

The significance of the environmental impacts of all planned discharges associated with the proposed Captain Field Development are considered to be low and are therefore considered acceptable when managed within the additional controls and mitigation measures identified.

Seabed Disturbance

A number of activities will be carried out which have the potential to impact on the seabed and its associated benthic communities. These include the laydown of the anchor system for the drilling rig, the discharge of drill cuttings from the upper sections of the wells, the discharge of cement from the top hole sections and the impacts associated with the subsea installation activities. Seabed impacts have been divided into permanent impacts and temporary impacts. The former are associated with the long term installation of new infrastructure and its associated stabilisation features e.g. the SUDS, flowlines, umbilicals and stabilisation material. Although some of these features will be removed upon final decommissioning, for the purposes of this EIA they have been classed as permanent. Temporary impacts include those associated with the drill rig anchor system, which will be recovered once the drilling campaign has been completed and the resettlement of suspended solids.

The significance of the environmental impacts on the is considered to be low and are therefore considered acceptable when managed within the controls and mitigation measures identified.

Underwater Noise

The main sources of underwater sound associated with the proposed Captain Field Development will result from the piling of the SUDS, vessel use and drilling operations.

Many marine organisms use sound for navigation, communication and prey detection. Therefore, the introduction of man-made sources of underwater noise has the potential to impact marine animals if it interferes with their ability to receive and use sound. Types of impact include temporary avoidance or behavioural changes, the masking of biological sounds as well as auditory and other injuries.

Although the sound from the proposed project does have the potential to cause disturbance to marine animals it is not expected to have a significant impact on any cetacean or fish species. Taking this into account and considering the mitigation measures outlined in Table 3, the significance of the environmental impact of the underwater sound associated with the vessels and the piling is considered low and is therefore acceptable when managed within the mitigation measures described.

Waste

Ithaca Energy is committed to applying the waste management hierarchy and managing all produced waste using approved methods. Waste will only be disposed of if it cannot be prevented, reclaimed or recovered. Waste produced will be correctly documented, transported, processed and disposed of in accordance with applicable legislation. The overall impact significance of waste generation is therefore considered to be low and is therefore acceptable when managed within the mitigation measures described.

Unplanned Hydrocarbon Releases

Modelling of a worst-case unplanned hydrocarbon release was carried out using the Oil Spill Contingency and Response (OSCAR) model. There is a potential risk to several environmental receptors from such releases, including internationally protected areas, the magnitude of which is dependent on the size of the release. Worst-case releases are rare in the industry and the likelihood of an unplanned hydrocarbon release reaching its full effect potential is such that the overall risk is reduced to as low as reasonably practicable. However, should an uncontrolled release occur there will be robust measures in place to ensure a co-ordinated and co-operative response.

Overall Conclusion

The proposed Captain EOR Stage 2 Phase II Project will be developed using proven technology incorporating the current best practices. A robust design, strong operating practices and a highly trained workforce will ensure the proposed project does not result in any significant long-term environmental, cumulative or transboundary effects. Additional measures will be in place during operations to effectively respond to unplanned events.

Table 3: Captain EOR Stage 2 Phase II Project commitments.

Aspect	Commitments
Physical presence	• Drilling rig routes will be selected in consultation with other users of the sea, with the aim of minimising interference to other vessels and the risk of collision; • Vessel use will be optimised by minimising the number of vessels required and length of time vessels are on site; • A post installation survey will be carried out following jetting of the flowlines and umbilicals to ensure the lines are over trawlable and to ensure there are no clay berms; • Consultation with the Scottish Fishermen's Federation (SFF) for all phases and operations; • Notice to Mariners will be circulated prior to rig mobilisation; • As required by HSE Operations Notice 6 (HSE, 2014), a rig warning communication will be issued at least 48 hours before any rig movement. Notice will be sent to the Northern Lighthouse Board (NLB) of any drilling rig moves and vessel mobilisation associated with the mobilisation and demobilisation of the drilling rig; • A Vessel Traffic Survey will inform a Consent to Locate application for the drilling rig; • A Collision Risk Management Plan will be produced, if required; • All vessels engaged in the project operations will have markings and lightings as per the International Regulations for the Prevention of Collisions at Sea (COLREGS) (IMO, 1972); • The drilling rig will be equipped with navigational aids and aviation obstruction lights system, as per the Standard Marking Schedule for Offshore Installations for example fog lights, aviation obstruction lights, helideck lighting and radar beacons; • The drilling rig will have a statutory 500 m safety zone to mitigate any collision risk; • An ERRV will patrol the area; • All subsea infrastructure out with the 500 m zones will be over-trawlable; • The use of pipeline stabilisation features (e.g. mattresses and rock cover) will be minimised through project design and will be installed in accordance with industry best practice and SFF recommendations.

Aspect	Commitments
Emissions to air	• The drilling rig and other project vessels will be subject to audits ensuring compliance with UK legislation and the Ithaca Marine Operations and Vessel Assurance Standard; • Vessel use will be optimised where possible by minimising the number of vessels required, and their length of time on site; • Vessels will be operated where possible in modes that allow for economical fuel use; and • Minimise flaring during well clean-up operations by sending fluids to BLP for processing as the base case and preferred option. • In accordance with the revised NSTA strategy, and associated Stewardship Expectation 11, as well as with the industry commitments within the NSTD, Ithaca Marine Operations and Vessel Assurance Standard will incorporate the impact of the Captain field production within developing controls including: • Asset GHG Emission Reduction Action Plans; • Flaring and venting reviews to identify/action zero routine flaring by 2030; • Active flare reduction strategy; • Active vent reduction strategy; • Emission key performance indicators and targets; and • Industry level benchmarking of flaring and venting. • These will ensure that opportunities for efficiency and reduction of atmospheric emissions, where not in conflict with safe operations, are identified, actioned as appropriate and reviewed.
Discharges to sea	• The drilling rig has been audited under Ithaca Energy's marine assurance standards and subject to rig recertification audits; • All vessels used will be MARPOL compliant; • Where technically feasible Ithaca Energy will prioritise the selection of chemicals which are PLONOR (Pose Little Or No Risk), or have the lowest RQ; and • The discharges of any water based hydraulic fluids, sand or chemicals are regulated by the OPPC and/or OCR regulations and reported through the EEMS. As such, Ithaca Energy will ensure that sampling, analysis and reporting are undertaken in line with the regulations and permit conditions.
Seabed disturbance	• Pre-deployment surveys will be undertaken to identify suitable locations for the drilling rig anchors; • Wells at Area D and Area E will be drilled in close proximity such that the anchors will only require to be laid once at each drill centre and the drilling rig can be skidded between wells; • Production well at Area B will use top hole sections from a suspended well; • Jet trenching rather than ploughing of flowlines and umbilicals; and • The use of mattresses, rockdump and grout bags will be minimised through optimal project design.
Underwater noise	• A qualified, trained and equipped marine mammal observer (MMO) will be present. The MMO will carry out a pre-piling survey of a 500 m mitigation zone and, if an animal is

Aspect	Commitments
	detected, the piling will be delayed until all marine mammals vacate the 500 m mitigation zone; • A soft-start/ramp-up of hammer energy will be employed where the hammer will commence at a low energy at the start of piling. The soft start will be such that maximum hammer energy will not be reached until after a period of 20 minutes; • Passive Acoustic Monitoring (PAM) will be employed during periods of low visibility to detect marine mammal presence; and • Avoiding commencing piling at night or in poor visibility when marine mammals cannot reliably be detected. If this cannot be avoided, then Passive Acoustic Monitoring (PAM) will be used
Waste	• Ithaca Energy will apply the principles of the Waste Management Hierarchy during all activities i.e. Reduce, Reuse, Recycle; • Existing asset and vessel WMPs will be followed; • Only permitted disposal yards/landfill sites will be used.
Accidental events	• Activities will be carried out by trained and competent offshore crews and supervisory teams; • An approved OPEP will be in place prior to any activities being undertaken; • Records will be kept of oil spill training and exercises as required by the OPEP; • Process Safety Assurance Processes will be identified and adhered to; • A co-ordinated industry oil spill response capability will be available; • Enhanced sharing of industry best practices via the Oil Spill Response Forum (OSRF) will continue for Company personnel; • A robust BOP pressure and functional testing regime will be in place; and • Appropriate mud weights will be used to ensure well control is maintained. • In case of an emergency, arrangements will be in place with a well capping provider to provide specialist advice and support; and • Oil spill control measures will be followed as outlined in the OPEP.

ACRONYMS

>	More Than
%	Percentage
% wt	Percentage Weight
‰	Per thousand
(H)	Height
(L)	Length
(W)	Width
‘	Minutes
"	Seconds/Inches
<	Less Than
≥	More than or equal to
°	Degrees
°C	Degrees Celsius
°F	Degrees Fahrenheit
µg/g	Micrograms per Gram
µg/l	Micrograms per Litre
µm	Micrometres
µPa	Micropascal
AEL	Associated Emission Level
AHV	Anchor Handling Vessel
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
ANP	National Agency of Petroleum, Natural Gas and Biofuels
API	American Petroleum Institute
AQS	Air Quality Standards
Ba	Barium
BAC	Background assessment concentration
BAP	Biodiversity Action Plan
BAT	Best Available Techniques
BAT	Best Available Technology
bbls	Barrels of Oil
BEIS	(the Department of) Business, Energy and Industrial Strategy
BLP	Bridge Linked Platform
BOP	Blowout Preventer
BPEOC	BP Exploration Operating Company
CA	Comparative Assessment
CCS	Carbon Capture and Storage

CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CH_4	Methane
CHARM	Chemical Hazard Assessment and Risk Management
cm	Centimetre
CMAPP	The Corporate Major Accident Prevention Policy
CMID	Common Marine Inspection Documents
CNS	Central North Sea
CNSE	Central North Sea Electrification
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalents
CO_2e/mboe	Carbon Dioxide Equivalents per…
COLREGS	Collision Regulations
CoP	Cessation of Production
COSHH	Control of Substances Hazardous to Health
COT	Cargo Oil Tank
cP	centiPoise
CSIP	Cetacean Stranding Investigation Programme
CSV	Construction Support Vessel
CtL	Consent to Locate
CIP	Communication & Interface Plan
D	Disclosive
dB	Decibels
dB re 1 µPa	Decibels relative to 1 mico Pascal
dB re 1 $\mu Pa^2 s$	Decibels relative to 1 squared mico Pascal second
DECC	Department of Energy and Climate Change
DEFRA	Department for Environment Food and Rural Affairs
DepCon	Deposit Consent
DHSV	Down Hole Safety Valve
DP	Dynamic Positioning
DREAM	Dose-related Risk and Effect Assessment Model
DSV	Dive Support Vessel
DTI	Department of Trade and Industry
DUKES	Digest of UK Energy Statistics
EC	European Commission
ED	European Datum
EEMS	Environmental Emissions Monitoring System
EH	Electro-Hydralic

EIA	Environmental Impact Assessment
ELV	Emission Limit Value
EMODnet	European Marine Observation and Data Network
EMS	Environmental Management System
ENVID	Environmental and socio-economic Impact Identification
EOR	Enhanced Oil Recovery
EPS	European Protected Species
ERAP	Emissions Reductions Action Plans
ERL	Effects Range Low
ERRV	Emergency Response and Rescue Vessel
ES	Environmental Statement
ES	Environmental Stewardship
ESAS	European Seabirds at Sea
ESIA	Environmental and Socio-Economic Impact Assessment
ESRA	Environmental and Socio-Economic Risk Assessment
ETAP	Eastern Trough Area Project
ETS	Emissions Trading Scheme
EU	European Union
EU ETS	European Union Emissions Trading Scheme
EUNIS	European Nature Information System
EUR	Estimated Ultimate Recovery
FARAM	Faunal Acoustic Risk Assessment Model
FeAST	Feature Activity Sensitivity Tool
FEPA	Food and Environmental Protection Act
FDP	Field Development Plan
FPSO	Floating Production Storage and Offloading
ft	Feet
g/kg	Grams per Kilogram
g/m^2	Grams per Metre Squared
GEBCO	General Bathymetric Chart of the Oceans
GEN	National Marine Plan General Policies
GHG	Greenhouse Gases
GTG	Gas Turbine Generator
GWP	Global Warming Potential
HAB	Harmful Algal Blooms
HES	Health, Environment and Safety
HC	Hydrocarbon
HF	High Frequency

HP	High Pressure
HPAM	Hydrolysed polyacrylamide
HQ	Hazard Quotient
HSE	Health Safety and Environment
HSE	Health and Safety Executive
HVO	Hydrotreated Vegetable Oil
Hz	Hertz
IAMMWG	Inter-Agency Marine Mammal Working Group
ICES	International Council for the Exploration of the Sea
ICUN	
IMO	International Maritime Organisation
INTOG	Innovation and Targeted Oil and Gas
IOGP	International Association of Oil & Gas Producers
IPCC	Intergovernmental Panel on Climate Change
IPIECA	International Petroleum Industry Environmental Conservation Association
IPPC	Integrated Pollution Prevention and Control
ISO	International Standards Organisation
ITOPF	International Tanker Owners Pollution Federation
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
JV	Joint Venture
kg	Kilogram
Kg/bbl	Kilogram per barrel of oil
kg/m^2	Kilogram per Metre Squared
kg/m^3	Kilogram per Metre Cubed
kHz	Kilohertz
kJ	Kilo Joules
km	Kilometre
km^2	Squared Kilometres
KPI	Key Performance Indicator
kt	Kilotonnes
KW	Kilowatts
KW/m	Kilowatts per metre
LAT	Lowest Astronomical Tide
LCP	Large Combustion Plant
LCS	Lower Captain Sandstone
LF	Low Frequency
LP	Low Pressure

LSA	Low Specific Activity
LTOBM	Lox Toxicity Oil Based Mud
m	Metre
m/s	Metres per Second
m^2	Square Metres
m^3	Cubic Metres
MAH	Major Accidents and Hazards
MARPOL	Maritime Pollution
MAT	Master Application Template
MCAA	Marine and Coastal Access Act
MCZ	Marine Conservation Zone
MEI	Major Environmental Incident
MER	Maximise Economic Recovery
MF	Mid Frequency
mg/kg	Milligrams per Kilogram
mg/l	Milligrams per Litre
MGO	
mm	Millimetre
mm^3/day	Cubic millimetres per day
MMBBL	Million Barrels of Oil
mmboe	Million Barrels of Oil Equivalent
MMO	Marine Mammal Observer
MMO	Marine Management Organisation
MoD	Ministry of Defence
MODU	Mobile Offshore Drilling Unit
MOL	Main Oil Line
MPA	Marine Protected Area
ms	Milliseconds
MSS	Marine Scotland Science
MTe	Million Tonnes
mTVDss	Metres True Vertical Depth Subsea
MU	Management Unit
MW(th)	Mega Watt (thermal)
N	North
N/A	Not Applicable
NAOI	North Atlantic Oscillation Index
N_2O	Nitrous Oxide
NCMPA	Nature Conservation Marine Protected Area

NLB	Northern Lighthouse Board
nm	Nautical Miles
NMFS	National Marne Fisheries Service
NMP	National Marine Plan
NMPi	National Marine Plan Interactive
NNS	Northern North Sea
N_2O	Nitrous Oxide
NOAA	National Oceanic and Atmospheric Administration
NORM	Naturally Occurring Radioactive Material
NOx	Nitrogen Oxides
NSS	North Sea Standard
NSTA	North Sea Transition Authority
NSTD	North Sea Transition Deal
NTG	Net-to-Gross
OCR	Offshore Chemicals Regulations
OEUK	Offshore Energies UK
OGA	Oil and Gas Authority
OGOC	Original Gas Oil Contact
OGUK	Offshore Energies UK (formerly Oil & Gas UK)
OMFE	Outer Moray Firth Electrification
OMS	Operating Management System
OOWC	Original Oil Water Contact
OPEP	Oil Pollution Emergency Plan
OPOL	Offshore Pollution Liability Association Ltd
OPPC	Oil Pollution Prevention and Control
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSCAR	Oil Spill Contingency and Response
OSPAR	Oslo/Paris Convention
OSRF	Oil Spill Response Forum
OSRL	Oil Spill Response Limited
PAH	Polycyclic Aromatic Hydrocarbons
PAM	Passive Acoustic Monitoring
Pb	Bubble Point Pressure
PCB	Polychlorinated Biphenyl
PETS	Portal Environmental Tracking System
PEXA	Practice and Exercise Area
PiP	Pipe in Pipe
PLONOR	Posing Little or No Risk

PMF	Priority Marine Features
PPC	Pollution Prevention and Control
PSD	Particle size distribution
psia	Pounds per square inch absolute
PTS	Permanent Threshold Shift
PW	Produced Water
PWA	Pipeline Works Authorisation
PWRI	Produced Water Re-injection
Q1, Q2, Q3, Q4	First quarter of the year, second quarter of the year etc.
RAM	Range-dependent Acoustic Model
RBA	Risk Based Approach
RHC	Rapid Hardening Cement
rms	Root Mean Squared
ROV	Remotely Operated Vehicle
RQ	Risk Quotient
Rs	Solution Gas-Oil Ratio
RSD	Relative Standard Deviation
SAC	Special Areas of Conservation: cSAC, candidate; pSAC, possible; dSAC, draft
SACFOR	Super-abundant, Abundant, Common, Frequent, Occasional and Rare
SAT	Subsidiary Application Template
SCANS	Small Cetacean Abundance in the North Sea
SCF	Standard Cubic Feet
SCR	Safety Case Regulations
SDS	Safety Data Sheet
SE	Stewardship Expectations
SEL	Sound Exposure Level
SFF	Scottish Fisheries Federation
SIMOPS	Simultaneous Operations
SINTEF	Stiftelsen for industriell og teknisk forskning
SMRU	Sea Mammal Research Unit
SNH	Scottish Natural Heritage (now NatureScot)
SO_2	Sulphur Dioxide
SOPEP	Shipboard Oil Pollution Emergency Plan
SOSI	Seabird Oil Sensitivity Index
SOx	Sulphur Oxides
SPA	Special Protection Area
SPL	Sound Pressure Level
SSS	Side Scan Sonar

stb	Stock tank barrel
SUCS	Southern Upper Captain Sandstone
SUDS	Subsea Umbilical Distribution Structure
SUDS	Seaside Umbilical Distribution Structures
te	Tonne
te/m^3	Tonnes per Metre Cubed
te/day(d)	Tonnes per day
Te/hr	Tonnes per hour
Te/yr	Tonnes per year
TeOE	Tonnes of Oil Equivalent
THC	Total Hydrocarbon Concentration
TOC	Total Organic Carbon
TOM	Total Organic Matter
TOOPEP	Temporary Operation Oil Pollution Emergency Plan
TVDss	True Vertical Depth subsea
UHB	Upheaval Buckling
UCS	Upper Captain Sandstone
UK	United Kingdom
UKBAP	UK Post-2010 Biodiversity Framework
UKCCC	UK Committee for Climate Change
UKCS	United Kingdom Continental Shelf
UKETS	United Kingdom Emissions Trading Scheme
UKHO	United Kingdom Hydrographic Office
UKNIR	UK National Inventory Report
UKOOA	UK Offshore Operators Association
US EPA	United States Environmental Protection Agency
USNEL	United States Naval Electronic Laboratory
UTM	Universal Transverse Mercator/Unitised Template Manifold
VOC	Volatile Organic Compounds
WBM	Water Based Mud
WF	Water Flood
WMP	Waste Management Plan
WONS	Well Operation Notifications System
WPP	Wellhead Protection Platform

1. Introduction

The Captain field lies in UKCS Block 13/22a (Licence No. P.324) *c.* 145 km northeast of Aberdeen, in the Outer Moray Firth (Figure 1-1). The field is operated by Ithaca Energy who has 85% interest equity, whilst Dana Petroleum (E&P) Limited holds a 15% non-operated working interest in the field.

Since early field life, production at the field has been supported with water injection, whilst the original Field Development Plan (FDP)[1] referenced an Enhanced Oil Recovery (EOR) strategy using the injection of polymers[2]. After initial trials at the Captain field a staged EOR development approach was adopted in 2016. An overview of the Captain field is provided in Section 1.1 whilst Section 1.2 gives further details on the polymer injection trials carried out and the different stages of the Captain EOR strategy. This Environmental Statement Report (ES) supports a number of the activities to be carried out as part of the second stage the EOR strategy, which is currently being progressed by Ithaca Energy (UK) Limited (Ithaca Energy).

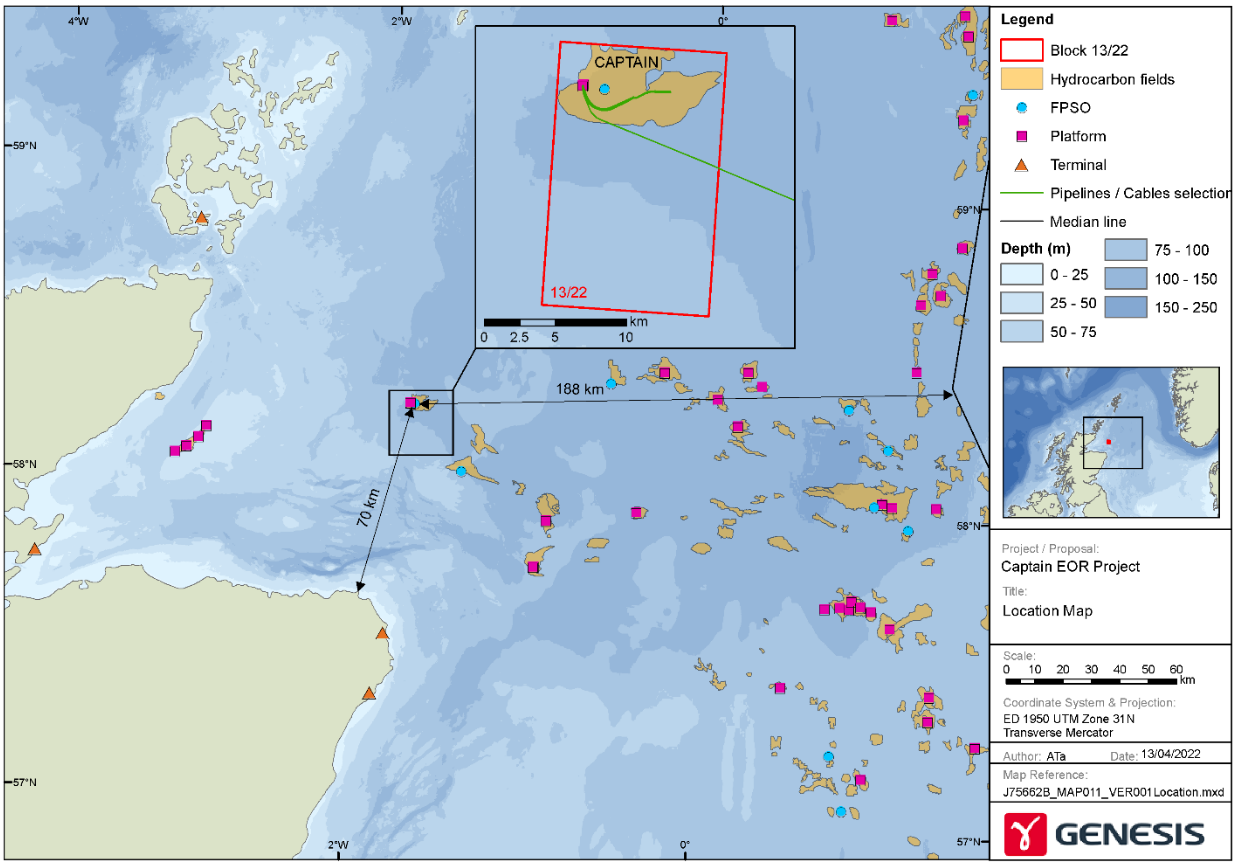


Figure 1-1: Location of the Captain Field Development.

[1] The development of, and production from, oil and gas fields in the United Kingdom's territorial waters and on the United Kingdom Continental Shelf ('UKCS') is subject to a licensing regime overseen by the North Sea Transition Authority (NSTA). Under the applicable seaward production licence, Licensees require the NSTA's consent to erect or carry out permanent works for the purpose of getting or conveying petroleum from a licensed area or to get petroleum from such an area. Such consent is referred to as a 'Development and Production Consent', and the document submitted in support of such a consent is referred to as the FDP. The original FDP for the Captain Field was submitted in Q1 1995.
[2] Sections 2.4.1 and 2.4.2 provide more details on polymer EOR.

1.1 Overview of the Captain Field

The Captain field was discovered in 1977 and has been producing since 1997. The field was developed over a number of stages. It was initially developed with a Wellhead Protection Platform (WPP) and the Captain Floating Production Storage and Offloading (FPSO) vessel. The WPP installation is a four-legged steel jacket structure supporting a self-contained drilling rig, personnel accommodation, helideck and all utility, ancillary and emergency systems. The location of the WPP wells is referred to as Area A.

In 2001 the second stage of the Captain Field Development was completed. This included the installation of a Bridge Linked Platform (BLP) bridge linked to the WPP. It is also connected to an 18-slot Unitised Template Manifold (UTM) at a subsea drill centre referred to as Area B. The bridge carries piping, interconnecting power and control cables and facilitates personnel access. There is no accommodation or drilling facilities on the BLP. The installation of the BLP de-bottlenecked the existing system to increase total field production capacity by separation of excess gas and produced water so that the total fluids sent to the FPSO are within its design capacity. The Area B UTM is linked to the BLP by two 16" production flowlines, a 12" power water, injection and test flowlines and various communications and chemical umbilicals.

The third stage of the Captain Field Development was completed in 2006 and comprised the development of an additional drill centre referred to as Area C. Area C is tied back to the Area B UTM by means of one production flowline and several other lines for control and well fluids. Area A, Area B and Area C fluids flow to the BLP for processing then onto the FPSO via the WPP for further processing and storage.

Captain crude oil is offloaded from the FPSO vessel to a dynamically positioned shuttle tanker and transported to onward sales point. Captain gas is exported and imported via a subsea pipeline connecting to the Frigg U.K. gas transportation system and then on to the St Fergus gas terminal.

Figure 1-2 shows the layout of the Captain Field Development and Figure 1-3 shows the installations associated with the field. Further details on the Captain field are provided in Section 2.

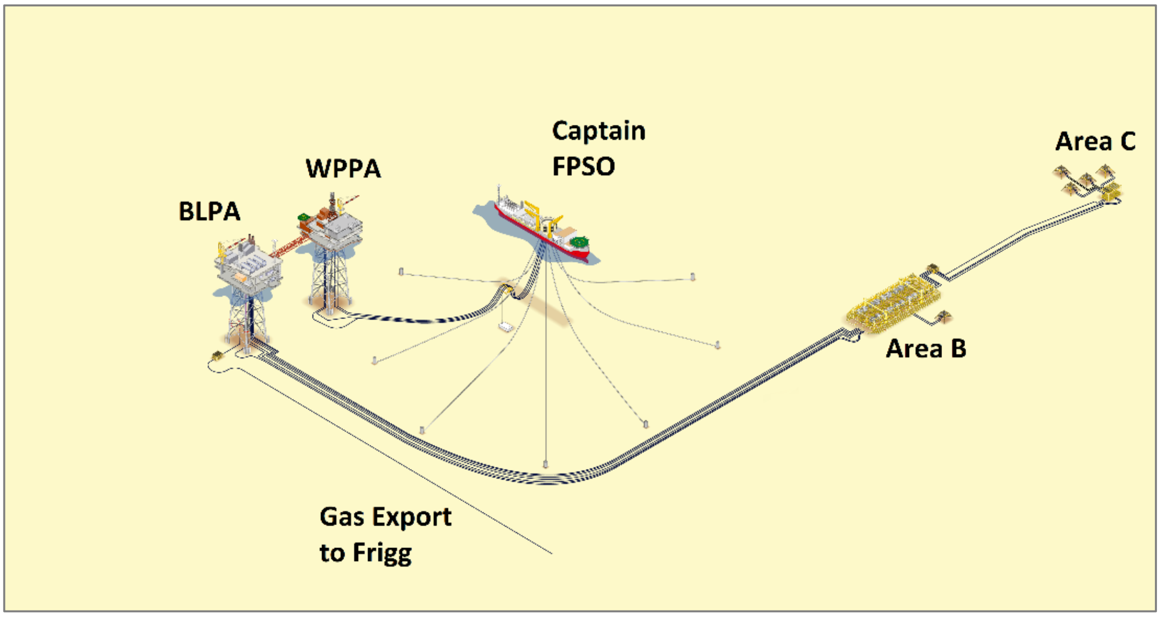


Figure 1-2: Indicative layout of the Captain Field Development.

Figure 1-3: Captain field showing WPPA (left foreground), BLP (right foreground), Captain FPSO (centre background) and shuttle tanker (left background).

1.2 Overview of the Captain Field Enhanced Oil Recovery Project

Since early field life, produced water has been injected at Captain to maintain reservoir pressure and provide reservoir sweep[3]. Polymer solution injection was proposed in the original Captain FDP and the concept was included as part of the original facilities design to enable a field trial to take place[4]. As part of a pilot EOR project, pilot polymer mixing and injection facilities were installed on the Captain FPSO and the WPP.

First injection of polymer solution to an existing water injection well in Area A was achieved in the autumn of 2010. After continuing to pilot polymer flood at Captain from 2010 through to 2017, a staged EOR development approach was adopted in 2016 whereby the Captain EOR Project aims to extend the pilot polymer solution injection scheme to the full field through a phased development.

Following the pilot study, the Captain EOR Project was split into two further stages: Stage 1 and Stage 2. The first stage (referred to as the Captain EOR Stage 1 Project) is still ongoing and three producers and one EOR injector well have been drilled from the WPP between 2018 and 2019. The Captain EOR Stage 1

[3] The term 'sweep' refers to the displacement of a hydrocarbon fluid from a reservoir rock by a flooding fluid e.g. water or polymers.
[4] The polymer solution acts as a displacing fluid at a higher viscosity than the normal Produced Water Re-injection (PWRI) water. The polymer solution works by displacing the fluid mobility ratio to the oil resulting in a much more efficient displacement of the oil to the adjacent production wells and thus allowing for EOR.

project was subsequently extended with two additional production wells and one injection well being drilled at the WPP between 2021 and 2022.

The second stage of the Captain EOR Project (the Captain EOR Stage 2 Project) includes some brownfield modifications across the three Captain installations (WPP/BLP/FPSO), as well as a significant expansion in the subsea area. The Captain EOR Stage 2 Project can be considered to be split into two phases (Phase I and Phase II) based on the schedule of activities and requirements under the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 (hereafter referred to as the 2020 Offshore EIA Regulations).

Captain EOR Stage 2 Phase I involves: the drilling of a new production well at Area C; the conversion of an existing water injection well at Area B to a polymer injection well; and the installation of a polymer injection flowline between the BLP and the converted polymer injection well at Area B. Other activities include topside modifications and the installation of a large riser caisson on the BLP. The riser caisson will accommodate all the risers associated with the EOR Stage 2 Phase II project. The offshore activities associated with Phase I are being undertaken in 2022. Under the 2020 Offshore EIA Regulations, the activities associated with EOR Stage 2 Phase I are considered to represent a Schedule 2 Project such that their environmental impacts have been captured under a number of permit applications including screening directions, chemical permit applications, Consent to Locate (CtL) etc.[5] The impacts of these Schedule 2 activities are generally not considered in detail in this ES, exceptions include the cumulative impacts on atmospherics during the production phase.

The Captain EOR Stage 2 Phase II Project (also referred to in this ES Report as the ‘proposed project’) which is covered by this ES Report involves:

- Drilling of six new polymer injection wells across two new drill centres (Area D and Area E);
- Drilling of one new production well at Area B (an existing drill centre);
- The installation and commissioning of the required subsea infrastructure;
- Ongoing modifications to the three Captain topsides; and
- Increased production rates.

Figure 1-4 summarises the drilling and installation activities associated with the Captain EOR Stage 2 Phase II Project. Further details are provided in Section 2.

[5] These activities have been captured in permits submitted under the following Master Application Templates (MAT): DRA/926, WIA/1313 and PLA/921.

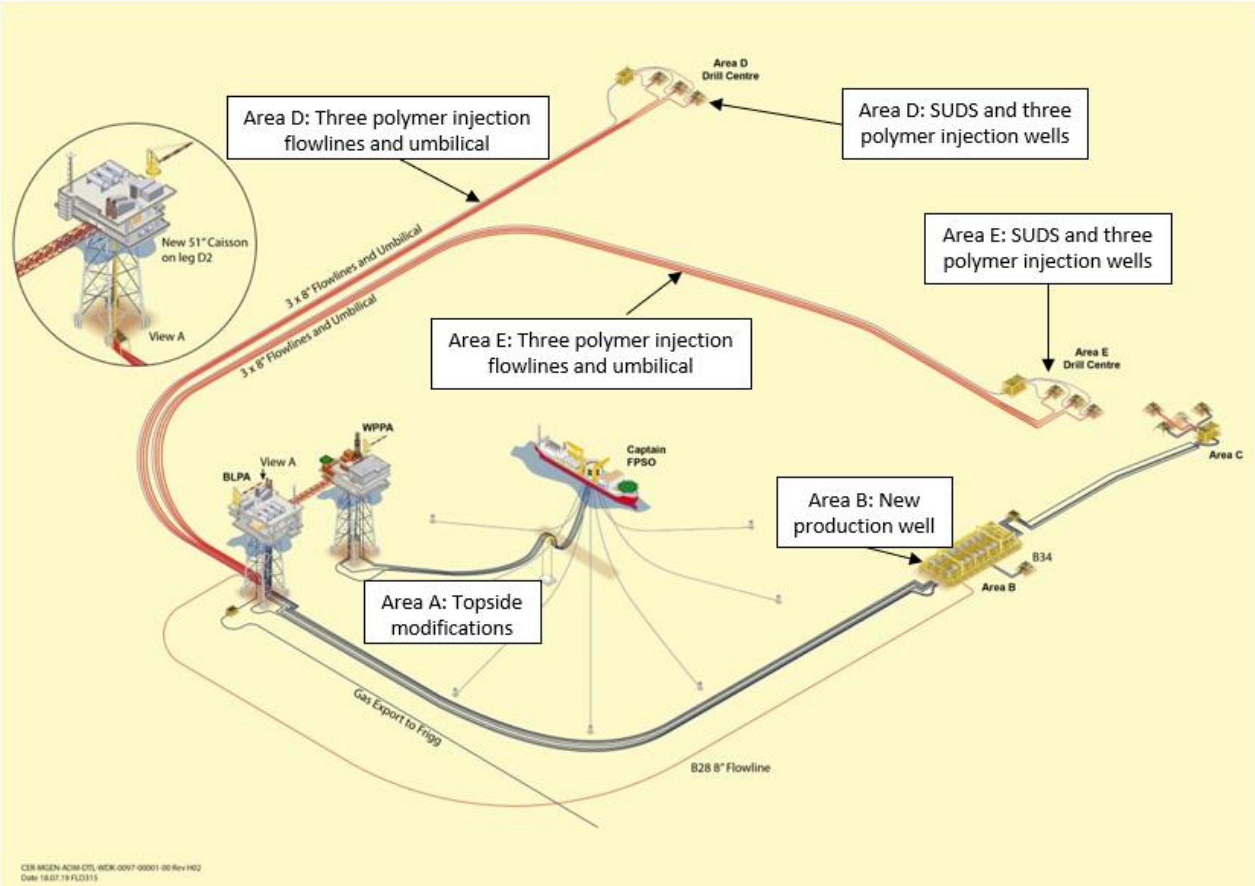


Figure 1-4: Representative schematic of the proposed Captain EOR Stage 2 Phase II Project activities.

1.3 Purpose of the Environmental Statement

Under the 2020 Offshore EIA Regulations, the proposed Captain EOR Stage 2 Phase II Project requires an Environmental Impact Assessment (EIA) and ES to be submitted to the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) for approval. This requirement is due to the anticipated increased volumes of hydrocarbons to be produced such that consent is being sought for the *'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'.*

The purpose of this ES is to report on the EIA process undertaken to meet both statutory and Ithaca Energy internal project requirements. The ES provides a public consultation document which supports consultees in the decision-making process and is therefore required to be a comprehensive report. The ES provides an opportunity to reassure the Regulator and consultees that Ithaca Energy is informed and understands:

- the likely consequences of the activities, emissions, discharges, and physical presence of the project;
- the local environment; and
- the nature of the environmental and commercial issues arising for other users of the sea.

The ES has been prepared in accordance with the 2020 Offshore EIA Regulations and guidance from OPRED (OPRED, 2021).

1.4 Scope of the Environmental Statement

The scope of the EIA and resultant ES includes the following activities:

- Drilling of the six polymer injection wells across two new drill centres (Area D and Area E)
- Drilling of one new production well at Area B (an existing drill centre);
- The installation and commissioning of the required subsea infrastructure;
- Modifications to the topsides of the BLP and the WPP platforms and the Captain FPSO and;
- Additional production (relative to operation without the Captain EOR Stage 2 Phase II project); and
- Decommissioning.

In line with the 2020 Offshore EIA Regulations, the EIA sets out to describe and evaluate the impacts of any emissions to air, discharges to sea, seabed disturbance, underwater noise, waste production and resource use resulting from the proposed development on a range of receptors including flora, fauna, water, air, climate, and material assets. In addition, the potential interactions with other users of the sea are considered. These aspects are considered for planned activities and unplanned (i.e. accidental) events.

1.5 Document Layout

To determine the environmental and socio-economic impacts of the proposed Captain EOR Stage 2 Phase II Project, an understanding of the regulatory context, stakeholder concerns, the proposed activities and the environmental and socio-economic baseline is required. Table 1-1 details the structure of the ES report.

Table 1-1: Structure of the ES.

Section No.	Title	Contents
	Non-Technical Summary	A summary of the ES Report.
1	Introduction	Introduction to the project and scope of the ES. This section also includes a summary of applicable legislation, Ithaca Energy Management System, areas of uncertainty and the consultation process to date.
2	Green House Gas Emissions Approach	Ithaca Energy's approach to reducing greenhouse gas emissions across their portfolio.
3	Project Description	A description of the drilling and subsea installation operations, an overview of the topside modifications and the anticipated production profiles.
4	Environmental and Socio-Economic Baseline	A description of the environmental and socio-economic receptors in the area.
5	Risk Assessment Methodology	Description of the methodology used to determine the significance of the environmental and social risk of the proposed activities.
6 to 11	Assessment of Aspects	Detailed assessment of Physical Presence (Section 6); Emissions to Air (Section 7); Discharges to Sea (Section 8); Seabed Disturbance (Section 9); Underwater Noise (Section 9); and Waste (Section 11) aspects of the development.
12	Accidental Events	Details of accidental events identified during the ENVironmental and socio-economic Impact IDentification (ENVID).
13	Conclusions	Key findings including a register of commitments.
14	References	Lists sources of information drawn upon throughout the ES.
Appendix A	Scotland's National Marine Plan	Assessment of the project against Scotland's National Marine Plan.
Appendix B	ENVID Results	Results of the ENVID.
Appendix C	Drill Cuttings Discharge Modelling	Modelling of the impacts associated with the discharge of drill cuttings.
Appendix D	Underwater Noise Modelling	Modelling of impacts of piling activities associated with the new manifold.
Appendix E	Supporting Information	Production profiles to supplement Section 3.

1.6 Legislative Overview

This section provides a summary of the current environmental legislation applicable to the project.

1.6.1 Environmental Impact Assessment

Offshore environmental control has developed significantly over the past thirty years and is continuing to evolve in response to increasing awareness of potential environmental impacts. Strands of both primary and secondary legislation, voluntary agreement, and conditions in consents granted under the petroleum licensing regime and international conventions have all contributed to the current legislative framework.

The main controls for new oil and gas projects are EIAs, which became a legal requirement of offshore developments in 1998. Current requirements are set out in the 2020 Offshore EIA Regulations and accompanying Guidance Notes for Industry (BEIS, 2021).

Schedule 1 of the 2020 Offshore EIA Regulations identifies those projects that require an ES to be prepared. As described previously, the proposed Captain EOR Stage 2 Phase II Project requires an ES due to the anticipated production profiles.

1.6.2 Protected Sites and Species

The EIA needs to consider the impact on the surrounding environment including any protected areas. Many protected areas have been designated in the UK under the European Union (EU) Nature Directives, in particular the Habitats Directive (92/43/EEC) and the Birds Directive (2009/147/EC). Since January 2021 these are now maintained and designated under the Habitats Regulations for England and Wales, Scotland, and Northern Ireland. Amendments to the Habitats Regulations mean that the requirements of the EU Nature Directives continue to apply to how European sites (Special Areas of Conservation (SACs) and Special Protection Areas (SPAs)) are designated and protected. The Habitats Regulations also provide a legal framework for species requiring strict protection, e.g. European Protected Species (EPS). All offshore projects or developments must demonstrate that they are not “likely to have a significant impact on the integrity of the conservation objectives for the protected site” or “significantly disturb European Protected Species (EPS)” either alone or in combination with other plans and projects.

1.6.3 Discharges to Sea

Oil Discharges

In accordance with the Oslo/Paris Convention (OSPAR) Recommendation (2001/1), the UK through OPRED has introduced regulatory requirements which reduce the permitted average monthly oil concentration in produced water discharged overboard from oil and gas installations to a maximum of 30 mg/l. OSPAR Recommendation 2001/1 also required contracting parties to reduce the total discharge of oil in produced water (PW) by 15% by 2006 measured against a 2000 baseline. The permits replaced the granting of exemptions under the Prevention of Oil Pollution Act 1971 and are issued under the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended). The original design of the Captain FPSO included provision for discharge of produced water, however this system has not been used since 1998 and all produced water at the Captain field is now reinjected; this will remain the case following implementation of the proposed project.

Chemical Discharges

In June 2000, the OSPAR Convention for the Protection of the Marine Environment in the North East Atlantic made a decision requiring a mandatory system for the control of chemicals (OSPAR Decision 2000/2 on a Harmonised Mandatory Control System for the Use and Reduction of the Discharge of Offshore Chemicals). This decision operates in conjunction with two OSPAR Recommendations:

- OSPAR Recommendation 2000/4: The application of a Harmonised Pre-Screening Scheme for Offshore Chemicals to allow authorities to identify chemicals being used offshore; and
- OSPAR Recommendation 2000/5: The application of a Harmonised Offshore Chemical Notification Format for providing data and information about chemicals to be used and discharged offshore.

OPRED implemented OSPAR Decision 2000/2 on the control of chemical use offshore, through the Offshore Chemicals Regulations (OCR) 2002 (as amended). The regulations require offshore Operators to apply for permits for the use and / or discharge of chemicals during all relevant offshore energy activities, including well operations, production operations, pipeline operations, and decommissioning operations. The 2011 Amendment Regulations extended the provisions to take enforcement action in the event of any unintentional offshore chemical release.

Risk Based Approach

OSPAR Recommendation 2012/5 for a Risk-Based Approach (RBA) to the Management of PW Discharges from Offshore Installations aims to produce a method for prioritising mitigation actions for those discharges and substances that pose the greatest risk to the environment. As all PW is reinjected at the Captain field, this is not applicable to the proposed project.

1.6.4 Atmospheric Emissions

Combustion installations on oil and gas platforms with a rated thermal input, including flaring of 20 MW(th) or more require permitting under the UK's Emissions Trading Scheme (UK ETS). The UK ETS replaced the UK's participation in the European Union ETS system on 1 January 2021. The EU ETS is based on Directive 2003/87EC establishing a scheme for Greenhouse Gas (GHG) emission allowance trading within the Community (the EU ETS Directive) and the UK ETS broadly aligns with the Directive. The UK ETS is implemented by the GHG Emissions Trading Scheme Order 2020 (as amended). The relevant provisions of the Order include the requirement to monitor and report carbon dioxide (CO_2) emissions, surrender allowances and to notify of any changes affecting the allocation of allowances.

Combustion installations on oil and gas platforms with a rated thermal input of 50 MW(th) or more require permitting under the Offshore Combustion Installations (Pollution Prevention and Control) Regulations 2013 (as amended). This includes conditions limiting releases notably for carbon monoxide (CO), oxides of nitrogen (NOx), oxides of sulphur (SOx), methane (CH_4) and volatile organic compounds (VOCs) and the demonstration of the use of Best Available Technique (BAT). Combustion installations with a rated thermal input of 1 MW(th) to 50 MW(th) also require permitting under Pollution Prevention and Control (PPC) regulations to comply with the Emission Limit Values (ELV's) as stipulated in the Medium Combustion Plant directive EU 2015/2193 of 25th November 2015 for sulphur dioxide (SO_2), NO_x and dust.

The revised North Sea Transition Authority (NSTA)[6] Strategy (February, 2021) retains a binding obligation to secure that the maximum value of economically recoverable petroleum is recovered from the strata beneath relevant UK waters. The Strategy also states that in doing so, appropriate steps must be taken to reducing GHG emissions and assist in meeting the UK net zero target. The Strategy is supported by Stewardship Expectations (SE). The NSTA 'Stewardship Expectation 11 – Net Zero' (March 2021) (SE 11) sets out the NSTAs expectations of the steps that should be taken across the exploration and production lifecycle, to reduce emissions and promote Carbon Capture and Storage (CCS) and hydrogen.

1.6.5 Marine and Coastal Access Act

The Marine and Coastal Access Act (MCAA) came into force in November 2009. The Act covers all UK waters except Scottish internal and territorial waters which are covered by the Marine (Scotland) Act (2010), which mirrors the MCAA powers. The MCAA provides the legal mechanism to help ensure clean, healthy, safe, productive, and biologically diverse oceans and sea by putting in place a new system for improved management and protection of the marine and coastal environment. It replaces and merges the requirements

[6] NSTA was formerly the Oil and Gas Authority (OGA)

of the Food and Environmental Protection Act 1985 (FEPA) Part II (environment) and the Coastal Protection Act 1949 (navigation). The MCAA has enabled:

- Establishment of the Marine Management Organisation (MMO) to operate as the competent marine planning authority in English territorial waters and UK offshore waters (for matters that are not devolved) such as marine licensing and enforcement of marine legislation;
- A strategic marine planning system to agree marine objectives and priorities and establish a series of marine plans to implement marine policy;
- A new marine licensing system for marine activities; and
- Powers enabling the designation of Marine Conservation Zones (MCZ) in the territorial waters adjacent to England and Wales and UK offshore waters.

However, the following are exempt from the MCAA as they are regulated under different legislation:

- Activities associated with exploration or production / storage operations that are authorised under the Petroleum Act 1998; and
- Additional activities authorised solely under the OPRED environmental regime, e.g. chemical and oil discharges.

Some oil and gas activities, which are not regulated by the Petroleum Act 1998 or under the OPRED environmental regime, require an MCAA licence.

1.6.6 National Marine Plan

The Scottish National Marine Plan (NMP) comprises plans for Scotland's inshore (out to 12 nm) and offshore waters (12 to 200 miles) as set out under the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009. The NMP represents a framework of Scottish Government policies for the sustainable development of marine resources. The NMP is underpinned by the following strategic objectives:

- Achieving a sustainable marine economy;
- Ensuring a strong, healthy, and just society;
- Living within environmental limits;
- Promoting good governance; and
- Using sound science responsibly.

These objectives are to be achieved through the application of 21 'General Planning Principles'. Development projects should take these principles into account in order to support the overall NMP objectives for sustainable development of Scotland's marine environment.

The NMP sets out specific key issues for the oil and gas sector in supporting the objectives of the plan:

- Maximise extraction;
- Re-use infrastructure;
- Transfer of skills to renewables and CCS;
- Co-operation with the fishing industry;
- Noise impacts to sensitive species;
- Chemical and oil contamination of water, sediments, and fauna;
- Habitat changes.

The NMP also sets out general policies and objectives as part of the UK's shared framework for sustainable development. The proposed operations as described in this ES have been assessed against all NMP objectives (Appendix A) and policies, but specifically GEN 1, 4, 5, 9, 12, 14 and 21:

GEN 1- General Planning and Principle

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

GEN 4 - Co–existence

Where conflict over space or resource exists or arises, marine planning should encourage initiatives between sectors to resolve conflict and take account of agreements where this is applicable.

GEN 5 - Climate Change

Marine planners and decision makers should seek to facilitate a transition to a low carbon economy. They should consider ways to reduce emissions of carbon and other GHGs.

GEN 9 - Natural Heritage

Development and use of the marine environment must:

- Comply with legal requirements for protected areas and protected species.
- Not result in significant impact on the national status of Priority Marine Features (PMF) (see Section 4).
- Protect and, where appropriate, enhance the health of the marine area.

GEN 12 – Water Quality and Resource

Developments and activities should not result in a deterioration of the quality of waters to which the Water Framework Directive, Marine Strategy Framework Directive or other related Directives apply.

GEN 14 – Air Quality

Development and use of the marine environment should not result in the deterioration of air quality and should not breach any statutory air quality limits. Some development and use may result in increased emissions to air, including particulate matter and gases. Impacts on relevant statutory air quality limits must be taken into account and mitigation measures adopted, if necessary, to allow an activity to proceed within these limits.

GEN 21 – Cumulative Impacts

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

These NMP policies and objectives have been considered during the development of the proposed project and when undertaking the EIA.

1.7 Ithaca Energy Management System

Ithaca Energy are committed to conducting activities in compliance with all applicable legislation and in a manner that minimises impacts on the environment. The proposed Captain EOR Stage 2 Phase II Project will be delivered in compliance with Ithaca Energy Environmental Management System (EMS) which has been developed in line with the principles of the International Standard for Environmental Management Systems (ISO14001:2015).

HES Policy and Company Management System Commitment

The Company's vision is to be the highest performing UK North Sea independent oil and gas company, focused on sustainably growing value. We strive to be leaders in terms of: process safety; occupational health and safety; environmental responsibility; asset reliability and efficiency. The Company aims to:

- Identify and reduce the risk from major accident hazards including process safety and environmental risks.
- Always be in control of work, taking time to reassess when conditions change.
- Understand the impact of errors and put in place barriers to mitigate the consequences.
- Promote a healthy workplace and mitigate significant health risks.
- Ensuring continual improvement in all aspects of our business.

Through consistent application of this policy and our Company Management System (CMS) we address the following:

Leadership

Our leaders are accountable for:

- Providing clear and consistent leadership in accordance with this policy and company values.
- Ensuring clear roles, responsibilities, and communications.
- Trusting and empowering our teams to apply a risk-based approach to decision making in accordance with this policy.
- Creating a culture that is built on our values and behaviours, enabling safe, reliable and secure operations and protection of the environment.
- Engaging with our community and other stakeholders.
- Ensuring that we comply with all applicable policies, codes and regulations and that we constructively work with the regulators to align objectives.

Organisation

Our organisation is fit-for-purpose and is designed to:

- Achieve results in accordance with Company values and policies.
- Ensure suitable and sufficient control of Major Accident Hazards.
- Ensure that staff and contractors are competent in their roles through the application of the Company Competence Assurance Process.
- Ensure structured and timely decision making.
- Ensure the effective management of safe work.

A Strong Safety Culture

Based on:

- The IOGP Life Saving Rules.
- Compliance with the provisions of our safety cases and this policy.
- The identification and management of Major Accident Hazards.
- The involvement of, and consultation with, our staff and contractors.
- The reporting and investigation of incidents and near misses.
- The use of stop work authority.
- The recognition and reward of desired behaviors through our performance management and reward processes.
- The implementation of company safety initiatives.

Stop Work Authority

Based on:

- Our employees and contractors understanding our leadership commitment to engage, encourage and support them.
- Everyone having the responsibility and authority to Stop Work.
- There being no repercussions when an action is taken to stop work.
- All employee's ideas being important, and always being encouraged to raise concerns.

Risk Management

Our people, at all levels of the organisation will:

- Systematically assess, prioritise and manage risk.
- Regularly review and re-evaluate risks.
- Maintain the integrity of dedicated systems through fit-for-purpose design and operating practices.
- Ensure that there are multiple, independent barriers in place to prevent Major Accident Hazards including, but not limited to, unplanned releases of hydrocarbons.

Asset Integrity Management

Our facilities, reservoirs and wells are designed and maintained to be fit-for-purpose throughout their lifecycles. This includes:

- Designing, constructing, modifying, operating and maintaining our facilities and wells to recognised safety and environmental protection standards, to avoid unplanned releases of hazardous substances and to prevent injury to people or harm to the environment.
- Minimising the potential for human error through the design and operation of our facilities.
- Maintaining the integrity of safety and environmental critical elements.
- Managing risks on a whole of life-cycle basis.
- Managing change in accordance with our management of change process.
- Compliance with all applicable codes, Regulations and Company standards.

Monitoring and Audit

Through a process of audit and workplace monitoring, we will examine our processes and operations to confirm:

- That our plans and processes are being correctly implemented.
- That we continually improve the effectiveness of our Company Management System (CMS) system including our verification and well examination schemes.
- The suitability and effective implementation of this policy.

Emergency Management

While prevention is the first priority, we are prepared for any emergency and have the tools to mitigate any incident quickly and effectively:

- We maintain a fit-for-purpose command and control system, based on defined scenarios and meet all UK legal requirements.
- We regularly test the effectiveness of the system through audits and exercises.
- We aim to prevent future incidents by identifying and eliminating their root causes.

This Policy applies to all offices and facilities operated by the Company.

The Company's Leadership shall champion the implementation of the Policy across the Company and lead the monitoring and auditing of its ongoing effectiveness.

Every individual has a duty to ensure they always comply with, and hold others accountable for compliance with this Policy, and prevent harm to themselves and others, and the environment.

This Policy is applicable without distinction between Company employees and contractors working for the Company.

This policy is a combined Health, Safety, Environmental and Corporate Major Accident Prevention Policy and satisfies the requirements of Section 2(3) of the Health and Safety At Work Act 1974 and Regulation 7 of the Offshore Installations Safety Case Regulations 2015.

[redacted]

Figure 1-5: Ithaca Energy's HSE Policy.

1.8 Areas of Uncertainty

This ES was prepared during the Optimise Phase of the proposed project. As a result, some assumptions have been made in order to undertake the EIA Where assumptions have been made, the environmental worst-case option was assessed. Assumptions and uncertainties are outlined below.

1.8.1 Rock Cover, Mattresses, and Grout Bags

Maximum anticipated quantities of rock cover, mattresses and grout bags are presented in the ES to assess the worst-case scenario in terms of impacts on the seabed. The requirements for stabilisation/protection material will be further assessed and confirmed in later PWA (Pipeline Work Authorisation) and associated environmental permit applications.

1.8.2 Production Profiles

Production profiles based on models have a certain degree of uncertainty associated with them. The production profiles presented in this ES are based on a high case and are an annualised average of the projected production from the Captain field.

1.9 Consultation Process

Consulting with stakeholders is an important part of the impact assessment process as it allows any concerns or issues which stakeholders may have, to be communicated and addressed. In June 2022, as part of the informal stakeholder engagement process, Ithaca Energy issued a Scoping Report to stakeholders. The Scoping Report provided an overview of The Project and the impacts to be assessed in the ES Report. Stakeholders were invited to comment on the Scoping Report with respect to any concerns they may have. In addition to issuing the Scoping Report Ithaca Energy held a Stakeholder Engagement Workshop in June 2022. Comments received on the Scoping Report and issue raised during the workshop are summarised in Table 1-2 and Table 1-3. The process of consultation will continue throughout the project.

As required by the 2020 Offshore EIA Regulations, a copy of the ES and the public notice has been made publicly available on the Company's website at the time of submission.

Table 1-2: Comments received on the Scoping Report.

Comments / issues / concerns raised on Scoping Report	Response
Marine Scotland Science (MSS) – received on 14/6/2022	
• MSS requests that the ES demonstrates how the project aligns with the general policies outlined in Chapter 4 of the National Marine Plan and the sector specific oil and gas policies outlined in Chapter 9.	Captured in Appendix A.
• MSS advise the ES demonstrates that the technology used in drilling of the wells represents the Best Available Technology (BAT). They ask that the ES consider whether the sediment type at the site lends itself to new technologies for the conductor sections that would reduce the amount of cuttings and discharge of cement to the seabed.	Addressed in Section 3.4.4.
• MSS advise that impacts associated with cement discharges are assessed.	Cement discharges are described in Section 3.6.7 and impact of discharges are considered in Section 8.1 and Section 9.1.
• MSS preference would be for pipelines to be routed together in common trenches in order to minimise seabed disturbance, and request that robust justification for individual trenches and the installation method is provided in the ES.	Justification for installation method is provided in Section 3.4.
• MSS advise reference to analogous studies when considering sediment disturbance and water column impacts associated with jet trenching activities	Worst case impacts have been assessed in Section 9.4.

Comments / issues / concerns raised on Scoping Report	Response
and where this is not possible specific modelling may be appropriate. Cumulative impacts associated with jet trenching activities should also be considered.	
• MSS request that the pipeline material is included in the ES and that the likelihood of upheaval buckling is discussed in the ES. In addition, MSS ask that a robust worst-case assessment for protective materials is provided in report.	Schematic showing components of the flowlines is presented in Section 3.7.3. Likelihood of upheaval buckling is considered low and is noted in Section 3. Worst case protection material has been captured (Section 3.7.4).
• MSS request that the ES discusses how the sampling stations were selected for the environmental baseline survey.	Section 4.2 describes the survey sampling strategy.
• 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.	Section 3.4 provides options considered for various elements of the proposed project. Selected option for each element is considered to represent BAT and BEP.
• MSS request that details of how other adjacent pipelines and cables are laid are included.	All existing flowlines to the to the existing drill centres are trenched and buried. Existing lines between the platforms and FPSO are surface laid lines and for the most part are laid within the existing 500 m zones.
• MSS requested that a local scale bathymetry map for the project area is included, highlighting any significant seabed features	Bathymetry map is presented in Section 4.3.
• MSS provided a number of very helpful references to support the description of the environmental and socio-economic baseline descriptions.	References used where applicable in Section 4.
Joint Nature Conservation Committee (JNCC) – received on 22/7/22	
• JNCC advised they were pleased to see that cuttings dispersion modelling and underwater noise modelling has been carried out to support the ES.	General comment
• JNCC advised that the existing surveys are sufficient to inform the ES.	General comment
Other consultees that received the Scoping Report	
Scottish Fishermen's Federation (SFF), Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) Note: at the time of writing, feedback on the Scoping Report had not been received from these consultees, though SFF and OPRED did attend the stakeholder engagement workshop (Table 1-3).	

Table 1-3: Comments from Stakeholder Engagement Workshop.

Stakeholder Engagement Workshop (7/6/2022)	Response
Stakeholders/consultees represented	
Attendees • Scottish Fishermen's Federation (SFF) • Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) **Apologies** • Joint Nature Conservation Committee (JNCC) • Marine Scotland Science (MSS)	
Comments / Issues / Concerns	
• OPRED advised the ES should include a chapter capturing the Company's Net Zero targets, policies, and emissions reduction strategy.	Captured in Section 2
• SFF advised they are aware of clay mounds being created during installation of existing Captain infrastructure. In addition, the advised that *Nephrops* are a prominent species in the area.	Section 9 captures Ithaca Energy's commitment to ensuring a safe seabed (including mitigation of any clay berms that may result from the installation activities).
• SFF advised that *Nephrops* are a prominent species in the area.	The presence of *Nephrops* in the area is captured in Section 4.

2. PATHWAY TO NET ZERO

This section discusses Ithaca Energy's GHG emissions strategy, policy and targets and how these are embedded in the Company's management systems. The section also summarises some of the progress Ithaca Energy has made and the opportunities which are still under evaluation.

2.1 Ithaca Energy Climate Targets

Ithaca Energy's objective is to provide a safe and healthy working environment for all its employees and contractors, while simultaneously minimising the environmental impact of the Company's operations by working to operate in an ever-cleaner manner. The control and management of these issues lies at the centre of the policies and procedures that constitute the health, safety and environmental management system and the culture of the business.

Ithaca Energy strives for industry leading levels of environmental performance. Key to this ambition is the Company's commitment to significantly reducing GHG emissions from our operations in line with the global transition to a low carbon economy and the UK Government's Net Zero Targets.

Ithaca Energy has a Greenhouse Gas Emissions Policy that is endorsed by the Executive Leadership Team and signed by the Chief Executive Officer (Figure 2-1). The policy sets our expectations and aligns them with those of the North Sea Transition Authority (NSTA) and Offshore Energies UK (OEUK) and outlines the targets of the organisation.

Decisions on emissions management are taken utilising industry best practice, expertise and recommendations such as:

- **Energy White Paper** which sets out how the UK will clean up its energy system and reach net zero by 2050.
- **The World Bank Zero Routine Flaring** commits governments and oil companies to end routine flaring by no later than 2030,
- **Methane Guiding Principles** which focus on areas of action to reduce methane emissions.
- **North Sea Transition Deal** which seeks to maximise the UK's oil and gas sector advantages to the shift to clean growth.
- **NSTA Stewardship Expectation 11** gives clarity on expected behaviours and good practices on GHG emissions reductions, reductions through entire lifecycle and collaboration throughout the industry.
- **OEUK Roadmap to 2035** which offers a route to help the industry reduce emissions, improve operations' sustainability and deliver low carbon solution at scale.

Greenhouse Gas Emissions Policy

Ithaca Energy strives for industry leading levels of environmental performance. Key to this ambition is our commitment to significantly reducing greenhouse gas emissions from our operations in line with the global transition to a low carbon economy and the UK Government's Net Zero Targets.

Our Targets:

- Reduce all our scope 1 and 2 CO2 and CO2 equivalent emissions of operated assets by 25% from 2019 levels in 2025
- Achieve 0.20% methane intensity by 2025
- Zero Routine Flaring by 2030
- Net Zero by 2050

To help meet these commitments, the Company will consistently apply its environmental management system across all business processes. Our success will be driven by:

Strong Leadership

Our leaders are accountable for:

- Providing clear and consistent leadership in accordance with this policy
- Ensuring clear definition of the roles and responsibilities to support this policy
- Communicating the company's commitment to reducing greenhouse gas emissions
- Invigorating the workforce to support decarbonization of the company
- Incorporating KPIs and targets into Leadership Performance contracts

Realising Key Operational Improvements

We will:

- Utilise existing Environmental Stewardship processes to identify atmospheric emissions abatement opportunities
- Embed best practice working techniques
- Invest in our assets to reduce greenhouse gas emissions
- Evaluate renewable fuel sources to power our office and installations
- Collaborate with peers to understand Best Available Techniques which aid and accelerate emissions reduction
- Promote opportunities to share supply chain and logistics synergies

Embracing Digitalisation and New Technology

We will:

- Use data and technology to better understand our emissions and provide operations teams with the data to make smart, lower emission operational choices
- Work with industry to develop and test new technology in support of emissions reductions

Measure and Control

We will:

- Measure and report our emissions accurately and transparently
- Align our energy management to ISO50001
- Control environmental discharges to ensure minimum impact
- Track abatement actions through to completion

Set High Standards of Environmental Performance

We will:

- Embed consideration of Greenhouse Gas reduction in to all our business processes and investment decisions including the quantification of the costs of Greenhouse Gas emissions into company decision making
- Assess new developments for Greenhouse Gas emissions to ensure life-cycle emissions of the project, from construction through to decommissioning, are considered in all investment decisions.
- Select low emissions strategies in line with the Greenhouse Gas Emissions Policy wherever economically possible
- Assess the life-cycle emissions of all acquisitions and mergers, proactively identifying the steps to reduce Greenhouse Gas emissions to maintain the Company's downward trend of emissions
- Encourage employees to maintain Greenhouse Gas emissions awareness and best practices
- Provide a working environment in which industry leading environmental performance is highly valued.

This Policy will be continually reviewed and updated alongside our business strategy as risks, regulations and new technology evolves.

[redacted]

Disclaimer: This policy is for information purposes only. No representation or warranty, express or implied, is made in respect of this policy or its contents. The Company hereby disclaims all liability for damages of any kind arising out of the use, reference to, or reliance on any information provided within this policy and the Company reserves the right to update and change the information contained within the policy at any time.

Figure 2-1: Ithaca Energy's GHG Emissions Policy.

Our Emissions Policy is a commitment to reduce the company's emissions and it provides a framework to develop and progress emissions reductions opportunities.

Ithaca Energy Targets

Ithaca Energy's targets with respect to GHGs are to:

- Reduce all our scope 1 and 2 Carbon Dioxide (CO_2) and Carbon Dioxide Equivalent (CO_{2e}) emissions of our operated assets by 25% from 2019 levels by 2025;
- Achieve 0.20% methane intensity of our operated assets by 2025;
- Zero routine flaring on our operated assets by 2030; and
- A Net Zero company by 2050.

Strong Leadership

Ithaca Energy's leadership team have set ambitious company targets and asset specific emissions reduction Key Performance Indicators (KPIs). Performance is reviewed by leadership monthly. Our leadership team regularly communicates reductions and performance at townhalls.

Realising Key Operational Improvements

Using our existing Environmental Management System process (see Section 2.3 on Environmental Stewardship) Ithaca Energy regularly assess emissions abatement opportunities. Using these processes, we have seen a net reduction in flaring and venting emissions across all our assets since 2019. As responsible joint venture (JV) partners, we are also encouraging and supporting large emissions abatement projects, such as electrification, on our non-operated assets.

Embracing Digitalisation and New Technology

We are an active member of working groups to develop and test innovative technologies at pace. We are using digital technology to visualise and communicate our performance.

Measure and Control

We ensure transparency through our emissions management and reporting processes and are enhancing this process using digitalisation.

Set High Standard of Environmental Performance

GHG abatement is considered during the full life cycle asset management. Training and awareness are key to ensure that we have a working environment that encourages best practices. Educational sessions take place frequently at all levels of the Company as are awareness sessions where external parties share their experiences of emissions reductions with the Company.

Ithaca Energy has a dedicated Energy Transition Team, who together with the assets, are responsible for delivering the Company's GHG targets and ensuring the Company does its part to align with the commitments set out in the North Sea Transition Deal. The Energy Transition Team:

- meet with the executive leadership team monthly;
- have a series of objectives in 2022 to align Ithaca Energy with the NSTA Stewardship Expectation 11;
- has a hopper of reduction projects (see Section 2.4) which cover short-, medium- and long-term emission reduction opportunities across CO_2, methane and other emissions with global warming potential, including a lookback and continuous improvement process to ensure reduction opportunities are achieved and sustained.

2.2 Environmental Management System

Ithaca Energy's Management System into which the Environmental Management System (EMS) is integrated, is certified to ISO 14001:2015 standard. The EMS was last verified as meeting the ISO 14001:2015 standard in April 2021. It is designed to implement the environmental policy of Ithaca Energy. It demonstrates a commitment to compliance with environmental legislation for all of Ithaca Energy's processes, activities, and objectives associated with hydrocarbon exploration and production.

Ithaca Energy's policy for protecting people and the environment is the primary aim of Ithaca Energy's expectations for health, safety, and environmental management, and provides a shared understanding throughout the Company of environmental performance expectations.

Our vision is to be the highest performing UK North Sea independent oil and gas company, focused on sustainably growing value.

We take pride in:

- Having a relentless focus on **high performance**;
- Continuously reducing the **health, environment and safety impact** of our operations;
- Developing an **engaged workforce**, in an inclusive, dynamic workplace; and
- Striving for **efficiency and simplicity** in all that we do.

The Ithaca Energy vision is reflected in the Company's Health, Environment and Safety (HES) Policy which meets the requirements of The Corporate Major Accident Prevention Policy (CMAPP) required by The Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015; The Safety Policy required by the Health & Safety at Work etc. Act 1974; and The Environmental Policy required by ISO 14001 environmental management standard (Figure 2-2).

The HES Policy is endorsed by the Chief Executive Officer of Ithaca Energy on behalf of the Board of Directors and is a commitment to assess and manage the risks and impacts associated with our operations; and a commitment to comply with legislative requirements and corporate policies.

ITHACA ENERGY

HES Policy and Company Management System Commitment

The Company's vision is to be the highest performing UK North Sea independent oil and gas company, focused on sustainably growing value. We strive to be leaders in terms of: process safety; occupational health and safety; environmental responsibility; asset reliability and efficiency. The Company aims to:

- Identify and reduce the risk from major accident hazards including process safety and environmental risks.
- Always be in control of work, taking time to reassess when conditions change.
- Understand the impact of errors and put in place barriers to mitigate the consequences.
- Promote a healthy workplace and mitigate significant health risks.
- Ensuring continual improvement in all aspects of our business.

Through consistent application of this policy and our Company Management System (CMS) we address the following:

Leadership

Our leaders are accountable for:

- Providing clear and consistent leadership in accordance with this policy and company values.
- Ensuring clear roles, responsibilities, and communications.
- Trusting and empowering our teams to apply a risk-based approach to decision making in accordance with this policy.
- Creating a culture that is built on our values and behaviours, enabling safe, reliable and secure operations and protection of the environment.
- Engaging with our community and other stakeholders.
- Ensuring that we comply with all applicable policies, codes and regulations and that we constructively work with the regulators to align objectives.

Organisation

Our organisation is fit-for-purpose and is designed to:

- Achieve results in accordance with Company values and policies.
- Ensure suitable and sufficient control of Major Accident Hazards.
- Ensure that staff and contractors are competent in their roles through the application of the Company Competence Assurance Process.
- Ensure structured and timely decision making.
- Ensure the effective management of safe work.

A Strong Safety Culture

Based on:

- The IOGP Life Saving Rules.
- Compliance with the provisions of our safety cases and this policy.
- The identification and management of Major Accident Hazards.
- The involvement of, and consultation with, our staff and contractors.
- The reporting and investigation of incidents and near misses.
- The use of stop work authority.
- The recognition and reward of desired behaviors through our performance management and reward processes.
- The implementation of company safety initiatives.

Stop Work Authority

Based on:

- Our employees and contractors understanding our leadership commitment to engage, encourage and support them.
- Everyone having the responsibility and authority to Stop Work.
- There being no repercussions when an action is taken to stop work.
- All employee's ideas being important, and always being encouraged to raise concerns.

Risk Management

Our people, at all levels of the organisation will:

- Systematically assess, prioritise and manage risk.
- Regularly review and re-evaluate risks.
- Maintain the integrity of dedicated systems through fit-for-purpose design and operating practices.
- Ensure that there are multiple, independent barriers in place to prevent Major Accident Hazards including, but not limited to, unplanned releases of hydrocarbons.

Asset Integrity Management

Our facilities, reservoirs and wells are designed and maintained to be fit-for-purpose throughout their lifecycles. This includes:

- Designing, constructing, modifying, operating and maintaining our facilities and wells to recognised safety and environmental protection standards, to avoid unplanned releases of hazardous substances and to prevent injury to people or harm to the environment.
- Minimising the potential for human error through the design and operation of our facilities.
- Maintaining the integrity of safety and environmental critical elements.
- Managing risks on a whole of life-cycle basis.
- Managing change in accordance with our management of change process.
- Compliance with all applicable codes, Regulations and Company standards.

Monitoring and Audit

Through a process of audit and workplace monitoring, we will examine our processes and operations to confirm:

- That our plans and processes are being correctly implemented.
- That we continually improve the effectiveness of our Company Management System (CMS) system including our verification and well examination schemes.
- The suitability and effective implementation of this policy.

Emergency Management

While prevention is the first priority, we are prepared for any emergency and have the tools to mitigate any incident quickly and effectively:

- We maintain a fit-for-purpose command and control system, based on defined scenarios and meet all UK legal requirements.
- We regularly test the effectiveness of the system through audits and exercises.
- We aim to prevent future incidents by identifying and eliminating their root causes.

This Policy applies to all offices and facilities operated by the Company.

The Company's Leadership shall champion the implementation of the Policy across the Company and lead the monitoring and auditing of its ongoing effectiveness.

Every individual has a duty to ensure they always comply with, and hold others accountable for compliance with this Policy, and prevent harm to themselves and others, and the environment.

This Policy is applicable without distinction between Company employees and contractors working for the Company.

This policy is a combined Health, Safety, Environmental and Corporate Major Accident Prevention Policy and satisfies the requirements of Section 2(3) of the Health and Safety At Work Act 1974 and Regulation 7 of the Offshore Installations Safety Case Regulations 2015.

[redacted]

Figure 2-2: HES Policy and Company Management System Commitment.

2.3 Environmental Stewardship

Ithaca Energy's Environmental Stewardship process identifies and addresses significant environmental aspects relating to our operations, driving continuous improvement in environmental performance and reducing our environmental impact. It is applied across the life cycle of an asset and is used to identify, assess and manage potential environmental impacts and benefits. To achieve this, the Company has implemented a step wise process to be followed on an annual basis. First, an inventory of all emissions, releases, wastes and potentially impacted natural resources is prepared. This is followed by a procedure to identify, assess, mitigate and manage any significant risks and impacts to the environment associated with our operations which generate atmospheric emissions, aquatic releases and wastes. The outcome is an annually updated ES plan. The management system is independently certified to the international standard ISO 14001:2015 and requires Ithaca Energy to engage independent auditors who verify that our onshore and offshore operations meet requirements of the standard. All Ithaca Energy operated assets are included in the ISO 14001:2015 certification.

The Environmental Stewardship plan includes objectives and targets for environmental performance, such as stretch targets for reduced flaring, reducing CO_2 intensity and no releases of Ozone Depleting Substances. The plan also includes details of improvement implementation programmes and the process for tracking progress in meeting environmental objectives. The Environmental Stewardship plan is approved by management and is aligned with other business priorities and the HES plans.

All Ithaca Energy activities have the potential to impact on the environment and are all subject to strict environmental regulatory controls which require Ithaca Energy to prepare and submit regulatory applications to gain approval both before activities begin and during the ongoing operational activities. We monitor and report our ongoing emissions, discharges and waste streams to ensure we meet regulatory requirements and do not cause significant impact on the environment. In the event of an unplanned release/spill to sea, or a non-compliance with regulatory requirements, notification would be made to the appropriate regulatory authorities and action taken to respond to any threat of or actual pollution. Investigations of incidents are conducted to gain any learnings or actions to prevent recurrence.

The Environmental Stewardship process is used to help provide assurance that we are protecting the environment and meeting our internal and regulatory requirements and obligations.

The Company's environment stewardship process includes a commitment to analysing and reducing GHG emissions, both direct and indirect, to contribute towards Ithaca Energy's goal of a 25% emissions reduction from 2019 level across our operated assets in 2025.

2.3.1 Environmental Stewardship Improvement Program

As part of the preparation of the annual Environmental Stewardship plan, improvement opportunities are identified by Ithaca Energy. These actions were grouped into improvement plans for Ithaca Energy's UK producing assets and for activities associated with drilling, including the use of a mobile offshore drilling unit (MODU) and the office.

The improvement opportunities centred around strengthening arrangements associated with prevention of, and response to, incidents and releases; produced water management; reduction of air emissions and management of waste. Progress in completing these actions is tracked throughout the year and is used as a leading measure of continual environmental performance improvement.

In 2021 the annual ES programme was expanded to run quarterly to give greater focus on emissions reduction opportunities, this has continued through 2022. Workshops take place with each operated asset including onshore and offshore engineers, Environmental Advisors and Energy Transition Advisors.

2.4 Ithaca Environmental Initiatives

Through Environmental Stewardship workshops and engagement Ithaca has identified several projects and opportunities to reduce CO_{2e} emissions and the intensity of our operations, the completed initiatives include:

- reducing weather induced extinguished flare events, thus reducing emissions of methane;
- operating the FPF-1 semi-submersible production platform (located at the Greater Stella Area) on a single gas turbine, improving power generation fuel efficiency and reducing atmospheric emissions;
- reducing Alba (the platform at the Alba field) and Captain flare rates through operational improvements, reducing atmospheric emissions, and optimising the use of the gas for power generation;
- enabling return to full flare recovery through the reparation of the FPF-1 flare ignition package;
- as part of the Jacky field late life asset management and associated decommissioning programme a renewable power module was installed to power the Jacky installation entirely from wind and solar through to the end of the asset life cycle.

To further reduce emissions, Ithaca Energy has a hopper of projects to consider which are in an early feasibility phase. These include:

- Platform flare recovery;
- Cargo tank vent vapour recovery;
- Replace hydrocarbon blanket gas with nitrogen;
- Additional compression equipment to improve reliability and reduce flaring;
- Right size equipment to fit its duty and avoid waste;
- Control logic improvements to reduce likelihood of trips and flaring events;
- An alternative fuel to replace diesel used offshore;
- Platform electrification from UK grid or offshore wind power; and
- Solar panels on the office.

2.4.1 Low Power Carbon

Ithaca Energy could significantly reduce GHG emissions by sourcing electrical power for its UKCS platforms from onshore or offshore renewables. As a leading member of the Outer Moray Firth Electrification (OMFE) group and as a co-venturer in Elgin-Franklin, part of the Central North Sea Electrification (CNSE) group, Ithaca Energy has been actively evaluating all the alternatives for low carbon power. These are significant and complex infrastructure project which bridges both the Petroleum Act and the Electricity Act 1989. There are several options being evaluated, ranging from power from shore, connection to Innovation and Targeted Oil and Gas (INTOG) leased wind farms, Scotwind leased wind farms, and local off-grid solutions.

The INTOG leasing round opened in August 2022, and Ithaca Energy has submitted letters of intent to wind developers in support of this ‘first of its kind’ seabed leasing round.

Engineering assessments have been undertaken to understand the platform modifications required to accept these sources of low carbon power. Depending on the extent of the electrification and existing operations, these modifications can include both electrical system changes and modifications to processing facilities.

2.4.2 Alternative Fuels

With the exception of the Captain FPSO, electrical power generation on our operated assets is predominately from fuel gas. Although there is some low-pressure fuel gas available, the Captain FPSO depends on imported diesel. Therefore, the Captain FPSO would be an ideal candidate to benefit from an alternative, low carbon fuel source. Although replacing diesel would not have the same magnitude of carbon abatement as full electrification projects, it could result in significant CO_2e reductions.

Alternative fuels include biodiesel, Hydrotreated Vegetable Oil (HVO), ammonia, and e-methanol. Replacing diesel with these alternative fuels present significant challenges such as safety implications, availability of supply and delivery logistics, making them non-viable at present. However, as a key member of the OEUK sustainable fuels group, Ithaca Energy continues to regularly review alternative fuels in the UKCS.

2.4.3 Action Plans

Ithaca has developed Emissions Reduction Action Plans (ERAP) for Methane, Carbon, and F-Gas (Figure 2-3). These have been developed with five shared Abatement Goals:

Goal 1 - Continually Reduce Our Emissions.

Goal 2 - Improve Accuracy of our Emissions Data.

Goal 3 - Increase Transparency.

Goal 4 - Advocacy for Policy and Regulation.

Goal 5 - Improve Industry Performance.

Each ERAP compliments the asset focused Environmental Stewardship process described above by ensuring the supporting EMS and business processes are updated to support ongoing emissions reduction.

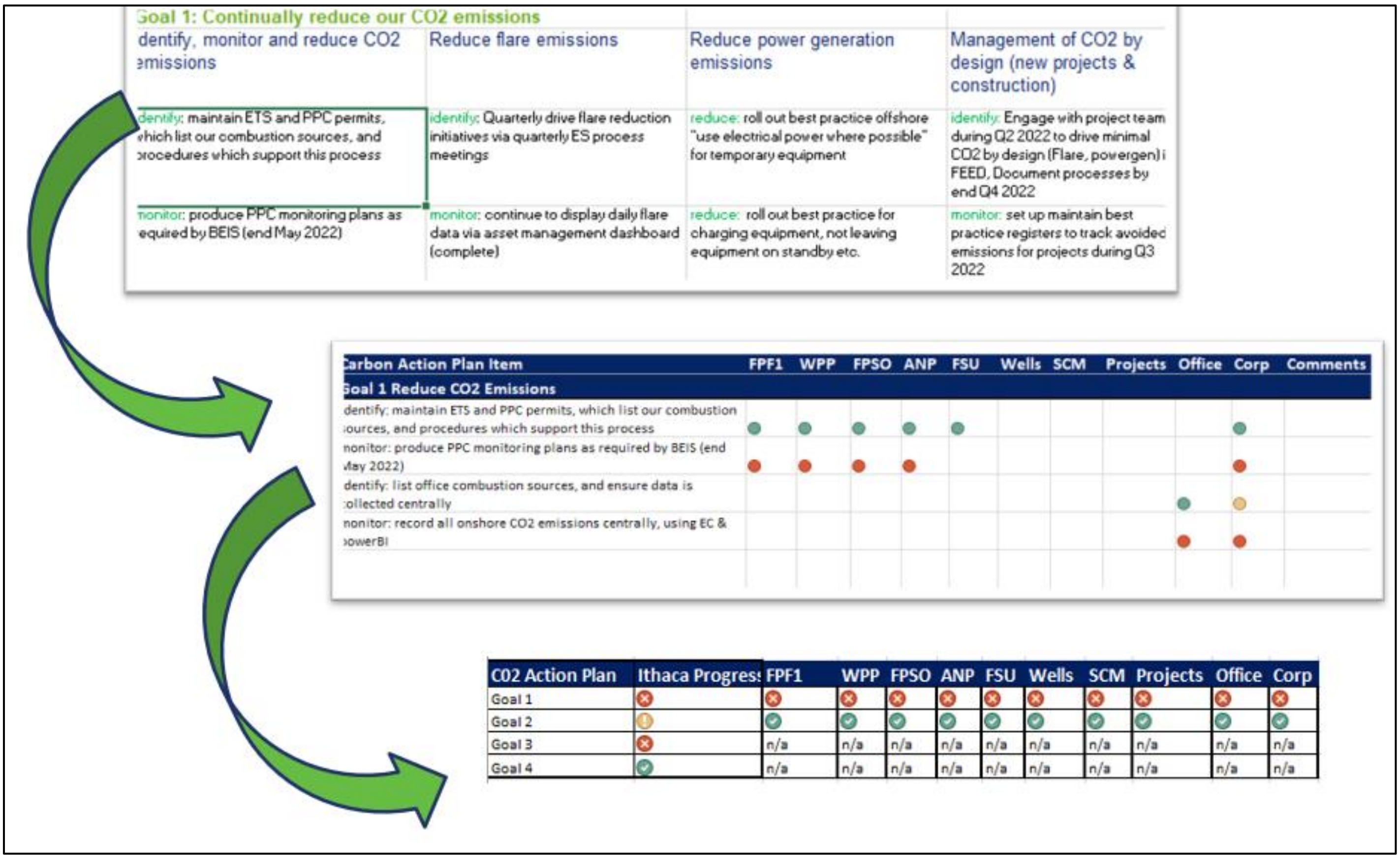


Figure 2-3: Illustration showing Goal 1 breakdown on ERAP.

2.4.4 ISO50001 Energy Management System Certification

ISO 50001 is the international standard for EMS. It is designed to enable organisations to establish systems and processes necessary to improve energy performance, including efficiency, use and consumption.

Ithaca Energy has a mature ISO14001 EMS and is using that as a basis to develop its energy management process. The Company has a target to achieve ISO50001 certification during 2023.

Within the ISO50001 is a framework of requirements for organisations:

- Develop a policy for more efficient use of energy;
- Fix targets and objectives to meet the policy;
- Use data to better understand and make decisions about energy use;
- Measure the results;
- Review how well the policy works, and
- Continually improve energy management.

Ithaca Energy has engaged an external company to complete a gap analysis with aim of certification to the standard.

2.4.5 Asset Emissions Reduction Action Plans

In 2020 ERAP were created for each asset which set out a summary of field CO_2e emissions sources and opportunities for reduction through both operational improvements or capex investments. These opportunities targeted both carbon dioxide and methane emissions. Execution of some of these opportunities have resulted in a 10% reduction in CO_2e versus the baseline. Considerable reductions in flaring and venting have been realised. Larger scale, longer term projects that were identified are continuing to be progressed with engineering studies and asset planning.

