STANDARD INFORMATION SHEET

Project Name	Curlew Decommissioning
Development Location	Curlew Cluster – Block 29/07
Project Reference Number	CDP-PT-HE-0702-00003
Type of Project	Decommissioning
Undertaker	Shell U.K. Limited 1 Altens Farm Road Nigg Aberdeen AB12 3FY
Licensees/Owners	Shell UK Limited (operator) Esso
Short Description	Shell proposes to decommission the Curlew field cluster consisting of the FPSO, three fields with associated subsea infrastructure, and the gas export pipeline. Following the cessation of production, the subsea infrastructure will be flushed, topside processes will be drained, flushed, purged and vented, and the FPSO will be disconnected and recycled. All subsea structures, exposed mattresses and grout bags will be removed. Pipelines and umbilicals will be decommissioned as per operations described in the Comparative Assessment Results Report. Following completion of the decommissioning activities, debris clearance survey and overtrawl trails will be carried out to ensure the seabed is left in a safe condition for other users.
Key Dates	Cessation of Production (CoP) – Q1/Q2 2019
Significant Environmental Effects Identified	No significant impacts identified after implementation of mitigation measures.
Report Prepared by	Advisian Ltd and BMT Cordah Ltd

Rev #	Date of Issue	Status Description	Originator	Checker	Approver
R01	13/08/2017	IFR– Issue for Review	G Jones	C Hawkings C Coleby	Tanya Romanenko
R02	26/11/2017	IFR – Issued for Review	G Jones C McCabe Ria McCann	C Hawkings C Coleby	Tanya Romanenko
R03	19/01/2018	IFR – Issued for Review	G Jones M Brosa	C Hawkings C Coleby	Tanya Romanenko
R04	20/04/2018	IFR– Issue for Review	Estera Zak Paul Wood	Paul Wood	Trevor Crowe
A01	15/05/2018	IFA – Issue for Approval	Estera Zak Paul Wood	Paul Wood	Trevor Crowe

NON-TECHNICAL SUMMARY

BACKGROUND

The Curlew Oil and Gas (O&G) offshore facility (referred to as the Curlew cluster) is situated in the Central North Sea (CNS) on the United Kingdom Continental Shelf (UKCS) Block 29/07 (refer to Figure 1). It is located approximately 210 km east of the Aberdeenshire coastline and 55 km west of the UK/Norway median line, in a water depth of approximately 92 m. The facility consists of a central processing Floating Production, Storage and Offloading (FPSO) vessel with three subsea field tie-backs and is connected into the Fulmar Gas Line (FGL) for export to St Fergus.

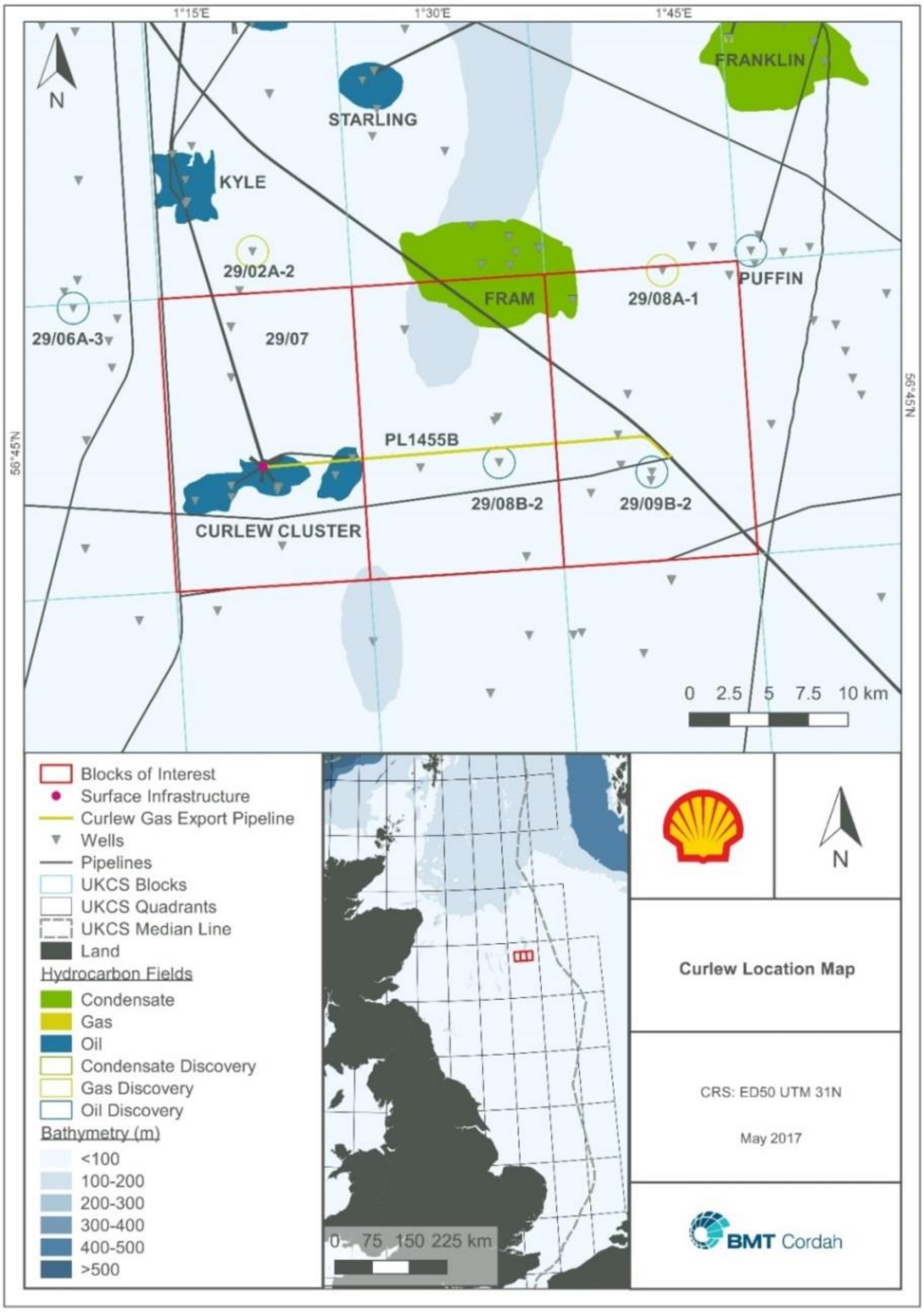


Figure 1 Location of the Curlew Cluster Infrastructure in the CNS

The FPSO is expected to reach the end of its economic and technical life in 2019. Shell proposes to decommission the FPSO and associated subsea production elements and facilities following Cessation of Production (CoP) in Q1/Q2 of 2019, unless plant failure or other issues make it uneconomical to continue, at which point CoP may occur sooner.

It is now considered that no specific foreseeable commercial opportunity exists for the re-use of the Curlew infrastructure that would warrant postponing decommissioning and extending the field's life.

Shell requested CoP on the Curlew FPSO facility in April 2016. A window of 2016 to 2019 has been agreed with the Oil & Gas Authority (OGA) to suspend production, subject to the final formal agreement. This window was granted to allow for the possibility of industry factors or some other significant event resulting in hydrocarbon recovery via the FPSO becoming uneconomical.

Exchange of Correspondence (EoC), outlining earlier removal of the FPSO before the Decommissioning Programmes (DPs) being approved, was shared with the Department for Business, Energy and Industrial Strategy (BEIS) in July 2017. The EoC has been agreed in principle and it will be formally submitted if required (Shell, 2017c).

In preparation for CoP, Shell commenced the formal Environmental Impact Assessment (EIA) process in 2017 to support the design of decommissioning activities and permitting requirements.

Environmental Statement Scope

This document describes the EIA process undertaken to support Shell's application for consent to decommission the Curlew cluster. This process will be concluded by a public consultation and a comprehensive review by various bodies, including BEIS.

The scope of the EIA and this resulting Environmental Statement (ES) includes environmental and social aspects of the following activities:

- Cleaning and disconnection of subsea system prior to removal of the Curlew FPSO off station
- Decommissioning of the Curlew FPSO including towing of the vessel to a yard
- Decommissioning of subsea infrastructure

This ES does not include Plug and Abandonment (P&A) of wells, neither normal operations of the FPSO.

The following potential key impacts have been assessed: seabed disturbance, discharges to sea, underwater noise, Energy use and atmospheric Emissions (E&E), waste, marine alien invasive species, accidental events, and an onshore Impact Assessment (IA) addressing the removal, transit and decommissioning of the FPSO. Potential impacts on designated protected sites, sensitive habitats, and cumulative and transboundary impacts are assessed.

Project aspects to be assessed in the ES were determined during project scoping. A summary of the findings of the scoping phase is presented in Appendix A.

Curlew Infrastructure

The Curlew cluster consists of the FPSO, three subsea fields, produced via six wells and subsea infrastructure, and a gas export pipeline:

- The Curlew B field consists of a single well tied back to the FPSO by a flexible pipeline and controlled by a subsea umbilical
- The Curlew C field consists of a single well tied back to the FPSO by a rigid production pipeline and controlled by a subsea umbilical
- The Curlew D field consists of four wells tied back to the FPSO by two flexible production pipelines which are controlled by a subsea umbilical
- Gas is exported from the Curlew field via a pipeline which ties into the FGL

Facilities and infrastructure within the scope of this Curlew decommissioning EIA include the following:

- FPSO
- Mooring system including associated suction anchor piles
- Risers
- Infield pipelines and spool pieces
- Umbilicals and jumpers
- Gas export pipeline and Subsea Isolation Valve (SSIV)
- Wellhead, manifold and protection structures
- Mid-water Arch (MWA) and associated tethering system
- Stabilisation materials (mattresses, grout bags and rock-placement)
- Debris

A phased approach will be taken for the Curlew Decommissioning Project, summarised as follows:

1. Cleaning and disconnection of subsea system prior to removal of the Curlew FPSO off station.
2. Decommissioning of the Curlew FPSO:
   - Towing of the FPSO to a cleaning/dismantling yard (Note FPSO may be taken to a preliminary yard for cleaning before it is sent to a second yard for recycling, or it may be taken to a single yard where cleaning and recycling activities will be completed at the same time in one location)
   - Dismantling and recycling of the FPSO
   - Final disposal of all materials that cannot be recycled
3. Decommissioning of subsea infrastructure:
   - Subsea removal
   - Decommissioning of subsea pipeline infrastructure as per Comparative Assessment (CA) recommendations
   - Debris removal
   - Seabed remediation as and if required

SCHEDULE

The proposed schedule of activities is as follows:

CoP	Q1/Q2 of 2019
FPSO disconnect and tow to selected yard	Q2 of 2019
Wells P&A	Q2 to Q4 2019
Subsea decommissioning	Estimated duration: 9 to 12 months Execution window of subsea decommissioning may take place any time from CoP Q1/Q2 2019 until 2023+

Please note the schedule is not fixed. CoP and decommissioning operations may begin sooner than Q1/Q2 2019 if plant failure or other issues make it uneconomical to continue operating.

Scope of Decommissioning Activities

In accordance with BEIS Decommissioning Guidance Notes (BEIS, 2011) and Oil and Gas UK's (OGUK's) Guidelines for Comparative Assessment in Decommissioning Programmes (OGUK, 2015,) the Project proposes the following activities to decommission the Curlew field and its associated elements (refer to Table 1). The EIA process was undertaken based on this scope.

Table 1 Proposed Decommissioning Operations

INFRASTRUCTURE	OPTION
FPSO	Post-CoP, the topside processes will be drained, flushed, purged and vented. Afterwards, the risers and mooring lines will be cut and the FPSO will be towed to a yard for cleaning and recycling; Other options have been evaluated; however, these have been deemed unfeasible.
Pipelines, inc. Umbilicals and Gas Export Pipeline	Following the CA process, pipelines will be left in situ; ends will be cut, removed and covered by rock. Where required, spot rock cover will be placed in depressions and known exposures areas. The Curlew C production pipeline will be capped from both ends to contain potential wax deposition.
Spools and jumpers	These will be fully removed and shipped onshore for cleaning and disposal.
Other subsea infrastructure	Manifold, MWA, etc. will be fully removed and shipped onshore for cleaning and disposal.
Mooring System	Mooring lines will be fully retrieved and disposed onshore; Suction anchor piles will be fully removed; if full removal is unsuccessful, the piles will be cut at Mean Seabed Level (MSL) and rock covered. Mooring trenches, created by movement of mooring lines on the seabed, will be filled with rock to either MSL or just below to allow backfill by natural soft sediment.
Mattresses and grouts nags	These will be removed and taken onshore for disposal, depending on their integrity.
Drill Cuttings Pile	Drill cuttings pile associated with Curlew DP1 and DP2 will be left in situ for natural degradation as they fall under the OSlo/PARis Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) Decision 2006/5 thresholds.

Following completion of decommissioning activities, the area will be subject to debris removal and overtrawl trials to ensure safe seabed conditions for other sea users. A post-decommissioning survey will be undertaken to assess magnitude and extent of impacts on the environment from the operations carried out.

BASELINE ENVIRONMENT

Wind speeds at Curlew range from 5.3 m/s up to a maximum of 19.8 m/s. Mean sea surface water temperatures in the Curlew area range from 6.5°C in winter to 14.5°C in summer, while sea bottom temperatures range from 6.5°C in winter to 7°C in summer.

The predominant regional current in the CNS is the Atlantic water inflow of the Fair Isle/Dooley current, which flows around the north of the Orkney Islands and into the North Sea. The water depth in the Curlew area is relatively uniform, ranging between 92 and 94 m Lowest Astronomical Tide (LAT).

A number of environmental surveys were undertaken throughout the project area between 2006 and 2016. The seabed survey of the Curlew area in 2016 found surface sediments comprising poorly sorted, very fine sands, with the occasional exception of coarse silt. The seabed survey along the Curlew C pipeline route in 2006 found sediments consisting of silty, fine sand with shell fragments.

Contaminant levels found in surface sediments of the Curlew area were elevated above background levels for several contaminants within 200 m of the drill centres. However, contamination levels are comparable to typical drill cuttings in the North Sea.

The European Nature Information System (EUNIS) biotope '*Paramphinome jeffreysii*, *Thyasira spp.* and *Amphiura filiformis* in offshore circalittoral sandy mud' (A5.376) was identified for the majority of the survey area.

Concentrations of burrowing megafauna, as well as presence of the epifauna sea pens *Pennatula phosphorea* and *Virgularia mirabilis* has led to the designation of the Curlew field area as "Sea-pen and Burrowing Megafauna Communities (OSPAR Threatened and Declining Species/Habitats (OSPAR T&D))/burrowed mud (Priority Marine Feature (PMF))".

The most abundant of the faunal species encountered were Annelida, Mollusca, Crustacea and Echinodermata. The most abundant taxon observed was the polychaete *Paramphinome jeffreysii* followed by other dominant polychaetes such as *Galathowenia oculata* and the bivalve *Axinulus croulinensis*.

Juvenile ocean quahog (*Arctica islandica)* were recorded in all but one of the 2016 samples in the Curlew field, but only at two locations in the 2006 survey along the pipeline route.

Spawning grounds for a number of fish species have been identified within the proposed project area including Norway pout, lemon sole, cod, sand eel and mackerel. In addition, the area also coincides with nursery grounds for Norway pout, plaice, mackerel, haddock, cod, whiting, blue whiting, herring, sand eel, ling, anglerfish, hake and spurdog.

Various whale and dolphin species are known to occur in the area of the proposed project, with data suggesting that high abundances of harbour porpoise, white-beaked dolphin, Atlantic white-sided dolphin and minke whale may occur in the area of the Curlew field. Low numbers of common dolphin and pilot whale may also be present. Harbour seals are unlikely to occur in the area, although low densities of grey seal may be found in the vicinity of the Curlew field.

Based on the Seabird Oil Sensitivity Index (SOSI), the sensitivity of seabirds to surface oil pollution in the vicinity of the Curlew field, pipeline and surrounding blocks was very low throughout the year, with the exception of June when sensitivity was medium in Block 29/9, and in September when sensitivity was very high in Block 29/11.

The closest offshore protected area is the Fulmar Marine Conservation Zone (MCZ), designated for subtidal sand, mud and mixed sediment habitats and the presence of *A. islandica.* It is located 15 km southeast of the gas export pipeline and 35 km from the Curlew cluster. The East of Gannet and Montrose Fields Nature Conservation Marine Protected Area (NCMPA) is approximately 20 km north of the Curlew cluster and 27 km northeast from the export pipeline. The East of Gannet and Montrose Fields NCMPA is designated for the protection of ocean quahog (*A. islandica*) aggregations, their supporting sands, gravel habitats and offshore deep sea muds.

There was no evidence of 'submarine structure made by leaking gases' or criteria meeting 'stony reef' habitat in the survey area.

The potential areas of 'Sea-pen and Burrowing Megafauna Communities' habitat, as well as several species of fish, dolphin and whale found with the vicinity of Curlew are all listed as PMFs which are considered to be of particular importance to Scotland's seas.

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 Curlew field and pipeline is situated in ICES rectangle 42F1. The average weight landings (2011 to 2015) of pelagic, demersal and shellfish species in 42F1 was 107, 239 and 93 tonnes respectively. Overall total landings contributed to 0.07% of the average total recorded UK landings 2011 to 2015 suggesting the fishing ground is of relatively low importance to the UK fishing industry.

Shipping in the area is considered to be very low to moderate.

There are no military activities associated with the Curlew area and there are no functioning or disused submarine cables in the immediate vicinity of the proposed project. The Curlew cluster is within a highly developed O&G area of the North Sea.

No dangerous wrecks or designated sites of archaeological interest occur in the blocks of interest or in the surrounding area. However, there are two potential non-dangerous or undesignated wrecks within the blocks. One, in Block 29/7a is approximately 900 m from the FPSO and is unidentified but has some associated floating debris attached, and the other is in Block 29/8b and is approximately 300 m north of the export line.

Impacts and Specific Commitments

A summary of the key findings of the proposed Curlew decommissioning EIA is presented in Table 2:

Table 2 Potential Environmental Impacts of the Decommissioning of the Curlew Hub

Impacts	Description	Significance of Residual Impacts
Seabed Disturbance	Disturbance to seabed is anticipated from the proposed decommissioning activities. The majority of the impacts will be associated with the short-term disturbance associated with the removal and temporary storage of infrastructure, subsequent debris surveys and overtrawl trails. Potential long-term impacts are primarily associated with the deposition of rock protection on trenches and any cut pipeline ends. The total cumulative seabed impacts associated with the decommissioning activities is estimated to be 53.3 km^2, of which 0.05 km^2 is associated with long term impact Although sensitive receptors present in the area, such as the sea pen and burrowing megafauna habitat and ocean quahog (*Arctica islandica*) will be impacted by the operations, it is anticipated that, without further disturbance, their recovery will take a few years based on their ability to burry themselves and availability of wider area supporting them.	Minor to Moderate

Table 2 Potential Environmental Impacts of the Decommissioning of the Curlew Hub (Continued)

Impacts	Description	Significance of Residual Impacts
Discharges to Sea	A number of chemical and hydrocarbon contaminated discharges are anticipated to occur as a result of the decommissioning activities. These will include discharges of chemicals from umbilical cores, which cannot be flushed; potential releases from the disturbance of some drill cuttings deposits; potential releases of wax and entrained contaminants (following disintegration of the Curlew C production pipeline) and releases of contaminants from infrastructure decommissioned in situ, such as plastic and steel. The potential releases will be of small volume and will take place over a prolonged period; the release rate of the contaminants will be slow, and likely dispersed and diluted readily. In addition, the Curlew C production pipeline will be capped from both ends to minimise releases of wax and potentially entrained contaminants to the marine environment. Impacts associated with these discharges are considered to pose no adverse effect on the receiving environment.	Minor
Underwater Noise	Elevated underwater noise will occur during decommissioning activities; however, the increased level has been assessed and it is concluded that it will not have negative impact on sensitive receptors, such us marine mammals. The elevated noise level will be associated with cutting operations and increased number of vessel present in the field. These are however temporary in nature and will take place across a few months. The project will not carry out pilling operations, neither use explosives.	Negligible to Minor
Energy Use and Atmospheric Emissions	Energy demand and atmospheric emissions are mainly associated with vessels executing the decommissioning works. Energy use and atmospheric emissions will also be associated with manufacturing of material proposed to be decommissioned in situ. Although the emissions are detectable, these are only a small fraction of the total North Sea emissions anticipated to be present during the decommissioning period. As the decommissioning activities are only temporary and primarily associated with moving vessels, this further reduces their significance.	Negligible to Minor

Table 2 Potential Environmental Impacts of the Decommissioning of the Curlew Hub (Continued)

Impacts	Description	Significance of Residual Impacts
Waste	The nature of any decommissioning project is that it generates a significant amount of waste, which needs to be properly managed and disposed of. The waste hierarchy will be followed during decommissioning activities to ensure that opportunities for recycling and reusing are utilised while landfill disposal is minimised. Waste will be managed on behalf of Shell by licensed and responsible sites, with appropriate Health, Safety and Environment (HSE) management system and track records.	Minor
Marine Alien Invasive Species	Flora and fauna encrusted to the hull of the FPSO may include species common to the UKCS and non-native species. If non-native species are present, these may pose a risk to the marine environment at the dismantling yard locations. Once the recycling yard is selected, an IA will be undertaken for the potential introduction and/or further contribution to existing populations of alien invasive species via hull fouling and ballast water exchange to ensure the potential impacts are managed to ALARP.	To be determined post-recycling yard selection
Accidental Events	During decommissioning activities, including the tow of the FPSO to a cleaning/recycling yard, there is a potential for accidental releases of hydrocarbons or other substances (e.g. from vessel collision). The impact of a potential release might be significant depending on the volume and composition of the fluids released; however, the likelihood of such event taking place is very low considering mitigations and controls put in place.	Minor
Onshore Impacts	There is the potential for the onshore phase of decommissioning to have an impact to the environment and communities in the vicinity of a dismantling (and/or a cleaning) yard. Multiple yards are being considered as a potential final destination for the FPSO. These are currently being assessed by Shell to ensure they meet the IMO Hong Kong International Convention 2009 for safe and environmentally sound recycling of ships, and that they meet legal requirements of the EU Regulation No 1257/2013 on ship recycling. It is believed that through the robust assessment and evaluation process, yards considered for the recycling of the Curlew FPSO are well established, licenced sites, technically capable to undertake the work, but also have sufficient HSE management system and processes in place to deliver work safely and in an environmentally sound manner, including the management of waste.	Negligible

Conclusions

It is the conclusion of this EIA that the recommended options presented for the decommissioning of the Curlew infrastructure can be completed without causing unacceptable adverse impact on the environment, including cumulative and transboundary effects.

The options for the Curlew Decommissioning Project have been selected through a formal CA process, developed in compliance with BEIS and OGUK guidelines, presented to and discussed with key stakeholders. This robust selection of options, 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.

Mitigation measures, safeguards and controls to reduce impacts have been identified and are discussed in individual impact sections. These will be captured in the project's Environmental Management Plan (EMP), which will include roles and responsibilities for their implementation.