As part of continual improvement, and with the guidance of the NSTA's Stewardship 11 expectations, the ERAPs will be revisited in Q3/Q4 2022 to refresh the status of the assets and explore further emissions reduction improvements.

2.4.6 Asset ERAP Opportunities

Table 2-1 summarises the emissions reduction opportunities identified in the 2020 Captain Development ERAP whilst Table 2-2 summarises the opportunities at other Ithaca Energy operated assets (Alba and FPF1).

Table 2-1: Captain Emissions Reduction Action Plan.

Opportunity Name	Opportunity Description	Emissions Source	Potential Annual Emissions Saving (te CO_2e/year)
Captain Solar Availability	Maximise power generated across the Captain field through use of fuel gas. Reduce power generated through diesel burn in either Solar turbines or Wartsila engines.	Power Generation	5,000
Fuel Gas Compressor Control	Fuel gas compressor control modification to allow fuel gas and import fuel gas use simultaneously.	Gas	1,000
Solar Engine A Upgrade	Replace Solar A 15 kbhp with to 16 kbhp model. This additional power will replace generation on diesel from FPSO.	Power Generation	1,200
BLP Flare Gas Recovery	Flare gas recovery.	Flare	17,600
FPSO P-4401 right sizing	FPSO P-4401 water return pump resizing to reduce recycle.	Diesel	600
Fuel Gas Compressor Start-up	Review fuel gas compressor start up consistency.	Flare	500
Recommission Fuel Gas Supply	Investigate potential on recommissioning fuel gas supply to FPSO fire heaters.	Diesel	500
Captain B Export Compressor Reinstatement	Opportunity to reduce our flaring in mid-2024 onwards, following EOR (Enhanced Oil Recovery) stage 2, by having the B export compressor available as a stand-by unit to provide effective sparing within gas export compression system.	Power Generation	11,000
FPSO COT (Cargo Oil Tank) Vapour Recovery	Recapture vented methane from cargo tanks and send to flare or re-use.	Venting	6,000
Captain Power Management Strategy	Evaluate different strategy for running power on Captain. May be scope for hybrid battery.	Diesel	500
Captain Waste Heat Recovery Unit (WHRU) Logic	Investigate replacing Logic on WHRU to stop trips.	Power Generation	500
FPSO Flare Gas Recovery	Flare gas recovery.	Flare	1,300
Add 3rd Solar	Install 3rd Solar Mars 100, and replace diesel power generation with lower carbon intensity fuel gas.	Power Generation	10,000
Alternative fuel for FPSO	Replace marine gasoil with bio-diesel blend or HVO. Lowering CO_2 footprint and reducing ETS carbon costs.	Power Generation	76,000

Table 2-2: Emission Reduction Action Plans for other Ithaca Energy operated assets in the UKCS.

Opportunity Name	Opportunity Description	Emissions Source	Annual Emissions Saving (te CO2e/year)
Alba ERAP			
Alba Unlit Flare Reduction	Reduce the duration of unlit flaring which occurs during high winds offshore.	Flare	14,000
Alba Flare Reduction	Improve control system on balancing Alba and Britannia gas. Improvements in compressor control logic and valves. Results in better pressure management and no need to flare.	Flare	28,000
Performance Testing Optimisation	Investigate Pump/Generator efficient test run time to minimum requirement. Opportunity to make efficiencies.	Power Generation	100
ANP Flare Recovery	Recapture base flaring from low pressure (LP) and high pressure (HP) flares.	Flare	16,000
Alba Turbine warmup recirculation	Evaluate recycle line for turbine warm-ups and Britannia gas supply to Solar.	Power Generation	1,000
Replace water injection pumps with more efficient models	Water injection is a high-power user, modern motors and pumps could be more efficient.	Power Generation	6,600
FPF1 ERAP			
Single GTG (Gas Turbine Generators) Operation	Operate on single GTG at higher efficiency than two.	Power Generation	11,500
FPF1 Flare Gas Recovery	Return FPF1 to a normally non-flaring installation as per the original design, allowing safe recovery of the gas that would normally be flared.	Flare	14,750
Reduce Hydrocarbon Purging	Replace purge gas with nitrogen and prevent venting methane from oily water sump and purge on atmospheric vent header.	Venting	14,000
Venting Survey	Reduce Scale of Venting and Flaring - Asset level atmospheric vent study, to include single valve isolation.	Venting	500
FPF1 Main Oil Line (MOL) Pump speed control	Switch MOL pump/LP separator level control logic to speed control. Use less pump power consumption.	Power Generation	350

2.5 Emissions Reduction Performance and Commitment

Ithaca's 2021 CO_2e intensity was 24 CO_2e/mboe generating approximately 498 ktCO_2e per year (as per the year ended December 31, 2021). This represents approximately a **10**% CO_2e emissions reduction as compared to its 2019 emissions baseline. We reduced CO_2e from flaring by 15% and CO_2e from extinguished flaring by 60% for the year ended December 31, 2021, as compared to the year ended December 31, 2019. Emissions from power generation remain our main source of emissions. Ithaca Energy continues to review opportunities to achieve our ambitious aim of a 25% reduction in 2025 and supports the OEUK Roadmap 2035 contribution to the UK Government's mandatory target of net zero GHG emissions by 2050.

The Captain EOR project is an opportunity to reduce GHG intensity, on average over field life (see Section 7), through increased production with a limited increase in energy consumption and flaring. This will be improved further by realising opportunities listed in Table 2-1. A number of those opportunities would likely not be possible without realising the value within the Captain field due to EOR. Whilst reduction opportunities would be reviewed without EOR, offsetting of emissions though reduction opportunities would be achieved sooner by progressing the project.

3. PROJECT DESCRIPTION

3.1 Project Overview

As described in Section 1.2 the Captain EOR strategy, has been split into different stages: the initial pilot study (completed), Stage 1 (completed) and Stage 2 (ongoing). Section 1.2 details the further split of the Captain EOR Stage 2 Project into two phases – Phase I and Phase II and how this ES covers those activities associated with EOR Stage 2 Phase II, execution of which is planned to commence in 2023 (see indicative schedule presented in Section 3.5).

As part of Captain EOR Stage 2 Phase II Project, the activities detailed in this section includes:

- Drilling of the six polymer wells across two new drill centres (Area D and Area E)
- Drilling of one new production well at Area B (an existing drill centre);
- The installation and commissioning of the required subsea infrastructure;
- Modifications to the topsides of the BLP and the WPP platforms and the Captain FPSO and;
- Additional production (relative to operation without the Captain EOR Stage 2 Phase II project); and
- Decommissioning.

3.2 Status of the Existing Captain Field

Section 1.1 provides an overview of the Captain field whilst Table 3-1 summaries the total number of wells at the field by the end of 2022 (which includes Captain EOR Stage 2 Phase I wells) and following drilling of the wells captured in this ES.

Table 3-1: Total well counts associated with Captain at the end of 2022 and following completion of the EOR Stage 2 Phase II Project.

Well type	Number of wells before the Captain EOR Stage 2 Phase II activities*	Number of wells after the Captain EOR Stage 2 Phase II activities
Platform wells (Area A)		
Production wells	18	18
Aquifer production well	1	1
Water injection well	4	4
Polymer injection wells	5	5
Area B		
Production wells	14	14
Water injection well	3	3
Polymer injection wells	1	1
Area C		
Production wells	3 (1 new plus 1 existing plugged)	3 (1 new plus 1 existing plugged)
Water injection well	0	0
Polymer injection wells	0	0
Area D and E		
Production wells	0	0
Water injection well	0	0
Polymer injection wells	0	6 in total (3 at each drill centre)
*Note the total well counts includes wells drilled as part of Stage 2 Phase I (i.e. the wells to be drilled/converted in 2022).		

3.3 Nature of the Reservoir

Hydrocarbons at the Captain Field are produced from three main reservoirs referred to as:

- the Upper Captain Sandstone (UCS);
- the Lower Captain Sandstone (LCS, including a compartment named Southern Upper Captain Sandstone or SUCS); and
- the Jurassic/ Ross Sandstone.

The UCS is a Lower Cretaceous deep water turbidite reservoir. It is a high NTG[1] (97%) sheet like sandstone deposited in an unconfined turbidite setting. The UCS oil is a moderately heavy biodegraded crude of an average API gravity of 19.7 degrees.

The LCS is a Lower Cretaceous deep water turbidite reservoir. It is a high NTG (90-95%) channelised turbidite sandstone. Despite a high NTG, local baffles between channels are present. Within the LCS, the oil is trapped in a complex stratigraphic and structural closure. The LCS oil is more biodegraded than the UCS oil and has viscosity of around 112cP. The oil API gravity is 18.63 degrees at Pb @ Tres of 957 psia. LCS oil is slightly more viscous than UCS oil at around 112cP.

[1] NTG: Net-to-Gross refers to the fraction of reservoir volume occupied by hydrocarbon-bearing rocks.

The Ross sandstone is a fluvio-deltaic Jurassic (Oxfordian) faulted reservoir located near the Captain Ridge. Oil is trapped in a complex faulted and stratigraphic closure. Average porosity is 26% and the NTG is 80 to 90%. In this area of the Field, oil is also trapped in the Burns sandstone (Lower quality sandstone – age Volgian), but to date it is unclear if the Burns sandstone contributes to production.

Characteristics of the Captain reservoir are summarised in Table 3-2. Figure 3-1 shows the UCS elevation whilst Figure 3-2 shows the existing wells and the proposed new wells at the Captain field.

Table 3-2: Reservoir Properties.

	UCS (Area A+B)	UCS (Area A)	LCS	Jurassic/ Ross
Original Oil Water Contact (OOWC) (ft tvdss*)	-2,982	-2,967	-2,992	-3,028
Original Gas Oil Contact (OGOC) (ft tvdss*)	-2,799	-2,723	N/A	NA
NTG	97%	97%	90-95%	80-90%
API Gravity (degrees)	19.7	19.7	18.8	20.26
Oil Viscosity (cP)	80	60	112	40
Temperature (°F)	87	87	87	87
Solution gas/oil ratio (Rs in SCF/stb at Pb)	132	132	98	155
*ft TVDss – feet True Vertical Depth subsea				

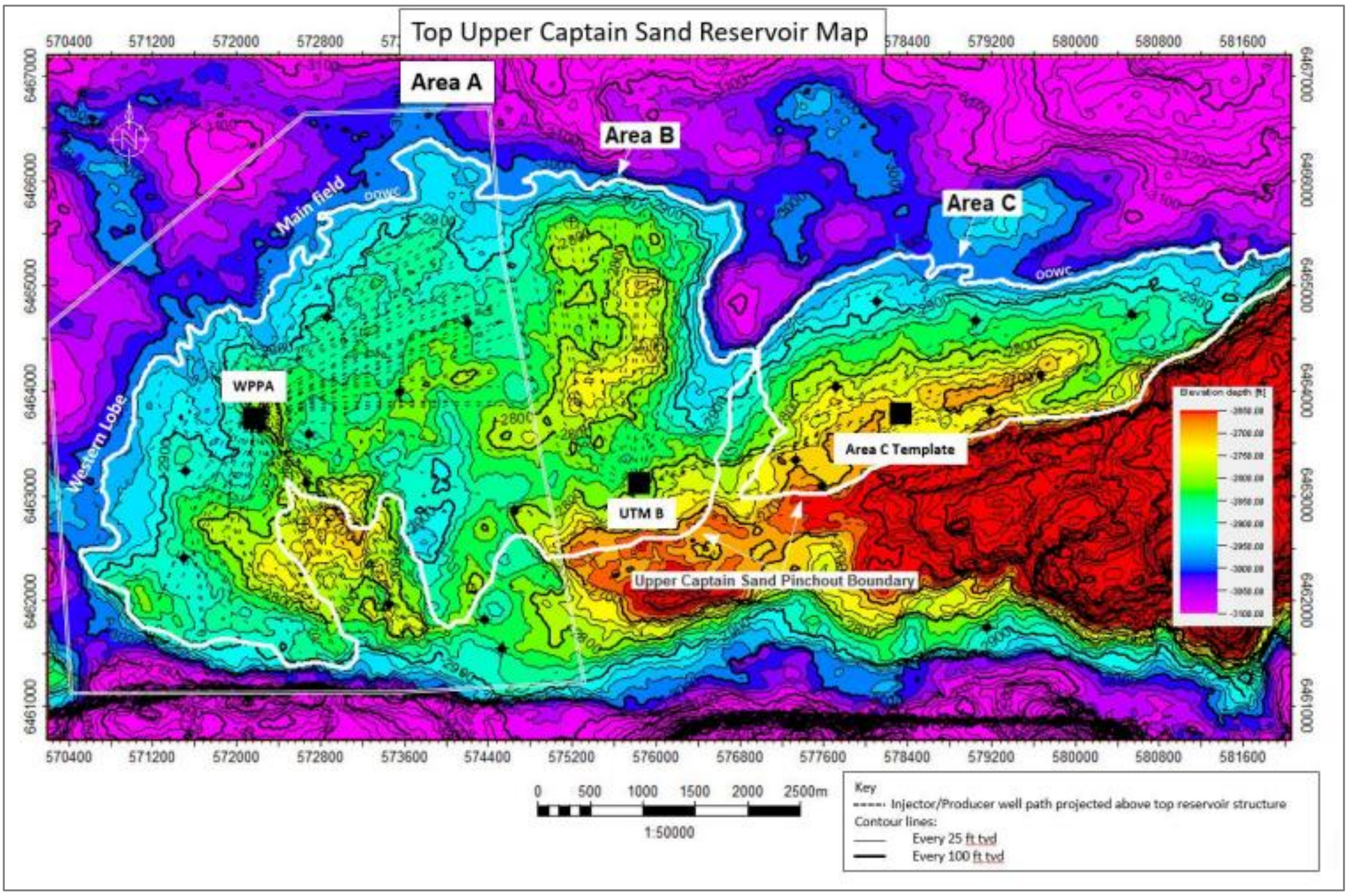


Figure 3-1: Top UCS (P50) reservoir elevation (ft tvdss). Area A, EOR Stage 1 Development, is highlighted with the white, square polygon. Area B&C, EOR Stage2 Development, is the area outside the square white polygon.

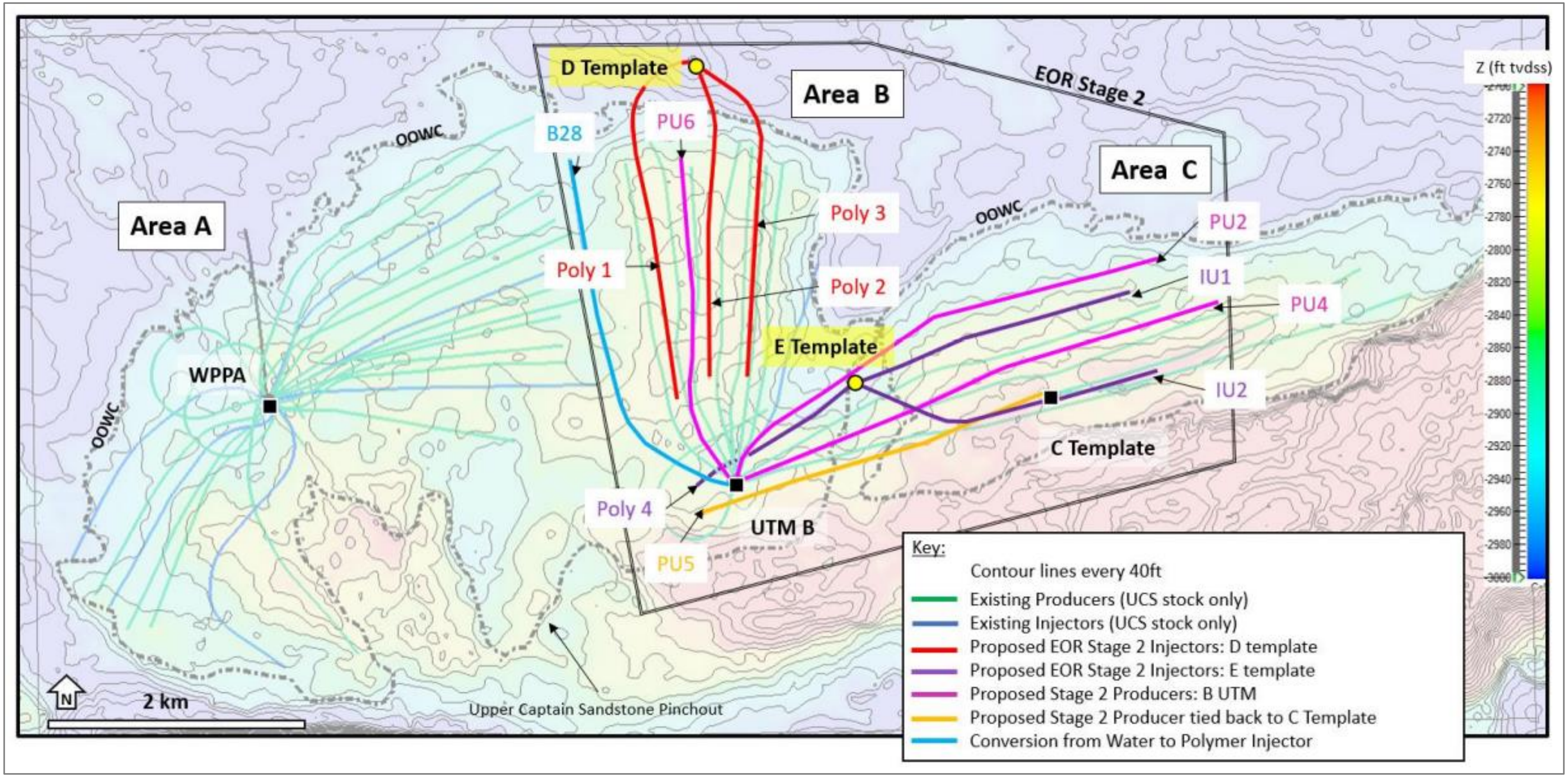


Figure 3-2: Captain structure map showing well stock prior to EOR Stage 2 Phases I and II Development (for note the proposed Stage 2 producer tied back to the C template and the conversion of Well B28 from water to polymer injection are both part of EOR Stage 2 Phase I and therefore are not considered in this ES).

3.3.1 Anticipated Recoverable Volumes

The estimated total recoverable volumes of oil from the Captain Field are anticipated to be 470 million barrels (MMBBL).

3.4 Option Selection

This sub section summarises the options considered for the following facets of the Captain EOR Stage 2 Phase II Project:

- Use polymer injection or continue with produced water/water injection;
- Type of polymer;
- Number and location of the polymer injection wells;
- Type of well;
- Number of flowlines and method of installation;
- Use of piled or gravity based Subsea Umbilical Distribution Structures (SUDS) at each drill centre.

3.4.1 Polymer Injection v's Use of Water Injection

If the new polymer injection wells are not drilled, there will be a *c*. 4% reduction in the recovery factor from the Captain field. The new polymer injection wells will inject a polymer solution, which acts as displacing fluid at a higher viscosity than the normal PWRI water. This changes the displacing fluid mobility resulting in much more efficient displacement of the oil to the adjacent production wells. The improved displacement of the oil from the polymer solution vs the PWRI water results in the EOR.

3.4.2 Type of Polymer

Captain uses a water soluble polymer to increase the viscosity of the injected water. There are two main types of water soluble polymer used in industry, namely Xantham and partially hydrolysed polyacrylamide (HPAM). Of these HPAM is the most widely used and easiest to manufacture in large quantities. Captain has been using a HPAM product since the first pilot, which was chosen based on its ability to provide high solution viscosity, while maintaining good injectivity in the injection wells. HPAM is commercially available in a solid powder form, and a liquid emulsion form. Captain uses HPAM in the liquid emulsion form, which significantly improves the ability to transport, store and mix the polymer product in an offshore location. The HPAM products used at Captain have undergone continuous development since the first pilot in 2011 with an aim to improve product performance, in particular the viscosity yield for a given concentration and the injection performance. The polymer product that will be injected into the EOR Stage 2 wells will be the same product that is currently being injected into the existing Stage 1 wells. Continuous technical optimisation of this product is expected to continue throughout the operational life of the Stage 2 wells, however the basic chemistry described above is not currently expected to change significantly.

3.4.3 Number and Location of the Polymer Injection Wells

Determining the optimal injection well number and spacing is a function of: (1) the polymer viscosity required to meet the optimal displacement ratio; (2) the reservoir thickness and properties; (3) oil saturation at that location; and (4) the desired phasing of oil production. In essence, the well spacing is a technical decision based on pore volume swept and injectivity decline, and an economic decision.

Given the target pore volumes to be swept at the Captain field by the polymer solution, a full field polymer flood requires the addition of the six new injectors and two infill producers (one of which is being drilled in 2022 at Area C and the second will be drilled at Area B as detailed in this ES).

In summary, the location of the injection and production wells allow the optimal reservoir pore volume to be swept. For note the original water injection well locations were peripheral and therefore not optimal for conversion to polymer injection wells.

Within each drill centre, the location of the wells has been selected to minimise the drilling effort and the length of the flowline and Electro-Hydraulic (EH) umbilical routes. It will be possible to skid the drilling rig between the wells within Area D and Area E such that the anchors will only be required to be placed once at each drill centre.

3.4.4 Type of Well

Selection of well technology included a review of the available geotechnical information for the area and a review of all available technologies. The review indicated that suction can based technologies may be suitable for Captain and Ithaca Energy engaged with the main provider of these technologies (NeoDrill CANDuctor) providing them with all available geotechnical information. Following evaluation of the existing geotechnical data, NeoDrill CANDuctor concluded that there was insufficient information to be able to engineer a suitable system. Schedule constraints, additional cost and emissions associated with a dedicated survey to obtain further geotechnical information was considered to be unlikely to offset the time, cost and environmental impact of drilled and cemented conductors. Given these constraints combined with the fact that to date the Captain field has been developed with drilled and cemented conductors it was determined to use this tried and tested approach for the proposed wells. To minimise the critical path rig time, and associated emissions, Ithaca Energy has elected to deploy the innovative Deltatek inner string conductor cement technology, Quickcure, which entails the pumping of heated seawater to speed up the cement setting process and minimise time "waiting on cement". This technology provides the opportunity to minimise excess cement to the seabed if returns are observed. This Deltatek "inner string" approach has also been used on the surface casing where cement returns are to the seabed to provide opportunities to minimise excess cement on the sea floor. The selected well technology is therefore considered to represent Best Available Technology (BAT).

3.4.5 Number of Flowlines and Flowline Installation Method

The polymer solution will be mixed topsides on the BLP and will flow to each of the polymer injection wells via individual flowlines. The nature of the polymer means it is not possible to utilise a single flowline to each drill centre as the performance of the polymer would be severely degraded. Utilising a single flowline to each drill centre would require a manifold to be installed at each drill centre to distribute the polymer to each injection well. Within the manifold pipework, valves would be required, including a choke valve to manage the distribution of the polymer flows to each well. Flowing the shear sensitive polymer through a choke valve and the various tees etc. within the manifold pipework would generate significant turbulence to the flow stream[2]. This turbulence would degrade the performance of the polymer to the point that it becomes ineffective, hence the requirement to lay a separate polymer flowline to each injection well.

The flowlines and EH umbilicals will be trenched their full lengths apart from on the approaches to the BLP, SUDS or wells. At these approaches the lines will transition out of the trench and be surface laid and protected with a combination of mattresses and 25 kg grout bags.

Given the small size of the flowlines and umbilicals, laying the lines exposed on the seabed was not a feasible option, whilst burying the lines was considered preferable to adding rock berms along the full line lengths.

Jet trenching has been selected over ploughing and backfilling due to the soil in the Captain field area, past trenching performance in the field and as a way of minimising the seabed disturbance.

The flowlines will be pressurised on the seabed before being jet trenched individually to 'lock-in' the expansion that the flowline experiences as a result of being pressurised. This helps to mitigate the requirement for subsequent rockdump to alleviate any buckling concerns. Should there be any issues encountered during the trenching operation (e.g. boulders causing large deformations, etc) then the risk of

[2] Shear sensitive liquids change viscosity when under stress or pressure.

upheaval buckling may still exist however, and it is on this basis that, what is considered to be a worst case, contingency volume of rockdump has been allowed for (see Section 3.7.4).

The option to lay 2+ lines in a single trench was explored, however it was not considered technically feasible as it would rule out the option of pressurising the flowlines prior to trenching. Given the nature of the flexible flowlines if multiple lines were to be laid within a single trench, without being pressurised, then the likelihood would be that the entire length would require to be rockdumped to mitigate buckling risks.

3.4.6 Subsea Umbilical Distribution Structures: Piled v's Gravity Based

Piled and gravity-based structure designs were initially considered for the three SUDSs. Whilst 500 m exclusion zones will be applied, Ithaca Energy has previously experienced fishing vessel incursions into the existing subsea drill centres at the Captain field and have had to remove nets from existing subsea trees. Therefore, a piled structure has been selected for the SUDS to be located at Area D and Area E. Utilising a piled design gives the advantage of providing a guaranteed foundation. Fishing vessel incursions have not occurred within the 500 m exclusion zones associated with the Captain platforms/FPSO, such that a gravity-based design has been selected for the third SUDS which will be located in close proximity to the BLP.

3.5 Schedule of Activities

Table 3-3 provides an indicative schedule for the offshore activities associated with the Captain EOR Stage 2 Phase II activities.

Table 3-3: Indicative schedule for the proposed Captain EOR Stage 2 Phase II activities.

Activity	2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Drilling of the polymer injection wells at Area D, and Area E and the production well at Area B	■	■	■	■	■	■		
Installation of subsea infrastructure		■	■					
First injection at Area D					■			
First injection at Area E					■			
First oil from new production well at Area B						■		
Note: as described previously the topside modifications required for the Captain EOR Stage 2 project commenced in 2021 and will be completed in 2023.								

3.6 Drilling

3.6.1 Drilling Rig

The COSLPioneer semi-submersible drilling rig will be used to drill the six new polymer injection wells and the new production well. This drilling rig is also being used to drill the Captain EOR Stage 2 Phase I production well and any lessons learned from this well will be applied to the wells to be drilled as part of Captain EOR Stage 2 Phase II.

3.6.2 Drilling Locations

The location of the top holes for each well are shown in Figure 3-3 and provided in Table 3-4. At Area D and Area E the polymer injection wells (three at each drill centre) will be located within 65 m of the new SUDS to be installed at each drill centre. The production well at Area B will be drilled at the existing UTM.

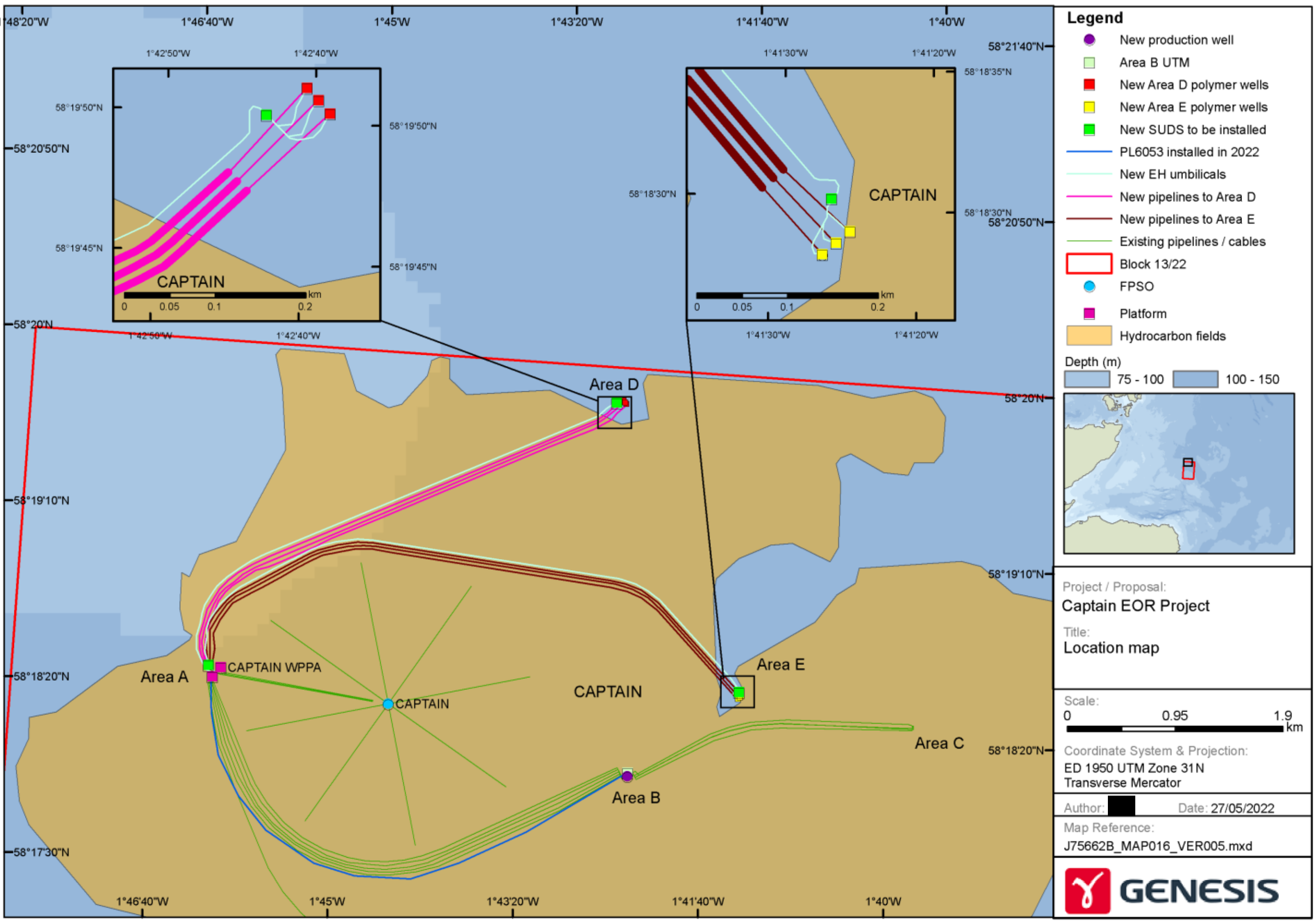


Figure 3-3: Location of new wells and subsea infrastructure associated with the Captain EOR Stage 2 Phase II project.

Table 3-4: Proposed locations of the six polymer injection wells and the production well.

Well	Co-ordinates (ED 1950 UTM Zone 30N)
Area D – D1	58°19' 50.30" N 01°42' 38.50" W
Area D – D2	58°19' 50.76" N 01°42' 39.34" W
Area D – D3	58°19' 49.84" N 01°42' 37.65" W
Area E – E1	58°18' 28.62" N 01°41' 25.47" W
Area E – E2	58°18' 28.18" N 01°41' 26.35" W
Area E – E3	58°18' 29.07" N 01°41' 24.60" W
UC02P production well (Area B)	Slot HH on the UTM

3.6.3 Positioning and Anchoring of the MODU

The COSLPioneer will self-propel to the first drilling location and will be held in position using eight anchors (maximum dimensions 6.4 m (W) x 7.1 m (L) each). The three polymer wells at each drill centre will be located *c*. 25 m apart such that the drilling rig can be skidded between the well locations within each drill centre. Therefore, the anchors will only be laid three times as part of the total campaign: i.e. once at Area D, once at Area E and once at Area B. The close proximity of the wells within each drill centre also allows the wells to be batch drilled and batch completed for maximum efficiency and therefore minimising the duration of the drilling campaign.

The anchors will be deployed using up to two Anchor Handling Vessels (AHVs). The precise anchor mooring spread for the drilling rig will be defined by a mooring analysis at each drill centre. The mooring analysis will be undertaken prior to bringing the drilling rig onto location at each drill centre and will take into account the water depth, currents, tides, prevailing wind conditions and any seabed features at the drilling locations. Details of the placement of the anchors will be provided in the CtL permit applications which will be submitted before the drilling rig is mobilised to each drill centre.

Whilst in position, and in accordance with the Petroleum Act 1998, a statutory 500 m safety exclusion zone will be automatically established around the COSLPioneer. Unauthorised vessels, including fishing vessels, are not permitted to enter this 500 m zone. Note, at the time of writing Ithaca Energy had applied for a 500 m exclusion zone at Area D and Area E.

Once on location, the COSLPioneer will be serviced by supply vessels which will transport drilling equipment, supplies, water, fuel and food and will backload wastes and surplus equipment to shore. Helicopters will also be used to transport personnel to and from the drilling rig. A dedicated Emergency Response and Rescue Vessel (ERRV) will be present in the field during drilling operations at Areas D and E. When drilling at Area B the Captain Platform ERRV may be shared, subject to risk assessment. Section 3.6.10 details the number of vessel days, and helicopter trips associated with the drilling campaign.

3.6.4 Blowout Preventer and Well Control Equipment

The drilling rig will be equipped with a Blowout Preventer (BOP) which is rated for pressures beyond the maximum pressure anticipated for the wells being drilled.

The function of the BOP will be to prevent uncontrolled flow from the wells to the surface during drilling by positively closing in the well in the event of an uncontrolled release from the reservoir into the well bore. The BOP is made up of a series of hydraulically operated rams that can be closed in an emergency from the drill floor, or from a safe location elsewhere on the rig. The BOP could also be operated subsea from a Remotely Operated Vehicle (ROV).

The integrity of the BOP will be tested prior to usage and periodically during the drilling. Inspection and testing of the BOP will be undertaken in line with the operator, Ithaca Energy procedures and UK legislation.

3.6.5 Well Design

The Captain wells will be drilled and completed in accordance with Ithaca Energy's Wells Standard and associated Well Delivery Process. The basic polymer injection well design is summarised in Table 3-5 and illustrated in Figure 3-4, whilst the basic production well design is summarised in Table 3-6 and illustrated in Figure 3-5. These well designs are similar to the wells drilled at the Captain field to date. Detailed well design specifics are still under analysis but will be provided in future drilling permit applications.

Table 3-5 – Polymer injection well design and programme.

Well section diameter (inches)	Length of section (m)	Mud System	Weight of mud (te)	Estimated weight of cuttings (Te)	Cuttings handlings
36"	58 - 79	Seawater and viscous sweeps.	500	91 - 124	Discharged at the seabed
17½"	328 - 352		300	122 - 131	
12¼"	684 - 968	WBM	676	137 - 194	Discharged at sea surface
8½"	1,161 – 2,114		205	112 - 204	
Total	**2,231 – 3,513**	**-**	**1,681**	**462 - 653**	

Table 3-6 –Production well design and programme.

Well section diameter (inches)	Length of section (m)	Mud System	Weight of mud (te)	Estimated weight of cuttings (te)	Fate of cuttings
36"	The new production well to be drilled at the Area B UTM will be drilled as a side-track to a previously abandoned well. The two top hole sections from the previously abandoned well will be used for the new well such that there will be no cuttings associated with these sections.				
20"					
14 ¾"	540	WBM	296	156	Discharged at sea surface
12 ¼"	1,800		509	358	
8 ½"	1,200		211	115	
Total	**3,540**	**-**	**1,017**	**629**	

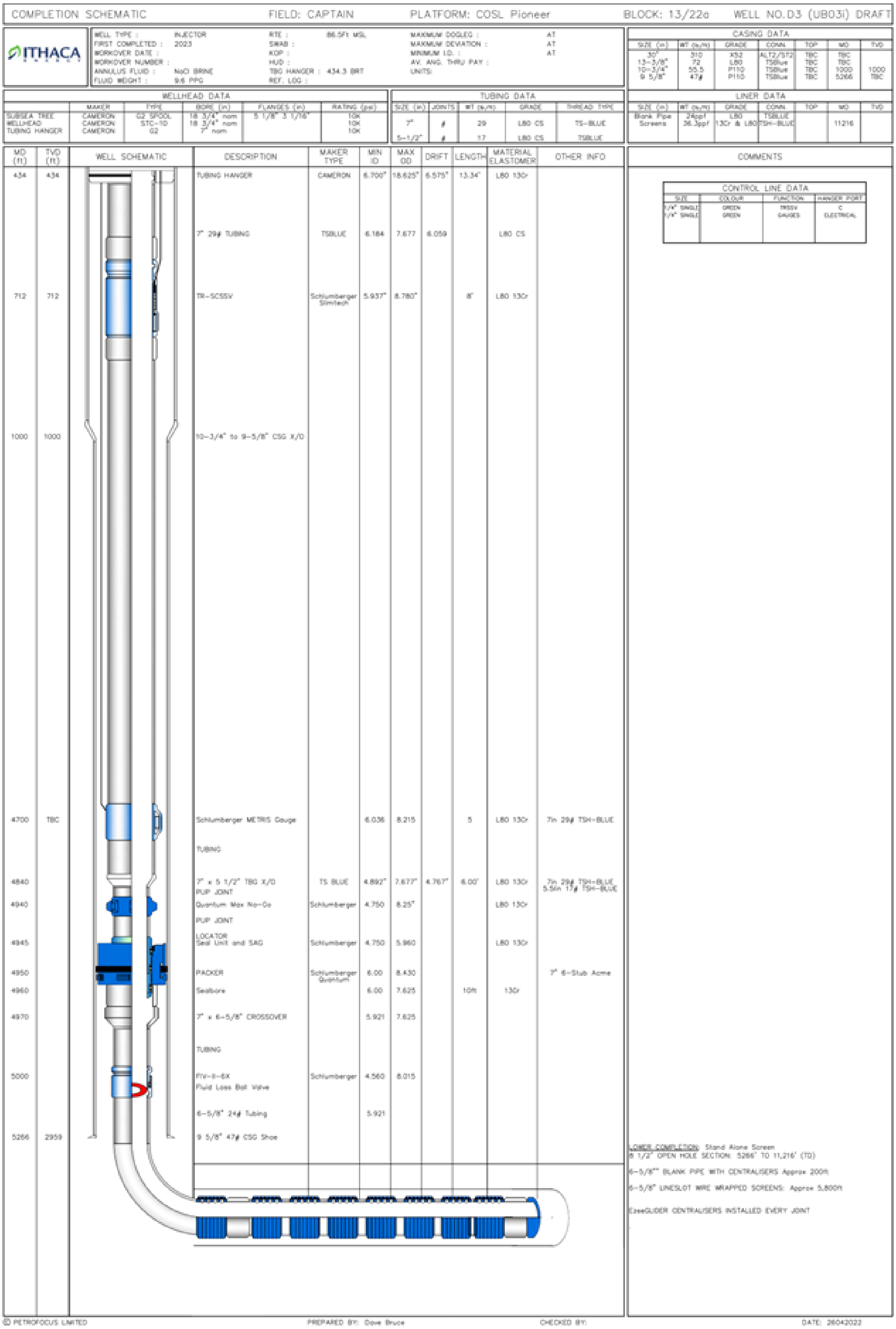


Figure 3-4: Example schematic of the polymer injection well.

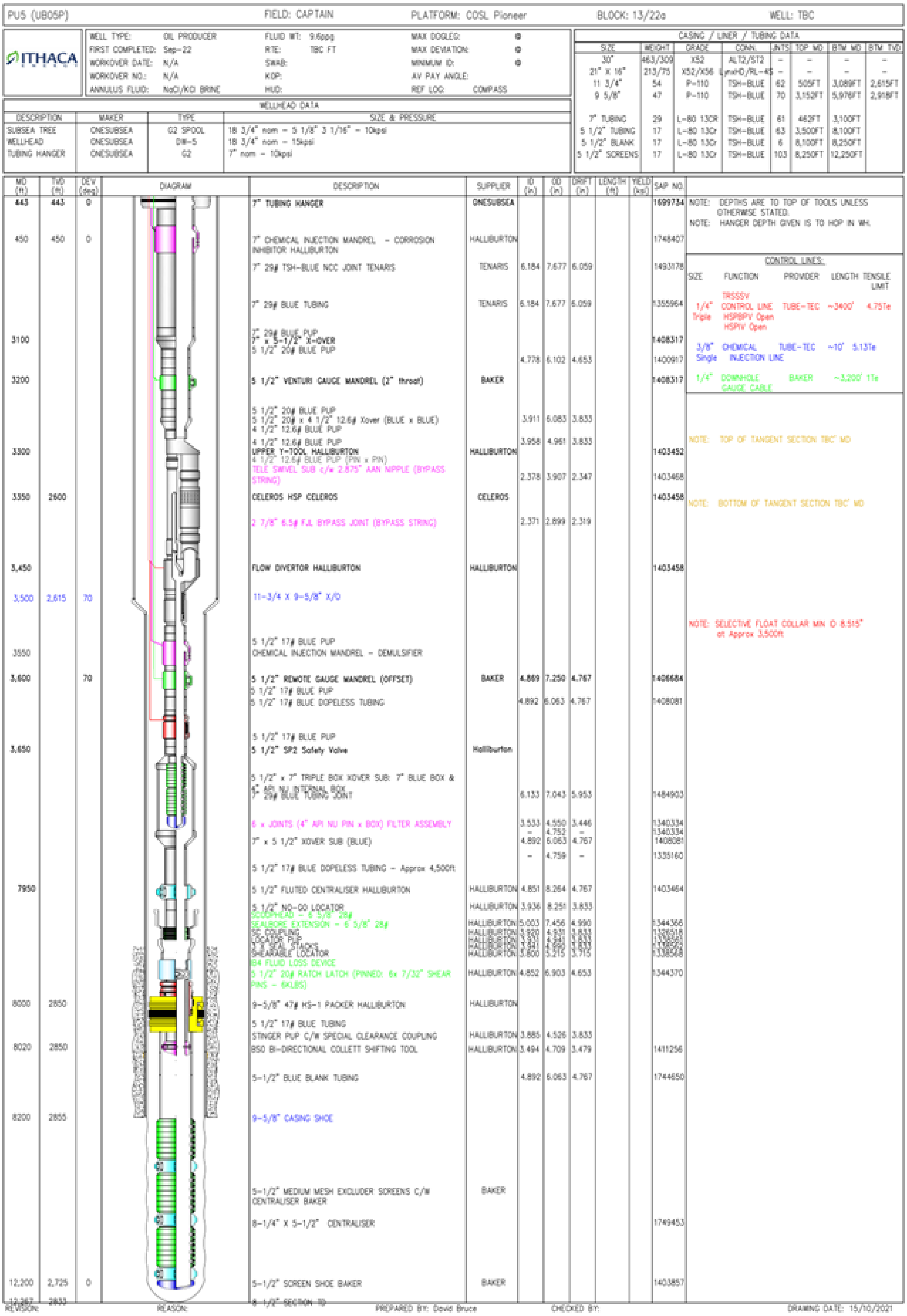


Figure 3-5: Example schematic of the production well.

3.6.6 Drilling Mud and Cuttings

Drilling fluids are required for a number of reasons including:

- Managing hydrostatic pressure and primary well control;
- Transportation of drill cuttings to the surface;
- Preservation of the wellbore to facilitate casing / completion installation; and
- Cooling and lubrication of the drill bit.

During drilling, fluids are continuously pumped down the drill string to the drill bit and returns to the surface through the annular space between the drill string and the sides of the well. Different mud formulations are required at different stages in the drilling operation because of variations in pressure, temperature and the physical characteristics of the rock being drilled.

As detailed in Table 3-5 and Table 3-6 all well sections will be drilled with either seawater and viscous sweeps or with Water Based Muds (WBM). The mud and entrained drill cuttings will be discharged to the marine environment for all sections. Table 3-5 and Table 3-6 summarises the maximum anticipated mud volumes and mass of cuttings associated with each well section. Full details of the mud composition and volumes will be provided in separate drilling permit applications prior to drilling commencing at each well.

3.6.7 Cementing Chemicals

Cement is used to secure the steel conductor and casings in the well bore, whilst cementing chemicals are used to modify the technical properties of the cement slurry. During cementing operations the majority of these chemicals are left downhole but a small quantity of cement may be discharged onto the seabed around the top of the 30" conductor and 20" casing while filling the annulus between them and the host rock formation with cement. This excess over the annulus volume is required to give confidence that the cement has completely filled the conductor annulus and displaced all the mud present to provide a strong bond, on which the entire well is secured. It is estimated that approximately 20 te of cement could be discharged on the seabed immediately adjacent to each well location. The ES assumes that at each well location the resultant cement patio will have a radius of 7.5 m. Subsequent use of cement is contained downhole as further casings do not require the cement to be pumped into the annulus all the way up to the surface.

Discharges of other cementing chemicals such as cement mix water and spacers may occur when cleaning out the cement mixing and pumping equipment. Cement mix water is the term used to describe the fluids used to mix the cement, whilst spacers are the fluids used to aid the removal of drilling fluids before cementing.

At the time of writing the detailed cement design has yet to be finalised, however, estimates of the type and volume of cement are provided in Table 3-7.

Table 3-7: Estimated cement requirements per well.

Cement job	Volumes	Cement type
Polymer inject well		
36"	100 bbls spacer + 440 bbls cement	RHC
17½"	150 bbls spacer + 470 bbls cement	RHC
12¼"	80 bbls spacer + 100 bbls cement	Class G
8½"	N/A	N/A
Production well at the UTM in Area B		
36"	The new production well to be drilled at the Area B UTM will be drilled as a side-track to a previously abandoned well. The two top hole sections from the previously abandoned well will be used for the new well such that there is no requirement for cement for these two sections.	
20"		
14 ¾"	80 bbls spacer + 100 bbls cement	Class G
12 ¼"	80 bbls spacer + 100 bbls cement	Class G
8 ½"	N/A	N/A

All cementing chemicals to be used will be selected based on their technical specifications and environmental performance. Class G cements have no additions other than calcium sulphate and/or water and are intended for use as a basic well cement. Chemicals with substitution warnings (i.e. chemicals that are considered to be harmful to the environment) will be avoided where technically possible. The cementing chemicals to be used have not yet been determined but will be detailed in subsequent drilling permit applications.

Similar to the drilling and cementing chemicals, the chemicals associated with the completions operations will be captured in the subsequent drilling permit applications.

3.6.8 Well Clean-up and Testing

No well fluids will be flowed to surface for the six polymer injection wells. In addition, there will be no flaring associated with the completion/clean-up of the new production well to be drilled at Area B.

3.6.9 Relief Well Location

A plan will be put in place for the drilling of a relief well to intersect the Captain wells in the event of a well blowout and will include a proposed drilling rig location from which a relief well could be drilled. Any well planned that is capable of flow to surface has a relief well planning package developed ahead of operations. In addition, the site survey will cover a minimum of one relief well location which is reviewed to confirm feasibility and trajectories are developed to ensure that it is feasible to drill, intersect and dynamically kill.

3.6.10 Drill Rig Support Activity

Various support vessels will be associated with the drilling operations such as AHVs, supply vessels etc. Table 3-8 summarises the estimated duration that each vessel will be on site and their estimated fuel use. Estimates provided are based on batch drilling the three polymer wells on each drill centre to maximise efficiency. The production well is estimated to take 100 days to drill. Due to the proximity of the wells at each drill centre, the rig will be skidded between the wells without having to relocate its anchors so as to minimise seabed disturbance.

Table 3-8: Fuel consumption of vessels associated with the drilling of the Captain wells.

Vessel type	Days on transit/on site*	Fuel consumption (te/d)**	Total fuel use (te)
Drilling rig	395 days Allows 141 days to drill the three wells at Area D, 154 days to drill the three wells at Area E and 100 days to drill production well at Area B	15	5,925
AHV (mob/demob/transit) x 2	24 days Two AHV and assumes four days transit per AHV for positioning of anchors at each site (i.e. at Area B, D and E)	27	648
AHV (working) x 2	24 Allows four days per AHV for positioning, connection and recovery of the anchors at each site (i.e. at Area B, D and E).	27	648
ERRV***	395 Assumes dedicated ERRV on site whilst drilling rig is on site	6	2,370
ERRV crew changes (crew changes every 28 days, 1 day allowed per change.	15 days Crew changes every 28 days, 1 day allowed per change.	10	150
Supply Vessel (mob/demob transit)****	197.5 days	10	1,975
Supply Vessel (working)****	197.5 days	6	1,185
Helicopter (te/hr)	Four trips per week (226 trips – 1.5 hours round trip) = 339 hours flying	0.7 te per hour	237
Total fuel use			**13,138**

* Drilling schedule still being developed, duration presented is the maximum anticipated.
**Source: The Institute of Petroleum, 2000.
*** As described in Section 3.6.3, it is possible that when drilling at Area B, the Captain Platform ERRV may be shared, however as a worst case the ES assumes that it will not be shared.
**** Assumes supply vessel for 125% of time rig is on location, allowing for 25% spot hire of a second supply vessel. Also assumes for total hire, half time is spent in mob/transit and half time working.

Note the relatively low fuel use associated with the drilling rig (see Table 3-8) is a result of COSL's continuous investment in reducing emissions. COSL Drilling Europe is ISO 14001 "Environmental Management System" and ISO 50001 "Energy Management System" certified. COSL continuously invests in technology and competence that improve energy performance. A major contributor to this philosophy has been the installation of COSL's Energy Control System on board the COSLPioneer; a system previously installed and proven on two sister vessels. This system monitors the energy consumption and delivers substantial reductions in CO_2 and NO_x by optimising operations and engine utilisation. Since installation on board the COSLPioneer the system calculated fuel savings of 1,661 MT in just over five months. This equates to a reduction over the same period of 5,267 MT in CO_2 and 88 MT in NO_x emissions respectively.

3.7 Subsea Infrastructure

As with the existing Captain field infrastructure, the subsea facilities for the Captain EOR Stage 2 Phase II Project will be designed in accordance with all statutory requirements for offshore facilities in the UK territorial waters using all relevant industry codes. Table 3-9 summaries the subsea infrastructure to be installed in support of the EOR Stage 2 Phase II Project. Figure 1-4 illustrates the new infrastructure to be installed and Figure 3-3 shows its location relative to the existing field infrastructure. The design life of the subsea facilities is 20 years.

Table 3-9: Subsea infrastructure associated with the captain EOR Stage 2 Phase II Project.

Item No.	Description
1	Seven Xmas trees: one each for the polymer injection wells and one for the new production well which will be located within the existing UTM at Area B.
2	Two piled SUDS, one at Area D and one at Area E, plus one gravity based SUDS at the BLP riser base location.
3	Three 6.6" (internal diameter) polymer injection flowlines from the BLP to Area D: *c*. 4,728 m in length with an external diameter of 228 mm.
4	A 4,709 m EH umbilical (110 mm outer diameter) from the BLP to Area D.
5	Three 6.6" (internal diameter) polymer injection flowlines from the BLP to Area E: *c*. 5,718 m in length with an external diameter of 228 mm.
6	A 5,757 m EH umbilical (110 mm outer diameter) from the BLP to Area E.
7	A 326 m EH riser umbilical (203 mm outer umbilical) from BLP topsides to the Riser base SUDS structure.
8	Three EH umbilical jumpers at Area D laid between the SUDS and the three wells: each one measuring 80 m.
9	Three EH umbilical jumpers at Area E laid between the SUDS and the three wells: each one measuring 80 m.

3.7.1 Xmas Trees

Section 3.4.3 details why the project requires six polymer injection wells across two drill centres. The Xmas trees associated with the polymer injection wells will comprise a modified design of the Captain subsea tree used for existing production wells. Each polymer injector well will have its own dedicated flowline and topside flow meter to enable individual injection rate monitoring. The injection pressures will also be monitored in each of the new injection wells. The Xmas trees for the polymer injection wells will have wellhead protection structures associated with them and will measure c. 4.92 m (L) x 4.89 m (W) x 5.8 m (H).

The production well will be drilled at one of the slots on the UTM and therefore the new Xmas tree for this well will be installed within the UTM.

3.7.2 Subsea Umbilical Distribution Structure

At Area D and Area E the EH umbilicals will tie into a SUDS. A piled SUDS will be installed at each drill centre as part of the EOR Stage 2 Phase II Project. EH umbilical jumpers will connect the SUDs to each of the wells within each location. The SUDS will each measure c. 6 m (L) x 6 m (W) x 3 m (H) and will weigh *c*. 50 te. The structures will be fishing friendly and will be located within the drill centre 500 m exclusion zones. Justification for using piled SUDS at the two new drill centres is provided in Section 3.4.6.

Four piles measuring around 25 m in length and 24" (*c*. 0.61 m) in diameter will be required for each SUDS. It is expected that it will take one hour to install each pile with the four piles at each structure being installed in a single day. The piling activities will start with a soft start and based on previous piling activities at the Area C, it is expected a maximum hammer energy of 20 kJ will be sufficient to install all piles. However, as a worst-case scenario, a maximum hammer energy of 90 kJ has been considered in the underwater noise modelling carried out to support the impact assessment (Appendix D).

A third SUDS structure will be installed at the BLP riser base location to distribute the functions from the single riser umbilical from the BLP topsides to the two umbilicals that serve Areas D and E. As this structure is located within the 500 m safety zone associated with the WPP and BLP platforms it does not require to be designed for fishing interaction and can therefore be gravity based. The size of the structure is anticipated to be 8 m (L) x 7 m (W) x 3 m (H) and weight around 70 te.

3.7.3 Flowlines, Umbilicals, Tie-In Spools and Jumpers[3]

As described in Section 3.4.5 separate 6.6" ID polymer flowlines to each polymer injection well are required. The flowlines will be of a flexible type construction with a cross-section as shown in Figure 3-6, where it will comprise a combination of metallic and polypropylene layers.

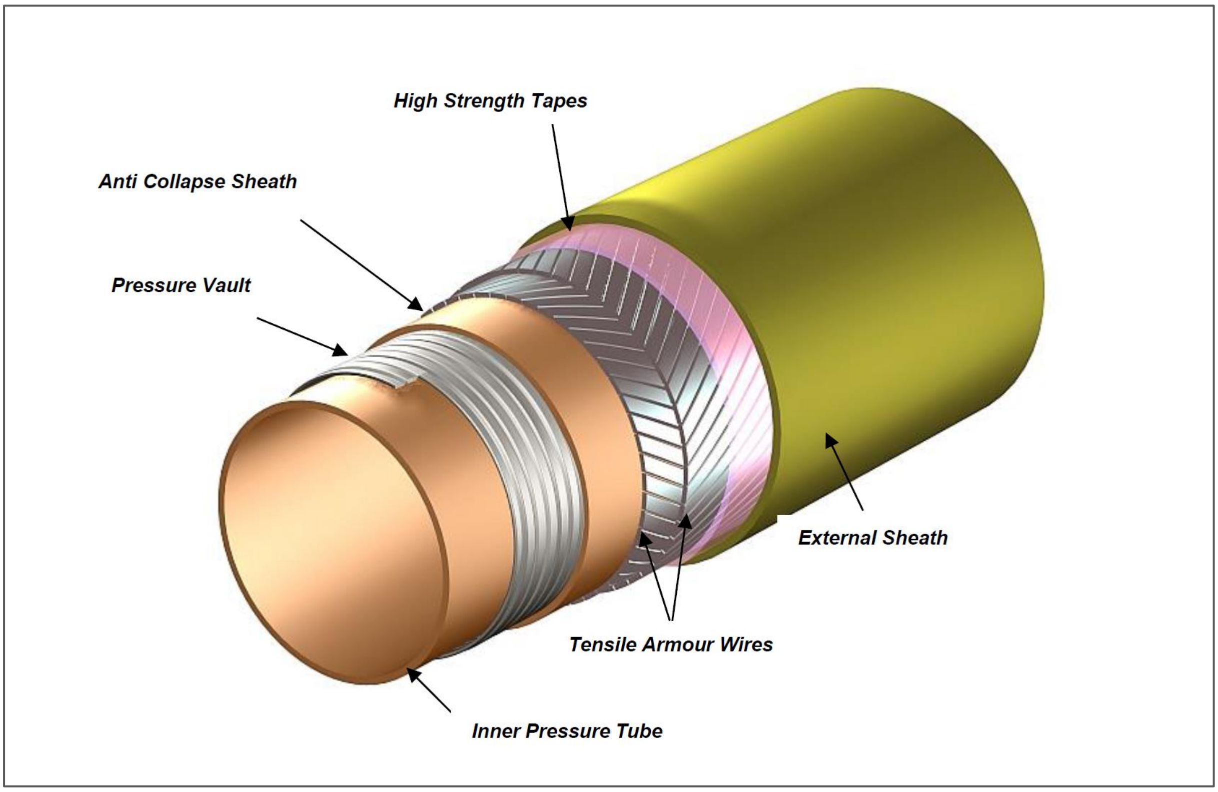


Figure 3-6: Schematic showing cross section of flowlines to be installed.

In addition to the flowlines each drill centre is served by a single EH umbilical which provides the control and monitoring of the Xmas trees. The EH umbilicals will be a combination of electrical cables, and hydraulic hoses, to effectively control and monitor the trees. There are no chemical lines within the umbilicals. At each drill centre, the EH umbilical will tie into the SUDS whist the polymer flowlines will tie directly into the polymer injection wells. The lengths of the flowlines and EH umbilicals are provided in Table 3-9.

The routing of the flowlines and umbilicals has been designed to minimise the route as far as practicable between the BLP and the drill centres taking accounting of:

- existing facilities in particular the existing FPSO mooring arrangement;
- Anchor patterns for locating the drilling rig at the drill centres;
- Approach angles at the drill centres to minimise the length of laydown loops required; and
- Avoidance of existing drilling locations.

[3] As part of the 2022 activities a new riser caisson will be installed on one of the legs of the BLP, through which the risers and dynamic umbilicals associated with the polymer injection wells will pass.

The selected route also avoids any crossing with other infield lines or with any third-party infrastructure.

Subsea flowlines will be supplied to the installation vessel on installation reels and surface laid in the field along the pre-determined routes. The flowlines will then be pressurised prior to jet trenching them to a depth of lowering of 1.0m from top of flowline/EH umbilical to mean seabed level. Given the nature of the soils in the area, it is anticipated that this depth of burial can be achieved, however the ES does capture some contingency rock cover if required (see Section 3.7.4). After the flowlines and umbilical have been laid on the seabed, a dedicated guard vessel will be on site until the jet trenching activities have been completed. The aim of the guard vessel is to advise any fishing vessels in the area of the presence of the temporarily exposed lines on seabed. Once trenched the flowlines will be depressurised down to ambient pressure to allow the tie-ins by diver to be carried out.

Once the flowlines and umbilicals have been installed and jet trenched, post lay surveys will be undertaken to determine if depth of burial has been achieved and to identify the presence of any excessive free-spans (areas where the flowlines bridge depressions or hollows in the seabed) that may need to be mitigated. The as-trenched survey will also check to ensure that there are no clay berms or spoil heaps left on the seabed following the trenching, which is considered unlikely given the jet trenching methodology. The flowlines and EH umbilical to each drill centre will be laid c. 15 m apart.

3.7.4 Subsea Infrastructure Protection

Whilst the flowlines and umbilicals will be trenched and buried along the majority of their length, mattresses and 25 kg grout bags will be used to provide stabilisation/protection to the flowline and umbilical ends as they exit the trenches at the line ends within the 500 m safety zones. In addition, it is possible that some rock cover may be required out with the exclusion zones to mitigate spanning and upheaval buckling risk. Table 3-10 summarises the maximum quantity of stabilisation features expected to be required for the proposed project.

Table 3-10: Anticipated quantities of protection features.

Item	Total	Approach to BLP	Area D	Area E
Mattresses 6 m (L) x 3 m (W) x 0.15 m (H)	412*	208	109	95
25 kg grout bags (biodegradable)	7,000*	3,000	2,000	2,000
Rock cover	20,000 te contingency only			
*Includes 20% contingency				

Prior to laying any rockdump, mattresses or grout bags, Ithaca Energy will submit a Deposit Consent application to the NSTA and the supporting environmental permit applications to OPRED.

All mattresses and grout bags will be laid within either the existing 500 m safety zones at the BLP or within the new 500 m zones that will be applied for at the Area D and Area E. All grout bags will utilise biodegradable hessian sacks.

3.7.5 Pipeline Testing and Commissioning

Following installation and hook-up pressure-testing operations will be performed to ensure system integrity, to test for any leaks and to prove the integrity of the tie-in connection points, and to prepare the system for the introduction of the polymer. Testing and commissioning operations may either be performed from the BLP or the installation vessel.

The pipelines will be pressurised in accordance with design codes to pressures above the maximum operating pressure. On completion of the testing programme the pressurisation fluid is expected to be discharged to the sea

The permitted discharge of chemicals to the marine environment is a routine part of subsea installation operations. The quantities of chemicals to be used and whether or not they are to be discharged to sea will be determined during the project detailed design stage and will be subject to a chemical permit application under the OCR. A risk assessment will be carried out as per the OCR for the relevant chemicals, profiles and associated application.

3.7.6 Subsea Installation Support Vessels

Various support vessels will be associated with the subsea installation activities. Typical vessel use, duration and fuel usage by vessels during installation are provided in Table 3-11.

Table 3-11: Vessel type and anticipated fuel usage during the installation of subsea infrastructure.

Vessel type	Days	Fuel consumption (te/d)[1]	Total fuel use (te)
Construction Support Vessel (CSV) (mob/demob/transit)	9	28	252
CSV (working)	22	25	550
Jet trenching vessel (mob/demob/transit)	3	18	54
Jet trenching vessel (working)	19	18	342
Rock dumping vessel (mob/demob/transit)	5	20	100
Rock dumping vessel (working)	2	20	40
Dive Support Vessel (DSV) (mob/demob/transit)	9	20	180
DSV (working)	32	20	640
Guard vessel (mob/demob/transit)	8	3.5	28
Guard vessel (working)	60	0.8	48
Total fuel use			**2,243**
Note: activities to be carried out by the CSV will include the pre-lay route surveys (hence why a separate line item has not been added for survey vessels).			

[1] Source: The Institute of Petroleum (2000).

3.8 Topsides Modifications

The Captain EOR Stage 2 Project includes a number of topside modifications. These modifications are being completed under the Captain EOR Stage 2 Phase I and therefore are not described in detail here. In summary the modifications commenced in 2021 and will be completed in 2023:

- Addition of new polymer pumping and mixing facilities on the BLP;
- A new water injection manifold on the BLP;
- A new riser casion at the BLP through which the Captain EOR Stage 2 Phase II risers and the dynamic umbilical will pass;
- An additional polymer transfer pump on the Captain FPSO;
- New polymer transfer pumps on the WPP;
- Modifications to existing infrastructure to tie-in the new facilities on the WPP, BLP and the FPSO.

It should be noted that the topside modifications to the BLP, WPP and FPSO do not require a flotel and do not include increases to the footprint of the existing topsides or to the existing power generation equipment.

3.9 Production

The target injection rate for each individual well is 30,000 bbls/day. The polymer will be stored on the FPSO and transferred to the WPP for mixing. From the WPP it will pass to the BLP for onward transport to the wells via the new flowlines.

The Captain field operates 100% reinjection such that there will be no PW discharges to sea. Increased inputs of PW resulting from the EOR Project will not result in exceedance of the existing PWRI system capacity.

Chemicals are used during the production of hydrocarbons to maintain process efficiency, for example: demulsifiers improve the separation of oil and water; scale inhibitors slow down the build-up of scale in pipework and valves and biocides reduce microbial growth.

Chemical usage and discharge will be captured in an update to the BLP/WPP production chemical permit prior to production commencing. Anticipated chemical requirements associated with the production of hydrocarbons from the Stage 2 Project are not expected to differ to those being used already at the Captain Field. As the Captain Field operates 100% reinjection there will be no PW discharges to sea as a consequence of the Captain EOR Stage 2 Project (both Phase I and Phase II).

Production profiles have been developed for the purpose of the Captain EOR Stage 2 Project. These forecast the likely volumes of oil and gas that will be produced. Anticipated high case volumes of oil and gas are presented here as the environmental impacts associated with the production of these volumes are likely to be greatest with respect to, for example, atmospheric emissions, discharges to sea etc.

Note as all PW will be reinjected, such that there will be no environmental impacts associated with their 'disposal', PW profiles are not presented here.

3.9.1 High Case Oil Production Profiles

Table 3-12 and Figure 3-7 show the anticipated high case oil production rates from the Captain field, assuming start-up in 2024. Maximised annual oil production for the field is anticipated in 2025 at a rate of *c*. 2,639 te/day. The mid- and low-case oil profiles are presented in Appendix E (Table E-1).

Table 3-12: High case oil production rate.

Year	Oil Production Rate (te/day)		
	Without Stage 2 project	Increase rate associated with Stage 2 Project	Total with Stage 2 project
2023	3,386	441	3,827
2024	3,643	1,165	4,808
2025	3,822	2,859	6,681
2026	3,892	2,555	6,447
2027	4,025	1,461	5,486
2028	3,374	1,198	4,572
2029	2,314	1,464	3,778
2030	1,933	675	2,608
2031	1,566	10	1,576
2032	1,335	0	1,335
2033	1,141	0	1,141
2034	1,041	0	1,049
2035	958	0	958

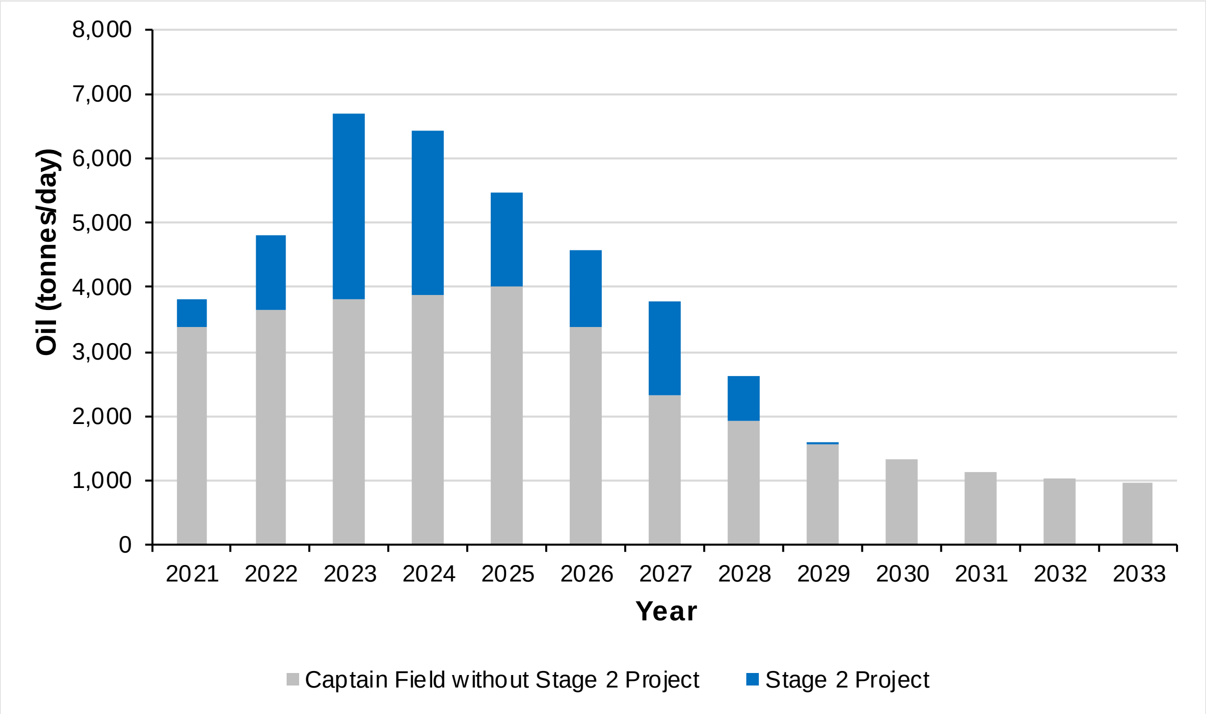


Figure 3-7: Captain field high case oil production rate alone and with Stage 2 Project high case production rate.

3.9.2 High Case Gas Production Profiles

Table 3-13 and Figure 3-8 show the anticipated high case gas production rates from the Captain Field, assuming start-up in 2023. Maximised annual gas production for the field is anticipated in 2025 at a rate of *c*. 289,657 m^3/day. The mid- and low-case gas profiles are presented in Appendix E (Table E-2).

Table 3-13: High case gas production rate.

Year	Gas Production Rate (m^3/day)		
	Captains Field without Stage 2 project	Stage 2 Project	Captains Field with Stage 2 project
2023	127,426	30,083	157,509
2024	135,922	67,012	202,934
2025	144,417	145,240	289,657
2026	147,248	135,080	282,328
2027	150,080.	93,294	243,374
2028	127,426	75,351	202,777
2029	87,783	79,939	167,722
2030	73,624	40,751	114,375
2031	59,466	7,785	67,251
2032	50,971	2,976	53,947
2033	42,475	574	43,049
2034	39,644	0	39,644
2035	36,812	0	36,812

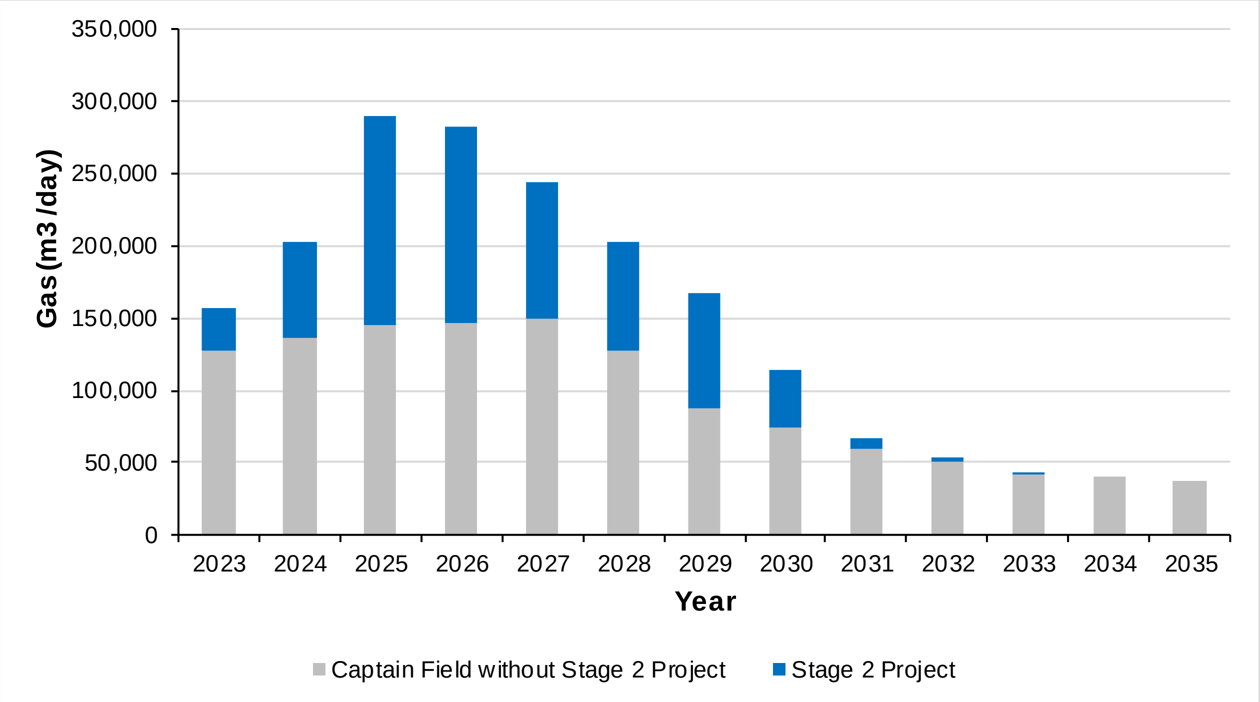


Figure 3-8: Captains field high case gas production rate alone and with Stage 2 Project high case production rate.

3.9.3 Vessel Use During Production

During production, the proposed Captain EOR Stage 2 Phase II project will not result in an increase to the ERRV, supply vessels or helicopters trips currently associated with the Captain Field. From 2024, the number of offloads increases from 20 to 31 in 2026 after which it begins to decline again. Table 7-7 presents the anticipated number of offloads through to end of field life and the associated fuel use.

Currently polymer is delivered to the Captain field once a week. From 2024 to 2029, this will increase to two deliveries per week, and from 2030 it will reduce to one trip per week. Table 7-8 shows the number of polymer offloads per year and the associated fuel use.

3.10 Key Permits and Consents

The Portal Environmental Tracking System ('PETS') is OPREDs environmental permitting system accessed via the UK Energy Portal. PETS integrates permits and consents under one centralised Master Application Template (MAT). There are six types of MAT available on the PETs system:

- Drilling Operations;
- Pipeline Operations;
- Production Operations;
- Decommissioning Operations;
- Well Intervention Operations; and
- A Standalone application.

Once a MAT has been created it can support various types of permit applications (referred to as Subsidiary Application Templates (SATs)).

Note that Oil Pollution Emergency Plans (OPEPs) and EU ETS Permits are not available on the PETS system.

3.10.1 Pollution Prevention and Control (PPC) Permit

It should be noted that the Captain EOR Stage 2 Phase II Project will require a slight increase in power demand on the platform. The existing PPC Permit will therefore be reviewed and any changes to fuel use as a result of the wells will be captured in a variation.

3.10.2 UK Emissions Trading Scheme (UKETS)

No new GHG Permit under the UK ETS Trading Scheme will be required; however, the description of the installation in the existing permit application will be updated to reflect the polymer injection wells and the new production well coming online.

3.10.3 Oil Pollution, Prevention and Control (OPPC)

Discharges of oil to sea are controlled under The Petroleum Activities (Oil Pollution, Prevention and Control) Regulations 2005. The existing BLPA Oil Discharge Life Permit will be updated to capture Captain Stage 2 Phase II coming online. In addition, Oil Discharge Term Permits will be required for the drilling activities.

3.10.4 Chemical Use and Discharges to Sea

The relevant permits to use and discharge chemicals offshore will be applied for in accordance with the OCR. All offshore activities are covered by the Regulations including oil and gas production, drilling of wells, discharges from pipelines and discharges made during decommissioning.

3.10.5 Oil Pollution Emergency Plan (OPEP)

To support the Captain EOR Stage 2 project, Ithaca Energy has submitted a Temporary Operation Oil Pollution Emergency Plan (TOOPEP) which interfaces with the existing approved Production Installation OPEP for the Captain Platform and the Non-Production Installation (NPI) OPEP for the COSLPioneer. The Captain OPEP will subsequently be updated to incorporate production from the Captain EOR Stage 2 project.

3.10.6 Consent to Drill

Ithaca Energy on behalf of their Co-Venturers will submit a Consent to Drill in the Well Operations Notifications (WONS) system to apply for consent to carry out drilling at the proposed project.

3.10.7 Consent to Locate (CtL)

Where applicable, Ithaca Energy will apply for the following CtLs:

- Mobile Installation, e.g. drilling rig;
- Permanent / fixed structure, e.g. Xmas trees; and
- Pipeline or cable system, e.g. polymer injection flowlines, and control umbilicals.

3.10.8 Pipeline Works Authorisation (PWA) and Deposit Consent (DepCon)

Ithaca Energy will submit an application for a PWA detailing the pipelines, structures and umbilical to be installed whilst an application for a DepCon will be submitted providing the location of any rockdump, grout-bags and mattresses required on the pipeline route.

3.11 Decommissioning

At Cessation of Production (CoP) the Captain infrastructure will be decommissioned in line with legislation in force at that time. In 2022 this would constitute the following:

- The Petroleum Act 1998 (as amended) and other relevant Regulations at the time of decommissioning;

- OPRED Decommissioning Guidance (November 2018);
- The UK Guidelines for Suspension and Abandonment of Wells;
- The Pipeline Safety Regulations 1996 requiring the safe decommissioning of pipelines;
- Any additional applicable legislation in place at the time of decommissioning; and
- Any other agreements with OPRED and relevant regulatory bodies.

Nearer the time of CoP, a full decommissioning plan will be developed in consultation with the relevant statutory authorities. The plan will be designed to ensure that potential effects on the environment resulting from the decommissioning of the facilities are considered and minimised.

3.11.1 Pipeline and Subsea Infrastructure

In line with current guidelines and legislation the decommissioning of the subsea pipelines would be subject to a CA and Decommissioning Programme. It is expected that the subsea structures will be removed from the seabed and returned to shore for reuse / recycling / disposal and a seabed clearance campaign conducted, however, this would be subject to future legislative requirements and guidance.

3.11.2 Wells

All well programmes will be subject to a Well Notification assessed by the Health and Safety Executive (HSE) under the Offshore Installations (Offshore Safety Directive) (Safety Case etc). Wells will be plugged and permanently abandoned in accordance with Offshore Energy UK (OEUK) well decommissioning guidelines (OGUK, June 2018) (or applicable guidance at that time). All well programmes will have been reviewed by the HSE Offshore Safety Department as required under the Design and Construction Regulations.

On completion of the well abandonment programme each conductor and internal tubing will thereafter be cut below the seabed. The subsea wellheads will then be recovered at location which could be conducted using either a DSV or semi-submersible drilling rig.

4. ENVIRONMENTAL BASELINE

4.1 Introduction

An understanding of the baseline environment is required to identify the potential environmental impacts of the proposed project and to provide a basis for assessing the potential interactions of the intended activities with the environment. The environmental receptors considered include seabed / sediments, plankton, benthos, birds, fish, marine mammals, cultural heritage and other sea users.

The Captain field lies in the Outer Moray Firth area of the UKCS Block 13/22, *c*. 70 km off the Moray coast and *c*. 188 km west of the UK/Norway median line. Water depths in the area range between *c.* 95 and 130 m (Figure 4-1).

4.2 Environmental Baseline Surveys

A number of environmental surveys have been carried out at the Captain. Where relevant this section draws on the findings of the three environmental surveys detailed in Table 4-1. Grab sample locations associated with these surveys are shown in Figure 4-1.

Table 4-1: Summary details of environmental surveys at the Captain field used to support the ES.

Survey Details	Report Reference
2021 Captain Site Survey. Survey Period 13th to 21 June 2021.	
Site survey including geophysical and environmental data acquisition. A habitat assessment was required to describe all habitats within the survey area and to identify the presence and extent of any Annex I habitats, as well as any other habitats or species of conservation interest. The aim of the environmental survey was to characterise the seabed sediment, existing contamination status and faunal community type. The survey also provides baseline information against which any future survey results can be compared and will be reported in the environmental baseline survey report. Grab samples were taken from 11 locations, eight of which covered sites previously sampled by Fugro in 2015. Samples were taken for physico-chemical and faunal analysis. Samples were taken using a 0.25 m² United States Naval Electronic Laboratory (USNEL) box core. Digital photographic stills and footage were taken at the grab sample locations and at three transect locations.	Habitat Assessment Report (Fugro 2021a) Environmental Baseline Report (Fugro 2021b)
2015 Captain Site Survey. Survey Period 16th March to 8th April 2015.	
Site survey including a geophysical, shallow geotechnical and environmental survey. Grab samples were taken from 29 locations using a dual van Veen 0.1 m^2 sampler. Digital photographic stills and footage were taken at the grab sample locations and at 28 transect locations. Samples were taken for physico-chemical and faunal analysis.	Habitat Assessment Report (Fugro 2015a) Environmental Baseline Survey (Fugro, 2015b) Environmental Field Results Report (Fugro, 2015c)
2014 Captain Site Survey. Survey Period 15th May to 12th June 2014	
Site survey including a geophysical, shallow geotechnical and environmental survey. The survey was carried out to allow Chevron to assess the expansion opportunities of the Captain field through the Captain EOR Project. Samples were taken from 21 locations. Digital photographic stills and footage were taken at the sampling locations and at six transect locations. Samples were taken for physico-chemical and faunal analysis.	Environmental Baseline Survey and Habitat Assessment Report (Fugro, 2014).

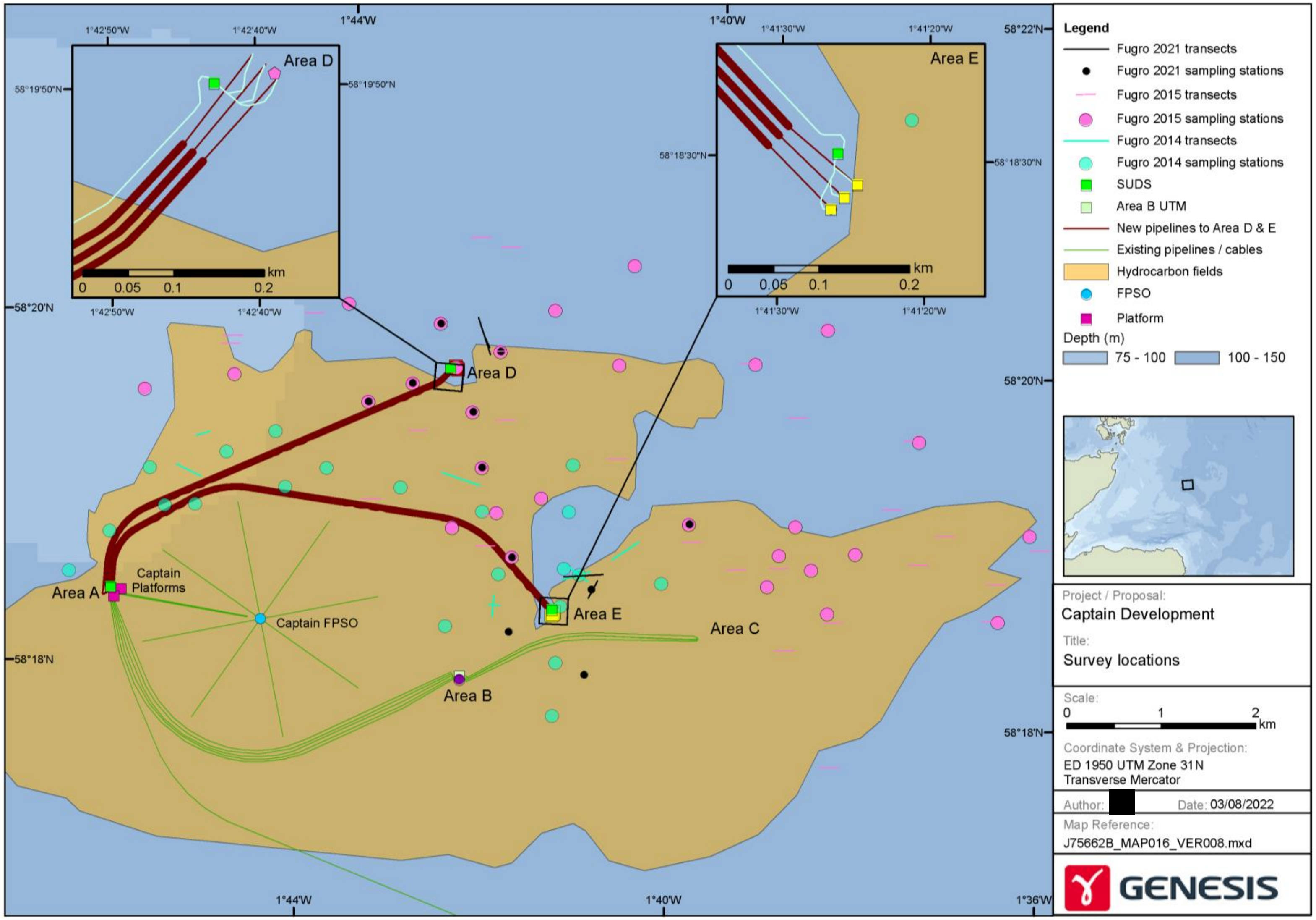


Figure 4-1: Survey sampling stations and transects.

4.3 Physical Environment

This section describes the current nature and status of the environment in the vicinity of the Captain field.