[This page is intentionally blank]

ABBREVIATIONS

%	Percent
AIS	Automatic Identification System
Al	Aluminium
ALARP	As Low As Reasonably Practicable
APE	Alkylphenols
As	Arsenic
Ba	Barium
BAC	Background Assessment Concentrations
BAP	Biodiversity Action Plan
BC	Background Concentrations
BEIS	Department for Business, Energy and Industrial Strategy
C	Carbon
CA	Comparative Assessment
Cd	Cadmium
CEFAS	Fisheries and Aquaculture Science
CEMP	Co-ordinated Environmental Monitoring Programme
CF	Control Framework
CH_4	Methane
cm	centimetre
CNS	Central North Sea
CO_2	Carbon Dioxide
CoP	Cessation of Production
Cr	Chromium
Cu	Copper
dB	Decibels
Db re 1 μPa2 S	Decibel relative to 1 squared Micro Pascal per second
dB re μPa	Decibel relative to pascal
dB re μPa-m	Decibel relative to Micro Pascal to a metre
dBht	Decibel hearing threshold
DECC	Department for Energy and Climate Change
DEFRA	Department for Environment, Food & Rural Affairs
DFPV	Drain, Flare, Purge and Vent
DP	Decommissioning Programme
DSV	Diving Support Vessel
E&E	Energy use and atmospheric Emissions
EC	European Commission
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMS	Environmental Management System
ENVID	Environmental (Social and Community Health) Identification
EoC	Exchange of Correspondence
EPS	European Protected Species
ERL	Effects Range Low
ERM	Effects Range Medium
ES	Environmental Statement
EU	European Union
EUNIS	European Nature Information System
Fe	Iron
FGL	Fulmar Gas Line
FOCI	Features of Conservation Importance
FPSO	Floating Production, Storage and Offloading
FRS	Fisheries Research Service
FSU	Floating Storage Unit
GJ	Gigajoules
HF	Hydrofluoric Acid
Hg	Mercury
HNO_3	Nitric Acid
HSE	Health and Safety Executive
HSE	Health, Safety and Environment
HSSE	Health, Safety, Security and Environment
HSSE&SP	Health, Safety, Security, Environment & Social Performance
Hz	Hertz

IA	Impact Assessment
ICES	International Council for Exploration of the Sea
IFR	Issued for Review
IHM	Inventory of Hazardous Materials
IMO	International Maritime Organisation
IOGP	International Association of Oil and Gas Producers
IOP	Institute of Petroleum
ITOPF	International Tanker Owners Pollution Federation
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
kHz	Kilohertz
km	kilometre
km^2	Square kilometre
KP	Kilometre Point
LAT	Lowest Astronomical Tide
m	metre
m/s	metres per second
m^2	Square metre
MARPOL	Marine Pollution (International Convention)
MCZ	Marine Conservation Zone
MDAC	Methane Derived Authigenic Carbonate
mm	millimetre
MMO	Marine Management Organisation
Mn	Manganese
MPA	Marine Protected Area
MS	Marine Scotland
MSFD	Marine Strategy Framework Directive
MSL	Mean Seabed Level
MWA	Mid-water Arch
N/A	Not Applicable
Nb	Niobium

NCMPA	Nature Conservation Marine Protected Area
ND	No Data
Ni	Nickel
nm	nautical miles
NOAA	US National Oceanic and Atmospheric Administration
NORBRIT	Norway-UK Joint Contingency Plan
NORM	Naturally Occurring Radioactive Material
NO_x	Nitrogen Oxides
O&G	Oil and Gas
OA	Osborn Adam
OBM	Oil-based Mud
ODS	Ozone Depleting Substance
OGA	Oil & Gas Authority
OGUK	Oil and Gas UK
OIW	Oil-in-Water
OPEP	Oil Pollution Emergency Plan
OPOL	Oil Pollution Operator's Liability
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSPAR	OSlo/PARis Convention for the Protection of the Marine Environment of the North-East Atlantic
OSPAR T&D	OSPAR Threatened and Declining Species and Habitats
P	Phosphorous
P&A	Plug and Abandonment
P&L	Plug and Lubrication
PAH	Poly Aromatic Hydrocarbon
Pb	Lead
PCB	Polychlorinated biphenyl
PMF	Priority Marine Feature
ppm	Parts per million
ppt	Parts per trillion
PTS	Permanent Threshold Shift
RMS	Root Mean Squared Average of Sound Pressure

ROV	Remotely Operated Vehicle
ROVSV	ROV Survey Vessel
S	Sulphur
SAC	Special Area of Conservation
SAL	Single Anchor Loading
SDU	Services Distribution Unit
SEA	Strategic Environmental Assessment
SEL	Sound Exposure Level
SEPA	Scottish Environment Protection Agency
SFF	Scottish Fishermen's Federation
Shell	Shell UK Ltd
Si	Silicon
SL	Sound Level
SNH	Scottish Natural Heritage
SOPEP	Ship Oil Pollution Emergency Plan
SOSI	Seabird Oil Sensitivity Index
SO_x	Sulphur Oxides
sp	A single (non-specified) species
SPL	Sound Pressure Level
spp	Several Species
SRFP	Ship Recycling Facility Plan
SSC	Suspended Sediment Concentration
SSIV	Subsea Isolation Valve
TBa	Total Barium
Te	Metric Tonne
TFS	Transfrontier Shipment
THC	Total Hydrocarbon Concentration
Ti	Titanium
TLP	Tension Leg Platform
TOC	Total Organic Carbon
TOM	Total Organic Matter
TTS	Temporary Threshold Shift
UK	United Kingdom of Great Britain and Northern Ireland
UKCS	United Kingdom Continental Shelf
UKOOA	United Kingdom Offshore Operators Association

UTA	Umbilical Termination Assembly
UV	Ultraviolet
V	Vanadium
VMS	Vessel Monitoring System
VOC	Volatile Organic Compounds
WBM	Water-based Mud
WMP	Waste Management Plan
WMS	Waste Management Strategy
WOW	Wait on Weather
Zn	Zinc
μg/g	micrograms per gram
μm	micrometre

[This page is intentionally blank]

CONTENTS

Standard Information Sheet i
Non-technical Summary iii
Abbreviations xiii
1. Introduction 1-1
1.1. Background 1-1
1.2. Scope of EIA 1-2
1.3. Policy, Legal and Administrative Overview 1-3
1.4. Objectives 1-3
1.5. Report Structure 1-4
1.6. Report Disclosure 1-5
2. Project Description 2-1
2.1. Overview of Curlew Infrastructure 2-1
2.2. FPSO 2-2
2.3. Subsea Infrastructure 2-2
2.4. Overview of Proposed Decommissioning Activities 2-10
3. Assessment of Alternatives 3-1
3.1. Introduction 3-1
3.2. Decommissioning of Subsea Infrastructure 3-1
3.3. Decommissioning of Curlew FPSO 3-3
4. Stakeholder Engagement 4-1
4.1. Approach 4-1
5. Offshore Environmental and Socio-economic Baseline Conditions 5-1
5.1. Offshore Cluster Location and Environmental Surveys 5-1
5.2. Physical Environment 5-4
5.3. Biological Environment 5-13
5.4. Conservation 5-29
5.5. Socio-economic Sensitivities 5-36
6. Process and Methodology of Impact Assessment 6-1
6.1. Impact Identification and Assessment 6-1
7. Seabed Disturbance 7-1
7.1. Sources of Potential Impact 7-1
7.2. Summary of Seabed Impact 7-5
7.3. Impact on Sensitive Receptors 7-6
7.4. Transboundary and Cumulative Impacts 7-9

7.5. Mitigation Measures, Safeguards and Controls 7-9
7.6. Impact Assessment Summary Statement 7-9
8. Discharges to Sea 8-1
8.1. Approach 8-1
8.2. Chemical Release from Umbilical Cores 8-1
8.3. Discharges from Drill Cuttings Deposits 8-2
8.4. Potential Contaminant Release from Wax Deposits 8-4
8.5. Contaminants Released from Infrastructure Left In Situ 8-6
8.6. Transboundary, Cumulative and In-Combination Impacts 8-10
8.7. Mitigation Measures, Safeguards and Controls 8-11
8.8. Impact Assessment Summary Statement 8-11
9. Underwater Noise 9-1
9.1. Regulatory Context 9-1
9.2. Approach 9-1
9.3. Sources of Potential Impact 9-2
9.4. Impact on Sensitive Receptors 9-5
9.5. Noise Modelling Impact Assessment 9-8
9.6. Transboundary, Cumulative and In-Combination Impacts 9-9
9.7. Mitigation Measures, Safeguards and Controls 9-9
9.8. Impact Assessment Summary Statement 9-10
10. Energy Use and Atmospheric Emissions 10-1
10.1. Approach 10-1
10.2. Sources of Potential Impact 10-1
10.3. Assumptions and Calculation Factors 10-1
10.4. Materials and Operations Inventories 10-3
10.5. Energy Use and Atmospheric Emissions from Curlew Decommissioning 10-4
10.6. Impacts on Sensitive Receptors 10-8
10.7. Transboundary, In-Combination and Cumulative Impacts 10-9
10.8. Mitigation Measures, Safeguards and Controls 10-9
10.9. Impact Assessment Summary Statement 10-9
11. Waste 11-1
11.1. Regulatory Context 11-1
11.2. Approach – Waste Management 11-2
11.3. Sources of Potential Impact – Waste Generation 11-2
11.4. Contractor Management 11-6
11.5. Transboundary and Cumulative Impacts 11-7

11.6. Mitigation Measures, Safeguards and Controls 11-7
11.7. Impact Assessment Summary Statement 11-8
12. Marine Alien Invasive Species 12-9
12.1. Regulatory Context 12-9
12.2. Impact Assessment 12-10
12.3. Mitigation Measures, Safeguards and Controls 12-11
12.4. Impact Assessment Summary Statement 12-11
13. Accidental Events 13-1
13.1. Approach 13-1
13.2. Sources of Potential Impact 13-1
13.3. Liquid Hydrocarbon (Oil) Release 13-2
13.4. Chemical Spill 13-7
13.5. Dropped Object(s) 13-8
13.6. Mitigation Measures, Safeguards and Controls 13-9
13.7. Impact Assessment Summary Statement 13-10
14. Onshore Impact Assessment 14-1
14.1. Applicable Legislation and Standards 14-1
14.2. Overview of Ship Dismantling Process 14-2
14.3. Noise 14-3
14.4. Light 14-3
14.5. Odour from Marine Growth 14-3
14.6. Road Transport 14-3
14.7. Fluids Containment and Management 14-4
14.8. Waste Management 14-4
14.9. Assessment of Dismantling Yards 14-4
14.10. Mitigation Measures, Safeguards and Controls 14-6
14.11. Impact Assessment Summary Statement 14-6
15. Conclusions 15-1
15.1. Environmental and Societal Effects 15-1
15.2. Mitigation Measures, Safeguards and Controls 15-2
16. Contacting Shell 16-1
17. References 17-1

[This page is intentionally blank]

1. INTRODUCTION

This ES presents the findings of the EIA conducted by Advisian Ltd and BMT Cordah Ltd on behalf of Shell UK Ltd (Shell) for the proposed decommissioning of the Curlew offshore O&G facility.

1.1. Background

The Curlew O&G offshore facility (referred to as the Curlew cluster) is situated in the CNS on the UKCS Block 29/07 (refer to Figure 1-1). It is located approximately 210 km east of the Aberdeenshire coastline and 55 km west of the UK/Norway median line, in a water depth of approximately 92 m. The facility consists of a central processing FPSO vessel with three subsea field tie-backs and is connected into the Fulmar pipeline for gas export to St Fergus.

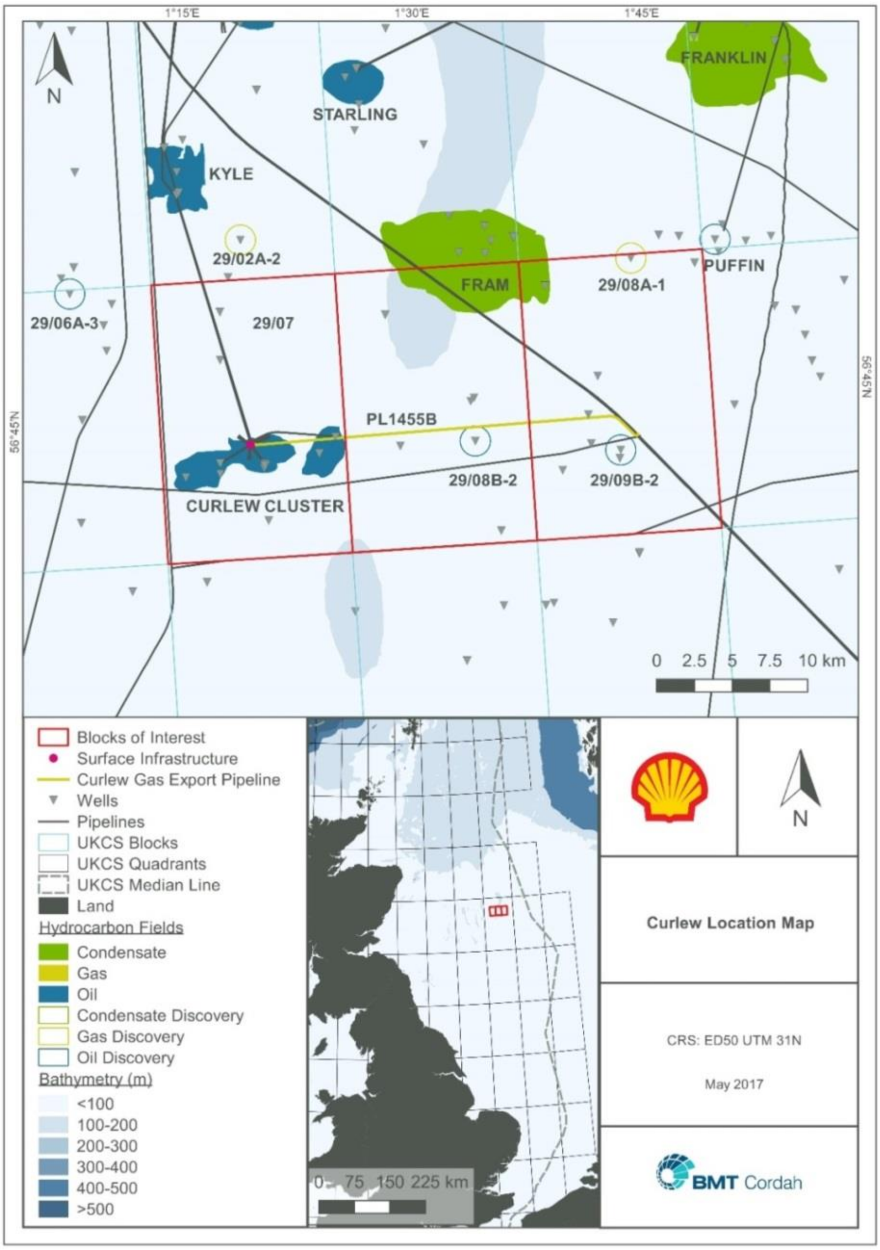


Figure 1-1 Location of the Curlew Cluster Infrastructure in the CNS

The FPSO started life as a tanker in 1983, and was converted to an FPSO for deployment to the Curlew field in 1997, when first oil was produced. The FPSO vessel was dry docked in 2009 for refurbishment and to extend its service life by 10 years. The FPSO is expected to reach the end of its economic and technical life in 2019. Shell proposes to decommission the FPSO and associated subsea production elements and facilities following CoP in Q1/Q2 of 2019, unless plant failure or other issues make it uneconomical to continue, at which point decommissioning operations may begin sooner.

It is now considered that no specific foreseeable commercial opportunity exists for the re-use of the Curlew infrastructure that would warrant postponing decommissioning and extending the field's life.

Shell requested CoP on the Curlew FPSO facility in April 2016. A window of 2016 to 2019 has been agreed with the OGA to cease production, subject to the final formal agreement. This window was granted to allow for the possibility of industry factors or some other significant event resulting in hydrocarbon recovery via the FPSO becoming uneconomical.

EoC outlining earlier removal of the FPSO before the Decommissioning Programme (DP) being approved, was shared with BEIS in July 2017. It has been agreed in principle and it will be formally submitted if required.

In preparation for CoP, Shell commenced the EIA process in 2017 to support the design of decommissioning activities and permitting requirements.

Decommissioning is being developed with a phased approach. Removal of hydrocarbons from all subsea infrastructure is to be completed while the FPSO is on station. Further work to deconstruct the subsea infrastructure will be undertaken once the FPSO is disconnected from the subsea infrastructure and transferred to a decommissioning yard for dismantling and recycling.

Decommissioning is being developed with the following phased activities:

- Phase 1 – Curlew FPSO removal: Flushing of pipelines and subsea facilities, disconnection of all pipelines and umbilicals from subsea trees, disconnection of the risers and mooring lines at the FPSO allowing sail away at the earliest convenience
- Later Phases
  - Wells P&A
  - Removal of subsea infrastructure within all Curlew field areas in accordance with the approved DPs

A guard vessel will be used for the duration between Phase 1 and the later phase of subsea infrastructure removal. At the end of all decommissioning phases, completion of decommissioning operations will be verified by overtrawl sweeps and as-left surveys.

1.2. Scope of EIA

The scope of the EIA includes environmental, social and community health aspects of the following activities:

- Cleaning and disconnection of subsea system prior to removal of the Curlew FPSO off station
- Decommissioning of the Curlew FPSO including towing of the vessel to a yard
- Decommissioning of subsea infrastructure

Wells P&A and normal operations of the FPSO were not included in this EIA.

1.3. Policy, Legal and Administrative Overview

Shell will comply with all relevant legislative, regulatory and policy standards and requirements for decommissioning of the Curlew cluster. Where specific standards and requirements apply, these are referenced and discussed in the relevant ES chapters as required.

1.3.1. UK Legal Framework

The decommissioning of offshore O&G infrastructure on the UKCS is principally governed by the Petroleum Act 1998, as amended by the Energy Act 2008. The Petroleum Act sets out the requirements for a formal DP, which must be approved by BEIS before the owners of an offshore Installation or pipeline may proceed with decommissioning. The DP needs to be supported by an EIA (resulting in an ES) and CA.

The 1992 OSPAR Convention decision 98/3 sets out the UK's international obligations on the decommissioning of offshore Installations. Decision 98/3 prohibits the dumping and leaving wholly or partly in place of offshore Installations.

In addition, relevant permits, e.g. Marine License, etc., will be applied for in order to undertake proposed activities. These permits require submission of the EIA justification, which will be based on the IA results documented in the ES.

1.3.2. Shell HSSE&SP Control Framework

In addition to being subject to the requirements of UK and European Union (EU) legislation, international treaties and agreements, Shell has company requirements, guidelines and standards that also need to be complied with. These are detailed in the Shell Health, Safety, Security, Environment & Social Performance (HSSE&SP) Control Framework (CF).

The EIA for the Curlew DP follows the requirements of the Shell CF IA manual to ensure compliance with national laws and applicable international standards.

1.4. Objectives

EIA is a systematic process that considers how a project will impact existing environmental conditions, and assesses the consequence and significance of such impacts. It is an iterative process, normally started at a project's inception, with certain key stages (refer to Table 1-1). Its key objective is to guide and inform decision making throughout the planning and design phases pf the project, by identifying significant impacts/risks associated with various project options. This ensures that where practical, potentially significant impacts and risks can be mitigated at the source.

Table 1-1 Key Stages of the Curlew EIA Decommissioning Programmes

IA Stage	Description
Scoping	Allows the study to establish the key issues, data requirements, and impacts to be addressed in the EIA and the framework or boundary of the study.
Assessment of alternatives	Demonstrates that other feasible approaches, including alternative project options, scales, processes, layouts, and operating conditions have been considered.
Project Description	Provides clarification of the purpose of the project and an understanding of its various characteristics, including stages of development, location and processes.
Description of environmental baseline	Establishes the current state of the environment on the basis of data from literature and field surveys, and may involve discussions with the authorities and other stakeholders.

Table 1-1 Key Stages of the Curlew EIA Decommissioning Programmes (Continued)

IA Stage	Description
Identification of key impacts/risks and prediction of significance	Seeks to identify the nature and magnitude of identified changes in the environment as a result of project activities, and assesses the relative significance of the predicted impacts/risks.
Impact/risk mitigation	Outlines the measures that will be employed to avoid, reduce, remedy or compensate for any significant impacts/risks. Mitigation measures will be developed into a project EMP. Aspects of the project which may give rise to significant impact/risks which cannot be mitigated to an acceptable or tolerable level may need to be redesigned. This stage will feed back into project development activities.
Presentation of the Environmental Statement	Reporting of the EIA process through production of an ES that clearly outlines the above processes. The ES provides a means to communicate the environmental considerations and management plans associated with the project to the public and stakeholders.
Monitoring	Project impacts will be monitored post decommissioning to verify that impact predictions are consistent with actual outcomes.

1.5. Report Structure

The structure for this Curlew decommissioning ES is detailed in Table 1-2.

Table 1-2 Curlew Decommissioning ES Structure

Section	Description
Non-technical Summary	A non-technical summary of the ES.
1. Introduction	An introduction to the project and the scope of the EIA.
2. Project Description	A description of the DPs scope, detailed materials inventory and description of planned decommissioning approach.
3. Assessment of Alternatives	A description of the outcomes of the CA process conducted by Shell.
4. Stakeholder Engagement	Details of the stakeholder consultation process applicable to the aspects of the EIA.
5. Offshore Environmental and Socio-economic Baseline Conditions	A detailed description of the environmental and societal sensitive receptors in the vicinity of the project area.
6. Process and Methodology of Impact Assessment	A summary of the methods and processes undertaken during the EIA.
7. Seabed Disturbance	Identification of potential sources of impact to offshore environmental and societal receptors from seabed disturbance.
8. Discharges to Sea	Identification of potential sources of impact to offshore environmental and societal receptors from discharges to sea and details of practicable mitigation strategies.
9. Underwater Noise	Identification of potential sources of impact to offshore environmental and societal receptors from underwater noise and details of practicable mitigation strategies.

Table 1-2 Curlew Decommissioning ES Structure (Continued)

Section	Description
10. Energy Use and Atmospheric Emissions	Identification of potential sources of impact to offshore environmental and societal receptors from E&E, and details of practicable mitigation strategies.
11. Waste	Identification of potential sources of impact to offshore environmental and societal receptors from project waste and details of practicable mitigation strategies.
12. Marine Alien Invasive Species	Identification of potential sources of impact to offshore environmental and societal receptors from marine growth and details of practicable mitigation strategies.
13. Accidental Events	Identification of potential sources of impact to offshore environmental and societal receptors from accidental events and details of practicable mitigation strategies.
14. Onshore Impact Assessment	Identification of potential sources of impact to onshore environmental, societal and community health receptors from transit and dismantling of the FPSO and details of practicable mitigation strategies.
15. Conclusions	Key findings and conclusions of the EIA.
16. Contacting Shell	Contact details and process for stakeholders to submit comments.
17. References	List of project references.
Appendix A: Scoping results	A summary of the findings of the scoping process. Project aspects and impacts/risks either scoped out or carried forward in to the next phase of the EIA.
Appendix B: Energy Use and Atmospheric Emissions Supporting Information	Additional information to support the E&E assessment.

1.6. Report Disclosure

Copies of the draft EIA issued for statutory and public consultation from 18th June to 18th July 2018 and supporting documents (DP and CA) are available online at: https://www.shell.co.uk/sustainability/curlew.html.

They are also available for inspection during the consultation at Shell U.K. Limited, 1 Altens Farm Road, Nigg, Aberdeen, AB12 3FY.

[This page is intentionally blank]

2. PROJECT DESCRIPTION

2.1. Overview of Curlew Infrastructure

An overview of facilities and infrastructure in scope of the boundary of the Curlew Field Decommissioning Project is shown in Figure 2-1.

Facilities and infrastructure in scope of Curlew decommissioning and the EIA process include the following:

- FPSO
- Mooring system including associated suction anchor piles
- Risers
- Infield pipelines and spool piece
- Umbilicals and jumpers
- Gas export pipeline and SSIV
- Wellhead, manifold and protection structures
- MWA and associated tethering system
- Stabilisation materials (mattresses, grout bags and rock-placement)
- Debris

Facilities and infrastructure not in scope of Curlew decommissioning and the EIA include:

- The Kyle field and associated infrastructure – this field was producing via the Curlew FPSO until 2005, when it was tied back to the Banff FPSO. The field and associated infrastructure will be subject of a separate DP
- Deep gas diverter and pigging skid assembly – these provide tie-in points for potential future developments, hence will be decommissioned at a later stage

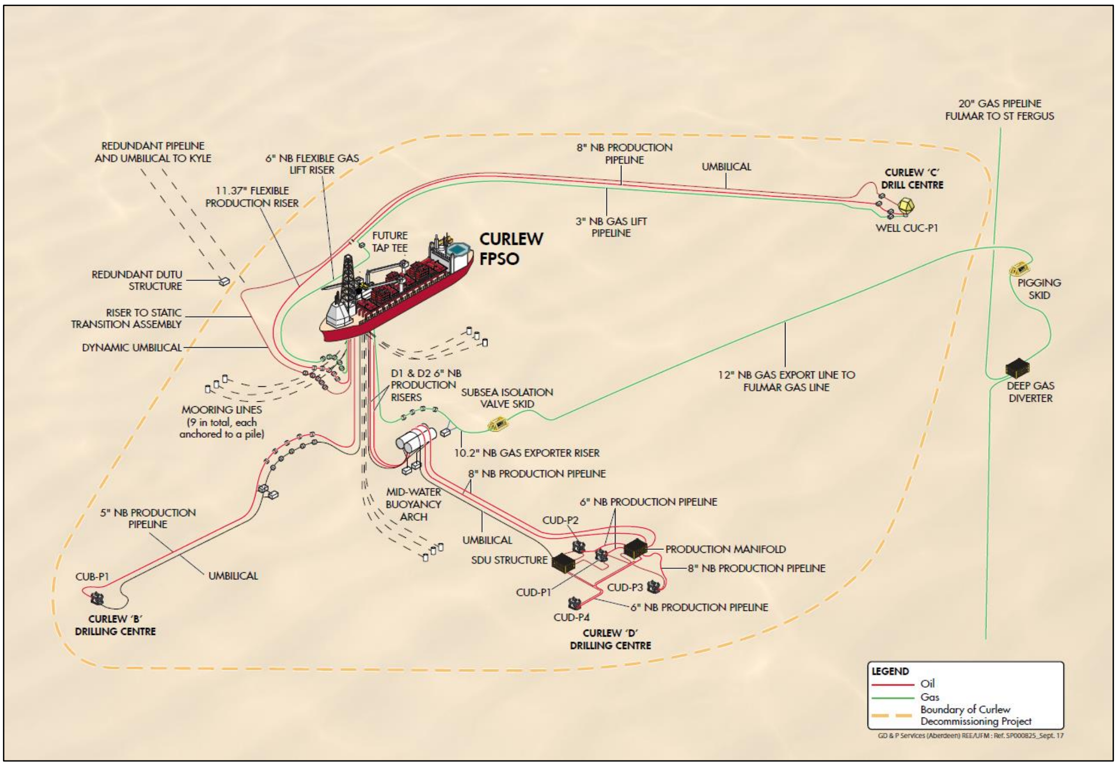


Figure 2-1 Infrastructure within (and outside) the Boundary of the Curlew Decommissioning Programmes

2.2. FPSO

The Curlew FPSO (refer to Figure 2-2) comprises a converted crude oil tanker, with a double side hull, single bottom design, registered under the United Kingdom flag and classed with Lloyds Register. The vessel has a light weight tonnage (i.e. the weight of the ship structure without cargo) of 24,259 metric tonnes (Te). The FPSO is 236 metres long and 40 metres wide. The tanker was converted to be capable of processing and offloading O&G products.

Figure 2-2 Curlew FPSO

2.3. Subsea Infrastructure

2.3.1. Pipelines, Umbilicals and Risers

Table 2-1 provides a summary of the pipelines, risers and umbilicals included within the scope of the Curlew Decommissioning Project.

The MWA, which is used to support the Curlew D risers and umbilical between the seabed and the FPSO, is tethered to and anchored by the weight base. This in turn is secured to the seabed by four structural piles. From the FPSO, gas is exported via a 12 inch gas export riser, SSIV structure, 12 inch gas export pipeline and pigging skid assembly to the FGL, where it connects to the deep gas diverter structure – itself being part of the FGL.

Table 2-1 Summary of Curlew Risers, Pipelines and Umbilicals

Pipeline Number	Description	Diameter (inch)	Approximate Length (km)	Burial Status/Comment
PL-1455A	FPSO to FGL Gas Export Riser	12	0.5	N/A Flexible riser with buoyancy modules
PL-1455B	FPSO to FGL Gas Export Pipeline	12	26.6	Trenched and buried to 1.5 to 1.8 m. Rock cover over majority of the section towards the FPSO, remainder being left for natural back fill. Rock cover depth between 0.1 and 0.8 m. Two areas of exposures at the FPSO end. Towards the Fulmar tie-in, laid in 1.5 m to 1.8 m trench with spot rock cover. Natural backfill has started infilling the trench, although the cover is potentially light
Curlew B				
PL-1450 (1.08)	FPSO to Curlew B Production Pipeline	5.5	2.4	In a trench 1.6 m deep and depth of cover between 0.6 m and 0.8 m. Flexible flowline
PL-1450 (1.09)	Curlew B Flexible Production Riser	5	0.3	N/A Fitted with buoyancy modules
PL-1451 (1.01)	Curlew B Umbilical Riser	N/A	0.3	N/A
PL-1451 (1.02)	Curlew B Umbilical Static Section	N/A	2.3	In a trench 0.6 m deep and depth of cover 0.6 m.
Curlew C				
PL-1798B	Curlew C Production Riser	12	0.3	N/A Flexible riser with buoyancy modules
PL-2523	Curlew C Production Pipeline	8	5.7	In a trench1.8 m deep with blanket rock placement. Target rock height 0.6 to 0.7 m with additional spot rock-placement up to 1.1 m.
PL-2524 (2.03)	Curlew C Gas Lift Riser	6	0.4	N/A
PL-2524 (2.04)	Curlew C Gas Lift Pipeline	3	5.7	In a trench 1.8 m deep with blanket rock-placement. Target rock height 0.6 to 0.7 m with additional spot rock-placement up to 1.1 m.
PLU-2525 (1.02)	Curlew C Umbilical	N/A	6.3	In a trench 1.8 m deep with blanket rock-placement. Target rock height 0.6 to 0.7 m with additional spot rock-placement up to 1.1 m.
Curlew D				
PL-1452 (1.15 and 1.16)	Curlew D Production Pipeline 1	8.25	1.6	In a trench 1.6 to1.8 m deep and depth of cover 0.6 to 0.7 m. Spot rock-placement in areas of low cover. Survey data identified some areas of exposure and low cover along the pipeline. Flexible flowline.
PL-1452 (1.17)	Curlew D Production Riser 1	7.5	0.3	N/A

Table 2-1 Summary of Curlew Risers, Pipelines and Umbilicals (Continued)

Pipeline Number	Description	Diameter (inch)	Approximate Length (km)	Burial Status/Comment
PL-1453 (1.10 and 1.11)	Curlew D Production Pipeline 2	8.25	1.6	In a trench 1.6 to1.8 m deep and depth of cover 0.6 to 0.7 m. Spot rock-placement in areas of low cover Flexible flowline
PL-1453 (1.12)	Curlew D Production Riser 2	7.5	0.3	N/A
PL-1454 (1.01)	Curlew D Umbilical Dynamic Riser	N/A	0.3	N/A
PL-1454 (1.02)	Curlew D Umbilical Static Section	N/A	1.7	In a trench1.6 to1.8 m deep and depth of cover 0.6 to 0.7 m. Spot rock-placement in areas of low cover.

2.3.2. Mooring System

The Curlew FPSO Mooring System consists of nine suction anchor piles (mooring anchors) and nine mooring lines (refer to Table 2-2). Each mooring line consists of a section of chain at the FPSO end, transitioning to a steel wire rope and then back to a chain section, before connection to the suction anchor pile. The nine mooring lines are arranged in groups of three (refer to Figure 2-4).

The suction anchor piles were installed in 1997 and two types are used at the Curlew Field (refer to Figure 2-3). The 7 m diameter piles were deployed at Anchor Sites 1, 2 and 3, while the 5 m diameter piles were deployed at the remaining Pile Sites (4, 5, 6, 7, 8 and 9).

Deployment into the seabed was initially achieved through their weight alone. Once they had reached a certain penetration depth, a suction pump was used to draw the pile further into the seabed. The suction anchor piles were installed to a depth where approximately 1.5 to 2 m of pile protruded above the seabed.

Each mooring line has an associated trench. This has developed over time where the chain/wire touches down on the seabed and has interacted with the seabed during tidal cycles and storm events. The touchdown point is approximately 150 meters away from the FPSO. These trenches are elliptical in shape and run in the direction of the mooring lines; they are approximately 3 to 10 m in width and approximately 100 m in length. The depth varies between the lines, but is estimated to be 4 m at maximum depth. The reason they are an issue is as a potential snagging risk to fisherman and other sea users.

Table 2-2 Summary of Curlew Mooring System

Subsea Installation	Size/Weight (Te)	Comment/Status	Latitude Longitude WGS84 Decimal Minute
FPSO Suction Anchor Piles	Anchor #1 7 m diameter x 12.3 m 108	Protrude between 1.5 and 2 m above the seabed.	56° 44.375'N 01° 18.890'E
	Anchor #2 7 m diameter x 12.3 m 108		56° 44.317'N 01° 18.938'E
	Anchor #3 7 m diameter x 12.3 m 108		56° 44.258'N 01° 18.976'E
	Anchor #4 5 m diameter x 13.5 m 54		56° 43.539'N 01° 17.670'E
	Anchor #5 5 m diameter x 13.5 m 54		56° 43.543'N 01° 17.584'E
	Anchor #6 5 m diameter x 13.5 m 54		56° 43.551'N 01° 17.504'E
	Anchor #7 5 m diameter x 13.5 m 54		56° 44.324'N 01° 16.940'E
	Anchor #8 5 m diameter x 13.5 m 54		56° 44.359'N 01° 16.988'E
	Anchor #9 5 m diameter x 13.5 m 54		56° 44.393'N 01° 17.037'E
Mooring Lines	3 at 1,350 m long 299 tonnes 6 at 950 m long 253 tonnes	Surface to seabed with associated trenches at touchdown point of wires/chains. Trenches approx. 100 m in length.	From each anchor location – approx. 220 or 150 m of studless 124 mm chain, 850 or 520 m of 6 strand wire, 15 m of studless 145 mm chain, 136 m of studless 145 mm double chain, approx. 125 m of studless 124 mm chain, to Curlew FPSO.

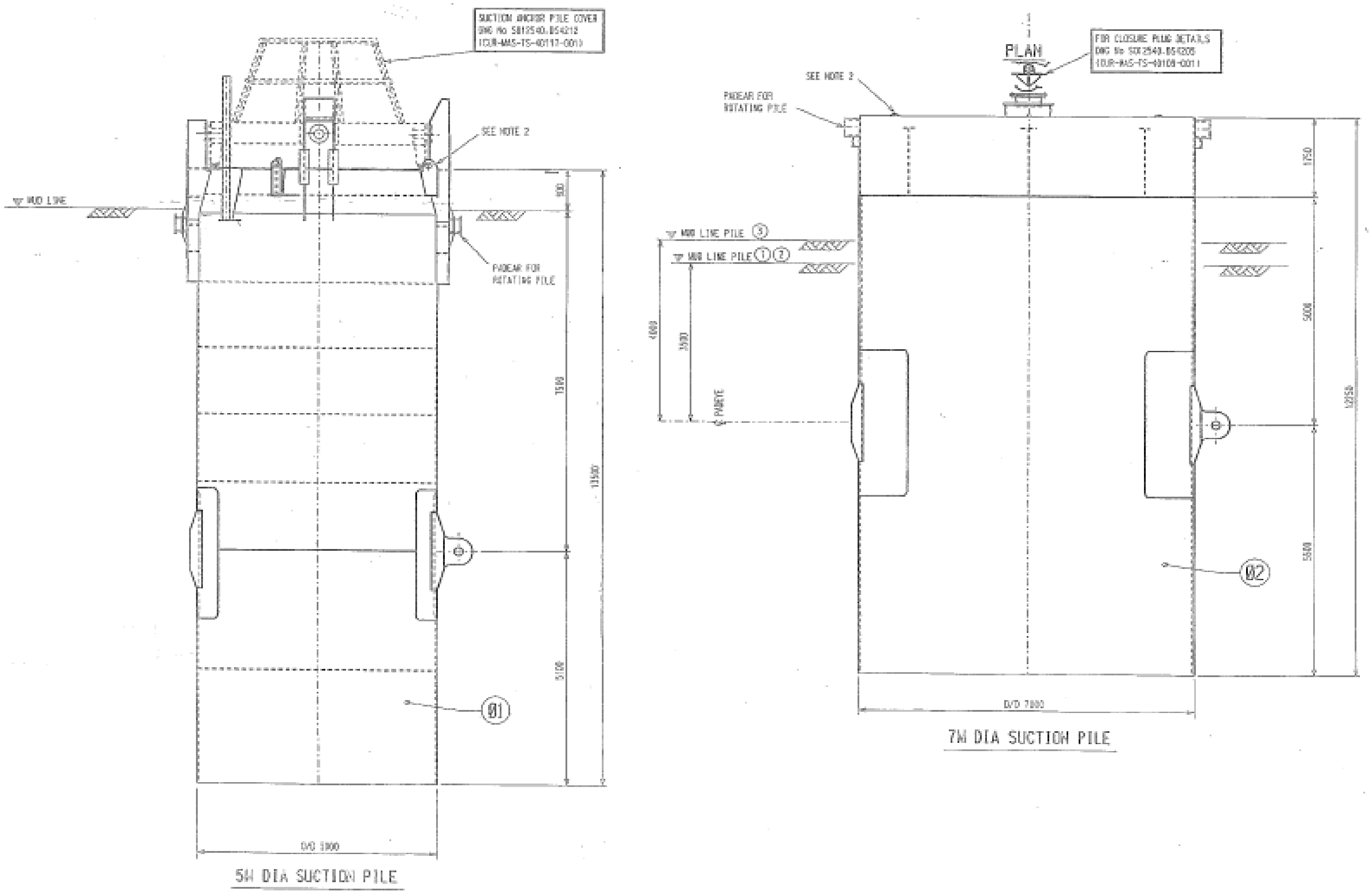


Figure 2-3 Curlew Mooring Suction Anchor Pile Schematic (5 m and 7 m Diameter)

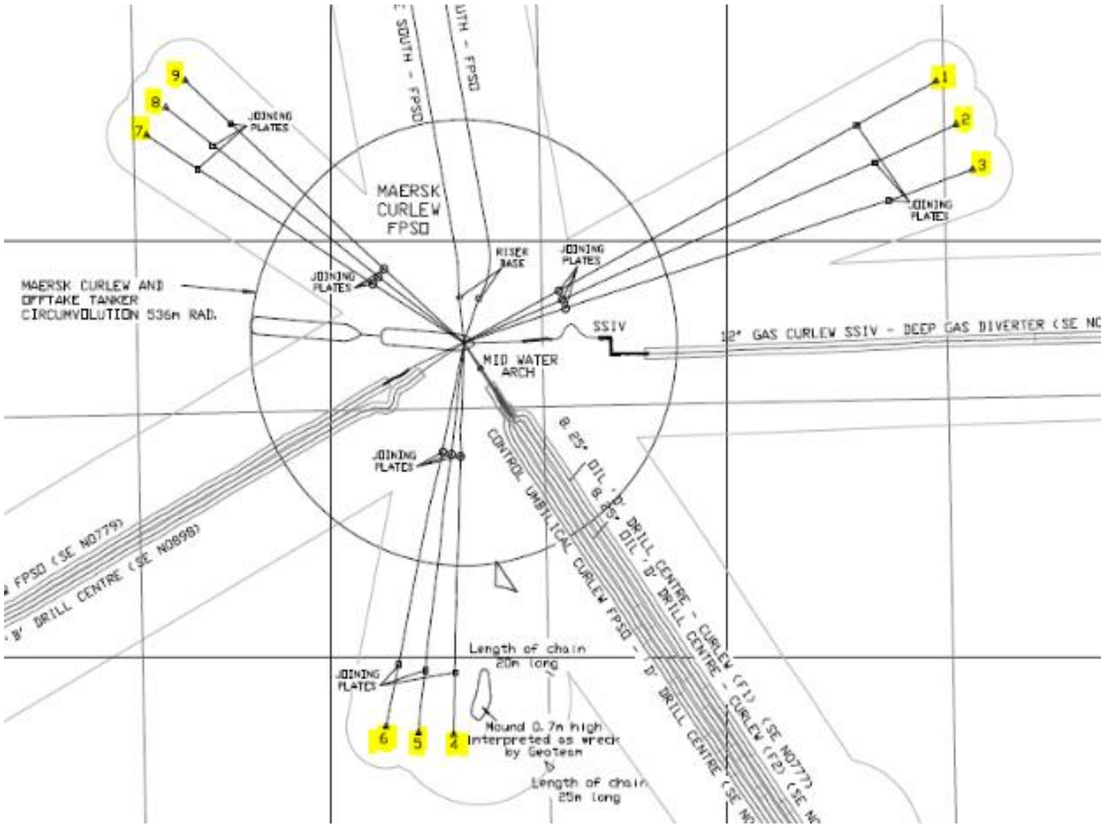


Figure 2-4 General Arrangement of the Curlew FPSO Mooring System

2.3.3. Wells

The Curlew production field consists of six wells located across three fields (refer to Table 2-3). A seventh well, Curlew DP4 was drilled only to the surface casing depth and has never produced. Further to those wells, there are seven exploration/appraisal wells, which have already been plugged and abandoned.

An overview of the drill cuttings deposits and assessment of potential impacts arising from these deposits are presented in Section 8.

Table 2-3 Summary of Curlew Wells

Well Name	Well Type	Drilled	Size/ Weight (Te)	Current Status	Discharges to Sea	Latitude; Longitude WGS84 Decimal Minutes
BP1L	Oil production	1997	4.0 m x 4.1 m x 6.6 m 37.0	Shut-in Not flown since 2007. Flushed in 2009.	Water-based Mud (WBM) and Oil-based Mud (OBM) drill cuttings discharged to sea	56°43.441′ N 01°15.677′ E
CP1S1	Oil production	2007	3.9 m x 3.9 m x 5.7 m 34.5	Producing	WBM drill cuttings discharged to sea. OBM drill cuttings skipped and shipped onshore	56°44′14.91 N 01°23′22.03 E

Table 2-3 Summary of Curlew Wells (Continued)

Well Name	Well Type	Drilled	Size/ Weight (Te)	Current Status	Discharges to Sea	Latitude; Longitude WGS84 Decimal Minutes
DP1S1	Gas/ condensate production	1996	4.0 m x 4.1 m x 6.6 m 37.0	Producing	WBM and OBM drill cuttings discharged to sea	56°43.325′ N 01°18.590′ E
DP2	Gas/ condensate production	1996	4.0 m x 4.1 m x 6.6 m 37.0	Shut-in, not producing	WBM and OBM drill cuttings discharged to sea	56°43.335′ N 01°18.577′ E
DP3	Oil production	1999	4.0 m x 4.1 m x 6.6 m 37.0	Producing	WBM drill cuttings discharged to sea. OBM drill cuttings skipped and shipped onshore	56°43.287′ N 01°18.644′ E
DP4A	Gas/ condensate production	2007	4.0 m x 4.1 m x 6.6 m 37.0	Shut-in, not producing	WBM drill cuttings discharged to sea. OBM drill cuttings skipped and shipped onshore	56°43.290′ N 01°18.530′ E

2.3.4. Additional Infrastructure

Table 2-4 provides a summary of additional infrastructure and Table 2-5 lists the spools and jumpers also included in the Curlew Decommissioning Project scope.

There are approximately 480 concrete mattresses (6 m x 3 m x 0.15 m, weighing approximately 5 Te each) deployed across the Curlew field area. The majority of these mattresses include polypropylene rope in their construction; however, there may be a number of mattresses manufactured using steel wire rope.

The majority of the mattresses are exposed with a small number buried or partially buried. As there is a mixture of mattress construction types, the mattress integrity status is unknown at this stage and current visual data are not conclusive. As a result, the integrity will not be known until lifting attempts are made during any removal operations.

There are approximately 3,000 grout bags at various locations throughout the field. These consist of 0.5 m^3 bags of aggregate weighing approximately 0.025 Te each. They act as subsea pipeline stabilisation features.

There has been rock cover deployed at various locations throughout the field. It is estimated that approximately 60,300 tonnes of rock have been deposited during the life of the field.