4.3.1 Hydrology and Meteorology

4.3.1.1 Bathymetry

Depths across the 2021 survey area ranged from 89.2 m LAT to 124.1 m (Figure 4-2; Fugro, 2021a). Across the 2021 survey area topographic highs were evident within the site predominantly in the north and south of the survey area. Seabed spurs extended from these topographic highs. The tops of these spurs were associated with an increase in acoustic reflectivity, and within these areas numerous boulders were observed. The 2015 survey identified several large mounds around the Area D drill centre which are thought to be associated with outcropping sediments (Fugro, 2015a).

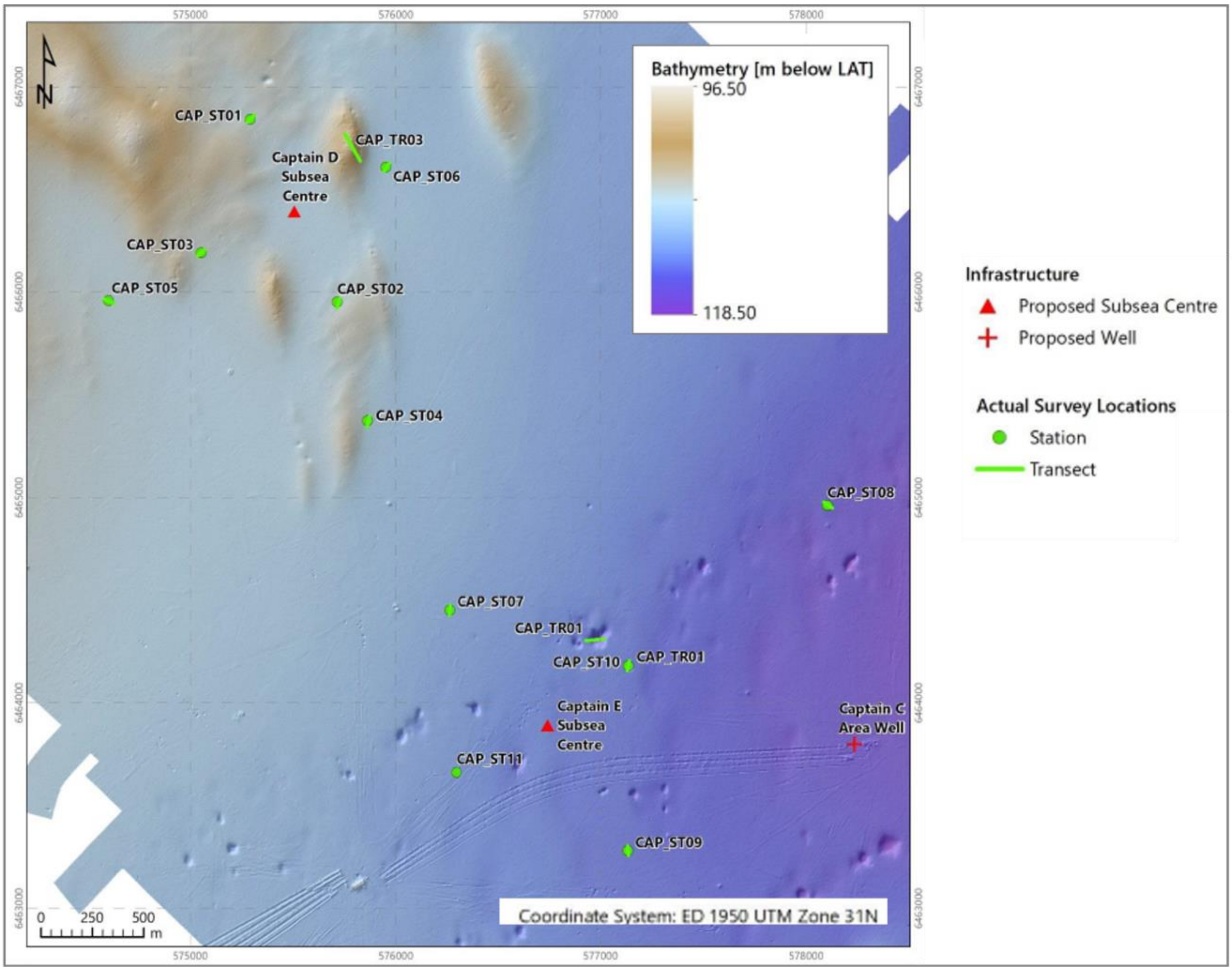


Figure 4-2: Bathymetry and environmental sampling stations across the 2021 survey area (Fugro, 2021a).

4.3.1.2 Water masses, currents and tides

Water masses, local current speeds and direction influence the transport, dispersion and ultimate fate of marine discharges, nutrients, plankton and larvae (OSPAR, 2010). The anti-clockwise movement of water through the North Sea and around the Central North Sea (CNS) region originates from the influx of Atlantic water, via the Fair Isle Channel and around the north of Shetland, and the main outflow northwards along the Norwegian coast (BEIS, 2016; Figure 4-3). Against this background of tidal flow, the direction of residual water movement in the CNS is generally to the southeast (DTI, 2001; BEIS, 2016). Offshore tidal current velocities in the region are between 0.01-1.0 m/s during mean spring tide (BEIS, 2016). The mean residual currents surrounding the Captain field are approximately 0.25-0.51 m/s (Wolf *et al*., 2016).

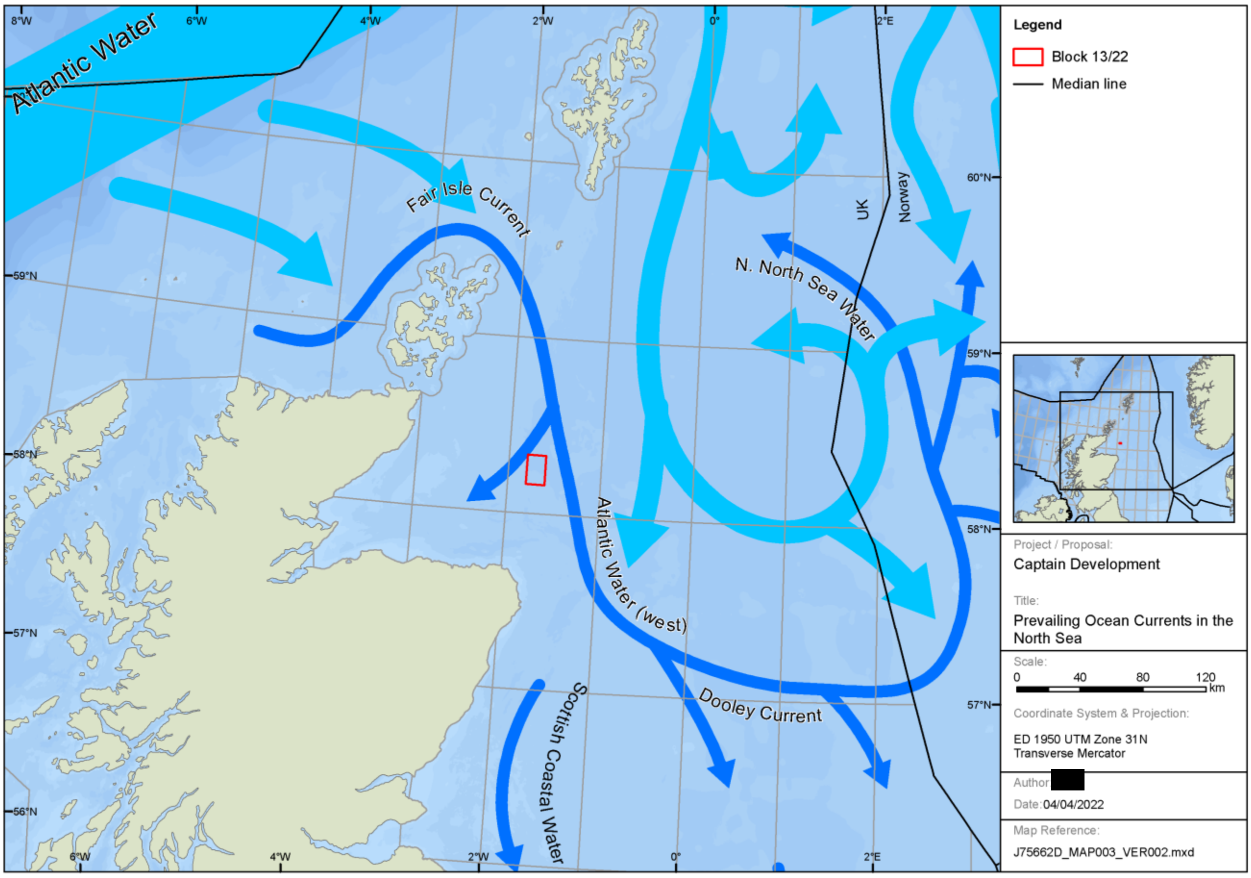


Figure 4-3: General circulation in the North Sea (Turrell, 1992).

4.3.1.3 Waves

Mean significant wave heights in the area are 1.9 m (Data Explorer, 2018) and as can be seen from Figure 4-4a around 50% of the waves in the area originate from a north and southeast direction and around 15% from a south / southwest direction (Data Explorer, 2018).

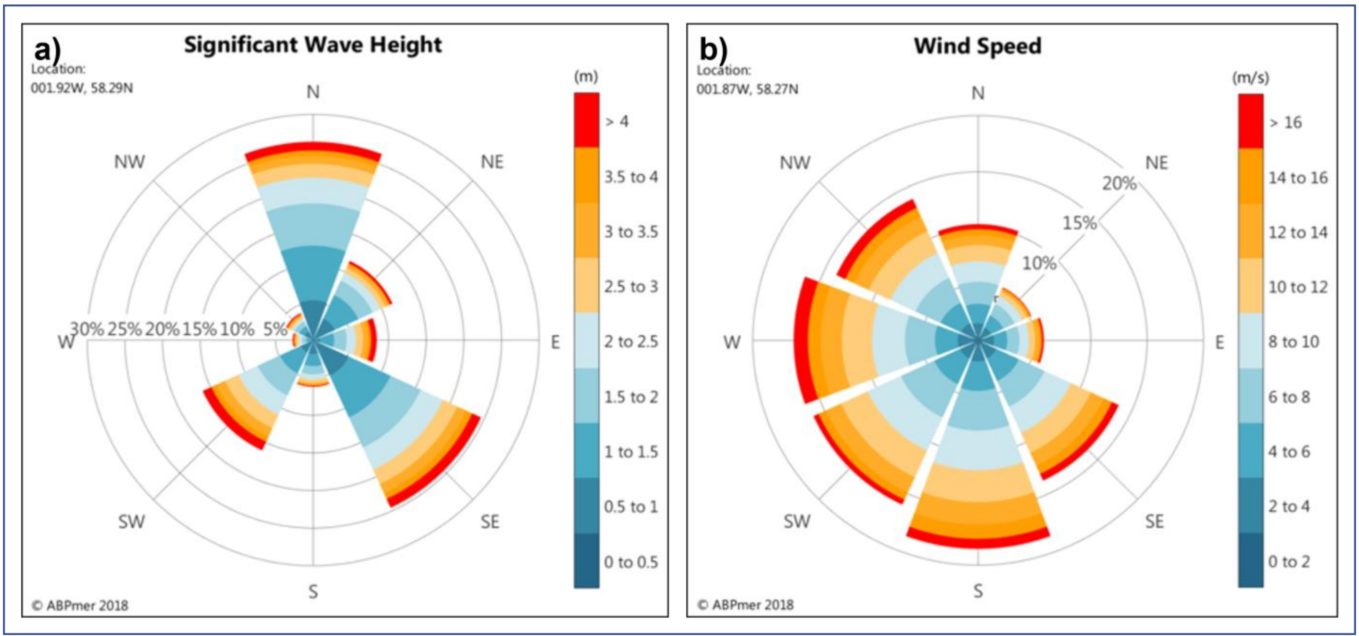


Figure 4-4: a) Wave rose and b) wind rose for the Captain area (Data Explorer, 2018).

4.3.1.1 Winds

Over the open CNS, wind direction varies considerably. Dominant directions range from southeast to northwest through southwest. North to northwest winds dominate in spring and summer (UKHO, 2013). Wind direction and speed directly influence the transport and dispersion of atmospheric emissions from an installation. These factors are also important for the dispersion of marine discharges, including oil releases, influencing the movement, direction and break up of substances on the sea surface. Mean wind speed in the area is 8.6 m/s and as can be seen from Figure 4-4b winds in the area originate from all directions though primarily from the northeast / east / southeast and south (Data Explorer, 2018).

4.3.1.2 Temperature and salinity

The temperature of the sea affects both the properties of the seawater and the fate of discharges and spills to the environment. Seawater temperatures vary with season, depth and proximity to land. The mean annual mean surface temperature in the area is approximately 9.5°C whilst the annual mean seabed temperature is approximately 8.5°C (Berx & Hughes, 2009).

Fluctuations in salinity are largely caused by the addition or removal of freshwater to or from seawater through natural processes such as rainfall and evaporation. Salinity in the area of the Captain field shows little variation with season and water depth. The annual mean surface and near bed salinity in the area is approximately 34.8‰ (Berx & Hughes, 2009).

4.3.2 Seabed Sediments

4.3.2.1 Sediment type

Seabed sediments comprising mineral and organic particles occur commonly in the form of mud, sand or gravel and are dispersed by processes driven by wind, tides and currents. The distribution of seabed sediments within the North Sea results from a combination of hydrographic conditions, bathymetry and sediment supply. The characteristics of the local sediments and the amount of sediment transport within a project area are important factors in determining the potential effects of possible developments (drill cuttings, installation of pipelines, anchor scouring) on the local seabed environment.

A modelled distribution of seabed sediments in the area of the Captain field is shown in Figure 4-5 (EMODnet, 2020). The data suggests that the main sediment types in Block 13/22 are offshore circalittoral mud and offshore circalittoral sand.

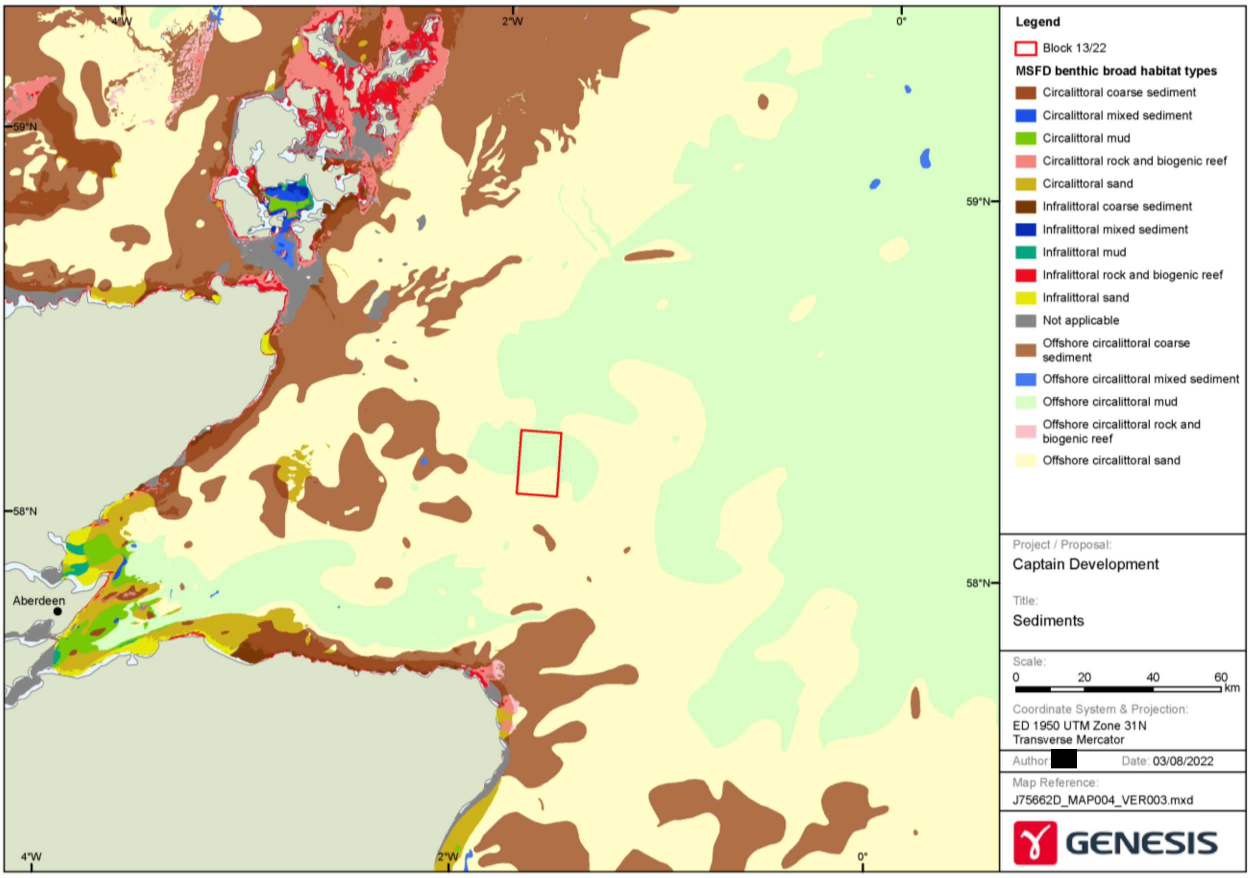


Figure 4-5: Modelled distribution of sediments in the CNS (EMODnet, 2020).

Data from surveys identified in Table 4-1 and Figure 4-1 showed the sediment characteristics to be indicative of a relatively homogenous sediment type across the survey area stations. The 2014, 2015, and 2021 surveys identified the main sediment type over the survey area as sandy mud/muddy sand, which is classified as the EUNIS biotope complex 'Deep circalittoral mud' (A5.37) (Fugro, 2014; Fugro, 2015a; and Fugro 2021a). Small, localised areas of high reflectivity were also observed and interpreted to comprise sandy mud with pebbles, cobbles, and boulders and to be representative of 'Deep circalittoral mixed sediments' (A5.45) (Fugro, 2015a and Fugro, 2021a).

This classification was also supported by particle size distribution (PSD) analysis of the sediment collected from grab samples. For example the PSD analysis of the 2021 samples confirmed that all stations were dominated by the sand fraction (mean 64.47%) with lower proportions of mud and gravel (mean 35.51% and 0.01%, respectively). Table 4-2 summarises the hierarchy of the assigned EUNIS classifications, and equivalent JNCC (2015) classifications, based on the video and photographic data. Figure 4-6 shows seabed photographs from the different surveys. The associated habitats are discussed further in Section 4.4.2.

Table 4-2: Habitat classifications (Fugro, 2021a).

EUNIS (EEA, 2019) Habitat Classification				Equivalent JNCC (2015) Classification
Environment Level 1	**Broad Habitat Level 2**	**Habitat Level 3**	**Biotope Complex Level 4**	
A Marine	A5 Sublittoral sediment	A5.3 Sublittoral mud	A5.37 Deep circalittoral mud	SS.SMu.Omu Offshore circalittoral mud
		A5.4 Sublittoral mixed sediments	A5.45 Deep circalittoral mixed sediments	SS>SMx.OMx Offshore circalittoral mixed sediments
EUNIS = European Nature Information System				

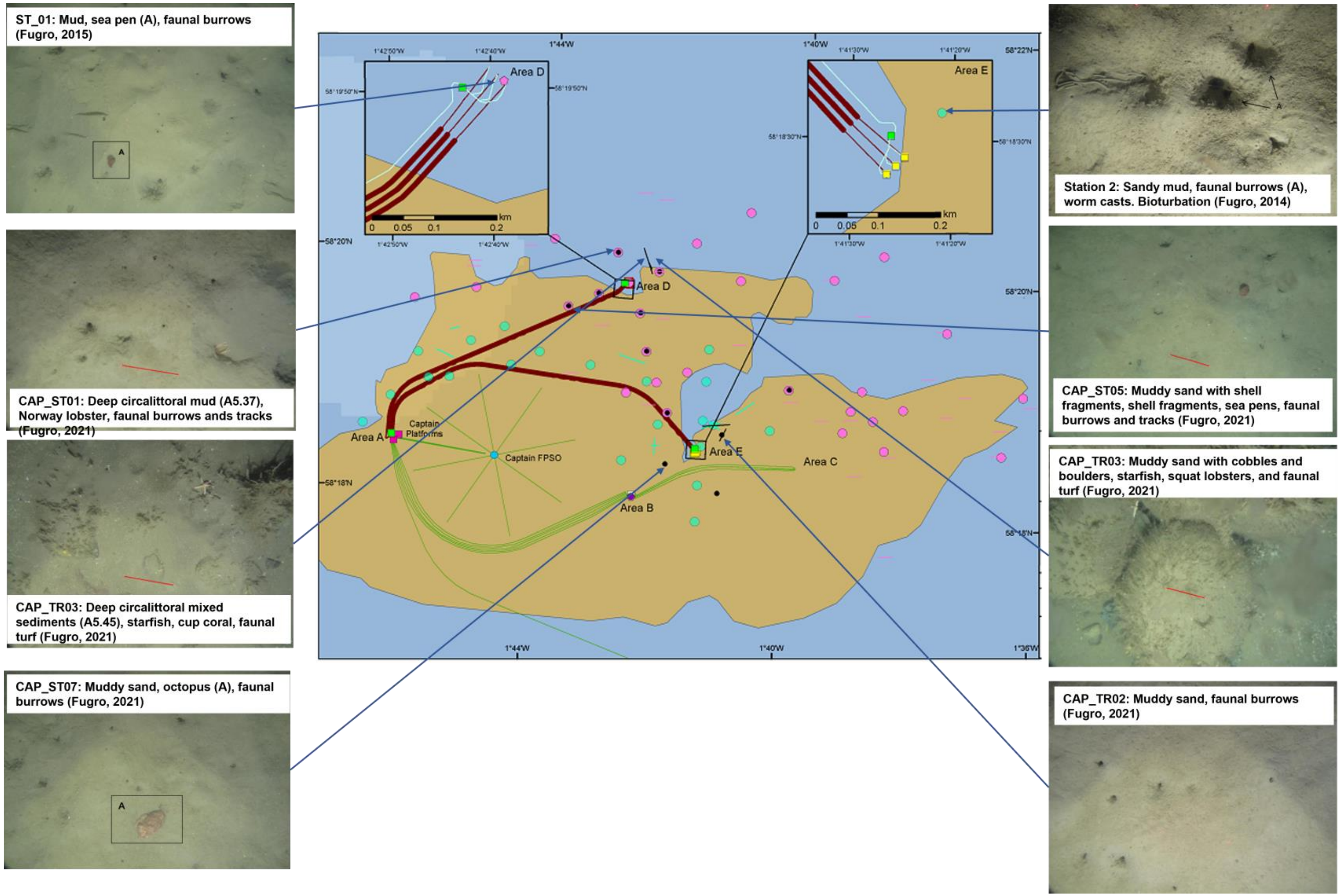


Figure 4-6: Example seabed photographs from the different surveys identified in Table 4-1

4.3.2.2 Sediment chemistry

Deep-water marine environments generally show relatively low levels of contamination compared to coastal waters and industrial estuaries.

Exposure of marine organisms to contaminants can occur either through uptake of dissolved fractions across the gills or skin, or direct ingestion of the pollutant. Organisms spending the majority of their lifecycle in the water column are likely to receive the highest exposure to contaminants that remain in solution, though some will also accumulate sediment-bound contaminants indirectly through their diet (i.e. digestion of animals that have accumulated the contaminants in their tissues). Organisms associated with the seabed (benthic organisms) are more exposed to particle-bound contaminants with the main exposure route being either directly through ingestion of contaminated sediments or through their diet. Benthic organisms can also absorb contaminants through the surface membranes as a result of contact with interstitial water.

Hydrocarbons

Across the samples collected as part of the 2015 survey the Total Hydrocarbon Content (THC) were generally low and consistently lower than the UKOOA regional mean (9.5 µg/g for the CNS) (Fugro, 2015a). The 2014 survey reported THC concentrations varied considerably across the survey area being low (1.1 µg/g to 5.6 µg/g) at the majority of stations. However at the stations closest to the WPP, THC were elevated and ranged from 4.1 µg/g to 694 µg/g. These higher concentrations were expected to be the result of previous drilling activities at the WPP (Fugro, 2015a).

The gas chromatographic profiles obtained from the sediments collected as part of the 2021 survey shared a common underlying hydrocarbon distribution typical of low-level weathered petroleum residues commonly found in CNS sediments (Fugro, 2021b). Total organic matter (TOM) and total organic carbon (TOC) content were low throughout the 2021 survey area, with mean values of 3.71% (RSD[1] 6%) and 0.50% (RSD 16%) respectively. The results indicated that the THC across the survey area were below the CNS mean background concentration. The mean THC value from this survey were comparable to the values obtained previously in the Captain field (outwith the WPP area) and the wider Outer Moray Firth region.

The reports associated with the 2021 survey concluded that there were no spatial trends in THC were apparent and the observed THC distribution is most likely a result of the natural heterogeneity of the sediment within the Captain survey area. Hence, THC levels sampled within the 2021 Captain survey area suggested that the concentrations recorded can be considered background and are unlikely to have a negative impact on the benthic community (Fugro, 2021b and Figure 4-7).

[1] RSD = Relative Standard Deviation

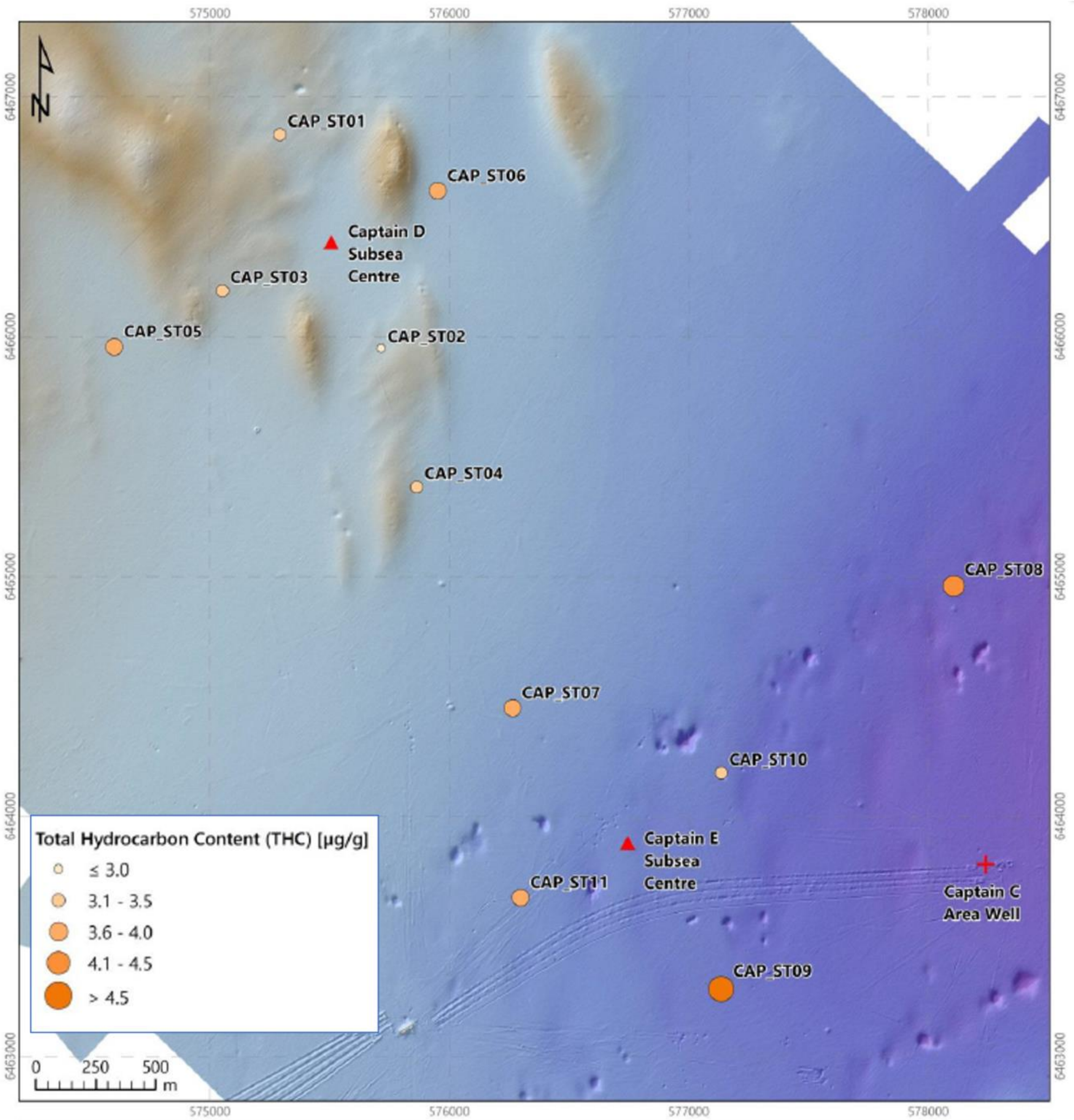


Figure 4-7: Spatial distribution of THC values across the 2021 environmental survey samples (Fugro, 2021b).

Heavy/Trace metals

The 2015 survey reported higher concentrations of heavy metals in the deeper muddier sediments towards the east of the survey site, which was further evidenced by significant positive correlations between the majority of metals and both mud and depth. Aluminium levels in the 2015 samples were higher and more varied than those recorded during the 2014 survey, reflecting the higher mud content in the 2015 survey area (Fugro, 2015b). When compared to UKOOA average value for the CNS, levels of copper and zinc were elevated at most of the 2015 sample sites, an observation that could not be explained through association with mud and organic matter content. The 2015 survey reported that all heavy and trace metals, except barium, showed a significant positive correlation (p-value<0.01) with depth, mud proportion, TOC and TOM. Only two stations from the 2015 survey showed elevated barium levels above UKOOA mean background levels and overall the 2015 results showed considerably lower barium concentrations than the 2014 survey (Fugro, 2015b).

Samples taken as part of the 2021 survey showed the mean concentrations of bioavailable metals reported across the survey area were comparable to previous surveys carried out in the Captain field, and the wider Outer Moray Firth (Fugro, 2021b). The mean concentrations of chromium, copper, iron, nickel, and zinc exceeded their CNS mean background concentration. All metals concentrations (*aqua regia* digest[2]) were below their respective effects range low (ERL) thresholds at all stations, suggesting that metals concentrations are of no obvious environmental concern.

4.4 Biological Environment

4.4.1 Plankton

Plankton are drifting organisms that inhabit the pelagic zone of a body of water and include single celled organisms such as bacteria as well as plants (phytoplankton) and animals (zooplankton). Phytoplankton are primary producers of organic matter in the marine environment and form the basis of marine ecosystem food chains. They are grazed upon by zooplankton and larger species such as fish, birds and cetaceans. Therefore, the distribution of plankton directly influences the movement and distribution of other marine species. Meroplankton includes the eggs, larvae and spores of non-planktonic species (fish, benthic invertebrates and algae).

The composition and abundance of plankton communities vary throughout the year and are influenced by several factors including depth, tidal mixing, temperature stratification, nutrient availability and the location of oceanographic fronts. Species distribution is directly influenced by temperature, salinity, water inflow and the presence of local benthic communities (Robinson, 1970; Colebrook, 1982).

Over the past 30 years, rising sea temperatures have been accompanied by a rise in the North Atlantic Oscillation Index (NAOI) (OSPAR, 2010). The NAOI is a measure of the pressure gradient between the relatively high subtropical surface pressure of the 'Azores High' and the relatively low surface pressure further north, the 'Icelandic Low'. An increase in the NAOI tends to result in higher temperatures in northern Europe (Met Office, 2019). The seasonal timing of phytoplankton and zooplankton production has altered in recent decades with some species present up to four to six weeks earlier than 20 years before. This directly affects their availability to predators such as fish (OSPAR, 2010).

Seasonal stratification also occurs as the water column is heated by solar radiation and wind and convection induced heat exchange. Stratification affects the vertical distribution of nutrients and has a major impact on the production and succession of phytoplankton. Phytoplankton blooms in spring are followed by depletion of nutrients and waning of phytoplankton in summer and autumn. Re-mixing of the water column and regeneration of nutrients occur during the winter. This cycle affects the structure of the food web throughout the year (Ruardij *et al.*, 1998; Vidal *et al.*, 2017).

The phytoplankton community in the area of the Captain field is dominated by the dinoflagellate genus *Tripos* (*T. fusus, T. furca, T. lineatus*), with diatoms such as *Thalassiosira* spp. and *Chaetoceros* spp. also abundant. Harmful Algal Blooms (HABs) observed in the region in recent years include the diatom *Pseudo-nitzschia,* a cause of amnesic shellfish poisoning, and the dinoflagellate *Alexandrium tamarense* (BEIS, 2016). Zooplankton communities in the North Sea are dominated by copepods, such as *Calanus* spp. *Acartia* spp. and *Metridia lucens*, occurring during the summer peak period (Nielsen and Richardson, 1989).

4.4.2 Seabed Habitat and Benthic Communities

Bacteria, plants and animals living on or within the seabed sediments are collectively referred to as benthos. Species living on top of the sea floor may be sessile (e.g. sea anemone) or freely moving (e.g. starfish). Animals living within the sediment are termed infaunal (e.g. tubeworms and burrowing clams) while animals living on the surface are termed epifaunal (e.g. crabs, starfish). Semi-infaunal animals, including sea pens, lie partially buried in the sediment. The majority of marine benthic invertebrates exhibit a life cycle that includes a planktonic larval phase from which the bottom dwelling juvenile and adult phases recruit.

Benthic organisms display a variety of feeding methods. Suspension and filter feeders capture particles which are suspended in the water column (e.g. sea pens) or transported by the current (e.g. mussels). Deposit

[2] Aqua regia microwave digestion is an acid mixture that allows a partial dissolution of metals, predominantly releasing those associated with fine sediments.

feeders (e.g. sea cucumbers) ingest sediment and digest the organic material contained within it. Other benthic species can be herbivorous (e.g. sea urchins), carnivorous (e.g. crabs) or omnivorous (e.g. starfish).

Sessile infaunal species are particularly vulnerable to external influences that may alter the physical, chemical or biological characteristics of the sediment as they are unable to avoid unfavourable conditions. Each species has its own response and degree of adaptability to changes in the physical and chemical environment. Consequently, the species composition and relative abundance in a particular location provide a reflection of the immediate environment, both current and historical (Clark, 1996).

4.4.2.1 Seabed Habitats

To assess the habitats present across the field, detailed analysis of video and still photographic data collected across the three surveys referenced in Table 4-1, was undertaken noting the locations of any observed changes in sediment type and/or associated faunal community.

As described in Section 4.3.2.1 the main sediment type across the Captain field is sandy mud/muddy sand, classified as the EUNIS biotope complex 'Deep circalittoral mud' while small, localised areas of 'Deep circalittoral mixed sediments' also occur (Fugro, 2015a and Fugro, 2021a).

In Scotland, habitats and species of conservation interest, termed Priority Marine Features (PMFs), are protected through the designation of Nature Conservation Marine Protected Areas (NCMPAs) under the Marine and Coastal Access Act (2009) and the Marine (Scotland) Act (2010). These features incorporate habitats and species included on the Oslo and Paris Commission (OSPAR) List of threatened and/or declining species and habitats (OSPAR, 2008) and Priority Species and Habitats recognised under the UK Post-2010 Biodiversity Framework (UKBAP).

The 'Deep circalittoral mud' observed across the Captain field are considered to be representative of the PMF broad habitat 'Burrowed mud' and 'Offshore deep-sea muds' and the priority habitat 'Mud habitats in deep water'. It is recognised that these habitats are widely distributed within the North Sea.

Sea pen and burrowing megafauna communities

A full assessment was carried out to determine whether the OSPAR listed threatened and/or declining habitat 'sea pen and burrowing megafauna communities' habitat was present. The habitat is defined as plains of fine mud which are heavily bioturbated with burrowing megafauna. Burrows and mounds may form a prominent feature of the sediment surface with populations of sea pens, *Virgularia mirabilis* and *Pennatula phosphorea*.

For each survey, counts of sea pens and burrowing megafauna were converted to the superabundant, abundant, common, frequent, occasional, rare (SACFOR) abundance scale used by the Marine Nature Conservation Review and JNCC to semi-quantitatively record the abundance and density of marine benthic flora and fauna (JNCC, 2015).

The JNCC (2014) habitat guidelines state that the seabed must be 'heavily bioturbated by burrowing megafauna with burrows and mounds forming a prominent feature of the sediment surface' (JNCC, 2014). Guidelines also state that burrows should be at least 'frequent' on the SACFOR scale to be classified as a 'Sea pens and burrowing megafauna community'. Across the 2021 grab sample and transect locations, sea pen densities ranged from occasional to frequent, and burrow densities were considered to range from common to abundant; however, mounds were not recorded at any station (see Table 4-3: note the location of each of the samples can be seen in Figure 4-8) (Fugro, 2021a). Though mounds were not observed, sea pens and burrows were observed in sufficient density to potentially comprise the habitat 'sea pen and burrowing megafaunal communities'. Results from the earlier 2014 and 2015 surveys also indicated the presence of this habitat across the area (Fugro, 2014, and Fugro 2015a). Figure 4-9 shows sea pens and burrowing megafaunal at one of the 2021 sampling locations.

Table 4-3: SACFOR assessment for sea pens and burrowing megafauna across the 2021 sample and transect locations (Fugro, 2021a).

Station/ Transect	EUNIS Biotope	Length of Section [m]	Sea Pens		Bioturbation		
			*Pennatula phosphorea**	*Virgularia* sp.*	Mounds*	*Nephrops norvegicus* Burrows†	Other Burrows*
CAP_ST01	'Deep circalittoral mud' (A5.37)	48	F	-	-	C	A
CAP_ST02	'Deep circalittoral mud' (A5.37)	51	F	-	-	A	A
CAP_ST03	'Deep circalittoral mud' (A5.37)	52	F	O	-	A	A
CAP_ST04	'Deep circalittoral mud' (A5.37)	60	F	O	-	C	A
CAP_ST05	'Deep circalittoral mud' (A5.37)	57	F	O	-	C	A
CAP_ST06	'Deep circalittoral mud' (A5.37)	54	F	-	-	C	A
CAP_ST07	'Deep circalittoral mud' (A5.37)	39	F	-	-	A	A
CAP_ST08	'Deep circalittoral mud' (A5.37)	50	O	-	-	A	A
CAP_ST09	'Deep circalittoral mud' (A5.37)	46	O	-	-	A	A
CAP_ST11	'Deep circalittoral mud' (A5.37)	49	O	-	-	A	A
CAP_TR01	'Deep circalittoral mud' (A5.37)	47	O	-	-	A	A
CAP_TR02	'Deep circalittoral mud' (A5.37)	85	O	-	-	A	A
CAP_TR03	Deep circalittoral mud' (A5.37)	78	F	-	-	C	A
	'Circalittoral mixed sediments' (A5.37).	28	F	-	-	-	C
	Deep circalittoral mud' (A5.37)	26	F	-	-	C	A

Notes

SACFOR Classifications: (3 cm to 15 cm)
Superabundant = 1 - 9/0.01 m^2
Abundant = 1 - 9/0.1 m^2
Common = 1 - 9/1 m^2
Frequent = 1 - 9/10 m^2
Occasional = 1 - 9/100 m^2
Rare = 1 - 9/1000 m^2

SACFOR Classifications: (> 15 cm)
Superabundant = 1 - 9/0.1 m^2
Abundant = 1 - 9/1 m^2
Common = 1 - 9/10 m^2
Frequent = 1 - 9/100 m^2
Occasional = 1 - 9/1000 m^2
Rare = 1 - 9/< 1000 m^2

SACFOR = semi-quantitative abundance scale from Superabundant, Abundant, Common, Frequent, Occasional to Rare
* = SACFOR Classification based on the assumption that adults achieve a size of 3 cm to 15 cm
† = SACFOR Classification based on the assumption that adults achieve a size of more than 15 cm

Key:	- = Absent	R = Rare	O = Occasional	F = Frequent	C = Common	A = Abundant	S = Super-abundant

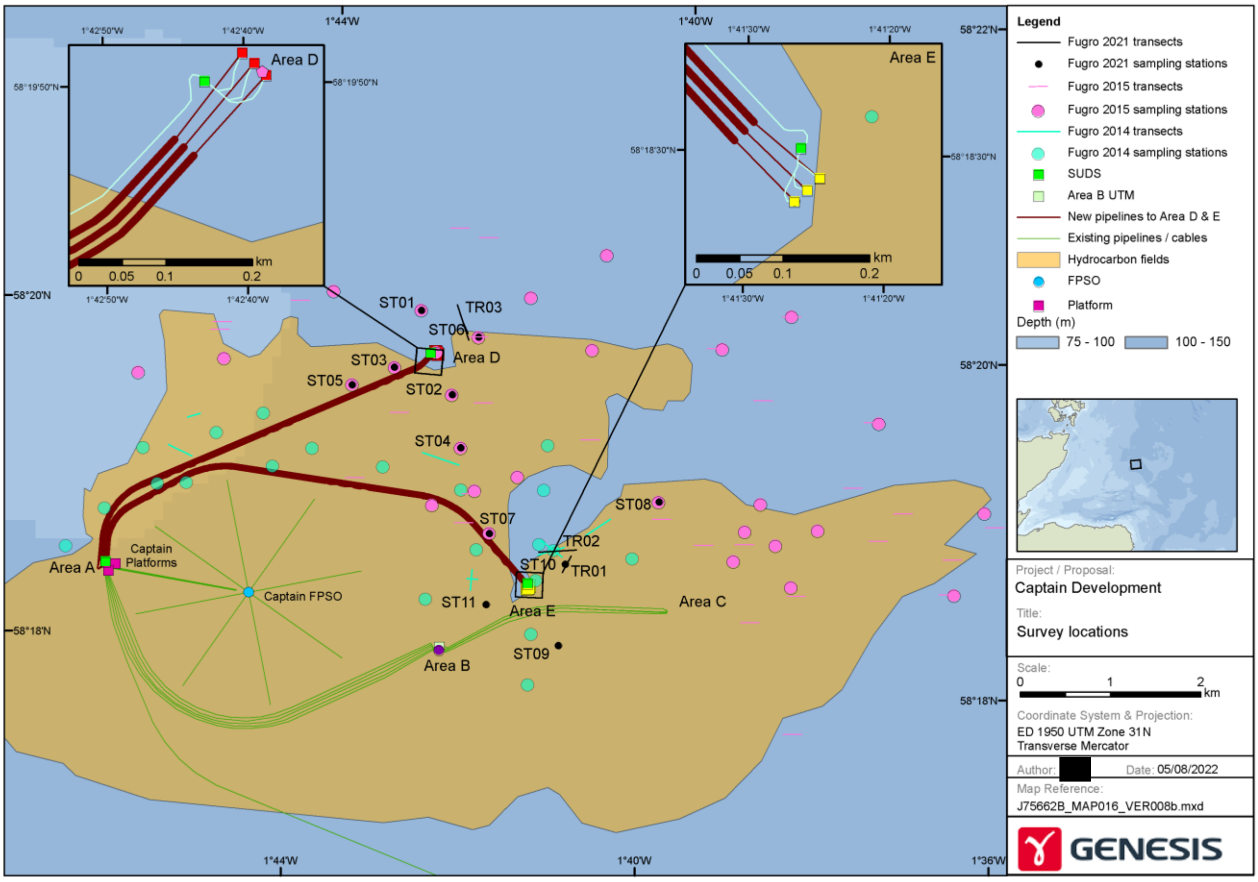


Figure 4-8: Location of sampling stations listed in Table 4-3.

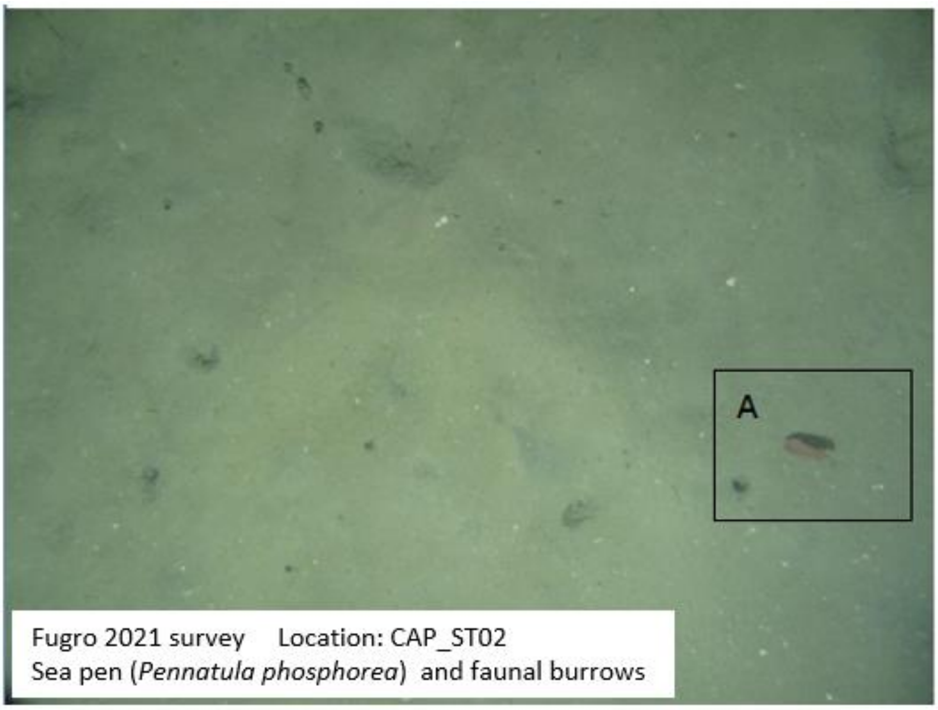


Figure 4-9: Sea pen and faunal burrows at a 2021 sampling station CAP-ST02 (Fugro 2021a).

Using criteria set out by Irving (2009) and refined by Golding *et al*. (2020), an area of cobbles and boulders was assessed to determine if they are representative of 'stony reefs' (Fugro, 2021a). This potential area of stony reef was identified north east of the Area D drilling centre at transect location TR03 as shown in Figure 4-8. The composition of cobbles and boulders was classified as being of low resemblance to a stony reef. However, areas of denser cobbles and boulders were morphologically heterogeneous, and small sections of boulders and cobbles consistent with 'medium reef' were observed in patches < 5 m in length. Either side of this, interspersed sections of soft sediment were observed that had composition representative of 'Not a reef'. Only one key reef species (*Alcyonium digitatum*) as described in Golding *et al*. (2020) was present across the assessed area. Authors of the survey report concluded that it is possible that the area represents an unstable stony reef.

No other Annex I habitats were identified.

4.4.2.2 Benthic Communities

Epibenthic fauna was observed to be relatively sparse across the Captain field area (Fugro, 2021b). The dominant epifauna observed were phosphorescent sea pens (*Pennatula phosphorea*), with sparse *Virgularia sp.*. Other taxa observed included a Norway lobster (*Nephrops norvegicus*), starfish (*Asteroidea*), possible brittlestars (*Ophiuroidea*), polychaetes (*Oxydromus sp.*), gastropods (*Euspira catena*, possible burrowing anemone (*Ceriantharia*), bivalve siphons (*Bivalvia*), a curled octopus *Eledone cirrhosa*) and faunal turf Hydrozoa/Bryozoa (Fugro, 2021b). At the start and end of transect TR03 (unstable stony reef area described above) were occasional scattered pebbles, cobbles or boulders were available for epibenthic attachment, taxa also included spoon worms (Echiura, *Maxmuelleria sp.*), possible anemone (Actiniaria), crab (*Cancer pagurus*), squat lobsters (Galatheoidea), possible brittlestars (Ophiuroidea), bryozoan crust (Bryozoa), hydroids (Hydrozoa, including *Tubularia sp.*) and Norway pout (*Trisopterus esmarkii*). This section likely represents a transitional area between mud habitats and coarser sediments (Fugro, 2021b).

Mixed sediment types usually comprise diverse epifaunal communities with a high number of infaunal polychaetes and bivalve species. The main infaunal species found in the area in terms of abundance were polychaetes broadly similar to those reported by Van Dalfsen (2007) and included *Sosane wahrbergi*, *Galathowenia* (*Myriochele*) *oculata* and *Owenia fusiformis*, together with *A. catherinae, Spiophanes kroyeri*, *Paramphinome jeffreysii* and *D. glaucus* (Fugro, 2014; 2015b). Across Area E, a very similar range of characterising species was also present, but the most abundant were *S. wahrbergi*, *A. catherinae*, and *Prionospio dubia*, together with *D. glaucus* and *Prionospio cirrifera* (Fugro, 2015b). The three dominant species recorded in the 2015 survey were *P. dubia, P. jeffreysii* and *G. oculata* (Fugro, 2015b).

Further benthic fauna associated with the mixed sediment habitat included starfish (Asteroidea, including *Asterias rubens*), cushion star (*Hippasteria phrygiana*), crab (*Cancer pagurus*), squat lobsters (Galatheoidea, including *Munida sp.*), soft coral (*Alcyonium digitatum*), sponges (Porifera), cup corals (*Caryophyllia smithii*), hydroids (Hydrozoa including *Tubularia sp.*), possible brittlestars (Ophiuroidea) and faunal turf (Hydrozoa/Bryozoa). Sea pens (*Pennatula phosphorea*), faunal tracks and burrows also occurred within in patches of soft sediment.

The dominant macrofaunal species in the surficial 10 cm sediment layer of the area were the polychaetes *Aricidea* (*Acmira*) *catherinae*, *Tharyx killariensis*, *Chaetozone setosa*, *Galathowenia oculata* and *Diplocirrus glaucus*, whereas the polychaete *Peresiella clymenoides* was the most abundant species within the deeper (>10 cm) sediment layer (Van Dalfsen, 2007). In terms of visible fauna (i.e. a mix of larger epifaunal and infaunal forms observed in washed samples) around the Captain WPP, Van Dalfsen (2007) noted the burrowing brittle stars *Amphiura spp.*, burrowing mud shrimps *Callianassa spp.*, (mainly *C. subterranea*) burrowing sea cucumbers, burrowing sea urchins, various bivalve mollusc species as well as a number of polychaete tubes.

Sea pens, mostly the phosphorescent sea pen *P. phosphorea,* were observed over the majority of the survey area, including around the platforms in the Captain field, although their abundance was low (Fugro, 2015b and Fugro 2021b). The slender sea pen *Virgularia mirabilis* was also observed but in much lower numbers; this was only recorded on seabed video footage at seven stations and with only two individuals identified in the seabed photographs.

There was no evidence of *Arctica islandica* in the stills or video footage taken as part of the 2015 and 2021 surveys (Fugro, 2015b and Fugro, 2021b). However, the majority of grab samples taken across both surveys did have evidence of *A. islandica* shells. *A. islandica* is on the OSPAR List of threatened and/or declining species and habitats. In addition, within Scottish waters *A. islandica* is considered a PMF.

4.4.3 Finfish and Shellfish

More than 330 fish species are thought to inhabit the shelf seas of the UKCS (BEIS, 2016). Pelagic species (e.g. herring (*Clupea harengus*), mackerel (*Scomber scombrus*), blue whiting (*Micromesistius poutassou*), and sprat (*Sprattus sprattus*) are found in mid-water and typically make extensive seasonal movements or migrations. Demersal species (e.g. cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), sandeels (*Ammodytes marinus*), sole (*Solea solea*) and whiting (*Merlangius merlangus*) live on or near the seabed and similar to pelagic species, many are known to passively move (e.g. drifting eggs and larvae) and / or actively migrate (e.g. juveniles and adults) between areas during their lifecycle.

Fish occupying areas near offshore oil and gas installations will be exposed to aqueous discharges and may accumulate hydrocarbons and other contaminating chemicals in their body tissues (Bakke *et al*., 2013). The most vulnerable stages of the life cycle of fish, to general disturbances such as disruption to sediments and oil pollution, are the egg and larval stages. Hence, recognition of spawning and nursery times and areas within a development region is important when considering potential disturbance caused by drilling and installation activities and when responding to accidental releases during operations.

The Captain field lies within International Council for the Exploration of the Sea (ICES) rectangle 45E8 and is a spawning and nursery ground for several commercially important species (Table 4-4 and Figure 4-10).

Table 4-4: Spawning grounds and nursery areas of some commercially and ecologically important fish species in the Captain field area (Coull *et al*., 1998; Ellis *et al*., 2012; Aires *et al*., 2014).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anglerfish	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Blue whiting	N	N	N	N	N	N	N	N	N	N	N	N
Cod	SN	S*N	S*N	SN	N	N	N	N	N	N	N	N
European hake	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Haddock	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Herring	N	N	N	N	N	N	N	SN	SN	N	N	N
Lemon sole	N	N	N	SN	SN	SN	SN	SN	SN	N	N	N
Ling	N	N	N	N	N	N	N	N	N	N	N	N
Mackerel (North Sea)	N	N	N	N	N	N	N	N	N	N	N	N
Nephrops	SN	SN	SN	S*N	S*N	S*N	SN	SN	SN	SN	SN	SN
Norway Pout	SN	S*N	S*N	SN	N	N	N	N	N	N	N	N
Plaice	S*	S*	S									S
Sandeel	SN	SN	N	N	N	N	N	N	N	N	SN	SN
Spotted ray	N	N	N	N	S*N	S*N	S*N	N	N	N	N	N
Sprat	N	N	N	N	S*N	S*N	SN	SN	N	N	N	N
Spurdog	N	N	N	N	N	N	N	N	N	N	N	N
Whiting	NJ	SNJ	SNJ	SNJ	SNJ	SNJ	NJ	NJ	NJ	NJ	NJ	NJ

Key:
S = spawning S* = peak spawning [2] N = nursery J = juveniles (i.e. 0 group fish) [3]
Blue highlighting indicates high intensity nursery grounds [1]

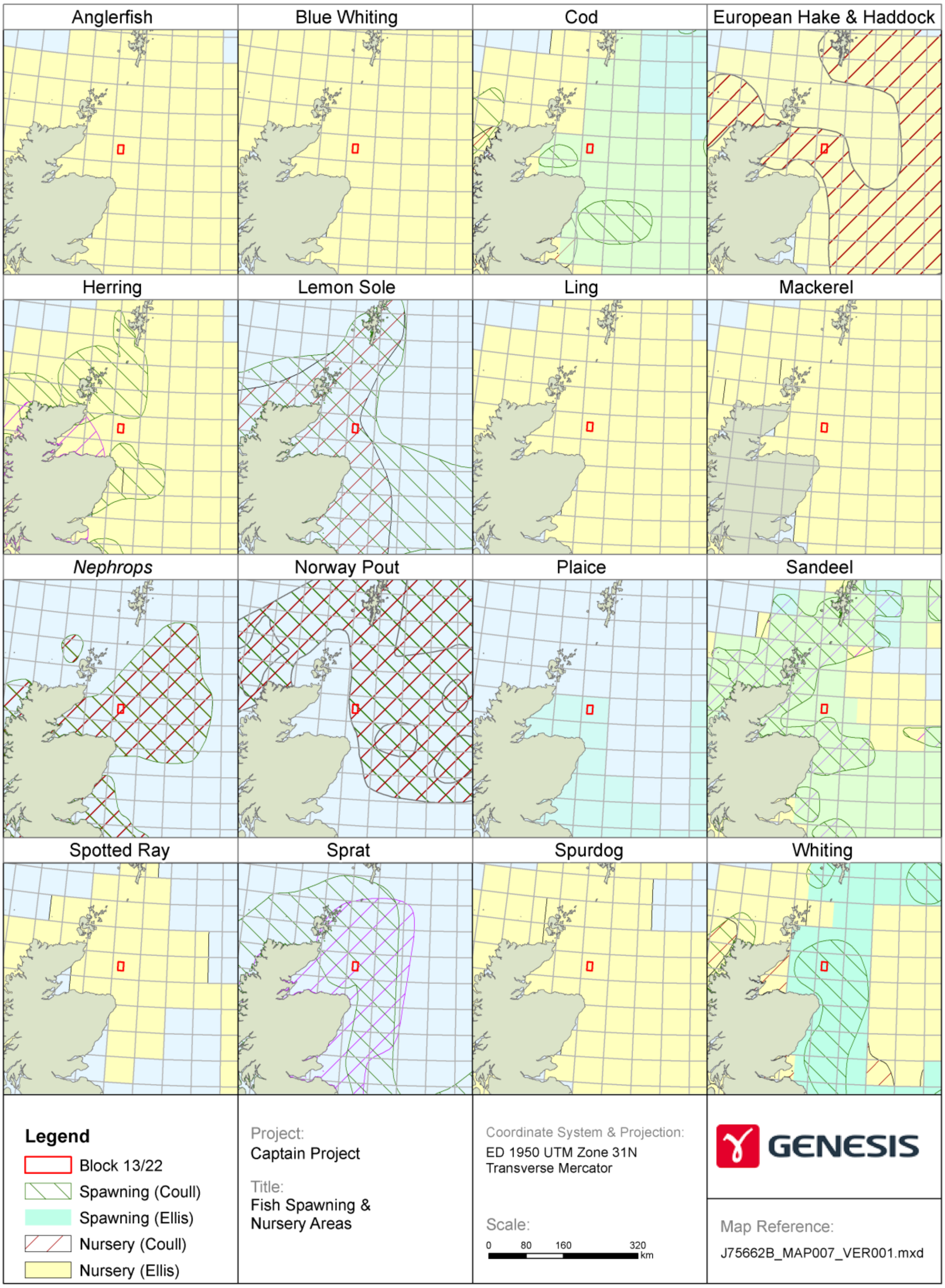


Figure 4-10: Fish spawning and nursery areas in the proximity of the Captain project area (Coull *et al*.,1998; Ellis *et al*., 2012).

Spawning and nursery areas tend to be transient and therefore cannot be defined with absolute accuracy (Coull *et al.,* 1998; Ellis *et al.,* 2012). In addition, the mapped spawning areas represent the widest known distribution given current knowledge and should not be seen as rigid unchanging descriptions of presence or absence (Coull *et al.*, 1998).

ICES rectangle 45E8 is located in an area of high intensity nursery ground for both anglerfish (*Lophius piscatorius*) and whiting (*Merlangius merlangus*) (Ellis *et al.,* 2012). González-Irusta and Wright (2016) reported that the Captain field is located in an "occasional" cod spawning area with seabed habitat preference for the species being strongly towards coarse sediments. As described in Section 4.3.2 the seabed at Captain is sandy mud/muddy sand, and therefore is considered an unfavourable habitat for cod spawning. Herring spawning areas defined by Coull *et al* (1998) overlap ICES rectangle 45E8 to the north and are located to the south in ICES rectangle 44E8, while a more recent study (Boyle and New, 2018) also demonstrate that herring spawning areas overlap with the Captain field.

Maps of the juvenile presence for each species identified in Aires *et al.,* (2014) are shown in (Figure 4-11).

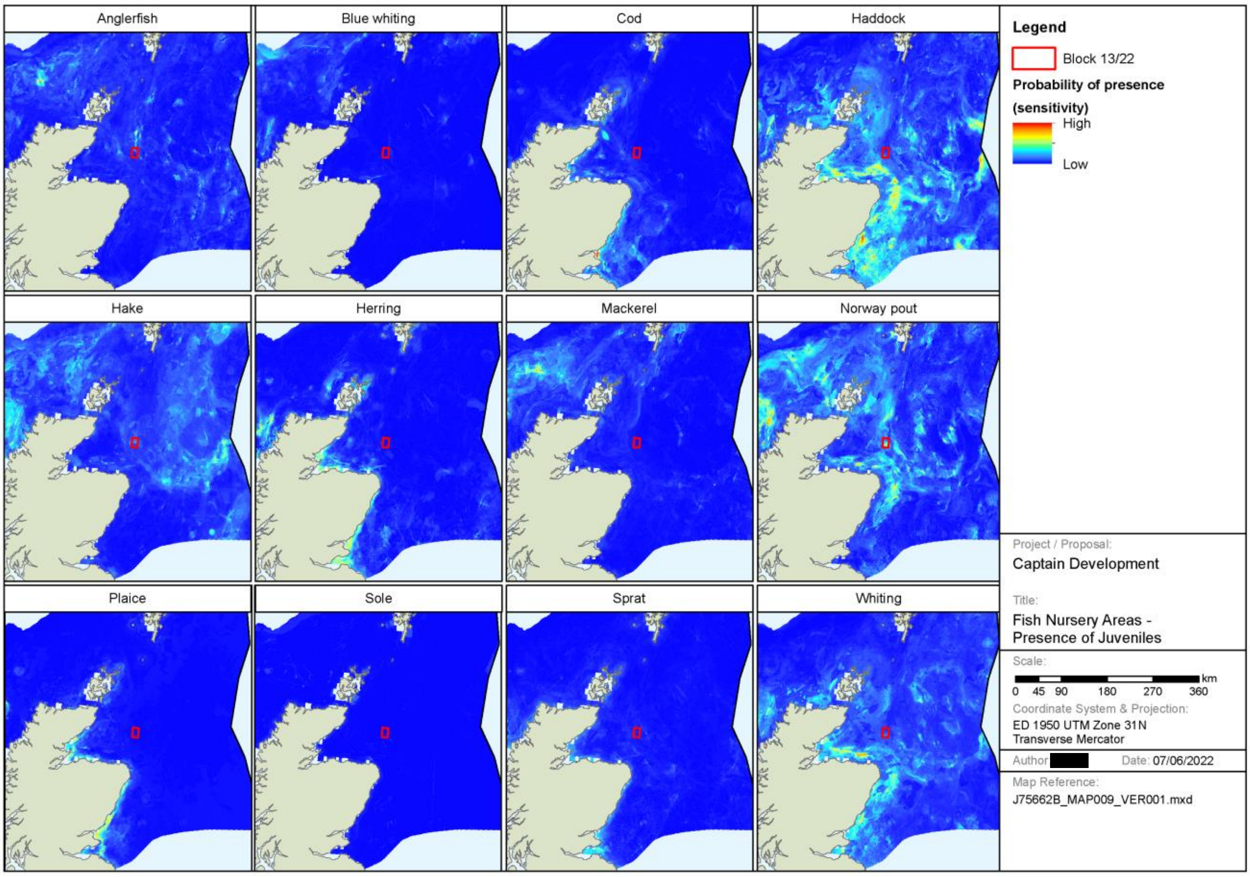


Figure 4-11: Fish juvenile presence in the proximity of Captain development area (Aires et al., 2014).

Whilst most species spawn into the water column of moving water masses over extensive areas, benthic spawners (e.g. herring, plaice and sandeel) have very specific habitat requirements, and therefore their spawning grounds are relatively limited and potentially vulnerable to seabed disturbance and change. Of the species identified above, herring, plaice, sandeel and *Nephrops* are among the species that may use the seabed for spawning in the area of the Captain field. Sandeels burrow at the seabed surface and so disturbance by means of increased siltation or surface abrasion can cause burrows to be infilled thereby affecting population density (Wright *et al*., 2000). Herring is also a demersal spawner and with the proposed operational period falling within the spawning period of this species they may be impacted.

Water depths at the Captain field range from 89.2 m LAT to 124.1 m LAT (see Section 4.3.1.1) and the sediment regime comprises approximately 30% fine sediments. Sandeels prefer spawning substrate with a low clay silt fraction (<10%) in water depths between 20 and 100 m, and so they are unlikely to use the area for spawning. Plaice are unlikely to use the area as they prefer coastal/protected areas; therefore, they are unlikely to be found in great numbers at the offshore Captain location. *Nephrops* are likely to be present and due to the nature of the sediment, are likely to spawn in the area.

The following species present in ICES rectangle 45E8 are listed as Scottish PMFs: anglerfish (*Lophius piscatorius*), blue whiting (*Micromesistius poutassou*), cod (*Gadus morhua*), herring (*Clupea harengus*), ling (*Molva molva*), mackerel (*Scomber scombrus*), Norway pout (*Trisopterus esmarkii*), sandeels (several members of the family *Ammodytes*), spurdog (*Squalus acanthias*) and whiting (*Merlangius merlangus*) (Marine Scotland, 2022).

4.4.4 Marine Mammals

Marine mammals include pinnipeds (seals) and cetaceans (whales, dolphins and porpoises). Marine mammals are vulnerable to the direct effects of oil and gas activities such as noise, contaminants and oil spills. They may also be affected indirectly by activities that affect prey availability.

4.4.4.1 Pinnipeds

Two species of seals live and breed in the UK, namely the grey seal (*Halichoerus grypus (Phoca vitulina*). Both grey and harbour seals are listed under Annex II of the EU Habitats Directive and are considered PMFs in Scottish waters. Approximately 36% of the world's grey seals breed in the UK (81% of these breed at colonies in Scotland with the main concentrations in the Outer Hebrides and in Orkney). Approximately 32% of harbour seals are found in the UK, however, this proportion has declined from approximately 40% in 2002. Harbour seals are widespread around the west coast of Scotland and throughout the Hebrides and Northern Isles (Special Committee on Seals, 2020). On the east coast, the distribution is more restricted with concentrations in the major estuaries, including the Moray Firth in Scotland.

Grey and harbour seals will feed both in inshore and offshore waters depending on the distribution of their prey, which changes both seasonally and yearly. Both species tend to be concentrated close to shore, particularly during the pupping and moulting season. Seal tracking studies from the Moray Firth have indicated that the foraging movements of harbour seals are generally restricted to within a 40–50 km range of their haul-out sites (Special Committee on Seals, 2020). The movements of grey seals can involve larger distances than those of the harbour seal and tracking of individual seals has shown that most foraging probably occurs within 100 km of a haul-out site although they can feed up to several hundred kilometres offshore (Special Committee on Seals, 2020).

Distribution maps based on telemetry data (1991 – 2016), count and effort data (scaled to the estimated population size in 2015) indicate that harbour seals are unlikely to occur in the vicinity of the Captain field though grey seals may be present at a density of 5-10 individuals per 5 km^2 (SMRU and Marine Scotland, 2017) (Figure 4-12).

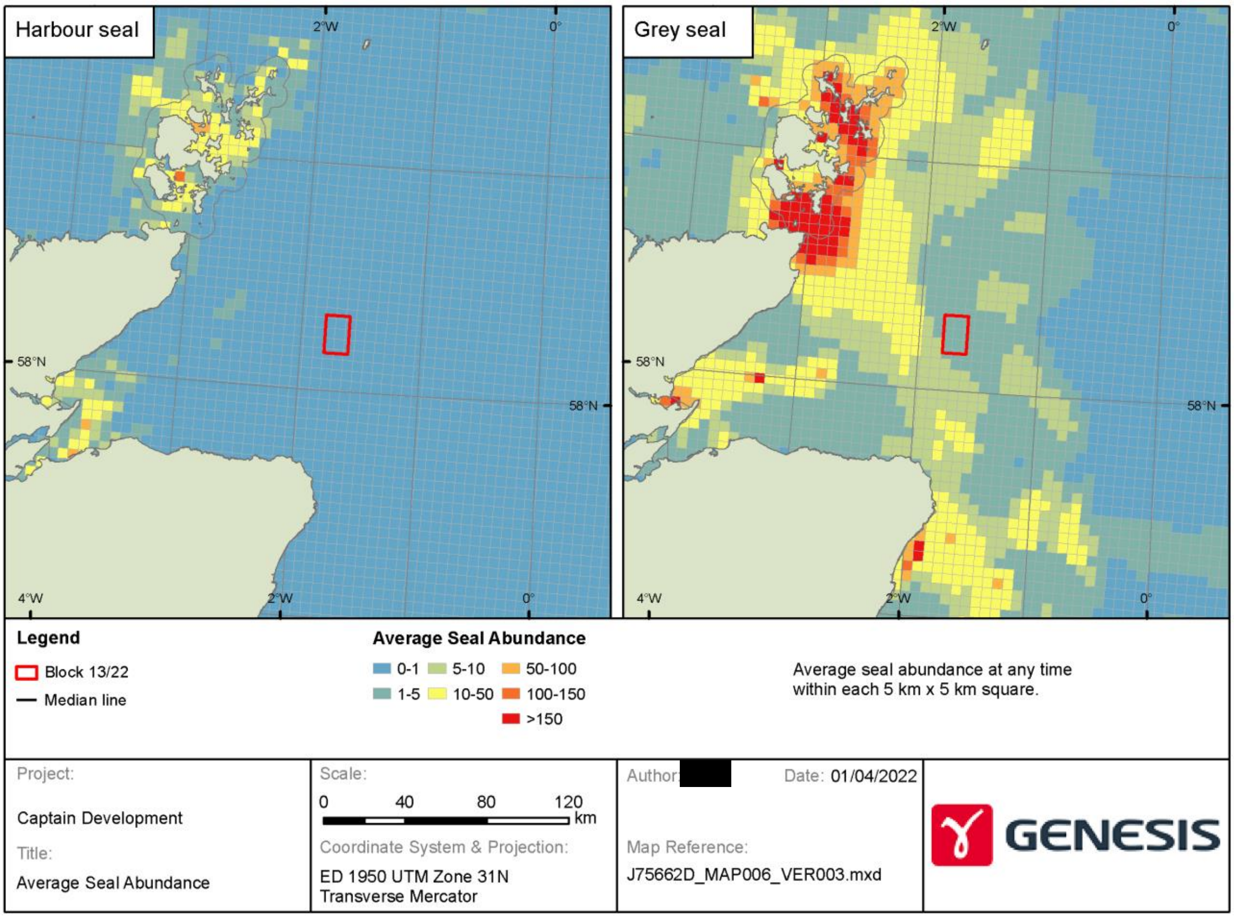


Figure 4-12: Harbour and grey seal distribution in relation to the Captain field (Russell et al., 2017).

4.4.4.2 Cetaceans

The CNS and Northern North Sea (NNS) have a moderate to high diversity and density of cetaceans, with a general trend of increasing diversity and abundance with increasing latitude. Harbour porpoise (*Phocoena phocoena*) and white-beaked dolphin (*Lagenorhynchus albirostris*) are the most widespread and frequently encountered species, occurring regularly throughout most of the year. Minke whales (*Balaenoptera acutorostrata)* are regularly recorded as frequent seasonal visitors. Coastal waters of the Moray Firth and the east coast of Scotland support an important population of bottlenose dolphins (*Tursiops truncates)*, while killer whales (*Orcinus orca*) are sighted with increasing frequency towards the north of the area. Atlantic white-sided dolphin *(Lagenorhynchus acutus*), Risso's dolphin (*Grampus griseus*) and long-finned pilot whale (*Globicephala melas*) can be considered occasional visitors, particularly in the north of the area (BEIS, 2016).

Many activities associated with the offshore oil and gas industry have the potential to impact on cetaceans by causing physical injury, disturbance or changes in behaviour. Activities with the potential to cause disturbance or behavioural effects include: drilling, seismic surveys, vessel movements, construction work including piling and decommissioning.

The distribution of cetacean species in UK waters has been compiled by the JNCC in the Atlas of Cetacean Distribution in North-West European Waters (Reid *et al*., 2003), which gives an indication of the monthly occurrence of cetacean species in the Captain area. The data suggest that minke whale (*Balaenoptera acutorostrata*), long finned pilot whale (*Globicephala melas*), bottlenose dolphin (*Tursiops truncatus*), Atlantic white-sided dolphin (*Lagenorhynchus acutus*), white-beaked dolphin (*Lagenorhynchus albirostris),* harbour porpoise (*Phocoena phocoena*) and killer whale (*Orcinus orca)* occur in the CNS at moderate densities (Table 4-5), with white beaked dolphin the most common species.

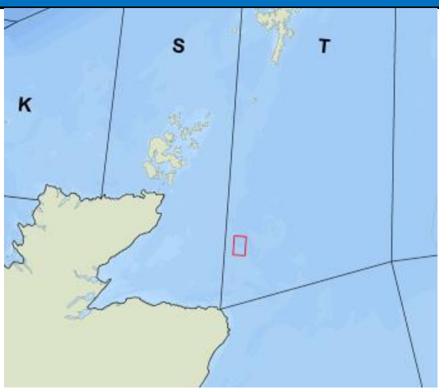
Table 4-5: Marine mammal seasonal abundance in the vicinity of Captain (Reid *et al*., 2003).

SPECIES	J	F	M	A	M	J	J	A	S	O	N	D
Minke Whale[1]					3		3	3				
Long Finned Pilot Whale												3
Killer Whale					3							
Bottlenose Dolphin	3											
White-beaked Dolphin[1]	3	2				3	2	1	2	3		1
Atlantic White-sided Dolphin[1]			2				3		3			
Harbour Porpoise[1]		2		2	2	2	1	2	2		2	2
Key	1 = High			2 = Moderate				3 =Low		Blank = No sightings		
Source: 1: Reid *et al.,* 2003.												

A series of Small Cetacean Abundance in the North Sea (SCANS) surveys have been conducted to obtain an estimate of cetacean abundance in North Sea and adjacent waters, the most recent of which is SCANS-III (Hammond *et al.,* 2017).

The Captain field is located within SCANS-III Block 'T'. Aerial survey estimates of animal abundance and densities (animals per km^2) within this area are provided in Table 4-6. The data confirm that some of those species identified by Reid *et al.,* (2003), frequent Block T (Hammond *et al.,* 2017).

Table 4-6: Cetacean Abundance in SCANS-III Survey Block T.

SCANS-III Block T	Species	Animal Abundance[1]	Density (animals/km^2)[1]	Management Units (MU) Population[2]
	Minke Whale	2,068	0.032	20,118
	White-beaked Dolphin	2,417	0.037	43,951
	Atlantic white-sided dolphin	1,366	0.021	18,128
	Harbour Porpoise	26,309	0.402	346,601
[1] Hammond *et al.*, (2017)	[2] Inter-Agency Marine Mammal Working Group (IAMMWG) (2021)			

4.4.5 Seabirds

The North Sea is an internationally important area for breeding and feeding seabirds. Using seabird density maps from European Seabirds at Sea (ESAS) data collected over 30 years, Table 4-7 identifies a number of the bird species (and their predicted maximum monthly abundance) known to occur in the Captain area (Kober *et al*., 2010). The data indicate that a number of seabird species are likely to occur in the area over the summer breeding season and winter months. For all species combined, up to 17 seabirds are predicted to occur per km^2 during the breeding season (April to October), whilst during the winter months (November to March) a maximum of 12 seabirds are predicted to occur per km^2.

Table 4-7: Predicted seabird density (maximum number of individuals per km^2) in the Captain project area (Kober et al., 2010).

Species	Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern Fulmar	Breeding			10.0 - 20.0	10.0 - 20.0	10.0 - 20.0	10.0 - 20.0	10.0 - 20.0					
	Winter	5.0 – 10.0	5.0 – 10.0						5.0 – 10.0	5.0 – 10.0	5.0 – 10.0	5.0 – 10.0	5.0 – 10.0
Sooty Shearwater	Summer							≤1.0	≤1.0	≤1.0	≤1.0	≤1.0	
Manx Shearwater	Additional										≤1.0	≤1.0	
European Storm Petrel	Breeding						≤1.0	≤1.0	≤1.0	≤1.0	≤1.0		
Northern Gannet	Breeding					≤1.0	≤1.0	≤1.0	≤1.0	≤1.0			
	Winter	≤1.0	≤1.0	≤1.0	≤1.0						≤1.0	≤1.0	≤1.0
Arctic Skua	Breeding					≤1.0	≤1.0	≤1.0	≤1.0				
Great Skua	Breeding					≤1.0	≤1.0	≤1.0	≤1.0				
	Winter	≤1.0	≤1.0	≤1.0	≤1.0					≤1.0	≤1.0	≤1.0	≤1.0
Black Legged Kittiwake	Breeding					5.0 – 10.0	5.0 – 10.0	5.0 – 10.0	5.0 – 10.0	5.0 – 10.0			
	Winter	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0						1.0 – 5.0	1.0 – 5.0	1.0 – 5.0
Great black-backed gull	Breeding				≤1.0	≤1.0	≤1.0	≤1.0	≤1.0				
	Winter	≤1.0	≤1.0	≤1.0						≤1.0	≤1.0	≤1.0	≤1.0
Leach's storm petrel	Breeding						≤1.0	≤1.0	≤1.0	≤1.0	≤1.0		
Lesser black-backed gull	Breeding					≤1.0	≤1.0	≤1.0	≤1.0				
	Winter	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0					1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0
Herring Gull	Breeding				≤1.0	≤1.0	≤1.0	≤1.0	≤1.0				
	Winter	≤1.0	≤1.0	≤1.0						≤1.0	≤1.0	≤1.0	≤1.0
Glaucous gull	Winter	≤1.0	≤1.0	≤1.0							≤1.0	≤1.0	≤1.0
Common Guillemot	Breeding					10.0 - 20.0	10.0 - 20.0						
	Additional								10.0 - 20.0	10.0 - 20.0			
	Winter	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0						1.0 – 5.0	1.0 – 5.0	1.0 – 5.0
Razorbill	Breeding					≤1.0	≤1.0						
	Additional								1.0 – 5.0	1.0 – 5.0			
	Winter	≤1.0	≤1.0	≤1.0	≤1.0						≤1.0	≤1.0	≤1.0
Little Auk	Winter	≤1.0	≤1.0	≤1.0								≤1.0	≤1.0
Atlantic Puffin	Breeding				1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0					
	Winter	≤1.0	≤1.0	≤1.0					≤1.0	≤1.0	≤1.0	≤1.0	≤1.0
ALL species combined	**Breeding**			10.0 - 20.0	10.0 - 20.0	10.0 - 20.0	10.0 - 20.0	10.0 - 20.0	10.0 - 20.0	10.0 - 20.0	10.0 - 20.0		
	Summer							>20.0	>20.0				
	Winter	10.0 - 20.0	10.0 - 20.0	10.0 - 20.0								10.0 - 20.0	10.0 - 20.0

Key	Not recorded	≤1.0	1.0 – 5.0	5.0 – 10.0	10.0 - 20.0	>20.0

Seabirds are generally not at risk from routine offshore oil and gas production operations. However, they may be vulnerable to pollution from less regular offshore activities such as well testing and flaring, when hydrocarbon dropout to the sea surface can occasionally occur, or from unplanned events such as accidental hydrocarbon spills.

The Seabird Oil Sensitivity Index (SOSI) identifies areas where seabirds are likely to be most sensitive to oil pollution by considering factors that make a species more or less sensitive to oil-related impacts. The index combines the seabird survey data with individual seabird species sensitivity index values. These values are based on a number of factors which are considered to contribute towards the sensitivity of seabirds to oil pollution, and include:

- habitat flexibility (the ability of a species to locate to alternative feeding grounds);
- adult survival rate;
- potential annual productivity; and
- the proportion of the biogeographical population in the UK (classified following the methods developed by Certain *et al.,* (2015).

The combined seabird data and species sensitivity index values are summed at each location to create a single measure of seabird sensitivity to oil pollution. The mean sensitivity SOSI data for the area is shown in Table 4-8. For blocks with 'no data', an indirect assessment has been made (where possible) using JNCC guidance (JNCC, 2017). The sensitivity of birds to surface oil pollution in the Captain field area is generally medium throughout the year. Exceptions are February and December when it is regarded as Extremely High and Very High respectively.

Table 4-8: SOSI data (and indirect assessment) for Block 13/22 (including adjacent Blocks; JNCC, 2017).

Block	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
13/16	5	5	5	3*	3	3	4	5	3	3*	5*	5
13/17	5	5	5	3*	3	3	5	5	3	3*	5	5
13/18	5	5	5	3*	3	3	5	5	4	4*	5	5*
13/21	5	1	5	5*	5	3	4	5	4	2*	2	1
13/22	5	1	5	3*	3	3	5	5	4	4*	5	2
13/23	5	1	5	4*	4	3	5	5	4	4*	5	3
13/26	5	3	5	1	1*	1	4	5	4	2*	2	1
13/27	5	1	5	1	5	2	4	5	4	2*	2	2
13/28	5	1	5	5*	4*	4	4	5	4	3	2	2
Key	1 Extremely High			2 Very High		3 High		4 Medium			5 Low	

Indirect Assessment – data gaps have been populated following guidance provided by the JNCC (JNCC, 2017).
** Data gap filled using data from the same Block in adjacent months.*

4.5 Conservation

4.5.1 Designated Sites

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

The closest area of conservation interest is the Southern Trench NCMPA, which lies approximately 47 km to the south (Figure 4-13). The site is designated for protection due to the presence of a variety of biodiversity and geological features, including, shelf deeps, fronts, burrowed mud, minke whale, sub-glacial tunnel valleys and moraines and slide scars from submarine mass movement (NatureScot, 2022). As discussed in Section 4.4.4, minke whale have been observed in the vicinity of the Captain field. Similarly, the waters surrounding the Captain field are important nursery grounds for various fish species (Section 4.4.3). The Southern Trench also acts as a nursery for juvenile fish, contains megafauna commonly found in mud and attracts the prey of minke whale – herring, cod and mackerel (JNCC, 2012).

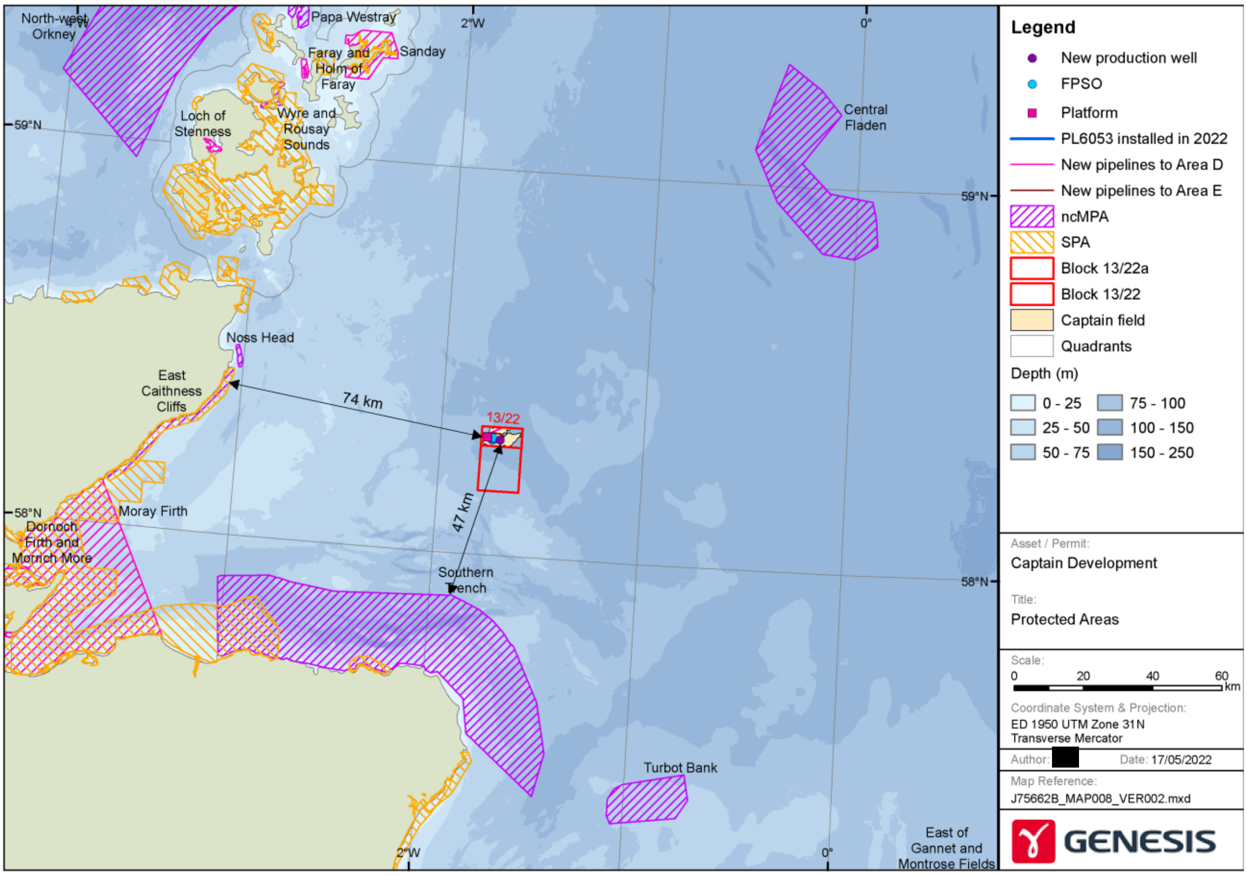


Figure 4-13: Protected sites in the vicinity of the Captain field.