Table 2-4 Summary of Additional Subsea Infrastructure Associated with the Curlew Decommissioning Project

Subsea Installation	No	Size/Weight (Te)	Comment/Status	Latitude; Longitude WGS84 Decimal Minute
Mid Water Arch	1	12 m x 8.5 m x 3.8 m 63.8 (in air) 56 (submerged)	Tethered by two chains (14 Te) to two clump weight bases (approx. 42 Te each) and 4 pin piles (triangular 2.2 m x 1 m x 12.3 m; approx. 10 m depth) @ 6.1 Te each	58° 44.016′N 01° 17.754′E
Curlew D Subsea Manifold	1	8 m x 6 m x 4.9 m 87.6 (in air) 66 (submerged)	Piled structure – on seabed Four circular driven piles (0.61 m diameter, approx. 13.7 m long; 9 m depth) @ 5 Te each	56° 43.327′N 01° 18.612′E
Protection Structure of the Curlew D Services Distribution Unit	1	10.6 m x 9.1 m x 2.9 m 134.5	Gravity-based structure – on seabed (penetration skirt, concrete panels)	56° 43.322′N 01° 18.564′E
Curlew C Wellhead Protection Structure*	1	6.2 m x 6.2 m x7.0 m 6.2	Structure fixed around wellhead tree and flowbase.	56° 44.133′N 01° 23.268′E
Gas Export Subsea Isolation Valve	1	15.4 m x 7.6 m x 2.6 m 44.3 (in air) 30.8 (submerged) Excludes secondary steel and roof	Gravity-based structure – on seabed (penetration skirt)	56° 44.049′N 01° 18.057′E
Mattresses	Approx. 480	6 m x 3 m x 0.15 5 Te each	On seabed	N/A
Grout Bags	Approx. 3000	0.5 m x 0.5 m x 0.5 m 0.025 Te each	On seabed	N/A
Curlew C Concrete Protection Structures	2	5 m x 4 m x 4 m (BUTA protective cover) 48	Gravity-based structures protecting the corrosion monitoring spool and the umbilical termination unit at Curlew C.	56° 44.144′N 01° 23.276′E
		8 m x 4 m x 2.3 m (FSM™ protective cover) 48		56° 44.142′N 01° 23.263′E

**Note – Only Curlew C has a wellhead protection structure.*

Table 2-5 Summary of Spools/Jumpers Associated with the Curlew Decommissioning Project

Number	Description
PL-2523 1.02	Curlew C monitoring spool to Curlew C production pipeline – 0.03 km
PL-2523 1.03	Curlew C wellhead spool to Curlew C production spool <0.1 km
PL-2523 1.04	Curlew C wellhead to Curlew C corrosion monitoring spool <0.1 km
PL-2524 2.07	Curlew C gas lift pipeline to Curlew C wellhead spool <0.1 km
PL-2524 2.08	Curlew C spool to Curlew C wellhead <0.1 km
PLU-2525 1.04	Curlew C UTA to Curlew C Well P1 umbilical electrohydraulic/chemical <0.1 km
PL-2452	Curlew D production manifold to Well P1 6 inch wet gas <0.1 km
PL-1728	Curlew D production manifold to Well P2 6 inch wet gas <0.1 km
PL-1727	Curlew D production manifold to Well P3 8 inch wet gas 0.1 km
PL-2453	Curlew D production manifold to Well P4 6 inch wet gas 0.1 km
PL-1454 1.08	Curlew D SDU to Well P1 umbilical <0.1 km
PL-1454 1.03	Curlew D SDU to Well P2 umbilical <0.1 km
PL-1726	Curlew D Well P2 to Well P3 umbilical 0.2 km
PLU-2455	Curlew D SDU to Well P3 umbilical (replacement) 0.2 km
PLU-2454	Curlew D SDU to Well P4 umbilical <0.1 km
PLU-2455 JCDPM	Curlew D production manifold to Well P3 umbilical <0.1 km
PLU-2454 JCDPM	Curlew D production manifold to Well P4 umbilical <0.1 km
PLU-2455 JW3	Curlew D SDU to Well P3 umbilical (replacement 2) 0.2 km
PL-3568	Curlew D SDU to Well P1 umbilical (replacement) <0.1 km
PL-3569	Curlew D SDU to Well P4 umbilical (replacement) <0.1 km

Status all – on seabed – some under stabilisation materials, i.e. mattresses/rock placement

2.3.4.1. *Recovery of Debris Associated with 2012 Winter Storm*

In 2012, Curlew was severely affected by a winter storm and approximately 30 different items were lost to sea. The locations of this various debris have been confirmed and it has been agreed that these will be removed during decommissioning activities.

2.4. Overview of Proposed Decommissioning Activities

A phased approach will be taken for the Curlew Decommissioning Project. Details of each phase are summarised as follows:

1. Cleaning and disconnection of subsea system prior to removal of the Curlew FPSO off station:
    - Flushing of pipelines and subsea infrastructure
    - Draining, flushing, purging and venting of topsides
    - Disconnection of the FPSO

2. Decommissioning of the Curlew FPSO
   - Towing of the FPSO to a cleaning/dismantling yard (Note FPSO may be taken to a preliminary yard for cleaning before it is sent to a second yard for recycling, or it may be taken to a single yard where cleaning and recycling activities will be completed at the same time in one location)
   - Dismantling and recycling of the FPSO
   - Final disposal of all materials that cannot be recycled as waste
3. Decommissioning of subsea infrastructure:
   - Subsea removal including:
     - Removal of subsea structures (manifold, SSIV and Services Distribution Unit (SDU) protection structure)
     - Removal of flexible risers/umbilical risers including associated MWA, tethers, anchor base, clump weights and buoyancy elements
     - Removal of mattresses and grout bags
     - Removal of mooring system
   - Decommissioning of subsea pipeline infrastructure as per CA recommendations (refer to Section 2.4.3)
   - Debris removal
   - Seabed remediation as and if required

A high-level time frame for decommissioning of the Curlew cluster is provided in Figure 2-5.

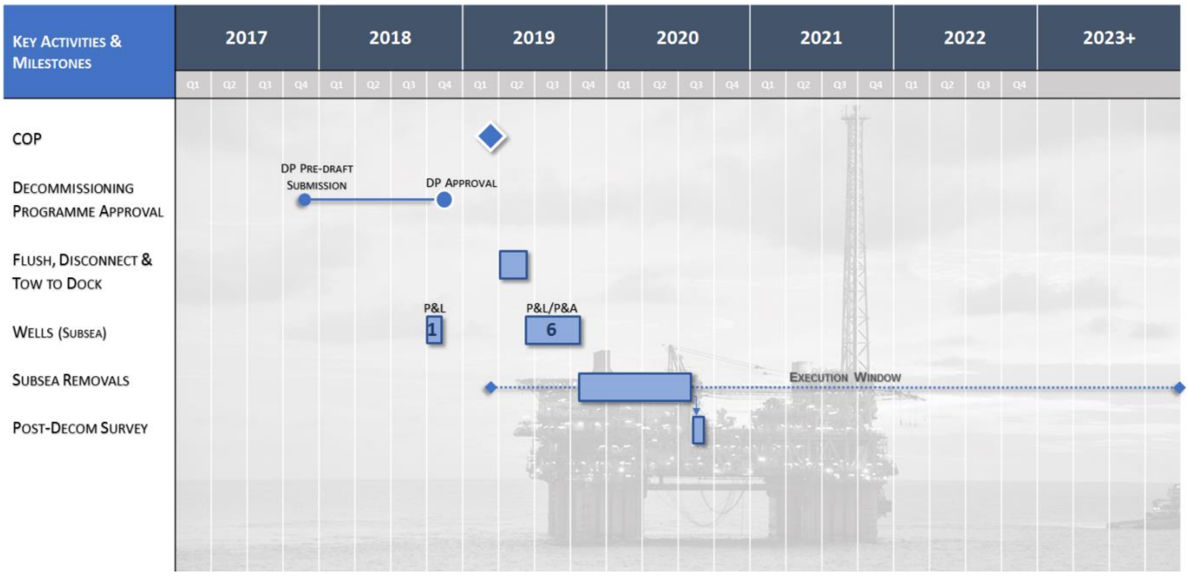


Figure 2-5 High-level Time Frame for the Curlew Hub Decommissioning Programmes

Wells

- Period 1 – Plug and Lubrication (P&L) of selected Curlew wells
- Period 6 – P&L of remaining wells with P&A of all Curlew wells

Subsea Removal

- Execution window may take place any time from CoP Q1/Q2 2019 until 2023+
- Box refers to estimated duration of the activity; approximately 9 to 12 months
- Post-decommissioning survey will take place after removal is complete

2.4.1. Cleaning and Disconnection of Subsea Facilities

Before disconnection from the wells and the FPSO, all pipelines will be flushed and displaced back to the FPSO to remove mobile hydrocarbons, and will be left filled with seawater.

The nature of the flushing will be slightly different for each pipeline. Typically, pipelines will be flushed with a minimum of two line volumes of seawater to remove all mobile hydrocarbons to an Oil-in-Water (OIW) level safe for diver intervention, and from which further cleaning would provide no further environmental benefit. The levels of OIW will be discussed and agreed with BEIS. The OIW levels will be communicated to BEIS at the time the flushing team proposes to cease the flushing activity.

The liquid hydrocarbons that can be recovered from flushing the lines will be exported by tanker as product; the gas will be used as fuel gas where practical, with the excess flared and/or vented in line with the permits agreed with the regulator. Produced water from the pipelines and seawater used for flushing that cannot meet permitted water quality for overboard discharge will be taken ashore for wastewater treatment.

Where technically feasible, contents of the umbilical cores will be flushed to the production pipelines and filled with seawater. A number of the umbilicals across the fields have blocked cores. As a result, it is not technically feasible to flush these cores. During disconnection activities, blocked umbilicals will be left open to the sea. The overview of blocked cores and impacts arising from the releases are presented in Section 8.

Following seawater flushing, the risers (production lines, gas lift line and umbilicals) will be cut just below the FPSO and temporarily stored on the seabed. Pipelines and umbilicals will be disconnected from the wells and stored on the seabed. These will be decommissioned during subsea operations.

Topside process equipment will be subject to a Drain, Flush, Purge and Vent (DFPV). All pumpable crude still stored in the crude oil tanks will be removed and taken away by a tanker. Chemical stock will be reduced to As Low as Reasonably Practicable (ALARP) during final weeks of operation. Unopened chemical containers, such as drums and intermediate bulk containers, will either be backloaded onshore or sent to another Shell Installation for re-use.

Chemicals in vessels, tanks and lines will be drained and flushed appropriately into either the hazardous drain tank, empty tote tanks or routed to the slops tanks. Those chemicals drained into tote tanks will also be backloaded. Chemicals drained into slops or hazardous drain tanks will be managed as per the chemical permit. The empty containers and already open containers which have not been drained will remain onboard the FPSO until they are decanted at the cleaning/dismantling yard. Diesel remaining onboard the FPSO post-CoP will be left for power generation and disposal onshore.

Following topside DFPV and subsea infrastructure flushing and disconnection, the FPSO will sail away to the cleaning/dismantling yard.

2.4.2. Decommissioning of Curlew FPSO

Various decommissioning options have been considered for the FPSO (refer to Section 3.3); however, due to the condition of the vessel and lack of suitable redeployment opportunities and/or third-party buyers, it has been recommended that recycling is currently the most realistic option.

Recycling of the FPSO will be undertaken by a ship dismantling yard. Currently, multiple yards are being considered as a final destination for the FPSO (refer to Section 14 for more details).

Depending on the capabilities of the dismantling yard, the FPSO may be taken to a cleaning yard first. This cleaning will involve the removal of any remaining fluids stored in tanks and pipework and semi solid deposits and liquids containing hazardous waste such as Naturally Occurring Radioactive Material (NORM). If it is more economically viable and the dismantling yard is licensed and capable of handling the cleaning and disposal of these waste materials, the FPSO will be taken directly to that yard for cleaning and recycling.

The FPSO will be towed to a cleaning/dismantling yard by multiple vessels to minimise the risk of loss of control (e.g. in high seas or in the event a towing vessel loses power). A preliminary assessment of the towing routes to each of the yards under consideration has been undertaken by Shell. The detailed assessment will be undertaken once the final yard(s) selection is made.

Once the FPSO is detached from the subsea tie-backs, it reverts to a ship. As such, all subsequent operations will be undertaken under the vessel's Ship Oil Pollution Emergency Plan (SOPEP) (BEIS, 2016a) in accordance with Marine Pollution (International Convention) (MARPOL) 73/78 and International Maritime Organisation (IMO) Guidelines.

2.4.3. Decommissioning of Subsea Infrastructure

The decommissioning of offshore O&G Installations and pipelines on the UKCS is controlled through the Petroleum Act 1998, as amended by the Energy Act 2008. The UK's obligations on decommissioning are governed principally by the 1992 OSPAR Convention. Agreement on the regime to be applied to the decommissioning of offshore Installations in the Convention area was reached at a meeting of the OSPAR Commission in July 1998 (OSPAR Decision 98/3). BEIS, formerly Department for Energy and Climate Change (DECC), guidance notes align with OSPAR Decision 98/3.

Pipelines currently do not fall within the remit of OSPAR Decision 98/3. As per the requirements of the BEIS Guidance Notes, pipelines must be considered on an individual case-by-case basis following a CA process considering all credible options.

The following elements of the Curlew hub were subject of the CA:

- Pipelines
- Pipeline ends
- Spools and jumpers, including mattresses
- Mooring suction anchor piles
- Mooring trenches

The following equipment will be fully removed and as such was NOT subject to a CA:

- Risers
- MWA
- Central subsea distribution unit
- Curlew D manifold
- SSIV
- Protective structures
- Mooring lines
- Grout bags
- Wellheads

[This page is intentionally blank]

3. ASSESSMENT OF ALTERNATIVES

3.1. Introduction

A CA is a detailed process that weighs up the pros and cons of various decommissioning options against key criteria.

This section summarises the preferred options for the Curlew Decommissioning Project, as selected during the Curlew CA workshop held on 8 to 9 August 2017. Full details of the process and outcomes of the CA are presented in the CA Report (Shell, 2017b) that accompanies the DP and this EIA report.

The Curlew CA followed the process described in the Subsea CA Methodology Report (Shell, 2017a), developed in compliance with BEIS Decommissioning Guidance Notes (DECC, 2011) and OGUK's Guidelines for Comparative Assessment in Decommissioning Programmes (OGUK, 2015).

3.2. Decommissioning of Subsea Infrastructure

The following elements of the Curlew infrastructure were subject to a CA process:

- Pipelines
- Pipeline ends
- Spools and jumpers, including mattresses
- Mooring suction anchor piles
- Mooring trenches

Decommissioning options were assessed in a multiple-stage process. For all Curlew subsea infrastructure, the methods were selected at the narrative and traffic light stage. A summary of the preferred decommissioning options is provided in Table 3-1 and Sections 3.2.1 to 3.2.2. For full details refer to the CA Report supporting the DP.

3.2.1. Narrative Conclusions

Where a particular piece of scope was in line with the BEIS guidance notes, such as a blanket rock covered pipeline, the decommissioning option was subject to preliminary selection at the initial screening workshop using narrative justification. The decommissioning options selected at the narrative stage of the CA included the following Curlew infrastructure and are described as follows:

- Curlew B production pipeline and umbilical route length
- Curlew C production pipeline and umbilical route length
- Curlew gas export pipeline, 0 km (FPSO end) to 10 km

During the CA workshop, the proposed methods were presented to and discussed with the key external stakeholders to confirm their acceptance of the proposed decommissioning method. This is termed a 'narrative conclusion' and did not require any further qualitative assessments.

Narrative conclusions as agreed with the stakeholders during the Curlew CA workshop are presented as follows.

3.2.2. Comparative Assessment Outcomes

Table 3-1 summarises the proposed options for the Curlew infrastructure, as selected during the Curlew CA workshop held on 8 to 9 August 2017.

Where multiple outcomes remain for a specific option, a worst-case scenario is provided. The impacts associated with these worst-case scenarios are addressed in Sections 7 to 13.

Table 3-1 Preferred Decommissioning Options (Worst-case Scenario provided where Multiple Outcomes Remain)

Grouping	Infra-structure	Pipeline Status	Option Selected	Worst-case Scenario
1	Curlew B production pipeline	In a trench 1.6 m deep and depth of cover between 0.6 m and 0.8 m	Decommission in situ with no intervention	Remediation of areas presenting a snagging hazard with rock placement based on the overtrawl trails
	Curlew B umbilical	In a trench 0.6 m deep and depth of cover 0.6 m	Provide spot rock cover at locations of exposures, then perform overtrawl survey to verify the pipeline does not present a snagging hazard	N/A
2	Curlew C production pipeline, gas lift and umbilical	In a trench 1.8 m deep with blanket rock-placement. Target rock height 0.6 to 0.7 m with additional spot rock-placement up to 1.1 m	Leave in situ, without remediation, verify with overtrawl trials	N/A
3	Curlew D production pipeline/ umbilical	In a trench 1.6 to 1.8 m deep and depth of cover 0.6 to 0.7 m. Spot rock-placement in areas of low cover.	Leave in situ, spot rock cover in areas of low cover/exposures or where overtrawl trials identify a snagging hazard	N/A
4	Curlew gas export line KP0 to KP10		Leave in situ with spot rock cover over the identified/ known areas of exposures	N/A
	Curlew gas export line KP10 toKP26		Leave in situ, following flushing operations complete as-left survey and the overtrawl trails to verify the pipeline is not a snagging risk.	If overtrawl trial fails, agree number and location of gateways for safe crossing zone over the pipeline.
5	Pipeline Ends with Rock		Curlew gas export pipeline end (at the FPSO) is laid on the seabed; however the end is protected by rock. Pipeline will be cut and existing rock berm extended over the pipeline.	N/A
			Curlew C production pipeline to be disconnected and ends capped. Pipeline ends to be lowered below the seabed and then rock covered to MSL	N/A
6	Pipeline ends without rock berm or not in close proximity to existing rock berm		Remove: Cut at acceptable depth and lift, fill with rock to MSL or lower pipeline end below seabed	N/A

Table 3-1 Preferred Decommissioning Options (Worst-case Scenario provided where Multiple Outcomes Remain) (Continued)

Grouping	Infra-structure	Pipeline Status	Option Selected	Worst-case Scenario
7/8	Spools and jumpers, including mattresses		Spools and jumpers, including protective mattresses will be fully removed.	N/A
9	Mooring trenches		Fill trenches with rock to below MSL; perform overtrawl with a chain mat to verify the trench is safe.	If overtrawl trail shows snagging hazard, fill trenches with rock to MSL
10	Suction anchor piles		Full removal	If full removal is unsuccessful, leave in situ, cut upper part to MSL and place rock berm on top.

3.3. Decommissioning of Curlew FPSO

Five disposal/recycling options considered for the Curlew FPSO following CoP:

- Life extension and redeployment: determining if any Shell project had an interest in re-using the Asset and undertaking refurbishment and upgrades. This would have involved storing the vessel for a limited period of time, in order to finalise a design for the upgrade and procure new topside equipment
- Sale to third party: if no Shell project was identified, the sale of the FPSO to a third party could have commenced using a suitable broker
- Recycle: if no offer was received, the recycling process would be carried out. The FPSO would be transported to a suitable recycling facility, where the vessel would be sold for scrap and disposed of in an environmentally responsible manner
- Lay up: the FPSO could have been transported to a convenient anchorage in sheltered waters while awaiting sale to a third party or a suitable internal deployment opportunity
- Conversion to trading tanker: reinstate the vessel to a trading oil tanker by removing topsides, flare and turret

Shell has recommended that recycling is currently the most realistic option, based on the condition of the FPSO and lack of suitable redeployment opportunities and/or third-party buyers.

[This page is intentionally blank]

4. STAKEHOLDER ENGAGEMENT

Stakeholder engagement is a recognised and important part of the EIA process, providing a mechanism for the concerns of consultees to be recorded, addressed and communicated within the ES, and where applicable acted upon during the subsequent phases of the project.

4.1. Approach

Stakeholders have been engaged from the early stages of the Curlew Decommissioning Project. Comments raised by stakeholders have been considered in the EIA process and in preparation of this ES. The statutory consultation period will provide formal opportunity for stakeholders to submit additional comment. Table 4-1 provides a summary of key engagement activities and outcomes relevant to the EIA.

Table 4-1 Key Issues Raised during Stakeholder Engagement to Date and How they have been Addressed in the EIA

Stakeholder	Consultation Focus	Outcome	Shell Response
Environmental Management Team, Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) June 2016	Overview of the project, including Ready to React phase and EoC. The scope of the pre-decommissioning survey included confirmation of drill cutting cores and that only the Curlew D P1 and P2 cuttings could be considered a pile under OSPAR 2006/5 Regime. Overview of the study results on the potential wax deposits in Curlew C production pipeline. Permit requirements related to execution of the project.	Curlew C pipeline to be plugged on both ends after disconnection from the FPSO. Safety, stability and plastic leaching into environment are relevant considerations. Advised that in certain circumstances, the use of mattresses to fill in O&G-related seabed depressions, and topped with rock to contain plastics, can be considered as a feasible decommissioning solution.	Curlew C pipeline will be plugged from both ends. Assessment of impacts from potential wax deposits is presented in Section 8. Impacts from plastic/metal leaching to the marine environment are also discussed in Section 8. Decommissioning of mattresses was a subject of the CA workshop, which concluded in full removal. Refer to Section 3.
Scottish Environment Protection Agency February 2017	Permit requirements related to transfer of waste including the FPSO vessel.	A TFS for waste is not required for FPSO and onboard equipment to remove from offshore station and transfer onshore to within the UK. A TFS would be required should the FPSO and onboard equipment be taken outside the UK for cleaning/recycling at the point of exit from the country (not from offshore location). The FPSO would not be classified as a waste to move to a UK location (e.g. if the intention was to warm stack and/or clean), but would be classified as a waste once it had been cleaned and due for towing to a recycling yard for disposal. A signed contract and final Inventory of Hazardous Waste is required for approval of TFS. Advised to confirm what waste cannot be handled in countries being considered for recycling of the FPSO (i.e. NORM, Ozone Depleting Substances (ODSs), Polychlorinated biphenyls (PCBs), fluorescent tubes, industrial smoke detectors, Mercury (Hg), etc.).	Shell is in the process of preparing TFS for potential dismantling locations. The Inventory of Hazardous Waste was conducted in July 2016 and it will be repeated prior to FPSO transit. Dismantling yards have been audited including review of the waste management. Refer to Sections 11 and 14 on Waste Management and Onshore IA.

Table 4-1 Key Issues Raised during Stakeholder Engagement to Date and How they have been Addressed in the EIA (Continued)

Stakeholder	Consultation Focus	Outcome	Shell Response
Offshore Decommissioning Unit OPRED April 2017	EoC and update on the progress of the project.	Adequate (minimum of 0.6 meters) burial status of pipeline proposed to be left in situ and full removal of mattresses is expected. Waste management to be in line with Waste Framework legislation. The end point for all FPSO waste to be outlined in the DP to inform stakeholders on the disposal pathways. Drill cuttings deposits overview.	Pipeline burial status was presented at the CA workshop; information also provided in the CA report supporting the DP. Mattresses were included in the CA process, which concluded all mattresses to be removed as long as it is feasible. CA outcomes are summarised in Section 3. Waste management is summarised in Section 11.
SFF June 2017	Outcome of the Environmental, Social and Community Health Scoping phase of the IA process.	Scottish Fishermen's Federation's (SFF's) concerns are the mooring trenches which pose high snagging risk to fisherman. Their preference would be to fill the trenches if they cannot be smoothed out. No objections raised to the proposed scoped in and scoped out impacts.	SFF invited and participated in the CA workshop. CA outcomes are summarised in Section 3.

Table 4-1 Key Issues Raised during Stakeholder Engagement to Date and How they have been Addressed in the EIA (Continued)

Stakeholder	Consultation Focus	Outcome	Shell Response
JNCC and MS July 2017	Outcome of the Environmental, Social and Community Health Scoping phase of the IA process.	5 years' worth of fishing data to be used in the IA instead of 1 year's worth of data. Confirmation of the presence of adults *Arctica islandica* was requested by the Joint Nature Conservation Committee (JNCC). Confirmation of the Curlew habitat to be classified as OSPAR threatened/declining 'Sea-pen and burrowing megafauna communities' based on results of sediment sampling. Remediation of mooring trenches: JNCC's preference is to avoid introduction of additional volumes of rocks in soft sediment environment; Marine Scotland (MS) advised that additional volume of rocks should be put into perspective, i.e. how many rocks are already there. Suction anchor piles are risk to fishermen and contingency options should be considered in the CA. Up-to-date inventories of all waste aboard, including locations and volumes per each material is critical, particularly in emergency situations. No objections were raised with regards to proposed impacts to be scoped in and scoped out.	Fishing data has been updated and is presented in Section 0. No adult *A. islandica* were found during the pre-decommissioning survey. Habitat around Curlew infrastructure classified as OSPAR threatened/declining 'Sea-pen and burrowing megafauna communities' habitat. Habitat conditions, including presence of OSPAR threatened/declining habitat was taken into account in section of decommissioning method of the mooring trenches. It is proposed to fill the trenches with rocks to certain depth to allow inflow of natural sediment characteristic for the area and re-establishment of the habitat, as long it is safe to other users. Contingency decommissioning option for suction anchor piles was also a subject of the CA. Overview of stabilisation material including estimates of existing rock cover is provided in Section 2. Inventory of Hazardous Materials (IHM) has been generated and it will be updated before the FPSO sails away from offshore location.

Table 4-1 Key Issues Raised during Stakeholder Engagement to Date and How they have been Addressed in the EIA (Continued)

Stakeholder	Consultation Focus	Outcome	Shell Response
CA Workshop – Participants: ▪ SFF ▪ MS ▪ BEIS ▪ JNCC ▪ Exxon Mobil (Project Partner) August 2017	CA workshop to allow Shell to compare the decommissioning options for pipelines and mooring system (trenches and anchor piles) against key criteria (safety, environmental, technical, societal and economic) and to support other decisions.	Refer to Section 3 for summary of CA outcomes.	

[This page is intentionally blank]

5. OFFSHORE ENVIRONMENTAL AND SOCIO-ECONOMIC BASELINE CONDITIONS

This section presents the offshore environmental and socio-economic baseline conditions of the areas potentially affected by Curlew decommissioning activities. This informs the identification of physical, biological, societal and community receptors that may be sensitive to potential impacts and risks from the project.

Where information is available, potential sensitivities of each of the decommissioning yards are summarised in Section 14. A high-level risk assessment of the yards and the FPSO towing routes is also provided in Section 14.

5.1. Offshore Cluster Location and Environmental Surveys

The Curlew facilities are located approximately 210 km east of the Aberdeenshire coastline and 55 km west of the UK/Norway median line, in a water depth of approximately 92 m. The facilities to be decommissioned are located within Quadrant 29. The majority of infrastructure is concentrated in the cluster located in Block 29/07 with the gas export pipeline cutting across Blocks 29/08 and 29/09.

5.1.1. Environmental Surveys

This section draws on a number of data sources, including published papers on scientific research in the area, studies commissioned by the O&G industry, and site-specific investigations commissioned as part of the exploration and development process.

Multiple site seabed surveys have been undertaken in and around the Curlew area; this includes site-specific environmental surveys Gardline in 2006 and Fugro in 2016 (refer to Figure 5-1). The sampling locations of the environmental survey undertaken by Fugro in 2013 are presented in Figure 5-2.

The results of the following surveys were used to inform the environmental description:

- The Curlew Pre-Decommissioning Environmental Survey UKCS Block 29/7 (Fugro, 2016) undertaken on 21 to 23 July 2016 aimed to provide an assessment of the benthic environment and seabed physico-chemical characteristics of the Curlew area. The aim of the survey was to inform the planned decommissioning process with regards to potential disturbance of contaminated sediments and habitats. Figure 5-1 indicates the survey sample locations. The survey involved the collection of environmental seabed samples, and video and photography of the seabed. The survey also collected core samples of drill cutting deposits from Curlew P1/P2, with focus on the assessment of the extent of the impact from historic discharges at the Curlew field
- Gardline Environmental Limited (Gardline) conducted an environmental survey on 15 to 16 October 2006 (Gardline, 2006) along the proposed pipeline and umbilical route between the Curlew FPSO and Curlew C well location. The main objective of the survey was to obtain sediment samples for an assessment of the environmental status of the seabed, prior to installation of a subsea pipeline and umbilical. Grab samples were taken from eleven stations along the pipeline route for quantitative and qualitative physico-chemical and macrofaunal analyses. Figure 5-1 indicates the survey sample locations within the Curlew C Field. The survey identified the seabed to be comprised of silty fine sand, with occasional exposures of underlying clay. Several lengths of cable, coils of wire and linear items of debris occurred within the survey area, including a 95 m length of cable 435 m east of the proposed Curlew C northern option location
- Fugro Survey Limited (Fugro) conducted a geophysical and habitat survey of the proposed pipeline route from Fram to Curlew, crossing Blocks 29/3, 29/7 and 29/8 (Fugro, 2013). Additional geophysical and habitats surveys were executed over the Curlew B and D sites

- The objective of the geophysical survey was to provide information on bathymetry, seabed features, Installation constraints and shallow soils within the route corridor and Curlew B and D sites. The habitat survey aimed to provide data on habitats within the survey area to identify any potentially sensitive habitats, including Annex I habitats. This was carried out through further investigation of side-scan sonar and bathymetric data as well as analysis of seabed photographic data, including stills and video footage
- The survey identified the PMF habitat 'offshore subtidal sands and gravels' throughout the survey area, and as such was determined to be suitable for supporting aggregations of ocean quahog (*Arctica islandica*), a PMF species. No live specimens of ocean quahog or signs of feeding siphons were observed within the survey area. No Methane Derived Authigenic Carbonate (MDAC) was recorded in the vicinity of the Curlew fields

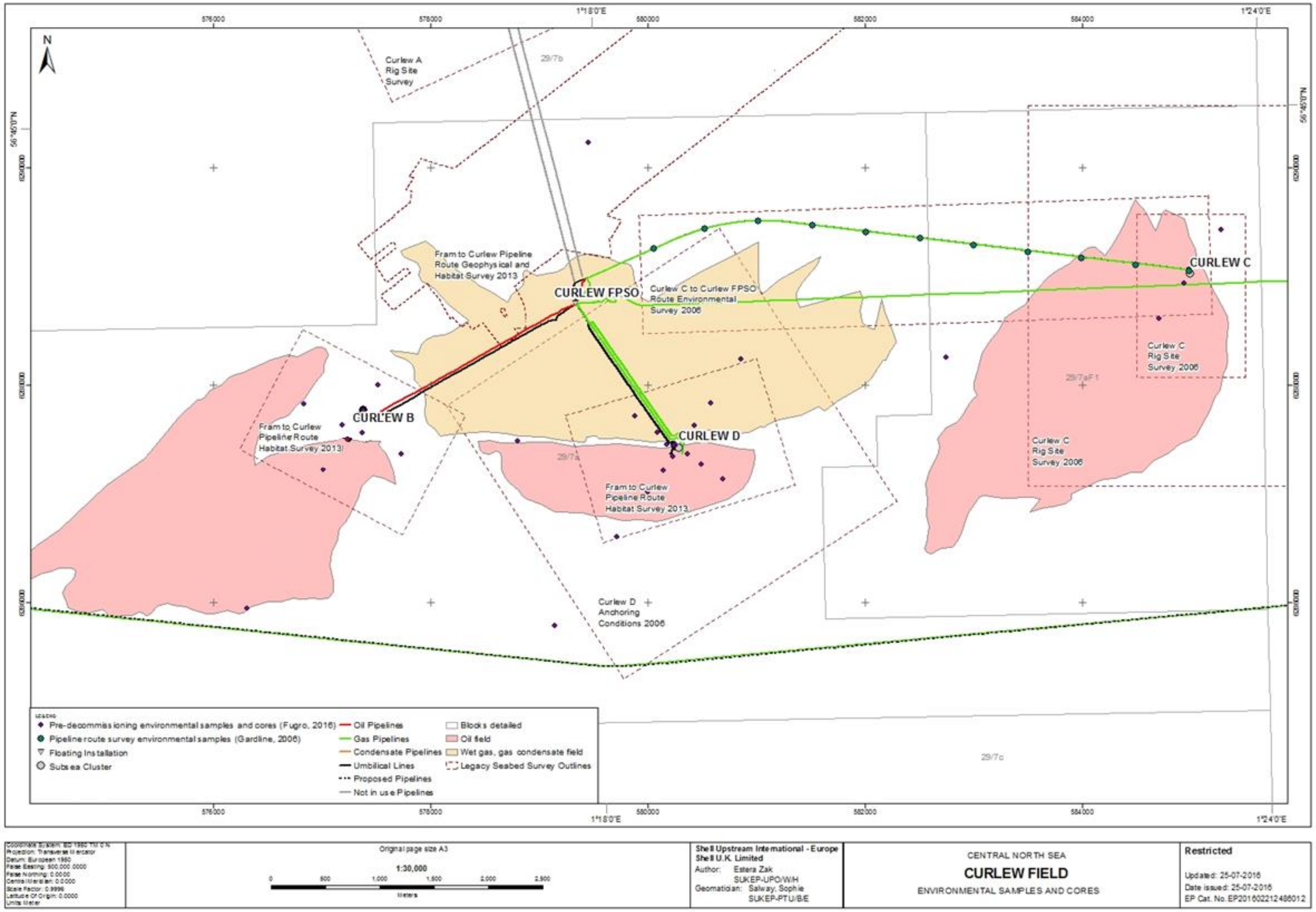


Figure 5-1 Curlew Field 2006 (Gardline) and 2013 (Fugro) Environmental Surveys, including Sample and Core Locations

5.2. Physical Environment

Characteristics of bathymetry, currents, meteorology, sea temperature, salinity, and seabed sediments in the Curlew area are described in the following subsections.

5.2.1. Bathymetry

The water depth in the Curlew area is relatively uniform, ranging between 92 m and 94 LAT. The seabed around the area is generally flat, with gradients of less than 0.1 ° (Gardline, 2006).

5.2.2. Wave and Currents

The dispersion, transport and ultimate fate of marine discharges, nutrients and plankton are influenced by the direction and speed of regional bodies of water and local currents (OSPAR, 2010a).

Cyclonical circulation in the North Sea is driven by a combination of winds, tidal forcing and topographically-steered inflows. The predominant regional current in the CNS is the Atlantic water inflow of the Fair Isle/Dooley current, which flows around the north of the Orkney Islands and into the North Sea (BMT Cordah, 1998; North Sea Task Force, 1993) (refer to Figure 5-2).

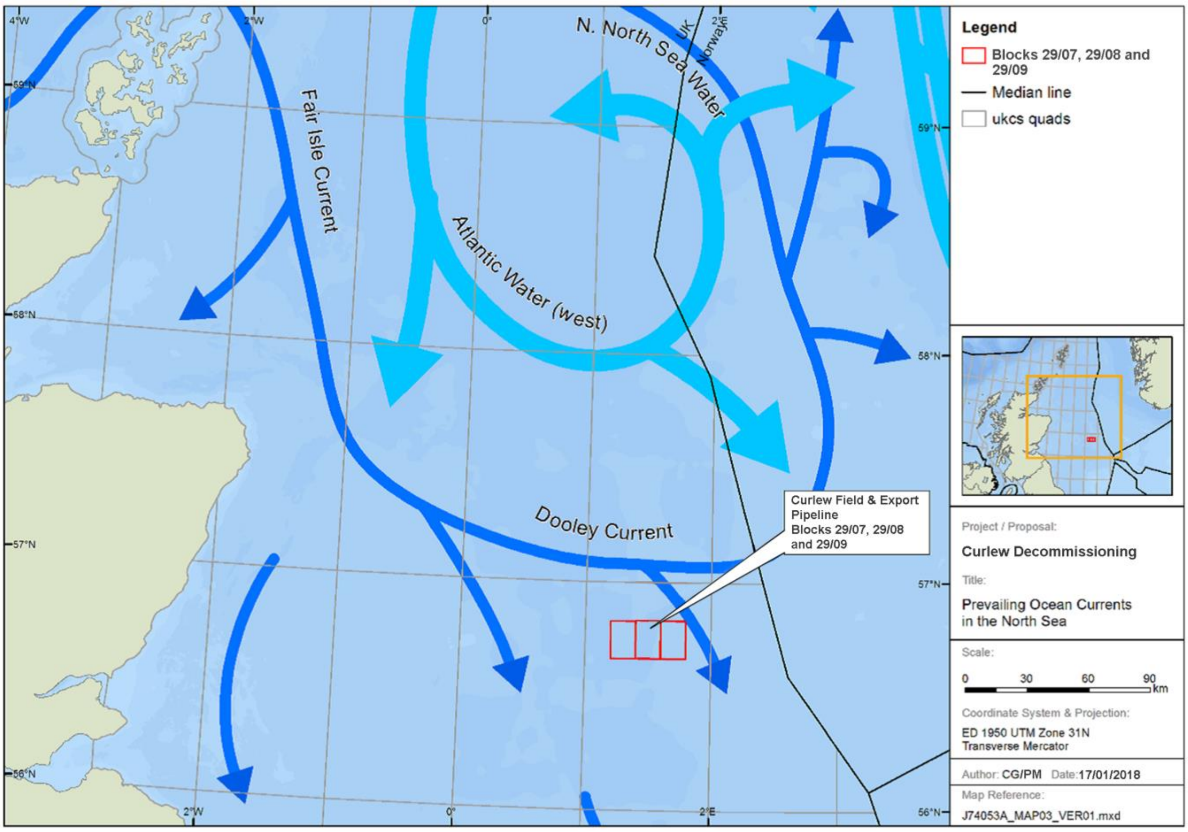


Figure 5-2 Ocean Currents in the North Sea

Tidal currents in the vicinity of the Curlew infrastructure are typical of the offshore CNS. Relatively weak surface currents exist, with a mean spring tidal current speed at the ocean surface of 0.36 m/s and at 1 m above the seabed 0.20 m/s (Shell, 2013). Residual current speed and total current speed are presented within Figure 5-3 and Figure 5-4.

Within the Curlew field, tidal currents are dominant and the primary current flow direction is approximately north-south (Figure 5-4) (Shell, 2013). Within the upper half of the water column of the Curlew project area, the total current speed is exceeded on average 75% of the time at 0.06 m/s. At 1 m above the seabed, the total current speed is exceeded on average 75% of the time at 0.04 m/s.

The annual mean significant wave height in the Curlew area ranges between 1.26 and1.50 m in summer and 2.76 and3.00 m in winter, with a mean tidal range of 2.01 to 2.25 m (ABPmer, 2016).

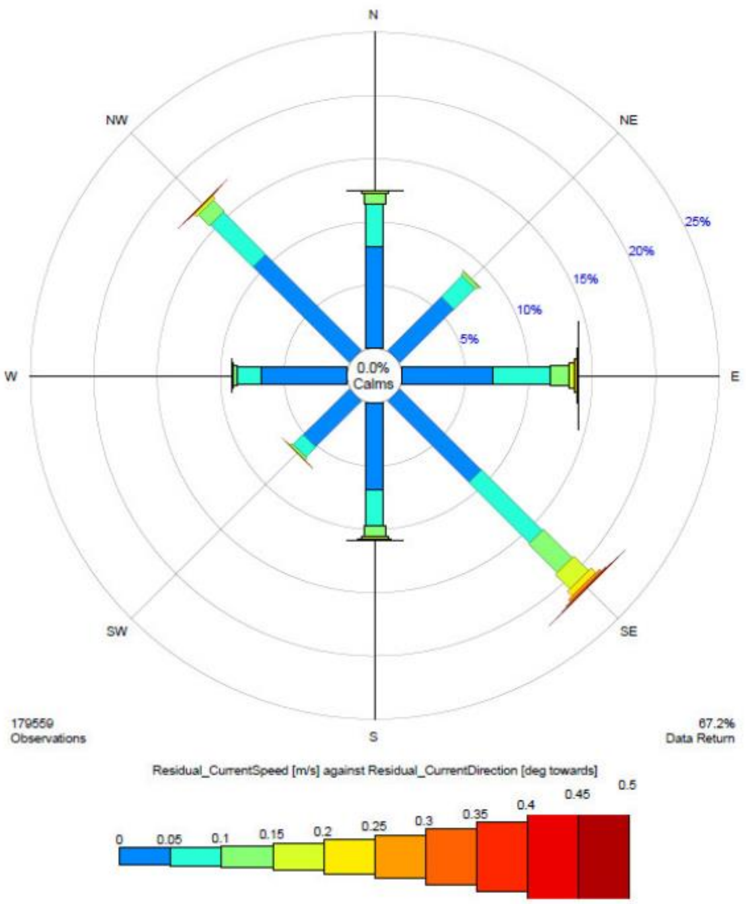


Figure 5-3 Operational Mean-depth Residual Current Speed versus Direction (Towards which Currents are Flowing) (Shell, 2013)

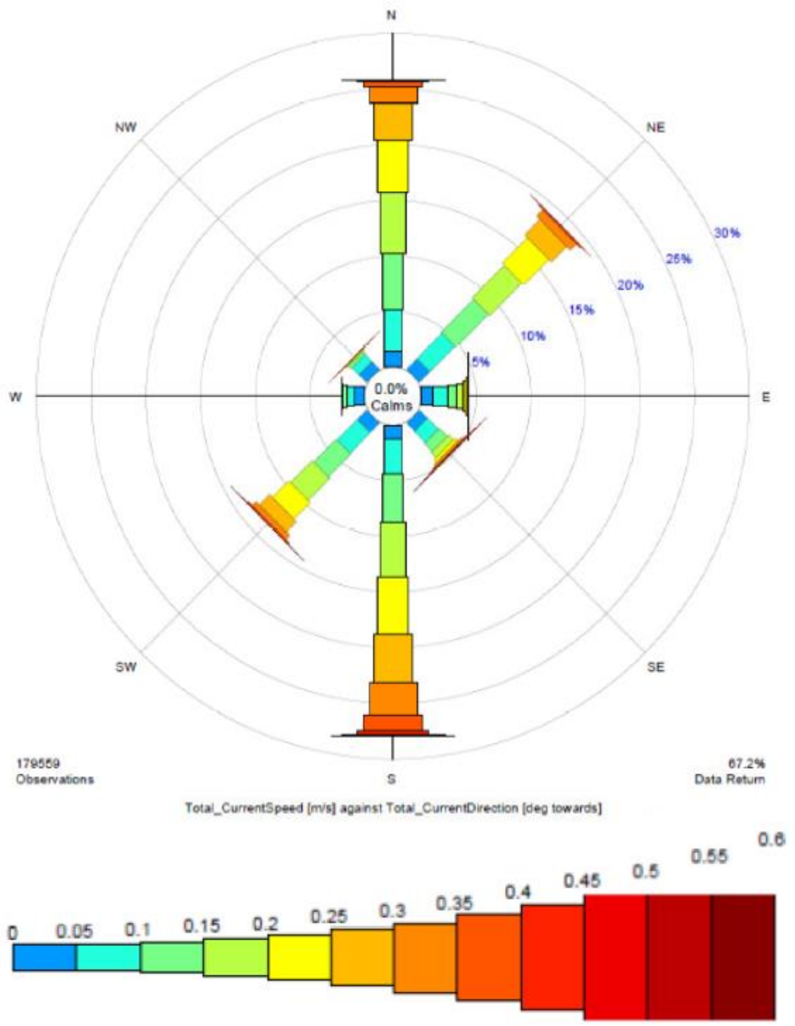


Figure 5-4 Operational Mean-depth Total Current Speed versus Direction (Towards which Currents are Flowing (Shell, 2013)

5.2.3. Meteorology

Data recorded for the CNS show that winds can originate from all directions, although there is a tendency for winds originating from the south and southwest to dominate (refer to Figure 5-5). There is some seasonality to wind direction, with winds originating from the south and west predominating September to March (UKDMAP, 1998). The average wind speed within the CNS is approximately 9 m/s at 10 m above mean sea level. Low-pressure systems cause the strongest winds and these usually track from approximately southwest to northeast across the Northwest European Continental Shelf, and have central pressures in the range 950 to 1040 mb. Any low-pressure system with a central pressure below 990 mb may result in gales.

Wind rose data obtained within the Curlew field is presented in Figure 5-5 and demonstrates that winds originate in all directions, although winds of south, southwest and westerly directions dominate, with little seasonal variation. For approximately 75% of the year at 10 m above mean sea level, wind speeds exceed 5.3 m/s, for 50% of the year wind speeds exceed 8.1 m/s, and for 1% of the year winds can reach speeds of approximately 19.8 m/s. The hourly average wind speed with an average recurrence of 100 years is 35 m/s at 10 m above mean sea level (Shell, 2013).

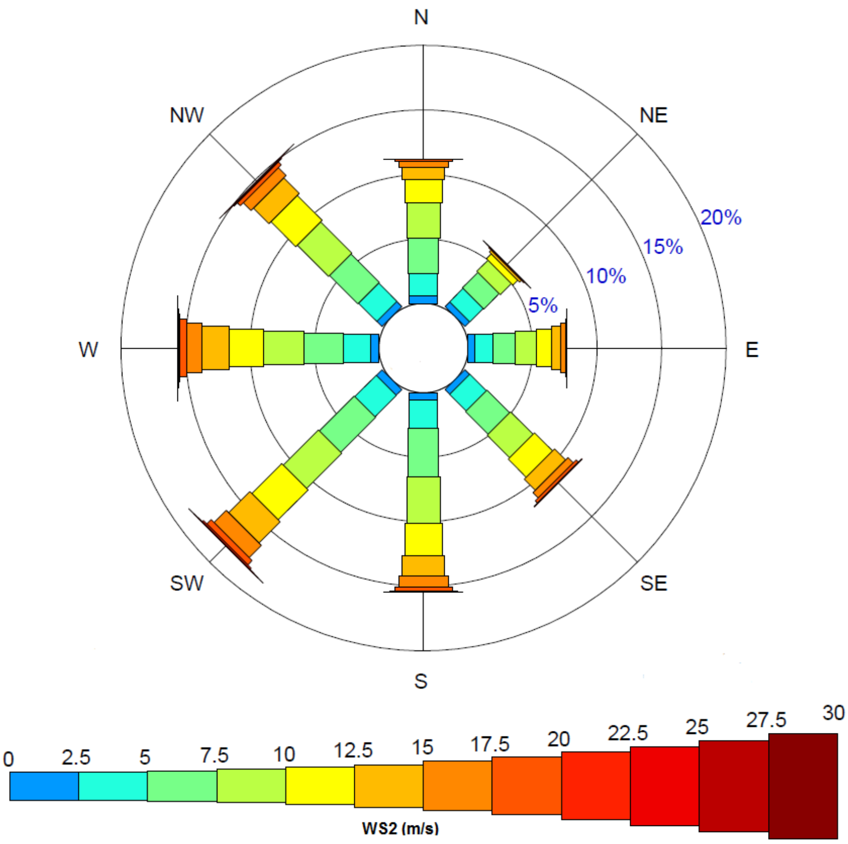


Figure 5-5 Hourly Mean Wind Speed Rose at 10 m above Mean Sea Level and Wind Directional Distribution for the Curlew Field (Shell, 2013)

5.2.4. Sea Temperature and Salinity

Mean sea surface water temperatures in the Curlew area range from 6.5°C in winter, to 14.5°C in summer, while sea bottom temperatures range from 6.5°C in winter, to 7°C in summer (NMPi, 2016). A seasonal thermocline can occur over the CNS, and may last from May to October (MAFF, 1981; UKDMAP, 1998). Mean sea surface and sea bottom salinity in the Curlew area ranges from 35.1 ppt in winter to 35 ppt in summer (UKDMAP, 1998).