4.5.2 Designated Species and Habitats

Four Annex II species occur in UK waters, harbour seals, grey seals, bottlenose dolphin and harbour porpoise[3]. As discussed in Section 4.4.4, harbour seals are unlikely to occur in the project area whilst grey seals have been recorded at a density of 5-10 individuals per 5 km^2. There is a resident population of bottlenose dolphins in the Moray Firth and despite their transient nature they tend to remain in coastal waters away from the Captain area (though they have been recorded in low numbers in January), whilst harbour porpoise have been recorded at moderate to high densities throughout the year (Table 4-5).

Under the Habitats Directive, all cetaceans recorded within the Captain area (Table 4-5) are listed as Annex IV European Protected Species (EPS)[4]. They are also identified as being of conservation importance in Scotland and are therefore considered to be PMFs.

The following fish species are also listed as PMF; anglerfish, blue whiting, cod, herring, ling, mackerel, Norway pout, sandeels, spurdog (also known as spiny dogfish) and whiting (Marine Scotland, 2022). Cod are also listed on the OSPAR List of Threatened and/or Declining Species (OSPAR, 2008).

As described in Section 4.4.2 the sediment in the area are representative of the PMF broad habitat 'Burrowed mud' and 'Offshore deep-sea muds' and the priority habitat 'Mud habitats in deep water and the Annex II habitat 'sea pens and burrowing megafauna'.

4.5.3 National Marine Plan

The NMP covers the management of both Scottish inshore waters (out to 12 nautical miles) and offshore waters (12 to 200 nautical miles). The aim of the NMP is to help ensure the sustainable development of the marine area through informing and guiding regulation, management, use and protection of the Marine Plan areas. The NMP principals are identified in Appendix A (Table A-1) along with an assessment of compliance against relevant policies through the impact assessment in Section 5.

4.6 Socio-Economic Environment

This section describes the socio-economic activities in the vicinity of the Captain field, which primarily include fishing, shipping and oil and gas operations.

4.6.1 Commercial Fisheries

The Captain field occurs within ICES rectangle 45E8. (Marine Scotland, 2021). Fishing effort statistical data for 2016 to 2020 (Table 4-9) shows that UK fishing effort within this rectangle varies both monthly and annually with fishing occurring at all times of the year. ICES rectangle 45E8 contributed, on average, 0.7% of the total number of days fished by UK fishing vessels between 2016 and 2020 (Marine Scotland, 2021) suggesting that 45E8 is of low to moderate importance to the UK fishing industry (Table 4-9 and Figure 4-14).

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[3] Annex II species are species of community interest whose conservation requires the designation of special areas of conservation.
[4] EPS species have full protection under The Conservation of Habitats and Species Regulations 2017. It is an offence to deliberately capture, injure or kill or deliberately disturb an EPS.

Table 4-9: Fishing effort (days) taken from ICES rectangle 45E8 (2016-2020) (Marine Scotland, 2021).

Year	Monthly Fishing Effort (days)												Total	UK Total	45E8 as % of UK
	J	F	M	A	M	J	J	A	S	O	N	D			
2016	60	74	20	101	94	205	59	132	65	46	54	47	958	131,590	0.7
2017	88	26	43	68	33	159	81	30	24	51	51	49	703	125,831	0.6
2018	44	40	55	101	21	46	73	103	35	91	126	107	843	124,844	0.7
2019	73	34	42	21	150	108	66	22	31	71	81	98	797	126,353	0.6
2020	75	77	70	14	52	68	54	45	74	75	107	68	779	103,918	0.7
Mean	60	74	20	101	94	205	59	132	65	46	54	47	816	122,507	0.7

Notes:

Monthly effort data are shown where five or more UK vessels over 10 m undertook fishing activity in a given year.

The fishing effort data includes the time spent travelling to fishing grounds as well as the time spent fishing.

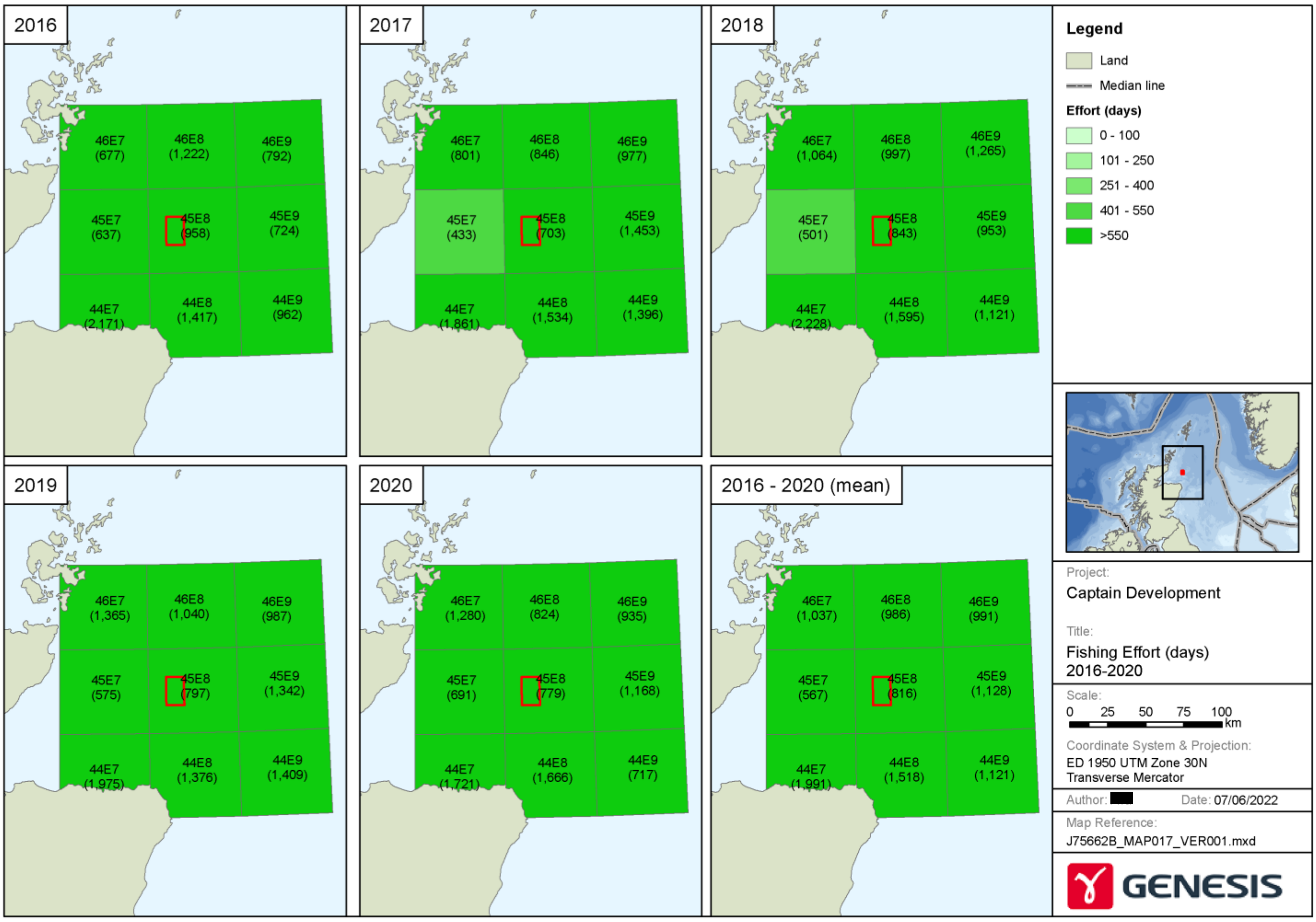

Figure 4-14: Fishing effort (days) (2016-2020) (Marine Scotland, 2021).

The annual weight (te) of landings for fish and shellfish in ICES rectangle 45E8 and the surrounding rectangles for the years 2016-2020 is shown in Figure 4-15. Demersal species made up the majority of the catch (by value and weight) in this area (Marine Scotland, 2021).

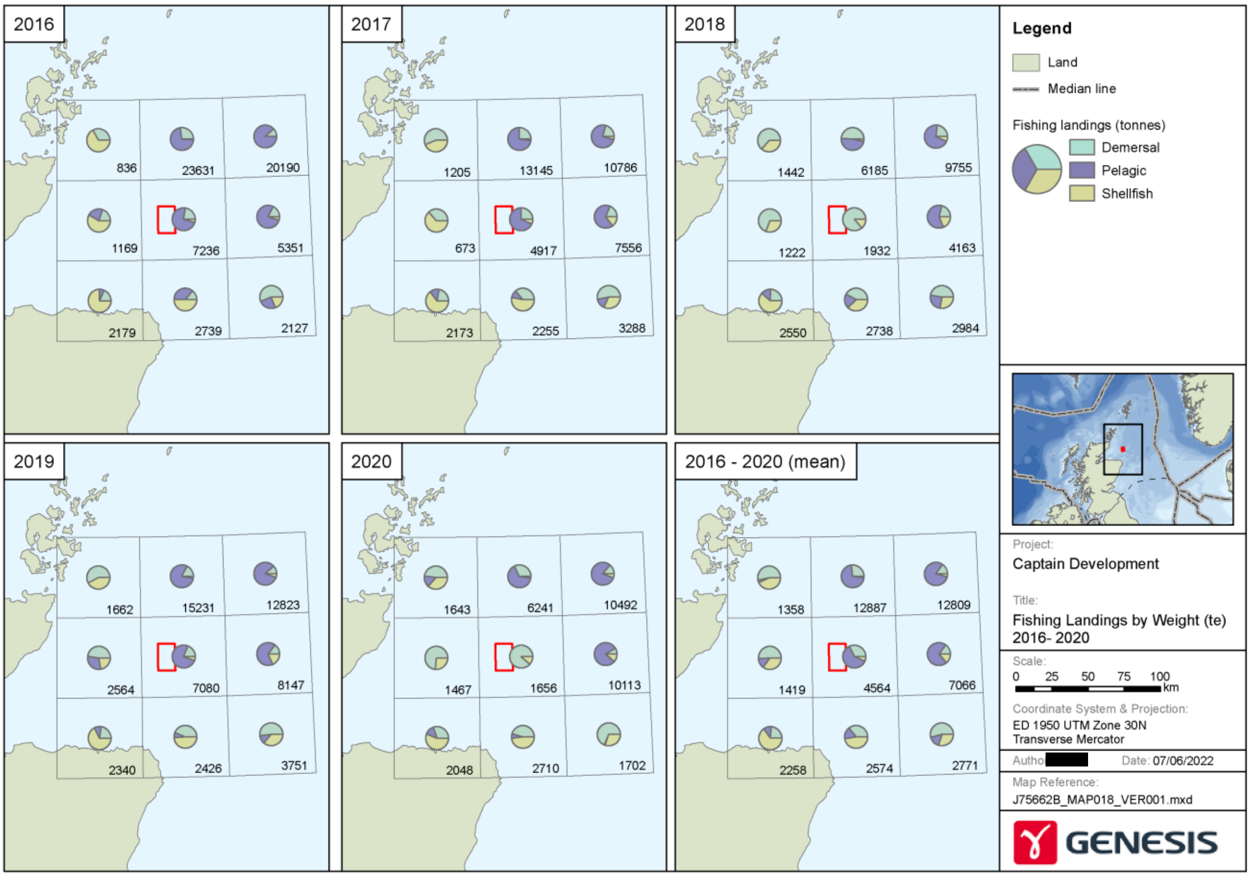

Figure 4-15: Landings (te) in 44F1 between 2016 and 2020 for demersal, pelagic, and shellfish catches (Marine Scotland, 2021).

The weight (te) and value (£) of landings from UK vessels for demersal, pelagic and shellfish species from ICES rectangle 45E8 are shown in Table 4-10. These landings equate to 1.5% (by weight) and 1.4% (by value) of total UK reported landings in 2020, also suggesting that this area is of high importance to the UK fishing industry. In addition, it demonstrates that bottom trawl gear is used emphasising the importance of ensuring a safe seabed as part of the proposed project.

Table 4-10: Landings (by species type) from ICES rectangle 45E8 (2020) (Marine Scotland, 2021).

Species Type	Weight (te)			Value (£)		
	UK Total	45E8	% of UK	UK Total	45E8	% of UK
Demersal	115,898	1,465	1.3	184,520,801	2,051,407	1.1
Pelagic	329,965	0	0.0	283,309,285	460	0.0
Shellfish	72,518	191	0.3	176,825,552	448,575	0.3
Total	518,381	1,656	1.5	644,655,638	2,500,442	1.4

4.6.2 Shipping Activities

The North Sea contains some of the world's busiest shipping routes, with significant traffic generated by vessels trading between ports at either side of the North Sea and the Baltic. North Sea oil and gas fields generate moderate vessel traffic in the form of support vessels, principally operating from Peterhead, Aberdeen, Montrose and Dundee in the north and Great Yarmouth and Lowestoft in the south (BEIS, 2016).

Shipping density for the Captain field (Block 13/22) has been classed a low by the Oil and Gas Authority (2016; Figure 4-16). The shipping density corresponds to an average of six vessels per day. The closest route passes 3.1 nautical miles to the east and, is used primarily by cargo vessels travelling to and from Faroe Islands and Humber ports (Anatec, 2015).

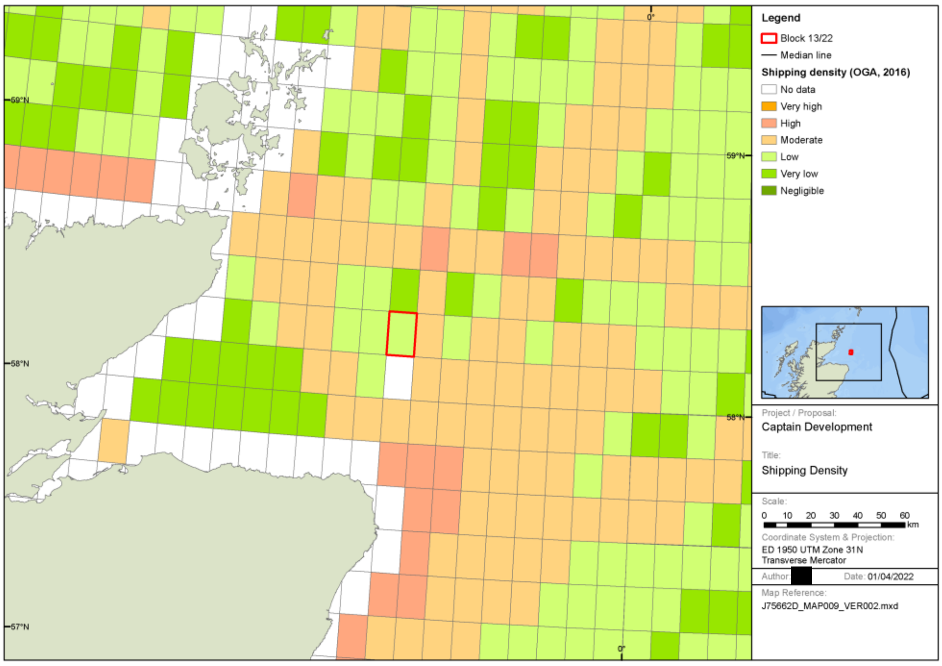

Figure 4-16: Shipping density as categorised by OGA (OGA, 2016).

4.6.3 Surrounding Oil and Gas Infrastructure

The Captain Development lies west of a relatively mature oil and gas area (Figure 4-17). The only surface installation with 40 km of the drilling location is the Ross FPSO located *c.* 27 km southeast of the proposed drilling location.

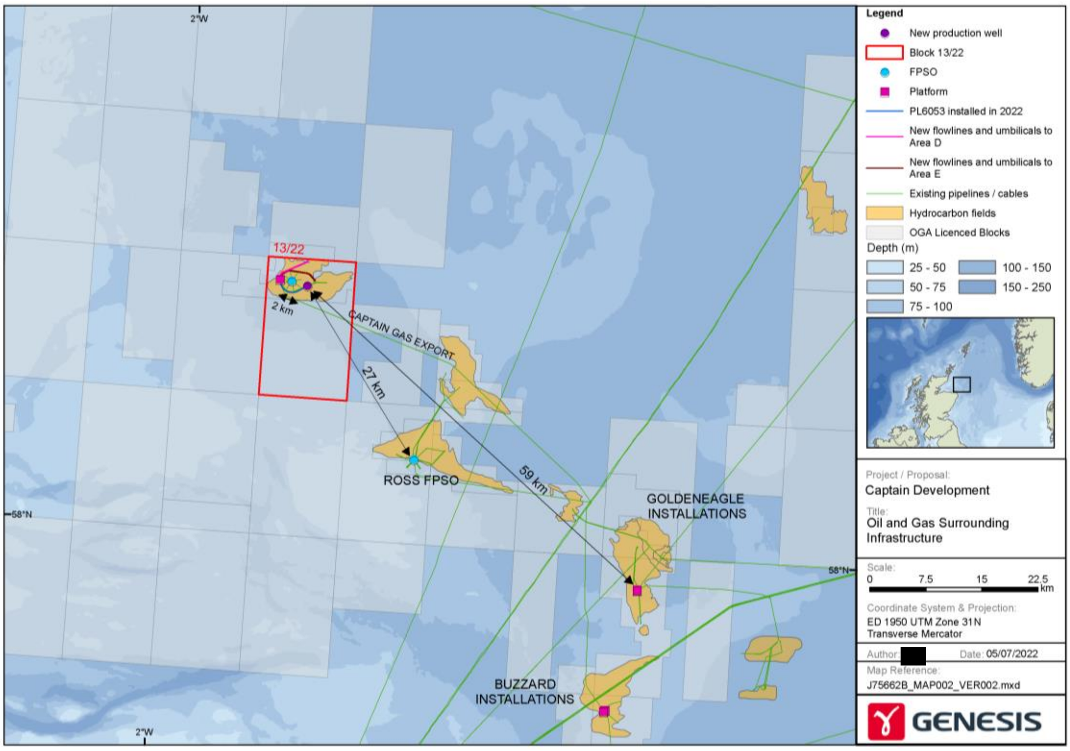

Figure 4-17: Nearby oil and gas infrastructure.

4.6.4 Military Activity

The Captain development is not located within any military practice and exercise areas (PEXA), nor are there any Ministry of Defence (MoD) related block restraints on Block 13/22. The nearest MoD practice and exercise area is *c*. 6 km to the west of the Captain platforms (Figure 4-18). At this distance the proposed drilling activities are not expected to be a concern for the MoD.

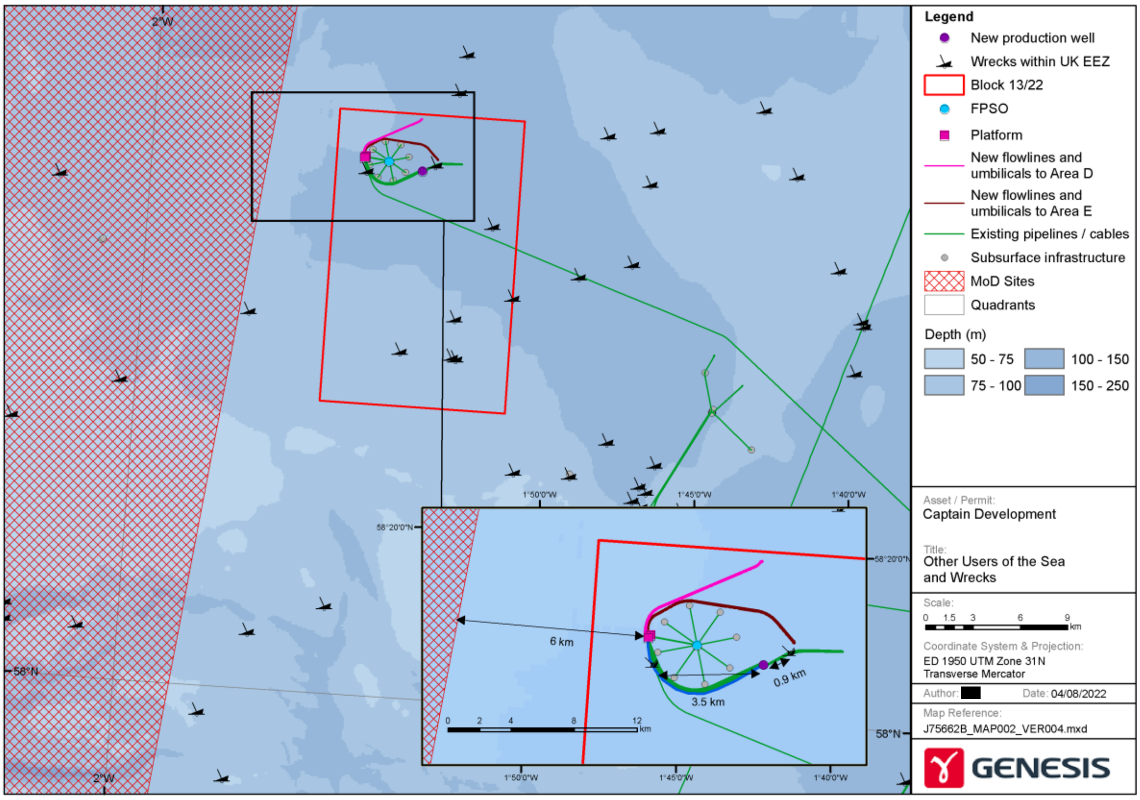

Figure 4-18: Proximity to MoD sites and wrecks.

4.6.5 Submarine Cables

According to the NMPi there are no aggregate extraction areas or subsea telecommunication cables within the vicinity of Block 13/22. The closest active cable to the Captain Development area is the KIS-ORCA cable (Caithness High Voltage Direct Current power cable), located *ca.* 44 km from the Block 13/22 (Scottish Government NMPI, 2022).

4.6.6 Offshore Wind farms

Block 13/22 intersects with the proposed NE6 one of the Scotwind programme proposed windfarm sites (NE6) however the proposed project location is 10 km northeast of the area (Figure 4-19). At this distance the proposed project activities will not impact on the NE6 floating wind farm project.

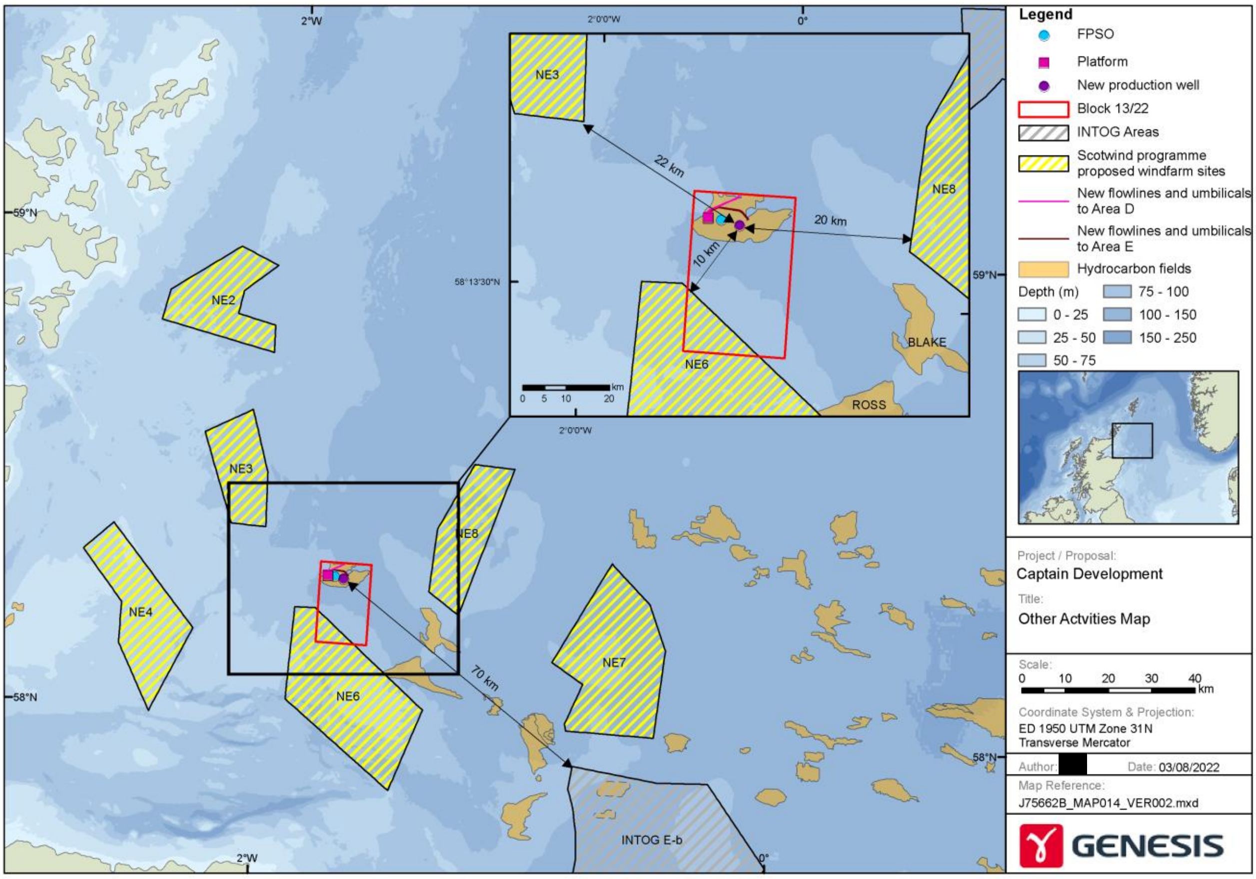

Figure 4-19: Location of the Captain field in relation to Scotwind sites and INTOG areas.

4.6.7 Wrecks

As shown in Figure 4-18 the closest wreck to the proposed project location is *c*. 0.9 km northeast of the well location and therefore will not be impacted by the mooring system.

4.6.8 Aquaculture and Shellfish Water Protection Areas

As can be seen in Figure 4-20 there are no aquaculture sites or shellfish protected areas within the immediate vicinity of the Captain field. The closest aquaculture sites and shellfish protected areas are the Dornoch Firth and Cromarty Bay, *c.* 142 km and 154 km respectively (Scottish Government NMPi, 2022).

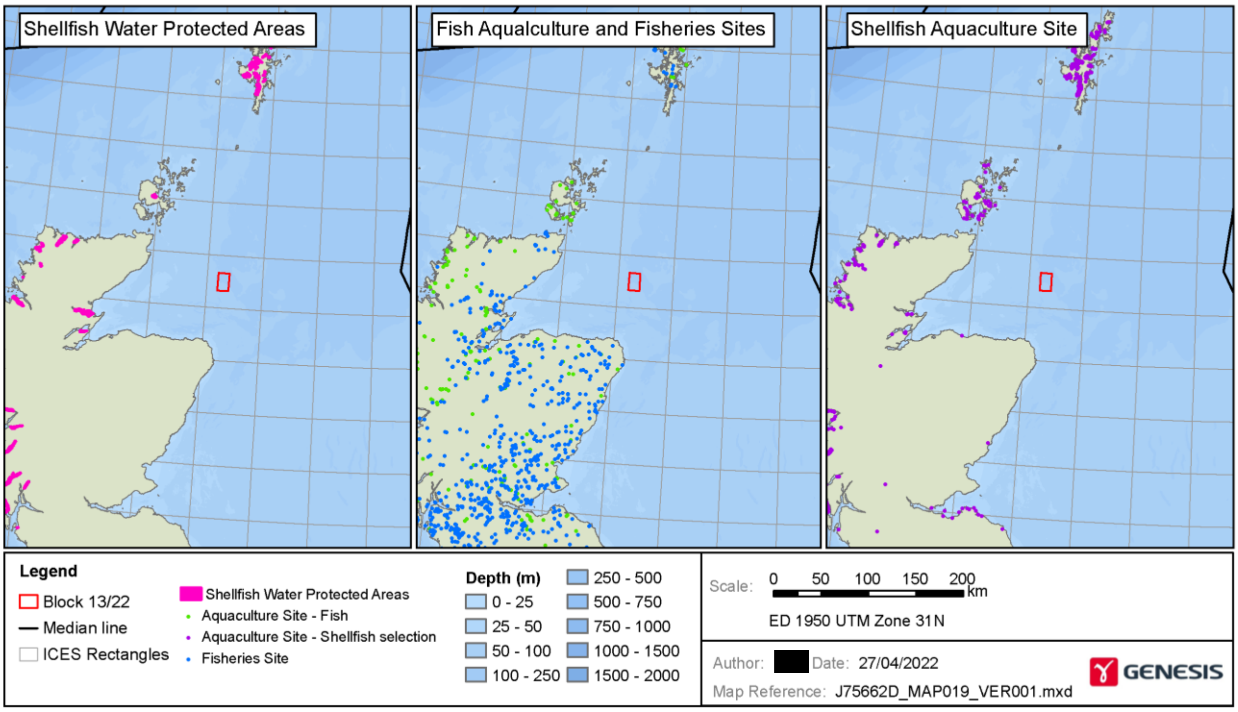

Figure 4-20: Location of aquaculture and shellfish water protection areas.

5. ENVIRONMENTAL IMPACT ASSESSMENT METHODOLOGY

5.1 Introduction

This section presents the Environmental and Socio-Economic Impact Assessment (ESIA) and the Environmental and Socio-Economic Risk Assessment (ESRA) matrices used to determine the impact of the planned and unplanned activities (respectively) associated with the Captain EOR Stage 2 Phase II project.

5.2 Receptors and Aspects

5.2.1 Environmental and Socio-Economic Receptors

Receptors considered in the ESIA and ESRA include:

Environmental receptors:

- Resource availability;
- Air quality;
- Water quality;
- Sediment quality;
- Plankton;
- Benthic communities (including flora and fauna);
- Fish;
- Marine mammals;
- Seabirds;
- Designated areas.

Socio-economic receptors:

- Landfill resources;
- Fisheries;
- Shipping.

5.2.2 Identification of Aspects

Aspects considered include:

- Energy use and emissions to air;
- Physical presence of vessels and drilling rig;
- Physical presence of infrastructure installed;
- Discharges to sea;
- Disturbance to the seabed;
- Underwater noise;
- Waste generation;
- Resource use; and
- Unplanned events.

The aspects associated with each activity were assessed in terms of their impact on the receptors in the area. For example, the use of vessels will result in emissions to air, discharges to sea, underwater noise, physical use of space and, if anchored, disturbance to the seabed. Receptors potentially impacted by these aspects include air quality, marine mammals, seabirds, other users of the sea, seabed sediments and benthic communities (if anchored).

5.3 ESIA for Planned Activities

The significance of the environmental/socio-economic impact of planned activities on each of the susceptible receptors is derived by considering the 'Receptor Sensitivity' in relation to the 'Magnitude of Effect' of the aspect.

5.3.1 Receptor Sensitivity

Four categories of Receptor Sensitivity are applied ranging from 'Low' to 'Very High' as shown in Table 5-1.

Table 5-1 Receptor Sensitivity to a planned activity and an unplanned event.

Category	Environmental / Societal Definition
(a) Low	**Flora/Fauna/Habitats - within the impacted area:** • Population sizes are considered to be of little to no geographical importance. • Species do not have designated conservation status and are of IUCN 'Least Concern'. • No designated habitat/sites. • Impacted species are widespread in the North East Atlantic region. **Air quality:** Emissions may impact on other nearby installations. **Water quality:** Open offshore water body. **Cultural heritage sites:** Site integrity is already compromised. **Resource availability:** (e.g. landfill sites, diesel use) Renewable and/or abundant. **Third party users:** have capacity to absorb change without impact.
(b) Medium	**Flora/Fauna/Habitats – within the impacted area:** • Significant numbers of at least one receptor of national importance (e.g. PMFs). • Significant numbers of a species which is listed as IUCN[1] 'Near Threatened'. • Nationally designated habitat/sites (e.g. PMFs). • Species may be of regional value. **Air quality**: Populated areas nearby. **Water quality**: Semi-enclosed water body with good flushing. **Cultural heritage sites:** Site is of local heritage importance. **Resource availability**: (e.g. landfill sites, diesel use) Renewable and/or available. **Third party users:** have capacity to absorb change without significant impact.
(c) High	**Flora/Fauna/Habitats – within the impacted area:** • Significant numbers of at least one receptor of regional (European) importance (e.g. Annex II / IV species and OSPAR designations). • Significant numbers of a species which are listed as IUCN 'Vulnerable'. • Regionally designated habitats/sites (e.g. OSPAR designations and Annex I habitats: SACs and SPAs). • Locally distinct sub-populations of some species may occur. **Air quality:** Densely populated areas nearby. **Water quality:** Semi-enclosed water body with limited flushing. **Cultural heritage sites:** Site is of regional heritage importance. **Resource availability:** (e.g. landfill sites, diesel use) Not renewable and/or limited availability. **Third party users:** have low capacity to absorb change and significant impact is likely to occur.

[1] International Union for Conservation of Nature

Category	Environmental / Societal Definition
(d) Very High	**Flora/Fauna/Habitat – within the impacted area:** • Significant numbers of at least one receptor of international importance. • Significant numbers of a species which are listed as IUCN 'Endangered' or 'Critically Endangered'. • Internationally designated habitats/sites (e.g. Ramsar sites). • At least one receptor is endemic (unique) to the area. **Air quality:** Very densely populated area with sensitive receptors such as schools and hospitals. **Water quality:** Enclosed water body with no flushing. **Cultural heritage sites:** Site is of international heritage importance. **Resource availability:** (e.g. landfill sites, diesel use) Not renewable and/or scarce availability. **Third party users:** have no capacity to absorb change e.g. unemployment due to long term closure of fisheries.

5.3.2 Climate Change

With respect to the emission of greenhouse gases, climate is considered a global receptor rather than a local receptor. The categories identified in Table 5-1 do not capture definitions for climate change. This is because the sensitivity status of climate is considered to be 'Very High' in line with the 2021 Climate Change Report produced by the Intergovernmental Panel on Climate Change (IPCC, 2021).

5.3.3 Magnitude of Effect

Definitions for the Magnitude of Effect on the receptors are presented in Table 5-2. Prior to determining the Magnitude of Effect, industry recognised 'base case' mitigation measures were assumed to be applied. For example, only MARPOL compliant vessels will be used. These industry recognised mitigations are considered prior to identifying the residual impact.

Table 5-2 Magnitude of Effect.

Magnitude Level		Description	
		Environmental Impact	Socio-economic Impact
0	**Positive/No effect** *Regulatory compliance or Company goals are not a concern.*	**No environmental concerns** • Positive environmental impact e.g. retaining a 500 m safety zone resulting in a 'protected area'. • No significantly negative environmental effects.	**No public concerns** • Possible enhancement in the availability of a resource benefitting the persons utilising the area e.g. removal of 500 m safety zones results in return of access to fishing grounds. • No impacts on sites or features of cultural heritage. • No impact on resource or landfill availability.
1	**Negligible** *Regulatory compliance or Company goals are not breached.*	**Negligible environmental effects** • Any effects are unlikely to be discernible or measurable and will reverse naturally. • No beaching or transboundary impacts.	**Limited local public awareness and no concerns** • An intermittent short-term decrease in the availability of a resource which is unlikely to be noticed e.g. vessels working out-with existing 500 m safety zones could temporarily impact on a shipping route or fishing area. • Undiscernible changes to a site or feature of cultural heritage that do not affect key characteristics and are not above background changes. • Undiscernible use of a resource (e.g. diesel, rock cover or landfill).

<table>
<tr><th colspan="2" rowspan="2">Magnitude Level</th><th colspan="2">Description</th></tr>
<tr><th>Environmental Impact</th><th>Socio-economic Impact</th></tr>
<tr><td>2</td><td>Minor
Regulatory compliance is not breached.</td><td>Minor, localised, short term, reversible effect
• Any change to the receptor is considered low, would be barely detectable and at same scale as existing variability.
• Recover naturally with no Company intervention required.
• No beaching or transboundary impacts.</td><td>Some local public awareness and concern
• A temporary (<1 year) decrease in the availability or quality of a resource e.g. access to fishing grounds may temporarily be inhibited due to presence of vessels.
• Minor changes to a site or feature of cultural heritage that do not affect key characteristics.
• Minor use of a resource (e.g. diesel, rock cover or landfill).</td></tr>
<tr><td>3</td><td>Serious
Possible minor breach of regulatory compliance.</td><td>Detectable environmental effect within the project area
• Medium localised changes to the receptor are possible.
• Localised Company response may be required.
• No beaching or transboundary impacts.</td><td>Regional / local concerns at the community or stakeholder level which could lead to complaints
• Medium decrease in the short-term (1-2 years) availability or quality of a resource affecting usage e.g. bring a rig on site for 1-2 years.
• Nuisance impacts e.g. marine growth odour coming from yards.
• Partial loss of a site or feature of cultural heritage.
• Moderate use of a resource (e.g. diesel, rock cover or landfill).</td></tr>
<tr><td>4</td><td>Major effect
Possible major breach of regulatory compliance.</td><td>Severe environmental damage extending beyond the project area
• High, widespread mid-term (2-5 years) degradation of the receptor.
• Company response (with Corporate support) required to restore the environment.
• Possible beaching and / or transboundary impacts.</td><td>National stakeholder concerns leading to campaigns affecting the Company's reputation
• High mid-term (2-5 year) decrease in the availability or quality of a resource affecting usage e.g. closure of fishing grounds.
• Substantial loss or damage to a site or feature of cultural heritage.
• High use of a resource (e.g. diesel, rock cover or landfill).</td></tr>
<tr><td>5</td><td>Critical effect
Major breach of regulatory compliance resulting in project delays and prosecution.</td><td>Persistent severe environmental damage
• Very high, widespread long-term (>5 years) degradation to the receptor that cannot be readily rectified.
• Major impact on the conservation objectives of internationally/nationally protected sites.
• Full Corporate response required.
• Major beaching and/or transboundary impacts.</td><td>International public concern and media interest affecting the Company's reputation
• Very high decrease in availability of a resource and potentially livelihood of users for > 5 years e.g. hydrocarbons on beaches affecting tourism or tainting of fish resulting in the long-term closure of fishing grounds.
• Total loss of a site or feature of cultural heritage.
• Significant use of a resource (e.g. diesel, rock cover or landfill).</td></tr>
</table>

5.3.4 Cumulative Impacts

The EIA sets the activities and potential impacts in the context of all other activities taking place in the Captain Field area to determine the additional cumulative effects of the new activities. The potential cumulative effects are discussed in the impact assessment chapters.

5.3.5 Environmental / Socio-Economic Impact Significance

The 'Receptor Sensitivity' and the 'Magnitude of Effect' were combined using the matrix presented in Table 5-3 to determine the level of impact for planned activities.

Table 5-3: Impact significance matrix.

		Receptor Sensitivity			
		(a) Low	(b) Medium	(c) High	(d) Very High
Magnitude of Effect	(0) Positive/No Effect				
	(1) Negligible				
	(2) Minor				
	(3) Serious				
	(4) Major				
	(5) Critical				

Definition of categories of risk significance	
(i) Positive / No Effect significance	• Positive or no environmental or socio-economic impact • No public interest or positive public support
(ii) Low significance	• No/negligible environmental and socio-economic impact • No concerns from consultees
(iii) Moderate significance	• Discernible environmental and socio-economic impacts • Requirements to identify project specific mitigation measures • Concerns by consultees which can be adequately addressed by the Company
(iv) High significance	• Substantial environmental and socio-economic impacts • Serious concerns by consultees requiring Corporate support • Alternative approaches should be identified

5.3.6 Transboundary Impacts

Where relevant, transboundary impacts of each aspect on the receptors is discussed in the impact assessment chapters e.g. the impact of emissions on climate change.

5.4 ESRA for Unplanned Events

To determine the environmental and socio-economic risk of an unplanned event (e.g. dropped object or well blowout), the following approach considers firstly the significance of the environmental or socio-economic impacts of an event should it occur and secondly the likelihood of the event occurring.

5.4.1 Environmental and Socio-economic Significance of an Unplanned Event

The ESIA approach described in Section 5.3 for determining the environmental and socio-economic impacts of planned activities was also used to determine the significance of impacts that may result from unplanned events.

5.4.2 Likelihood of an Unplanned Event

Five categories of 'likelihood' have been identified as presented in Table 5-4.

Table 5-4: Likelihood of an unplanned event.

Likelihood Category	Definition
Extremely Remote	Has never occurred within industry or similar industry but theoretically possible.
Remote	Similar event has occurred elsewhere but unlikely to occur with current practices.
Unlikely	Event has occurred in the industry during similar activities
Possible	Event could occur during project activities.
Likely	Event is likely to occur more than once during the project.

5.4.3 Environmental Risk of an Unplanned Event

Combining the significance of the environmental/socio-economic impact with the 'likelihood of the unplanned event occurring' allows the level of environmental risk to be determined using the matrix presented in Table 5-5. Note the potential for a beneficial impact significance has been removed as it is not expected that an unplanned event would lead to a beneficial environmental or socio-economic impact.

Table 5-5: ESRA matrix for unplanned activities.

		Environmental Significance of Unplanned Event*		
		(ii) Low	(iii) Moderate	(iv) High
Likelihood of Event	Extremely Remote	Low	Low	Low
	Remote	Low	Low	Medium
	Unlikely	Low	Medium	Medium
	Possible	Low	Medium	High
	Likely	Low	High	High

*Note the numbers associated with each significance level range from (ii) to (iv) in keeping with assignment in Table 5-3.

Low risk	• Negligible environmental and socio-economic risks. • Mitigation measures are industry standard and no project specific mitigation required. • No consultee concerns.
Medium risk	• Discernible environmental and socio-economic risks. • Consultee concerns can be adequately resolved. • Local public interest.
High risk	• Significant environmental and socio-economic risks. • Serious consultee concerns. • Media interest and reputational impacts.

5.5 Assessment of Significance of Environmental and Socio-Economic Risks

Using the information provided in Sections 3 and 4 and the criteria set out above, Appendix B (ENVID table) identifies all activities associated with the proposed project and their potential environmental risk.

The ENVID table is split into five nodes:

- Vessel Use;
- Drilling Phase;
- Subsea Installation Phase;
- Topside Modifications;
- Production Phase.

The assessment showed that with the application of industry standard mitigation measures the majority of the planned activities are expected to have a low environmental/socio-economic significance of impact. Exceptions include:

- The impact of atmospheric emissions from different activities were identified as potentially having a Moderate impact significance on climate change.
- Disturbance to the seabed associated with the jet trenching of the six polymer injection flowlines and the two umbilicals. The impact of this disturbance was also identified as potentially having a Moderate impact significance.

Sections 6 – 11 further assess the impacts of the aspects/activities that:

- Are subject to regulatory control;
- Were found to have a moderate significance impact (for planned events) or a Medium environmental risk (in the event of accidental events);
- Were raised during the consultation phase; or
- Were identified as areas of public concern.

Section 12 presents the results of modelling carried out to determine the impact of a major hydrocarbon loss.

6. PHYSICAL PRESENCE

This section discusses the potential impacts associated with:

- the presence of the vessels and drilling rig during the proposed drilling, installation, commissioning and production activities; and
- the permanent presence of the new subsea infrastructure and associated stabilisations,

on other sea users and animals (other than the benthic species) using the impact assessment methodology presented in Section 5. The impacts on the seabed and the local benthic communities are discussed in Section 9 'Seabed Disturbance'.

6.1 Presence of Vessels and the Drilling Rig

Vessels associated with the drilling, installation (and commissioning) and production phases of the proposed project are summarised in Table 3-8, Table 3-11, Table 7-7 and Table 7-8.

It is expected the COSLPioneer semi-submersible drilling rig will be on site for around 395 days. Anchor vessels will be required before the drilling rig is set down at each drilling location whilst an EERV, and supply vessel will be required throughout the drilling campaign.

The subsea installation and associated pipeline commissioning activities are anticipated to require around 169 vessel days as detailed in Table 3-11. Installation and commissioning activities will require a CSV, a jet trenching vessel, a DSV, a guard vessel and possibly a rock dumping vessel. Some activities will require more than one vessel on site at any one time e.g. the guard vessel will be on site whilst the CSV and jet trenching vessels are present.

Increased production, as a result of the Captain EOR Stage 2 Phase II Project, is not anticipated to require an increase in the frequency of supply vessels, ERRV vessels or helicopters serving the Captain field. However, there will be an increase in shuttle tanker offloads (i.e. offload of oil from the FPSO to the shuttle tanker) and polymer supply vessel transits (see Tables 7-7 and 7-8). Shuttle tanker offloads will increase from *c*. 20 per year to up to 31 per year in 2026. After 2026, the number of offloads will decrease such that in 2030 it is estimated to be 10 offloads/year and in 2034 it is estimated to be 3 offloads/year. Following commencement of polymer injection at the six new injection wells (in 2024), polymer supply vessel transits will increase from one to two per week. It will remain at two per week until 2029 after which time it will drop back to one transit per week.

The physical presence of the drilling rig and the vessels at the Captain field could result in navigational hazards and a restriction to fishing operations. Lighting associated with the drilling rig and vessels may results in disturbance to birds whilst vessel noise may disturb marine mammals.

6.1.1 Impact of Vessels and Drilling Rig on Other Sea Users

When compared to shipping levels throughout the North Sea, shipping levels in the area of the Captain field are considered low (see Section 4.6.2). The Captain field is located within ICES rectangle 45E8. The information presented in Section 4.6.1 suggests that fishing effort within this rectangle is high when compared to other ICES rectangles across the UKCS.

To minimise navigation hazards, all vessels engaged in the project operations will have markings and lightings as per the International Regulations for the Prevention of Collisions at Sea (COLREGS) (International Maritime Organisation (IMO), 1972) and vessel use will be optimised where possible.

The COSLPioneer will be equipped with marine navigational aids and an aviation obstruction lights system, as per the Standard Marking Schedule for Offshore Installations (HSE, 2009), to warn ships and aircraft of their position. The systems comprise:

- Marine navigation lights;
- Fog-lights;
- Aviation obstruction lights;
- Helideck beacons (helideck status light system);
- Foghorns;
- Fog detector;
- Helideck lighting;
- Radar beacons.

As required by HSE Operations Notice 6 (HSE, 2014), a rig warning communication will be issued at least 48 hours before any rig movement. The COSLPioneer routes will be selected with the aim of minimising interference to other vessels and the risk of collision. At each drilling location, a 500 m safety zone will be in place before the drilling rig is brought on location. In addition, a CtL permit application will be submitted to OPRED which will be supported with a vessel traffic survey and if required a collision risk assessment. An ERRV will also be on location and will warn other sea users of the presence of the drilling rig.

As the activities are taking place at the existing Captain field the increase in vessel traffic is not anticipated to result in a significant change to existing levels.

Though fishing effort in the area is deemed relatively high, as a receptor the sensitivity of the fishing is considered Low (A) as it is considered to have the capacity to absorb any change associated with the presence of the vessels and drilling rig. Similarly the sensitivity of shipping as a receptor is considered Low (A). Given: the use of navigational aids; the presence of an ERRV and 500 m safety zones; the submission of a CtL; Ithaca Energy's commitment to submitting statutory notifications of any drilling rig moves and potential schedule changes; and the Company's commitment to only using vessels adhering to the COLREGS, the magnitude of effect of the physical presence of the drilling rig and vessels on other sea users is deemed Minor (2). Given the Low sensitivity and the Minor magnitude of effect, the impact significance is considered Low such that any social impacts associated with the presence of the drilling rig and vessels are thought to be negligible.

6.1.2 Impact of Vessels and Drilling Rig on Marine Mammals

Note the impacts of underwater noise associated with vessels and drilling activities are discussed in Section 10, whilst this section focuses on the physical presence of the vessels and COSLPioneer drilling rig. From Section 4.4.4 it can be seen that a number of marine mammals occur in the area which could be disturbed by the increase in vessel traffic. In addition, there could be an increased risk of injury to marine mammals through vessel strikes. Given that all cetaceans are EPS and harbour porpoise and bottle nose dolphins, are Annex II species, receptor sensitivity is considered Medium (B).

Marine mammals may be attracted to installations due to increased prey abundance (Todd *et al*. 2009); however, no evidence of impacts of installations on marine mammals on the UKCS have been reported. As the proposed activities will take place within a well-developed oil and gas area, it is likely that marine mammals have been habituated to vessel activity in the area. In addition, the evidence for lethal injury from boat collisions with marine mammals suggests that collisions with vessels are very rare (Cetacean Stranding Investigation Programme (CSIP), 2011). Out of 478 post-mortem examinations of harbour porpoise in the UK carried out between 2005 and 2010, only four (0.8 %) were attributed to boat collisions.

Cetaceans are therefore anticipated to quickly adapt to the presence of the drilling rig and vessels, which will occupy a very small proportion of their overall available habitat such that the magnitude of effect of the presence of the drilling rig and vessels is deemed to be Minor (2). Given the Medium receptor sensitivity and the Minor magnitude of effect, the impact significance is considered Low such that any impacts of the vessels and drilling rig on marine mammals are thought to be negligible.

6.1.3 Impact of Vessels and Drilling Rig on Birds

As described in Section 4.4.5 a number of bird species are found in the Captain field area. Given that may of the birds are likely associated with SPAs, the sensitivity of birds as a receptor is considered Medium (B).

The vessels and drilling rig have the potential to cause displacement of seabirds from foraging habitat and may cause flying birds to detour from their flight routes. For example, auk species (e.g. guillemot, little auk) are believed to avoid vessels by up to 200 to 300 m but gull species (e.g. kittiwake, herring gull and great black-backed gull) are attracted to the presence of them (Furness and Wade, 2012). Seabird densities in the North Sea are reported to be seven times greater within 500 m of a platform. Lights are known to attract seabirds, however, increased food availability at the installation and the availability of roost sites may also be a factor (Weise *et al*. 2001).

Though evidence suggests that the presence of vessels and the drilling rig could cause some bird species to be displaced from their foraging area, the very small proportion of their overall available habitat that will be occupied by the vessels and drilling rig means the impact is not considered to be noticeable. In addition, given the existing oil and gas vessel activity in the area, including the existing Captain installations, it is expected that the impact of the vessels and drilling rig on bird migration routes will not to be significant. Therefore, the magnitude of impact of the physical presence of the vessels and drilling rig on birds is considered Minor (2). Given the Medium sensitivity and the Minor magnitude of effect, the impact significance is considered Low such that any impacts of the vessels and drilling rig on seabirds are thought to be negligible.

6.2 Presence of Subsea Infrastructure

All subsea infrastructure including the wellheads, Xmas trees, manifolds, pipelines, spools, umbilical jumpers and pipeline protection materials (e.g. rock dump, concrete mattresses, and grout bags) have the potential to impact fishing operations and wildlife as a result of their physical presence.

6.2.1 Impact of Subsea Infrastructure on Other Sea Users

Subsea infrastructure will be installed as part of the Captain EOR Stage 2 Phase II project. Fisheries in the area are dominated by demersal landings with a large portion of shellfish species also being taken (see Section 4.6.1). Fishing gear used to target these species is towed along the seabed, and therefore may interact with subsea structures (including stabilisation material) that it comes into contact with. Interactions between fishing gear and infrastructure may result in damage to fishing gear, loss of fishing gear, loss of fishing time, spoilt catches and injuries/fatalities to fishermen (Rouse *et al.*, 2018). Damage to subsea infrastructure may also occur as a result of snagging and dropped anchors.

The new pipelines and umbilicals will be trenched and buried such that infrastructure laid out with any 500 m safety zones is not expected to interact with fishing gear. On the approach to the BLP and the two drill centres, the untrenched length of the lines will be minimised and limited to within the 500 m safety zones. At the time of writing the use of rock dump to mitigate spans along the lines was not expected, though the ES does capture a contingency volume of 20,000 te (see Table 3-10). Should this rock be required, it will be laid in a profile that is over trawlable.

The two new drill centres (Area D and Area E) will have 500 m zones associated with them, within which the SUDS and wells will be located. To mitigate the potential for fishing gear to encroach on these safety zones, the SUDS at each of these two drill centres will be piled (see Section 3.4.6).

The SUDS to be installed at the BLP will be located well within the existing 500 m zone, whilst the new production well will be drilled within the existing 500 m zone at Area B.

Prior to installing the subsea infrastructure, the project will apply for a Pipeline Works Authorisation (PWA), including a Deposit Consent to deposit materials; and the development will comply with any notification requirements associated with the PWA approval. In addition, the project will submit a CtL application to OPRED and the location of all infrastructure to be installed will be submitted for inclusion on the admiralty charts. Taking cognisance of the addition of two new 500 m exclusion zones (in an area with relatively high fishing activity) and Ithaca Energy's adherence to the mitigation measures identified means the magnitude of impact of the new infrastructure on fishing activity is considered Minor (2).

Given that receptor sensitivity is considered Low (A) (see Section 6.1.1) and the magnitude of effect is considered Minor (2), the impact significance is considered Low such that any impacts of the subsea infrastructure on fishing activity is thought to be negligible.

6.2.2 Impact of Subsea Infrastructure on Marine Mammals and Fish

With respect to the impact of subsea infrastructure on fish and cetacean's receptor sensitivity is considered Medium (B) due to the presence of designated species e.g. PMFs (such as cod, mackerel and sandeel) and EPS (cetaceans). Marine mammals and fish in the area are anticipated to adapt to the presence of the subsea infrastructure, which will occupy a very small proportion of their overall available habitat such that the magnitude of effect is deemed Negligible (1). The impact significance is therefore considered Low such that the impact of the subsea infrastructure on marine mammals and fish is thought to be negligible.

Note, the impact on the benthic communities is discussed separately in Section 9 'Seabed Disturbance'.

6.3 Decommissioning Phase

At CoP the Captain infrastructure will be decommissioned as part of a Decommissioning Programme. At the commencement of the decommissioning activities, vessel activity in the area will increase relative to the number of vessels typically present in the area of the development during the production phase.

It is expected that at end of field life it will be technically feasible to recover the Xmas trees, spools, umbilical jumpers, manifold, mattresses and grout bags. In line with current OPRED guidance (BEIS, 2018), a comparative assessment (CA) will be carried out to determine the fate of the flowlines and umbilicals.

Should the CA determine that the pipeline should be decommissioned *in situ*, Ithaca Energy will agree an ongoing monitoring plan with the relevant authority (currently this is OPRED).

6.4 Cumulative and Transboundary Effects

The proposed activities will result in a modest increase in activity as a result of additional vessel movements. Given that these activities will occur within a well-established area for oil and gas activity and for the most part (i.e. drilling, installation and commissioning phases) will be short term in nature, significant cumulative impacts are not expected.

The Captain Field is located *c.* 188 km from the UK/Norway median line and therefore no transboundary impacts associated with the physical presence of the drilling rig or vessels are expected.

6.5 Mitigation Measures

The following industry standard mitigation measures will be undertaken to minimise the impacts associated with the physical presence of the vessels, drilling rig, and subsea infrastructure associated with the Captain EOR Stage 2 Phase II project.

Proposed Mitigation Measures

- Drilling rig routes will be selected in consultation with other users of the sea, with the aim of minimising interference to other vessels and the risk of collision;
- Vessel use will be optimised by minimising the number of vessels required and length of time vessels are on site;
- A post installation survey will be carried out following jetting of the flowlines and umbilicals to ensure the lines are over trawlable and to ensure there are no clay berms;
- Consultation with SFF for all phases and operations;
- Notice to Mariners will be circulated prior to rig mobilisation;
- As required by HSE Operations Notice 6 (HSE, 2014), a rig warning communication will be issued at least 48 hours before any rig movement. Notice will be sent to the Northern Lighthouse Board (NLB) of any drilling rig moves and vessel mobilisation associated with the mobilisation and demobilisation of the drilling rig;
- A Vessel Traffic Survey will inform a Consent to Locate application for the drilling rig;
- A Collision Risk Management Plan will be produced, if required;
- All vessels engaged in the project operations will have markings and lightings as per the International Regulations for the Prevention of Collisions at Sea (COLREGS) (IMO, 1972);
- The drilling rig will be equipped with navigational aids and aviation obstruction lights system, as per the Standard Marking Schedule for Offshore Installations for example fog lights, aviation obstruction lights, helideck lighting and radar beacons;
- The drilling rig will have a statutory 500 m safety zone to mitigate any collision risk;
- An ERRV will patrol the area;
- All subsea infrastructure out with the 500 m zones will be over-trawlable;
- The use of pipeline stabilisation features (e.g. mattresses and rock cover) will be minimised through project design and will be installed in accordance with industry best practice and SFF recommendations.

Applying the risk assessment methodology described in Section 5 and taking account of the mitigation measures listed above, the impact significance of the physical presence of the vessels, drilling rig and subsea infrastructure associated with the proposed project is considered Low. In addition, the environmental impact significance in relation to marine mammals, and birds is considered low (the environmental impact significance in relation to benthic species in considered separately in Section 9). The environmental and socio-economic impacts are therefore considered acceptable when managed within the additional controls and mitigation measures described. The proposed project will be conducted in compliance with all NMP policies; an assessment against the relevant NMP objectives is given in Appendix A.

7. ATMOSPHERIC EMISSIONS

This section identifies the various sources of atmospheric emissions associated with project activities and subsequent hydrocarbon production operations. The quantity of atmospheric emissions is estimated, and their impacts assessed using the assessment methodology presented in Section 5.

Following the adoption of appropriate control and mitigation measures, residual effects and impacts are assessed in the context of the sensitivity of, and the dispersive capacity of, the receiving environment.

7.1 Sources

The general use of vessels (including the drilling rig), and the production of hydrocarbons have been identified as warranting further assessment in terms of the impact of their atmospheric emissions. As described in Section 3.6.8 there will be no flaring associated with clean-up and completion of any of the wells to be drilled as part of the proposed project.

7.1.1 Vessel Use During Drilling and Installation

Vessels required in support of the proposed drilling and subsea installation activities will release atmospheric emissions.

Anticipated vessel use for drilling and subsea installation activities are summarised in Table 3-8 and Table 3-11 respectively. Topside modifications associated with the Captain EOR Stage 2 Project (both Phase I and Phase II) have commenced and will be completed in 2023. As described in Section 3.8 these modifications do not require a flotel and have not required an increase to the existing support/supply vessel activity at the Captain field. Therefore, emissions related to vessels supporting topside modifications are not considered further.

While contracts securing the services of named vessels have not yet been established, the fuel consumption of generic vessel types (e.g. AHV, CSV etc.) are well understood. Table 7-1 shows the expected vessel emissions based on predicted vessel requirements. Emissions factors used were taken from the Environmental Emissions Monitoring System (EEMS) Atmospheric Emission Calculations guidance (EEMS, 2008).

Table 7-1: Fuel use and emissions associated with vessel use.

Source	Fuel Use (Te)	Emissions From Fuel Use (Te)						
		CO_2	NOx	N_2O	SO_2	CO	CH_4	VOC
EEMS Emissions Factor[1]		**3.2**	**0.0594**	**0.00022**	**0.002**	**0.0157**	**0.00018**	**0.002**
Vessel use associated with the proposed drilling activities (see Table 3-8)	13,138	42,043	780	3	26	206	2	26
Vessel use associated with the subsea installation activities (see Table 3-11)	2,234	7,148.8	133	0.5	4	35	0.4	4
Total	**15,372**	**49,191**	**913**	**3**	**31**	**241**	**3**	**31**
UK shipping emissions 2019 (UKCCC, 2020)		13,680,000						
Total vessel emissions as % of 2019 UK shipping emissions		0.4						
[1] Emissions calculated using EEMS emission factors (EEMS, 2008).								

7.1.2 Production of Hydrocarbons

The principal atmospheric emissions that will arise during production are associated with power generation, compression, flaring and fugitive emissions at the Captain host.

Modifications to the Captain FPSO, BLP and WPP process heating and flaring systems are required as part of Captain EOR Stage 2 project (both Phase I and Phase II). These topside modifications include the installation of new polymer mixing and pumping facilities. The Captain FPSO will also require additional polymer transfer pumps. All the new equipment to be installed as part of the topside modification are electrically powered and will tie into the existing power supply on the respective installations.

The additional power requirements and resulting emissions increases from the topside modifications are discussed in Section 7.2.

7.2 Emissions Increases Associated with Captain Production

For emissions during production, quantities of emitted gases have been calculated on the basis of the high case production profiles and the high case forecasted fuel gas, flare gas and diesel consumption figures associated with the proposed Captain EOR Stage 2 Phase II Project. Equivalent values for the low- and mid-case production profiles and production profiles without the proposed project, using the corresponding case fuel gas, flare gas and diesel consumption figures are given in places for comparison. Other contributors to the Captain Field's total emissions during production which are not dependent on the low-, mid-, high-production profile cases including fugitive emissions, whilst shuttle tanker emissions and polymer transport emissions are also presented.

The high production profile case presented in Section 3 represents an optimistic estimate of the exported product. For determining the GHG intensity (emissions per barrel of oil equivalent) for the field, the high-case profile frequently provides a lower GHG intensity figure than for the low- and mid-case production profile. The low case production profile is used in this section to determine the GHG intensity figures to present the higher, less favourable GHG intensity.

Increased oil production associated with the proposed Captain EOR stage 2 Phase II project is currently planned to be achieved in Q2 2024. The production profiles presented in Section 3, and the emission estimates presented in this section for 2024 are based on achieving this date.

7.2.1 Power Generation and Heating

Power for the Captain field BLP/WPP installations can be provided by two dual fuel gas turbine generators (GTG). Electrical power can be exported from the FPSO to BLP/WPP via an existing subsea cable when power requirements exceed the capacity of the turbine generators. Power for the Captain FPSO is provided by five fuel generators which can operate on a variety of fuel (diesel, fuel gas and crude oil); however, the generators primarily operate on diesel due to insufficient fuel gas. Process heating is provided on the FPSO via three dual fuel process heaters which currently operate on diesel due to insufficient fuel gas. The FPSO process heaters will run on fuel gas following the implementation of proposed project. As described in Section 7.1.2, additional equipment including polymer injection pumps and additional transfer pumps will be installed on the respective Captain field installations leading to additional electrical demand. Additional process heating requirements due to increased production may be required which will increase the load on the existing dual fuel process heaters.

Power requirements are not directly proportional to the production throughput. The Captain field operates with a typical baseline power load of 28 MW. The additional total installed power requirements from the new equipment required for the Captain Stage 2 project is ~ 2.7 MW. The net power requirement for the EOR Stage 2 Phase II expansion will increase by approximately 10%. There is no anticipated change in fuel gas and diesel use on the BLP/WPP; however, diesel use is forecasted to increase on the FPSO from 2024 to provide the additional 10% power required. The timing of the additional load is 2024 onwards in line with the anticipated schedule for first injection of polymer at area D and E, and the first oil of the new production well. The only difference between the low- and mid- production case fuel use, which are equivalent, and the high case production case fuel use with EOR Stage 2 Phase II is increased diesel use on the FPSO required to support the anticipated increase in gas processing.

The proposed Captain EOR Stage 2 Phase II Project will result in an incremental increase in produced gas which will result in a reduction in the requirement for import gas. The additional produced gas will be utilised in the process heaters.

The total emissions across the three Captain installations without and with the proposed Captain EOR Stage 2 Phase II Project are presented in Table 7-2 and illustrated in Figure 7-1. The calculated emissions in Table 7-2 are based on the EEMS emissions factors for GTGs, except for fuel gas CO_2 emissions factors which are derived from fuel gas sample analysis. Figure 7-1 also shows the total diesel use without and with the proposed project (as noted above diesel use is anticipated to only increase on the FPSO). After 2023, the increase in fuel use and emissions due to the proposed Captain EOR Stage 2 Phase II Project over the Captain field life is relatively consistent as illustrated in Figure 7-1.

Table 7-2: Total emissions for fuel use at the Captain installations without/with the proposed Project.

Year	With/without proposed EOR Stage 2 Phase II	Fuel Use (Te)	Emission from power generation and heating diesel use (Te)						
			CO_2	NO_x	N_2O	SO_2	CO	CH_4	VOC
2023	Without	52,263	152,875	1,461	11	52.69	494	28	44
2023	With	52,263	152,875	1,461	11	52.69	494	28	44
2024	Without	56,068	164,059	1,571	12	56.72	530	30	48
2024	With	61,494	181,422	1,863	14	67.57	607	31	57
2025	Without	54,598	157,750	1,371	12	47.99	491	32	40
2025	With	61,095	178,540	1,720	13	60.99	583	33	52
2026	Without	58,298	168,515	1,470	13	51.52	525	34	43
2026	With	63,220	184,265	1,735	14	61.36	595	35	52
2027	Without	53,637	155,204	1,365	12	47.98	485	31	40
2027	With	60,134	175,994	1,714	13	60.98	578	32	52
2028	Without	55,023	161,288	1,565	12	56.71	524	29	48
2028	With	60,448	178,651	1,856	13	67.56	601	30	57
2029	Without	52,088	152,624	1,476	11	53.46	495	27	45
2029	With	57,514	169,986	1,768	13	64.31	572	28	55
2030	Without	54,059	158,480	1,539	12	55.78	515	28	47
2030	With	59,484	175,843	1,830	13	66.63	592	29	57
2031	Without	51,649	151,460	1,474	11	53.45	492	27	45
2031	With	57,075	168,823	1,765	13	64.30	570	28	55
2032	Without	54,498	159,644	1,541	12	55.78	518	29	47
2032	With	59,924	177,007	1,833	13	66.63	595	30	57
2033	Without	51,649	151,460	1,474	11	53.45	492	27	45
2033	With	57,075	168,823	1,765	13	64.30	570	28	55
2034	Without	54,059	158,480	1,539	12	55.78	515	28	47
2034	With	59,484	175,843	1,830	13	66.63	592	29	57
2035	Without	55,301	161,984	1,563	12	56.56	525	29	47
2035	With	60,727	179,347	1,855	13	67.41	602	30	57

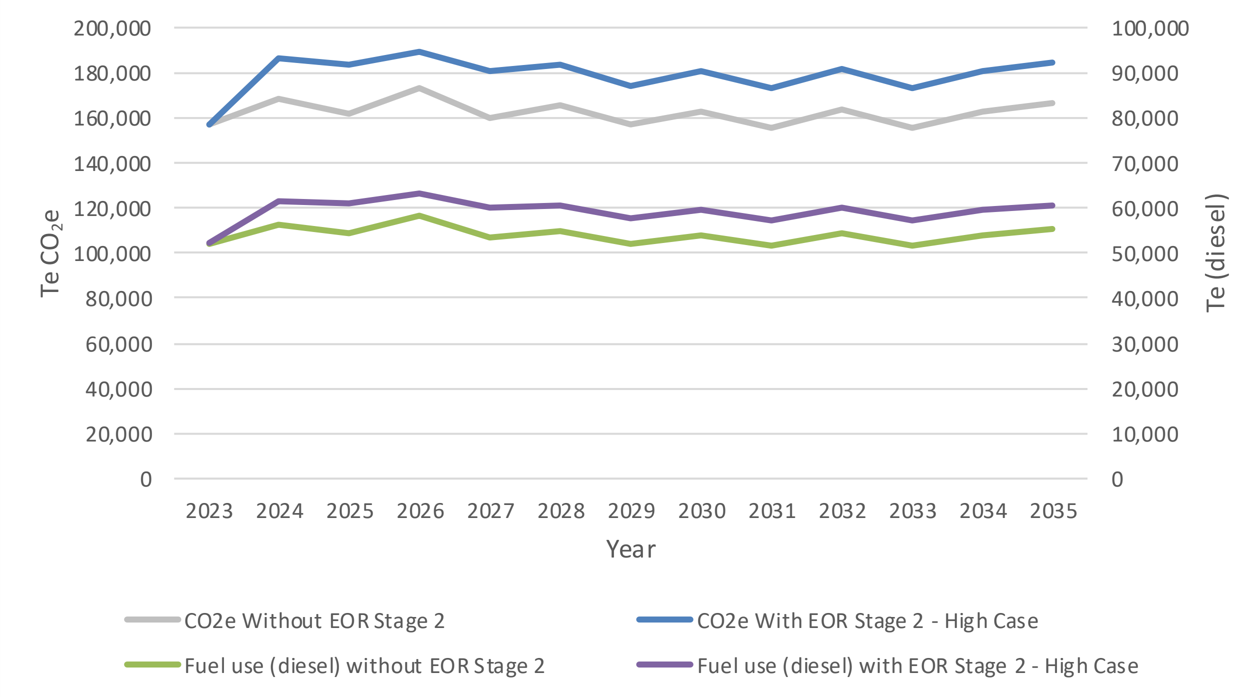

Figure 7-1: CO_2e and diesel use at the Captain installations with and without Captain EOR Stage 2 Phase II.

7.2.2 Flaring

On the Captain BLP/WPP and FPSO installations, produced gas is used as fuel gas and in periods of gas deficiency, import gas is blended with produced gas. Under normal operating conditions neither blended gas nor import gas are flared and only produced gas is flared.

On the FPSO flare gas is process gas (produced gas and import gas).

Flaring at the Captain field is only occurs during start-up and optimisation operations, process system reliability and unplanned events. Any increase in produced gas will be used in the fuel gas system on the WPP/BLP for power generation and on the FPSO in the process heaters, thereby reducing the requirement for gas import and diesel consumption. The increase in produced gas is not anticipated to result in an increase in current flaring rates.

Flaring emissions from the Captain field with and without the Captain EOR Stage 2 Phase II Project are shown in Table 7-3. There is a single set of flaring figures as Captain EOR Stage 2 Phase II is not anticipated to lead to increased flaring. All emissions apart from the CO_2 emissions were calculated using the default EEMS emission factors. The flared gas declines over the course of the Captain field life in line with the decline in production from the field.

Table 7-3: Emissions from flaring at Captain field with and without EOR Stage 2.

Year	Calculated Flare gas (Te)	Calculated emission from flaring (Te)						
		CO_2	NO_x	N_2O	SO_2	CO	CH_4	VOC
2023	11,525	30,625	13.55	0.91	0.14	75.67	203.30	22.59
2024	10,948	29,093	12.88	0.87	0.14	71.89	193.13	21.46
2025	10,401	27,639	12.23	0.83	0.13	68.29	183.47	20.39
2026	9,881	26,257	11.62	0.78	0.12	64.88	174.30	19.37
2027	9,387	24,944	11.04	0.75	0.12	61.63	165.59	18.40
2028	8,918	23,697	10.49	0.71	0.11	58.55	157.31	17.48
2029	8,472	22,512	9.96	0.67	0.11	55.63	149.44	16.60
2030	8,048	21,386	9.46	0.64	0.10	52.84	141.97	15.77
2031	8,048	21,386	9.46	0.64	0.10	52.84	141.97	15.77
2032	8,048	21,386	9.46	0.64	0.10	52.84	141.97	15.77
2033	8,048	21,386	9.46	0.64	0.10	52.84	141.97	15.77
2034	8,048	21,386	9.46	0.64	0.10	52.84	141.97	15.77
2035	8,048	21,386	9.46	0.64	0.10	52.84	141.97	15.77

7.2.3 Venting

As the crude oil is not completely stabilised prior to storage in the cargo tanks, the Captain FPSO utilises a diesel fired inert gas generator to provide inert gas to fill the tank vapour space during offloading operations and to safeguard against any possibility of creating a hazardous atmosphere during tank operations. Venting of gases from the cargo tank vent is directly proportional to production rate. There will be an increase in venting from the FPSO cargo tanks during offloading activities as a result of increased production from the Captain field in the early years after the implementation of proposed Captain EOR Stage 2 Phase II Project in line with the production profiles. The venting rate due to production is estimated as 0.045 kg/bbl with an average of 1.2 tonnes/day.

The venting rate for the low-, mid- and high production cases for Captain EOR Stage 2 Phase II and the rate from without the Captain EOR Stage 2 Phase II are presented in Table 7-4. Over the course of the Captain field life the high production profile case results in the higher venting rate.

Table 7-4: Captain FPSO Venting Rate.

Year	Without Captain EOR Stage 2 Phase II (Te)	With Captain EOR Stage 2 Phase II		
		Low case production (Te)	Mid case Production (Te)	High case production (Te)
2023	425	464	458	461
2024	434	537	577	580
2025	447	694	819	804
2026	375	646	742	776
2027	257	462	553	661
2028	215	358	434	552
2029	174	265	326	455
2030	148	192	261	314
2031	127	155	182	190
2032	116	115	124	154
2033	106	97	102	125
2034	100	90	91	92
2035	98	88	85	82

The emissions due to venting for high case production presented in Table 7-5 are calculated using the estimated figures and the EEMS emission factors for venting. The CH_4 and VOC venting emissions peak in 2025 before declining over the rest of the Captain field life. Figure 7-2 illustrates the CH_4 and VOC venting emissions for the case without EOR Stage 2 Phase II and the high production case.

Table 7-5: Emissions from venting at Captain field over field life (High Case).

Year	Vent gas (Te/)	Emission (Te/)						
		CO_2	NO_x	N_2O	SO_2	CO	CH_4	VOC
2023	461	n/a	n/a	n/a	n/a	n/a	415	46
2024	580	n/a	n/a	n/a	n/a	n/a	522	58
2025	804	n/a	n/a	n/a	n/a	n/a	724	80
2026	776	n/a	n/a	n/a	n/a	n/a	699	78
2027	661	n/a	n/a	n/a	n/a	n/a	594	66
2028	552	n/a	n/a	n/a	n/a	n/a	497	55
2029	455	n/a	n/a	n/a	n/a	n/a	409	45
2030	314	n/a	n/a	n/a	n/a	n/a	283	31
2031	190	n/a	n/a	n/a	n/a	n/a	171	19
2032	154	n/a	n/a	n/a	n/a	n/a	139	15
2033	125	n/a	n/a	n/a	n/a	n/a	112	12
2034	92	n/a	n/a	n/a	n/a	n/a	82	9
2035	82	n/a	n/a	n/a	n/a	n/a	74	8

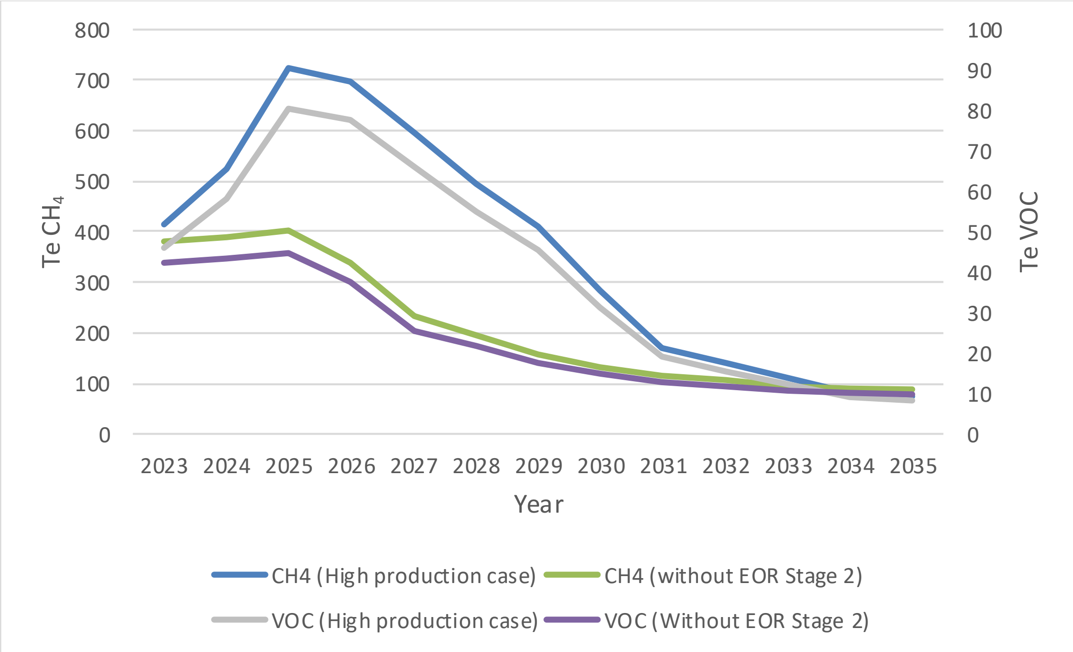

Figure 7-2: Captain Field Venting Emissions for High Production and without Captain EOR Stage 2 Phase II.

7.2.4 Fugitive Emissions

Fugitive emissions are reported annually via EEMS for the Captain field from the WPP only. For the purposes of the impact assessment, the 2019 EEMS fugitive emissions have been assumed to hold constant each year over life of field and used to calculate total fugitive emissions. The 2019 fugitive emission are presented in Table 7-6.

Table 7-6: EEMS fugitive emission at Captain field (WPP) in 2019.

Source	(Te/yr)	Emission (Te/yr)						
		CO_2	NO_x	N_2O	SO_2	CO	CH_4	VOC
Fugitive emissions	11.48	0.32	0.00	0.00	0.00	0.00	11.14	0.02

7.2.5 Shuttle Tanker Emissions

Increased production at the Captain field is not anticipated to require an increase in the frequency of supply vessels or helicopters servicing the Captain installations during operational life of field.

The emissions associated with shuttle tankers fuel use during loading activities and transit to and from the Captain field with the implementation of the Captain EOR Stage 2 project is assessed in this section. Due to the increased production based on the high production case, an increase in the number of annual shuttle tankers for oil loading is anticipated in the early years following the implementation of Captain EOR Stage 2. To quantify the historic emissions associated with shuttle tankers diesel use during loading, the maximum loading duration over the period of 2017-2021 is derived.

The associated emission during loading is calculated using the forecasted number of annual offloads, the maximum historic duration of loading and vessel fuel consumption rate. The emissions associated with shuttle tanker transit are calculated based an appropriate vessel fuel consumption rate and the conservative assumption that the total time to transit to and from the Captain field is 24 hours. The derived total emissions associated with shuttle tanker transit to the Captain field and loading activities are shown in Table 7-7.

Table 7-7: Captain Field EOR Stage 2 Emissions from Shuttle Tanker Loading and Transit.

Year	Number of offloads	Vessel fuel use (Te)	Emission from fuel use (Te)						
			CO_2	NO_x	N_2O	SO_2	CO	CH_4	VOC
2017-2021	19[1]	204[1]	653[1]	12[1]	0.04[1]	0.41[1]	3.21[1]	0.04[1]	0.41[1]
2023	16	170	542	10.07	0.04	0.34	2.66	0.03	0.34
2024	20	220	704	13.07	0.05	0.44	3.45	0.04	0.44
2025	28	305	977	18.14	0.07	0.61	4.80	0.05	0.61
2026	31	332	1,061	19.69	0.07	0.66	5.20	0.06	0.66
2027	24	258	826	15.33	0.06	0.52	4.05	0.05	0.52
2028	19	203	650	12.06	0.04	0.41	3.19	0.04	0.41
2029	13	144	459	8.53	0.03	0.29	2.25	0.03	0.29
2030	10	109	350	6.49	0.02	0.22	1.72	0.02	0.22
2031	7	74	237	4.39	0.02	0.15	1.16	0.01	0.15
2032	5	50	161	3.00	0.01	0.10	0.79	0.01	0.10
2033	4	40	127	2.36	0.01	0.08	0.62	0.01	0.08
2034	3	37	118	2.18	0.01	0.07	0.58	0.01	0.07
2035	3	37	118	2.18	0.01	0.07	0.58	0.01	0.07

[1]Historic average (2017-2021)

The emissions from shuttle tanker loadings diesel use from 2023-2028 are predicted to be above the historic average in line with the increase in shuttle tanker loading. Emissions are predicted to decrease below the historic average in line with the reduction in number of annual shuttle tanker offloads from 2028 onwards as shown in Figure 7-3.

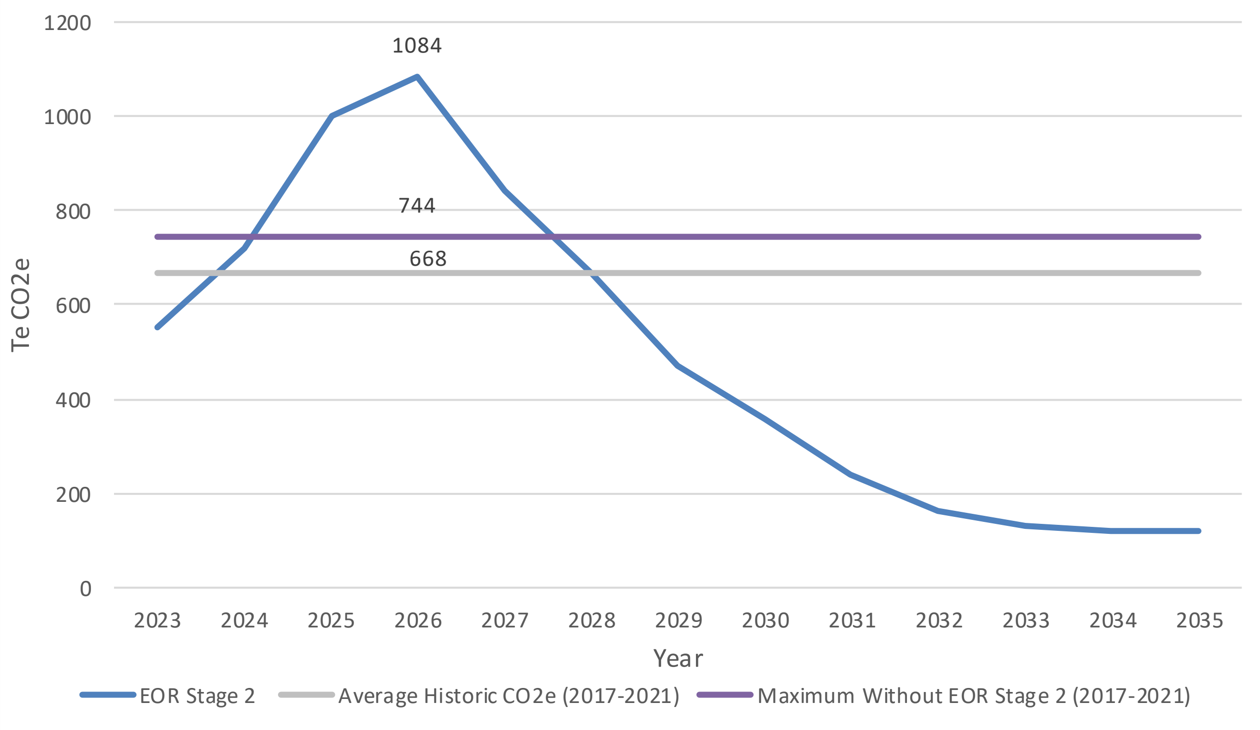

Figure 7-3: Captain Field Shuttle Tanker CO_2e.

7.2.6 Polymer Transport Emissions

The proposed Captain EOR Stage 2 Phase II Project is reliant on increased supply of polymer for injection to accelerate production of hydrocarbons. The impact of the polymer transport due to the proposed project on emissions is assessed in this section.

The transportation of the polymer to the Captain Field without EOR Stage 2 requires one delivery per week deliveries. The frequency of polymer vessel sailings is expected to remain at one per week until 2024 – 2029 where two sailings per week will be required to meet the demand for polymer injection for EOR Stage 2. From 2030 to the end of field life, the frequency of polymer vessel sailing will reduce to one per week due to a decline in the polymer demands for EOR Stage 2 Phase II.