5.2.5. Seabed Sediments

The distribution of seabed sediments within the North Sea results from a combination of hydrographic conditions, bathymetry and sediment supply. Seabed sediments comprising mineral and organic particles may be present as mud, sand or gravel.

The seabed sediment distribution in the CNS is illustrated in Figure 5-6. Sediments classified as sand and slightly gravelly sand cover approximately 80% of the CNS (Gatliff, 1994). These sandy sediments occur over a wide range of water depths, from the shallow coastal zone down to about 110 m in the north and to below 120 m in isolated depths to the south and west. The carbonate (shell) content of the sand fraction is generally less than 10% (Gatliff, 1994).

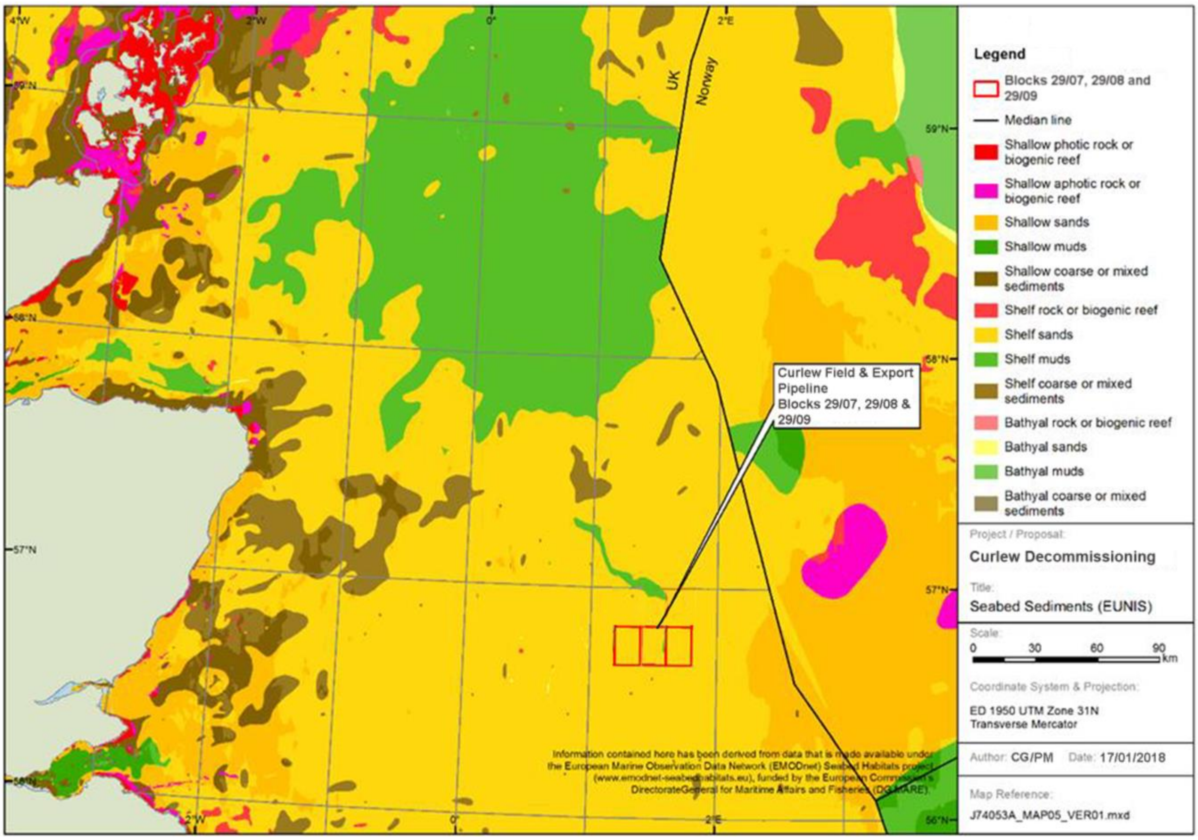


Figure 5-6 North Sea Sediment Type (EU SeaMap, 2015)

5.2.5.1. *Curlew C Pipeline Route Survey*

The 2006 Curlew C pipeline route survey (Gardline, 2006) identified sediments consisting of silty, fine sand with shell fragments, reaching a maximum thickness of 1.8 m, and generally <1 m thick. The silty, fine sand veneer was underplayed with mostly soft and very soft clay.

Mean particle size diameters ranged from 49 to 72 µm, and sediments ranged from coarse silt to very fine sand in the area (Gardline, 2006). The main substrate, based on particle size analysis of the samples at all the stations within the survey area, contained between 57 and 65% fine sand to very fine sand, and between 27 and 42% fine material.

Sediment Total Organic Matter (TOM) content ranged from 1.1 to 2.1%. Total Organic Carbon (TOC) concentrations ranged from 0.7 to 1.3%. Total Hydrocarbon Concentrations (THCs) ranged from 4.811 to 7.490 µg/g. This is relatively low considering the close proximity of the Curlew field to previous drill sites (Gardline, 2006).

Sediment Barium (Ba) concentrations suggested that sediments were not contaminated with drill cuttings, despite the relatively close proximity of a number of historic drill sites (Gardline, 2006). Significant correlations were found between lithium concentrations and all other metals analysed except Ba and Cadmium (Cd), suggesting that varying sediment granulometry exerted a strong influence on measured metal concentrations. The Curlew C survey samples were analysed using the Hydrofluoric Acid (HF) method which enables comparison to the OSPAR Background Concentrations (BCs) and Background Assessment Concentration (BAC) levels and The United Kingdom Offshore Operators Association (UKOOA) background levels. No metal concentrations exceeded the OSPAR BC and BAC thresholds while Ba, chromium and Lead (Pb) exceeded the UKOOA mean but are below the 95th percentile, as shown in Table 5-1.

5.2.5.2. *Pre-decommissioning Survey*

The pre-decommissioning survey of the Curlew area classified surface sediments predominantly as poorly sorted, very fine sands, with the exception of two remaining samples classified as coarse silt (Stations D23 and C13), due to slightly higher proportions of silt and clay particles (Fugro, 2016). The mean particle diameters (including the reference and field reference stations) ranged from 44 to 102 μm (mean 78 μm) and the variation across the stations was low. The Curlew D sediment core subsamples were generally slightly coarser with mean particle size ranging from 74 to 204 μm.

Total carbonate (as calcium carbonate) and organic matter content in the surface sediments ranged from 2.2 to 14.9% (mean 5.3%) and 0.6 to 9.4% (mean 2.1%) respectively (Fugro, 2016). TOC levels ranged from 0.30 to 0.60% (mean 0.43%). In the sediment cores, total carbonate and organic matter content ranged from 1.5 to 11.3% and from 1.0 to 4.3% respectively. TOC ranged from <0.02 to 0.50%.

THC in surface sediment samples ranged from 4.5 to 56.4 μg/g, with the highest values recorded at Stations B03, B01, B11 and D23 (Fugro, 2016). THC recorded in the Curlew D core samples ranged from 2.4 μg/g in the 30 cm section from station D01 to 305 μg/g in the top section at D01.

Sediment hydrocarbon analysis indicates that drill cuttings deposits containing synthetic drill fluid 'Versaplus' are restricted to within 200 m of the Curlew B and D drill centres (Fugro, 2016). Changes in the drill cuttings composition and decreases in the concentration of drill fluid hydrocarbons, compared to the results of post-drilling surveys undertaken in 1997 and 1998 (Gardline), indicate considerable environmental weathering has occurred since drilling was completed. Sediment cores indicate no evidence of anoxic surface conditions within 100 m of Curlew D (Fugro, 2016).

The ratio of hydrocarbons to barite for sediments containing drilling fluid were all well below the expected ratio for fresh drilling mud. This confirms that drill fluid inputs have degraded considerably since discharge (Fugro, 2016).

The total concentrations of sediment PCBs recorded in the Curlew area were comparable to the OSPAR BAC values. Alkylphenol concentrations were highest within the surface and core sediments collected within 100 m of Curlew B and D, with nonylphenol concentrations exceeding the Norwegian Pollution Control Authority Class V levels in a number of the Curlew D core sections. The concentration of organotin compounds was typically lower than the analytical detection limit. However, dibutyl tin levels of up to 7.65 ng/g were recorded in the samples collected close to Curlew D (Fugro, 2016).

The sediment chemistry results are presented within Table 5-1, which shows no recorded exceedances in accordance with OSPAR Effects Range Low (ERL) guidance criteria (OSPAR, 2014) which is the concentration below which adverse effects on organisms are rarely observed. The maximum recorded Hg level did exceed the ERL at Station D23 which is 100 m from the Curlew D cuttings pile.

UKOOA mean background levels were exceeded for mean and maximum measured values for THC, Ba, Total Barium (TBa), Cd, Chromium (Cr), Copper (Cu), Iron (Fe), Hg, Pb and Zinc (Zn). Nickel (Ni) exceeded UKOOA mean levels for maximum concentration levels only.

UKOOA 95th percentile levels were exceeded for maximum and mean concentrations of Ba and TBa. Maximum concentrations were exceeded only for THC, Cd, Cu, Pb and Zn.

Table 5-1 Sediment Chemistry from the Curlew Pre-decommissioning Environmental Survey in 2016 (Fugro, 2016) and the Curlew C Environmental Baseline Survey (Gardline, 2006)

Survey	Level	THC	PAH*	As	Ba	TBa	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
Curlew Pre-Decommissioning Environmental survey (HN03 digest) (Fugro, 2016)	Min	4.50	0.156	1.82	97	346	<0.020	9.56	1.48	3,600	0.008	1.99	4.50	11.3
	Max	56.40	0.602	4.42	5,450	32,400	0.156	16.00	12.60	7,260	0. 306	7.55	40.10	87.3
	Mean	10.60	0.286	2.78	979	3,120	0.032	11.70	3.13	5,130	0.036	5.49	10.80	23.3
Curlew C Environmental Baseline Survey (HF digest) (Gardline, 2006)	Min	4.81	0.234	2.80	320	-	0.040	19.00	2.60	-	<0.090	6.00	12.00	15.0
	Max	7.49	0.431	4.40	380	-	0.090	29.00	4.00	-	<0.090	8.80	15.00	21.0
	Mean	5.90	0.327	3.60	346	-	0.060	25.00	3.40	-		7.50	13.00	19.0
OSPAR ERL/Medium (OSPAR, 2014)	ERL	-	-	-	-	-	1.200	81.00	34.00	-	0.150	20.90	47.00	150.0
	ERM	-	-	-	-	-	9.60	370.00	270.00	-	0.710	51.60	218.00	410.0
UKOOA – CNS HNO_3 Digest (UKOOA, 2001)	Mean	9.51	-	-	178	348	0.030	9.13	2.41	4,725	0.030	7.31	6.75	13.5
	95th Percentile	40.10	-	-	523	720	0.120	31.00	6.00	11,160	0.120	19.00	16.70	32.6
UKOOA – CNS HF Digest (UKOOA, 2001)	Mean	-	-	-	348	-	0.760	23.90	6.30	7,333	0.170	11.50	12.60	21.3
	95th Percentile	-	-	-	720	-	1.000	54.00	18.00	11,960	0.580	21.70	26.80	43.4

Key for applicable exceedances:

OSPAR ERL	UKOOA Mean	UKOOA 95th Percentile

5.2.5.3. Drill Cuttings

Sediment cores of the top 0.5 m of the seabed were collected by Remotely Operated Vehicle (ROV) at five stations located around Curlew D to investigate the depth and composition of any drill cuttings present in close vicinity to the drill centre. The sediment chemistry results of the core samples are given in Table 5-1.

The results show that 'Versaplus' synthetic drilling fluid components, used to drill the wells, was present in all surface sediment samples and lower concentrations were present in some of the subsurface layers. The proportion of drilling fluid compounds decreased with depth at all stations, with the exception of D04 where slightly higher concentrations of 'Versaplus' were recorded in the deepest lying layer.

The THCs reported in the surface layer collected from the cores were considerably higher than UKOOA background values, ranging from 46.5 to 305 $\mu g g^{-1}$ but relatively low when compared to hydrocarbon concentrations typically recorded in North Sea cuttings piles containing OBM drilling muds such as North West Hutton which had an average concentration of 49000 $\mu g g^{-1}$ (BMT Cordah, 2004) and Millar, where the concentration ranged from 18,000 to 77,000 $\mu g g^{-1}$ (Aquatera, 2008). Considerably lower hydrocarbon concentrations were recorded in the deeper-lying layers subsampled from the Curlew D cores, with concentrations ranging from 2.4 to 25.7 $\mu g g^{-1}$, with the highest results being only marginally higher than UKOOA mean levels. The data suggest that the cuttings deposits in the area of seabed sampled around Curlew D are relatively shallow (typically less than 10 cm deep).

Poly Aromatic Hydrocarbon (PAH) concentrations were highest in the core samples dominated by drilling fluid components and, as was the case for total hydrocarbons, the values were relatively low when compared to concentrations recorded in typical North Sea piles. All PAH concentrations were below the ERL threshold concentrations, indicating that ecological affects would be not expected for these samples (Fugro, 2016).

Overall, the data indicate that cuttings deposits containing synthetic drilling fluid are restricted to the areas in close proximity to the Curlew D drill centre with no evidence of any drilling fluid being recorded more than 200 m from Curlew D.

Seabed samples around Curlew B were compared to results from a post drilling survey from 1998 (Gardline, 1998). The comparison showed changes in the proportion of drilling fluid components and decreases in the concentrations of drilling fluid hydrocarbons. This indicates that considerable environmental weathering has occurred. The pre-decommissioning survey showed no evidence of anoxic subsurface conditions in sediments within 100 m of Curlew D (Fugro, 2016).

As only water-based fluids were discharged to sea while drilling the Curlew C well, the survey showed no evidence of any synthetic drilling fluids (Fugro, 2016).

The sediment metals concentrations show Ba at all stations and elevated Hg, Pb and Zn levels (exceeding ERL thresholds) were recorded at three of the stations (refer to Table 5-2). Sediment metal concentrations were typically highest in the surface layer, indicating relatively shallow cuttings deposits when compared with those recorded previously for North Sea cuttings piles.

Table 5-2 Sediment Chemistry of Curlew D Core Samples (Fugro, 2016)

Concentrations Expressed as $\mu g g^{-1}$ Dry Sediment																
Core	Depth (cm)	Drill Fluid (DF)	DF Conc.	THC	PAH	As	Ba	TBa*	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
D01 62 m 306°	T – 0	Versaplus	186	305	0.782	6.55	3440	28500	0.272	27.4	12.8	13600	0.334	6.32	51.6	165
	M – 15	-	-	6.3	0.058	1.46	1650	3380	<0.02	5.00	1.77	2990	0.073	3.16	3.48	14.2
	B – 30	-	-	2.4	0.014	1.53	142	5660	<0.02	4.36	3.80	2700	0.002	3.55	<3.00	11.1
D02 57 m 303°	T – 0	Versaplus	130	199	0.549	4.6	1770	14400	0.046	9.82	4.66	6650	0.056	5.83	8.70	56.8
	M – 10	Versaplus	0.3	5.8	0.040	1.88	299	6220	<0.02	5.29	3.37	2890	0.004	4.43	<3.00	6.47
	B – 20	-	-	2.6	0.034	2.09	112	3040	<0.02	4.79	<1.00	2740	0.010	4.14	<3.00	7.36
D03 42 m 302°	T – 0	Versaplus	33.6	60.4	0.196	1.98	2990	17300	0.056	6.46	3.05	3400	0.160	3.65	14.9	41.4
	M – 19	-	-	9.3	0.124	4.68	2640	3510	0.201	10.2	6.09	7380	0.727	7.10	73.8	179
	B – 37	-	-	6.0	0.075	3.67	4320	5900	0.047	12.1	8.71	7290	0.114	7.95	10.4	44.2
D04 56 m 310°	T – 0	Versaplus	25.4	46.5	0.324	2.34	2060	56200	0.047	6.53	2.78	3670	0.108	4.14	8.12	32.7
	M – 12	Versaplus	1.6	9.4	0.066	2.74	752	15000	<0.02	4.3	1.24	2650	0.009	3.41	3.05	12.9
	B – 25	Versaplus	6.3	25.7	0.293	2.27	1040	25300	<0.02	9.72	1.57	3130	0.013	4.08	4.00	13.4
D05 58 m 298°	T – 0	Versaplus	17.1	72.5	0.493	2.05	3090	13500	0.052	7.95	3.75	5410	0.136	4.55	12.8	42.0
	M – 13	Versaplus	11.4	12.6	0.062	1.63	1920	7980	0.022	5.17	4.38	3180	0.021	3.50	3.86	14.3
	B – 26	-	-	8.1	0.116	2.60	4780	9500	0.070	9.60	4.14	5940	0.340	6.38	18.6	63.1
TOTAL	Min	-	0.3	2.4	0.010	1.46	112	3040	<0.02	4.30	<1.00	2650	0.002	3.16	<3.00	6.47
	Max	-	186	305	0.782	6.55	4780	56200	0.272	27.4	12.8	13600	0.727	7.95	73.8	179
	Mean	-	45.7	51.4	0.215	2.8	2070	14400	0.058	8.58	4.17	4910	0.140	4.81	14.5	46.9
OSPAR ERL/Medium (OSPAR, 2014)		ERL		-	-	-	-	-	1.200	81.00	34.00	-	0.150	20.90	47.00	150.0
		ERM		-	-	-	-	-	9.60	370.0	270.0	-	0.710	51.60	218.0	410.0
UKOOA – CNS HNO_3 Digest (UKOOA, 2001)		Mean		9.51	-	-	178	348	0.030	9.13	2.41	4,725	0.030	7.31	6.75	13.5
		95th Percentile		40.10	-	-	523	720	0.120	31.00	6.00	11,16	0.120	19.00	16.70	32.6
OSPAR Drill Cuttings Threshold (OSPAR, 2006)		50 mg/kg														

OSPAR ERL	UKOOA Mean	UKOOA 95th Percentile	OSPAR Drill cuttings threshold

5.3. Biological Environment

This section summarises the characteristics of plankton, benthos, finfish and shellfish spawning, and nursery grounds, marine mammals, seabirds and offshore conservation areas relevant to the Curlew field.

5.3.1. Plankton

The plankton community comprises drifting organisms, suspended in the pelagic zone and transported by currents. It includes 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 most 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 varies 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. The seasonal timing of phytoplankton and zooplankton production has altered in recent decades, with some species present up to 4 to 6 weeks earlier than 20 years ago, and this directly affects their availability to predators such as fish (OSPAR, 2010a)

Seasonal stratification of the water column into layers of different temperatures has an important impact on phytoplankton abundance. A peak in phytoplankton abundance usually occurs every spring, with phytoplankton communities dominated by relatively large diatoms, e.g. *Thalassiosira spp.* and *Chaetoceros spp.* (OESEA, 2016). There may be an additional, but smaller, peak in phytoplankton numbers during the autumn with smaller dinoflagellate species, e.g. *Ceratium*, dominating (SAHFOS, 2001).

Zooplankton communities in the North Sea are dominated by copepods, e.g. *Calanus spp. Acartia spp* and *Metridia lucens*, occurring during the summer peak period (Nielsen and Richardson, 1989), particularly *Calanus finmarchicus* and *C. helgolandicus*, in terms of productivity and biomass (OESEA, 2016). The larger zooplankton includes krill (*Euphausiacea*), salps and doliolids (*Thaliacea*) and jellyfish (*Siphonophorea* and *Medusea*), which are more abundant in late summer and autumn (OESEA3, 2016).

The plankton community, although vulnerable to chemical or hydrocarbon releases to the sea, is less vulnerable to accidental releases than other species such as the benthos, because most phytoplankton have a rapid population growth and there is, during most of the year a continual exchange of individuals in the water mass.

5.3.2. Benthic Fauna

Benthic fauna comprises species which live either within the seabed sediment (infauna) or on its surface (epifauna). Such species may be sedentary or mobile, and may encompass a variety of feeding habits (e.g. filter-feeding, predatory or deposit-feeding), and occupy a variety of different niches. Epifaunal and infaunal species are particularly vulnerable to external influences which alter the physical, chemical or biological characteristics of the sediment. These organisms are largely sedentary and are thus unable to avoid unfavourable conditions.

Benthic fauna are also typically divided into categories, principally according to size. The largest are the megafauna, comprising animals usually living on the seabed, large enough to be seen in seabed photographs and caught by trawl (i.e. brittle stars, sea urchins, sea cucumbers, sea spiders, sponges and corals). Macrofauna are defined as those animals larger than 500 µm. Meiofauna comprise the smaller interstitial animals (mainly nematode worms and harpacticoid copepods) with a lower size limit of between 45 and 62 µm (Kennedy and Jacoby, 1999).

As part of the site survey carried out in 2006 (Gardline, 2006) and pre-decommissioning environmental survey carried out in 2016 (Fugro, 2016), the benthic fauna of the Curlew region was described. A comparison of the benthic taxonomic compositions identified during the two surveys is presented in Figure 5-7.

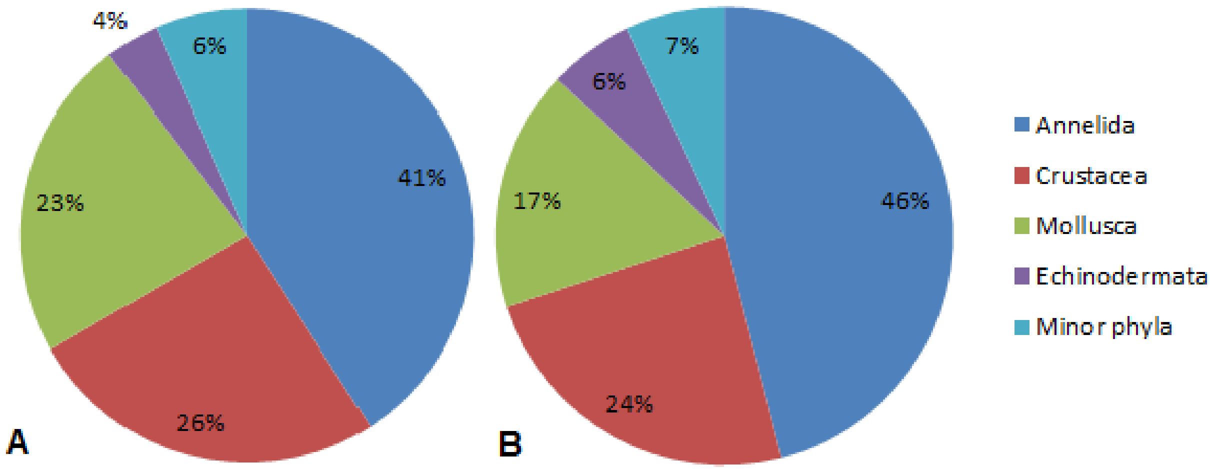


Figure 5-7 Taxonomic Composition Identified during Fugro 2016 (A) and Gardline 2006 (B) Environmental Surveys

5.3.2.1. *2016 Pre-decommissioning Survey (Fugro)*

During the pre-decommissioning environmental survey, a total of 66,365 individual animals were recorded, of which 318 adult taxa were identified. Adult taxa consisted of 40.9% polychaete annelids, 25.8% crustaceans, 23% molluscs, 3.8% echinoderms and 6.6% minor phyla including *cnidarian, nemertea* and *sipuncula*. The proportion of individuals in several major taxonomic groups was consistent between stations, suggesting a uniform community in the area. The phyletic composition of species was typical of the CNS, where polychaetes have been found to account for approximately 50% of the species.

The sampling stations in 2016 displayed similar phylogenetic composition with regards to numbers of taxa and species composition, including stations located around the subsea tie-backs and reference stations. The top ten species recorded in highest abundances were similar between sampling stations, with the polychaete *Paramphinome jeffreysii* the most abundant and dominant at all stations, with 731 individuals per 0.3 m^2. Other dominant species included the polychaetes *Galathowenia oculata*, *Spiophanes kroyeri*, *Spiophanes bombyx* and the bivalves *Axinulus croulinensis* and *Adontorhina similis*.

5.3.2.2. *2006 Site Survey (Gardline)*

The site survey undertaken in 2006 (Gardline, 2006) identified a total of 127 adult taxa, consisting of 46% polychaete annelids, 24% crustaceans, 17% molluscs, 6% echinoderms and 7% minor phyla.

A total of 5,930 individuals were recovered from 22 samples, with 513 (9%) of these being juvenile specimens. Polychaete annelids (bristle worms) accounted for 85%, molluscs (bivalves and snails) 4%, echinoderms (starfish, sea cucumbers, etc.) 4%, and crustaceans (shrimps, crabs, etc.) 3% of the adult records.

Other taxonomic groups included representatives from the *Phoronida* (Horseshoe worms), *Nemertea* (Ribbons worms), *Cnidaria* (anemones and corals) *Hemichordata* (Acorn worms) and *Sipuncula* (Peanut worms), accounting for 4%. The numerical dominance of polychaetes was attributable to the diversity and abundance of two species, *Paramphinome jeffreysii* (1,792 records) and *Galathowenia oculata* (950 records); together accounting for 51% of all adult records. Juvenile records indicated 354 of the 513 (69%) were echinoderms. Immature brittle stars data indicated the order *Spatangoida* made up 333 of these records, whilst all except one of the remainder were juvenile brittle stars from the class Opiuroidea. Adult *Spatangoida* were relatively scarce in the survey area, with only five records from two species.

5.3.2.3. *Species of Conservation Importance*

Indicator species and opportunistic species that increase in number in response to the presence of contaminants were not observed in abundance in either the 2006 or 2016 surveys. The phylogenetic composition across the two surveys was relatively similar, displaying similar dominant species across survey sites (Gardline 2006; Fugro, 2016).

Concentrations of burrowing megafauna, as well as presence of the epifauna sea pens *Pennatula phosphorea* and *Virgularia mirabilis*, has led to the designation of the habitat across the 2016 survey as the OSPAR habitat 'sea pen and burrowing megafauna communities', which is listed within the 'OSPAR List of Threatened and/or Declining Species and Habitats (Region II – North Sea) (refer to Section 5.4.2.2).

The juvenile ocean quahog (*Arctica islandica)* was recorded during both the 2016 pre-decommissioning environmental survey and the 2006 environmental surveys (Fugro, 2016; Gardline 2006) (refer to Section 5.4.2.1). Considerably larger concentrations were observed during the 2016 survey, with the species recorded across all but one sampling site, as opposed to the two individuals recorded during 2006 survey efforts (Fugro, 2016; Gardline 2006). The ocean quahog is of conservation importance and is listed within the OSPAR list of threatened and/or declining species and habitats (Region II – Greater North Sea).

5.3.3. Benthic Habitat Classification

Seabed photography and grab sample data were used to classify habitats to the lowest practical level in accordance with the EUNIS habitat classification. Figure 5-8 displays examples of seabed sediments reported throughout the survey area.

The EUNIS biotope '*Paramphinome jeffreysii, Thyasira spp.* and *Amphiura filiformis* in offshore circalittoral sandy mud' (A5.376) was identified for the survey area. The macrofauna analysis of grab samples demonstrated the high abundance of *Paramphinome jeffreysii*, with a mean of 243 individuals at every grab sample station. Four species of *Thyasira* were recorded within the survey area: *Thyasira biplicata, Thyasira equalis, Thyasira flexuosa* and *Thyasira sarsi*. *T. equalis* was the most common and occurred in all but seven of the grab sample stations. *Amphiura filiformis* was the least common of the biotope defining species, although another brittle star species *Amphiura chiajei* was counted in higher abundances.

Seabed features of note were a boulder and dense aggregations of shell fragments around a boulder with attached anthropogenic debris (i.e. fishing gear). An anoxic layer was observed during grab sampling, and the sulphur-oxidising bacteria *Beggiatoa sp.* was also observed (refer to Figure 5-8).

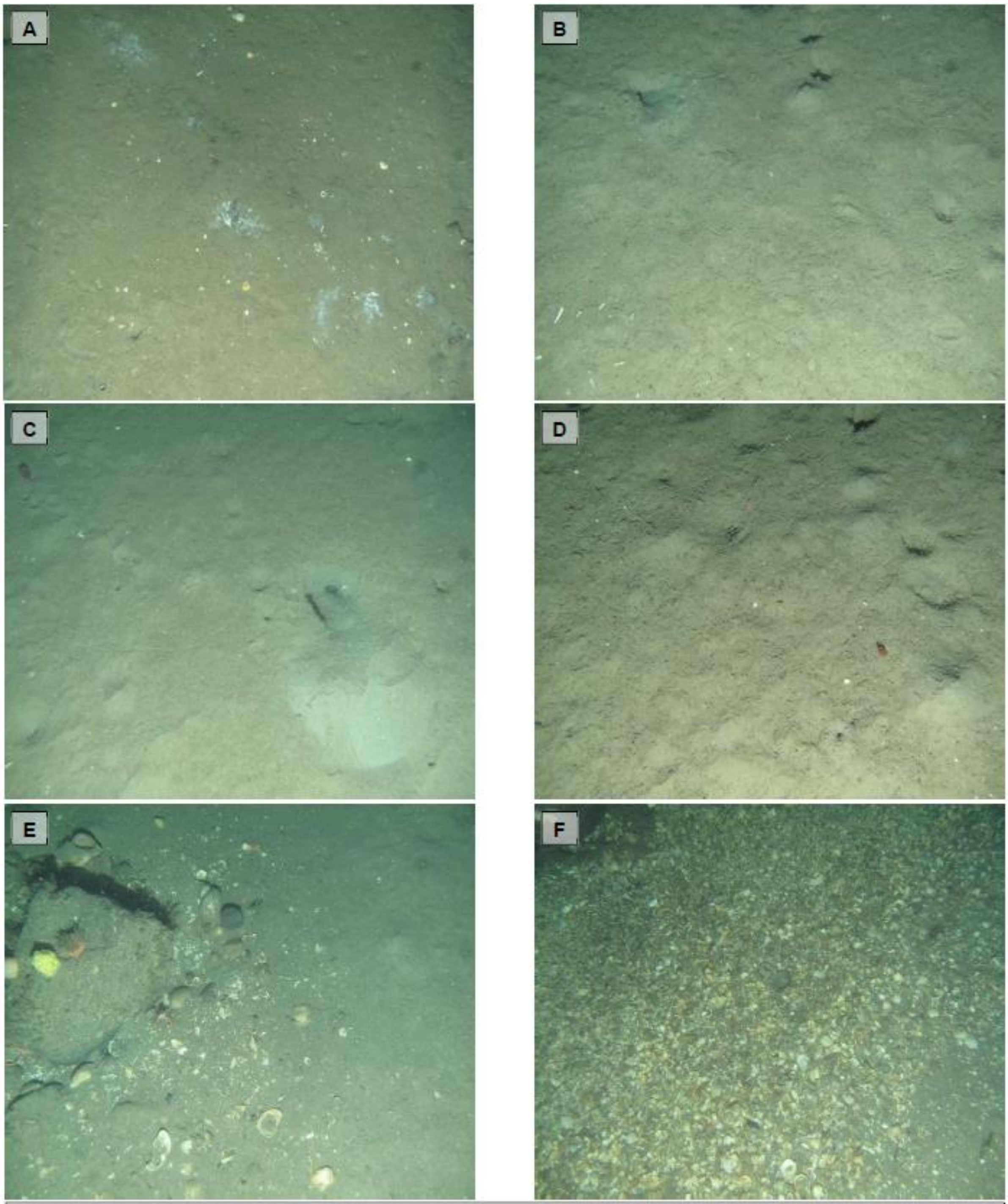


Photo A: B03_02. Mud/sandy mud with shell fragments. Sulphur-oxidising bacteria *Beggiatoa* sp
Photo B: B25_06. Sand/muddy sand. Sea pen *Pennatula phosphorea*
Photo C: C14_02. Mud/sandy mud. Faunal burrows and sea pen *Pennatula phosphorea*
Photo D: D21_04. Sand/muddy sand. Sea pen *Pennatula phosphorea*
Photo E: D22_01. Sand/muddy sand with boulder. Squat lobster (*Munida* sp.), sea urchin (*Echinus ?esculentus*), egg mass, anemone (Actiniaria), hydroid/bryozoan turf (Hydrozo/Bryozoa)
Photo F: TR_01_05. Aggregation of shell fragments overlying sandy mud and boulder

Figure 5-8 Example Seabed Photographs (Fugro, 2016)

5.3.4. Fish and Shellfish

Adult and juvenile stocks of finfish and shellfish are an important food source for seabirds, marine mammals and other fish species. Species can be categorised into pelagic and demersal finfish and shellfish:

- Pelagic species occur in shoals swimming in mid-water, typically making extensive seasonal movements or migrations between sea areas. Examples include herring, mackerel, blue whiting and sprat
- Demersal species live on or near the seabed and include cod, haddock, plaice, sand eel, sole, and whiting
- Shellfish species are demersal (bottom-dwelling) molluscs, such as mussels and scallops, and crustaceans, such as shrimps, crabs and *Nephrops norvegicus* (Norway lobster)

Generally, there is little interaction between fish species and offshore O&Gdevelopments. However, some fish and shellfish species are vulnerable to some offshore O&G activities, such as discharges to sea (Centre for Environment, Fisheries and Aquaculture Science (CEFAS), 2001). The most vulnerable period for fish species is during the egg and juvenile stages of their life cycles (Ellis *et al.*, 2012; Rogers & Stocks 2001). Fish that lay their eggs on the sediment (e.g. herring and sand eel) or which live in intimate contact with sediments (e.g. sand eel and most shellfish) are susceptible to smothering by discharged solids (Coull *et al.*, 1998). Other ecologically sensitive fish species include cod, most flatfish (including plaice and sole) and whiting because in the North Sea these stocks are considered outside 'safe biological limits' (EEA, 2015).

The following data sources illustrate fish spawning and nursery locations within ICES rectangle 42F1, where the Curlew cluster lies:

- Industry-commissioned Fisheries Sensitivity Maps in British Waters (Coull, *et al.* , 1998)
- Strategic Environmental Assessment (SEA) 2 Technical Report on North Sea Fish and Fisheries (CEFAS, 2001)
- CEFAS led spawning and nursery areas of fish of commercial and conservation importance (Ellis *et al.*, 2012)

This data is represented in Figure 5-9, Figure 5-10, and Figure 5-11.

Fish spawning and nursery grounds are dynamic features and are rarely fixed in one location from year to year. The information provided in Figure 5-9 represents the widest known distribution given current knowledge, and should not be seen as rigid, unchanging descriptions of presence or absence (Coull *et al.*, 1998; Ellis *et al.*, 2012). Spawning times represent the generally accepted maximum duration of spawning (Coull *et al.*, 1998).

Figure 5-10 and Figure 5-11 provide an indication of the likely positions of juvenile concentrations around the UK, rather than a definitive description of the limits of all nursery grounds (Coull *et al.*, 1998).

The Curlew cluster lies within spawning grounds for cod (*Gadus morhua*; January to April), lemon sole (*Microstomus kitt*; April to September), mackerel (*Scomber scombrus*; May to August), sand eels (*Ammodytidae* spp.; November to January) and Norway pout (*Trisopterus esmarkii*; January to April) (Coull *et al.*, 1998; Ellis *et al.*, 2012). The area is also used as nursery grounds for anglerfish (*Lophius piscatorius*), blue whiting (*Micromesistius poutassou*), cod, European hake (*Merluccius merluccius*), haddock (*Melanogrammus aeglefinus*), herring (*Clupea harengus*), Norway pout, ling (*Molva molva*), mackerel, plaice (*Pleuronectes platessa*), sand eels, spurdog (*Squalus acanthias*) and whiting (*Merlangius merlangus*) (Aires *et al.*, 2014; Coull *et al.*, 1998; Ellis *et al.*, 2012).

Data from Aires *et al.* (2014) indicates the probable presence of Age 0 group fish, using previously identified nursery grounds by Coull *et al.* (1998) and environmental habitat variables. Age 0 group fish are defined as fish in the first year of their lives and can also be classified as juvenile. Aires *et al.* (2014) data indicates within Block 29/7 a very high probability for haddock, high probability for Norway pout, medium probability for hake and low probability for anglerfish and whiting. In Block 29/8 there is medium probability for cod, European hake and Norway pout and low probability for herring and whiting. In Block 29/9, probability is medium for anglerfish, European hake and Norway pout and low for cod, haddock and herring. The probability of nurseries in ICES rectangle 42F1 was high for haddock, medium for anglerfish, cod and European hake and low for Norway pout and whiting.

Cod, whiting, Norway pout, blue whiting, mackerel, herring, ling, sand eel and anglerfish are mobile species on the PMF list, which require an appropriate level of protection and conservation (Scottish National Heritage (SNH), 2014).

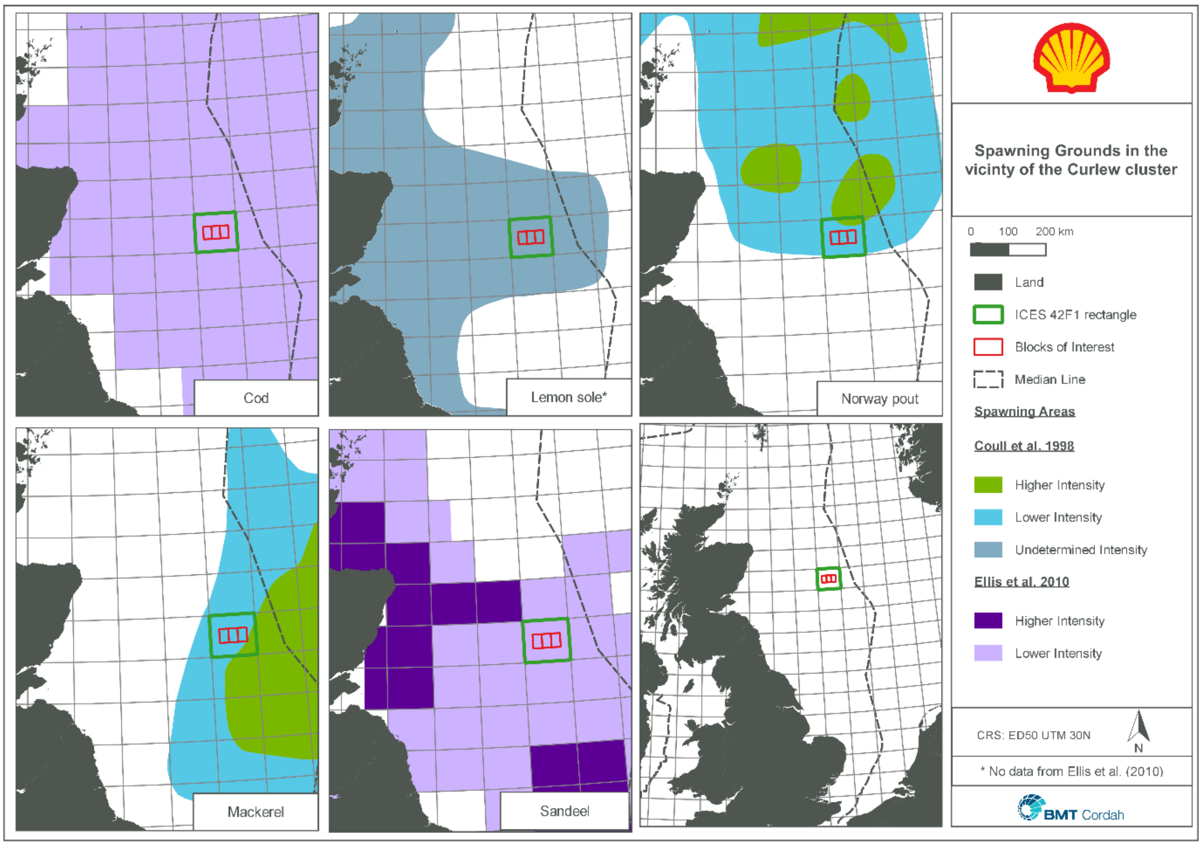


Figure 5-9 Key Fish Spawning Areas around Curlew Infrastructure

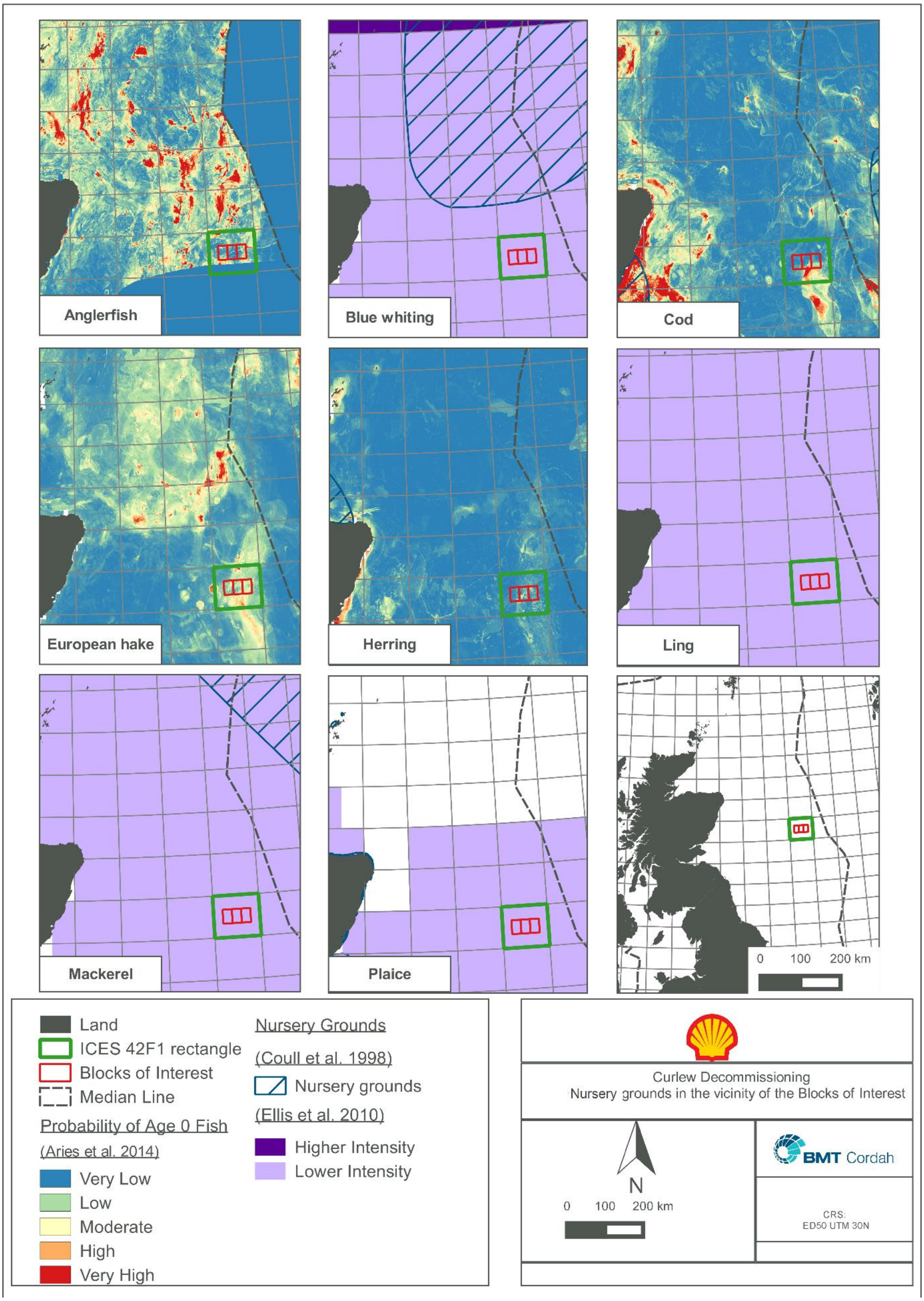


Figure 5-10 Key Fish Nursery Areas around Curlew Infrastructure

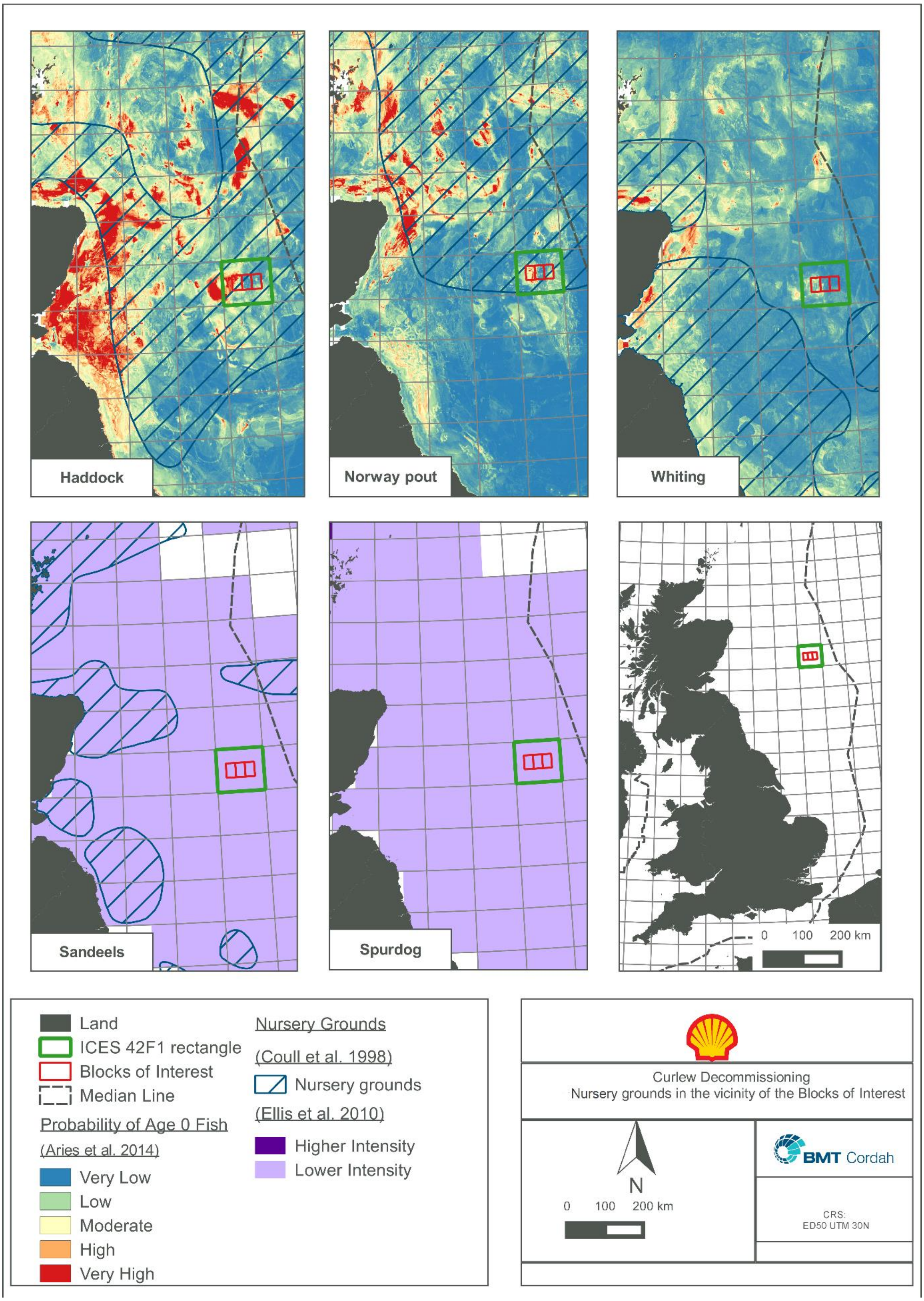


Figure 5-11 Continued Key Fish Nursery Areas around Curlew Infrastructure

5.3.5. Sharks, Rays and Skates

Chondrichthyans include sharks, rays and chimaeras, which have typically slow growth rates, late age at maturity and low reproductive output. They are generally considered to be vulnerable to human activities (e.g. overfishing). These species require suitable substratum and habitat preferences for the deposition of eggs such as sponges, bryozoans, hydroids and soft corals (Ellis *et al.*, 2012).