The emissions from polymer transport are calculated using the polymer vessel diesel fuel consumption rate of 10 Te/day. Each delivery is conservatively assumed to require a day for a roundtrip to transit between shore and the Captain FPSO. The emission due to polymer vessel transport are presented in Table 7-8 below.

Table 7-8: EOR Stage 2 Polymer transport emissions.

Year	No. of sailings per year	Vessel fuel consumption transit per year (Te)	Emission from polymer vessel transport (Te)						
			CO_2	NO_x	N_2O	SO_2	CO	CH_4	VOC
2019	52	520	1,664	31	0.114	1.04	8.16	0.094	1.04
2020	52	520	1,664	31	0.114	1.04	8.16	0.094	1.04
2021	52	520	1,664	31	0.114	1.04	8.16	0.094	1.04
2022	52	520	1,664	31	0.114	1.04	8.16	0.094	1.04
2023	52	520	1,664	31	0.114	1.04	8.16	0.094	1.04
2024	104	1,040	3,328	62	0.229	2.08	16.33	0.187	2.08
2025	104	1,040	3,328	62	0.229	2.08	16.33	0.187	2.08
2026	104	1,040	3,328	62	0.229	2.08	16.33	0.187	2.08
2027	104	1,040	3,328	62	0.229	2.08	16.33	0.187	2.08
2028	104	1,040	3,328	62	0.229	2.08	16.33	0.187	2.08
2029	104	1,040	3,328	62	0.229	2.08	16.33	0.187	2.08
2030	52	520	1,664	31	0.114	1.04	8.16	0.094	1.04
2031	52	520	1,664	31	0.114	1.04	8.16	0.094	1.04
2032	52	520	1,664	31	0.114	1.04	8.16	0.094	1.04
2033	52	520	1,664	31	0.114	1.04	8.16	0.094	1.04
2034	52	520	1,664	31	0.114	1.04	8.16	0.094	1.04
2035	52	520	1,664	31	0.114	1.04	8.16	0.094	1.04

7.3 Aggregated Emissions

Of interest to the impact assessment are:

- The maximum emission levels for substances that reduce air quality; and
- The aggregated emissions of GHGs over the field life.

7.3.1 Emission Gases Impacting Air Quality

Section 3.5 presents an indicative schedule for the proposed drilling, installation and commissioning activities For the consideration of realistic worst-case impacts, it has been assumed that all drilling, installation and commissioning activities will occur in 2023.

Based on the data presented in Sections 7.1 and 7.2, total emissions relating to the high production case at the Captain field in 2023 are presented in Table 7-9. This includes all emissions from drilling, installation, well completions, flaring, shuttle tanker loading and polymer transport for Captain field production in 2023.

Table 7-9: Total emissions relating to Captain field in 2023 (High production case).

Total Emission 2023	Hydrocarbons use (Te)	Emission from fuel flare and venting (Te)						
		CO_2	NO_x	N_2O	SO_2	CO	CH_4	VOC
Installation, completion, and operation with EOR Stage 2 Phase II	79,861	234,897	2,428	16	85	821	660	145

The peak year for total emission and CO_2e based on the high production case attributed to the Captain field, following the drill and installation activities in 2023, has been identified as 2026. Table 7-10 presents the aggregated emissions for the high production case from Section 7.2.1, Section 7.2.2, Section 7.2.3 and Section 7.2.4 for 2026. The emissions for the case without the proposed Captain EOR Stage 2 Phase II Project and the low- and mid-production cases are presented for comparison.

Table 7-10: Production emissions attributed to Captain field for peak year of CO_2e (occurring in 2026).

Peak Year for Captain Field	Hydrocarbons use (Te)	Emission from fuel flare and venting (Te)							
		CO_2	NO_x	N_2O	SO_2	CO	CH_4	VOC	CO_2e
Power Generation and heating	63,220	184,265	1,735	14	61	595	35	52	-
Flaring	9,881	26,257	12	0.78	0.12	65	174	19	-
Shuttle Tanker	332	1,061	20	0.07	0.66	5	0.06	0.66	-
Polymer Transport Vessel	1,040	3,328	62	0.23	2.08	16	0.19	2.08	-
Venting	776	n/a	n/a	n/a	n/a	n/a	699	78	-
Fugitive	11	0.32	0.00	0.00	0.00	0.00	11.14	0.02	-
Total (High Production case)	**75,260**	**214,911**	**1,828**	**15**	**64**	**682**	**919**	**152**	**242,354**
Total (Mid Production Case)	**75,225**	**214,911**	**1,828**	**15**	**64**	**682**	**888**	**149**	**241,579**
Total (Low Production Case)	**75,129**	**214,911**	**1,828**	**15**	**64**	**682**	**802**	**139**	**239,419**
Total without Captain EOR Stage 2 Phase II	**69,289**	**197,090**	**1,525**	**14**	**53**	**602**	**557**	**102**	**215,116**

7.3.2 GHG Emissions

To consider the impacts from the least favourable case, GHG intensity figures are presented for the low case production profiles during production field life along with estimates for emissions during the installation and completion.

Table 7-11 presents the CO_2e for the Captain field without the proposed Captain EOR Stage 2 Phase II Project and with the low-, mid- and high-production profile cases over the Captain field life. The values for CO_2e are derived using Global Warming Potential (GWP) for the 100-year time horizon values for CO_2, methane and nitrous oxide from the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (IPCC, 2007).

Table 7-11: Total installation and operation CO2e emissions by year.

Year	Captain Field Emission (Te CO_2e)			
	without EOR Stage 2 Phase II	with EOR Stage 2 Phase II (Low Case)	with EOR Stage 2 Phase II (Mid Case)	with EOR Stage 2 Phase II High Case)
2023	205,178	205,949	205,828	205,880
2024	215,063	236,875	237,791	237,863
2025	207,305	236,144	238,944	238,617
2026	215,116	239,419	241,579	242,354
2027	197,231	221,458	223,514	229,429
2028	200,948	223,601	225,319	227,961
2029	189,734	211,015	212,403	215,296
2030	193,845	212,258	213,807	215,002
2031	186,149	204,098	204,716	204,879
2032	194,320	211,529	211,742	212,421
2033	185,691	202,691	202,784	203,304
2034	192,762	209,723	209,740	209,760
2035	196,313	213,291	213,215	213,162
Total Operations	**2,579,655**	**2,828,054**	**2,841,381**	**2,855,928**
Installation, Completions and Start-up (2023)	0	50,268	50,268	50,268
Total Development	**2,579,655**	**2,878,322**	**2,891,649**	**2,906,196**

The CO_2e figures presented in Table 7-11 are used in conjunction with production profiles to generate estimates for the GHG intensity of the product as kg CO_2e per barrel of oil equivalent (boe). Table 7-12 present the GHG intensities and over field life (including pre-production emissions) for the case without the proposed Captain EOR Stage 2 Phase II Project and with the proposed project for the different production profiles.

Table 7-12: Total installation and operation GHG emissions by year.

Year	GHG intensity (Kg CO_2e/ boe)			
	without EOR Stage 2 Phase II	with EOR Stage 2 Phase II (Low Case)	with EOR Stage 2 Phase II (Mid Case)	with EOR Stage 2 Phase II High Case)
2023	21.0	24.0	24.3	24.2
2024	21.7	19.3	18.0	17.9
2025	20.2	14.8	12.7	12.9
2026	25.0	16.1	14.1	13.6
2027	33.4	20.8	17.5	15.1
2028	40.8	27.2	22.6	18.0
2029	47.5	34.7	28.3	20.5
2030	56.9	48.1	35.6	29.7
2031	63.9	57.3	48.8	46.9
2032	73.1	80.4	74.4	60.0
2033	75.9	90.6	86.9	70.9
2034	83.7	101.6	100.8	99.8
2035	87.4	105.3	109.5	112.6

7.4 Impact on Air Quality

Increased concentrations of NO_x, SO_2 and VOCs in the atmosphere can result in the formation of photochemical pollution in the presence of sunlight, comprising mainly low level ozone, but by-products may include nitric acid, sulphuric acid and nitrate-based particulate. The formation of acid and particulates contributes to acid rainfall and the dry deposition of particulates. If such deposition occurs at sea, it is possible that the substances will dissolve in seawater. The ultimate fate of emitted pollutants can often be difficult to predict owing to the dependence on metocean conditions (especially wind), which may be highly variable and lead to wide variations in pollutant fate over short timescales.

7.4.1 Drilling, Installation and Commissioning Phases

Vessel emissions, summarised in Table 7-1 will be of localised extent, of relatively short duration, and take place a substantial distance (*c*. 70 km) from the nearest coastline. They are expected to disperse rapidly and dilute to background concentrations, resulting in localised and short-term impacts to air quality.

Given the offshore location of the proposed project, the sensitivity of air quality as a receptor is considered Low (A). As the emissions will disperse rapidly the magnitude of effect of the emissions produced during the drilling, installation and commissioning phases is considered Minor (2). The impact significance is therefore considered Low such that any environmental impacts are regarded as negligible.

7.4.2 Production Phase

As part of the PPC permit application for the Captain FPSO an atmospheric emissions dispersion modelling study was performed which assessed emissions from the Captain FPSO and the cumulative impacts from the Captain complex which included the Captain WPP/BLP under worst case operating scenarios of all turbines and Wartsila engines operating at full load. The result of the assessment indicated that all predicted concentrations at receptor locations are substantially below long-term and short-term air quality objectives, and they were no predicted exceedance of any air quality objective at receptor locations.

The maximum NO2 short-term concentration on the modelled grid is predicted to exceed the short-term air quality objective for a worst-case scenario where all the Wartsila engines on the FPSO are operating at full load simultaneously. In this scenario, 97.6% of the contribution to the NO2 concentration is from the Wartsila engines on the FPSO.

However, this breach does not occur in an area of relevant public exposure and as such does not pose a risk to human health. Therefore, the impact from atmospheric emissions is not predicted to be significant.

As detailed in Section 7.3.1, there is an increase in the quantities of hydrocarbons combusted at the Captain field due to the proposed project. The peak emission year for the high production case shown in Table 7-10 shows the increase in NOx, SO2, CO and VOC emission of 20%, 21%, 13% and 49% respectively compared with the case without the Captain EOR Stage 2 Phase II Project. This increase in emissions is anticipated to be within the worst-case scenario modelled as part of the atmospheric emission dispersion modelling study.

As described in Section 7.4.1, the sensitivity of air quality as a receptor is considered Low (A). As the emissions will disperse rapidly the magnitude of effect of the increase in emissions during the production phase considered Minor (2). The impact significance is therefore considered Low such that any environmental impacts are regarded as negligible.

7.4.3 Decommissioning Phase

A range of specialist and support vessel types will be required at various times, and for various durations, to undertake the decommissioning activities at the end of field life. This will lead to an increase in vessel activity relative to that associated with production. The extent, magnitude and duration of impact on air quality from the offshore decommissioning activities are anticipated to be less than those for the drilling, installation and commissioning phases. This will be confirmed during the preparation of the decommissioning programme and supporting documents.

7.4.4 Transboundary and Cumulative Impacts to Air Quality

The Captain field is located approximately 188 km from the UK/Norway median line. Given this distance and the localised nature and low level of air quality impacts expected, no transboundary impacts are anticipated.

The emissions reported for the UK, and for the UKCS offshore oil and gas industry, in 2019 are presented in Table 7-13 in units of thousand tonnes per year. It should be noted that UKCS EEMS emission data do not account for emission due to vessel transit. The emissions from shuttle tanker and polymer transport in transit have been included as part of the emission assessment presented in Section 7.2. Therefore, the comparison of the Captain field emission against the UKCS EEMS emissions will be conservative.

The contribution that the proposed Captain EOR Stage 2 Phase II Project will make to the cumulative emissions across the UKCS, and to UK emissions as a whole can be seen from comparison of the data in Table 7-13 with that in Table 7-10.

By way of example, the NO_x emissions from production at the Captain field in 2026 (the year of highest emissions) would be approximately 3.6% of the annual emissions from the UKCS offshore industry in 2019, and approximately 0.2% of the annual UK emissions in 2019.

Table 7-13: Emissions from the UK, and from the UKCS, in 2019.

Year	Emissions (Thousand Te/Yr)						
	CO_2	NOx	N_2O	SO_2	CO	CH_4	VOC
UK Emissions (2019)[1]	369,700	852	68	167	1,653	1,980	814
UKCS Emissions (2019)[2]	13,683	51	1	2	31	40	47

[1] UK Greenhouse Gas Inventory, 1990 to 2019 from the Annual Report for submission under the Framework Convention on Climate Change (UK NIR, 2021).
[2] UKCS EEMS emissions data (EEMS, 2021).

7.5 Impact on Climate Change

In isolation the GHG emissions from the Captain field would not cause a change to the global climate, however it is their contribution to the cumulative impact of total global emissions that is of relevance in assessing the impact of the development. As such, the Captain field GHG emissions detailed in Section 7.2 are considered in the context of the UK emissions and the UK commitments to emissions reductions.

7.5.1 Captain GHG Emissions in the Present National and Sector-Wide Context

The total GHG emissions for 2019 across the UK were reported in the UK National Inventory Report (UK NIR, 2021) as 453 $MTeCO_2e$. The UK offshore oil and gas sector accounted for 14.9 $MTeCO_2e$ (EEMS, 2021), approximately 3% of the UK total.

The incremental additional GHG emissions resulting from high production of Captain field with the proposed Captain EOR Stage 2 Phase II Project peak in 2026 at 0.24 $MTeCO_2e$, which is 0.05 % of the UK total in 2019 and 1.62 % of the UKCS oil and gas total in 2019. Table 7-14 presents the Captain field GHG emissions without the proposed project and with the peak year of emission with the proposed Captain EOR Stage 2 Phase II Project.

Table 7-14: Captain field incremental GHG emissions in the context of total UK and UKCS.

GHG Source	Emission MTe CO_2e	% UK Total	% UKCS Total
UK Emission (2019)[1]	453	-	-
UKCS Emissions (2019)[2]	15	-	-
Captain field without EOR stage 2	0.22	0.05	1.44
Captain field with EOR stage 2 maximum year (High production case)	0.24	0.05	1.62

[1] UK Greenhouse Gas Inventory, 1990 to 2019 from the Annual Report for submission under the Framework Convention on Climate Change (UK NIR, 2021)
[2] UKCS EEMS emissions data (EEMS, 2021)

7.5.2 Captain Field GHG Emissions in the Future National Context

The Climate Change Act 2008, which committed the UK government by law to reducing greenhouse gas emissions by at least 80% of 1990 levels by 2050, was amended in 2019 to commit to achieving 100% reduction (net zero) by 2050. The Climate Change (Scotland) Act (2019) establishes an accelerated target for achieving net zero emissions by 2045 in Scotland.

The Climate Change Act requires the government to set legally-binding 'carbon budgets' to act as stepping stones towards the 2050 target. A carbon budget is a cap on the amount of greenhouse gases emitted in the UK over a five-year period.

Table 7-15 shows the UK Carbon Budgets allocation set under the UK Climate Change Act alongside the projected additional emissions from the development of the Captain field without and with the proposed project.

Under the high production case, the Captain field (with the proposed Captain EOR Stage 2 Phase II Project) spans the 4^{th}, 5^{th} and 6^{th} Carbon Budget periods, with the drilling, installation, start-up of polymer injection (at Area D and Area E) and the first four years of operation with the proposed EOR expansions occurring in the 4^{th} budget period. The subsequent 5 years of operation will occur in the 5^{th} budget period, and the final three years of production will occur in the 6^{th} budget period. The total future GHG emissions from the Captain field with the proposed Captain EOR Stage 2 Phase II Project within each budget period are presented within Table 7-15 as million tonnes of CO_2 equivalent and as a percentage of the UK budget allocations. The CO_2e emissions from the Captain field with EOR Stage 2 Phase II represent a small proportion of the UK 4^{th}, 5^{th} and 6^{th} Carbon Budget allocations.

Table 7-15: Captain field GHG emissions in the context of UK Carbon Budgets.

Carbon Budget	Budget Period	UK Budget Allocation	Captain field without EOR Stage 2 Phase II		Captain field with EOR Stage 2 Phase II	
		MTe CO_2e	MTe CO_2e	% of Budget Allocation	MTe CO_2e	% of Budget Allocation
1	2008 - 2012	3,018	-		-	
2	2013 - 2017	2,782	-		-	
3	2018 - 2022	2,544	-		-	
4	2023 - 2027	1,950	1.04	0.05	1.15	0.06
5	2028 - 2032	1,725	0.96	0.06	1.08	0.06
6	2033 - 2037	965	0.57	0.06	0.63	0.06

[1] UK Committee for Climate Change Sixth Carbon Budget Report (UKCCC, 2020)

7.5.3 Captain Field GHG Emissions in the Future Oil & Gas Sector Context

In October 2017 the UK Government published its Clean Growth Strategy (UK Government, 2017) setting out policies and proposals for meeting future carbon budgets, together with pathways to the 2050 target (then of 80% reduction). In keeping with the Net Zero pathway, the UK Government and offshore oil and gas industry established a North Sea Transition Deal (NSTD) in 2021 which, among other actions, agreed targets for staged reductions in GHG emissions from the UKCS as presented in the first two columns of Table 7-16. Based on the recorded UKCS GHG emissions for 2018, the third column of the table shows the target emissions for subsequent years stipulated in the NSTD. The final two columns of the table present the proportion of the NSTD budget that incremental GHG emissions from the Captain field would account for under case without EOR Stage 2 and with EOR Stage 2.

Table 7-16 Captain field GHG emissions in the context of the North Sea Transition Deal

Year	North Sea Transition Deal		Captain field (High production case)	
	% of 2018	MTe CO_2e	without Captain EOR Stage 2 Phase II (%)	with Captain EOR Stage 2 Phase II (%)
2018	100	14.54	-	
2025	90	13.09	1.58	1.82
2027	75	10.90	1.81	2.07
2030	50	7.27	1.78	1.97
2050	0	0	-	-

[1] North Sea Transition Deal (BEIS, 2021)

The GHG emissions from the Captain field with the proposed project represent a small proportion of the UKCS and UK annual totals and make up a small proportion of the 4th, 5th and 6th Carbon Budget allocations and of the total UKCS emissions targets established for 2025, 2027 and 2030 under the NSTD.

7.5.4 Captain GHG Emissions Relative to Production

The proposed Captain EOR Stage 2 Phase II Project will accelerate the production of recoverable hydrocarbons from the Captain field.

The low-, mid- and high-case production from the Captain field with the proposed Captain EOR Stage 2 Phase II Project will result in an increase in GHG emissions. The CO_2e emissions increase in 2023 for all the production profile cases is 25%, however the 2023 emissions increase includes the additional emissions from drilling and installation activities.

The maximum increase in high-production case CO_2e emissions from 2024-2035 is 16% compared to the base case without EOR Stage 2 occurring in 2027. The total increase in CO_2e emissions over the field life for the high production case is 11% with the proposed project compared to the CO_2e emissions without the proposed Captain EOR Stage 2 Phase II Project, while the total increase in production (boe) is *c*. 74%.

The maximum increase in mid-production case CO_2e emissions from 2024-2035 is 15% compared to the base case without EOR Stage 2 occurring in 2025. The total increase in CO_2e emissions over the field life for the mid production case is 10% with the proposed project compared to the CO_2e emissions without the proposed Captain EOR Stage 2 Phase II Project while the total increase in production (boe) is *c*. 58%.

The maximum increase in low-production case CO_2e emissions from 2024-2035 is 14% compared to the base case without EOR Stage 2 occurring in 2025. The total increase in CO_2e emissions over the field life for the low production case is 10% with the proposed project compared to the CO_2e emissions without the proposed Captain EOR Stage 2 Phase II Project while the total increase in production (boe) is *c*. 38%.

In 2019, oil and gas production in the UKCS amounted to 89.5 million tonnes oil equivalent (DUKES, 2021) (approximately 639 mmboe). The sector resulted in emission totalling 15 MTe CO_2e as shown in Table 7-14 giving an average GHG intensity of 23 kgCO_2e/boe.

Figure 7-4 presents the GHG intensity for the different production cases compared with the average UKCS GHG intensity of 23 kgCO_2e/boe. The least favourable GHG intensity for the Captain field with EOR Stage 2 is for low production case. The low production GHG intensity with EOR Stage 2 remains less than the UKCS average GHG intensity until 2027. The low production case with EOR Stage 2 (with an estimated life of field production of 96 mmboe) remains below the GHG intensity for the Captain field without EOR Stage 2 (with an estimated life of field production of 69 mmboe) until 2031, after which the decrease in production results in increased GHG intensity. Similarly, for the Captain field mid and high production cases (with estimated life of field production of 109 and 121 mmboe respectively), the GHG intensities remains below the Captain GHG intensity without EOR until 2032 and 2034 respectively.

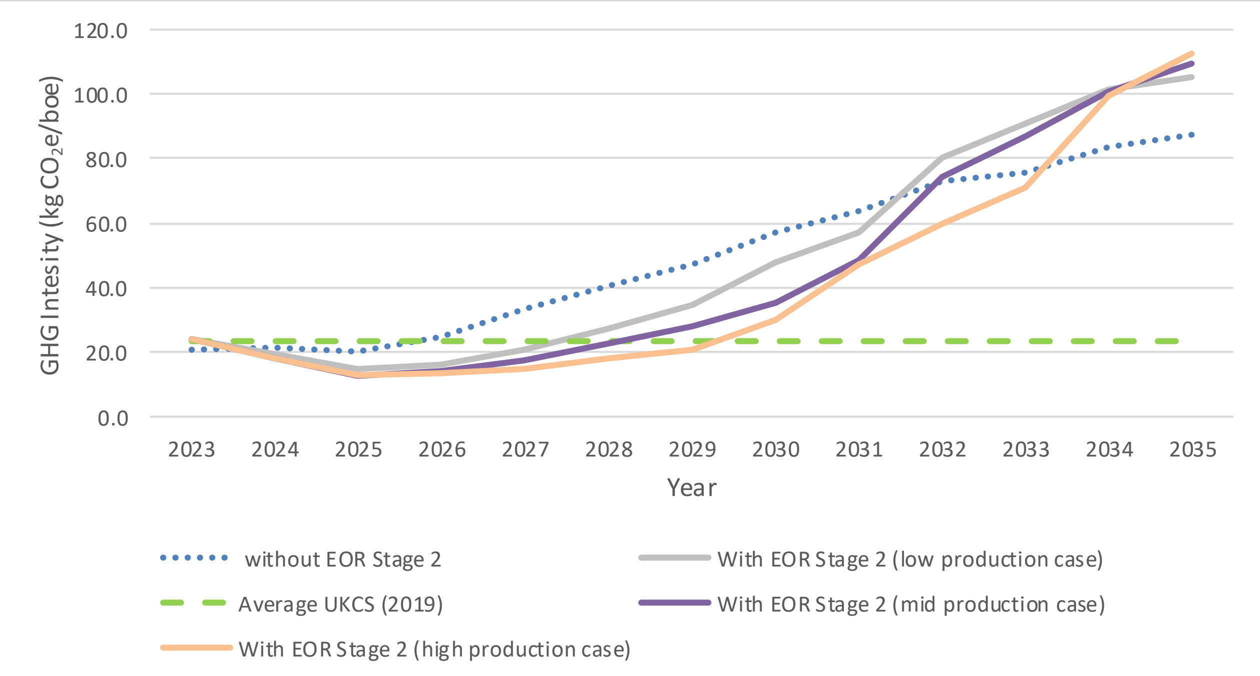

Figure 7-4: Captain field GHG intensity.

According to the NSTA (OGA, 2020), the GHG intensity of imported Liquified Natural Gas (LNG) is on average 59 kgCO_2e/boe and the GHG intensity of natural gas imported by pipeline from Norway is given as approximately 18 kgCO_2e/boe as presented in Table 7-17.

The corresponding GHG intensity of imported oil is more difficult to ascertain. A study to estimate GHG intensities of global oil production has been published by Masnadi *et al.* (2018) involving a comprehensive analysis of available datasets pertaining to multiple aspects of oil production and their differences between regions, onshore and offshore, around the world. The study concluded a global average GHG intensity of crude oils up to the point of delivery to refinery as being 10.3 gCO_2e/MJ (Masnadi *et al,* 2018), which approximately translates to 63 kgCO2e/barrel. The estimation method derived by the Masnadi *et al.* study is relatively complex and direct comparison with the NSTA figures for the UKCS should be made with a degree of caution. Of relevance to such a comparison is the GHG intensity estimated by the Masnadi *et al* study for oil production in the UK of 7.9 gCO_2e/MJ for UK oil production, which approximately translates to 48

$kgCO_2e$/barrel roughly twice the estimate derived directly from BEIS data. The GHG intensity estimates for the Captain field production cases and other sources of oil and gas relevant to meeting the future UK demand are presented in Table 7-17.

Table 7-17: GHG Intensity estimated for Captain field and other sources.

Oil and/or gas source	GHG Intensity kgCO2e/boe
UKCS Oil and Gas (2019 Production (2019)	23
UKCS Gas Production (2019)	22
UK Oil Production (2015)	48
Global Average Oil Production (2015)	63
UK imported LNG (2019)	59
UK imported Norwegian LNG (2019)	18
Captain Field Base Case (Without the Captain EOR Stage 2 Phase II Project)	37
Captain Field Low Production Case (with the Captain EOR Stage 2 Phase II Project)	30
Captain Field Mid Production Case (with the Captain EOR Stage 2 Phase II Project)	26
Captain Field High Production Case (with the Captain EOR Stage 2 Phase II Project)	24

The GHG intensity of the Captain field for oil and gas production is *c*. 37 $kgCO_2e$/boe over the field life. The implementation of the proposed Captain EOR Stage 2 Phase II Project results in a GHG intensity to 30 $kgCO_2e$/boe for the low-production case, 26 $kgCO_2e$/boe for the mid-production case and 24 $kgCO_2e$/boe for the high-production case over the Captain field life. Therefore, even in the low-production case, there is a reduction of the Captain field GHG intensity by 19% compared to the production without the proposed Captain EOR Stage 2 Phase II Project.

Further consideration has been given to whether the Captain field would still provide GHG value in the context of reductions required under the NSTD, there are no equivalent forecasts for hydrocarbon production in the basin beyond 2024. Table 7-18 presents the Captain production without EOR Stage 2 and with EOR Stage 2 for the low, mid and high production cases for the target years of the NSTD.

Table 7-18: Captain field production.

Year	Without Captain EOR Stage 2 Phase II (mmboe)	With Captain EOR Stage 2 Phase II (mmboe)		
		Low case	Mid case	High case
2019	0.00	0.00	0.00	0.00
2025	10.27	15.98	18.85	18.52
2027	5.90	10.63	12.74	15.22
2030	3.41	4.42	6.01	7.23
2050	0.00	0.00	0.00	0.00

Table 7-19 presents the Captain field production detailed in Table 7-18 as a percentage of the UKCS 2019 total.

Table 7-19: Captain field production in the context of the UKCS.

Captain field production as % UKCS total for 2019				
Year	Without Captain EOR Stage 2 Phase II (%)	With Captain EOR Stage 2 Phase II (%)		
		Low case	Mid case	High case
2019	-	-	-	-
2025	1.61	2.50	2.95	2.90
2027	0.92	1.66	1.99	2.38
2030	0.53	0.69	0.94	1.13
2050	-	-	-	-

The demand in the UK for oil and gas is predicted to decline significantly over the next 30 years to 2050, although the UK Government forecasts show that oil and gas will remain an important part of the UK energy mix for the foreseeable future, including under net zero (OGA, 2021). As production from existing fields naturally depletes, meeting the continued demand will require a combination of either the development of new fields within the UKCS and/or imports.

7.5.5 Climate Change Impact Conclusion

Impacts from GHG emissions are difficult to assess in isolation because they derive from all cumulative emissions, rather than from any one activity. Nevertheless, GHG emissions from Captain Field are low in the context of current UK and UKCS emissions and in the context of projected targets for future emissions reductions. Ithaca Captain EOR Stage 2 Phase II would therefore contribute to achieving the goals for emissions reduction in the UKCS established by the NSTD.

The sensitivity of climate change as a receptor is considered Very High (D). As (1) the GHG emissions from the Captain field are considered relatively low in the context of the UK and UKCS emissions and (2) the proposed project reduces the GHG intensity at the Captain field, the magnitude of effect is considered Low (1) such that the impact significance of the emissions associated with the proposed Captain EOR Stage 2 Phase II Project is Low.

7.6 Mitigation Measures

The following measures will be adopted to ensure that the impacts associated with energy use and atmospheric emissions during the drilling, installation, commissioning and production phases are minimised to 'as low as reasonably practicable'.

Proposed Mitigation Measures:

- The drilling rig and other project vessels will be subject to audits ensuring compliance with UK legislation and the Ithaca Marine Operations and Vessel Assurance Standard;
- Vessel use will be optimised where possible by minimising the number of vessels required, and their length of time on site;
- Vessels will be operated where possible in modes that allow for economical fuel use; and
- Minimise flaring during well clean-up operations by sending fluids to BLP for processing as the base case and preferred option.
- In accordance with the revised NSTA strategy, and associated Stewardship Expectation 11, as well as with the industry commitments within the NSTD, Ithaca Marine Operations and Vessel Assurance Standard will incorporate the impact of the Captain field production within developing controls including:
- Asset GHG Emission Reduction Action Plans;
- Flaring and venting reviews to identify/action zero routine flaring by 2030;
- Active flare reduction strategy;
- Active vent reduction strategy;
- Emission key performance indicators and targets; and
- Industry level benchmarking of flaring and venting.

These will ensure that opportunities for efficiency and reduction of atmospheric emissions, where not in conflict with safe operations, are identified, actioned as appropriate and reviewed.

The impact of the emissions associated with the proposed project on air quality will be localised, short term and will mainly occur *c*.70 km from the nearest shoreline. The significance of impact to the local ecological receptors is therefore considered to be low.

The emission of exhaust gases that impact air quality at the Captain field are anticipated to be higher following the introduction of the proposed Captain EOR Stage 2 Phase II Project; the NOx, SO_2 and CO up to 21% at it's peak. However, the total emissions for the Captain field will remain within the levels previously modelled that show environmental impact to be low. The significance of impact on air quality over the life of field for Captain is therefore considered to be low.

The Captain EOR Stage 2 Phase II Project will result in a small increase in GHG emissions (an average of increase of CO_2e emissions 13% annually) compared to the case without the proposed EOR Stage 2 Phase II Project, while accelerating the recovery of hydrocarbons and increasing the hydrocarbon production. In the context of UKCS oil and gas production, the Captain field with the proposed project offers relatively low GHG emission per barrel of oil equivalent. In addition, the proposed project lowers the forecasted GHG intensities at the Captain field relative to the estimated intensities in the absence of the proposed project.

The proposed project will be conducted in compliance with all NMP policies; an assessment against the relevant NMP objectives is given in Appendix A.

8. DISCHARGES TO SEA

This section assesses the planned and permitted marine discharges from the proposed Captain EOR Stage 2 Phase II Project using the impact assessment methodology presented in Section 5. All phases will involve the discharge of sewage and food waste from vessels; however, these discharges will be in line with MARPOL requirements such that the environmental impact significance of different routine vessel discharges are considered low and are not assessed further.

8.1 Drilling Phase

8.1.1. Sources of Discharges Associated with the Drilling Phase

As described in Section 3.6, it is proposed to drill six new polymer injection wells and one new production well as part of the proposed project. Apart from routine vessel discharges (under MARPOL) there will be two main planned (and permitted) sources of discharges associated with the drilling activities:

- Discharge of drill cuttings and associated drilling fluids; and
- Discharge of cement and associated chemicals.

8.1.1.1 Discharge of Drill Cuttings and Associated Drilling Fluids

As described in Section 3.6.5 the top hole sections will be drilled using seawater and viscous sweeps and the lower sections using WBMs. All cuttings will be discharged to the marine environment, with cuttings from the top hole sections being discharged at the seabed and those from the lower sections being discharged from the drilling rig to the water column (see Table 3-5 and Table 3-6 for estimates of drill cuttings produced and discharged).

8.1.1.2 Cement and Cementing Chemicals

As described in Section 3.6.7, when drilling a well, cement is used to secure the steel conductor and casings in the well bore, whilst cementing chemicals are used to modify the technical properties of the cement slurry. The discharges associated with these cementing operations are described briefly here and will be detailed in the drilling permit applications submitted to OPRED prior to commencement of drilling. These include:

- Discharge of residual mixed cement from the rig following a cementing operation;
- Discharge of cement as a result of an aborted cementing job;
- Discharge of cement spacers, mix-waters and cement unit washings; and
- Discharge onto the seabed of excess cement pumped down the well.

Residual mixed cement, aborted cement jobs, cement spacers, mix-waters, and cement unit washings

Prior to carrying out the cementing job, dry cement is mixed in a cement unit on board the drilling rig before being pumped into the wellbore. Cement mix-water[1] is pre-mixed in pits onboard the drilling rig before being mixed with cement solids to form a slurry which is pumped into the well. Prior to cementing the top hole section, cement spacer[2] will be pumped directly into the annulus to ensure that any cement placed there gels up to maintain the structural integrity. The top hole cement spacer is discharged at the seabed. Following a cement job the cement unit is washed to remove any residual chemical additives and / or cement slurry from the lines as any cement slurry left in the lines will set and block the line rendering the cement unit

[1] Water with soluble and suspended additives required to ensure that the cement has the correct properties
[2] A spacer is a fluid used to separate the drilling fluids and cement mixes.

incapable of performing the next job until this blockage is removed. The water and residual cement are discharged overboard.

The need to abort a cement job could arise for a number of reasons including a total failure of the pumping equipment, a blockage (either on surface or down the wellbore) in the pipes through which the cement is pumped, or due to changing downhole well conditions (i.e., wellbore collapse, losses, or well control scenarios). In these instances, the consequences of not discharging mixed cement would be severe with the potential for cement to settle in the pumps, pits and lines on the rig, rendering the equipment unusable until the hardened cement is removed from surface equipment. This could in turn result in major workscopes associated with disconnecting, removing and cleaning the lines before reconnecting them in order to return the equipment to operational status.

Excess cement returned to seabed

Once injected, the majority of the cementing material remains down hole, although with the top hole sections some discharge to the seabed is anticipated when the annulus is filled with cement and casings are cemented back to the seabed. Any cement returns (estimated at a maximum of 20 te per well) will be discharged in the immediate vicinity of the wellhead and will likely impact on an area already impacted by the drill cuttings.

The cement mixture is designed to set rapidly, and the majority of the slurry will set into masses of inert solid cement, smothering a small area of seabed near to the casing, and ultimately will behave similar to inert hard substrate. Discharges to the seabed are at a density of around 1.9 te/m^3 in a semi-cohesive state and as mentioned are expected to flow onto the area already disturbed by cuttings from drilling the top hole sections, with some dispersion into the water column. The majority of the slurry will set into a thin diluted crust of weakened, inert solid cement and smother a small area of seabed near to the casing, and ultimately will behave as an inert hard substrate.

Large cement deposits on the seabed are not expected. Should they occur, they will be addressed in the mandatory debris survey at the decommissioning stage at the end of field life. It is not expected any deposits would be capable of posing a hazard to towed fishing gear in the area. However, if any large deposits are identified during the decommissioning stage, relevant measures will be taken to mitigate any potential dangers in the area.

8.1.2. Impacts of Discharges Associated with the Drilling Phase

The impacts associated with the deposition of drill cuttings on the seabed and the return of cement to the seabed are discussed in Section 9 (Seabed Disturbance), whilst this section focuses on the discharges to the water column.

Modelling of the fate of the drill cuttings from the three polymer injection wells to be drilled at Area D was carried out using Dose-related Risk and Effect Assessment Model (DREAM) to predict environmental risks to the seabed and the water column as a result of the discharge of drill cuttings (full details of the scenario modelled, assumptions made, results and uncertainties are provided in Appendix C). With respect to the impact on the water column, the results indicated that the volume of the water column where there is a risk to over 5% of sensitive species varies over time and that the volume at risk reduces rapidly after each discharge stops and disappears completely within 24 hours of the last discharge from each well.

The primary risk to the water column over this period was from the barite and bentonite particles (combined contribute to c. 70% of the risk) whilst the chemicals and reservoir oil[3] contribute c. 30% of the risk.

Any discharges of cement to the water column (e.g. from planned flushing operations of the cement unit or from an aborted cement job) are expected to disperse rapidly in the upper water column. Stark and Mueller (2003) concluded that at North Sea temperatures, cement particles that have been diluted will not increase significantly in particle size due to their hydration reaction and will remain in the range 10-30 microns or smaller which is controlled by their manufacture and specification. Such particles will take many days to settle through the water column and will be in an inert reacted state once on the seabed. The initial discharge may affect plankton in the localised area of the plume, with rapid recovery expected similar to a discharge of drilling solids.

Suspended sediments in the water column resulting from the discharge of the drill cuttings or cement washes have the potential to impact on the flora and fauna associated with the water column.

Primary production by phytoplankton may be impacted by reduced light penetration and nutrient availability, however given the short duration of the discharges, and their dilution following discharge, any potential impacts on primary production are not considered measurable. Argendt *et al*. (2011) found that some species of copepods (species of zooplankton) were found to feed at lower rates in the presence of high concentrations of suspended sediments. Their findings also suggest that in the presence of ongoing high levels of elevated sediments, egg production rates by some zooplankton could be reduced. Again as the discharges are short term and will be diluted immediately, any potential impacts on zooplankton are expected to be at an individual level (e.g. particle may clog filter feeding structures) and not a population level such that any impacts on zooplankton of these discharges are also not considered measurable.

Todd *et al*. (2015) carried out a review of the potential impacts of marine dredging activities on marine mammals. The authors concluded that there was no evidence of significant impacts on marine mammals of suspended sediments. Therefore it is expected that any impacts from the discharged drill cuttings and cement fluids will not be measurable.

The sensitivity of fish to suspended sediments varies greatly between species and their life history stages and depends on sediment composition (particle size and angularity), concentration and the duration of exposure (Newcombe and Jensen, 1996). Being the major organ for respiration and osmoregulation, gills are directly exposed to, and affected by, suspended solids in the water. If sediment particles are caught in or on the gills, gas exchange with the water may be reduced leading to oxygen deprivation (Essink 1999; Clarke and Wilber 2000). This effect is greatest for juvenile fish as they have a higher oxygen demand and small gills at higher risk of clogging (FeBEC 2010). As some fish species in the area are considered to be PMFs (Section 3.5.2) including sandeel, mackerel and cod, receptor sensitivity is considered Medium (b). However, given the relatively small volume of water expected to be impacted by sediments, and the relatively short time period that the sediments will be in the water column, the magnitude of impact is considered Negligible. The overall impact significance is therefore considered Low such that any impacts of the suspended drill cuttings is considered negligible.

Given that a number of fish species in the area of the Captain field are considered to be PMFs (see Section 4.4.3), and t that all cetaceans are considered Annex IV species and harbour porpoise are Annex II species, the sensitivity of receptors in the water column is considered Medium (B). The results of the drill cuttings discharge modelling indicate that any potentially significant impacts on the water column will disappear within 24 hours. In addition, it is expected that over a period of hours, the cement discharges to the water column (e.g. following the washing of the cement unit or as a result of an aborted cement job) will be indistinguishable from background suspended solids concentrations. The Magnitude of Effect of these discharges on the water

[3] Any reservoir oil that may be discharged will be associated with the cuttings from the 8½" section (lowest hole section). The modelled assumed 0.688 te of reservoir oil per well. This volume of oil represents 0.34 % of the weight of cuttings from the 8½" section and aligns with the average volumes of oil associated with the cuttings from other wells drilled at the Captain field.

column is therefore considered Negligible (1). The overall impact significance is therefore considered Low such that any impacts of the suspended drill cuttings and cement discharges are thought to be negligible. Note the impacts on benthic species is considered in Section 9 (Seabed Disturbance).

8.2 Subsea Installation and Commissioning Phase

As described in Section 3.7.5, following installation and hook-up of the flowlines, testing and commissioning operations will be required to test the integrity of the lines.

These discharges could contain chemicals including oxygen scavengers and biocides to mitigate the risks of corrosion or bacterial growth whilst an ultraviolet-fluorescent dye may be added to assist in leak detection.

Ithaca Energy aims to minimise the effect of the chemicals used/discharged during its operations and as such, wherever possible, chemicals will be chosen which are PLONOR (Pose Little Or No Risk) or are of a Hazard Quotient (HQ) <1. All CHARMable (Chemical Hazard Assessment and Risk Management) chemicals discharged will be further assessed by calculating a Risk Quotient (RQ). Where chemical use and discharge results in a RQ value >1, thus indicating a possible risk of the discharge causing harm to the marine environment, further investigation of the product will be carried out to determine if there is an alternative product that can be used which produces a lower RQ.

There is also the possibility of some hydraulic fluids being released during subsea valve operation and maintenance. However given the use of water based hydraulic fluids, any environmental impacts will be limited.

All chemicals used during pipeline testing and commissioning will be risk assessed within the relevant Chemical Permit applications. The testing will be carried out over a short timescale and the amount of chemicals discharged to the marine environment will be minimised.

Marine flora and fauna may be affected on a localised level but given Ithaca Energy's commitment to prioritise the use of chemicals which are PLONOR, or are of a HQ <1, the rapid dilution that will occur on discharge means that the magnitude of effect is considered Negligible (1). Combined with a receptor sensitivity of Medium (B) the impact of significance is considered Low such that any impacts of the chemicals discharged during commissioning are thought to be negligible.

8.3 Production Phase

8.3.1 Water Discharges

Formation water is naturally trapped in oil and gas reservoirs and despite efforts to produce the hydrocarbons selectively, a fraction of this water is brought to the surface mixed with oil and gas. This produced water may comprise dispersed oil, metals and organic compounds such as dissolved hydrocarbons, organic acids and phenols.

The PWRI system at the Captain Field is designed such that 100 % of the PW is reinjected. Therefore, there will be no PW discharges to sea and as such, PW is not discussed further within this section.

Discharges of cooling water and drainage water at the Captain installations are not anticipated to change as a result of the Captain EOR Sage 2 Phase II Project and are therefore not discussed further.

8.4 Decommissioning Phase

Some planned discharges to sea are likely to occur during the decommissioning of the Captain Field, including the infrastructure installed as a result of the proposed Captain OER Stage 2 Phase I Project. These may include the following:

- Routine MARPOL compliant discharges from vessels associated with the decommissioning activities;
- Discharges associated with well abandonment; and
- Discharges resulting from the disconnection / cutting and recovery (where applicable) of the umbilicals, flowlines etc.

Discharges to sea resulting from the decommissioning activities will be described in the Environmental Appraisal submitted in support of the Decommissioning Programme.

All discharges that may be contaminated with hydrocarbons will be treated to below minimum levels required at the time of decommissioning or shipped to shore for treatment and disposal.

8.5 Cumulative and Transboundary Effects

The cumulative impact of drill cuwttings and cement on the seabed are discussed in Section 9. In relation to all other discharges, given the proposed mitigation measures no significant cumulative impacts are anticipated.

The Captain Field is located *c.* 188 km from the UK/Norway median line and therefore no transboundary impacts are anticipated from the discharges associated with the proposed drilling, installation, commissioning, production or decommissioning activities.

8.6 Mitigation Measures

The following industry standard mitigation measures will be undertaken to minimise the impacts of any discharges to sea associated with the proposed Captain EOR Stage 2 Phase II Project.

Proposed Mitigation Measures

- The drilling rig has been audited under Ithaca Energy's marine assurance standards and subject to rig recertification audits;
- All vessels used will be MARPOL compliant;
- Where technically feasible Ithaca Energy will prioritise the selection of chemicals which are PLONOR, or have the lowest RQ; and
- The discharges of any water based hydraulic fluids, sand or chemicals are regulated by the OPPC and/or OCR regulations and reported through the EEMS. As such, Ithaca Energy will ensure that sampling, analysis and reporting are undertaken in line with the regulations and permit conditions.

Applying the risk assessment methodology described in Section 5 and taking account of the mitigation measures listed above, the impact significance associated with the discharges to sea (other than those associated with the accumulation of drill cuttings or cement on the seabed, which are discussed in Section 9, Seabed Disturbance) is considered low. The impacts are therefore considered acceptable when managed within the additional controls and mitigation measures described. The proposed activities will be conducted in compliance with all NMP policies; an assessment against the relevant NMP objectives is given in Appendix A.

9. SEABED DISTURBANCE

A number of activities will be carried out during the proposed project which have the potential to impact the seabed and the associated benthic communities in the area. This section quantifies the area of potential seabed disturbance and assesses the impact of the disturbance using the risk assessment methodology presented in Section 5.

The extent to which the benthic habitats will be impacted depends on the size of the area that will be affected and the temporal extent of the impact e.g. positioning of the mooring anchors associated with the semi-submersible rig can have a temporary impact in the vicinity of the anchors whilst the area of seabed beneath the infrastructure to be installed can be considered a permanent impact. In addition, species sensitivity and the habitat type in the area, and whether they are unique to the area or of significant conservation importance, are important in determining the overall impact of the proposed project.

9.1 Drilling Phase

During the drilling phase the seabed will be disturbed as a result of:

- The laying of the anchors and anchor lines required for the drilling rig (see Section 3.6.3);
- Discharge of drill cuttings (see Section 3.6.5, and Appendix C);
- Return of cement to the seabed during cementing of the top hole section of the polymer injection wells (see Section 3.6.7); and
- Installation of the Xmas trees (see Section 3.7.1).

The anticipated area of disturbance associated with each of these sources are presented in Table 9-1.

As described in Section 8.1.2 cuttings discharge modelling was carried out in support of the ES (Appendix C). The scenario modelled was the release of cuttings from the three wells to be drilled at Area D. Figure 9-1 shows the cuttings thickness expected following completion of the drilling of the three wells. For the three wells, the area showing a burial depth of > 6.5 mm occurs within 15 to 180 m of the wells and covers an area of 0.019 km^2. The area where sediment thickness is > 6.5 mm reduces from 0.019 km^2 to 0.0087 km^2 after 10 years. Note 6.5 mm is the depth that in the absence of any other stressors there is a risk to more than 5% of the species most sensitive to change. The > 6.5 mm threshold for burial thickness is based on the probability that a specific species will escape a given depth of burial with both exotic (e.g. drill cuttings) and native sediments. The threshold was derived from the burial sensitivity of 33 species (Smit *et al*., 2006 and Kjeilen Eilersten *et al*., 2004). With respect to drill cuttings, Table 9-1 allows for the same area of impact at the Area B, D and E drill centres and therefore represents a worst case as only one well will be drilled at Area B.

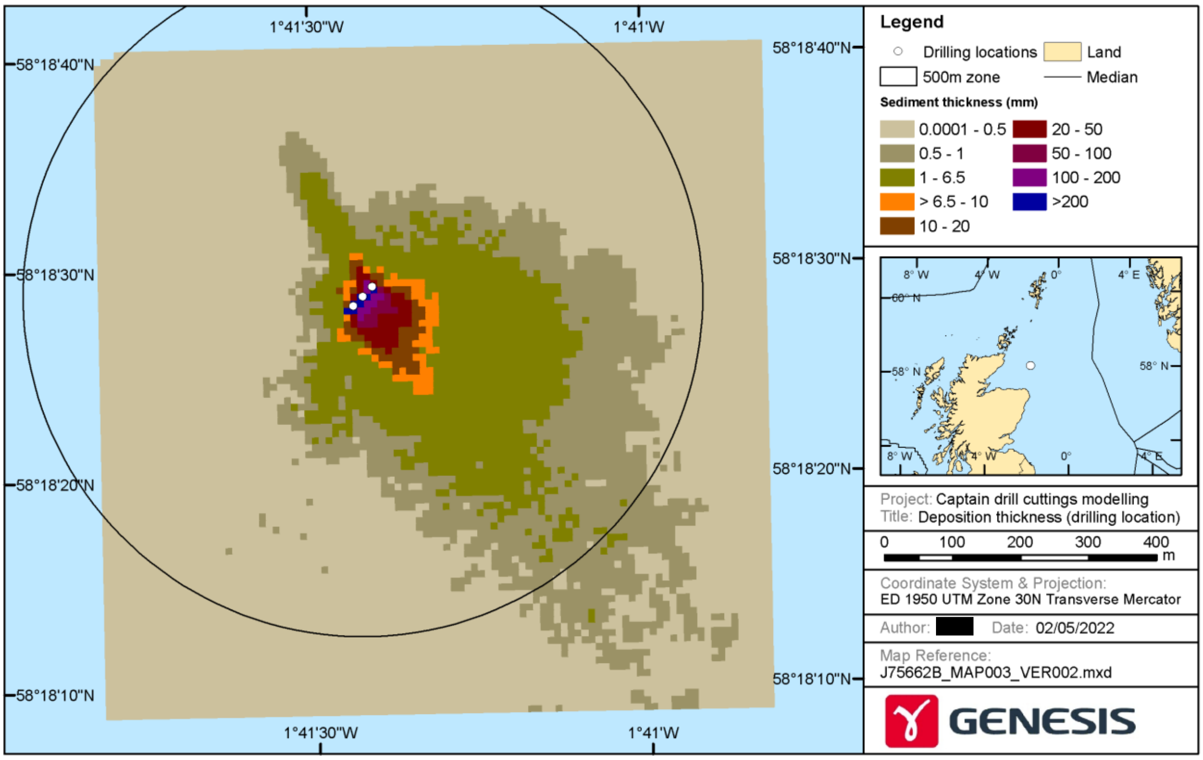

Figure 9-1: Depositional thickness around the drilling location at the end of drilling (Genesis, 2022, Appendix C).

9.2 Installation Phase

During the installation phase the seabed will be disturbed as a result of:

- Jet trenching of the flowlines and umbilicals (see Section 3.7.3);
- Installation of the tie-in spools and jumpers at Area D and Area E (see Section 3.7.3);
- Installation of the three SUDS (see Section 3.7.2); and
- Installation of the stabilisation features (see Section 3.7.4).

Table 3-9 and Table 3-10 summarise the subsea infrastructure and stabilisation features to be installed as part of the proposed project. Table 9-1 summarises the seabed areas anticipated to be temporarily and permanently impacted by the proposed installation activities. It should be noted, the area of disturbance presented represents a worst case, for example of the area impacted by the grout bags will likely also be impacted by the mattresses and infrastructure. Rock dump was assessed based on the worst case estimate. The flowlines and EH umbilicals will be trenched their full lengths apart from on the approaches to the BLP, SUDS or wells. At these approaches the lines will transition out of the trench and be surface laid and protected with a combination of mattresses and 25 kg grout bags.

Given the small size of the flowlines and umbilicals, laying the lines exposed on the seabed was not a feasible option, whilst burying the lines was considered preferable to adding rock berms along the full line lengths. Jet trenching has been selected over trenching and burying due to the soil in the Captain field area, past trenching performance in the field and as a way of minimising the seabed disturbance.

Whilst the flowlines and umbilical's will be trenched and buried along the majority of their length, mattresses and 25 kg grout bags will be used to provide stabilisation/protection to the ends as they exit the trenches at the line ends within the 500 m safety zones. In addition, it is possible that some rock cover may be required outwith the exclusion zones to mitigate spanning.

The impacts of the anticipated disturbance on the seabed and its associated ecosystem are discussed in Section 8.5.

9.3 Production Phase

No planned seabed disturbance is anticipated to occur during routine production operations.

9.4 Assessment of Seabed Disturbance

Table 9-1 summarises the total area of disturbance associated with the drilling and installation activities. A number of worst-case assumptions have been made to determine the maximum impact, for example a worst case volume of rockdump has been assumed.

Including the footprint of the discharged cuttings it is anticipated that the maximum area of permanent seabed disturbance associated with the proposed drilling and installation activities is *c.* 0.016 km^2, whilst the maximum area of temporary disturbance is estimated at *c.* 1.777 km^2.

Table 9-1: Anticipated area of seabed disturbance associated with the proposed drilling and installation activities.

No.	Infrastructure	Assumptions	Area of seabed impacted during installation (km^2)	
			Temporarily impacted	Permanently impacted
1	8 x semi-submersible anchors	Assumes the area of disturbance when positioning each anchor is 25 m x 10 m (includes drag on the seabed). As the anchors will be recovered at the end of the drilling campaign, the impact is considered temporary. Each of the anchors will be laid at three sites: Area B, Area D and Area E.	0.006	N/A (See Note 1)
2	8 x semi-submersible anchor lines	Assumes a maximum of 750 m of each anchor line impacting on the seabed. At Area D and Area E, the anchors will not be relocated when moving between the three polymer injection wells. However, it is assumed that part of the anchor chains will scrape across the seabed whilst the rig is being skidded between wells. As a worst case a corridor width of 50 m along each anchor line is assumed to be impacted during the anchor line layout and skidding activities at Area D and Area E. At Area B, only one well to be drilled, therefore corridor width of disturbance of 10 m allowed for each anchor line at this location.	0.66	N/A
3	Cement deposits	Discharged cement at top of each of the polymer injection wells. Assumes an area with a radius of 7.5 m is impacted. Note the production well will use top-hole sections from a previously drilled well such that no cement returns associated with that well.	N/A	0.0011
4	Drill cuttings.	Ten years after discharge of cuttings from three wells the area of impact where sediment thickness is > 6.5 mm reduces from 0.019 km^2 to 0.0087 km^2. As a worst case the ES assumes: • area of permanent disturbance at Area D and E is 0.0206 km^2 (i.e. 0.0087 km^2 x 2). • area of temporary disturbance across the three areas is 0.0174 km^2 (i.e. (0.019 km^2 - 0.0087 km^2) x 2).	0.0174	0.0206

No.	Infrastructure	Assumptions	Area of seabed impacted during installation (km^2)	
			Temporarily impacted	Permanently impacted
		Note as the production well are Area B, is being drilled as a side track well, there will be no cuttings discharged at the seabed at this location.		
5	Xmas trees associated with the six polymer injection wells	Dimensions: *c.* 4.92 m (L) x 4.89 m (W). A worst case of temporary disturbance of 2 m on each side of each Xmas tree has been allowed for. As mentioned in Section 3.7.1, the Xmas tree associated with the production will be installed within the existing UTM.	0.00033	0.00014
6	Jet trenching of four lines to Area D	Calculation assumes the EH umbilicals and polymer injection flowlines to Area D are all 4,728 m in length (see Table 3-9 for actual lengths). Target is to lay the flowlines 15 m apart, however, to allow for any jet trenching difficulties, it is assumed the lines will be laid 20 m apart. Corridor width of temporary disturbance where suspended sediments may settle out to a depth of > 0.6 mm across the four lines is assumed to be 100 m (see Figure 9-2).	0.4728	N/A
7	Jet trenching of four lines to Area E	Calculation assumes the EH umbilicals and polymer injection flowlines to Area D are all 5,757 m in length see Table 3-9 for actual lengths). Assumptions made are as for Row 5.	0.5757	N/A
8	2 x piled SUDS (one at Area D and one at Area E)	Dimensions: *c.* 6 m (L) x 6 m (W) x 3 m (H). To assess the temporary area of disturbance a worst case of 2 m on either side of each structure is assumed.	0.000144	0.000096
9	1 x gravity-based SUDS (at BLP riser base)	Dimensions: 8 m (L) x 7 m (W). To assess the temporary area of disturbance a worst case of 2 m on either side of the structure is assumed.	0.000076	0.000056
10	Mattresses	Anticipated up to 412 mattresses will be required (measuring 6 m (L) x 3 m (W)). As a worst case it is assumed that an additional area of 2 m on each side of each mattress will be temporarily impacted during installation.	0.021424	0.007416
11	Grout bags	175 te of grout bags (7,000 x 25 kg) to be used. Assessment assumes 1 te of grout bags permanently impacts on 1 m^2 of seabed.	See Note 2.	0.000175
12	Rockcover (contingency)	ES allows for 20,000 te of continency rock. Assessment assumes 1 te of rock permanently impacts on 1 m^2 of seabed and also temporarily impacts on 1 m^2 of seabed.	0.02	0.02
Total			**1.7771**	**0.0163**

Note:
1. As the flowlines and umbilicals are to be jet trenched, they will only exhibit temporary disturbance to the seabed prior to burial, hence a permanent area of impact has not been included.
2. Temporary area of disturbance associated with the 25 kg grout bags is expected to overlap with the temporary area of disturbance associated with the mattresses and therefore has not been calculated separately.
3. As the spools and umbilical jumpers will be protected by mattresses and grout bags, the area of seabed impacted by these items is captured within the footprint of that covered within line items 10 and 11. Therefore, separate rows for the tie-in spools and umbilicals have not been added. A similar approach has been taken for the umbilical that will connect to the SUDS to be located at the base of the BLP.

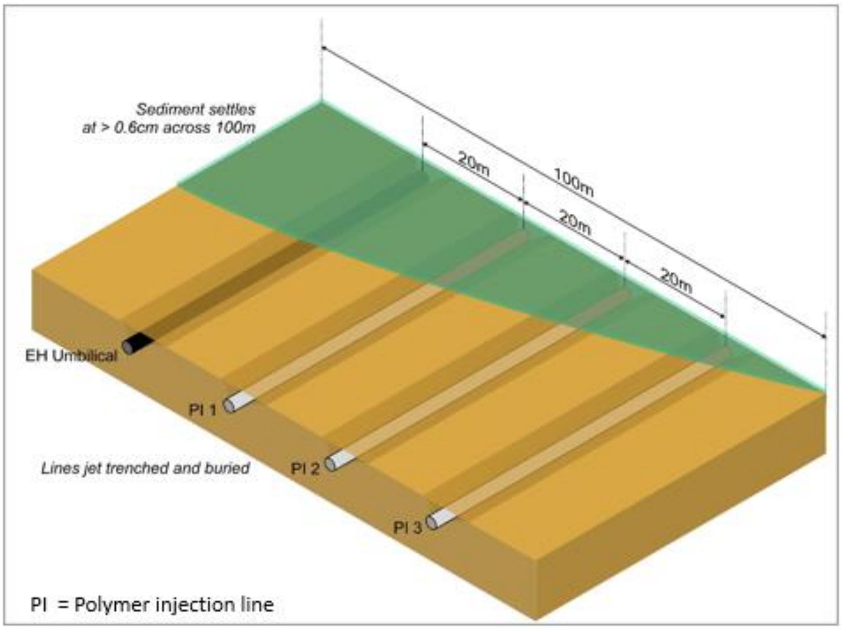

Figure 9-2: Illustration showing how corridor of disturbance of 100 m was selected to determine footprint of disturbance from jetting of lines to Area D and Area E (see row item 5 in Table 9-1).

The physical disturbance resulting from the placement of the drilling rig's anchors and associated anchor lines, and the installation of the subsea infrastructure and accompanying stabilisation features can cause mortality or displacement of mobile benthic species in the impacted area, direct mortality of sessile seabed organisms that cannot move away from the contact area and direct loss of habitat. In addition, disturbance from sediment re-suspension will occur in the immediate area when the structures are initially positioned.

Mattresses, rockdump and grout bags have similar impacts in terms of loss of habitat and smothering of the benthos. In addition to causing mortality or displacement of benthic animals the stabilisation features may also create habitats for benthic organisms that live on hard substrates e.g. sponges, soft corals and tubeworms, sea slugs, hermit crabs and brittle stars (Coolen *et al*., 2018).

The installation of the anchors associated with the drilling rig will likely cause some scars on the seabed. The anchors will, however, be subsequently recovered such that the substrate in the area will not change. The flowlines and umbilicals are to be jet trenched and buried, which will temporarily reduce the sediment quality, however, this will recover due to the backfilling of the trenches.

The cuttings from the top-hole sections of the wells and the cement deposits following cementing of the top-hole sections will result in a change in composition of the seabed in a small area in close proximity to the wells. The drilling activities will result in small pieces of rock ('cuttings') being returned to the seabed.

As described in Section 9.1 cuttings modelling was undertaken using DREAM to predict environmental risks to the seabed and the water column as a result of the discharge of cuttings during drilling of the three polymer injection wells at Area D.

The discharge of drill cuttings is expected to result in a very localised temporary reduction in water quality in the lower part of the water column (approximately 10 m above the seabed), primarily due to an increase in suspended solids (barite and bentonite). On the seabed, discharged cuttings will change the grain size in the immediate vicinity of the wells and is expected to result in a burial thickness that could be a risk to some of the animals in the area. In addition, some benthic animals may be impacted by chemical concentrations and oxygen depletion.

The modelling predicted that the maximum estimated deposited sediment thickness (cuttings pile height) was 1.51 m, in the immediate vicinity of one of the wells, reducing rapidly with distance. The modelling outputs indicate that the deposited cuttings could result in a combined risk to seabed sediment > 5% in a maximum area of 0.1098 km^2 *c*. 237 days after drilling commences. This footprint reduces over time, to 0.0285 km^2 after 10 years though in reality re-colonisation by benthic organisms would result in a faster seabed recovery. Note the combined risk takes account of burial thickness, grain size change, oxygen deletion and toxicity whilst the area of impact presented in Table 9-1 relates to the area over which depth of burial is > 0.6 cm.

Across the Captain field numerous cobbles and boulders have been observed (Fugro, 2015a; and Fugro, 2021a) such that though the seabed in the area primarily comprises deep circalittoral mud', there are existing natural features and subsea infrastructure (associated with the Captain field) that provide a substrate for benthic species to inhabit (see Figure 4-6 for growth of benthic species on existing boulders). Therefore though the drill cuttings, cement discharges, stabilisation features and SUDs may be laid on muddy sediments, rather than introducing hard substrates for new benthic species to attach to, they will increase the footprint of the existing hard substrates on which species may settle.

It is possible that disturbed sediment particles may be transported via tidal currents for re-settlement over adjacent seabed areas. This may have indirect negative effects on the benthic ecology in the vicinity, including smothering and scour of seabed communities causing a loss of species diversity, abundance and biomass in effected areas. Sessile epifaunal species may be particularly affected by increases in suspended sediment concentrations as a result of potential clogging or abrasion of sensitive feeding and respiratory apparatus (Nicholls *et al*., 2003). Larger, more mobile animals, such as crabs and fish, are expected to be able to avoid any adverse suspended solid concentrations and areas of deposition. Re-suspended sediments could have a negative impact on suspension feeding organisms such as sea pens and bivalves including *A. islandica,* both of which are known to occur in the area (see Section 4.4.2). Within Marine Scotland's Feature Activity Sensitivity Tool (FeAST) *A. islandica* are described as having a high sensitivity to sub-surface abrasion and siltation changes although damage is related to body size with larger specimens being more vulnerable. *A. islandica* burrow into the sediment and use a short inhalant siphon which sits above the sediment surface for feeding and respiration (Taylor, 1976). Surface abrasion and siltation may therefore damage/clog the inhalant siphon; however it should be noted that following smothering/burial (up to 40 cm), they are able to burrow to the surface (Powilleit *et al*., 2009). *A. Islandica* is therefore not considered sensitive to smothering of up to 30 cm of material added to the seabed in a single event (Tyler-Walters & Sabatini, 2017). Given the widespread distribution of *A. islandica* across the CNS, any mortality caused to individual specimens as a result of the proposed activities is not considered significant given the relatively limited area of impact.

Recovery times for faunal communities following disturbance resulting from the installation activities are difficult to predict, although some studies have attempted to quantify timescales. Collie *et al*. (2000) examined impacts on benthic communities from bottom towed fishing gear and concluded that, in general, sandy sediment communities were able to recover rapidly, although this was dependent upon the spatial scale of the impact. It was estimated that recovery from a small-scale impact, such as a fishing trawl, could occur within about 100 days. It was assumed that recolonisation was through immigration into the disturbed area rather than from settlement or reproduction within the area.

Where avoidance by fish is not possible the sensitivity to suspended sediments varies greatly between species and their life history stages, dependent upon sediment composition (particle size and angularity), concentration and the duration of exposure (Newcombe and Jensen, 1996). Being the major organ for respiration and osmoregulation, gills are directly exposed to and affected by suspended solids in the water. If sediment particles are caught in or on the gills, gas exchange with the water may be reduced leading to oxygen deprivation (Essink

1999; Clarke and Wilber 2000). This effect is greatest for juvenile fish as they have small easily clogged gills and higher oxygen demand (FeBEC 2010).

IOGP report 543 (IOGP, 2016) examines evidence relating to the effect of cuttings discharges on early-stage fish life and concludes that they generally have a low toxicity to pelagic invertebrates and early life stages of fish. Studies on early life stages of sea scallops, lobsters and haddock (Cranford *et al.,* 1998) showed a slight reduction in survival of haddock and fed (but not unfed) lobster after 96 hours exposure at 100 mg/l of drilling fluid suspension and no effect on fertilisation, survival or growth of sea scallops.

The ability for organisms including fish species to detect predators may be reduced as a result of low visibility associated with suspended sediments. In instances of persistent and widespread suspended sediments there is the possibility of reduced feeding success among juvenile fish which may influence survival, year-class strength, recruitment and overall condition (Clarke and Wilber, 2000). However, as the proposed activities are relatively short term any impacts from low visibility are expected to be temporary and are not considered significant.

Given the presence of designated species in the area e.g. *A. islandica* which is considered an OSPAR threatened and or declining species and a number of PMFs (see Section 4.5.2), receptor sensitivity in the area is considered Medium (B). Any changes to the receptors impacted are not considered significant. Most receptors are expected to be impacted at an individual level rather than a population level and once drilling and installation activities are completed, recovery of the ecosystem is expected to commence such that the long term magnitude of effect of disturbance to the seabed from all activities is considered Minor (2). Combining a Medium sensitivity with a Minor magnitude of effect, the impact significance is considered Low such that any environmental impacts are considered to be negligible.

9.5 Decommissioning Phase

The decommissioning activities at Captain will result in some temporary disturbance to the seabed. Sources of disturbance could include:

- Seabed sampling for pre-decommissioning survey work;
- Localised dredging or jetting to allow access for cutting;
- Recovery of subsea infrastructure;
- Potential temporary wet storage of items following disconnection and prior to recovery;
- Temporary positioning of baskets for recovery of tie-in spools etc.; and
- Anchoring of drilling rig during well abandonment.

The environmental appraisal submitted in support of the Decommissioning Programme will capture the impacts associated with the disturbance of the seabed. The activities will be further detailed in the relevant permit applications prior to commencement of offshore campaigns. It is anticipated that the area disturbed by the decommissioning activities will mostly be within the area disturbed by the installation activities.

9.6 Cumulative and Transboundary Effects

The drilling activities and infrastructure to be installed as part of the proposed Captain EOR Stage 2 Phase II project will increase the footprint of the infrastructure associated with the Captain Area including the footprint of rock should it be necessary to use the contingency rock. However, the increase in impacts have been minimised where possible, e.g. use of jet trenching as opposed to ploughing, using existing top hole sections for the production well, locating the polymer injection wells at Area D and E in close proximity such that the anchors can be laid once at each drill centre, ensuring the overall cumulative effect is kept to a minimum.

The Captain field is located *c.* 188 km from the UK/Norway median line and therefore no transboundary impacts are anticipated from the seabed impacts associated with the proposed activities.

9.7 Mitigation Measures

The following mitigation measures are proposed to minimise the impacts associated with disturbance to the seabed resulting from the proposed project.

Proposed Mitigation Measures

- Pre-deployment surveys will be undertaken to identify suitable locations for the drilling rig anchors;
- Wells at Area D and Area E will be drilled in close proximity such that the anchors will only require to be laid once at each drill centre and the drilling rig can be skidded between wells;
- Production well at Area B will use top hole sections from a suspended well;
- Jet trenching rather that ploughing of flowlines and umbilicals; and
- The use of mattresses, rockdump and grout bags will be minimised through optimal project design.

Applying the risk assessment methodology described in Section 5 and taking account of the mitigation measures listed above, the significance of impact of the seabed disturbance resulting from the proposed activities is considered low.

The proposed project will be conducted in compliance with all NMP policies; an assessment against the relevant NMP objectives is given in Appendix A.

10.UNDERWATER SOUND

This chapter assesses the impact of sound associated with the proposed Captain project, using the risk assessment methodology outlined in Section 5.

10.1 Introduction

Marine fauna use sound for navigation, communication and prey detection (Southall *et al*., 2007; Richardson, *et al*., 1995). Therefore, the introduction of anthropogenic underwater sound has the potential to impact on marine animals by interfering with the animal's ability to use and receive sound (OSPAR, 2009). Offshore exploration and production activities invariably generate underwater sound; for example, during geophysical exploration, during drilling activities or piling operations and from the vessel operations. The level and frequency range of sound generated varies with the type of activity.

It is generally accepted that exposure to anthropogenic sound can induce a range of adverse effects on marine life (e.g. OSPAR, 2009). The type and extent of potential impact associated with sound on an animal depends on many factors including the level and frequency characteristics of the sound, hearing sensitivity and behaviour of the species, propagation characteristics of the operational area and whether or not marine species are using the areal extent of the sound field. Potential impacts can vary from insignificant impacts such as temporary avoidance or small changes in behaviour to significant impacts such as auditory and physical injury (Southall *et al.,* 2007; Southall *et al.,* 2019; National Marine Fisheries Service (NMFS), 2018; Richardson *et al.,* 1995).

The Offshore Marine Regulations 2007 (as amended, 2010) make it an offence to injure or disturb EPS (including all marine mammals), where disturbance has a likelihood of impairing their ability to survive, to breed or reproduce, to rear or nurture their young, or to migrate. It also includes the likelihood of significantly affecting the local distribution or abundance of the species. New projects must assess if their activity, either alone or in combination with other activities, is likely to cause an offence involving an EPS.

10.2 Noise Sources Associated with the Proposed Project

Activities associated with the proposed Captain Stage 2 Phase II Project, resulting in the generation of underwater sound, include:

- Drilling activities;
- Rock dumping activities (contingency);
- Vessel operations; and
- Piling of the SUDSs to be installed at Area D and Area E.

These underwater noise sources are discussed in more detail in the next Section.

10.3 Impacts of Noise Sources

10.3.1 Drilling Activities

Rotating equipment such as generators and pumps all result in underwater noise during drilling operations. In general, noise from drilling operations has been found to be predominantly low frequency (< 1,000 Hz) with relatively low source levels (Greene, 1987; Nedwell and Edwards, 2004; McCauley, 1998). Furthermore, a study by Greene (1987) found that the noise generated by drilling activities from a semi-submersible drilling rig did not exceed local ambient levels beyond 1 km. Noise associated with the drilling activities is therefore considered to be of a relatively low level and is not considered further in the ES.

10.3.2 Rock Dumping Activities

It is not expected that rockdump will be required, however the ES captures a contingency of 20,000 te spot rockdump to mitigate UHB (see Section 3.7.4). Nedwell and Edwards (2004) reported the sound from the *Rollingstone*, a vessel with a specialised underwater chute to position rock on the seabed. The vessel used dynamic positioning and was powered by two main pitch propellers, two bow thrusters and two azimuth thrusters. It was concluded that the sound levels were dominated by the vessel and not the rock dumping activities. Noise associated with the rock dumping activities is therefore considered to be of a relatively low level and is not considered further in the ES.

10.3.3 Vessel Operations

Within the UKCS, vessel traffic is a substantial contributor to general anthropogenic underwater noise with the primary sources of sound coming from the propellers, propulsion and other machinery (Ross, 1976; Wales and Heitmeyer, 2002). Tables 3-8, Table 3-11, Table 7-7 and Table 7-8 summarise the total vessel requirements for each phase of the project.

Richardson *et al*. (1995) reviewed the effects of sound from vessels on marine mammals. They noted that it is not always possible to distinguish between effects due to the sound, sight or even smell of a vessel to an animal but there is evidence that sound from vessels has an impact on marine mammals. Animals have been reported to display a range of reactions from ignoring to avoiding the sound. The latter can lead to temporary displacement from an area. Vessel sound can mask communication calls between cetaceans, reducing their communication range (Jensen *et al*., 2009). It is not obvious whether temporary behavioural reactions translate into long-term effects on an individual or population. Exposure to low frequency shipping sound may be associated with chronic stress in whales; Rolland *et al*. (2012) reported a decrease in baseline levels of stress-related faecal hormones concurrent with a 6 dB reduction in underwater sound along the shipping lane in the Bay of Fundy, Canada, when traffic levels decreased.

Anthropogenic sound has the potential to interfere with acoustic communication, predator avoidance, prey detection, reproduction and navigation in fish. The effects of "excessive" sound on fish include avoidance reactions and changes in shoaling behaviour (Slabbekoorn *et al*., 2010). Prolonged avoidance of an area may interfere with feeding or reproduction or cause stress-induced reduction in growth and reproductive output. Fish exhibit avoidance reactions to vessels and it is likely that radiated underwater sound is the cause; for example, sound from research vessels has the potential to bias fish abundance surveys by causing fish to move away (de Robertis and Handegard, 2013; Mitson and Knudsen, 2003). Reactions include diving, horizontal movement and changes in tilt angle (de Robertis and Handegard, 2013). Popper *et al*. (2014) reviewed the effects of vessel sound on fish. They noted that there is no direct evidence of mortality or potential mortality to fish from vessel sound or other continuous sound sources The authors concluded that the likelihood of sound from vessels causing mortality or injury to fish was remote, even for fish in close proximity to vessels, however, it is possible sound from vessels may cause some behavioural disturbance to fish.

As receptors to underwater sound, marine mammals and fish receptor sensitivity is considered Medium (B) due to a number of the species being designated (e.g. as Annex II species, or PMFs; see Section 4.5.2). The area around the Captain field presents many background sound sources associated with vessel movements to which marine mammals and fish are exposed. As the marine mammals and fish in the area are accustomed to the presence of vessels, such that any impacts from vessel noise are typically behavioural impacts, the magnitude of effect of the increased vessel noise on these receptors is considered Minor (2). Given the Medium receptor sensitivity and the Minor magnitude of effect, the impact significance of the increased vessel noise in the area is considered Low such that any environmental impacts are thought to be negligible.

10.3.4 Piling Activities

Piling requires a hydraulic hammer to forcibly drive tubular steel piles into the seabed, resulting in substantial levels of pulsed underwater sound being generated. The level of this sound depends on numerous factors such as the size and operating energy level of the hammer, the diameter and length of the piles, the sub-surface depth of pile, number of hammer strikes, and the physical factors that will influence sound propagation (such as bathymetry, type of seabed substrate, water temperature and salinity).

Four piles measuring around 25 m in length and 24" (*c.* 0.61 m) in diameter will be required for each SUDS. It is expected that it will take one hour to install each pile with the four piles at each structure being installed in a single day. The piling activities will start with a soft start and based on previous piling activities at the Area C, it is expected a maximum hammer energy of 20 kJ will be sufficient to install all piles. However, as a worst-case scenario, a maximum hammer energy of 90 kJ has been considered in the underwater noise modelling carried out to support the impact assessment.

Piling of the SUDSs will be the loudest sound source associated with the proposed project and will be the activity that results in the largest extent of potential injury or behavioural disturbance to marine mammals and fish. Therefore, underwater sound propagation modelling has been conducted to estimate the potential impacts of piling the SUDSs (Appendix D).

10.3.4.1 Marine Mammals

Section 4.4.4 describes the abundance, distribution and seasonal occurrence of marine mammals known to occur in the Captain area. Marine mammals have been grouped by the National Oceanic and Atmospheric Administration (NOAA) according to the hearing range for the species (Table 10-1; NMFS, 2018) indicating which activities present during the development may produce sounds within the hearing range of the various hearing groups. In many species sensitive to underwater sound, sensitivity is related to their use of high frequency sound for echolocation.

Table 10-1: Marine mammal known to occur in the Captain area and hearing group.

Functional hearing group	Generalised hearing range	Species known to occur in the Captain area
Low-frequency (LF) cetacean	7 Hz to 35 kHz	Minke whale
Mid-frequency (MF) cetacean	150 Hz to 160 kHz	Atlantic white-sided dolphin, white-beaked dolphin
High-frequency (HF) cetacean	275 Hz to 160 kHz	Harbour porpoise, other species while echolocating
Phocid pinnipeds	50 Hz to 86 kHz	Grey seal
* The frequency bands distinguish between very broad categories of sensitivity and sound sources		

Offshore piling has been recognised as an activity that could, under certain conditions, cause disturbance and/or injury to marine mammals (JNCC, 2010). The potential impact of underwater sound on the marine mammal receptors has been assessed using the recommended JNCC guidance (JNCC, 2010). To support the assessment of the impact of piling, underwater sound propagation modelling was carried out. Full details of the modelling are available in Appendix D.

The predicted sound levels from piling have been compared with the NOAA (NMFS, 2018) precautionary thresholds for permanent threshold shift (PTS) to marine mammals. These thresholds are based on a comprehensive review of evidence for impacts of underwater sound on marine mammals and are now widely applied as appropriate precautionary criteria for assessing the impact of underwater sound on marine mammals (JNCC, 2010a).

As discussed in detail in Appendix D predicted sound levels from the proposed piling at Captain have been compared to the NOAA zero-to-peak sound pressure level (SPL) and cumulative sound exposure level (SEL) thresholds for PTS onset. The predicted distances to the NOAA PTS thresholds are summarised in Table 10-2. As the distances shown in Table 10-2 are less than the nominal 500 m mitigation zone radius include in the JNCC Guidelines (JNCC, 2010), implementation of JNCCs standard mitigation measures (see Section 10.5) will further reduce the likelihood of PTS occurring for all marine mammal groups.

Table 10-2: Predicted maximum distances from the piling location where sound levels decrease to below the NOAA zero-to-peak SPL and cumulative SEL thresholds for potential PTS onset using a 90 kJ hammer energy.

Marine Mammal Hearing Group	Predicted Maximum Distance to Threshold [1]	
	NOAA unweighted zero-to-peak SPL thresholds for potential PTS onset	NOAA unweighted cumulative SEL thresholds for potential PTS onset [2]
LF Cetaceans	10 m	Threshold not exceeded
MF Cetaceans	10 m	Threshold not exceeded
HF Cetaceans	50 m	Threshold not exceeded
Phocid Pinnipeds	10 m	Threshold not exceeded

[1] Predicted distances have been rounded up to the nearest 10 m.
[2] Estimated for marine mammals swimming away from the piling location at 2 m/s

Table 10-3 presents the results of the modelling for predicting the distance associated with any marine mammal behavioural disturbance due to piling at the Captain field area. The predicted disturbance is consistent with observations made during piling activities at other developments. The piling activities at each SUDS are expected to be completed within one day of commencement, such that any marine mammals disturbed are expected to return to the area after cessation of activities. Any disturbance experienced is therefore considered to be temporary.

Table 10-3: Predicted distances where sound levels decrease to below the adopted marine mammal behavioural disturbance thresholds and areas of potential disturbance for a 90 kJ hammer energy.

Criterion	SEL Behavioural Disturbance Threshold (dB re 1 µPa^{2}s)	Distance [1]
Tougaard (2016) criteria for behavioural disturbance to all marine mammals	145	8 km

[1] Predicted distance has been rounded up to the nearest 1 km.

With the application of JNCC guidance any impacts of the proposed piling activities on marine mammals are considered to be short term behavioural impacts rather than resulting in injury such that the magnitude of effect is considered Minor (2). Given the Medium receptor sensitivity (see Section 10.3.3) and the Minor magnitude of effect the impact significance of piling noise on marine mammals is considered Low such that any environmental impacts are thought to be negligible.

10.3.4.2 Fish

The fish species associated with the project area are identified in Section 4.4.3. Fish species differ in their hearing capabilities depending on the presence of a swim bladder, which acts as a pressure receiver (McCauley, 1994). Most fish can hear within the range of 100 Hz to 1 kHz, with some able to detect lower frequencies. Within this range, the hearing threshold varies from approximately 50 dB re 1 µPa for hearing specialists to 110 dB re 1 µPa for non-specialists. Fish with a connection between the swim bladder and otolith system have more sensitive hearing and may detect frequencies up to 3 kHz (Popper *et al*., 2003). Many species of fish produce sounds for communication that are typically emitted at frequencies below 1 kHz (Montgomery *et al*., 2006).

Table 10-4: Fish groupings with respect to presence/absence of swim bladder.

Fish group	Species
Fishes with no swim bladder	Mackerel
Fishes with swim bladder involved in hearing	Herring
Fishes with swim bladder not involved in hearing	Anglerfish, blue whiting, cod, Norway pout, sandeel, spurdog and whiting

Potential impacts to fish species were also assessed by comparing the underwater sound modelling results presented in Appendix D to the Popper *et al*. (2014) fish injury thresholds. The results summarised in Table 10-5 predicts that any injury to fish will be limited to distances up to a maximum of 20 m from the location of the piling activities.

Table 10-5: Predicted distances from the piling location where sound levels decrease to below the Popper zero-to-peak SPL thresholds for injury/potential mortality using a 90 kJ hammer energy.

Fish Group	Predicted Maximum Distance to Threshold Exceedance *
Fishes with no swim bladder	10 m
Fishes with swim bladder involved in hearing	20 m
Eggs, larvae, and fishes with swim bladder not involved in hearing	20 m
* Predicted distances have been rounded up to the nearest 10 m.	

With the implementation of a piling soft-start procedure it is expected that any fish in the area would disperse to areas where injury or mortality would not occur, therefore any occurrence of injury to fish would be low. Furthermore, if fish are disturbed by sound, evidence suggests they will return to an area once the activity causing the disturbance has ceased (Slabbekoorn *et al*., 2010). Therefore the magnitude of effect of underwater sound associated with the piling activities on fish is considered Minor (2). Given the Medium receptor sensitivity (see Section 10.3.3) and the Minor magnitude of effect, the impact significance of piling noise on fish is considered Low such that any environmental impacts are thought to be negligible.

10.4 Cumulative and Transboundary Effects

The additional vessels will cause a modest increase in underwater noise in the area. However, as the vessels will be located within a well-developed oil and gas area and piling activities will be relatively short term in nature, any cumulative impacts of underwater sound are not considered significant. Similarly, given the short time period associated with the piling activities, any cumulative impacts of underwater sound from these activities are not considered significant.

The Captain field is located *c.* 188 km from the UK/Norway median line and therefore no transboundary impacts associated with the underwater sound from the vessels or piling activities are expected.

10.5 Mitigation Measures

The following industry standard mitigation measures will be undertaken to minimise the impacts of the underwater noise sources associated with the Captain EOR Stage 2 Phase II project.

Proposed Mitigation Measures

- A qualified, trained and equipped marine mammal observer (MMO) will be present. The MMO will carry out a pre-piling survey of a 500 m mitigation zone and, if an animal is detected, the piling will be delayed until all marine mammals vacate the 500 m mitigation zone;
- A soft-start/ramp-up of hammer energy will be employed where the hammer will commence at a low energy at the start of piling. The soft start will be such that maximum hammer energy will not be reached until after a period of 20 minutes;
- Passive Acoustic Monitoring (PAM) will be employed during periods of low visibility to detect marine mammal presence; and
- Avoiding commencing piling at night or in poor visibility when marine mammals cannot reliably be detected. If this cannot be avoided, then PAM will be used.

Applying the risk assessment methodology described in Section 5 and taking account of the mitigation measures listed above, the impact significance of the various underwater noise sources associated with the proposed project is considered Low. The impacts are therefore considered acceptable when managed within the additional controls and mitigation measures identified. The proposed project will be conducted in compliance with all NMP policies; an assessment against the relevant NMP objectives is given in Appendix A.

11. WASTE GENERATION

This section discusses the types of waste likely to be generated as a result of the proposed Captain EOR Stage 2 Phase II Project, and the waste management procedures that will be implemented to minimise and monitor the volumes produced and disposed to landfill. Waste will be generated during all phases of the project.

Ithaca Energy is committed to reducing waste production and to managing all produced waste, by applying approved and practical methods and by adhering to a waste hierarchy similar to that shown in Figure 11-1 (Scotland's Environment, accessed 2020). Waste will only be disposed of if it cannot be prevented, reclaimed or recovered. All wastes will be managed in accordance with Ithaca Energy's Waste Management Procedure and via the existing waste contract. The procedure establishes the controls required to manage the hazards associated with the transportation and disposal of waste from offshore sites and the processes, and verification activities necessary to ensure legal obligations are satisfied.

Figure 11-1: Representative schematic of Scotland's Environment waste hierarchy (Scotland's Environment, 2020).

Consent to transfer to the United Kingdom shore is not required but Duty of Care (under the Environment Protection Act 1990) makes it the waste producer's responsibility to ensure that waste is only transferred to an appropriately licensed carrier who should have a Waste Carrier Registration. Transfer of Controlled Waste requires a Transfer Note to be completed (or Consignment Note in the case of Special Waste). The Transfer Note details the type and quantity of waste, from whom and to whom the waste has been transferred, the category of authorised person to whom the waste has been consigned, relevant licence numbers, time, place and date of transfer.

11.1 Vessel Waste

Waste will be generated from a number of vessels associated with the proposed activities including AHVs, supply, DSVs, CSV, jet trenching vessels etc. (Tables 3-8, 3-11, 7-7 and 7-8) identify anticipated vessel requirements). Waste from these vessels will be managed in line with the individual vessel Waste Management Plan (WMP) in accordance with MARPOL requirements, which regulate discharges of waste to sea from ships.

11.2 Drilling Waste

Drilling rigs generate various waste products during routine operations including contaminated cuttings, waste oil, chemical and oil contaminated water and scrap metal. Wastes will be minimised by use of appropriate procurement controls, and all wastes will be properly segregated for recycling / disposal / treatment. The appointed waste management contractor will supply monthly reports of waste sent to shore and will complete Controlled Waste Transfer Notes as required, and records of monthly disposals will be maintained. Waste Management Duty of Care audits will also be carried out.

11.3 Installation and Commissioning

Installation activities will routinely generate a number of wastes including scrap metal, wooden crates etc. All wastes will be properly segregated for recycling/disposal/treatment in accordance with Ithaca Energy's Waste Management Procedure and Controlled Waste Transfer Notes will be completed.

11.4 Production Phase

The Captain installations comply with Ithaca Energy's waste management procedures. Controlled waste transfer notes will continue to be completed as required and records on monthly waste disposal activities will be maintained. The proposed project is not expected to result in a change to the current waste streams occurring at the Captain installations.

11.4.1 General Waste

The Captain installation's general waste streams are segregated by personnel at the source of generation, and manually handled to the appropriate labelled waste receptacle until transferred onshore for disposal. All waste is segregated in accordance with waste management procedures and controlled waste transfer notes will be completed. Waste Management Duty of Care audits will also be carried out. Production of general waste on the Captain installations are not expected to change as a result of the proposed Captain Stage 2 EOR Project.

11.4.2 Laboratory Waste

The Captain installations adhere to 100% reinjection and so there are no PW discharges. Any other chemicals are segregated on site and sent to shore for disposal via a licensed contractor. As for g eneral waste streams, a WMP is in place to minimise laboratory waste. Production of laboratory waste on Captain installations is not expected to change as a result of the proposed project.

11.4.3 Special Waste

The Captain installations ship to shore a number of hazardous solid and liquid waste streams which may include Naturally Occurring Radioactive Material (NORM) / Low Specific Activity (LSA) scale. The types of hazardous wastes handled on the Captain installations will not change as a result of the proposed project.

11.5 Decommissioning Phase

The waste generated as a part of the decommissioning activities will be a combination of both hazardous (special) and non-hazardous wastes. As operator, Ithaca Energy will have in place a WMP developed to identify, quantify (where possible) and discuss available disposal options for waste resulting from the decommissioning activities. Where possible, materials will be recycled or sold and reused taking into account a waste hierarchy similar to that shown in Figure 11-1.

It is intended that recovered infrastructure will be returned to shore and transferred to a decommissioning facility, which will have all necessary approvals and licences in place and possess the capability to reuse or recycle the majority of recovered material. The minimisation of waste is a factor considered at every stage of the project.

11.5.1 Cumulative and Transboundary Effects

Waste will be managed in line with existing procedures and significant cumulative or transboundary impacts are not expected.

11.6 Mitigation Measures

The following mitigation measures are proposed to minimise the waste produced from the proposed Captain EOR Stage 2 Phase II project.

Proposed Mitigation Measures

- Ithaca Energy will apply the principles of the Waste Management Hierarchy during all activities i.e. Reduce, Reuse, Recycle;
- Existing asset and vessel WMPs will be followed;
- Only permitted disposal yards / landfill sites will be used.

As a receptor, landfill sites can be considered a finite resource, such that applying the assessment methodology presented in Section 5, the sensitivity of landfill sites as a receptor is considered Medium (B). With the application of the above control measures the magnitude of effect of waste generated throughout the project is deemed to be Negligible (1). Given the Medium sensitivity and the Negligible magnitude of effect, the impact significance is considered Low such that any environmental impacts associated with waste production are thought to be negligible.

The proposed project will be conducted in compliance with all NMP policies; an assessment against the relevant NMP objectives is given in Appendix A.

12. ACCIDENTAL EVENTS

In line with OPRED Guidance (BEIS, 2021) this ES assesses in detail the impact of a worst-case hydrocarbon release i.e. a subsea well blowout at the Captain field. However, it is acknowledged that other spills could occur during the different project phases. These other spill sources are summarised before detailing the environmental risks associated with an accidental hydrocarbon release from a subsea well blowout.

The Captain field has an approved Oil Pollution Emergency Plan (OPEP) in place, and this will be amended to capture the proposed Captain wells including details on the flowrate and interface with the drilling rig. The likelihood of an accidental event at the Captain installations is not considered to change as a result of the proposed Captain EOR Stage 2 Phase II Project.

12.1 Overview of Potential Hydrocarbon Releases

12.1.1 Drilling Phase

Loss of contaminated discharges

During drilling, in addition to a potential subsea well blowout (see below), accidental releases of contaminated discharges could include the loss of cleaning chemicals, mud inventory, other oily slops etc. There is also a risk of an accidental spillage of mud or diesel during bunkering operations.

These releases could result in toxic or sub-lethal effects on sensitive organisms and ecosystems. The resultant impacts depend on spill size, prevailing wind, sea state, temperature and sensitivity of environmental receptors affected (e.g. benthic species, fish, marine mammals, birds and protected areas).

Approved operational procedures will be adhered to in order to mitigate the likelihood of such accidental events and to minimise their impact should they occur. For example, the quantities of chemicals stored on the drilling rig will be optimised. Control of Substances Hazardous to Health (COSHH) assessments will be completed and Safety Data Sheets (SDS) will be made available. Where possible given technical requirements, chemicals that are PLONOR, have a RQ < 1, or do not carry substitution warnings will be prioritised. Spill kits will be located in close proximity to chemical and oil storage areas to enable a quick response.

Procedures, in line with best industry practice guidelines will be in place to minimise the risk of an accidental spill from bunkering. These will include, for example, regular checks of the integrity of the hose and competence of operators. Trained personnel will undertake bunkering operations in accordance with approved procedures. Containment facilities and drains will be inspected as part of marine assurance standards.

An approved OPEP will be in place to respond to an accidental hydrocarbon release. Ithaca Energy is a member of Oil Spill Response Limited (OSRL) and the Offshore Pollution Liability Association Ltd. (OPOL). Local access to dispersant will be available via the ERRV. OPPC permit requirements will be adhered to. Any accidental hydrocarbon release from a drilling rig at the Captain field will be responded to in accordance with arrangements set out in the Captain installations OPEPs.

The environmental impact is considered to vary between the different accidental discharges identified. For example, the severity of impact (Table 5-2) associated with a release of hydrocarbons during bunkering operations is considered Minor (2) whilst the impact associated with a loss of fuel inventory is considered Serious (3). However, when the likelihood of these accidental events taking place is taken into account most are considered a low risk. Any risk will be reduced to As Low As Reasonably Practicable (ALARP) and managed under the mitigation measures described such that it is considered acceptable.

Well blowout

A well blowout refers to the uncontrolled release of hydrocarbons from a well after the pressure control systems have failed. Primary well control is achieved by maintaining a hydrostatic pressure in the wellbore greater than the pressure of the fluids in the formation being drilled, but less than the formation fracture pressure. In a worst-case scenario, there can be insufficient pressure in the wellbore fluids (i.e. the drilling mud or completion fluids) to resist formation pressure and an influx occurs. Wellbore fluids are carefully designed, monitored and actively managed to prevent such occurrences.

Well blowouts are most likely to occur during drilling operations. In the event of an influx, the flow of reservoir fluids into the well is stopped by closing the BOP which is the initial stage of secondary well control. The BOP has multiple sets of rams that can close off the well bore in an emergency. Secondary well control is completed by circulating the well with kill weight fluid and displacing the influx out of the well. A blowout can occur if primary and secondary well control fails.

Down hole safety valves (DHSVs) are in place to seal wells should an unplanned well event occur during production. These DHSVs complement valves contained within the tree. Wells are plugged with cement and decommissioned when production has ceased.

The International Association of Oil & Gas Producers (IOGP) has issued datasheets (IOGP, 2019) on well blowout frequencies for drilling operations of a North Sea Standard (NSS), where the operation is performed with a BOP installed and the “two barrier” principle is followed (Table 12-1). The dataset is derived from the SINTEF well blowout database where a blowout is defined as an incident where formation fluid flows out of the well or between formation layers after all the predefined technical well barriers or the activation of the same have failed. Well blowout frequencies have been calculated per well drilled in the North Sea and are not an annual frequency. Note that well blowout frequency per total wells drilled is very low, indicating that the likelihood of a well blowout occurring is very remote. The likelihood of a blowout occurring at a maximum flow rate, or for an extended period of time, is lower still.

Table 12-1: Well blowout frequencies for North Sea offshore operations (IOGP, 2019).

Operation	Gas	Oil	Unit
Development drilling (oil)*	4.2×10^{-5}	3.4×10^{-5}	Per well drilled
Development drilling (HP/HT)	2.6×10^{-4}	2.1×10^{-4}	
Development drilling shallow gas (topside)	1.7×10^{-3}	-	
Development drilling shallow gas (subsea)	1.0×10^{-3}	-	
* This figure is relevant to the proposed Captain EOR Stage 2 Phase II Project. Other types of well are shown for comparison.			

The impacts of a well blow-out are considered in Section 12.2. Given the offshore location a detailed assessment of a loss of diesel inventory has not been included. However, modelling of a spill of 3,500 m^3 diesel has previously been carried out using OSCAR[1] to support the drilling permit application (DRA/926). In summary the model predicted a low probability of diesel reaching the surrounding coastlines and a low probability of the diesel reaching the UK/Norway median line (<5% for both surface water and water column).

[1] Further details on the OSCAR model are provided in Section 12.2.1.

12.1.2 Installation and Commissioning Phase

During the installation and commissioning phase, there is a risk of accidental discharges of water-based hydraulic fluids or treated seawater. This release could result in short-term localised effects on water quality, flora and fauna. To mitigate the potential of such releases occurring, containment facilities will be inspected as part of the vessels HSE Management System audit, and a chemical risk assessment will be undertaken as part of the Pipelines MAT application. Industry standard operating procedures and checks will be carried out to prevent such a release where possible. Chemicals that are PLONOR, have a RQ < 1 and/or do not carry substitution warnings will be prioritised where technically possible.

With the above mitigation measures in place the magnitude of effect of accidental discharges of water-based hydraulic fluids or treated seawater is considered Minor (2) whilst the environmental risk is considered low (likelihood ranked as remote). The risk is therefore considered acceptable when managed within the additional mitigation measures described.

12.1.3 Production Phase

The potential for accidental events associated with the production phase is not considered to differ to the current potential of such events at the Captain field.

Mitigation measures include the pre-existing 500 m safety zones at the Captain installations and at Area B as well as the application of 500 m zones to be located at the two new drill centres (Area D and Area E). Further mitigation measures include, optimal material selection, operating procedures in place and preference for the use of water-based hydraulic fluids. With these mitigation measures in place the environmental risk of an accidental event is considered low (likelihood of remote) and therefore acceptable when managed within the mitigation measures described.

12.1.4 Decommissioning Phase

During decommissioning activities, the impact of any accidental events are anticipated to be within the range of impacts discussed in the previous sections.

12.2 Assessment of a Well- Blowout

12.2.1 Modelled Scenario and Results

In support of the existing approved Captain OPEP, stochastic (probability) modelling using the SINTEF Oil Spill Contingency and Response (OSCAR) modelling package was carried out for a well blow-out scenario at the field (Ithaca Energy, 2022). The model using a declining release rate from 1,808.52 m^3 / day to 512.86 m^3 / day by day (resulting in a worst-case volume discharge of 88,615.6 m^3)[2]. This scenario represents a worst-case blow-out at the Captain field and therefore has been used to support this ES.

[2] OSCAR supports two different types of simulations: stochastic (probabilistic) and deterministic. The stochastic simulation feature of OSCAR allows for a spill scenario to be simulated multiple times over different weather conditions, with the results from each individual stochastic simulation being aggregated, and a number of statistical parameters computed. To analyse a single spill scenario, the deterministic mode of OSCAR allows for a spill scenario to be simulated over a single specified time interval and outputs can be presented in terms of key parameters such as oil thickness on the sea surface, concentrations on the shoreline, in the sediment and in the water column.

The stochastic model outputs included:

- the probability (>10%) of surface oil meeting or exceeding 0.3 µm;
- the probability (>1%) and shortest time of surface oil crossing a median line; and
- the probability (>1%) and shortest time for shoreline oiling along UK and Member State coastlines respectively.

Note as the oil spill modelling described here has previously been approved by OPRED (in the exiting OPEP and in various drilling permit applications), only a summary of the results is provided here.

Outputs of the stochastic modelling results for each season are presented in Figure 12-1 (probability of surface oiling > 0.3 µm) and Figure 12-2 (arrival times). Table 12-2 summarises the time taken to cross various median lines and to arrive at the shore.

The modelling predicted a 90-100% probability of surface oil crossing the UK/Norway median line at any time during the year. There is also up to a 90-100% chance of shoreline oiling at the north-east Scottish coastline depending on the time of year. It should be noted that the modelling assumes no intervention/response methods in order to determine the environmentally worst-case. In reality, Temporary Offshore Oil Pollution Emergency Plan (TOOPEP) would be implemented to respond to the spill.

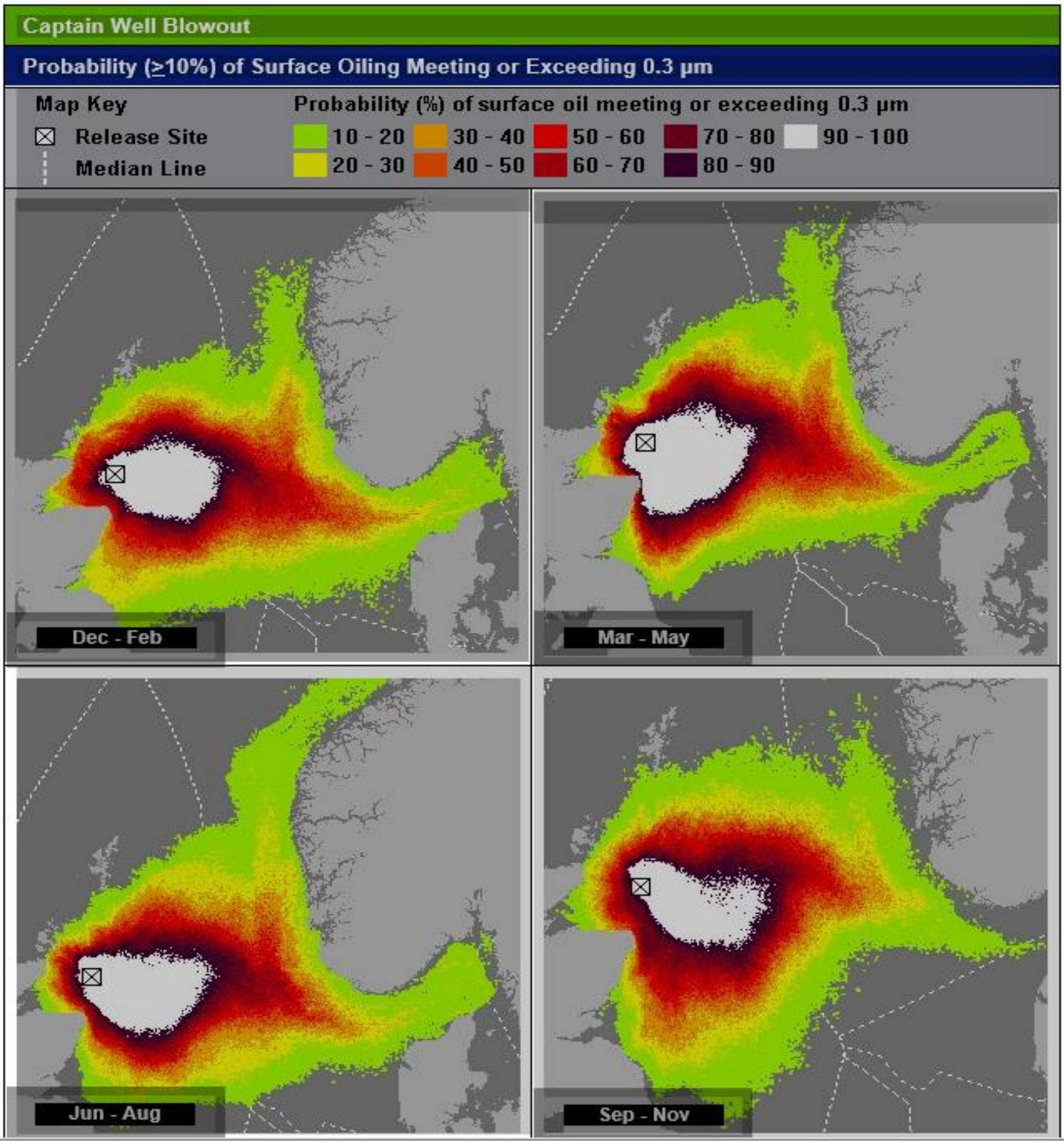

Figure 12-1: Probability of surface oiling meeting or exceeding 0.3 µm.

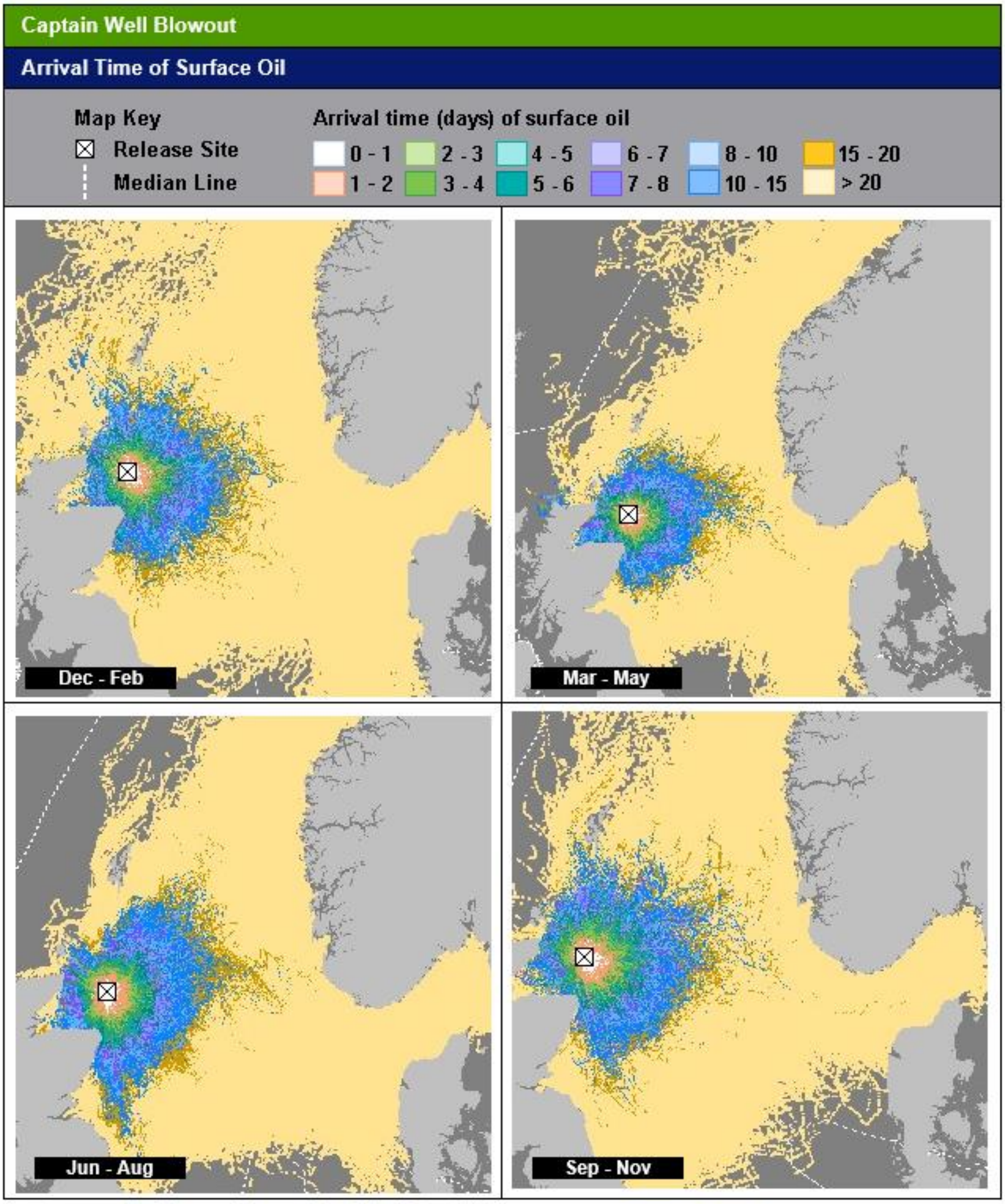

Figure 12-2: Arrival time of surface oil.

Table 12-2: Probability (≥1%) and shortest time of surface oil crossing median line

Captain Well Blowout				
Probability (≥1%) and shortest time of surface oil crossing median line				
Member States	**Dec – Feb**	**Mar – May**	**Jun – Aug**	**Sep – Nov**
Norwegian Waters	90 – 100%	90 – 100%	90 – 100%	90 – 100%
	7 days	7 days	7 days	7 days
Danish Waters	40 – 50%	30 – 40%	30 – 40%	10 – 20%
	19 days	>20 days	>20 days	>20 days
Swedish Waters	30 – 40%	20 - 30%	20 - 30%	5 – 10%
	>20 days	>20 days	>20 days	>20 days
German Waters	5 – 10%	5 – 10%	5 – 10%	1 – 5%
	>20 days	>20 days	>20 days	>20 days
Dutch Waters	5 – 10%	5 – 10%	5 – 10%	1 – 5%
	>20 days	>20 days	>20 days	>20 days
Faroese Waters	1 – 5%	-	-	1 – 5%
	>20 days	-	-	>20 days
Probability (≥1%) and shortest time for shoreline oiling				
Shoreline	**Dec – Feb**	**Mar – May**	**Jun – Aug**	**Sep – Nov**
United Kingdom				
Scotland				
Shetland	60 - 70%	30 - 40%	50 – 60%	70 - 80%
	7 days	11 days	>20 days	8 days
Orkney	70 – 80%	70 – 80%	80 – 90%	70 – 80%
	48 hours	67 hours	3 days	3 days
Highlands	70 – 80%	70 – 80%	70 – 80%	70 – 80%
	3 days	80 hours	3 days	3 days
Grampian	80 – 90%	90 – 100%	70 – 80%	70 – 80%
	3 days	80 hours	4 days	52 hours
Tayside to Fife	30 – 40%	30 – 40%	20 – 30%	40 – 50%
	12 days	18 days	>20 days	19 days
Lothian to Borders	30 – 40%	30 – 40%	5 – 10%	30 – 40%
	>20 days	>20 days	>20 days	>20 days
England				
Northeast	30 – 40%	20 – 30%	10 - 20%	40 – 50%
	>20 days	>20 days	>20 days	>20 days
Yorkshire and The Humber	10 – 20%	5 – 10%	1 – 5%	20 – 30%
	>20 days	>20 days	>20 days	>20 days
East Midlands	-	-	-	1 – 5%
	-	-	-	>20 days
Member States				
Norway	50 – 60%	70 – 80%	80 – 90%	60 – 70%
	>20 days	>20 days	17 days	>20 days
Denmark	60 – 70%	30 – 40%	50 – 60%	30 – 40%
	>20 days	>20 days	>20 days	>20 days
Sweden	30 - 40%	20 – 30%	40 – 50%	20 – 30%
	>20 days	>20 days	>20 days	>20 days

12.2.2 Assessment of the Environmental Impact of a Well Blow-Out

The environmental impact of a hydrocarbon spill depends on various factors which include:

- Location and time of the spill;
- Spill volume;
- Hydrocarbon properties;
- Prevailing weather and metocean conditions;
- Environmental sensitivities; and
- Spill response strategy.

12.2.3 Impact on Water Quality

When a hydrocarbon enters the marine environment, it will become exposed to numerous 'weathering' processes which will impact the behaviour and fate of the hydrocarbon. As each hydrocarbon has its own specific properties each one will weather differently. Captain Crude is an ITOPF Category Group III oil. The specific gravity of oil is its density in relation to pure water, which has a specific gravity of 1. Captain Crude has a specific gravity of 0.93 indicating that the oil is likely to remain on the sea surface during calmer conditions, however; there is the potential for this oil to suspend below the sea surface during rougher weather conditions.

The fate and effect of a spill is also dependent upon the chemical and physical properties of the hydrocarbons. Due to the asphaltene content of Captain crude, the oil may emulsify (the oils' ability to absorb water) in the marine environment. Based on this alone it is unclear if Captain crude will readily form a stable mousse in the marine environment. Under laboratory conditions, Captain crude has been shown to form a stable mousse with a maximum water uptake of 51% at 20°C. However, experience during a previous incident indicated that little emulsification occurred on that occasion.

12.2.4 Sediment Quality

Captain crude may suspend below the sea surface during rougher weather conditions and it is anticipated that the magnitude of effect on seabed sediments could be Serious (3). Given the presence of habitats identified as PMFs and Annex I (see Section, 4.4.2) the receptor sensitivity is considered Medium (B). The impact significance is therefore considered Moderate and as the likelihood of a spill is considered Remote, the environmental risk of a well blow-out on sediment quality is considered Low.

12.2.5 Plankton

The planktonic community is composed of a range of microscopic plants (phytoplankton) and animals (zooplankton) that drift with the oceanic currents. As hydrocarbons can float on the water's surface and disperse within the ocean as it weathers, plankton may be exposed to both floating hydrocarbon slicks and to small, dissolved droplets of hydrocarbon in the water column (Cormack, 1999; Almeda *et al*., 2013). Changes in the patterns of distribution and abundance of phytoplankton can have a significant impact on the entire ecosystem (Ozhan *et al*., 2014). Both oil and oil biodegradation can impact phytoplankton in the immediate vicinity of a spill. Hydrocarbon slicks can inhibit air-sea gas exchange and reduce sunlight penetration into the water, both essential to photosynthesis and phytoplankton growth (González et al., 2009).

Zooplankton at the surface are thought to be particularly sensitive to oil spills due to their proximity to high concentrations of dissolved hydrocarbon and to the additional toxicity of photo-degraded hydrocarbon products at this boundary (Bellas *et al*., 2013). Following an oil spill, zooplankton may suffer from loss of food resources in addition to the toxic effects from direct exposure, resulting in mortality or impaired feeding, growth, development, and reproduction (Blackburn *et al*., 2014 and references therein).

The distribution of plankton across the UKCS is generally uniform and widespread such that it is likely that plankton numbers would recover after the impact of an oil spill and most studies have found that there is a rapid return to normal densities and community compositions once oil in water background levels have returned (IPIECA-IOGP, 2015). Given the widespread distribution of plankton in the North Sea, receptor sensitivity is considered Low (A) whilst the magnitude of effect is considered Minor (2) such that the impact significance is considered Low. As the likelihood of a spill is considered Remote, the environmental risk of a well blow-out on plankton is considered Low.

12.2.6 Habitats and Benthic Species

Seabed habitats and associated benthic species may potentially be impacted by a well blowout where hydrocarbons are present in the water column or in the seabed sediment.

In response to hydrocarbon exposure, benthic fauna can either move, tolerate the pollutant (with associated impacts on the overall health and fitness), or die (Gray *et al*., 1988; Lee and Page, 1997). The response to hydrocarbons by benthic species differs depending on their life history and feeding behaviour, as well as the ability to metabolise toxins, especially PAH compounds. However, severe oil pollution typically causes initial massive mortality and lowered community diversity, followed by extreme fluctuations in populations of opportunistic mobile and sessile fauna (Suchanek, 1993).

As described in Section 4.4.2 seabed surveys carried out in the area of the Captain field identified a number of benthic species in the area including filter feeders (e.g. sea pens and *A. islandica*). Filter feeders are vulnerable to ingesting oil during feeding. Generally, infaunal polychaetes are particularly affected by oil pollution (Suchanek, 1993), however, their recolonisation of effected areas varies with some species decreasing after an oil spill whilst others may be the first colonisers (Blackburn *et al.,* 2014 and references therein). Burrowing bivalves and small crustaceans called amphipods can be sensitive to even brief exposures of relatively low hydrocarbon concentrations (IPIECA-IOGP, 2015; Suchanek, 1993), possibly because of their low dispersal rate and limited mobility. *P. jeffreysii* is known to be highly tolerant of hydrocarbon contamination (MarLIN, 2016 and references therein) and intolerant of elevated heavy metal concentrations such as copper (Rygg, 1985).

According to FeAST (Marine Scotland, 2020), oil from spills would have to be dispersed deep into the water column to affect a burrowed mud feature. Information on the impacts of hydrocarbons on sea pens is limited (Hill and Wilson, 2000), however, a study on the impact of oil on deep-sea megafauna (McClain *et al.,* 2019) notes that at the Deepwater Horizon oil spill site in 2017 (seven years after the spill incident), there was lowered species diversity and sessile fauna such as sea pen were absent. This may reflect low resiliency to pollution, especially in cnidarians.

Given the presence of habitats and species identified as PMFs and Annex II/Annex I (see Section, 4.4.2) the receptor sensitivity is considered Medium (B) whilst the magnitude of effect is considered Serious (3). The impact significance is therefore considered Moderate, however as the likelihood of a spill is considered Remote, the environmental risk of a well blow-out on sediment quality is considered Low.

12.2.7 Fish

Exposure of fish to hydrocarbons can occur either through uptake across the gills or skin or by direct ingestion of the pollutant through contaminated prey. Pelagic species, which spend the majority of their life cycle in the water column, are likely to receive the highest exposure to contaminants that remain near the surface, whereas demersal fish species, associated with the seabed, are more likely to be exposed to particle-bound contaminants.

The likelihood of adult fish mortality due to open water hydrocarbon spills is small (IPIECA-IOGP, 2015). Significant effects on wild stocks have seldom been detected and fish are thought to actively avoid hydrocarbons (ITOPF, 2014). However, hydrocarbons have been detected in fish bile over one year after the Deepwater Horizon oil spill (Murawski *et al.*, 2014), suggesting that adult fish may accumulate hydrocarbons after a large hydrocarbon spill event. A spill could have the potential to impact fish spawning success because the eggs and larvae of many species are very sensitive to pollution. Joye *et al.* (2016) reported an estimated 2–5 trillion fish larvae were killed as a consequence of the Deepwater Horizon oil spill (2010) and while that was a deep-sea oil blowout, it gives a sense of scale on the potential impacts of a blowout to fish populations.

The Captain field is located within ICES rectangle 45E8 and a number of fish spawning and nursery grounds occur there (see Section 4.4.3). Several of these are PMF including anglerfish, blue whiting, cod, herring, mackerel, ling, Norway pout, sandeels, spurdog and whiting. The eggs and larvae of broadcast spawners, such as Norway pout, which are widely dispersed, could be exposed to oil in the water column. The contamination of the water column above the threshold of 10 µg/l, at probabilities of 90 to 100%, is restricted to a relatively small area in comparison to the size of spawning grounds in the North Sea (all species that spawn in the Captain area spawn over extensive areas of UK waters) and sediment contamination is not anticipated.

Given the presence of fish species identified as PMFs the receptor sensitivity is considered Medium (B) whilst the magnitude of effect is considered Serious (3). The impact significance is therefore considered Moderate, however as the likelihood of a spill is considered Remote, the environmental risk of a well blow-out on fish is considered Low.

12.2.8 Seabirds

Seabirds are particularly sensitive to the effects of surface oil pollution, and some oil pollution incidents have resulted in mass mortality of seabirds (e.g. Munilla *et al*., 2007; Votier *et al*., 2005). Mortality occurs from the ingestion of oil, which results in liver and other organ failure, as well as contamination of plumage, which destroys the insulating properties, leading to hypothermia (Alonso-Alvarez *et al*., 2007). The impact of oil pollution on seabird populations depends on the numbers of seabirds at sea around the pollution incident and on the seabird species present. Diving seabirds such as seaducks (*Anatidae*), divers (*Gaviidae*), cormorants (*Phalacracoracidae*), grebes (*Podicepididae*) and auks (*Alcidae*) are more susceptible than more aerial species such as gulls (*Laridae*) (Webb *et al.*, 2016).

Susceptible species tend to spend a greater proportion of their time at sea and have limited ability to locate alternative feeding sites. At population level, species with small or geographically limited populations, a low potential reproductive rate (productivity) and low adult survival rates are particularly sensitive due to their limited ability to recover (Webb *et al.*, 2016). Seabird sensitivity to surface oil pollution in the Captain field area is generally medium throughout the year. Exceptions are February and December when it is regarded as Extremely High and Very High respectively (see Section 4.4.5).

Given the potential vulnerability of seabirds to surface oil pollution and fact that many of the species in the area will be associated with coastal SPAs, the receptor sensitivity is considered High (C) whilst the magnitude of effect is considered Major (4). The impact significance is therefore considered High, however as the likelihood of a spill is considered Remote, the environmental risk of a well blow-out on seabirds is considered Medium.

12.2.9 Marine Mammals

Marine mammals may be exposed to hydrocarbons either internally (swallowing contaminated water, consuming prey containing oil-based chemicals, or inhaling of volatile hydrocarbon related compounds); and externally (swimming in hydrocarbon or dispersants contacting the skin).

The effects of hydrocarbons on marine mammals are dependent upon species but may include:

- Hypothermia due to conductance changes in skin or fur;
- Toxic effects and secondary organ dysfunction due to ingestion of oil;
- Congested lungs;
- Damaged airways;
- Interstitial emphysema due to inhalation of oil droplets and vapour;
- Gastrointestinal ulceration and haemorrhaging due to ingestion of oil during grooming and feeding;
- Eye and skin lesions form continuous exposure to oil;
- Decreased body mass due to restricted diet; and
- Stress due to oil exposure and behavioural changes.

There is little documented evidence of cetacean behaviour being affected by hydrocarbon spills. The available evidence suggests they do not necessarily avoid slicks. In the months following the *Exxon Valdez* spill there were observations of harbour porpoises swimming through light to heavy crude oil sheens. Stressed or panicking cetaceans tend to move faster, breathe more rapidly and therefore surface more frequently into oil and increase exposure (Harvey and Dahlheim, 1994).

Cetaceans have smooth skins with limited areas of pelage (hair covered skin) or rough surfaces. Hydrocarbon tends to adhere to rough surfaces, hair or calluses of animals, so contact may cause only minor adherence. However, cetaceans can be susceptible to inhaling hydrocarbon and hydrocarbon vapour when they surface to breathe. This may lead to damaging of the airways, lung ailments, mucous membrane damage or even death.

The likelihood that a feeding cetacean would ingest a sufficient quantity of hydrocarbon to cause sublethal damage to its digestive system, or to present a toxic body burden, is low (IPIECA-IOGP, 2015). Ingestion of subtoxic quantities may have chronic effects and there is potential for PAHs to accumulate in tissues of whales before they are eventually metabolized, and for contaminants to be passed to juveniles through the mother's milk.

Several cetacean species are known to occur in the vicinity of the Captain field (Section 4.4.4) with sightings of harbour porpoise, minke whale, white-beaked dolphin and killer whale throughout the year. Therefore, it is possible that a hydrocarbon spill at Captain could impact cetaceans.

Seals are vulnerable to hydrocarbon pollution because they spend much of their time near the surface and regularly haul out on beaches. Stochastic oil modelling of the well blow-out scenario identified a potential for significant adverse impact on seals because of predicted oil beaching. Seals have been seen swimming in hydrocarbon slicks during several documented spills (Geraci and St. Aubins, 1990). Most seals scratch themselves vigorously with their flippers but do not lick or groom themselves, so are less likely to ingest hydrocarbon from skin surfaces. However, a seal mother trying to clean an oiled pup may ingest hydrocarbon, and it is pups that are most vulnerable to hydrocarbon spills when they reach breeding colonies on the shoreline. Furthermore, seals use smell to identify their young in a large colony. If the mother cannot identify its pup because its scent has been masked by hydrocarbons, this can result in abandonment and starvation.

Given that the marine mammals in the area include PMFs, and Annex II and Annex IV species the receptor sensitivity is considered High (C) whilst the magnitude of effect is considered Major (4). The impact significance is therefore considered High, however as the likelihood of a spill is considered Remote, the environmental risk of a well blow-out on seabirds is considered Medium.

12.2.10 Offshore Protected Areas

The stochastic modelling predicts that several protected areas could potentially be affected by a hydrocarbon spill at Captain. The extent of surface contamination and condensate in the water column for the blowout scenario, in relation to the offshore protected areas is shown in Figure 12-1 and Figure 12-2 and as can be seen from Figure 4-13, there are multiple offshore designated areas that would be impacted. These offshore areas tend to be designated for seabed features i.e. habitat types and associated benthic animals. As described previously (Section 12.2.4) it is anticipated that the magnitude of effect on seabed sediments could be Serious (3). Given the presence of habitats and species identified as PMFs and Annex I/Annex II within the offshore designated areas the receptor sensitivity is considered Medium (B), whilst the magnitude of effect is considered. The impact significance is therefore considered Moderate and as the likelihood of a spill is considered Remote, the environmental risk of a well blow-out on offshore protected areas is considered Low.

12.2.11 Coastal / Near Shore Protected Areas

Considering the location of the protected areas shown in Figure 4-13, and the probability of beaching (Figure 12-1 and Table 12-2) it is possible that the oil from a blow-out at the Captain field could impact on the water column in the location of a number of near shore and coastal protected areas. Given the presence of habitats and species identified as PMFs and Annex I/Annex II/Annex IV within the coastal and nearshore designated areas the receptor sensitivity is considered High (C), and the magnitude of effect is considered Major (4). The impact significance is therefore considered High, however as the likelihood of a spill is considered Remote, the environmental risk of a well blow-out on seabirds is considered Medium.

12.2.12 Fisheries, Aquaculture and Shellfish Protected Areas

Localised mortality of eggs and larvae which may occur following a spill rarely impacts wider fish stocks, and adult fish are relatively resilient to hydrocarbon spills. More significant impacts may be found near shore, where hydrocarbons can accumulate and exposure, particularly of intertidal and shallow subtidal benthos, caged animals and seafood products that are cultivated in fixed locations (ITOPF, 2014).

Fishing effort by UK vessels in the Captain area is moderate when compared to other areas of the UKCS (Section 4.6.1).

There are no aquaculture sites or shellfish protected areas within the immediate vicinity of the Captain field, though it is recognised that a blow-out could impact on such sites (see Figure 12-1 and Figure 4-20).

The sensitivity of commercial fisheries, aquaculture sites and shellfish protection waters as receptors is considered Medium (B) as there may be some short-term availability of fisheries resources whilst after a period of time the aquaculture and shellfish protection waters would reopen. However given the commercial impact, the magnitude of effect is considered Serious (3) such that the impact significance is considered Moderate, however as the likelihood of a spill is considered Remote, the environmental risk of a well blowout on fisheries, aquaculture and shellfish protection areas is considered Low.

12.2.13 Transboundary and Cumulative Impacts

Probabilities of crude on the surface and in the water column, and arrival times are discussed earlier in Section 5.2. The probability of crude crossing international UK/Norway median line in as a result of a well blowout is high throughout the year.

In the unlikely event of a well blowout, a large volume of gas containing methane, ethane and CO_2 could potentially be released contributing to localised poor air quality and cumulatively to global climate change (as noted following the Deepwater Horizon event, see for example Middlebrook *et al*., 2012).

12.3 Major Environmental Incident Assessment

Under the Offshore Safety Directive (2013/30/EC) and the implementing UK regulations, the Offshore Installations (Offshore Safety Directive) (Safety Case) Regulations 2015, 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) of the European Parliament and of the Council on environmental liability with regard to the prevention and remedying of environmental damage".

"Environmental damage" is defined in Directive 2004/35/EC as:

- Damage to protected species and natural habitats, which is any damage that has significant adverse effects on reaching or maintaining the favourable conservation status of such habitats or species. The significance of such effects is to be assessed with reference to the baseline condition, taking account of the criteria set out in Annex I";
- "Water damage, which is any damage that significantly adversely affects the ecological, chemical and/or quantitative status and/or ecological potential, as defined in Directive 2000/60/EC, of the waters concerned, with the exception of adverse effects where Article 4(7) of that Directive applies"; and
- "Land damage, which is any land contamination that creates a significant risk of human health being adversely affected as a result of the direct or indirect introduction, in, on or under land, of substances, preparations, organisms or micro-organisms".

Diesel and chemicals will not be present in any volume that, if spilled, would result in a significant environmental impact, or an MEI. A diesel spill is not considered to be a significant threat to the marine environment, due to the characteristics of diesel and subsequent behaviour upon release. Diesel has very high levels of light ends, evaporating quickly on release. Evaporation is more rapid in higher wind speeds, warmer water and air temperatures. The low asphaltene contents prevents emulsification, reducing its persistence in the marine environment.

A well blow-out scenario during the proposed drilling activities is considered to be a MAH. The impact of a well blowout on various receptors is considered in Section 12.2. Hydrocarbon spilled during a well blow out may impact protected features of several protected conservation sites in the area by increasing the level of hydrocarbons in the water column. Thus, the release can either directly affect protected species of these sites or impact the environmental quality of the habitats supporting them, that may affect their ability to maintain or reach favourable conservation status. The area affected by the worst-case spill may overlap with spawning and nursery grounds of a number of fish species which are of conservation concern either at national Scottish, OSPAR, European or International Red list. Adult and juveniles may become exposed and become affected by the condensate in the water column although with moderate significance. The potential extent of the surface sheen area in the blowout event, may increase the exposure of various protected bird species and some marine mammals. Based on the assessment presented in Section 12.2, it is concluded that a well blowout at the Captain field location could lead to significant impacts that could affect the favourable conservation status of seabirds and marine mammals. Therefore such a release is considered to qualify as a MEI as defined in the Safety Case Regulations 2015.

12.4 Natural Disasters

Some natural disasters could increase the risk of a major pollution event occurring at the Captain field. For example, an earthquake could lead to damage to the subsea infrastructure and potential loss of well control. The likelihood of an earthquake of sufficient magnitude on the UKCS to impact seabed infrastructure is extremely remote.

Climate change effects, such as sea level change and extreme weather events, are not considered to significantly alter the range of effects considered. Extreme weather may make accidents to the drilling rig more likely, but the rig has procedures in place for making safe and shutting down operations during extreme weather, along with emergency procedures in the case of rig damage, and a full loss of fuel inventory has been considered in the Captain platform OPEP.

12.5 Mitigation Measures

The mitigation measures associated with potential accidental events are captured in Sections 5 to 10. More specifically the mitigation measures associated with preventing a subsea well blowout are summarised here.

Proposed Mitigation Measures

- Activities will be carried out by trained and competent offshore crews and supervisory teams;
- An approved OPEP will be in place prior to any activities being undertaken;
- Records will be kept of oil spill training and exercises as required by the OPEP;
- Process Safety Assurance Processes will be identified and adhered to;
- A co-ordinated industry oil spill response capability will be available;
- Enhanced sharing of industry best practices via the Oil Spill Response Forum (OSRF) will continue for Company personnel;
- A robust BOP pressure and functional testing regime will be in place; and
- Appropriate mud weights will be used to ensure well control is maintained.
- In case of an emergency, arrangements will be in place with a well capping provider to provide specialist advice and support; and
- Oil spill control measures will be followed as outlined in the OPEP.

All wells in the UK are subject to well examination schemes as per the Offshore Safety Directive 2015. The purpose is to provide assurance that the well is designed and constructed properly and is maintained adequately. This provides a scheme of quality control and quality assurance and incorporates current industry guidance. It is essential for the examination to demonstrate that the pressure boundary of the well is controlled throughout the well’s life cycle and that the pressure containment equipment that forms part of the well is suitable for this purpose. Examination of planned well programmes and operations must be carried out by an independent and competent person. Independent examination ensures that 'Good Oilfield Practice' and company standards are incorporated during drilling and well intervention operations. This contributes to risk reduction and prevention of loss of containment through application of the 'as low as reasonably practicable' (ALARP) principle.

Ithaca Energy's commitment to ensuring protection of the environment are set out in the corporate HES policy (a copy of which is provided in Section 1.7). Ithaca Energy follow the International Standards Organisation (ISO) 14001 standard and has an externally verified EMS. The Company's EMS covers activities including exploration, drilling and production and will be applied to the proposed Captain EOR Stage 2 Phase II Project. The EMS governs those aspects of the operations that can be controlled, such as discharges, and establishes a subsequent auditing process.

The activities associated with the proposed development are also covered in a project specific HES plan which ensures that the project is managed in such a way that all of Ithaca Energy's HES policies are adhered to throughout all phases of the proposed project. Particular emphasis will be paid to having a robust design, quality equipment, quality construction and operational best practices.

Oil spills can occur at any phase of a project, including drilling, completion, production and export. The following provides a high-level overview of proposed areas of planning and preparation that either reduce the probability and/or consequence of a spill/release, including failure of well control.

Ithaca Energy will take measures to minimise the risk of a blowout through well design and well control measures. These include a well control barrier and BOP equipment.

In the event of a blowout, the drilling rig will try to disconnect from the well and move away from location. A second rig or intervention vessel would be mobilised to the location with the intention of placing a second BOP or a capping device on the flowing well or by drilling a relief well and re-establishing well control.

As a member of OSRL, Ithaca Energy will have access to well capping devices to contain the well.

If primary and secondary well control is lost by way of a blowout and oil flows uncontrollably from the well to the environment a relief well may be required to stop the flow of oil and bring the well back under control. A suitable rig would be sourced from the UK market. An inventory is maintained by Ithaca Energy and their contractors to ensure that stocks of all materials required for a relief well are available at short notice. Ithaca Energy has insurance provisions in place to cover well control/re-drill situations as well as legal liabilities, and the Company is a member of OPOL which provides rapid compensation to parties directly affected by an oil spill.

Ithaca Energy's oil spill contingency plans will be fully documented in the OPEPs that will accompany the development and operational phases.

It is recognised that a well blow-out could result in a major impact of some receptors, however with the application of the mitigation measures identified, the likelihood of such an event occurring at the Captain field is considered Remote such that the environmental risk is considered ALARP.

13. CONCLUSIONS

A detailed assessment of the potential environmental impacts associated with the proposed Captain EOR Stage 2 Phase II project has been carried out. The identification of the potential impacts is based on the nature of the proposed activities and was informed by available literature and guidance documents, industry specific experience and consultation with OPRED and their consultees. The commitments made in this ES will be incorporated into environmental management plans for the drilling, installation, commissioning and operations phases of the proposed project.

13.1 Environmental Effects

The potential impacts to the environment from all phases of the project were assessed. The environmental aspects of each of the key activities for each phase of the project were identified and quantified in terms of their effect on receptors and their magnitude of this effect. The results were assessed on the basis of the impact significance (for planned activities) or the risk posed to the environment (for unplanned), and were summarised as being either low, medium or high significance.

The environmental impact assessment considered both planned activities and unplanned events. The assessment showed that with the application of the mitigation measures identified, the impacts of the planned activities are of low significance whilst a well blowout was found to result in a medium environmental risk.

13.2 Minimising Environmental Impact

Following identification of suitable mitigation and control measures, additional assessment was undertaken for the activities initially identified as medium or high risk. This includes quantification of seabed disturbance and oil spill modelling. Following implementation of identified mitigation and control measures, all residual risks to the environment are considered to be ALARP.

The execution of the proposed Captain EOR Stage 2 Phase II project, incorporating the control measures identified in this ES, is not expected to have a significant impact on the environment.

Routine discharges to sea would be expected to disperse within a limited distance from the development. It is therefore unlikely that planned discharges will have a transboundary impact given that the nearest median line (UK/Norway median line) is *c*. 182 km from the Captain field. Hence no significant transboundary impacts were identified as a result of planned activities. There is a risk of transboundary impacts associated with an accidental release of oil, as discussed in Section 12. Such releases are rare, and measures will be in place to minimise the likelihood of such an event occurring. However, should an unplanned release occur, there will be measures in place to ensure a co-ordinated and co-operative response.

The emissions to air associated with the proposed project will have a transboundary impact on terms of contributing to climate change. However this contribution is considered relatively low, whilst the proposed project actually reduces the GHG intensity over the remainder of field life, when compared against the values should the project not progress.

13.3 Commitments

Project specific commitments and mitigation measures to minimise the impact of the proposed project on the environment have been highlighted throughout the ES and are summarised in Table 13-1.

Table 13-1: Captain EOR Stage 2 Phase II project commitments.

Aspect	Commitments
Physical presence	• Drilling rig routes will be selected in consultation with other users of the sea, with the aim of minimising interference to other vessels and the risk of collision; • Vessel use will be optimised by minimising the number of vessels required and length of time vessels are on site; • A post installation survey will be carried out following jetting of the flowlines and umbilicals to ensure the lines are over trawlable and to ensure there are no clay berms; • Consultation with SFF for all phases and operations; • Notice to Mariners will be circulated prior to rig mobilisation; • As required by HSE Operations Notice 6 (HSE, 2014), a rig warning communication will be issued at least 48 hours before any rig movement. Notice will be sent to the Northern Lighthouse Board (NLB) of any drilling rig moves and vessel mobilisation associated with the mobilisation and demobilisation of the drilling rig; • A Vessel Traffic Survey will inform a Consent to Locate application for the drilling rig; • A Collision Risk Management Plan will be produced, if required; • All vessels engaged in the project operations will have markings and lightings as per the International Regulations for the Prevention of Collisions at Sea (COLREGS) (IMO, 1972); • The drilling rig will be equipped with navigational aids and aviation obstruction lights system, as per the Standard Marking Schedule for Offshore Installations for example fog lights, aviation obstruction lights, helideck lighting and radar beacons; • The drilling rig will have a statutory 500 m safety zone to mitigate any collision risk; • An ERRV will patrol the area; • All subsea infrastructure out with the 500 m zones will be over-trawlable; • The use of pipeline stabilisation features (e.g. mattresses and rock cover) will be minimised through project design and will be installed in accordance with industry best practice and SFF recommendations.

Aspect	Commitments
Emissions to air	• The drilling rig and other project vessels will be subject to audits ensuring compliance with UK legislation and the Ithaca Marine Operations and Vessel Assurance Standard; • Vessel use will be optimised where possible by minimising the number of vessels required, and their length of time on site; • Vessels will be operated where possible in modes that allow for economical fuel use; and • Minimise flaring during well clean-up operations by sending fluids to BLP for processing as the base case and preferred option. • In accordance with the revised NSTA strategy, and associated Stewardship Expectation 11, as well as with the industry commitments within the NSTD, Ithaca Marine Operations and Vessel Assurance Standard will incorporate the impact of the Captain field production within developing controls including: • Asset GHG Emission Reduction Action Plans; • Flaring and venting reviews to identify/action zero routine flaring by 2030; • Active flare reduction strategy; • Active vent reduction strategy; • Emission key performance indicators and targets; and • Industry level benchmarking of flaring and venting. These will ensure that opportunities for efficiency and reduction of atmospheric emissions, where not in conflict with safe operations, are identified, actioned as appropriate and reviewed.
Discharges to sea	• The drilling rig has been audited under Ithaca Energy's marine assurance standards and subject to rig recertification audits; • All vessels used will be MARPOL compliant; • Where technically feasible Ithaca Energy will prioritise the selection of chemicals which are PLONOR, or have the lowest RQ; and • The discharges of any water based hydraulic fluids, sand or chemicals are regulated by the OPPC and/or OCR regulations and reported through the EEMS. As such, Ithaca Energy will ensure that sampling, analysis and reporting are undertaken in line with the regulations and permit conditions.
Seabed disturbance	• Pre-deployment surveys will be undertaken to identify suitable locations for the drilling rig anchors; • Wells at Area D and Area E will be drilled in close proximity such that the anchors will only require to be laid once at each drill centre and the drilling rig can be skidded between wells; • Production well at Area B will use top hole sections from a suspended well; • Jet trenching rather that ploughing of flowlines and umbilicals; and • The use of mattresses, rockdump and grout bags will be minimised through optimal

Aspect	Commitments
	project design.
Underwater noise	• A qualified, trained and equipped marine mammal observer (MMO) will be present. The MMO will carry out a pre-piling survey of a 500 m mitigation zone and, if an animal is detected, the piling will be delayed until all marine mammals vacate the 500 m mitigation zone; • A soft-start/ramp-up of hammer energy will be employed where the hammer will commence at a low energy at the start of piling. The soft start will be such that maximum hammer energy will not be reached until after a period of 20 minutes; • Passive Acoustic Monitoring (PAM) will be employed during periods of low visibility to detect marine mammal presence; and • Avoiding commencing piling at night or in poor visibility when marine mammals cannot reliably be detected. If this cannot be avoided, then Passive Acoustic Monitoring (PAM) will be used
Waste	• Ithaca Energy will apply the principles of the Waste Management Hierarchy during all activities i.e. Reduce, Reuse, Recycle; • Existing asset and vessel WMPs will be followed; • Only permitted disposal yards / landfill sites will be used.
Accidental events	• Activities will be carried out by trained and competent offshore crews and supervisory teams; • An approved OPEP will be in place prior to any activities being undertaken; • Records will be kept of oil spill training and exercises as required by the OPEP; • Process Safety Assurance Processes will be identified and adhered to; • A co-ordinated industry oil spill response capability will be available; • Enhanced sharing of industry best practices via the Oil Spill Response Forum (OSRF) will continue for Company personnel; • A robust BOP pressure and functional testing regime will be in place; and • Appropriate mud weights will be used to ensure well control is maintained. • In case of an emergency, arrangements will be in place with a well capping provider to provide specialist advice and support; and • Oil spill control measures will be followed as outlined in the OPEP.

13.4 Overall Conclusion

Ithaca Energy on behalf of itself and its Co-Venturer, Dana Petroleum (E&P), is proposing to further enhance recover of hydrocarbons at the Captain field via the proposed Captain EOR Stage 2 Phase II project. The field is well understood and the Captain EOR Stage 2 Phase II project will use proven technology incorporating current best practices and latest generation equipment. A robust design, strong operating practices and a highly trained workforce will ensure the proposed project does not result in any significant long-term environmental, cumulative or transboundary effects. Existing measures at the field will remain in place during the operating phase to effectively respond to potential emergency scenarios.

The ES assesses the worst-case impact of the project on the environment and is therefore very conservative. Even then, applying the mitigations measures identified it is the conclusion of this ES that the current proposal for the Captain EOR Stage 2 Phase II project can be completed without causing any significant long term environmental impacts or cumulative or transboundary effects.

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APPENDIX A – SCOTLAND'S NATIONAL MARINE PLAN

A.1 Scotland's National Marine Plan

Scotland's NMP (Marine Scotland, 2015) covers the management of both Scottish inshore waters (out to 12 nm) and offshore waters (12 to 200 nm). The aim of the NMP is to help ensure the sustainable development of the marine area through informing and guiding regulation, management, use and protection of the NMP areas. The activities associated with the proposed Captain EOR Stage 2 Phase II project have been assessed against each of the NMP objectives, details of which can found in Table A-1.

Table A-1: The proposed Captain EOR Stage 2 Phase II Project assessed against Scotland's NMP principles.

Scotland's National Marine Plan Principle Number	Applicable?	Assessment Against Principle
GEN 1 General planning principle		
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 proposed project is an expansion to an existing field. The EIA assesses potential impacts to the environment and to other sea users.
GEN 2 Economic benefit		
Sustainable development and use which provides economic benefit to Scottish communities is encouraged when consistent with the objectives and policies of this Plan.	✓	The proposed project will provide jobs and tax revenues to the economy.
GEN 3 Social benefit		
Sustainable development and use which provides social benefits is encouraged when consistent with the objectives and policies of this Plan.	✓	The EIA considers impacts to other sea users in decision making e.g. fisheries and pipelines. Lifecycle of the project is assessed for environmental and economic implications.
GEN 4 Co-existence		
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 EIA process involved consultation with other sea users (SFF).
GEN 5 Climate change		
Marine planners and decision makers must act in the way best calculated to mitigate, and adapt to, climate change.	✓	Fuel use associated with vessel movements and the drill rig will be minimised. No flaring associated with well clean up and testing.
GEN 6 Historic environment		
Development and use of the marine environment should protect and, where appropriate, enhance heritage assets in a manner proportionate to their significance.	✓	A number of surveys have been carried out and used to support the EIA. EIA takes cognisance of the wrecks in the area.
GEN 7 Landscape/seascape		
Marine planners and decision makers should ensure that development and use of the marine environment take seascape, landscape and visual impacts into account.	×	Subsea infrastructure only being installed.
GEN 8 Coastal process and flooding		
Developments and activities in the marine environment should be resilient to coastal change and flooding, and not have unacceptable adverse impact on coastal processes or contribute to coastal flooding.	×	Offshore Development.

Scotland's National Marine Plan Principle Number	Applicable?	Assessment Against Principle
GEN 9 Natural heritage		
Development and use of the marine environment must: a) Comply with legal requirements for protected areas and protected species. 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.	✓	Environmental surveys undertaken in the area. Design and installation method of the subsea infrastructure informed by these surveys.
GEN 10 Invasive non-native species		
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.	✓	All vessels will follow IMO regulations. All vessels, including the drilling rig, will be regulatory compliant, e.g. the International Convention for the Control and Management of Ships' Ballast Water and Sediments, and subject to audit prior to contract award.
GEN 11 Marine litter		
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.	✓	Contractor management plans will be in place. All vessels will follow IMO requirements.
GEN 12 Water quality and resource		
Developments and activities should not result in a deterioration of the quality of waters to which the Water Framework Directive, MSFD or other related Directives apply.	✓	Discharges to sea have been identified and assessed. The proposed project will not result in any measurable deterioration of water quality in the area.
GEN 13 Noise		
Development and use in the marine environment should avoid significant adverse effects of man-made noise and vibration, especially on species sensitive to such effects.	✓	Impacts of the noise generated from the piling of the SUDS have been assessed. Results show that with the implementation of JNCCs standard mitigation measures the likelihood of a permanent threshold shift occurring is low for all the marine mammal hearing groups. The appropriate mitigation measures will be adopted in relation to the piling as well as vessel and drill rig noise.
GEN 14 Air quality		
Development and use of the marine environment should not result in the deterioration of air quality and should not breach any statutory air quality limits.	✓	Emissions to air quantified in the EIA. Assessment concludes that they will present a low environmental risk to air quality the duration of which will be minimised as far as possible.
GEN 15 Planning alignment A		
Marine and terrestrial plans should align to support marine and land-based components required by development and seek to facilitate appropriate access to the shore and sea.	×	Offshore project.
GEN 16 Planning alignment B		
Marine plans should align and comply where possible with other statutory plans and should consider objectives and policies of relevant non-statutory plans where appropriate to do so.	×	Applies to inshore waters only.

Scotland's National Marine Plan Principle Number	Applicable?	Assessment Against Principle
GEN 17 Fairness		
All marine interests will be treated with fairness and in a transparent manner when decisions are being made in the marine environment.	×	Competent Authority responsibility.
GEN 18 Engagement		
Early and effective engagement should be undertaken with the general public and all interested stakeholders to facilitate planning and consenting processes.	✓	The EIA is subject to public and informal consultations. A copy of the ES and the public notice has been made publicly available. A Scoping Document was issued and engagement meetings were held with SFF and OPRED.
GEN 19 Sound evidence		
Decision making in the marine environment will be based on sound scientific and socio–economic evidence.	✓	Environmental baseline prepared with reference to available literature and site-specific survey data.
GEN 20 Adaptive management		
Adaptive management practices should take account of new data and information in decision making, informing future decisions and future iterations of policy.	✓	Ithaca Energy's decision making takes into account best understanding of the marine environment through surveys and using latest available scientific data.
GEN 21 Cumulative impacts		
Cumulative impacts affecting the ecosystem of the marine plan area should be addressed in decision making and plan implementation.	✓	Cumulative impacts are considered in the EIA and are considered proportionate to the size of the project.

A.2 Marine Strategy Framework Directive (MSFD)

The aim of the European Union's MSFD is to protect more effectively the marine environment across Europe. The MSFD outlines a transparent, legislative framework for an ecosystem-based approach to the management of human activities which supports the sustainable use of marine goods and services. The overarching goal of the Directive is to achieve 'Good Environmental Status' (GES) by 2020 across Europe's marine environment. Note following Brexit, the UK has made amendments to the Marine Strategy Regulations 2010, which transpose the requirements of the EU's Marine Strategy Framework Directivehttps://www.gov.scot/publications/eu-exit-marine-environmental-legislation-scotland-2/pages/10/ into domestic law, so that they continue to be effective now that the UK is no longer part of the EU.

The MSFD does not state a specific programme of measures that Member States should adopt to achieve GES, except for the establishment of MPAs. The MSFD does however outline 11 high level descriptors of GES in Annex I of the Directive. The activities associated with the proposed Captain EOR Stage 2 Phase II Project have been assessed against each of the GES descriptors details of which can be found in Table A-2.

Table A-2: The proposed Captain EOR Stage 2 Phase II Project assessed against the MSFD GES descriptors.

Marine Strategy Framework Directive: Good Environmental Status Objectives	Applicable?	Assessment Against Objective
GES 1		
Biological diversity is maintained and recovered where appropriate. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.	✓	Linked to GEN 9. Environmental surveys undertaken in the project area. Design and installation method of the subsea infrastructure informed by these surveys.
GES 2		
Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.	✓	Linked to GEN 10. All vessels will follow IMO regulations. All vessels, including drilling rig, will be regulatory compliant, e.g. the International Convention for the Control and Management of Ships' Ballast Water and Sediments, and subject to audit prior to contract award.
GES 3		
Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.	✓	Linked to GEN 9. Environmental surveys undertaken in the project area. Design and installation method of the subsea infrastructure informed by these surveys.
GES 4		
All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.	✓	Linked to GEN 9. Environmental surveys undertaken in the project area. Design and installation method of the subsea infrastructure informed by these surveys.
GES 5		
Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.	✓	Linked to GEN 9. Environmental surveys undertaken in the project area. Design and installation method of the subsea infrastructure informed by these surveys.
GES 6		
Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.	✓	Linked to GEN 9. Environmental surveys undertaken in the project area. Design and installation method of the subsea infrastructure informed by these surveys.
GES 7		
Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.	✓	Linked to GEN 12. Seabed disturbance and potential impact on marine ecosystems assessed in EIA.
GES 8		
Concentrations of contaminants are at a levels not giving rise to pollution effects.	✓	Linked to GEN 12. The proposed project will not result in the deterioration of water quality in the Captain field area.
GES 9		
Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.	✓	Linked to GEN 12. The proposed project will not result in the deterioration of water quality in the project area.
GES 10		

Marine Strategy Framework Directive: Good Environmental Status Objectives	Applicable?	Assessment Against Objective
Properties and quantities of marine litter do not cause harm to the coastal and marine environment.	✓	Linked to GEN 11. Contractor management plans will be in place. All vessels will follow IMO requirements.
GES 11		
Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.	✓	Linked to GEN 13. Piling of the SUDS was identified as a significant source of marine noise, and therefore this was modelled and the severity was assessed. Results show that with the implementation of JNCCs standard mitigation measures the likelihood of a permanent threshold shift occurring is low for all the marine mammal hearing groups. The appropriate mitigation measures will be adopted.

A.3 Oil and Gas Marine Planning Policies

Objectives and policies for the Oil and Gas sector should be read subject to those set out in the NMP and the MSFD. It is recognised that not all of the objectives can necessarily be achieved directly through the marine planning system, but they are considered important context for planning and decision making. The proposed project activities have been assessed against the oil and gas marine planning policies, details of which can be found in Table A-3.

Table A-3: The proposed Captain EOR Stage 2 Phase II Project assessed against the Oil and Gas Marine Planning Policies.

Oil and Gas Marine Planning Policies	Applicable?	Assessment Against Policy
Oil & Gas 1		
The Scottish Government will work with BEIS, the new Oil and Gas Authority and the industry to maximise and prolong oil and gas exploration and production whilst ensuring that the level of environmental risks associated with these activities are regulated. Activity should be carried out using the principles of Best Available Technology (BAT) and Best Environmental Practice. Consideration will be given to key environmental risks including the impacts of noise, oil and chemical contamination and habitat change.	✓	Environmental risks addressed/assessed where necessary in the EIA.
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, 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.	×	The project is an expansion of the existing Captain Field with all wells being tied back to existing topsides facilities.
Oil & Gas 3		
Supporting marine and coastal infrastructure for oil and gas developments, including for storage, should utilise the minimum space needed for activity and should take into account environmental and socio-economic constraints.	✓	The Captain field is an offshore development. Seabed disturbance and physical presence of the infrastructure have been assessed.
Oil & Gas 4		
All oil and gas platforms will be subject to 9 nautical mile consultation zones in line with Civil Aviation Authority guidance.	×	No new surface installations being installed.

Oil and Gas Marine Planning Policies	Applicable?	Assessment Against 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.	✓	Existing Captain OPEP and Safety Case will be updated to incorporate the proposed project. A drilling OPEP will be in place during drilling operations.
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 National Contingency Plan and the Offshore Safety Directive.	✓	Existing Captain OPEP and Safety Case will be updated to incorporate the proposed project. A drilling OPEP will be in place during drilling operations.

Appendix B: Captain EOR Stage 2 Phase II ENVID

Row	Aspect	Source/ Activity	Receptors and Potential impacts	Standard Industry Mitigation	Receptor Sensitivity	Magnitude of Effect	Impact Significance	Likelihood (U)	Environmental Risk (U)	Comments on Scoring
				Node 1: Vessels for the drilling, installation, and topside modifications						
1.1	**Physical presence**	AHVs, ERRVs, CSVs, jet trenching vessel, rock dumping vessel, DSV and guard vessel. Note: The presence of the drilling rig is considered under Node 2 whilst the presence of vessels associated with the production phase are covered under Node 5.	Receptor: Other sea users. Navigation hazard, and restriction of fishing operations. Shipping density in the area of the Captain Field is considered to be relatively low. The Captain field occurs within ICES rectangle 45E8, with the area targeted for pelagic, demersal and shellfish species. Relative to other ICES rectangles across the UKCS, fishing activity is considered moderate in the area.	Optimise vessel use. Ongoing consultation with SFF for all operations including surveys. Notice to mariners prior to operations starting. A vessel traffic survey/collision risk assessment will be undertaken (as required). Guard vessel on site during installation of the flowlines and umbilicals.	A	2	Low	N/A	N/A	Fishing and shipping activities in the area are considered to have the capacity to absorb any change associated with the presence of other vessels such that the Sensitivity of the fishing and shipping activities in the area is considered Low(A). The Magnitude of Effect of the presence of the vessels on current shipping and fishing activities is considered Minor (2) due to the relatively short period of time the vessels will be on location and the fact that the project is an extension of an existing development. Overall Impact Significance of vessels on other sea users is therefore considered Low.
1.2			Receptors: Birds and marine mammals. Possible behavioural changes in marine mammals e.g. could be attracted to the vessel or may move away from the area. The vessels also have the potential to cause displacement of seabirds from foraging habitat and may cause migrating birds to detour from their flight routes.	Optimise vessel use.	B	2	Low	N/A	N/A	Marine mammals sighted in the Captain area include harbour porpoise, Atlantic white-beaked dolphin, white beaked dolphin, minke whale (PMF), killer whale (PMF), long finned pilot whale, and bottle nose dolphin. Given the presence of these PMFs and the fact that marine mammals are considered a European Protected Species (EPS) their Sensitivity is considered to be Medium (B). The North Sea is a busy shipping area and has well developed fishing and oil and gas industries, such that marine mammals in the region are habituated to the presence of vessels. In addition, the evidence for lethal injury from boat collisions with marine mammals suggests that collisions with vessels are very rare (Cetacean Stranding Investigation Programme, 2011). The Magnitude of Effect on marine mammals is therefore considered Minor (2) such that the Impact Significance of vessels on marine mammals is considered Low. Though evidence suggests that the presence of the vessels could cause some bird species to be displaced from their foraging area, the very small proportion of their overall available habitat that will be occupied by the vessels means the impact is not considered to be noticeable. In addition, given the existing oil and gas vessel activity in the area, it is expected that the impact of the vessels on bird migration routes (e.g. they could be attracted to the vessel lights at night)is not significant. Therefore, the Magnitude of Effect on birds is considered Minor (2) such that the Impact Significance of vessels on birds is considered Low.
1.3	**Emissions to Air**		Receptor: Climate change. Emissions to atmosphere result in a minor contribution to global warming, acidification and photochemical smog (compared to overall activity in the North Sea).	Use of low-sulphur fuel. Minimise use of vessels, through efficient journey planning and potential use of hybrid supply vessels. Review vessel Common Marine Inspection Documents (CMID) as part of vessel assurance (evidence of maintenance). UK Air Quality Standards not exceeded. Vessels will be MARPOL compliant. Optimise helicopter transfers.	D	2	Moderate	N/A	N/A	The assessment methodology does not easily lend itself to assessing climate change, with the Sensitivity of climate change as a receptor being considered Very High (D) in line with 2014 Climate Change Report produced by the Intergovernmental Panel on Climate Change (IPCC, 2014). Ithaca Energy, acknowledges that the atmospheric emissions associated with the use of vessels will contribute to climate change, however the relatively short duration of the vessel campaigns, means the Magnitude of Effect of the incremental increase in emissions to the atmosphere as a result of the vessel activities is considered Minor (2) such that the Impact Significance is considered Moderate.
1.4			Receptor: Air quality. Possible reduction in local air quality.		A	2	Low	N/A	N/A	As the installation activities will take place offshore the Sensitivity of air quality as a receptor is considered Low (A). The relatively short duration of the vessel campaigns, means the Magnitude Effect of the vessel emissions on air quality is considered Minor (2) such that the overall Impact Significance on air quality is considered Low.
1.5	**Discharges to Sea**	Vessel sewage/ food waste, ballast water and biofouling.	Receptor: Water quality. Water quality in immediate vicinity of discharge may be reduced (deoxygenation), but effects are usually minimised by rapid dilution in receiving body of water and non-continuous discharge.	Minimise use of vessels, through efficient journey planning. Ithaca Energy will review vessel CMID as part of vessel assurance and all vessels will be compliant with the Company's MAS. Vessels will be MARPOL compliant. All contracted vessels will originate from countries adhering to the International Maritime Organisation (IMO) Convention. Ithaca Energy's audit procedures will ensure that the contracted vessels ballasting procedures are in line with IMO Convention aimed at preventing associated harmful effects. All discharges of ballast water will be monitored, and records maintained. As part of the Company's auditing process, only vessels adhering to the IMO 2011 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Species will be used. All member states of IMO are signed up to these guidelines.	A	1	Low	N/A	N/A	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). As all vessels will be IMO and MARPOL compliant the Magnitude of Impact of any discharges is considered Negligible (1) such that the overall Impact Significance is considered Low.
1.6	**Seabed Disturbance**	Interaction of vessels with the seabed. Re-settlement of sediment plumes, inducement of tidal scour etc.	Receptor: Benthic flora and fauna In shallow waters, increased turbidity caused by vessel propellers can cause disturbance to the seabed.	All vessels used will maintain their position using Dynamic Positioning (DP).	B	1	Low	N/A	N/A	The Captain field does not occur within any designated area, however it is recognised that there are sea pens and burrows in the area in sufficient density to potentially comprise the OSPAR listed threatened and/or declining species and the habitat 'Sea pen and burrowing megafauna communities'. In addition, subtidal sands and gravels, a priority habitat within UK waters, also occur in the area. Receptor Sensitivity is therefore considered Medium (B). However as all vessels will be on DP and given that the water depths across the Captain field are > 90 m (such that suspension of sediments due to the thrusters is not expected) the Magnitude of Effect of any disturbance to the seabed as a result of the vessels is considered Negligible (1) such that the Impact Significance is considered Low.

Row	Aspect	Source/ Activity	Receptors and Potential impacts	Standard Industry Mitigation	Receptor Sensitivity	Magnitude of Effect	Impact Significance	Likelihood (U)	Environmental Risk (U)	Comments on Scoring
1.7	**Underwater Noise**	General vessel noise including DP.	Receptors: Marine mammals and fish. Noise from DP has the potential to cause disturbance to marine mammals and fish in the form of temporary displacement from the area.	Minimise use of vessels, through efficient journey planning and potential use of hybrid supply vessels.	B	1	Low	N/A	N/A	As described above (Row 1.2), a number of marine mammals are known to occur in the area, and their Sensitivity is considered to be Medium (B). Some of the fish species in the area are considered to be PMFs (e.g. anglerfish, herring, mackerel, ling, blue whiting, cod, ling, sandeels, whiting and spur dog) such that their Sensitivity as a receptor is also considered Medium (B). The North Sea is a busy shipping area and has well developed fishing and oil and gas industries, such that marine mammals and fish in the region are habituated to the presence of vessels. Any impacts from vessel noise on these receptors is expected to be behavioural rather than physical, such that they may cause marine mammals or fish to vacate the area, however they would be expected to return once the vessels have left the location. The Magnitude of Effect of underwater noise on marine mammals and fish is therefore considered to be Negligible (1) such that the Impact Significance is considered Low.
1.8	**Waste**	General operational waste.	Receptor: Landfill take. Waste to landfill.	Compliance with MARPOL requirements. Ithaca Energy will look to vessel owner to minimise all wastes during the project (monthly reporting of waste sent to shore; Waste Management Plan and Waste Record Book; Waste Management Duty of Care audit). Waste minimisation and supply chain management. Waste will be managed in line with the waste hierarchy.	A	1	Low	N/A	N/A	Sensitivity of landfill as a receptor is considered Low (A) as landfill options are considered abundant. MARPOL Annex V applies to all ships/vessels and generally prohibits the discharge of all garbage into the sea (there are some exceptions which relate for example to food waste and cleaning agents). As vessels will be compliant with MARPOL, there will be no significant impact offshore. Ithaca Energy recognise landfill sites as a finite resource, however as the vessels will have WMPs in place that will adhere to the waste hierarchy principle of reduce, reuse recycle, the Magnitude of Effect of any vessel waste is considered Negligible (1) and the Impact Significance is considered Low.
1.9	**Use of Resources**	Fuel for power generation.	Receptor: Resource use Energy use.	MARPOL compliant. Ithaca Energy will review vessel CMID as part of vessel assurance (evidence of maintenance) Optimise vessel use.	A	1	Low	N/A	N/A	Sensitivity of fuel availability as a receptor is considered Low (A). Ithaca Energy recognise that hydrocarbon-based fuel is a finite resource, however given the relatively short duration of the proposed vessel activities and the use of MARPOL compliant vessels the Magnitude of Effect of fuel use on total fuel supply is considered Negligible (1) such that the Impact Significance is considered Low.
1.10	**Unplanned Events**	Helicopter crash. Loss of helifuel to sea.	Receptor: Water quality and Marine flora and fauna. Water quality deterioration impacting on marine flora and flora.	Auditing of company to ensure helicopter maintenance etc.	B	1	Low	Remote	Low	A number of marine mammals are known to occur in the area, many of which are PMFs (See Row 1.2). Similarly many of the fish species in the Project area are considered to be PMFs (Row1.7). Receptor Sensitivity is therefore considered Medium (B). Given the relatively small volume of diesel that would be released and that spilled diesel would be expected to evaporate and disperse quickly (see Row 1.12) the Magnitude of Effect of a spill is considered Negligible (1). With the application of standard industry mitigation the likelihood of a helicopter crash occurring is considered Remote therefore the environmental risk is considered to be Low.
1.11		Minor chemical / hydrocarbon spill from vessels.	Receptor: Water quality. Water quality deterioration.	Vessel SOPEPs in place. Optimised quantities of chemicals procured & stored on board. COSHH, Task Hazard Assessments are completed and MSDS sheets are available. Design features including drip pans, bunded areas, process and hazardous drains. Procedures in place for secondary containment should bunding fail. Spill kits located in close proximity to chemical storage areas. Best practise bunkering procedures. Ithaca Energy auditing vessels to ensure all above are in place.	A	2	Low	Unlikely	Low	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). Any impact on water quality from a spill is considered to be localised and have a short term, reversible effect therefore the Magnitude of Effect of a minor spill is considered Minor (2). With the application of standard industry mitigation the likelihood of a spill occurring is considered Unlikely and the environmental risk is considered to be Low.
1.12		Loss of diesel inventory (e.g. resulting from a vessel collision and subsequent loss of containment).	Receptor: Water quality and flora and fauna on the water column. Water quality deterioration.	Exclusion zone in place. Emergency response plans in place including vessel SOPEPs.	B	3	Moderate	Remote	Low	Diesel has very high levels of light ends, and as a result will evaporate and naturally disperse quickly if released into the marine environment. The low asphaltene content prevents emulsification from occurring, therefore, reducing its persistence in the marine environment. Modelling of a diesel spill (3,500 m3) to support the drilling permit for well UB05P (DRA/926) suggested that only around 3 m3 would beach with probability of beaching at each of the sites range from 3 % to 13 %. Given low anticipated volumes of diesel expected to beach, and the potential to impact on designated species (e.g. marine mammals) receptor Sensitivity is considered Medium (B). As a loss of diesel inventory will result in a breach of regulatory compliance, localised changes to water quality and possibly behavioural changes to marine mammals, the Magnitude of Effect is considered Serious (3) with the resultant Impact Significance considered to be Moderate. With the application of standard industry mitigation the likelihood of a spill occurring is considered Remote such that the environmental risk is considered Low.

Row	Aspect	Source/ Activity	Receptors and Potential impacts	Standard Industry Mitigation	Receptor Sensitivity	Magnitude of Effect	Impact Significance	Likelihood (U)	Environmental Risk (U)	Comments on Scoring
Node 2: Drilling										
2.1	**Physical Presence**	Physical presence of the drilling rig and associated anchors.	Receptor: Other sea users. Navigation hazard, and restriction of fishing operations. Anchors will be located outwith the 500 m exclusion zones associated with the drilling rig.	Ithaca Energy will inform the Hydrographic Office, Northern Lighthouse Board, Kingfisher/FishSafe and the MoD prior to rig mobilisation. The drilling rig will have marking and lighting as per the Standard Marking Schedule for Offshore Installations. Ithaca Energy will apply for 500 m exclusion zones whilst the drilling rig is on each location. Notice will be sent to the Northern Lighthouse Board of any drilling rig moves. The ERRV will act as a guard vessel warning over sea users of the presence of the anchors. Anchor location will be reported to FishSAFE.	A	2	Low	N/A	N/A	UK fishing industry and vessels in the area are expected to have the capacity to absorb change without noticeable impact therefore their Sensitivity is considered to be Low (A). The drilling rig will operate within the 500 m exclusion zone and the ERRV will act s a guard vessel such that any impacts on other sea users are considered Minor (2) and the Impact Significance is considered Low.
2.2			Receptors: Birds and marine mammals. Possible behavioural changes in marine mammals e.g. could be attracted to the drilling rig or may move away from the area. The drilling rig also have the potential to cause displacement of seabirds from foraging habitat and may cause migrating birds to detour from their flight routes.	Efficient drilling schedule (e.g. batch drilling where possible to minimise duration of drilling).	B	2	Low	N/A	N/A	See Row 1.2 for justification for ranking.
2.3	**Emissions to Air**	Exhaust emissions from drilling operations (i.e. burning of diesel).	Receptor: Climate change. Emissions to atmosphere result in a minor contribution to global warming, acidification and photochemical smog (compared to overall activity in the North Sea).	A rig Health, Safety and Environment Management System audit will be carried out as part of awarding contract (including planned maintenance system implementation). UK Air Quality Standards not exceeded. The six polymer injection wells will be batch drilled to maximise efficiency and reduce carbon footprint. The rig is currently being modernised with an Energy Control System, converting the unit into a low emission sixth-generation drilling unit.	D	2	Moderate	N/A	N/A	The Sensitivity of climate change as a receptor is considered Very High (D) (see Row 1.3). Ithaca Energy, acknowledges that the atmospheric emissions associated with the use of the drilling rig will contribute to climate change, however the relatively short duration of the drilling campaign and the maximisation of drilling efficiency, means the Magnitude of Effect of the incremental increase in emissions to the atmosphere as a result of the drilling activities is considered Minor (2) such that the overall Impact Significance is considered Moderate and therefore should be assessed in further detail in the ES.
2.4			Receptor: Air quality. Possible reduction in local air quality.		A	2	Low	N/A	N/A	As the drilling activities will take place offshore the Sensitivity of air quality as a receptor is considered Low (A). The duration of the drilling campaign, means the Magnitude of Effect of the rig emissions on air quality is considered Minor (2) such that the overall Impact Significance is considered Low.
2.5		Flaring resulting in release of CH_4, CO_2, SOx, NOx, VOC, NOx and particulates.	Not appliable as there will be no flaring associated with the well clean-up for the polymer injection wells or for the new production well.							
2.6	**Discharges to Sea**	Deliberate discharge to sea from drilling operations. During the drilling phase, drill cuttings and associated drilling fluids (sea water and bentonite sweeps and WBM), brine, cementing chemicals & clean up chemicals will be discharged to sea. In addition, there will be small quantities of reservoir oil associated with drill cuttings from the lower section of each well.	Receptor: Water quality and marine flora and fauna. Disturbance to seabed is discussed below under 'Seabed Disturbance'.	Chemical selection process will aim to select the lowest toxicity chemicals for a given technical requirement. No oil based drilling fluids to be used. Chemical use and discharge will be assessed in drilling operations MAT. Cement use will be minimised by good operating practice.	B	2	Low	N/A	N/A	Given the marine mammals, birds and fish species known to occur in the area, the Sensitivity of receptors that may be impacted by the discharges associated with the drilling activities is considered to be Medium (B). Taking account of the proposed mitigation measures and the results of the cuttings dispersion modelling carried out in support of the ES, the Magnitude of Effect on the water column of these discharges to sea is considered to be Minor such that the Impact Significance is considered Low.
2.7		Food waste and domestic sewage from the drilling rig.	Receptor: Water quality. Water quality in immediate vicinity of discharge may be reduced (deoxygenation), but effects are usually minimised by rapid dilution in receiving body of water and non-continuous discharge.	Semi submersible rig will be MARPOL compliant.	A	1	Low	N/A	N/A	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). As the drilling rig will be I MARPOL compliant the Magnitude of Impact of food waste and domestic sewage discharges is considered Negligible (1) such that the overall Impact Significance is considered Low.
2.8		Discharge of hydrocarbons/ chemicals to sea i.e. from machinery space drainage.	Receptor: Water quality.	Adherence to OPPC Regulations.	A	2	Low	N/A	N/A	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). Discharges will be in line with permitted limits and regulated and therefore the Magnitude of Effect is considered Minor (2) and the Impact Significance of the discharge of hydrocarbons/ chemicals on water quality is considered Low.

Row	Aspect	Source/ Activity	Receptors and Potential impacts	Standard Industry Mitigation	Receptor Sensitivity	Magnitude of Effect	Impact Significance	Likelihood (U)	Environmental Risk (U)	Comments on Scoring
2.9	**Seabed Disturbance**	Impacts of anchors and associated anchor lines on seabed habitat and water column.	Receptor: Seabed habitat due to direct disturbance and water quality due to temporarily suspended sediments.	Pre-rig site surveys. Pre-lay anchor handling plans. The polymer injection wells are located such that at drill centre D and drill centre E, it will not be necessary to re-position the rig for each well. That is to say the rig will only require to be positioned once at each of these two drill centres (and once at Area B for the drilling of the production well).	B	2	Low	N/A	N/A	See Row 1.6 for justification for ranking of receptor Sensitivity. The anchors and associated lines will require to be laid three times, and could impact on the designated habitats known to occur in the area. However, these habitats are widespread in the CNS area such that the Magnitude of Impact is considered Minor (2) and the Impact Significance is considered Low.
2.10		Discharge of drill cuttings and associated drilling fluids directly onto the seabed.	Receptor: Seabed habitat and associated benthic species. Water column due to temporarily suspended sediments.	Drilling fluids for each well section will be seawater and viscous sweeps or water based muds, no oil base muds will be used.	B	2	Low	N/A	N/A	See Row 1.6 for justification for ranking of receptor Sensitivity. The Magnitude of Effect is considered Minor (2) such that the Impact Significance is considered Low. Note the results of a cuttings discharge modelling study were used to support the ranking.
2.11		Cement plateau on seabed as result of cementing the top holes sections.	Receptor: Marine flora and fauna. Disturbance to seabed impacting on benthic species.	Visual monitoring of cement operations.	B	2	Low	N/A	N/A	See Row 1.6 for justification for ranking of receptor Sensitivity. The cement plateaus will occur on an area of seabed that will likely also be impacted by the drill cuttings. The Magnitude of Effect is considered Minor (2) give that the volume of discharged cement will ne minimised with the application of dye to the cement and the use of ROV to visualise when the cement has reached the seabed.
2.12	**Underwater Noise**	Noise and vibration from rig engines and machinery.	Receptor: Marine mammals and fish Noise from DP has the potential to cause disturbance to marine mammals and fish in the form of temporary displacement from the area and behavioural changes. Disturbances to the animal communities may occur within a range of several km. Potential injury to fauna (e.g. cetaceans) by short range exposure.	Minimise rig movements through pre-lay anchors. Minimise drilling schedule where possible for example through batch drilling of the polymer injection wells at Area D and Area E.	B	1	Low	N/A	N/A	See Row 1.7 for justification for ranking of receptor Sensitivity. Rotating equipment such as generators and pumps all result in underwater noise during drilling operations. In general, noise from drilling operations has been found to be predominantly low frequency (< 1,000 Hz) with relatively low source levels (Greene, 1987; Nedwell and Edwards, 2004; McCauley, 1998). Furthermore, a study by Greene (1987) found that the noise generated by drilling activities from a semi-submersible drilling rig did not exceed local ambient levels beyond 1 km Underwater noise associated with drilling activities is therefore considered Negligible (1) such that the Impact Significance is considered Low.
2.13	**Waste**	General rig waste. Drilling rigs generate a number of wastes during routine operations including waste oil, chemical and oil contaminated water, scrap metal, etc.	Receptor: Use of landfill. Land take from use of landfill.	Wastes will be minimised by use of appropriate procurement controls. All wastes to be properly segregated for recycling / disposal / treatment. Waste will be dealt with in accordance with regulatory requirements. Monthly reporting of waste sent to shore; Waste Management Plan and Waste Record Book; Waste management Duty of Care audit. Targets and KPIs. Adhere to waste hierarchy. Ithaca Energy auditing contractors to ensure all of the above.	A	1	Low	N/A	N/A	Sensitivity of landfill as a receptor is considered Low (A) as landfill options are considered abundant. Ithaca Energy recognise landfill sites as a finite resource, however as the majority of waste will be recycled and the rig will have a WMP in place that will adhere to the waste hierarchy principle of reduce, reuse recycle, the Magnitude of Effect is considered to be Negligible (1) and the Impact Significance is considered Low.
2.14	**Use of Resources**	Fuel used for power generation. Use of potable water Use of materials for well construction and drilling an clean-up	Receptor: Resource use including fuel, fresh water, steel, chemicals and cement.	Having the semi-submersible drilling rig anchored will use less fuel than having it on DP. Well design optimisation. Materials selection. Chemical use minimised where possible.	A	1	Low	N/A	N/A	Sensitivity of the resources identified is considered to be Low (A) and given their general abundance and the relatively small volumes to be used for this project, the Magnitude of Effect is considered Negligible (1) such that the Impact Significance is considered Low.
2.15	**Unplanned Events**	Deck drains. Discharge of hazardous drainage water.	Receptor: water quality.	Spill kit availability, premobilisation audits or drill rig audits, bunding and containment for chemical storage.	A	1	Low	Possible	Low	See Row 1.5 for justification for ranking of receptor Sensitivity. The Magnitude of Effect on water quality of small discharges is considered to be Negligible (1) given that they will be rapidly dispersed by currents, any effects are unlikely to be measurable and will reverse naturally such that the Impact Significance is considered Low. The likelihood of a discharge of hazardous drainage water occurring is considered Possible and the environmental risk is considered to be Low.
2.16		Loss of containment of fuel or WBM or chemicals during bunkering.	Receptor: water quality.	Good hose management. Spill kit availability, premobilisation audits or drill rig audits, bunding. Bunkering procedures will be developed in line with Best Practice Guidance. Maintenance and procedures. Approved TOOPEP in place. A rig Health, Safety and Environment Management System audit ensured contractor has procedure in place to deal with a spill. For local response, dispersant available on board standby vessel. Bunkering procedures will be developed in line with Best Practice Guidance. Continuous monitoring during bunkering.	A	1	Low	Remote	Low	See Row 1.5 for justification for ranking of receptor Sensitivity. Given the open nature of he North Sea, it is expected that any discharges would be dispersed rapidly such that no significant impact would be expected on the fauna in the water column. With te application of the mitigation measures identified, The Magnitude of Effect on water quality of discharges associated with bunkering is considered to be Negligible (1) given that volumes released would be minimised as a result of continuous monitoring. In addition, any discharges will be rapidly dispersed by currents, and any effects are unlikely to be measurable and will reverse naturally such that the Impact Significance is considered Low. With the application of standard industry mitigation the likelihood of a spill occurring during bunkering is considered Remote therefore the environmental risk is considered to be Low.

Row	Aspect	Source/ Activity	Receptors and Potential impacts	Standard Industry Mitigation	Receptor Sensitivity	Magnitude of Effect	Impact Significance	Likelihood (U)	Environmental Risk (U)	Comments on Scoring
2.17		Major loss of drilling rig fuel inventory e.g. following vessel collision.	Receptor: Water quality and flora and fauna on the water column. Water quality deterioration.	Exclusion zone in place. Standby vessels on site. Drilling rig will have marking and lighting as per the Standard Marking Schedule for Offshore Installations. Notice will be sent to the Northern Lighthouse Board of any drilling rig moves and vessel mobilisation associated with the mobilisation and demobilisation of the semi submersible rig. Approved TOOPEP in place.	B	3	Moderate	Remote	Low	Diesel has very high levels of light ends, and as a result will evaporate and naturally disperse quickly if released into the marine environment. The low asphaltene content prevents emulsification from occurring, therefore, reducing its persistence in the marine environment. Modelling of a diesel spill (3,500 m3) to support the drilling permit for well UB05P (DRA/926) suggested that only around 3 m3 would beach with probability of beaching at each of the sites range from 3 % to 13 % . Given low anticipated volumes of diesel expected to beach, and the potential to impact on designated species (e.g. marine mammals) receptor Sensitivity is considered Medium (B). As a loss of diesel inventory will result in a breach of regulatory compliance, localised changes to water quality and possibly behavioural changes to marine mammals, the Magnitude of Effect is considered Serious (3) with the resultant Impact Significance considered to be Moderate. With the application of standard industry mitigation the likelihood of a spill occurring is considered Remote such that the environmental risk is considered Low.
2.18		Blowout. Uncontrolled hydrocarbon flow to surface.	Receptor: marine mammals, birds and fish Water quality deterioration impacting on marine flora and flora.	Well design & planning. Drill contractor/ Ithaca Energy procedures. Well examination schemes. Compliance with Regulations & Best Practice. Regular BOP testing. Rig designed to be in accordance with IP17 Planning relief well. Crew competence. Audit of drilling contractor. Approved TOOPEP in place. Containment and drainage facilities inspected as part of rig Health, Safety and Environment Management System audit. Member of OSRL and OPOL. Access to dispersant via the Emergency Response and Rescue Vessel (ERRV).	C	4	High	Remote	Medium	Modelling of a well blowout scenario (total release of 88,615 m3) suggests that depending on the time of year, the probability of beaching could be up to 100% on UK coastlines. In addition, beaching on international coastlines e.g. Norway could be up to 90%. Given the presence of designated habitats and species along the UK coastline, receptor Sensitivity is considered High (C). Maximum volume of shoreline oiling is estimated at c. 4,553 m3. Given the estimate volume of oiling and the potential impact on marine mammals, fish, seabirds, benthic habitats etc., the Magnitude of Effect is considered Major (4) such that the Impact Significance is considered High. With the application of standard industry mitigation the likelihood of a blowout occurring is considered Remote therefore the environmental risk is considered to be Medium.
2.19		Dropped object resulting in interaction with seabed.	Receptor: marine flora and fauna. Loss of seabed habitat, smothering of benthic organisms.	Risk assessment prior to equipment transfer. Expected that the dropped object would be recovered.	B	1	Low	Possible	Low	See Row 1.6 for justification for ranking of receptor Sensitivity. The Magnitude of Impact of a dropped object is considered Negligible (1) such that the Impact Significance is considered Low. Likelihood of an object being dropped during drilling activities is considered Possible, however when considered with the low Impact Significance the environmental risk is considered Low.
				Node 3: Subsea Installation Activities						
3.1	**Physical Presence of Subsea Infrastructure**	Presence of installation vessels is covered under Node 1 Vessel Use.								
3.2		Physical presence of subsea infrastructure.	Receptor: Fisheries. Navigation hazard, restriction of fishing operations, snagging risk to fishing nets.	Early consultation with SFF. Minimisation of footprint through design. Will comply with PWA notification requirements. Consent to Locate will be submitted. Flowline will be surface laid and jet trenched to a depth of lowering of 1.0m from top of flowline to mean seabed level. Guard vessel on site whilst the lines are temporarily laid exposed on the seabed and before they are jet trenched. If contingency rock is required it will be laid in a profile that is over trawlable. Confirmation of safe seabed for fishing trawlability. Tree system design is fishing friendly and allows for backing off of fishing gear. Slab sided structure design for SUDS is fishing friendly and allows for backing off of fishing gear.	A	2	Low	N/A	N/A	See Row 1.1 for justification for ranking of receptor Sensitivity. The long-term permanent presence of the new infrastructure outwith any 500 m zones should not cause a nuisance to fishers as it will be trenched to a minimum depth of 1 m. Access to fishing grounds will be temporarily inhibited during the installation activities but this will be relatively short term, such that the Magnitude of Effect on fisheries is considered Minor (2) and the overall Impact Significance is considered Low.
3.3	**Emissions to Air**	Atmospheric emissions associated with the subsea infrastructure installation vessels including helicopters are covered under Node 1 Vessel Use.								
3.4	**Discharges to Sea**	Discharges to sea associated with the subsea infrastructure installation vessels are covered under Node 1 Vessel Use.								
3.5		Hydro/ leak testing. Potential discharge of chemicals during leak testing of flowlines.	Receptor: Water quality. Water quality deterioration.	Chemical selection process will aim to select the lowest toxicity chemicals for a given technical requirement. Discharge of fluids, will follow procedures which will minimise environmental impact.	A	1	Low	N/A	N/A	See Row 1.6 for justification for ranking of receptor Sensitivity. Given the aim to select te lowest toxicity chemicals, the Magnitude of Impact of any discharges is considered Negligible (1) such that the overall Impact Significance is considered Low.
3.6	**Seabed Disturbance**	Disturbance to the seabed associated with installation of the polymer injection flowlines and umbilicals.	Receptor: Seabed habitat and marine flora and fauna. Seabed disturbance, loss of habitat, temporary suspended solids, loss of benthic organisms. Seabed disturbance in area possessing benthic PMF species including *Arctica islandica* .	Pre lay pipeline route surveys. Minimising flowline and umbilicals lengths. Vessels associated with installation activities will all be DP vessels. Jet trenching selected over plough and backfill. The former has a smaller footprint of disturbance. Rock cover will only be used as a contingency such that maximum anticipated volume to be used is estimated at 20,000 te. Fall pipe will be used to lay rock if required.	B	3	Moderate	N/A	N/A	See Row 1.6 for justification for ranking of receptor Sensitivity. Flowlines and umbilicals will be jet trenched. Seabed will recover naturally once activities are finished. There is the potential for spot rock dumping on the flowline routes should sufficient depth of burial not be possible from the trench and bury operations. Jet trenching will result on sediment being suspended in the water column and subsequent settlement over an ara that extends beyond the footprint of the trenches. Taking cognisance of the number and length of lines to be installed, the possible use of rock cover and the settling of disturbed sediment over a wider area, the Magnitude of Effect on seabed habitats and associated benthic communities is considered Serious (3) and the Impact Significance is considered Moderate.
3.7		Disturbance to the seabed associated with installation of the three SUDS, jumpers, mattresses and 25 kg grout bags.	Receptor: Seabed habitat and associated benthic communities. Introduction of hard substrates to the seabed. Considered a permanent impact due to being on location to end of field life.	Lifting procedures in place. Expected that the SUDS, jumpers, mattresses and 25 kg grout bags will be recovered at end of field life. All items identified will be laid within 500 m exclusion zones.	B	2	Low	N/A	N/A	See Row 1.6 for justification for ranking of receptor Sensitivity. Given the relatively small area of impact associated with the installation of the items identified, the Magnitude of Effect is considered Minor (2) and the Impact Significance is considered Low.

Row	Aspect	Source/ Activity	Receptors and Potential impacts	Standard Industry Mitigation	Receptor Sensitivity	Magnitude of Effect	Impact Significance	Likelihood (U)	Environmental Risk (U)	Comments on Scoring
3.8		Disturbance of features of archaeological interest.	Receptor: Wrecks Suspended sediments settling over the wrecks.	Anchor pattern will be developed to avoid wreck.	B	A	Low	N/A	N/A	Due to the presence of wrecks within the Captain field, receptor Sensitivity is ranked as Medium (B). Given the location of the wrecks relative to the activities associate d with the proposed installation activities, the wrecks are not expected to be directly impacted. Similarly any suspended sediments are not expected to settle over the wrecks at any measurable depth such that the Magnitude of Effect is considered Negligible and the Significance of Impact is considered Low.
3.9	**Underwater Noise**	Underwater noise resulting from piling of the SUDS at Drill Centres D and E. Note: Underwater noise associated with vessels is considered in Row 1.7.	Receptor: Fish and marine mammals. Generates elevated sound levels which can affect the behaviour of fish and marine mammals in the area.	Compliance with JNCC protocol for minimising the risk of injury to marine mammals from piling noise: use of soft start, Marine Mammal Observers (MMOs) and passive acoustic monitoring (PAM).	B	2	Low	N/A	N/A	See Row 1.7 for justification for ranking of receptor Sensitivity. A modelling study has been carried out and the results show that with the application of the mitigation measures there is no physical damage expected to marine mammals and fish in the area. Some temporary displacement of marine mammals from the area would be expected, such that the Magnitude of Effect is considered Minor (2) and the Significance of Impact is considered Low.
3.10	**Waste**	General vessel waste is covered under Node 1 Vessel Use.								
3.11		General waste from pipelay and installation of infrastructure. Pipelay and installation generate a number of wastes during routine operations including scrap metal, wooden crates etc.	Receptor: Use of landfill. Land take from use of landfill.	All wastes to be properly segregated for recycling / disposal onshore. Waste will be dealt with in accordance with regulatory requirements. Contractors will be audited to ensure above.	A	1	Low	N/A	N/A	Sensitivity of landfill as a receptor is considered Low (A) as landfill options are considered abundant. Ithaca Energy recognise landfill sites as a finite resource, however as the majority of waste will be recycled and the installation vessels will have a WMP in place that will adhere to the waste hierarchy principle of reduce, reuse recycle, the Magnitude of Effect is considered to be Negligible (1) and the Impact Significance is considered Low.
3.12	**Use of Resources**	Fuel use associated with subsea infrastructure installation vessels is covered under Node 1 Vessel Use.								
3.13		Construction of flowlines, umbilicals and other subsea infrastructure.	Receptor: Resource use. Resource use such as steel, plastic inners, polyethylene structures.	Scrap metal wastes to be properly segregated for recycling / disposal onshore. Company policy to minimise materials use.	A	1	Low	N/A	N/A	Sensitivity of the use of materials (e.g. steel) and chemicals as a receptor is considered Low (A) as all are considered abundant. Given the abundance of these resources the Magnitude of Effect of materials and chemicals use is considered Negligible (1) such that the Impact Significance of resource use during drilling is considered Low.
3.14		Chemical use including seawater inhibitors during flowline commissioning.	Receptor: Resource use Use of chemicals.	Chemical use minimised where possible.	A	1	Low	N/A	N/A	
3.15	**Unplanned Events**	Unplanned events impacting on the subsea infrastructure after production has commenced are considered under Node 5 Operations.								
3.16		Failure of installation equipment connection. Loss of water-based hydraulic fluid to sea.	Receptor: Water quality. Water quality deterioration.	Contractor selection. Follow standard operating procedures and checks.	A	1	Low	Unlikely	Low	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). The hydraulic fluids will be water-based and will disperse rapidly in the water column to undetectable levels therefore the Magnitude of Effect is considered Negligible (1). With the application of standard industry mitigation the likelihood of a failure of equipment is considered unlikely such that the Environmental Risk is considered Low.
					Node 4: Topside Modifications					
4.1	Topside modifications to support the Captain EOR Stage 2 (Phases I and II) project commenced in 2021 and are due to be completed in 2023. The activities have not required the use of walk to work vessels or additional supply vessels. Seabed disturbance is limited to impacts associated with a new riser caisson installed in 2022 (captured in PLA/921 and therefore outwith the scope of the ES). The topside modifications are not considered to result in any significant impacts requiring further assessment in the ES.									
					Node 5: Production Phase					
5.1	**Physical Presence**	ERRV, and supply vessels and offloading shuttle tanker.	Receptor: Fisheries. Navigation hazard, restriction of fishing operations.	Optimise vessel use. ERRV requirements will not change to current requirements during the production. Supply vessel transits are not expected to increase as a result of the increased production associated with the proposed project. There will be an increase in tanker offloads and vessel transits associated with the polymer.	A	1	Low	N/A	N/A	See Row 1.1 for justification for ranking of receptor Sensitivity. As the only increase in vessels during production will be limited to additional shuttle tanker offloads and polymer transport vessels, any impact will be intermittent and short term. The Magnitude of Effect on fishermen is therefore considered Negligible (1) such that the Impact Significance is considered Low.
5.2			Receptor: Birds and marine mammals. Disturbance from vessel presence.		B	2	Low	N/A	N/A	See Row 1.2 for justification for ranking of receptor Sensitivity and Magnitude of Effect.
5.3	**Emissions to Air**	Vessel emissions	Receptor: Climate change. Emissions to atmosphere result in a minor contribution to global warming, acidification and photochemical smog (compared to overall activity in the North Sea).	Only change to vessels will be increase in number of tanker offloads and delivery of polymer.	D	2	Moderate	N/A	N/A	See Row 1.3 for justification for ranking of receptor Sensitivity. Ithaca Energy, acknowledges that the atmospheric emissions associated with the increased tanker offloads will contribute to climate change, however the relatively short duration of each vessel trip, and small number of increased offloads means the Magnitude of Effect of the incremental increase in emissions to the atmosphere as a result of the vessel activities during production is considered Negligible (1) such that the overall Impact Significance is considered Low.
5.4			Receptor: Air quality. Possible reduction in local air quality.		A	2	Low	N/A	N/A	See Row 1.4 for justification for ranking of receptor Sensitivity. Given the small increase in vessel during production as a result of the proposed project, the Magnitude of Effect of the increased vessel emissions on air quality is considered Negligible (1) such that the overall Impact Significance is considered Low.
5.5		Helicopter movements.	No anticipated increase in helicopter trips during production as a result of the proposed project.							

Row	Aspect	Source/ Activity	Receptors and Potential impacts	Standard Industry Mitigation	Receptor Sensitivity	Magnitude of Effect	Impact Significance	Likelihood (U)	Environmental Risk (U)	Comments on Scoring
5.6		Power generation from essential systems diesel generator.	Receptor: Climate change. Emissions to atmosphere result in a minor contribution to global warming, acidification and photochemical smog (compared to overall activity in the North Sea).	Small increase in fuel use at the Captain FPSO. Asset GHG Emission Reduction Action Plans	D	2	Moderate	N/A	N/A	See Row 1.3 for justification for ranking of receptor Sensitivity. Additional equipment including polymer injection pumps and extra transfer pumps will be installed on the Captain installations leading to additional electrical demand. Additional process heating requirements due to increased production may also be required which will increase the load on the existing duel fuel process heaters. Power requirements are not directly proportional to the production throughput. There is no anticipated increase change in fuel gas and diesel use on the BLP or WPP platforms however, diesel use is forecasted to increase on the FPSO from 2024 to provide the additional 10% power required. With respect to climate change, the Magnitude of Effect of the incremental increase in emissions to the atmosphere as a result of the forecasted increase on the FPSO is considered Minor (2) such that the overall Impact Significance is considered Moderate.
5.7			Receptor: Air quality. Possible reduction in local air quality.		A	1	Low	N/A	N/A	See Row 1.4 for justification for ranking of receptor Sensitivity. Due to the relatively small increase in diesel use and the offshore location of the Captain field the Magnitude of Effect of the incremental increase in emissions to the atmosphere as a result of power generation is considered Negligible (1) such that the overall Impact Significance is considered Low.
5.8		Flaring during production.	No anticipated increase in flaring at the Captain field during production as a result of the proposed Captain Stage2 Phase II project.							
5.9 **5.10**		Venting of cargo storage tanks on the FPSO. Release of VOCs.	Receptor: Climate change. Emissions to atmosphere result in a minor contribution to global warming, acidification and photochemical smog (compared to overall activity in the North Sea).	No venting during drilling. UK Air Quality Standards not exceeded. Asset GHG Emissions Reduction Action Plans. Methan Action Plan.	D	2	Moderate	N/A	N/A	See Row 1.3 for justification for ranking of receptor Sensitivity. As the crude oil is not completely stabilised prior to storage in the cargo tanks, the Captain FPSO utilises a gas/diesel fired inert gas generator to provide inert gas to fill the tank vapour space during offloading operations and to safeguard against any possibility of creating a hazardous atmosphere during all tank operations. Venting of gases from the cargo tank vent is directly proportional to production rate. Therefore given the increase in tank offloads, there will be a small increase in venting of VOCs resulting from the proposed project. Venting would be occasional and any gases would be rapidly dispersed offshore. Given this, the Magnitude of Effect of any venting emissions on air quality is considered Minor (2) such that the overall Impact Significance is considered Moderate.
5.11	**Discharges to Sea**	Discharge of domestic sewage, food waste & drainage water.	No difference to current discharges.							
5.12		Produced water	Not applicable as all produced water is reinjected at the Captain field.							
5.13	**Seabed Disturbance**	No planned additional seabed disturbance associated with production.								
5.14	**Underwater Noise**	Increase in vessels	Receptor: Marine mammals and fish. Noise from DP has the potential to cause disturbance to marine mammals and fish in the form of temporary displacement from the area.	Optimise use of vessels through efficient journey planning.	B	1	Low	N/A	N/A	See Row 1.7 for justification for ranking of receptor Sensitivity. The proposed project will result in a small increase in vessels in the area The North Sea is a busy shipping area and has well developed fishing and oil and gas industries, such that marine mammals and fish in the region are habituated to the presence of noise. Therefore, the Magnitude of Effect of the underwater noise resulting from the increased vessels during production is considered Negligible (1) such that the Impact Significance is considered Low.
5.15	**Waste**	Production of general waste at the Captain assets is not expect to increase above existing levels. Waste will continue to be managed in line with the waste hierarchy								
5.16	**Use of Resources**	Fuel use for increase in vessel numbers	Receptor: Resource use Resource use e.g. energy use for power generation.	MARPOL compliant. Ithaca Energy will review vessel CMID as part of vessel assurance (evidence of maintenance) Optimise vessel and helicopter use.	A	1	Low	N/A	N/A	Sensitivity of fuel availability as a receptor is considered Low (A) Ithaca Energy recognise that hydrocarbon-based fuel is a finite resource, however given that during the production phase the only increase in vessels relative to existing vessel activity is an increase in shuttle tanker offloads and vessel transits for the polymer (All of which will be MARPOL compliant) , the Magnitude of Effect of fuel use is considered Negligible (1) such that the Impact Significance is considered Low.
5.17		Materials for routine maintenance operations.	No change from existing maintenance activities.							
5.18		Production chemicals and polymer	Receptor: Resource use. Use of chemicals.	Chemical use minimised where possible.	A	2	Low	N/A	N/A	At Captain, specific employees have been assigned responsibility for managing chemicals at designated portions of the supply and use chain. These employees are responsible for ensuring that chemicals used in their specific areas are covered by a chemical permit and that use and discharge is tracked adequately to ensure it remains within permitted quantities. Sensitivity of chemical availability as a receptor is considered Low (A). The use of chemicals will be minimised as far as practicable such that the Magnitude of Effect is considered Minor (2) and the Impact Significance Low.
5.19	**Unplanned Events**	Potential for unplanned events and type of unplanned events during production are generally not expected to change relative to existing.								

REPORT

Captain Development - Drill Cuttings Modelling

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ABBREVIATIONS

'	Minute
"	Second/Inch
%	Percent
‰	Parts per thousand
<	Less Than
>	More Than
°	Degrees
°C	Degrees centigrade
µm	Micrometre
CFSR	Climate Forecast System Reanalysis
DREAM	Dose-related Risk and Effects Assessment Model
E	East
ED	European Datum
EOR	Enhanced Oil Recovery
ES	Environmental Statement
HYCOM	Hybrid Coordinate Ocean Model
kg/m^3	Kilogram per cubic metre
km	Kilometre
km^2	Square kilometre
km^3	Cubic kilometre
Koc	Organic carbon-water partition co-efficient
m	Metre
MEMW	Marine Environmental Modelling Workbench
mm	Millimetre
N	North
NCEP	National Centre for Environmental Prediction
NMPi	National Marine Plan interactive
PEC	Predicted Environmental Concentration
PEC_{sed}	Predicted Environmental Change
PNEC	Predicted No Effect Concentration
$PNEC_{sed}$	Predicted No Effect Change

Pow	Octanol/water partition coefficient
ppb	Parts per billion
PSD	Particle Size Distribution
S	South
t	Tonnes
UTM	Universal Transverse Mercator
W	West
WBM	Water-Based Mud
WGS84	World Geodetic System 1984

1.0 INTRODUCTION

As part of the Captain Development Enhanced Oil Recovery (EOR) project, Ithaca Energy are proposing to drill six polymer injection wells across two new drill centres at the Captain field using a semi-submersible drilling rig. The two new drill centres are referred to drill centre D and drill centre E and three wells will be drilled at each location.

To support the Environmental Statement (ES) for the Captain Development Enhanced Oil Recovery (EOR) project (Genesis, 2022) modelling of the discharge of drill cuttings from the three wells at drill centre D has been carried out using the Dose-related Risk and Effect Assessment Model (DREAM).

As the two drill centres are only 2.8 km apart, the metocean conditions are similar at both locations, therefore the results of the modelling at drill centre D are expected to be representative of what would happen to the discharged drill cuttings at drill centre E. In addition, the drill centres are sufficiently far apart that there is no overlap of the main cuttings piles, although finer material from both drill centres would potentially accumulate in the same locations but not in any significant thicknesses.

Anticipated section lengths and associated cuttings volumes for each of the wells were reviewed and modelling is based on the largest discharge of cuttings (referred to as well UCO2i which is located at drill centre D). Modelling assumed the same well design for each well.

Drill cuttings modelling was used to predict the fate of discharged cuttings from the wells in terms of:

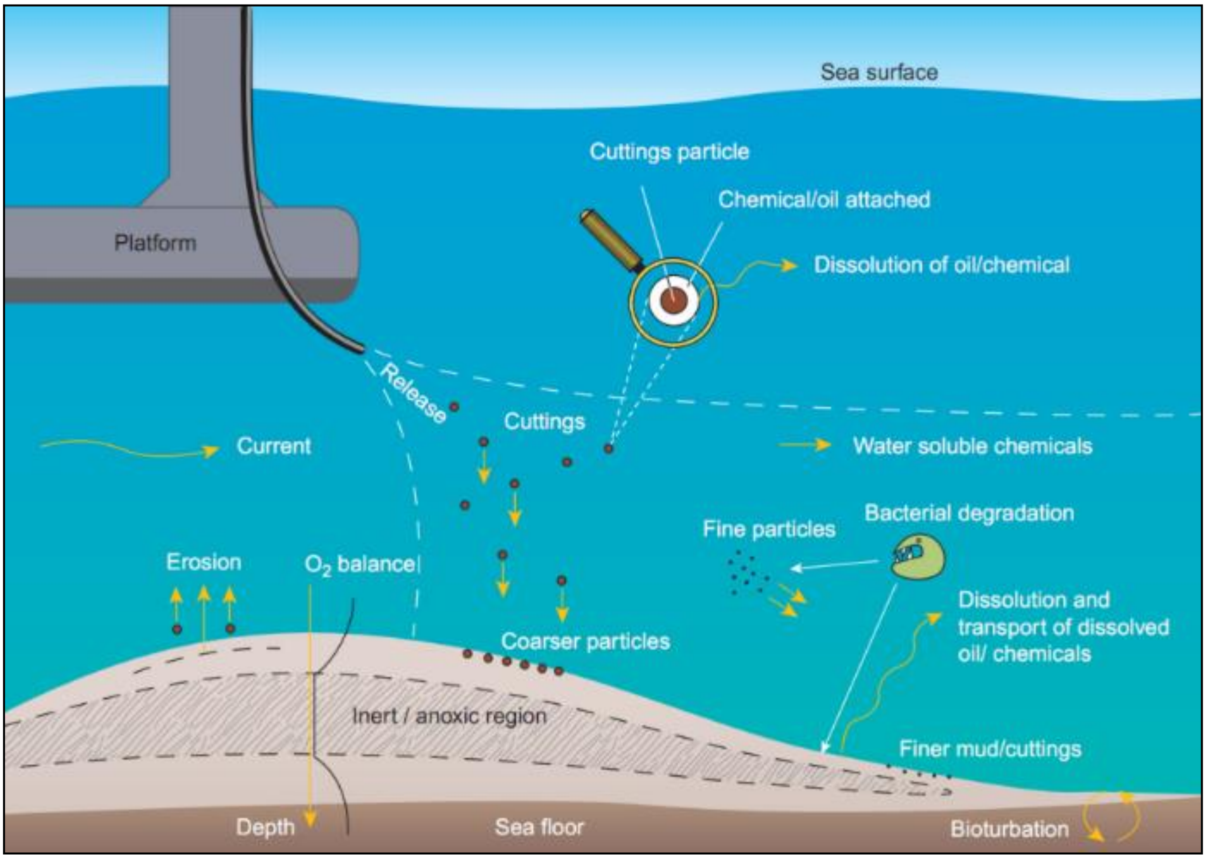
- Depositional thickness on the seabed;
- Environmental risk to the seabed resulting from burial thickness, grain size change, toxicity and pore water oxygen depletion; and
- Environmental risk in the water column resulting from toxicity and particle stresses.

2.0 OVERVIEW OF THE MODELLING METHODOLOGY

2.1 DREAM/ParTrack

The cuttings discharges were modelled using DREAM published by Sintef, as part of the Marine Environmental Modelling Workbench (MEMW) suite of models, version 13.1.0. This incorporates the ParTrack sub-model for modelling dispersion and settlement of solids. The model predicts the fate of materials discharged to the marine environment, specifically their dispersion and changes to their physicochemical composition.

The model has been developed to calculate the dispersion and deposition on the seabed of drilling mud and cuttings as well as the dispersion of chemicals in free water masses. The model consists of a plume model and a far-field model. The calculations are based on the "particle" approach, combined with a near field plume model and the application of external current fields for the horizontal advection of the particles. The plume model takes into account effects from water stratification on the near-field mixing, ambient currents and geometrical configuration of the outlet. Once plume advection ceases, particles fall out of the plume and deposit on the seabed. Vertical velocity (rise/fall) of the particles depends on their size and density as well as on the agglomeration of solids in the presence of oil-related components. The far-field model includes the downstream transport and spreading of particles and dissolved matter, once the plume mode is terminated. The processes involved are illustrated in Figure 2-1.



Source: Rye *et al.* (2006)

Figure 2-1: Processes involved in the DREAM model.

Model predictions have been validated through field measurements at the Troll-A field in the Norwegian Sea, where reasonably good correspondence was obtained between measured and simulated deposition of the cuttings on the sea floor (Rye, 2010; Jødestøl and Furuholt, 2010).

2.2 Risk Assessment Method

The risk assessment method was initially developed for assessing impacts due to the discharge of toxic stressors (i.e. chemicals) to the marine environment or particle stressors (e.g. barite and bentonite) and was primarily intended for the assessment of produced water and other chemical discharges.

The methodology is based on a comparison of modelled concentrations of chemicals in the water column (termed the Predicted Environmental Concentration, (PEC)) and the highest theoretical concentration of the same chemicals at which harmful effects are not expected to occur in marine organisms (termed the Predicted No Effect Concentration, (PNEC)). In cases where the ratio PEC:PNEC exceeds 1, a risk to at least 5% of the most sensitive species occurs. This methodology is used by the DREAM/ParTrack model to calculate the risk to the water column due to toxicity from chemicals in drill cuttings discharges.

The protocol for assessing risks from drill cuttings discharges was further developed by the Environmental Risk Management System joint industry project to include the assessment of risk to seabed sediment and was founded on well-established scientific studies such as those in Smit *et al*. (2006), Trannum (2004), Kjeilen-Eilertsen *et al.* (2004) and Neff (2005). The assessment methodology for sediments is similar to that for the water column and is based on a combined risk approach using the PEC_{sed}:$PNEC_{sed}$ ratio. However, for sediments PEC_{sed} represents the Predicted Environmental Change (as opposed to predicted environmental concentration used for water column), and $PNEC_{sed}$ is the Predicted No Effect Change (as opposed to Predicted No Effect Concentration used for water column). Where PEC_{sed}: $PNEC_{sed}$ exceeds 1, a risk to at least 5% of the most sensitive species occurs. Where there is a risk to less than 5% of the most sensitive species, this is considered a tolerable risk level.

Trannum (2004), Kjeilen-Eilertsen *et al*. (2004) and Neff (2005) established that in the absence of any other stressors sediment risk would exceed 5% when:

- Chemical concentrations in pore water exceeded the PNEC;
- Burial thickness exceeded 6.5 mm;
- Median grain size change exceeded 52.7 µm; and
- Oxygen content was depleted by more than 20%.

The effects of burial include mortality of organisms, reduced growth of some species, reduced larval settlement and changed fauna composition. Effects can be short-term and mainly on an individual level, or they can be more long-term and affecting whole populations (Kjeilen-Eilertsen *et al.*, 2004). In general, the effect of burial mainly depends on the mobility of organisms in the sediment matrix and on the settling rate of particles. Sedentary organisms, which have no or very limited abilities to move, such as attached barnacles or mussels, are very sensitive (Smit *et al*., 2006).

Following the settlement of drilling particles, benthic communities have been observed to be dominated by opportunistic species which generally are small, with short life spans and high population growth rates. There is considerable variability in species responses to specific sediment characteristics. The factors ultimately controlling infauna distributions may not be sediment grain size *per se* or factors linked to grain size such as organic content, but rather interactions between hydrodynamics, sediments and infauna and how these affect sediment distribution, larval supply, particle flux and pore water chemistry (Smit *et al*., 2006). DREAM uses the change in median grain size to represent the overall changes in sediment characteristics.

3.0 MODEL INPUT DATA

3.1 Metocean Data

3.1.1 Currents and Winds

The study draws on one year of three-dimensional water column current data (daily resolution) obtained from the Hybrid Coordinate Ocean Model (HYCOM), spanning March 2009 – March 2010. The earliest planned drilling date for this project is March 2023, therefore a model start date of 1st March 2009 was selected.

The study draws on one year of two-dimensional wind data obtained from the National Centre for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR), spanning March 2009 – March 2010.

The wind data is used to generate wave height predictions within the model that feed into surface dispersion and resurfacing calculations.

3.1.2 Temperature and Salinity

Water column temperature and salinity profile information is used in the modelling. Local salinity and temperature data for surface and bottom waters was obtained from National Marine Plan Interactive (NMPi) maps (Scottish Government, 2022). As the drilling campaign will begin in March, Spring (March-May) averages for the area were used.

Spring average sea temperature varies from 6.83°C at the seabed to 7.18°C at the sea surface. Salinity variation in the water column is minimal and an average value of 34.91‰ was used at the surface and the seabed.

3.2 Bathymetry

Bathymetry data used in the DREAM model is based on the Sea Topo 8.2 database (Jakobsson *et al.*, 2008).

3.3 Seabed Sediments

DREAM requires an average grain size of surrounding sediments to evaluate the change in grain size distribution as a result of the drill cutting discharge. The sediments around the well are predominantly fine sand (Fugro, 2021), with a median background sediment grain size of 0.188 mm.

3.4 Well Design and Drilling Discharges

Cuttings are discharged from each drilled section in the wells. The model inputs include:

- The well locations;
- The well design and geometry of each section;
- The mass of the mud components discharged from each section; and
- An assumed drilling schedule showing the likely drilling durations per section.

3.4.1 Well and Discharge Location

The wells will be drilled from a semi-submersible rig the coordinates of which are shown in Table 3-1.

Table 3-1: Coordinates of wells and discharge location.

Well name	Latitude	Longitude
UB04i	58°18'25.793"	-1°41'32.522"
UC01i	58°18'26.681"	-1°41'30.769"
UC02i	58°18'26.237"	-1°41'31.646"

Note: Coordinate reference system is World Geodetic System 1984 (WGS 84)

3.4.2 Well Design

The well design comprises four sections as summarised in Table 3-2. Seawater and bentonite sweeps will be used during the first two sections of each well and the cuttings will be discharged directly at the seabed. Subsequent sections will be drilled using Water Based Mud (WBM) and will be discharged at the sea surface from the drilling rig. The same design is assumed for all wells.

Table 3-2: Well design.

Section Diameter (inches)	Section Length (m)	Mud Type	Release Depth
36	76	Seawater and Sweeps	Seabed
17.5	330	Seawater and Sweeps	Seabed
12.25	879	Glydril WBM - KCl	Sea surface
8.5	2,117	FloPro WBM	Sea surface

3.4.3 Mud Components

A summary of mud compositions and the discharged components is shown in Table 3-3. All three wells assume the same design.

Table 3-3: Mud components modelled for each well.

Section Diameter (inches)	Rock Cuttings (t)	Barite (t)	Bentonite (t)
36	120	100	25
17.5	123	50	25
12.25	176	250	0
8.5	205	0	0
Total	**624**	**400**	**50**

3.4.4 Added Chemicals and Reservoir Oil

Table 3-4 and 3-5 summarise the chemicals used for each well section and Table 3-6 summarises the key physico-chemical and toxicological properties of those chemicals.

Table 3-4: Drilling chemicals used in each well section.

Chemical (t)	Section				
	1	2	3	4	Total
DUO-VIS	1.139	1.169	1.678	1.946	5.932
CONQOR 404 EH	0.142	0.146	0.210	0.243	0.741
GLYDRIL MC	1.709	1.753	2.517	2.919	8.898
LUBE 776	1.495	1.534	2.202	2.554	7.785
FLO-VIS PLUS	1.139	1.169	1.678	1.946	5.932
THRUCARB	1.709	1.753	2.517	2.919	8.898
THRUCARB 20	1.709	1.753	2.517	2.919	8.898
THRUCARB 40	1.709	1.753	2.517	2.919	8.898
THRUTROL	1.139	1.169	1.678	1.946	5.932
Reservoir Oil	-	-	-	0.688	0.688

Table 3-5: Completion chemicals released as a batch at the end of each well section.

Chemical (t)	Section				
	1	2	3	4	Total
FLO-VIS PLUS	1.138	1.168	1.676	1.944	5.926
SAFE-COR	0.427	0.438	0.629	0.729	2.222
SAFE-SURF* EU	2.495	2.561	3.676	4.263	12.995
THRUTROL	1.138	1.168	1.676	1.944	5.926

Table 3-6: Physical, chemical and toxicological properties.

Chemical name	Drilling (D) and/or Completion (C)	Density (kg/m^3)	Solubility [1, 2]	Biodegradation (% (days))	Log Pow[3]	PNEC (ppb)
DUO-VIS	D	1.5	823,900	49 (28)	-0.67	207
CONQOR 404 EH	D	1.4	1,000,000	20.6 (28)	-4.94	143
GLYDRIL MC	D	1.012	1,000,000	70 (28)	-	310
LUBE 776	D	1	557,300	79 (7)	-0.1	11
FLO-VIS PLUS	D/C	1.5	873,700	49 (28)	-0.84	207
THRUCARB	D	2.5	557,300	99.99 (28)	-0.1	1,000
THRUCARB 20	D	2.5	1,000,000	64.8 (15)	-	980
THRUCARB 40	D	2.7	1,000,000	64.8 (14)	-	980
THRUTROL	D/C	1.5	557,300	66.5 (28)	-0.1	232
SAFE-COR	C	1.1	981,300	69 (28)	-1.72	433
SAFE-SURF* EU	C	0.99	1,000,000	73 (28)	-	13
Reservoir Oil	D	0.8225	0.000001		6.18[4]	5

Notes:
1-Vapour pressure assumed to be 0.000001 for all chemicals (not shown in table)
2-Where no solubility data is available but chemicals are classed as soluble in water a high solubility (1,000,000) has been assumed
3-LogPow – log of the octanol-water partition coefficient, Koc – organic carbon-water partition coefficient
Where no LogPow data was available, it was derived from a Koc of 0.00, in line with guidance in Annex 4 of the Risk Based Approach Guidelines (BEIS, 2020).
4-The LogPow for the reservoir oil is based on a Koc of 1,510,000
5- It is likely that all the THRUCARB chemicals, could be replaced with SAFE-CARB chemicals (which are PLONOR) and THRUTROL with FLOTROL (also PLONOR).

Reservoir oil has been included in the model for the 8½" section of each well, where drilling passes through the reservoir. The mass of oil was determined based on an average percentage (0.34%) of oil on cuttings from the last 15 wells drilled at the Captain field. This was multiplied by the volume of the 8½" section to produce a mass of reservoir oil of 0.688 tonnes.

3.4.5 Particle Size Distribution

The model has a default particle size distribution (PSD) for drill cuttings that was obtained from a review of data from drilling in Norwegian waters during the development of the DREAM/ParTrack model (Saga, 1994). PSDs for barite and bentonite in the model are based on industry standard distributions.

Table 3-7 summarises the cuttings PSD used in the model.

Table 3-7: Cuttings PSD (model default).

Approximate% In Each Size Class[1]	Size Interval (µm)	Fraction (%)	Cumulative Fraction (%)
Fines (silt/clay) Up to 62.5 µm ~50%	1–10	10	10
	10–20	10	20
	20–30	10	30
	30– 45	10	40
	45–60	10	50
Sand 62.5 µm to 2000 µm ~35%	60–100	10	60
	100–400	10	70
	400–1000	10	80
Gravel 2000 to 6000 µm ~15% Cobbles >6000 µm (% included in gravel)	1000–4000	10	90
	4000–7000	10	100

Notes:
[1] Wentworth Scale (Wentworth, 1922) – note that size intervals used do not exactly match the divisions on the Wentworth scale therefore percentage within each size class is approximate.

3.4.6 Drilling Schedule

Each well takes approximately 16 days to drill, including time in between sections for running and cementing casing.

The modelled drilling schedule is shown in Table 3-8 and is compressed to optimise model run time. The modelled schedule is based on the following assumptions:

- Completion chemicals are released as a one hour batch release within 24 hours of the completion of drilling at each section;
- A 24-hour time gap has been allowed between sections;
- A three day time gap has been allowed between wells; and
- The model runs for a further five days after drilling is completed to allow for dispersion in the water column.

This gives an overall model run duration of 53 days.

Table 3-8: Modelled drilling sequence and schedule.

Section	Days (from the start of the model)					
	UB04i	Batch 1	UC01i	Batch 2	UC02i	Batch 3
1	0	1	17	18	34	35
2	2	3	19	20	36	37
3	4	9	21	26	38	43
4	10	14	27	31	44	48
Extra days	3		3		5	
Model ends	53					

The well will take longer to be drilled in reality than in the model and allow more time for dispersion between discharges from individual sections. The model set up is conservative in that it will potentially result in slightly greater impacts in the water column because there is less time for dispersion between the discharges. Impacts on the seabed are unlikely to be significantly different as a result of the shorter modelled discharge timings, given that seabed recovery takes place over much longer timescales.

3.5 Model Configuration

A range of grid sizes and model timesteps have been used in order to optimise specific outputs, whilst not resulting in unmanageable model run times.

Two grid sizes were used to evaluate particle dispersion:

- Larger, coarser grid to evaluate risk of impacts to the water column; and
- A smaller, finer grid to evaluate impacts on the seabed.

This reflects the likely extent of particle dispersion. Water column dispersion of dissolved and suspended particles occurs over a wide area, whereas deposition of drill cuttings is a more localised event.

Different timesteps and overall model durations were used to allow short-term and long-term impacts to be investigated. A description of each configuration used is summarised in Table 3-9.

Table 3-9: Model configuration.

Aspect	Domain Size	Cell Size	Time Step	Model Duration	Sediment Model?
Water column	30 km × 30 km	100 m × 100 m	3 hours	53 days	Not included
Seabed	1 km × 1 km	10 m × 10 m	15 mins	53 days plus 10 years[1]	Included

[1] Main DREAM model run for 53 days using timestep shown, followed by the sediment model which was run for 10 years using a 24-hour timestep.

4.0 RESULTS

4.1 Terminology

The results of the modelling runs are presented in the following sections in relation to seabed sediment impacts and water column impacts.

The following terms are used throughout:

- The maximum instantaneous risk is the area (in the case of seabed sediment) or the volume (in the case of the water column) where the risk to over 5% of the most sensitive species is greatest at a specific point in time during the simulation;
- The total risk is the overall area (seabed) or volume (water column) where there has been a risk to over 5% of the most sensitive species at any point in time during the simulation. This can also be referred to as the cumulative risk or swept path; and
- The maximum instantaneous risk and the total risk can be computed for individual stressors or for all stressors combined. Thus, combined sediment risk is the sum of the individual risks resulting from burial thickness, grain size change, oxygen depletion and toxicity of the cuttings.

4.2 Cuttings Thickness

The model predicts a maximum estimated thickness of cuttings around the wells of 1.51 m (1,510 mm), adjacent to well UC01i (Figure 4-1 and Figure 4-2). Significant thicknesses (over 6.5 mm) are predicted to occur over an area of 0.019 km^2 (up to approximately 175 m from the discharge location in south easterly direction, but significantly less in north and west directions). Materials of grain size greater than 0.5 mm will spread further, covering a predicted area of 0.2716 km^2. To put this into context, a typical exclusion zone around a platform of 500 m radius is equivalent to an area of 0.785 km^2. Over time the area where thickness is greater than 6.5 mm gradually reduces, this is discussed in Section 4.3.

Very fine particles (<0.5 mm grain size) will spread over much larger distances, extending beyond the model domain. The distribution of these very fine particles does not change significantly over time.

If only one well was drilled significant thicknesses (over 6.5 mm) are predicted to occur over an area of 0.0056 km^2.

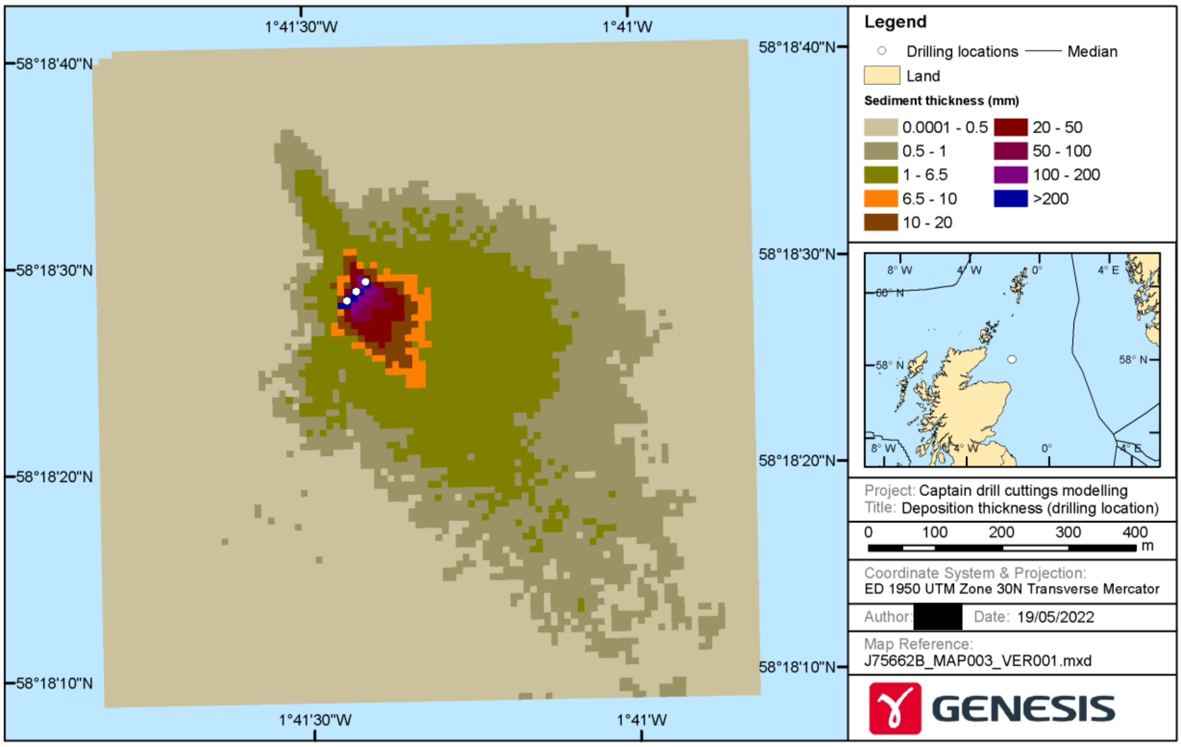
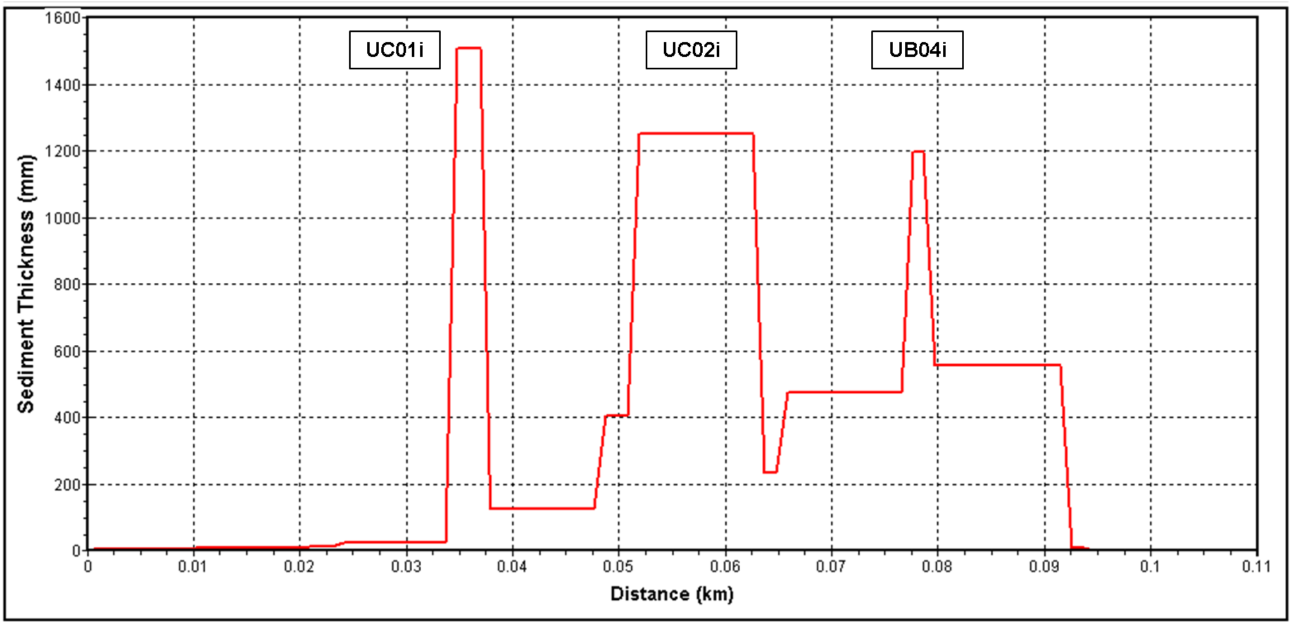


Figure 4-1: Deposition thickness around the drilling location at the end of drilling.



Note: Coordinates of cross section: start point (1°41'29"W, 58°18'28"N) and end point (1°41'34"W, 58°18'25"N)

Figure 4-2: NE to SW cross section of deposition thickness at the end of drilling (53 days).

4.3 Risk to the Seabed Sediment

Risk to the sediment has been modelled for the duration of drilling and over a 10-year period post drilling. The following sections summarise the predicted risk around the well locations as well as the components making up that risk.

As noted in Section 2.2, combined risk to the seabed sediment is made up of risk contributions resulting from the following stressors:

- Burial thicknesses greater than 6.5 mm;
- A median grain size change greater than 52.7 µm;
- Oxygen content depletion greater than 20%; and
- Toxicity (where reservoir oil and/or chemical concentration exceeds the PNEC).

A risk of less than 5% to the most sensitive species is considered to be tolerable. Figure 4-3 shows the total combined risk around the drilling location.

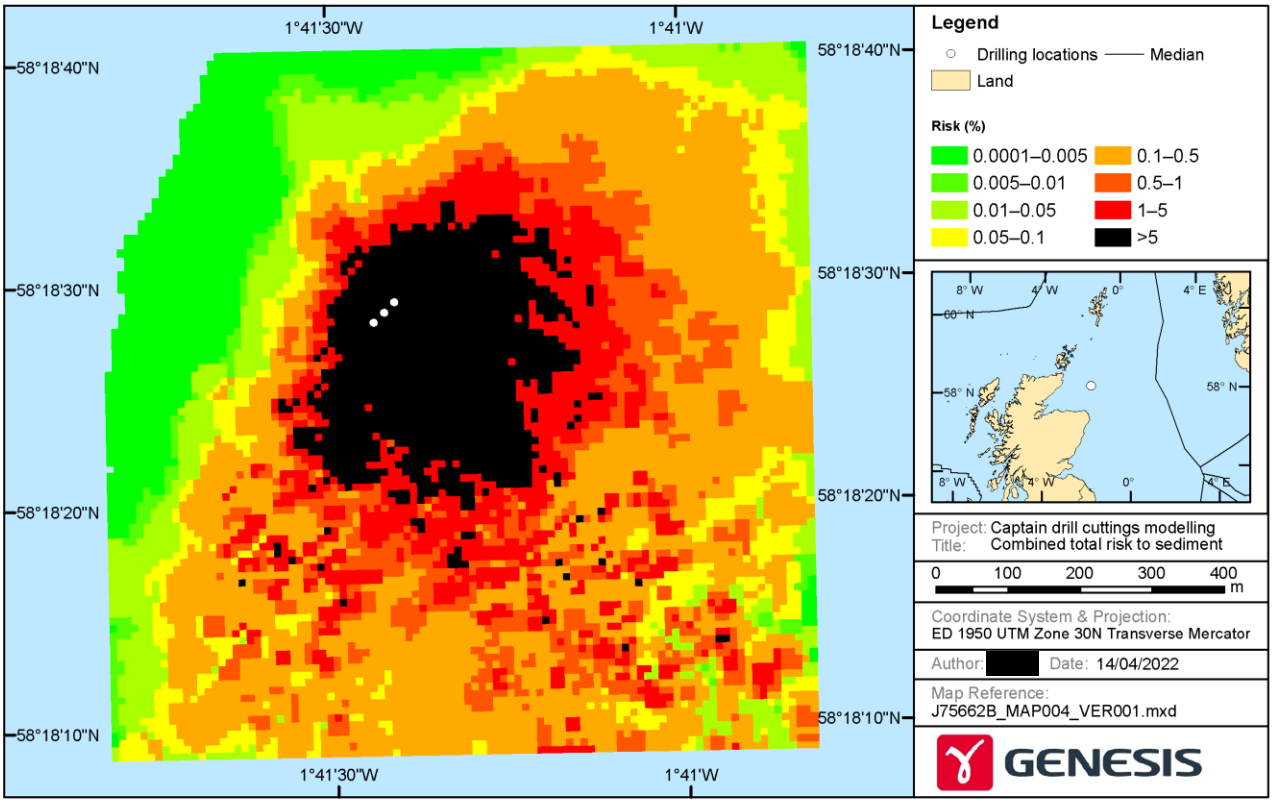


Figure 4-3: Predicted total combined risk to sediments (swept path).

The contribution to the combined risk can be broken down to establish which stressors are the key contributors. This is shown in Figure 4-4.

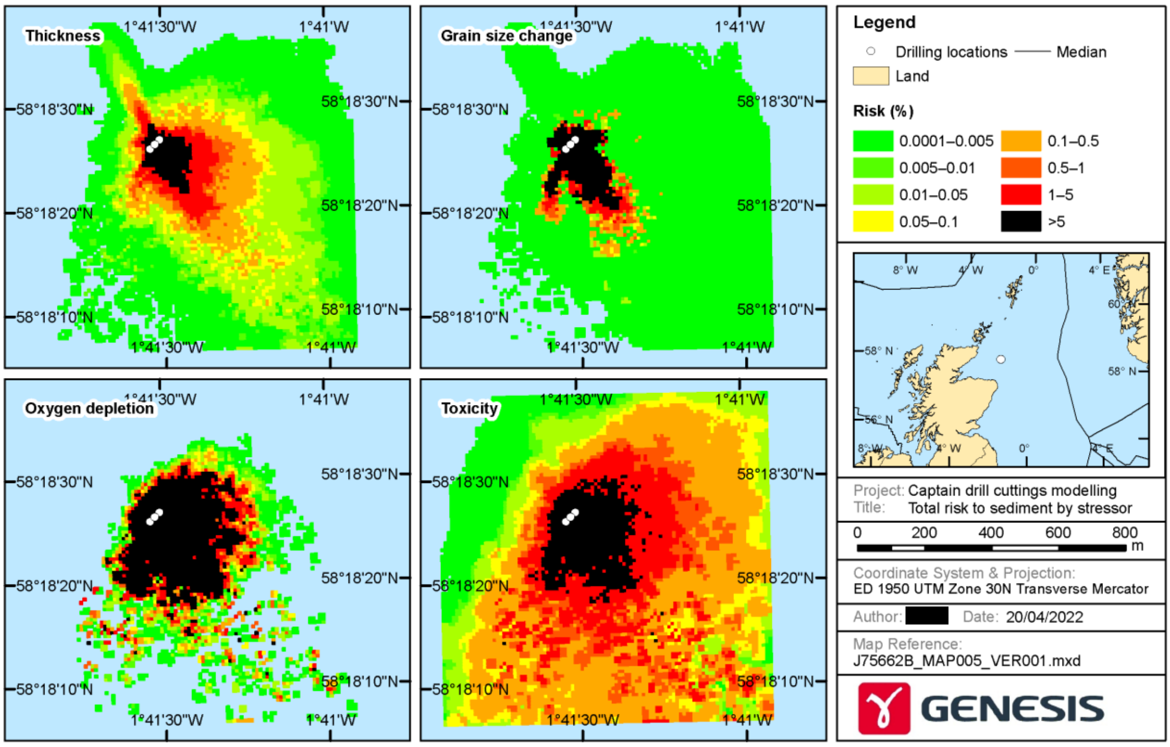


Figure 4-4: Predicted total risk contributions from individual seabed stressors (swept path).

Time-averaged contributions to risk are summarised in Figure 4-5 and Figure 4-6. The main contributor to the risk is oxygen depletion (53.9%). Grain size contributes 27.8%, reservoir oil 10.0% and thickness 8.3%. There is no contribution from toxicity of the chemicals due to most chemicals having a relatively high PNEC, along with high solubility in water and not readily adsorbing to the sediment particles (negative logPow). In contrast the reservoir oil adsorbs strongly onto the cuttings and the sediment and has a low solubility in water.

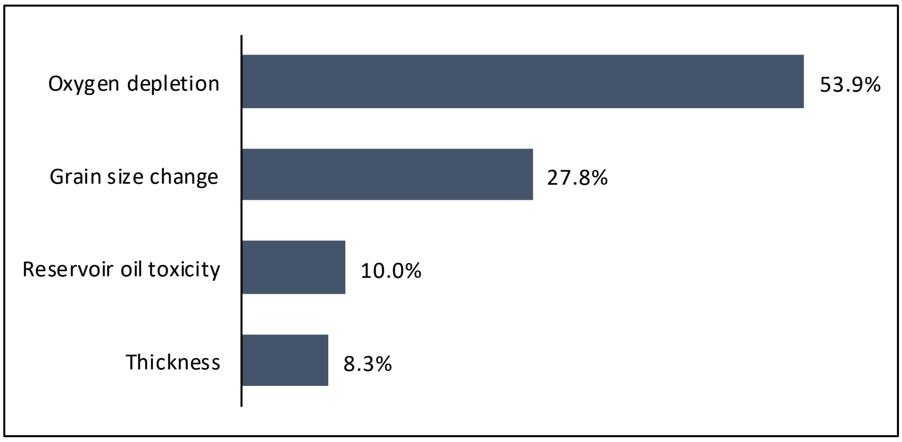


Figure 4-5: Weighted contributions to time-averaged risk.

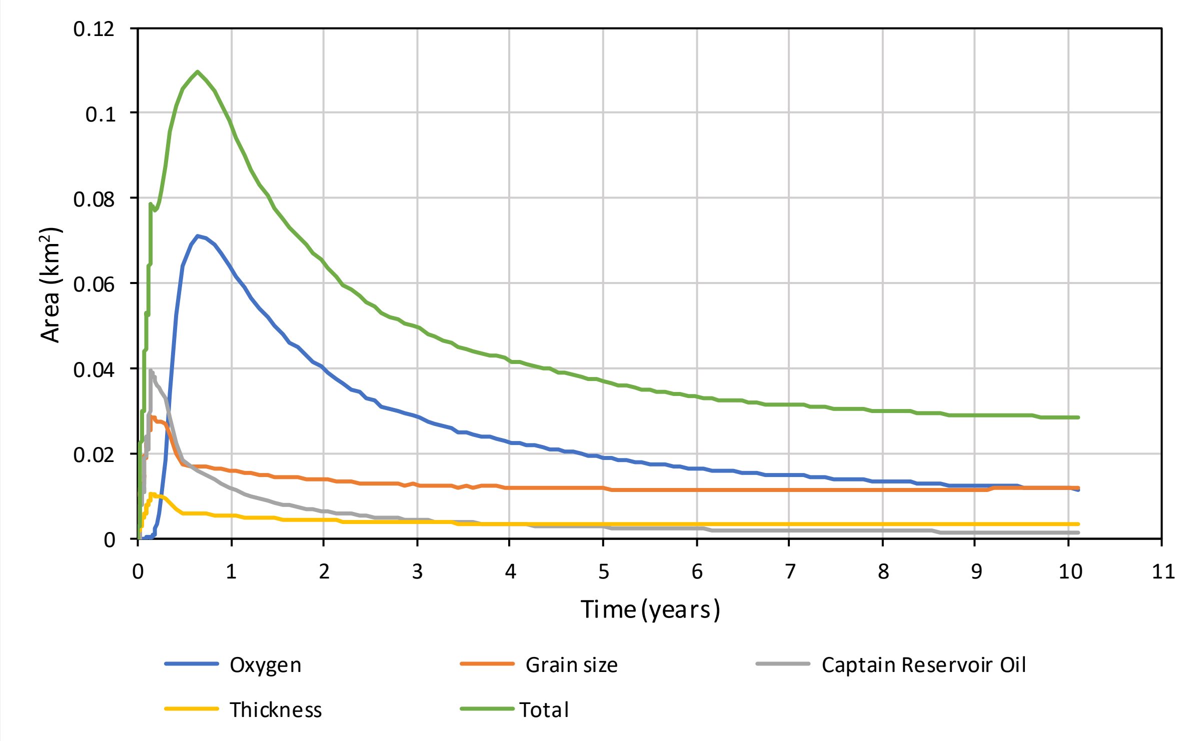


Figure 4-6: Contribution to area where there is risk to more than 5% of sensitive species over whole model period for each sediment stressor.

The evolution of predicted combined risk (at the end of drilling, 237 days, five years and ten years after the end of drilling) is shown in Figure 4-7 and summarised in Table 4-1. Risk at 237 days is shown as this corresponds to the maximum extent.

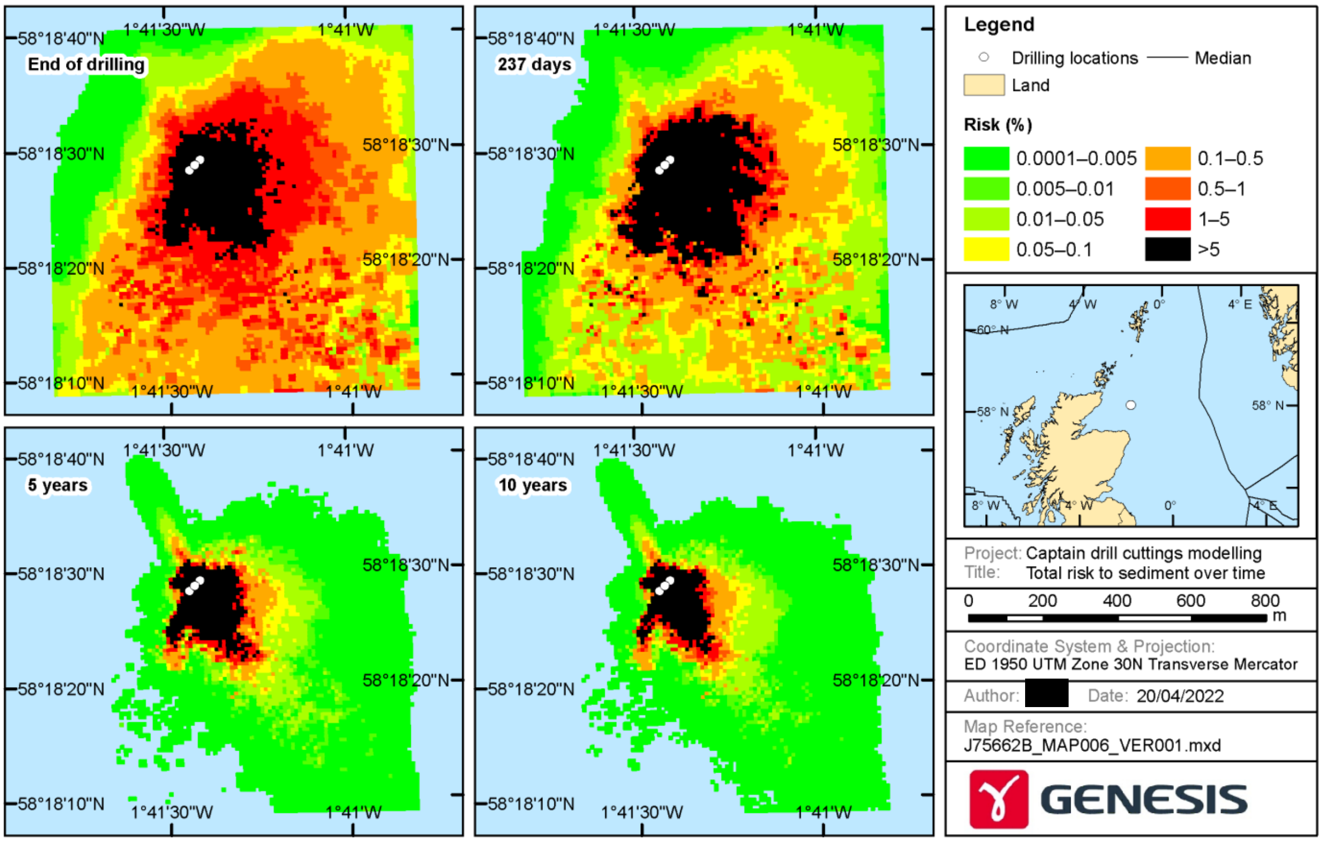


Figure 4-7: Predicted combined risk to the sediment over time.

The area where there is a risk to more than 5% sensitive species is 0.0785 km^2 when drilling discharges end (at 53 days), reducing to 0.362 km^2 after 5 years and 0.0285 km^2 after 10 years as shown in Table 4-1.

Table 4-1: Predicted combined risk over time.

Time period	Units	Description	Area where combined risk is >5% (km^2)	Reduction in area (%)
53	days	End of drilling discharge	0.0785	-
237	days	Maximum extent of risk	0.1098	-39.87
5	years	5 years post drilling	0.0362	53.89
10	years	10 years post drilling	0.0285	63.69

As noted above the main risk stressors as a result of the modelled drilling discharges are oxygen depletion and grain size. The maximum extent of risk occurs 237 days after drilling commences and is driven by an increase in oxygen depletion (the most dominant stressor) after the end of drilling. This is a result of oxygen being consumed as the reservoir oil breaks down.

It is worth noting that the model calculates the risk resulting from burial thickness based on the areas of the seabed where the thickness of cuttings exceeds 6.5 mm (see Section 4.2). This thickness reduces over time because of bioturbation and re-suspension. Both these processes are included in the model. However, the model does not account for recolonization of the sediment over time. Therefore, the area where there is a risk to over 5% of the species is likely to reduce faster than shown and the areas shown in Table 4-1 are conservative. Overall, the area at risk is localised, extending approximately 350 m from the wells.

4.4 Risk to the Water Column

The total risk in the water column is shown in Figure 4-8. Although the area where the risk to the most sensitive species exceeds 5% appears relatively extensive (2.377 km^3), it should be noted that this plot shows the swept path (that is all areas where risk is greater than 5% at any point in time during the entire model run). In practice the area where risk exceeds 5% at any instance in time would be much smaller than that shown in Figure 4-8. The area of 5% risk and above occurs in the lower half of the water column and at the surface, as shown in the cross section in Figure 4-9. This is because the discharge changes from being at the seabed for the top two sections to the sea surface for the remaining sections.

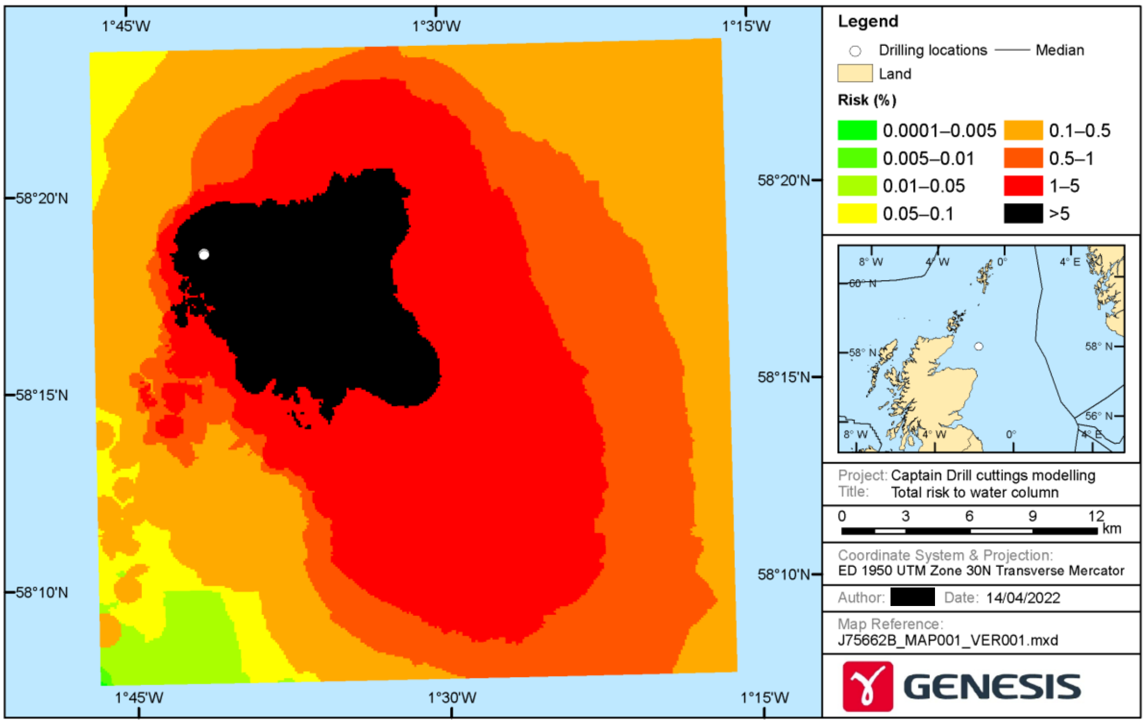


Figure 4-8: Total risk to the water column (swept path).

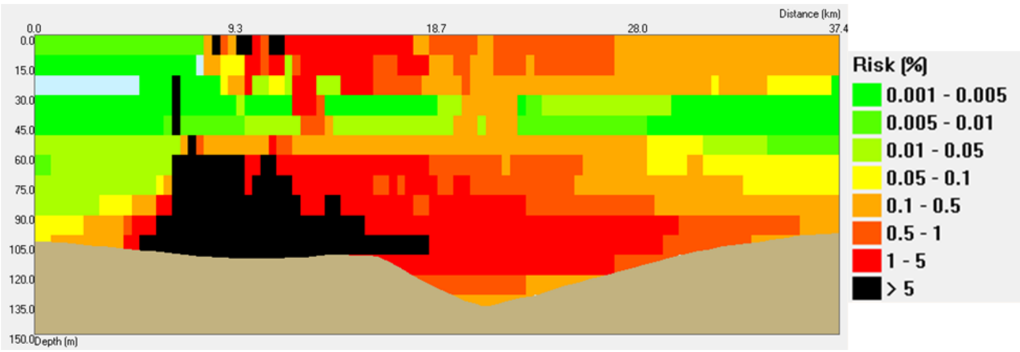


Figure 4-9: Northwest to southeast cross section of total risk.

Figure 4-10 and Figure 4-11 show a snapshot of risk in the water column at 21 days from the start of drilling. The maximum instantaneous volume where there is a risk to more than 5% of sensitive species is 0.3296 km^3. This occurs at 21 days, after the second section of the second well has been drilled. As can be seen in the figures there is one large plume at that point in time at depth resulting from the seabed discharge of cuttings from the top two sections, just before the surface discharge of the third section begins.

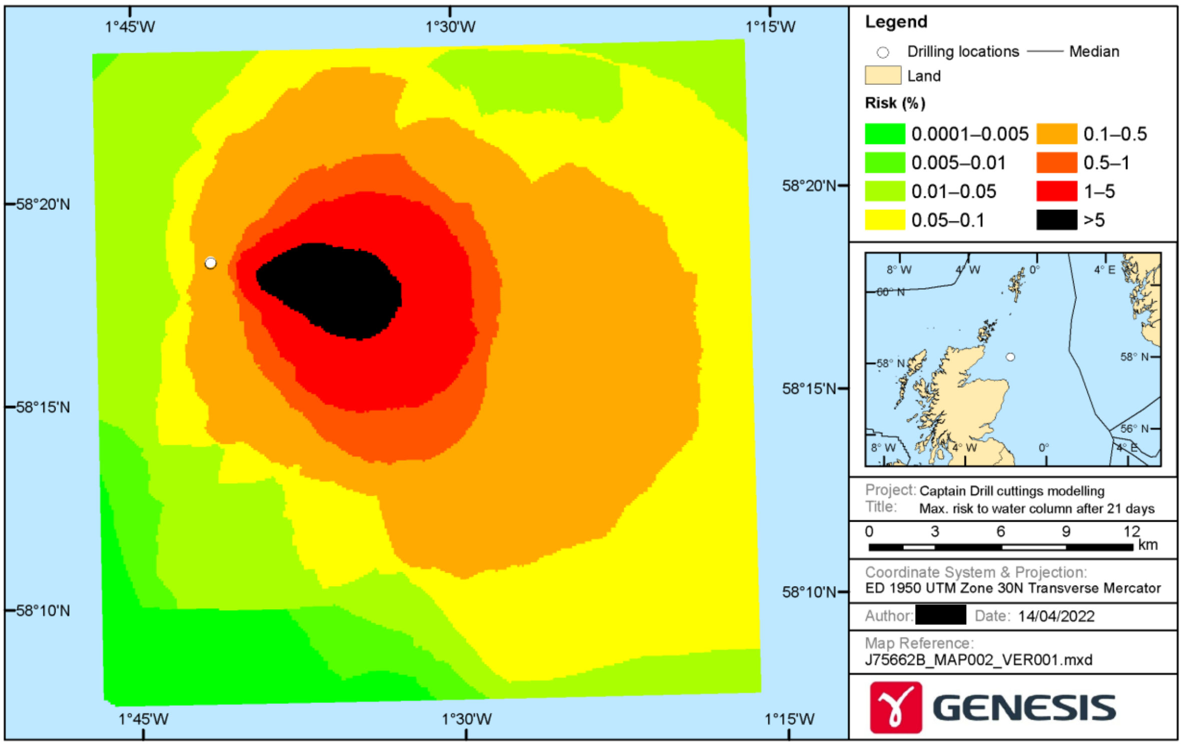


Figure 4-10: Instantaneous risk to the water column after 21 days.

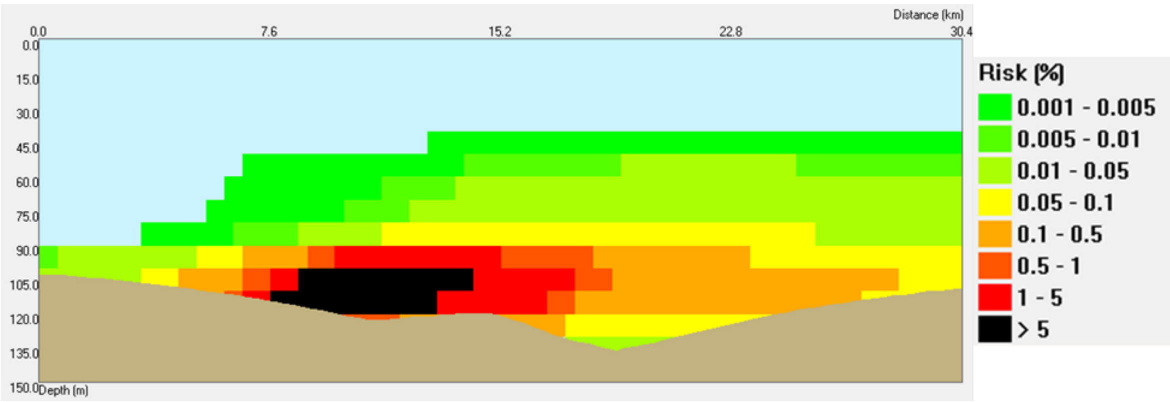
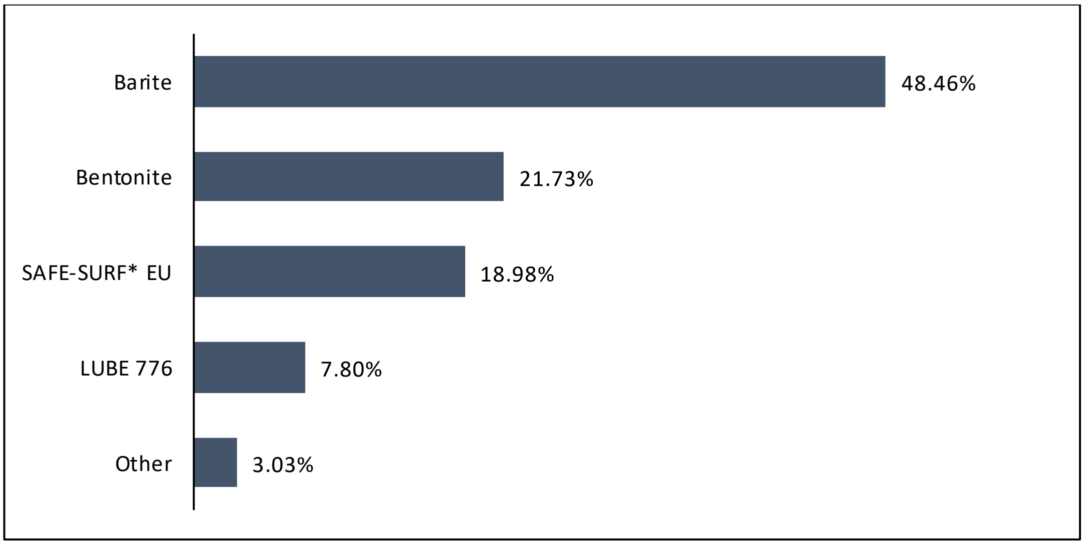


Figure 4-11:West to east cross sections of instantaneous risk after 21 days.

The primary contributors to the water column risk are from barite (48.5%) and bentonite (21.7%) and SAFE-SURF* EU (19.0%) as shown in Figure 4-12.

All chemicals and the reservoir oil combined contribute 29.8% of the risk.



Note: “Other” comprises of chemicals for which contribution to risk was less than 1%

Figure 4-12: Time-averaged contributions to risk in the water column.

The volume of water column where there is a risk to over 5% of sensitive species varies over time (Figure 4-13). There is a peak, shortly after drilling each section. The volume at risk reduces rapidly after each discharge stops and disappears completely within 24 hours of the last discharge for each well.

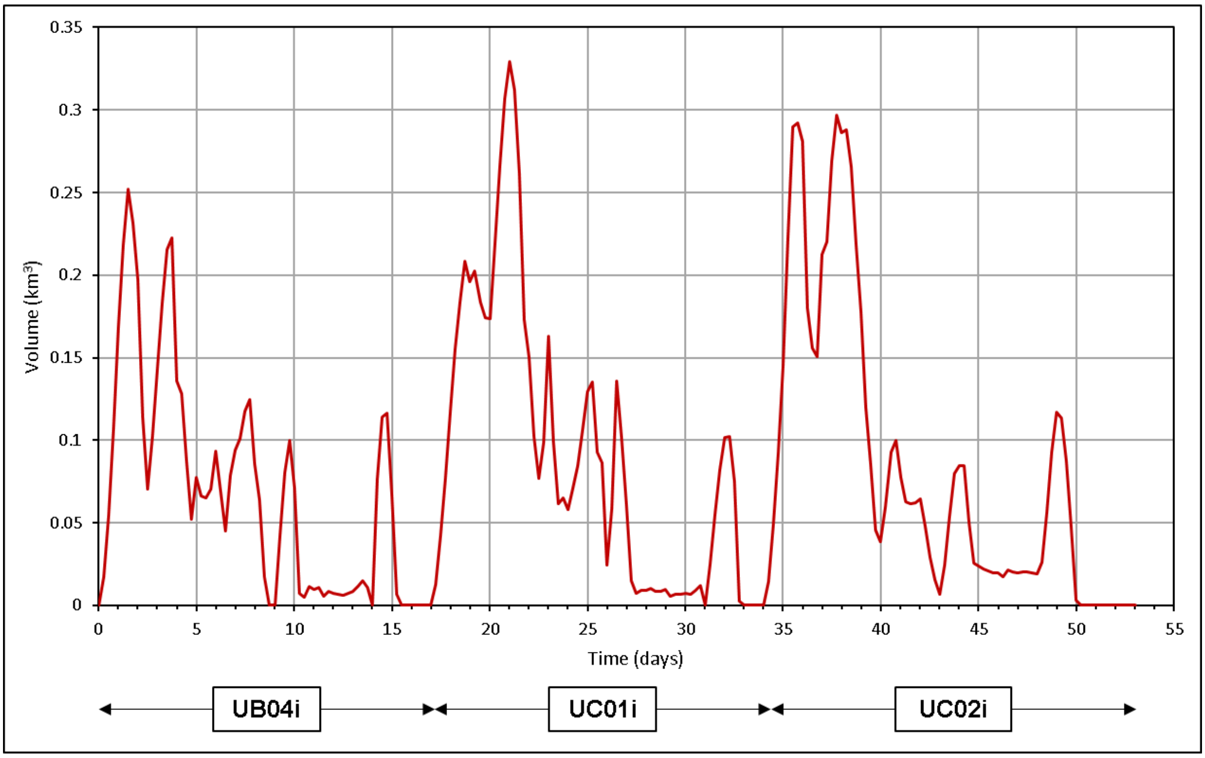


Figure 4-13: Volume of water where there is risk to over 5% of species over time.

4.5 Summary of Outputs

The model outputs are summarised in Table 4-2. The potential impact to the seabed covers a relatively small area. The key contributors to risk in sediments were oxygen depletion and grain size change. The risk to the seabed is reduced to an area of 0.0285 km² after 10 years from the end of drilling.

Table 4-2: Summary of model outputs.

Model output	Criteria	Value
Cuttings deposition		
Thickness	Maximum thickness - end of drilling (m)	1.51
	Area where thickness >6.5 mm - end of drilling (km²)	0.019
Risk to sediment		
Thickness (%)	>6.5 mm	8.34
Grain size (%)	>52 µm	27.80
Oxygen depletion (%)	>20%	53.88
Reservoir oil toxicity (%)	Toxicity (PNEC exceeded)	9.98
Chemical Toxicity (%)	Toxicity (PNEC exceeded)	0
Area where there is a total combined risk (>5%) to the most sensitive species (km²)	End of drilling	0.0785
	237 days	0.1098
	5 years	0.0362
	10 years	0.0285
Risk to water column		
Bentonite (%)	Physical effect of particles	21.73
Barite (%)	Physical effect of particles	48.46
Cuttings (%)	Physical effect of particles	0.01
Toxicity of added chemicals and/or reservoir oil (%)	Toxicity (PNEC exceeded)	29.8
Volume where combined risk to >5% most sensitive species (km³)	Maximum instantaneous volume	0.3296
	Total volume (swept path)	2.377

Note: 500 m safety zone area is equivalent to 0.785 km²

5.0 MODEL UNCERTAINTIES

5.1 Metocean Data

The Metocean data used was for the year 2009, starting in March to match the likely start date of the drilling. Use of a different start date or a different set of current data would result in small changes to the precise pattern of cuttings deposition but the predicted extent of risk is likely to be of a similar magnitude.

5.2 Sediment Grain Size and Burial Thickness

Grain size change is an important parameter and it should be noted that the thresholds for this parameter within the risk assessment are based on the analysis of environmental monitoring data from the Dutch section of the North Sea, the Norwegian Sea and the Barents Sea covering 300 species (Smit *et al*., 2006). There may be regional differences in prevailing fauna that would give different thresholds for the drilling location. However, the basis of the threshold is considered to represent the best available data and covers a wide range of benthic fauna.

The threshold for burial thickness is based on the probability that a specific species will escape a given depth of burial with both exotic (e.g. drill cuttings) and native sediments. The threshold was derived from the burial sensitivity of 33 species (Smit *et al*., 2006 and Kjeilen Eilersten *et al*., 2004).

5.3 Chemical Uncertainty

Several the chemicals entered in the model did not have solubility data available so were entered as fully soluble in water. This is effectively a worst case with respect to the water column but results in there being no chemical toxicity contribution to the sediment risk. If actual solubility data was available, there could be some chemical contribution to risk seen in the sediment. However, given that most of the discharge takes place at the sea surface, depositional thickness is limited, and it is unlikely that there would be a significant impact on the sediment.

6.0 CONCLUSIONS

The cuttings modelling was undertaken using DREAM to predict environmental risks to the seabed and the water column as a result of the discharge of cuttings during drilling of three wells (UB04i, UC01i and UC02i) in Block 13/22 using WBM.

The maximum estimated deposited sediment thickness (cuttings pile height) was 1.51 m, in the immediate vicinity of the well, reducing rapidly with distance;

The following risks were predicted:

- The model predicted that the deposited cuttings from drilling could result in a risk to seabed sediment of greater than 5% in a maximum area of 0.1098 km^2 237 days after drilling commences. This represents a small area of seabed, which reduces over time, to 0.0362 km^2 after 5 years and 0.0285 km^2 after 10 years; though in reality re-colonisation by benthic organisms would result in a faster seabed recovery.
- The risk to the sediment mainly results from oxygen depletion (53.88%) and change to grain size (27.8%).
- The volume of the water column where there is a risk to over 5% sensitive species reaches up to 0.3296 km^3 at any one point in time but is transient in time and space. The risk to the water column disappears within 24 hours of the cessation of drilling.
- The primary contributors to the water column risk are from barite (48.46%), bentonite (21.73%) and SAFE-SURF* EU (18.98%).
- Overall, the risk to the sediment and the water column is low and unlikely to result in significant environmental impacts. Environmental impacts are discussed in Chapter 4 of the ES.

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REPORT

Captain EOR ES: Underwater Noise Modelling for Piling

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ABBREVIATIONS

dB	Decibels
dB re 1 µPa	Decibels relative to one micropascal
dB re 1 µPa^{2}s	Decibels relative to one micropascal square second
dB re 1 µPa^{2}s-m	Decibels relative to one micropascal square second at one metre
dB re 1 µPa-m	Decibels relative to one micropascal at one metre
deg. C	Degrees Celsius
ED	European Datum
EMODnet	European Marine Observation Data Network
FARAM	Faunal Acoustic Risk Assessment Model
g/kg	Grams per kilogram
HF	High Frequency
Hz	Hertz
IAMMWG	Inter-Agency Marine Mammal Working Group
JNCC	Joint Nature Conservation Committee
kg/m^3	Kilograms per cubic metre
kJ	Kilojoules
km	Kilometres
km^2	Square kilometres
LF	Low Frequency
m	Metres
m/s	Metres per second
MF	Mid Frequency
MMO	Marine Mammal Observer
MU	Management Unit
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration

PAM	Passive acoustic Monitoring
PE	Parabolic Equation
PTS	Potential Threshold Shift
RAM	Range-dependent Acoustic Model
SCANS	Small Cetaceans Abundance Surveys
SEL	Sound Exposure Level
SPL	Sound Pressure Level
SUDS	Subsea Umbilical Distribution Structures
UTM	Universal Transverse Mercator
VHF	Very High Frequency
WOA	World Ocean Atlas

1.0 INTRODUCTION

As part of the Captain Stage 2 Project, piling will be required for the installation of two Subsea Umbilical Distribution Structures (SUDSs), one each at the Area D and Area E drill centres (see Figure 1-1). The SUDSs are separated by approximately 2.8 km and will require four piles for installation, resulting in a total of eight piles being installed. It is expected that it will take one hour to install each pile with the four piles at each SUDS being installed in a single day. Based on experience of piling at Captain Area C, it is expected that a maximum hammer energy of 20 kJ will be sufficient to install the piles (after a soft start hammer energy of 10 kJ).However, as a worst-case scenario, a maximum hammer energy of 90 kJ (also with a soft-start of 10 kJ) is also considered. Details of the piling that will be conducted at Captain Area D and Area E are summarised in Table 1-1.

This report presents underwater noise modelling results for assessing potential impacts that the piling of the two SUDSs may have on marine mammals and fish.

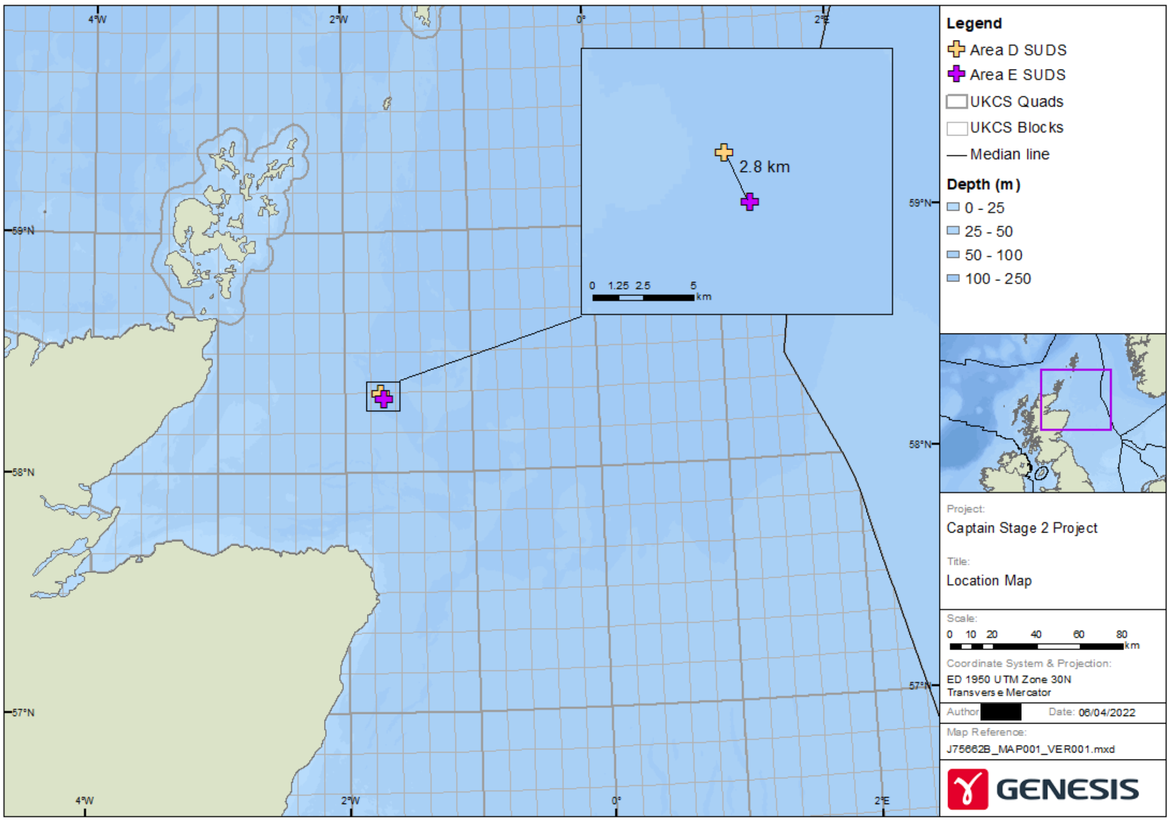

Figure 1-1: Location of piling activities.

Table 1-1: Details of piling.

Parameter	Value
Number of piles to be installed	8 (4 at each SUDS location)
Duration to install a single pile	1 hour
Maximum number of piles installed in any 24-hour period*	8
Pile length	26 m
Pile penetration depth	22 m
Soft-start hammer energy	10 kJ
Maximum hammer energy	Most likely maximum hammer energy: 20 kJ Worst-case maximum hammer energy: 90 kJ
* The modelling assumes that the two SUDS will be piled in a single 24 hour period, though it is possible there may be a few days 'break' before the second SUDS is installed.	

2.0 MODELLING METHODOLOGY

This section discusses the modelling methodology adopted to estimate potential impacts from piling associated with the Captain Stage 2 Project. The characterisation of the piling noise source is firstly discussed before details of the noise propagation model are presented.

2.1 Piling Source Characterisation

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

Based on previous experience of piling at Captain Area C, it is expected that piling of the SUDSs will be conducted using an impact hammer with a capacity of 90 kJ. It is anticipated that a maximum hammer energy of 20 kJ will be sufficient to install all piles for the SUDSs and this has been considered in the modelling as the most likely maximum hammer energy required. However, a worst-case scenario involving a maximum hammer energy of 90 kJ has also been considered.

To derive source levels for use in the piling modelling, a representative third octave band sound exposure level (SEL) frequency spectrum measured during piling with an 800 kJ hammer (Ainslie *et al*., 2012) has been scaled to different hammer energies used in the modelling of piling at Captain. It has been assumed that the source SEL scales linearly with hammer energy, which has been demonstrated by measurements made throughout the soft-start and energy ramp-up during piling (Robinson *et al.*, 2007). The scaled third octave band SEL spectra for the different hammer energies that have been used in the modelling are shown in Figure 2-1. The piling soft-start/ramp-up procedures and zero-to-peak sound pressure level (SPL) and SEL source levels assumed in the modelling for the installation of single piles are shown in Table 2-1.

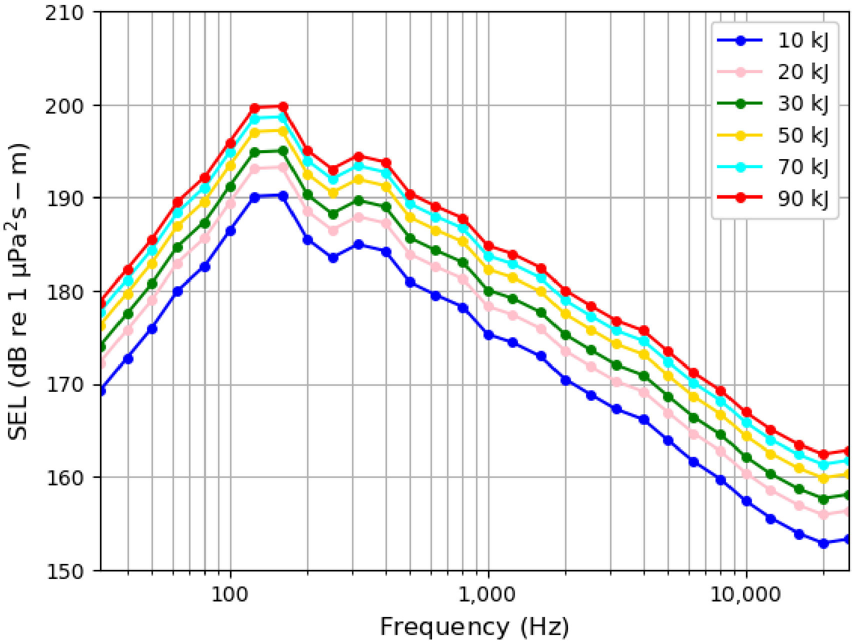

Figure 2-1: Third octave band SEL spectra used in the piling modelling.

Table 2-1: Piling procedures and broadband source levels assumed in the modelling for the installation of single piles.

Hammer Energy (kJ)	Duration (minutes)	Strike Rate (blows/minute)	Source Level	
			Zero-to-peak SPL (dB re 1 µPa-m)	SEL (dB re 1 µPa^{2}s-m)
Maximum hammer energy of 20 kJ (most likely maximum hammer energy)				
10	20	46	222.5	196.5
20	40	46	225.5	199.5
Maximum hammer energy of 90 kJ (worst-case maximum hammer energy)				
10	10	46	222.5	196.5
30	10	46	227.2	201.2
50	10	46	229.4	203.4
70	10	46	230.9	204.9
90	20	46	232.0	206.0

2.2 Noise Propagation Modelling

There are various algorithms that can be used for underwater noise propagation modelling e.g. parabolic equation, ray tracing, normal mode, wavenumber integration, energy flux density and semi-empirical algorithms (Jensen *et al.*, 2011). The Genesis in-house modelling software FARAM (Faunal Acoustic Risk Assessment Model) has been used in this study. FARAM employs the parabolic equation (PE) and ray tracing algorithms developed by Collins (1993) and Porter and Liu (1994), respectively, for estimating received noise levels from various sources. When estimating received noise levels, FARAM incorporates:

- A site-specific bathymetric grid to account for the influence of varying bathymetry on noise propagation;
- Site-specific range and depth dependent water column temperature, salinity, and sound speed profiles based on modelled hydrological conditions;
- Acoustic properties of the predominant seabed sediments in the modelling area;
- Frequency dependent propagation effects (e.g. volume attenuation, reflection, scattering at different frequencies);
- Specific properties of the piling noise source under consideration (e.g. spectral content, hammer energy, strike rate);
- Auditory weighting functions that characterise the hearing ability of different marine mammal hearing groups;
- Movement of mobile marine receptors (e.g. swim speed, depth and trajectory) when calculating received cumulative SEL; and
- The most up-to-date thresholds for assessing potential impacts to marine fauna.

2.2.1 Parabolic Equation Algorithm

PE models approximate the wave equation, allowing a solution to be found computationally (Jensen *et al.,* 2011). This is one of the most popular wave-theory techniques for modelling sound propagation in spatially varying environments (Jensen *et al.,* 2011). The computational scheme used in FARAM is based on the Range-dependent Acoustic Model (RAM) implementation of the PE (Collins, 1993). The RAM PE algorithm incorporates acoustic propagation effects resulting from varying bathymetry, range dependent sound speed depth profiles, and geo-acoustic properties.

The PE algorithm is best suited to calculation of low frequency sound propagation since the computational complexity and implementation time of the PE method significantly increases with frequency. The PE algorithm is therefore generally restricted to modelling the propagation characteristics of low frequency sound sources, since modelling of high frequencies becomes prohibitively time consuming. Given this restriction, the PE model has been used for computation of low frequency sound propagation (<500 Hz).

2.2.2 Ray Tracing Algorithm

For modelling propagation of higher frequencies (>500 Hz), the Bellhop Gaussian beam ray tracing algorithm (Porter and Liu, 1994) has been used. Bellhop is an efficient ray tracing program that is well suited for the modelling of higher frequency sound sources. However, it can also provide accurate results for low frequency propagation in certain circumstances. Similar to the RAM PE algorithm discussed previously, Bellhop also incorporates acoustic propagation effects resulting from varying bathymetry, range dependent sound speed depth profiles, and geo-acoustic properties. Bellhop also accounts for increased sound attenuation due to volume absorption. This type of sound attenuation becomes more prominent at higher frequencies and cannot be neglected without overestimating received levels at large distances from the sound source.

2.2.3 Environmental Data

The implemented noise propagation model accounts for various site-specific environmental properties including a bathymetric grid, geographically and depth varying sound speed profiles and geo-acoustic properties of the sediment. To model the effects of these properties, input data is required that describes the surrounding environment.

2.2.3.1 Bathymetry

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

The bathymetry data that has been used in the noise model (Figure 2-2) is provided by EMODnet, which is a high-resolution digital terrain model for European Seas (EMODnet, 2022a). The EMODnet bathymetry is based on almost 10,000 datasets obtained from bathymetric surveys, with bathymetric data provided at a spatial resolution of 1/16 arc minutes. The water depth at the piling locations are approximately 105 m and 110 m, respectively.

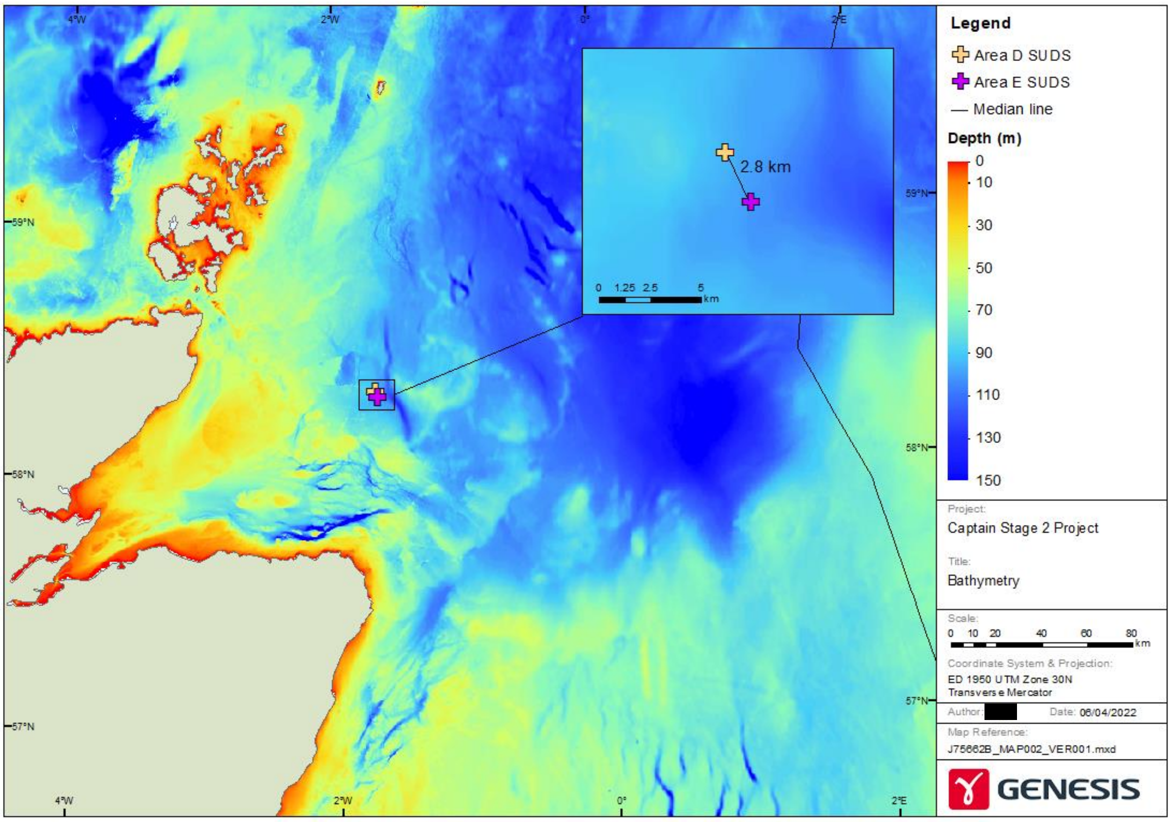

Figure 2-2: Bathymetry in the region of the piling locations.

2.2.3.2 Seabed Properties

The implemented propagation model accounts for attenuation effects due to interactions with the seabed. Sediments in the region of the piling locations are shown in Figure 2-3 (EMODnet, 2022b). The main sediment types in the region are offshore circalittoral muds and sands. However, the FARAM propagation model is limited to modelling a single seabed substrate. A sandy seabed has been assumed in the model. This is likely to be conservative since harder sediments such as sands and gravels typically result in longer range propagation compared to softer sediments such as muds and silts (Jensen *et al.*, 2011). The geo-acoustic properties associated with the seabed that have been used in the modelling are shown in Table 2-2 (Jensen *et al.*, 2011).

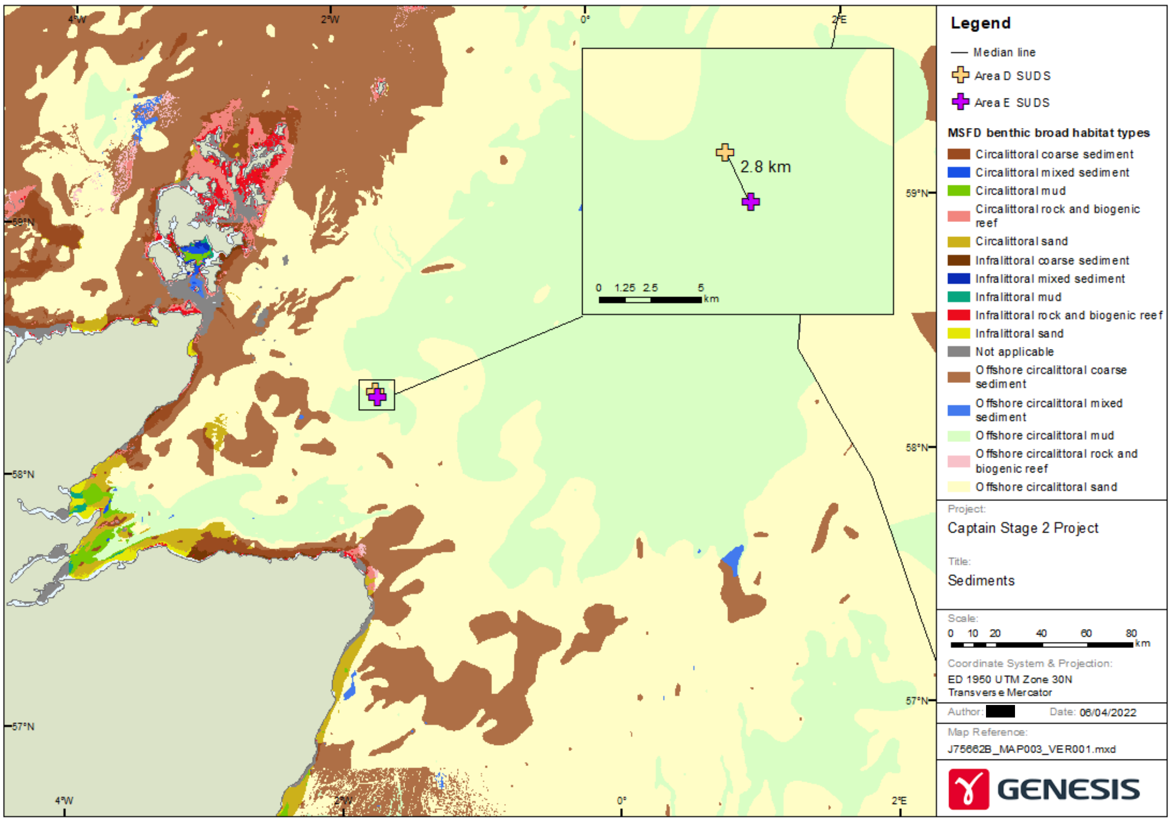

Figure 2-3: Sediments in the region of the piling locations.

Table 2-2: Geo-acoustic parameters of the seabed that have been used in the modelling.

Parameter	Value
Sediment type	Sand
Sound speed in sediment	1,650 m/s
Sound attenuation in sediment	0.8 dB/wavelength
Sediment density	1,900 kg/m^3

2.2.3.3 Sound Speed

A major factor that influences sound propagation in water is the speed of sound through the water column, which influences how sound refracts as it propagates through the water. FARAM allows for geographically and depth varying sound speed profiles. Sound speed data can be derived from water column temperature and salinity data (Jensen *et al*., 2011). Sound speed profiles for the model location were derived from temperature and salinity profiles taken from the World Ocean Atlas (WOA) from 2013 (WOA, 2013). Example temperature, salinity, and sound speed profiles used in the modelling are shown in Figure 2-4.

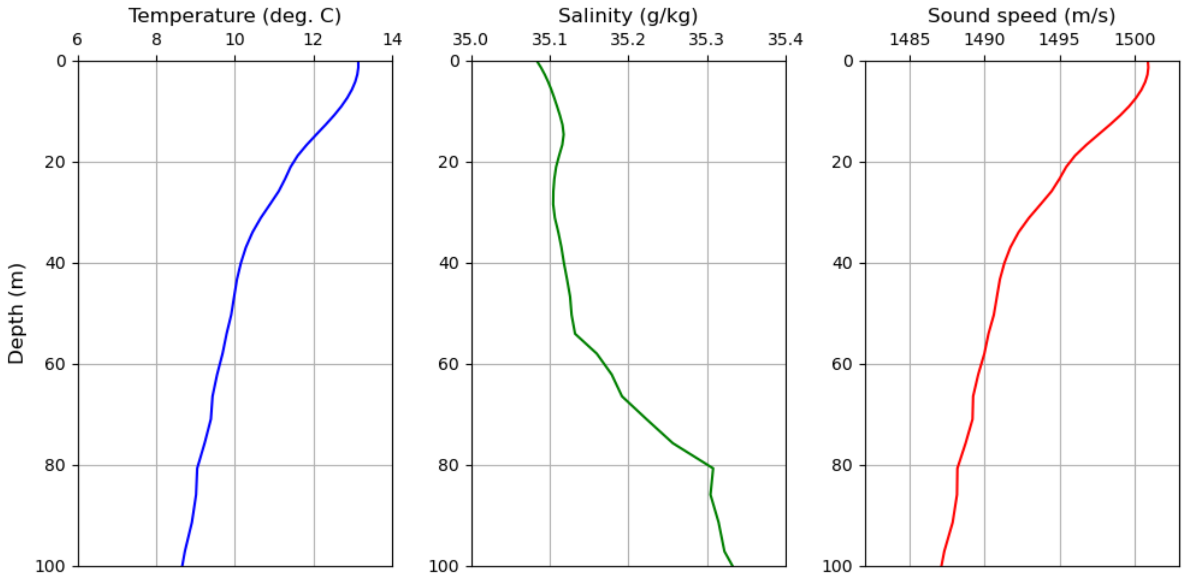

Figure 2-4: Example temperature, salinity, and sound speed depth profiles used in the modelling.

3.0 NOISE IMPACT ASSESSMENT METHODOLOGY

Sound is important to marine mammals and fish for navigation, communication, predator avoidance and prey detection. Underwater noise generated by human activities can have an adverse impact on marine mammals and fish (Richardson *et al.,* 1995; Southall *et al.,* 2007, 2019, 2021; National Marine Fisheries Service (NMFS), 2018; Popper *et al.,*). The thresholds adopted in this report for assessing potential impacts to marine mammals and fish are based on a comprehensive review of evidence of underwater noise impacts.

3.1 Marine Mammals

Potential impacts to marine mammals have been assessed in this report using thresholds for permanent threshold shift (PTS) and behavioural disturbance. PTS is a permanent change in a marine mammal's hearing sensitivity, whilst behavioural disturbance can vary from low level disturbance such as small changes in normal behaviour to higher levels of disturbance such as displacement from a favourable area.

3.1.1 PTS

PTS thresholds for marine mammals have been suggested by the National Oceanic and Atmospheric Administration (NOAA) (NMFS, 2018) and Southall *et al.* (2019) based on the most recent studies and are recognised as the appropriate criteria for assessing impacts to marine mammals from underwater noise. NOAA (NMFS, 2018) and Southall *et al.* (2019) proposed grouping marine mammals into functional hearing groups for assessing potential impacts. NOAA proposed grouping marine mammals into low frequency (LF) cetaceans, mid frequency (MF) cetaceans, high frequency (HF) cetaceans, otariid pinnipeds, phocid pinnipeds and sirenians. Southall *et al.* (2019) proposed equivalent hearing groups but renamed the MF cetacean and HF cetacean hearing groups as HF cetaceans and very high frequency (VHF) cetaceans, respectively. Table 3-1 shows marine mammal species that have been sighted in the North Sea and the Captain project area (Hammond *et al.*, 2021; Waggitt *et al.*, 2019; Russell *et al.*, 2017) categorised according to these hearing groups.

Table 3-1: Marine mammals commonly sighted in the North Sea and in the region of the project location categorised by hearing group.

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

[1] Species listed are the most sighted marine mammal species in the North Sea (Hammond *et al.,* 2021; Waggitt *et al.,* 2019; Russell *et al.,* 2017). Species highlighted in bold are those that are more likely to be present in the region of the Captain project area.

The PTS thresholds proposed by NOAA (NMFS, 2018) and Southall *et al.* (2019) are shown in Table 3-2. As dual-metric criteria, the onset of PTS is considered to potentially occur when noise levels exceed either the zero-to-peak SPL or cumulative SEL thresholds (NMFS, 2018; Southall *et al.,* 2019). The zero-to-peak SPL thresholds are unweighted and do not take into consideration the hearing range of any marine mammals. In contrast, the cumulative SEL thresholds are weighted and account for the hearing capabilities of marine mammals by frequency weighting received SELs using generalised auditory weighting functions. The auditory weighting functions proposed by NOAA and Southall *et al.* (2019) are shown in Figure 3-1 (note that the Southall *et al.,* (2019) nomenclature is used in this figure).

Table 3-2: NOAA (NMFS, 2018) and Southall *et al.* (2019) thresholds for PTS to marine mammals.

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

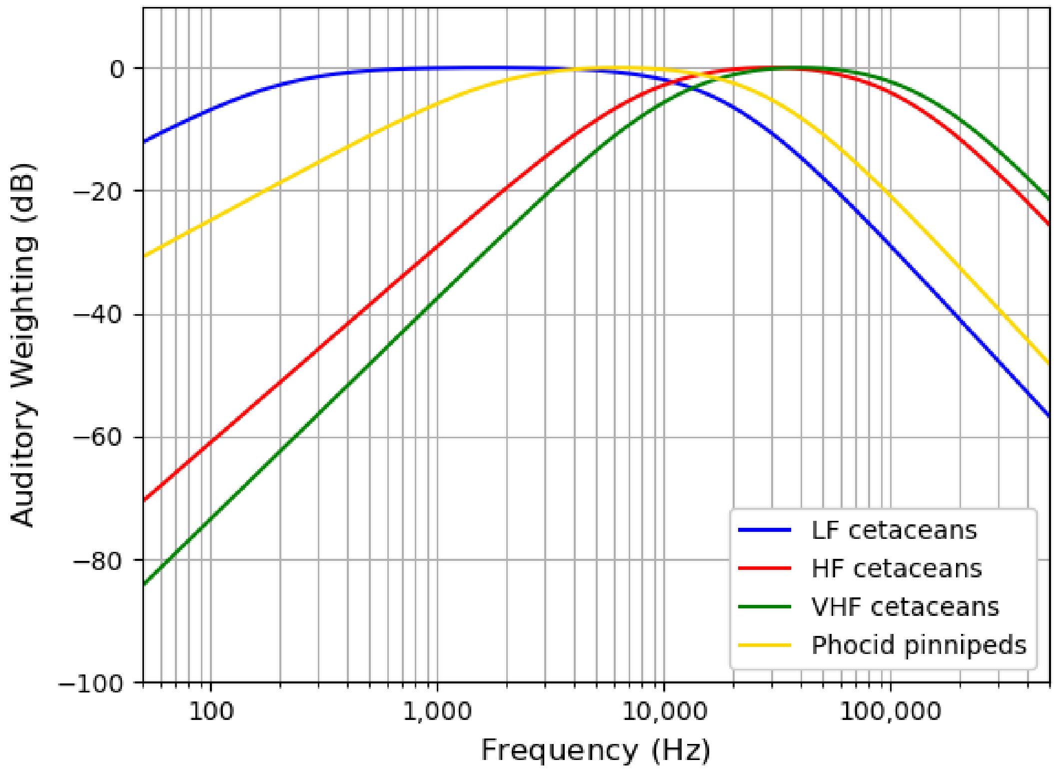

Figure 3-1: Auditory weighting functions for different marine mammal hearing groups.

In the remainder of this report, the Southall *et al.* (2019) nomenclature is used when referring to different marine mammal hearing groups. However, it is important to note that the Southall *et al.* (2019) threshold values and auditory weighting functions are the same for the comparative groups as those proposed by NOAA (NMFS, 2018). Therefore, the adoption of the Southall *et al.* (2019) guidance or NOAA (NMFS, 2018) guidance provides the same estimated impacts to marine mammals.

3.1.2 Disturbance

Thresholds for behavioural disturbance to marine mammals are less well defined compared to PTS thresholds. Numerous studies on marine mammal behavioural responses to sound exposure have not resulted in consensus regarding the appropriate metric or thresholds for assessing behavioural reactions. Southall *et al.* (2007; 2021) concluded that the available data on marine mammal behavioural responses were too variable and context-specific to justify proposing single value disturbance criteria. This is because different marine mammal species and even different individuals from the same species can exhibit a wide range of responses to the same sound (Southall *et al.*, 2007, 2021; NMFS, 2018).

Thompson *et al.* (2013) showed that harbour porpoises exhibited avoidance from a seismic survey at unweighted SELs between 145 - 151 dB re 1 µPa^{2}s. Lucke *et al.* (2009) also reported that a captive harbour porpoise consistently showed behavioural responses at unweighted SELs exceeding 145 dB re 1 µPa^{2}s. Based on these results, and given the lack of evidence of specific disturbance thresholds for other species, Tougaard (2016) suggested that behavioural disturbance to all marine mammal species should be assessed using an unweighted SEL threshold of 145 dB re 1 µPa^{2}s. This threshold is adopted in this report for estimating potential behavioural disturbance to all marine mammals (Table 3-3).

This threshold suggested by Tougaard (2016) was derived based on measurements of harbour porpoise disturbance from airgun arrays (Thompson *et al.,* 2013; Lucke *et al.,* 2009). However, this threshold is also thought to be relevant to piling (Tougaard, 2016). Brandt *et al.* (2016) analysed the effect of piling on harbour porpoise from the construction of eight offshore wind farms within the German North Sea between 2009 and 2013. Harbour porpoise monitoring data from using porpoise detectors was combined with aerial survey and noise level data. The results showed that detections of harbour porpoise during piling declined by less than 20% at SELs below 145 dB re 1 µPa^{2}s and that displacement of harbour porpoise at SELs below 145 dB re 1 µPa^{2}s could not clearly be related to the noise from the piling.

The adoption of the threshold in Table 3-3 may overestimate behavioural disturbance impacts to marine mammal species other than harbour porpoise (Tougaard, 2016). This is because it is thought that harbour porpoises are more sensitive to underwater noise than many other species. This is supported by the fact that the PTS thresholds for VHF cetaceans (the hearing group which harbour porpoise belong to) are significantly lower than the thresholds for all other hearing groups (see Table 3-2), suggesting that they are more sensitive to underwater noise than other species.

Table 3-3: Marine mammal behavioural disturbance thresholds.

Criteria	SEL Behavioural Disturbance Threshold (dB re 1 µPa^{2}s)
Tougaard (2016) criteria for behavioural disturbance to all marine mammals	145

3.2 Fish

3.2.1 Injury

Popper *et al*. (2014) have defined criteria for injury to fish based on a comprehensive review of publications related to impacts from various high-energy sources including piling. Injury thresholds are derived in Popper *et al*. (2014) for:

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

The thresholds for potential injury to fish species, eggs and larvae, and sea turtles proposed in Popper *et al*. (2014) are shown in Table 3-4.

Table 3-4: Thresholds for potential injury to fish, and fish eggs and larvae.

Fish Group	Potential Mortal Injury Thresholds	
	Zero-to-peak SPL (dB re 1 µPa)	Cumulative SEL (dB re 1 µPa^{2}s)
Fishes with no swim bladder	213	219
Fishes with swim bladder involved in hearing	207	207
Fishes with swim bladder not involved in hearing	207	210
Eggs and larvae	207	210

3.2.2 Behavioural Disturbance

Documented disturbance effects of underwater noise on fish behaviour are variable, ranging from no discernible effect (Wardle *et al.,* 2001) to startle reactions followed by immediate resumption of normal behaviour (Wardle *et al*., 2001; Hassel *et al*., 2004). Avoidance of airgun noise has also been observed (Hassel *et al*., 2004).

Despite some documented behavioural disturbance effects, there are no well-established criteria or thresholds for assessing behavioural disturbance to fish from underwater noise. In fact, it was concluded in Popper *et al*. (2014) that there lacked sufficient evidence to recommend specific thresholds that correspond to behavioural disturbance for fish. Therefore, a quantitative assessment of behavioural disturbance to fish and fish eggs and larvae is not considered in this report.

4.0 MODELLING RESULTS AND IMPACT ASSESSMENT

This section presents the noise propagation modelling and impact assessment results for the proposed piling activities.

4.1 Marine Mammals

4.1.1 PTS

Received noise levels from the piling of the SUDSs have been predicted in terms of unweighted zero-to-peak SPL to identify potential areas where the instantaneous onset of PTS may occur to marine mammals. Figure 4-1 shows the predicted zero-to-peak SPL received by marine mammals when the hammer is operating at an energy of 20 kJ (most likely maximum hammer energy), whilst Figure 4-2 shows the predicted zero-to-peak SPL with the hammer operating at an energy of 90 kJ (worst-case maximum hammer energy). The contours in Figure 4-1 and Figure 4-2 highlight the zero-to-peak SPL thresholds for the potential onset of PTS to marine mammals.

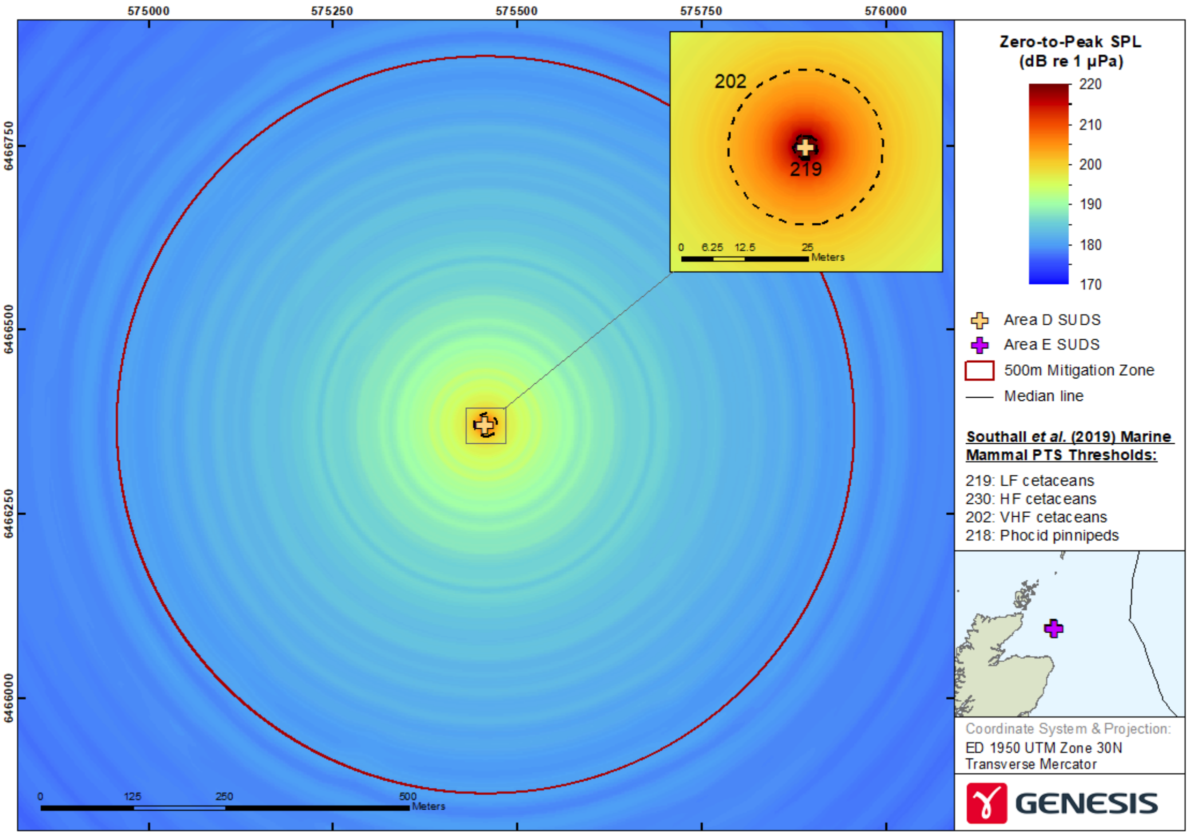

Figure 4-1: Predicted zero-to-peak SPL received by marine mammals during piling with the hammer operating at 20 kJ (most likely maximum hammer energy).

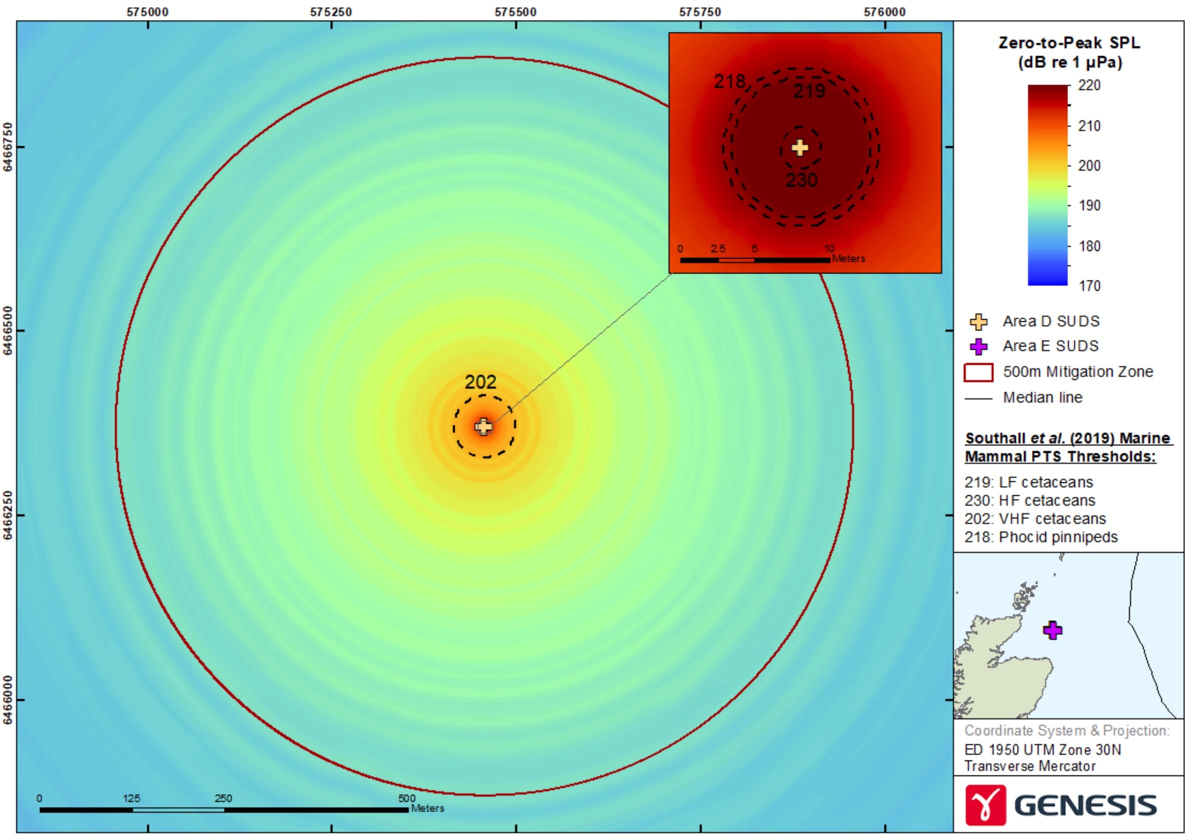

Figure 4-2: Predicted zero-to-peak SPL received by marine mammals during piling with the hammer operating at 90 kJ (worst-case maximum hammer energy).

The predicted maximum distances where the zero-to-peak SPL thresholds for PTS onset are exceeded during the piling are summarised in Table 4-1. It is predicted that the zero-to-peak SPL noise levels generated during the piling will not exceed the PTS thresholds for any marine mammal hearing group outside the standard 500 m mitigation zone that will be employed during piling operations. If any marine mammals are observed or detected in the 500 m mitigation zone before the start of piling, the piling will be delayed until all marine mammals have vacated the mitigation zone. With this mitigation measure in place, the probability of zero-to-peak SPL noise levels generated during the piling causing PTS to marine mammals is predicted to be low.

Table 4-1: Predicted maximum distances from the piling location where the zero-to-peak SPL thresholds for PTS onset to marine mammals are exceeded.

Marine Mammal Hearing Group	Zero-to-peak SPL PTS Threshold (dB re 1 µPa)	Maximum Distance to Threshold Exceedance (m) [1]
Maximum hammer energy of 20 kJ (most likely maximum hammer energy)		
LF cetaceans	219	10
HF cetaceans	230	10
VHF cetaceans	202	20
Phocid pinnipeds	218	10
Maximum hammer energy of 90 kJ (worst-case maximum hammer energy)		
LF cetaceans	219	10
HF cetaceans	230	10
VHF cetaceans	202	50
Phocid pinnipeds	218	10
[1] Predicted distances have been rounded up to the nearest 10 m.		

The cumulative SEL received by marine mammals over a full day of piling has been predicted and compared to the PTS thresholds. In the cumulative SEL modelling scenarios it is assumed that 8 piles will be installed in a single day with each pile taking one hour to install (see Table 1-1). Both the most likely maximum energy and worst-case maximum energy piling procedures shown in Table 2-1 have been modelled for the installation of each pile.

Following the guidance of Southall *et al.* (2019), the cumulative SELs received by marine mammals have been calculated by weighting the received SELs from each pile strike using the auditory weighting functions shown in Figure 3-1 and integrating the sound exposure over the full piling duration. Marine mammals have been simulated as swimming away from the piling location at the onset of piling, which has been observed during piling activities (Brandt *et al.*, 2011, 2016, 2018; Carstensen *et al.*, 2006; Dahne *et al.*, 2013). The received cumulative SEL has been calculated for marine mammals swimming away from the piling location at a constant swim speed of 2 m/s. Results are presented showing the furthest distance that marine mammals must be from the piling location at the start of the piling in order to not be exposed to cumulative SEL exceeding the PTS threshold when they swim away.

The predicted initial distances that marine mammals must be from the piling location at the start of piling in order to not be exposed to cumulative SELs exceeding the PTS thresholds after they swim away are shown in Table 4-2. The modelling predicts that the PTS thresholds will not be exceeded for any marine mammals when they swim away from the piling location. Therefore, the probability of cumulative SELs causing PTS to marine mammals is predicted to be low.

Table 4-2: Predicted maximum distances that marine mammals must be from the piling location at the start of piling in order to not be exposed to cumulative SEL exceeding the PTS thresholds when they swim away.

Marine Mammal Hearing Group	Cumulative SEL Threshold for PTS (dB re 1 µPa²s)	Swim Speed (m/s)	Maximum Distance to Threshold Exceedance (m) [1]
Maximum hammer energy of 20 kJ (most likely maximum hammer energy)			
LF cetaceans	183	2	Threshold not exceeded
HF cetaceans	185	2	Threshold not exceeded
VHF cetaceans	155	2	Threshold not exceeded
Phocid pinnipeds	185	2	Threshold not exceeded
Maximum hammer energy of 90 kJ (worst-case maximum hammer energy)			
LF cetaceans	183	2	Threshold not exceeded
HF cetaceans	185	2	Threshold not exceeded
VHF cetaceans	155	2	Threshold not exceeded
Phocid pinnipeds	185	2	Threshold not exceeded
[1] Predicted distances have been rounded up to the nearest 10 m.			

4.1.2 Disturbance

Behavioural disturbance to all marine mammal species has been estimated based on comparison of single-pulse SELs with the threshold of 145 dB re 1 µPa²s suggested by Tougaard (2016). Figure 4-3 shows the maximum predicted unweighted single-pulse SEL during piling at a single location with the hammer operating at maximum hammer energy of 20 kJ (most likely maximum hammer energy), whilst Figure 4-4 shows the corresponding maximum predicted unweighted single-pulse SEL with the hammer operating at maximum hammer energy of 90 kJ (worst-case maximum hammer energy). The contours highlighted in these figures signify the adopted threshold for assessing potential disturbance to all marine mammals.

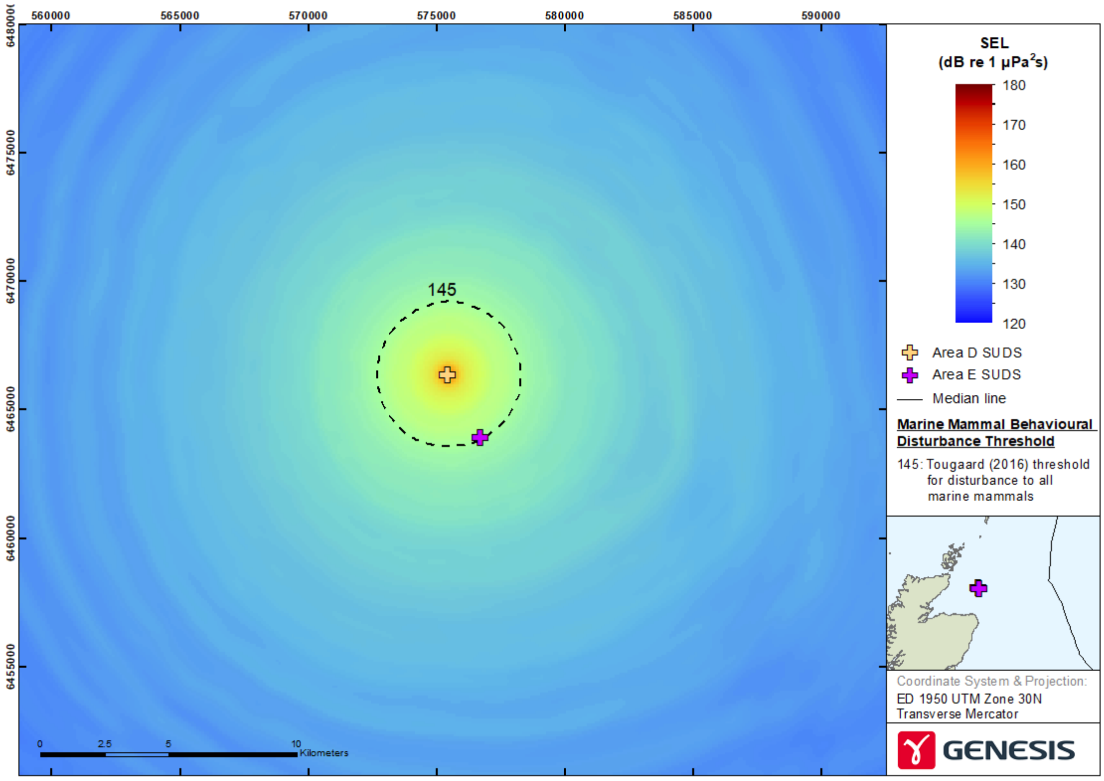

Figure 4-3: Predicted unweighted single-pulse SEL received by marine mammals during piling at a single location with the hammer operating at 20 kJ (most likely maximum hammer energy).

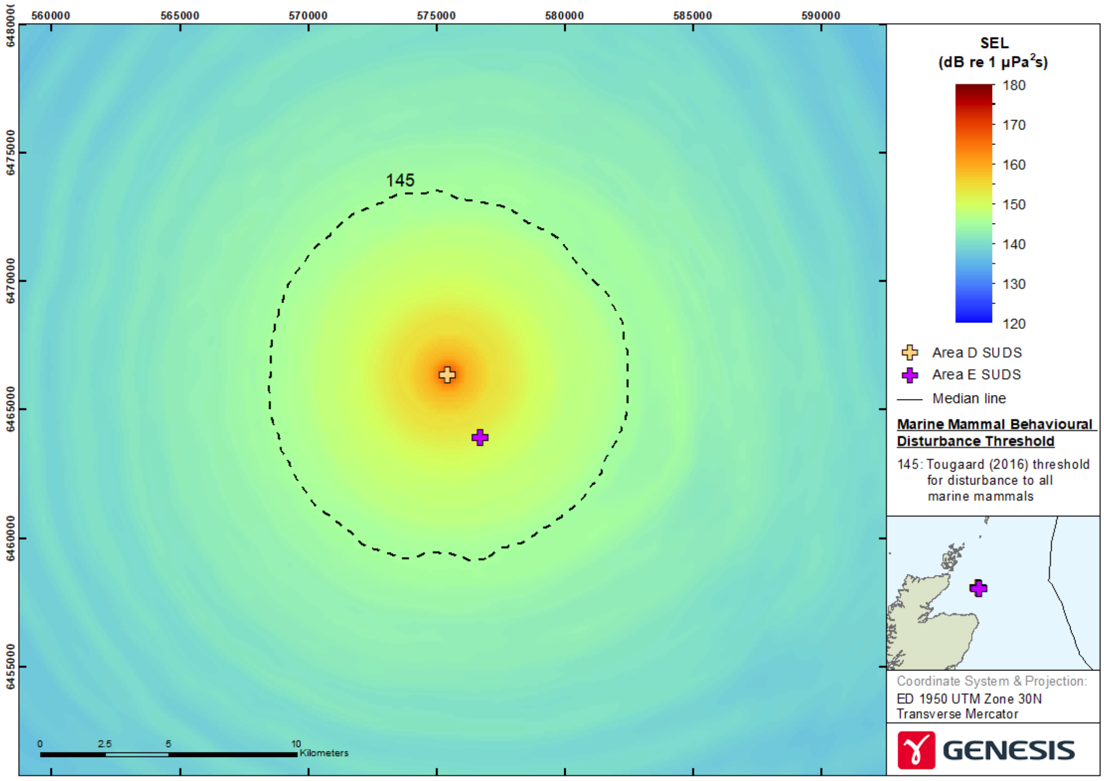

Figure 4-4: Predicted unweighted single-pulse SEL received by marine mammals during piling at a single location with the hammer operating at 90 kJ (worst-case maximum hammer energy).

Table 4-3 summarises the predicted distances from the piling locations where behavioural disturbance might occur to marine mammals during the piling at Captain. The modelling predicts that disturbance to marine mammals could potentially occur at a distance of 3 km if the hammer operates at a maximum energy of 20 kJ, and at a distance of 8 km if the hammer operates at a maximum energy of 90 kJ.

Aerial surveys conducted during piling with a 500 kJ hammer at the Alpha Ventus Offshore Wind Farm (Dahne *et al.,* 2013) showed that significant displacement of harbour porpoise occurred at approximately 10 km from the piling location, although some harbour porpoise could be displaced at distances of up to 25 km. Using noise measurements and harbour porpoise monitoring data from the piling of eight offshore wind farms in the German North Sea, Brandt *et al.* (2016) showed that detections of harbour porpoise during piling declined by less than 20% at distances of 10 to 15 km from the piling location where the SEL was below 145 dB re 1 μPa^2s (the threshold for disturbance adopted in this assessment). The predicted distances where disturbance may occur to marine mammals for piling at Captain (3 – 8 km) are lower than those reported in Dahne *et al.* (2013) and Brandt *et al.* (2016). This is because the piling at Captain will be conducted using a relatively small maximum hammer energy (20 – 90 kJ) and will generate lower noise levels compared to the hammers used during piling of the offshore wind farms examined by Dahne *et al.* (2013) and Brandt *et al.* (2016).

Table 4-3: Predicted maximum distances where the adopted marine mammal behavioural disturbance threshold is exceeded.

Criteria	SEL Behavioural Disturbance Threshold (dB re 1 μPa^2s)	Maximum Distance to Threshold Exceedance (km) [1]
Maximum hammer energy of 20 kJ (most likely maximum hammer energy)		
Tougaard (2016) criteria for behavioural disturbance to all marine mammals	145	3
Maximum hammer energy of 90 kJ (worst-case maximum hammer energy)		
Tougaard (2016) criteria for behavioural disturbance to all marine mammals	145	8
[1] Predicted distance have been rounded up to the nearest 1 km.		

The combined maximum unweighted single-pulse SEL has been predicted for the installation of all eight piles (four at Area D and four at Area E). Figure 4-5 shows the predicted combined unweighted single-pulse SELs for the installation of all piles with the hammer operating at maximum hammer energy of 20 kJ (most likely maximum hammer energy), whilst Figure 4-6 shows the corresponding maximum predicted combined unweighted single-pulse SELs with the hammer operating at maximum hammer energy of 90 kJ (worst-case maximum hammer energy).

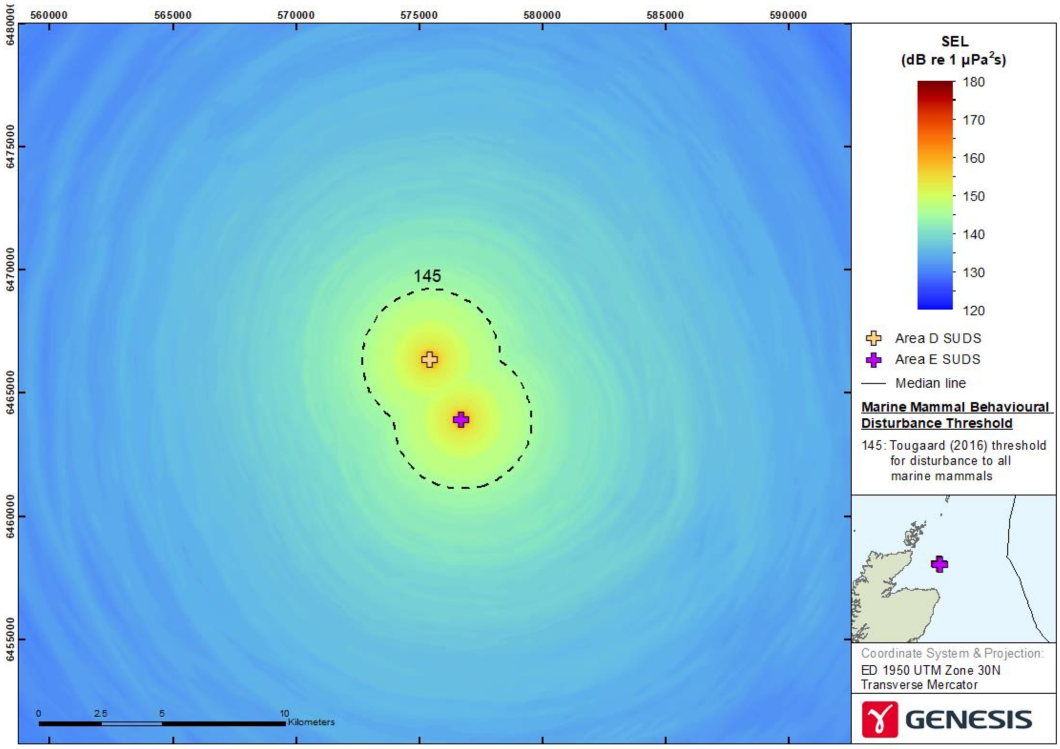

Figure 4-5: Predicted unweighted single-pulse SEL received by marine mammals for the installation of all eight piles with the hammer operating at 20 kJ (most likely maximum hammer energy).

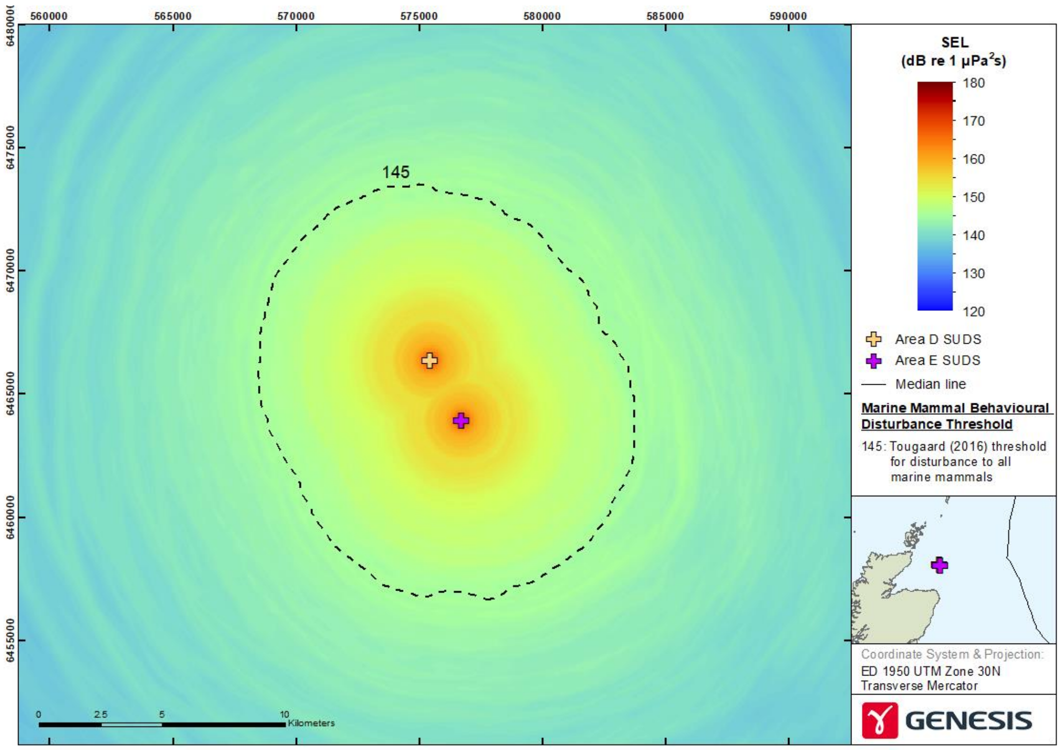

Figure 4-6: Predicted unweighted single-pulse SEL received by marine mammals for the installation of all eight piles with the hammer operating at 90 kJ (worst-case maximum hammer energy).

Based on the predicted disturbance areas shown in Figure 4-5 and Figure 4-6, the number of marine mammals that may be disturbed during piling at Captain have been predicted using the Small Cetaceans Abundance Surveys (SCANS)-III densities (Hammond *et al.,* 2021) and seal densities from Russel *et al.* (2017). The estimated number of marine mammals that could potentially be disturbed during the piling are shown in Table 4-4. The predicted number of harbour porpoises, white-beaked dolphins, white-sided dolphins, minke whales and grey seals that could potentially be disturbed during piling at Captain are relatively small compared to the management unit (MU) populations (Inter-Agency Marine Mammal Working Group (IAMMWG), 2021).

Table 4-4: Estimated number of marine mammals and percentages of MU populations that may be disturbed by the piling at Captain.

Species	Disturbance Area (km^2)	Density (animals/km^2) [1]	Number of Mammals Disturbed	MU Population [2]	Percentage of MU Population Disturbed (%)
Maximum hammer energy of 20 kJ (most likely maximum hammer energy)					
Harbour porpoise	40	0.402	17	346,601	0.005
White-beaked dolphin	40	0.037	2	43,951	0.005
White-sided dolphin	40	0.0209	1	18,128	0.006
Minke whale	40	0.032	2	20,118	0.010
Grey seal	40	0.04 – 0.2	2 – 8	N/A	N/A
Maximum hammer energy of 90 kJ (worst-case maximum hammer energy)					
Harbour porpoise	196	0.402	79	346,601	0.023
White-beaked dolphin	196	0.037	8	43,951	0.018
White-sided dolphin	196	0.0209	5	18,128	0.028
Minke whale	196	0.032	7	20,118	0.035
Grey seal	196	0.04 – 0.2	8 – 40	N/A	N/A

[1] Cetacean densities are from SCANS-III data (Hammond *et al*., 2021) and seal densities are from Russell *et al.* (2017).

[2] MU populations are from IAMMWG (2021).

Studies based on impacts arising from piling noise have indicated that displaced marine mammals return to the area within relatively short periods of time, usually within three days once the piling has ceased (Brandt *et al.,* 2011, 2016, 2018; Carstensen *et al.,* 2006). It has been demonstrated that even long-term piling over several months or years (e.g. during the construction of wind-farms) is unlikely to have a significant long-term impact on marine mammal populations levels (Nabe-Nielsen *et al.,* 2018; Nabe-Nielsen, 2020).

The piling at Captain is expected to be completed within a single day and it is expected that any marine mammals disturbed will return to the area within a short period of time after the piling has finished. Given the small estimated number of marine mammals that may be disturbed and the short duration of the piling at Captain, it is concluded that the piling at Captain will not have a significant adverse effect on any marine mammal population.

4.2 Fish

4.2.1 Injury

To quantitatively assess any potential injury to fish and fish eggs and larvae from the proposed piling at Captain, received noise levels in terms of unweighted zero-to-peak SPL and unweighted cumulative SEL have been predicted and compared to the Popper *et al*. (2014) thresholds for injury (Table 3-4).

Figure 4-7 shows the predicted zero-to-peak SPL received by fish species and fish eggs and larvae when the hammer is operating at an energy of 20 kJ (most likely maximum hammer energy), whilst Figure 4-8 shows the predicted zero-to-peak SPL with the hammer operating at an energy of 90 kJ (worst-case maximum hammer energy). The contours in these figures highlight the Popper *et al*. (2014) zero-to-peak SPL thresholds for potential injury to fish species and fish eggs and larvae.

The predicted distances where the zero-to-peak SPL thresholds for injury to fish species and fish eggs and larvae are exceeded are shown in Table 4-5. It is predicted that injury to the most sensitive fish species and eggs and larvae will be limited to a maximum distance of 20 m from the piling locations.

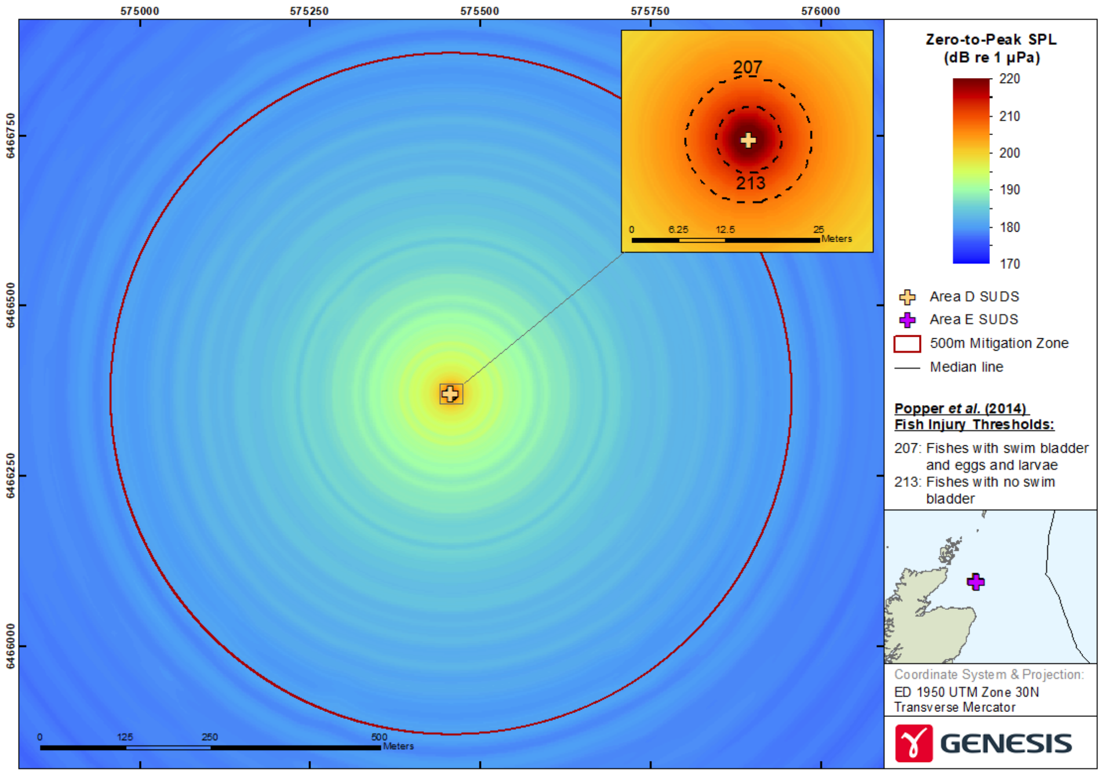

Figure 4-7: Predicted zero-to-peak SPL received by fish during piling with the hammer operating at 20 kJ (most likely maximum hammer energy).

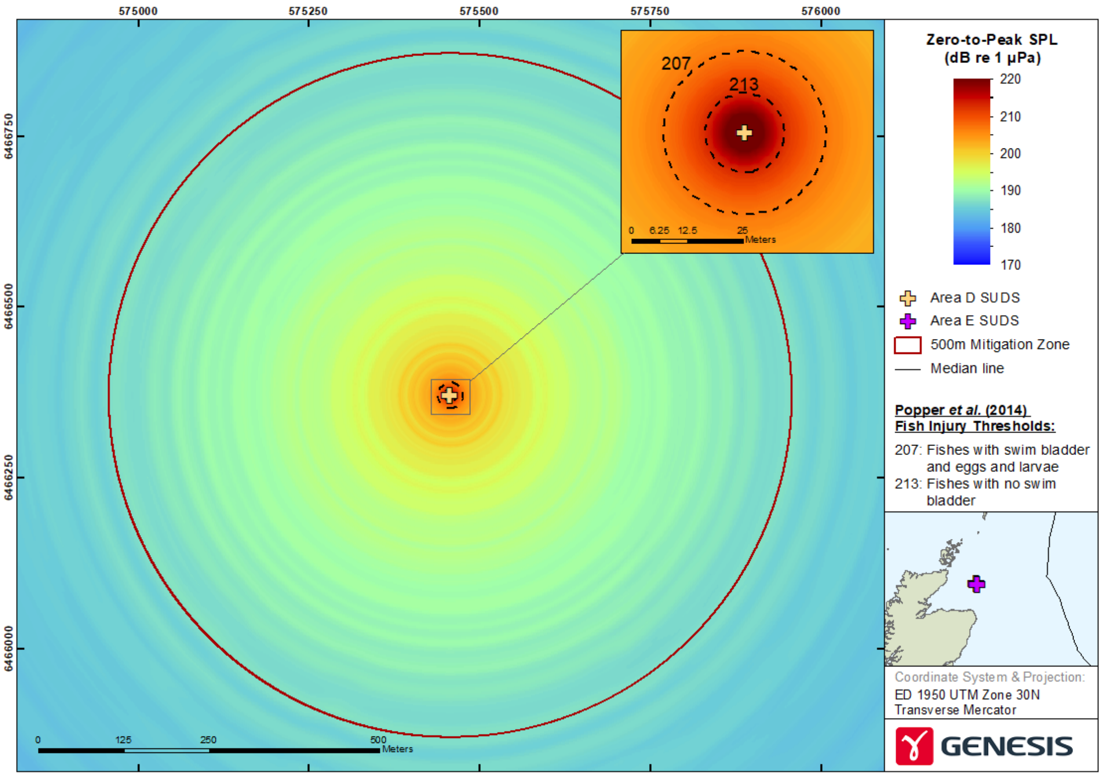

Figure 4-8: Predicted zero-to-peak SPL received by fish during piling with the hammer operating at 90 kJ (worst-case maximum hammer energy).

Table 4-5: Predicted maximum distances from the piling location where the zero-to-peak SPL thresholds for injury to fish and fish eggs and larvae are exceeded.

Fish Group	Zero-to-peak SPL Injury Threshold (dB re 1 µPa)	Maximum Distance to Threshold Exceedance (m) [1]
Maximum hammer energy of 20 kJ (most likely maximum hammer energy)		
Fishes with no swim bladder	213	10
Fishes with swim bladder involved in hearing	207	10
Fishes with swim bladder not involved in hearing	207	10
Eggs and larvae	207	10
Maximum hammer energy of 90 kJ (worst-case maximum hammer energy)		
Fishes with no swim bladder	213	10
Fishes with swim bladder involved in hearing	207	20
Fishes with swim bladder not involved in hearing	207	20
Eggs and larvae	207	20
[1] Predicted distances have been rounded up to the nearest 10 m.		

The cumulative SEL received by fish species and fish eggs and larvae has also been calculated. In the cumulative SEL modelling it is assumed that mobile fish will swim away from the piling location at 0.5 m/s, whilst fish eggs and larvae are assumed to remain stationary throughout the piling. The predicted minimum initial distances that fish must be from the pile sound source at the start of pile driving operations (i.e. safety distances) in order not to be exposed to cumulative SELs above the Popper *et al*. (2014) thresholds for potential injury are summarised in Table 4-6. The modelling predicts that the cumulative SEL injury thresholds will not be exceeded if fish swim away from the piling location at 0.5 m/s. It is predicted that fish eggs and larvae that cannot move away from the piling may potentially be injured at distances of up to 10 m from the piling location. However, given the small impact area compared to the large spawning grounds in the North Sea, it is not expected that the piling operations at Captain will have a significantly adverse effect on any spawning fish.

Table 4-6: Predicted maximum distances that fish species and fish eggs and larvae must be from the piling location at the start of piling in order to not be exposed to cumulative SEL exceeding injury thresholds when they swim away.

Fish Group	Cumulative SEL Injury Threshold (dB re 1 µPa^{2}s)	Swim Speed (m/s)	Maximum Distance to Threshold Exceedance (m) [1]
Maximum hammer energy of 20 kJ (most likely maximum hammer energy)			
Fishes with no swim bladder	219	0.5	Threshold not exceeded
Fishes with swim bladder involved in hearing	207	0.5	Threshold not exceeded
Fishes with swim bladder not involved in hearing	210	0.5	Threshold not exceeded
Eggs and larvae	210	Stationary	10
Maximum hammer energy of 90 kJ (worst-case maximum hammer energy)			
Fishes with no swim bladder	219	0.5	Threshold not exceeded
Fishes with swim bladder involved in hearing	207	0.5	Threshold not exceeded
Fishes with swim bladder not involved in hearing	210	0.5	Threshold not exceeded
Eggs and larvae	210	Stationary	10
[1] Predicted distances have been rounded up to the nearest 10 m.			

4.2.2 Disturbance

A quantitative assessment of behavioural disturbance to fish could not be conducted since there are no well-established disturbance thresholds for fish. However, if fish are disturbed by noise, evidence suggests they will return to an area once the activity generating the noise has ceased (Slabbekoorn *et al*., 2010). The piling at Captain is expected to be completed in a single day. Any disturbance to fish is expected to be of a short duration and therefore it is concluded that the piling at Captain will not have a significant impact on any fish species.

5.0 MITIGATION MEASURES

To minimise the risk of potential impacts of noise from the piling, the following mitigation measures recommended by the Joint Nature Conservation Committee (JNCC) 'Guidelines for minimising the risk of injury to marine mammals from piling noise' (JNCC, 2010) will be adhered to:

- A qualified, trained and equipped marine mammal observer (MMO) will be present. The MMO will carry out a pre-piling survey of a 500 m mitigation zone and, if an animal is detected, the piling will be delayed until all marine mammals vacate the 500 m mitigation zone;
- A soft-start/ramp-up of hammer energy will be employed where the hammer will commence at a low energy at the start of piling. The soft-start will be such that maximum hammer energy will not be reached until after a period of 20 minutes; and
- Passive Acoustic Monitoring (PAM) will be employed during periods of low visibility to detect marine mammal presence.

6.0 CONCLUSIONS

This report has presented underwater noise propagation modelling results for assessing the potential impacts that piling of the SUDSs may have on marine mammals and fish species and fish eggs and larvae. The modelling results were used to assess any potential impacts to marine mammals based on a comparison of estimated received noise levels with the Southall *et al.* (2019) thresholds for potential PTS onset and relevant thresholds for behavioural disturbance. Potential injury to fish species and fish eggs and larvae was also assessed by comparing predicted noise levels to the injury thresholds established by Popper *et al*. (2014).

The modelling results indicate that the likelihood of marine mammals being exposed to noise levels that may cause PTS during the piling is low and will be minimised to negligible levels when the standard JNCC (2010) 'Guidelines for minimising the risk of injury to marine mammals from piling noise' are followed.

The modelling predicts that behavioural disturbance to marine mammals could potentially occur at 3 – 8 km from the piling locations. However, any behavioural disturbance that may occur will only be temporary since the piling is expected to be completed within a single day. If any marine mammals are disturbed, they will likely return to the area within a short period of time (one to three days) once the piling has finished. Therefore, it is not expected that the piling at Captain will have any long-term significant effects on any marine mammal populations.

The modelling results indicate that injury to fish species and fish eggs and larvae during the piling will be localised to the immediate vicinity of the piling locations (within 20 m). Given the small predicted areas where fish eggs and larvae may suffer injury relative the large spawning areas across the North Sea it is not expected that the piling at Captain will have a significant effect on spawning fish.

It is concluded that the piling of the SUDSs will not have a significant impact on marine mammals, fish, and fish eggs and larvae.

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APPENDIX E – ADDITIONAL SUPPORTING MATERIAL

Section 3.9.1 presents the high-case oil production profiles associated with the proposed Captain EOR Stage 2 Phase II Project, whilst Table D-1 also includes the profiles for the mid- and low-case profiles.

Table: D- 1: High-, low- and mid- case oil profiles associated with the proposed Captain EOR Stage 2 Phase II Project.

Year	Base Case (without the proposed Captain EOR Stage 2 Phase II Project)		With Captain EOR Stage 2 Phase II					
			High Case		Mid Case		Low Case	
	bbl/d	tonnes/d	bbl/d	tonnes/d	bbl/d	tonnes/d	bbl/d	tonnes/d
2021	22.9000	3385.95	22,901.62	3,386,191	22,901.62	3,386,191	22,901.62	3,386,191
2022	24.6400	3643.23	25,961.44	3,838,612	25,157.76	3,719,780	25,804.33	3,815,382
2023	25.8500	3822.13	28,053.10	4,147,881	27,912.64	4,127,112	28,241.87	4,175,792
2024	26.3200	3891.63	35,243.96	5,211,108	35,049.86	5,182,409	32,579.02	4,817,074
2025	27.2200	4024.70	48,971.31	7,240,809	49,857.08	7,371,778	42,280.52	6,251,521
2026	22.8200	3374.12	47,254.20	6,986,920	45,158.47	6,677,050	39,311.67	5,812,553
2027	15.6500	2313.98	40,215.40	5,946,176	33,685.44	4,980,668	28,122.45	4,158,135
2028	13.0700	1932.51	33,510.81	4,954,847	26,378.91	3,900,337	21,744.83	3,215,151
2029	10.5900	1565.82	27,689.75	4,094,157	19,860.94	2,936,602	16,106.11	2,381,420
2030	9.0300	1335.16	19,115.79	2,826,427	15,882.15	2,348,306	11,692.15	1,728,780
2031	7.7200	1141.47	11,550.68	1,707,862	11,110.59	1,642,791	9,439.44	1,395,699
2032	7.0400	1040.92	9,375.17	1,386,196	7,541.19	1,115,026	6,968.58	1,030,362
2033	6.4800	958.12	7,592.13	1,122,558	6,185.62	914,595	5,934.36	877,444
2034	6.1000	901.93	5,574.88	824,291	5,519.56	816,113	5,474.36	809,429
2035	5.9500	879.76	5,022.14	742,565	5,165.10	763,703	5,370.99	794,145

Section 3.9.2 presents the high-case gas production profiles associated with the proposed Captain EOR Stage 2 Phase II Project, whilst Table D-2 also includes the profiles for the mid- and low- case profiles.

Table D-2: High-, low- and mid- case gas profiles associated with the proposed Captain EOR Stage 2 Phase II Project.

Year	Base Case (without the proposed Captain EOR Stage 2 Phase II Project) m^3/day	With Captain EOR Stage 2 Phase II (m^3/day)		
		High Case	Mid Case	Low Case
2021	127,427	127,106	127,106	127,106
2022	135,922	144,173	140,053	154,174
2023	144,417	158,711	156,614	157,509
2024	147,248	185,955	201,697	202,934
2025	150,080	247,028	295,301	289,657
2026	127,427	231,724	268,976	282,328
2027	87,783	166,326	201,770	243,374
2028	73,624	127,812	157,337	202,777
2029	59,466	93,919	117,842	167,772
2030	50,971	67,077	93,772	114,375
2031	42,476	53,800	64,447	67,251
2032	39,644	38,614	42,262	53,947
2033	36,812	32,487	34,088	43,049
2034	33,980	29,866	30,154	30,507
2035	33,980	29,332	28,021	27,110