Work is underway to develop National Plans of Action for conservation and management of sharks in UK waters (Fowler *et al.*, 2004). The UK Biodiversity Action Plan (BAP), succeeded by UK Post-2010 Biodiversity Framework in July 2012, has identified several shark species for priority conservation including angel shark, spiny dogfish, undulate ray, sandy ray, tope shark, common skate and basking shark (JNCC, 2015b).

The distribution of the chondrichthyans on the UKCS is not extensively documented. The species that may be encountered in the project area are:

- Spurdog (*Squalus acanthias*)
- Lesser spotted dogfish (*Scyliorhisnus canicula*)
- Nurse hound (*Scyliorhisnus stellaris*)
- Starry ray (*Amblyraja radiata*)
- Cuckoo ray (*Leucoraja naevus*)

Nursery areas of these species tend to be typically in shallower coastal areas, with the exception of spurdog and cuckoo ray juveniles which can be found farther offshore (Ellis *et al.*, 2012). Available data suggest nursery grounds for spurdog occur in ICES rectangle 42F1 (Ellis *et al.*, 2012).

5.3.6. Marine Mammals

Marine mammals include whales, dolphins and porpoises (cetaceans) and seals (pinnipeds). This broad group may be vulnerable to the effects of O&G activities and can be impacted by noise, contaminants, oil spills and any effects on prey availability (SMRU, 2001). The abundance and availability of prey, including plankton and fish, can be of prime importance in determining the numbers and distribution of marine mammals and can also influence their reproductive success or failure. Changes in the availability of principal prey species may be expected to result in population level changes of marine mammals, but it is not currently possible to predict the extent of any such changes (SMRU, 2001).

5.3.6.1. *Cetaceans*

All cetaceans in the region are European Protected Species (EPS) and PMF. Harbour porpoise (*Phocoena phocoena*) are also Annex II species.

Cetaceans can be divided into two main categories: baleen whales (*Mysticeti*), which feed by sieving water through a series of baleen plates; and toothed whales (*Odontoceti*), which have teeth for the capture of prey.

The JNCC has compiled an Atlas of Cetacean Distribution in Northwest European Waters which gives an indication of the annual distribution and abundance of cetacean species in the North Sea (Reid *et al.*, 2003). Figure 5-12 presents the annual abundance and distribution of a selection of cetacean species that may be found in the vicinity of the Curlew. Table 5-3 presents cetacean species that are reported in the vicinity of the Curlew cluster.

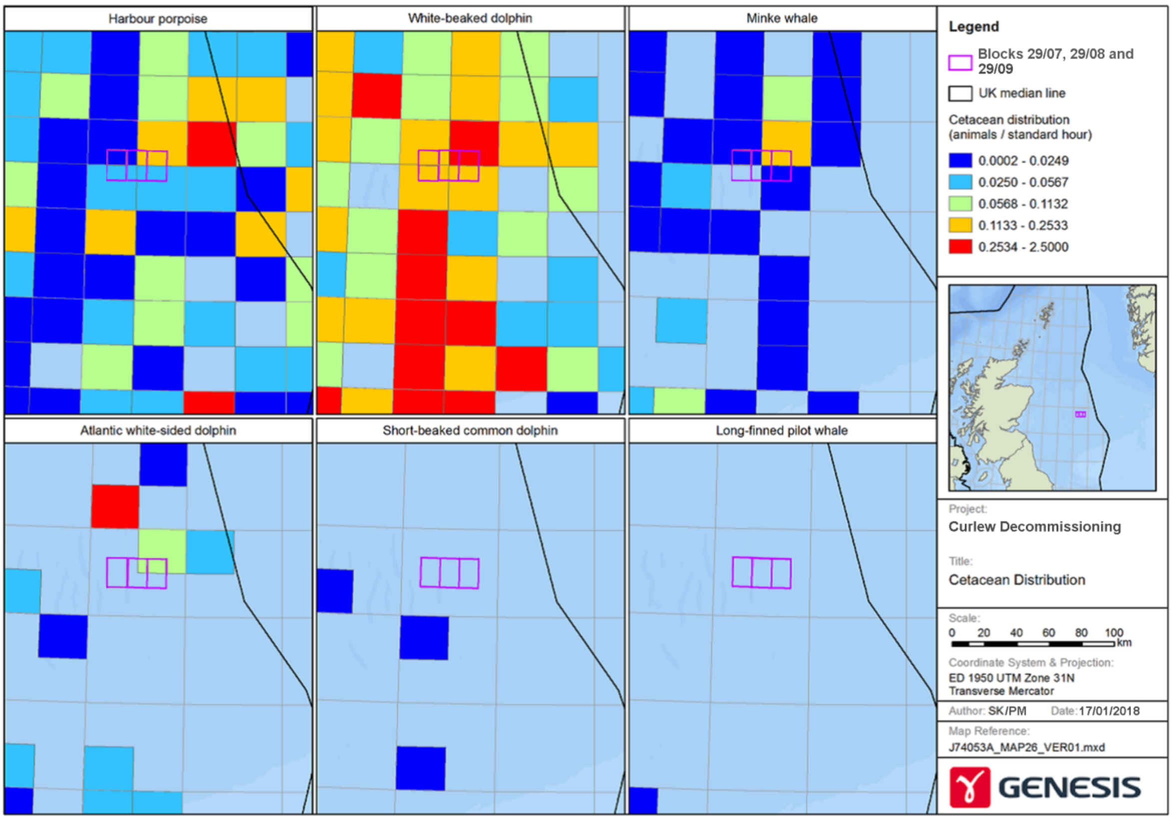


Figure 5-12 North Sea Distribution of a Selection of Cetacean Species (Reid *et al.*, 2003)

Table 5-3 Cetacean Species in the Vicinity of the Curlew

Species	Description
Harbour porpoise *Phocoena phocoena*	Harbour porpoises are the smallest and most abundant cetacean species in UK waters. They typically occur in groups of one to three individuals in shallow waters, although they have been sighted in larger groups and in deep waters. They are present in UK waters throughout the year.
White-beaked dolphin *Lagenorhynchus albirostris*	White-beaked dolphins are usually found in water depths of 50 to 100 m in pods of around 10 individuals, although larger pods have been seen. They are present in UK waters throughout the year with most sightings recorded between June and October.
Minke whale *Balaenoptera acutorostrata*	Minke whales are the most abundant whale species in the North Sea and usually occur in water depth of 200 m or less. They are usually sighted in pairs or in solitude although feeding groups of 15 individuals have been recorded. Minke whales are predominantly summer visitors and make seasonal migrations to the same feeding grounds.
Atlantic white-sided dolphin *Lagenorhynchus acutus*	Atlantic white-sided dolphin distribution in the North Sea varies seasonally and inter-annually. In the CNS they have been sighted in pods of 10 to 100 individuals. They can be seen in deep waters around the north of Scotland throughout the year and enter shallower continental waters of the North Sea in search of food.

Table 5-3 Cetacean Species in the Vicinity of the Curlew (Continued)

Species	Description
Common dolphin *Delphinus delphis*	The majority of common dolphin sightings are recorded in deep water, over or beyond the 1000 m depth contour, but common dolphins occasionally use coastal waters. They occur more frequently over areas of high seabed relief and in warmer, more saline waters.
Pilot whale *Globicephala melas*	Pilot whales mainly occur in temperate and sub-Arctic regions of the North Atlantic, and in the southern oceans. Most records of long-finned pilot whales around the UK are from waters deeper than 200 m deep, with few occurrences in the shallower waters of the North Sea. Sightings of long-finned pilot whales in the North Sea are more numerous during winter months.

Source: Adapted from Fram IA (Shell 2017b), 2017 – SCANS III, 2017; Reid *et al.*, 2003; MacLeod *et al.*, 2003; Hammond *et al.*, 2002; SMRU, 2001; Northridge *et al.*, 1995; Klinowska, 1991; BODC, 1998.

From Table 5-3, the main cetacean species occurring in the Curlew area are minke whale (*Balaenoptera acutorostrata*), long-finned pilot whale (*Globicephala melas*), common dolphin (*Delphinus delphis*), white-beaked dolphin (*Lagenorhynchus albirostris*), white-sided dolphin (*Lagenorhynchus acutus*) and harbour porpoise (*Phocoena phocoena*), with most sightings occurring in the spring and summer months (Reid *et al.*, 2003; UKDMAP, 1998). Marine mammals reported in the vicinity of the Curlew are summarised in Table 5-4 (Reid *et al.*, 2003; SCANS III, 2017).

Table 5-4 Seasonal Cetaceans Sightings around Curlew

Species	J	F	M	A	M	J	J	A	S	O	N	D
Minke whale					L	L	M	L	L			
Long-finned pilot whale								L				
Common dolphin						L	L					
White-beaked dolphin	L	H		VH	VH	L	H	M	H	H	M	
White-sided dolphin					H		VH	L	H			
Harbour porpoise		M		L	VH	H	M	H	H	L	H	

Key

Larger whales		Dolphins, porpoises and smaller whales	
VH	Very High (≥5 animals/km)	VH	Very high (>0.49 animals/km)
H	High (3 to 4 animals/km)	H	High (0.20 to 0.49 animals/km)
M	Moderate (2 animals/km)	M	Moderate (0.10 to 0.19 animals/km)
L	Low (1 animal/km)	L	Low (0.01 to 0.09 animals/km)
(pale yellow)	Observations outside Quadrant 29		
(dark yellow)	Observations within Quadrant 29		
	No observations		

Source: Reid et al. (2003); SCANS III, 2017

Minke whales, long-finned pilot whale, common dolphin, white-beaked dolphin, white-sided dolphin and harbour porpoise are mobile species on the PMF list, which require an appropriate level of protection and conservation (SNH, 2014).

A series of large scale aerial and ship cetacean abundance surveys have been conducted in the North Sea and adjacent waters in the summers of 1994, 2005 and 2016 (SCANS, SCANS-II and SCANS-III respectively). The surveys have been conducted by institutions including the Sea Mammal Research Unit of St. Andrews University, JNCC, and the Institute of Marine Research in Norway (Hammond *et al.*, 2017).

The Curlew field is located within the SCANS-III survey Block R and is in close proximity to the border of survey Block Q (refer to Figure 5-13). Estimates of cetacean abundance and density, collected using aerial survey methods, are presented for both blocks (refer to Table 5-5). The SCANS-III data suggests that harbour porpoises, white-beaked dolphins, white-sided dolphins and minke whales have the potential to occur within the vicinity of the Curlew field. Data on bottlenose dolphins within Block R was likely collected within the coastal areas of the block, as this species are typically found within coastal and near-shore areas, and are therefore unlikely to be recorded within the area of the Curlew field (Reid *et al.*, 2003).

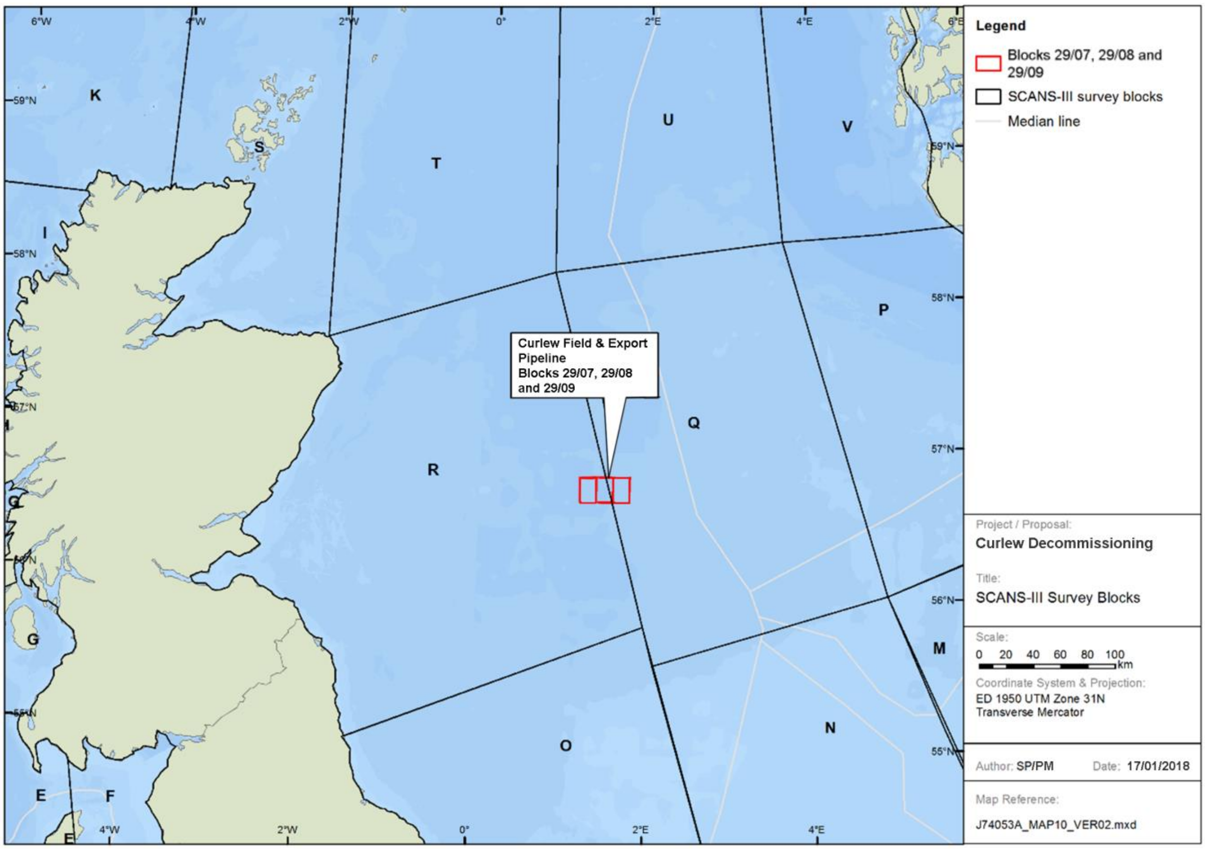


Figure 5-13 SCANS-III Survey Blocks

Table 5-5 Cetacean Species Abundance and Density in SCANS-III Survey Blocks R and Q (Hammond *et al.*, 2017).

Survey Block	Species	Animal Abundance per Survey Block	Animal Density (per km^2)
R	Harbour porpoise	38,646	0.599
	Bottlenose dolphin	1,924	0.03
	White-beaked dolphin	15,694	0.243
	White-sided dolphin	644	0.01
	Minke whale	2,498	0.039
Q	Harbour porpoise	16,569	0.333
	Minke whale	384	0.007

5.3.6.2. *Pinnipeds*

Two species of seal are resident in UK waters: the grey seal (*Halichoerus grypus*) and the harbour or common seal (*Phoca vitulina*), both occurring regularly over large parts of the North Sea (SMRU, 2001).

Grey seal

The northeast Atlantic contains approximately half of the world's population of grey seals with approximately 38% occurring in the UK. The population size within UK waters is estimated at 111,600 (BEIS, 2016a). Approximately 88% of the UK population of grey seals breed in Scotland, mainly in the Hebrides and Orkney. Major colonies are also present on Shetland and the east coast of Scotland (BEIS, 2016a).

Grey seals spend most of the year at sea, travelling long distances between haul-out sites, and ranging widely in search of prey (BEIS, 2016a). The majority of the grey seal population will be on land for several weeks from October to December during the pupping and breeding seasons, and again in February and March during the annual moult. Densities of grey seals offshore are likely to be lower during these periods (BEIS, 2016a).

Harbour seal

Harbour seal strongholds within the UK are Shetland, Orkney, the east coast of the Outer Hebrides, most of the Inner Hebrides and the west coast of Scotland, the Moray Firth and the Firth of Tay. Harbour seal counts in the UK are estimated at a minimum of 28,000 animals; the vast majority of which are found in Scotland (BEIS, 2016a). Harbour seals haul out on tidally exposed areas of rock, sandbanks or mud. Pupping occurs on land between June and July, and the moult between August and September (BEIS, 2016a).

Tracking of seals suggests they make feeding trips lasting 2 to 3 days, travelling less than 40 km from their haul-out sites, and ultimately returning to the same haul-out site from which they departed (Johnston *et al.*, 2002). Grey seals may spend more time further offshore than harbour seals. Both grey and harbour seals are listed in Annex II of the Habitats Directive.

The Curlew cluster is located 210 km from the nearest coastline; therefore it is unlikely that grey or harbour seals would be found in the vicinity of the platform (Jones *et al.*, 2015; refer to Figure 5-14).

Grey and common seals are mobile species listed on the PMF list, which require an appropriate level of protection and conservation (SNH, 2014).

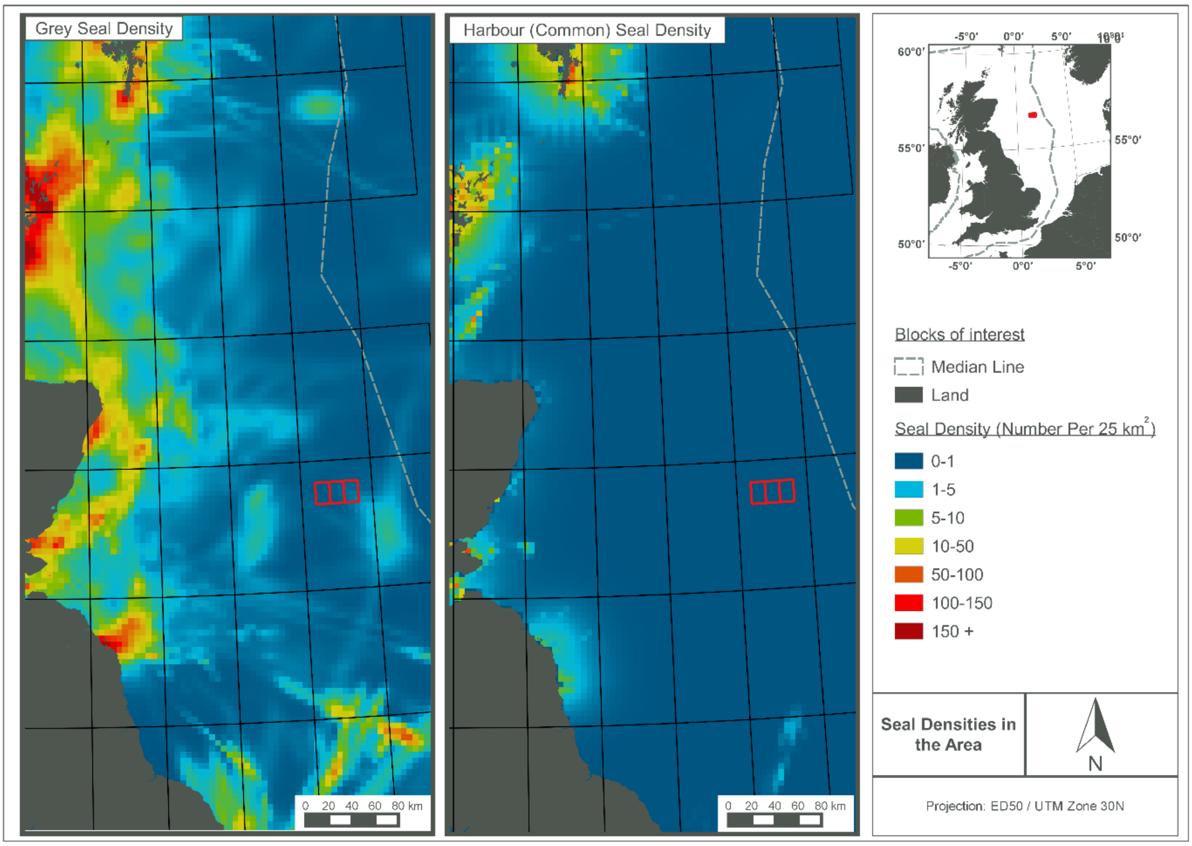


Figure 5-14 Seal Densities in the Vicinity of Curlew Infrastructure

5.3.7. Seabirds

Important numbers of several species of seabird breed on the North Sea coastal margin, and depend on the offshore North Sea for their food supply and, for much of the year, their habitat. Species commonly found in offshore North Sea waters include the fulmar (*Fulmarus glacialis*), gannet (*Morus bassanus*), guillemot (*Uria aalge*), razorbill (*Alca torda*), kittiwake (*Rissa tridactyla*); and herring (*Larus argentatus*), great black-backed (*Larus marinus*) and lesser black-backed (*Larus fuscus*) gulls (DTI, 2001). Other species which are recorded at lower levels include the Pomarine skua (*Stercorarius pomarinus*), Arctic skua (*Stercorarius parasiticus*), black-headed gull (*Larus ridibundus*), common gull (*Larus canus*), common tern (*Sterna hirundo*), Arctic tern (*Sterna paradisaea*), little auk (*Alle alle*), and puffin (*Fratercula arctica*) (DTI, 2001).

These species are known to breed regularly around the mainland North Sea coasts and the UK. Other species known to breed along the coast of the North Sea include the Manx shearwater (*Puffinus puffinus*), storm petrel (*Hydrobates pelagicus*), Leach's petrel (*Oceanodroma leucorhoa*), great cormorant (*Phalacrocorax carbo*), shag (*Phalacrocorax aristotelis*), great skua (*Catharacta skua*), little tern (*Sterna albifrons*), sandwich tern (*Sterna sandvicensis*), roseate tern (*Sterna dougallii*) and black guillemot (*Cepphus grylle*) (DTI, 2001; BEIS, 2016b). Each year over 7 million seabirds breed in the UK (BEIS, 2016b).

In general, offshore areas of the North Sea contain peak numbers of seabirds following the breeding season and through winter, with birds tending to forage closer to coastal breeding colonies in spring and early summer, within 50 to 200 km from the coast and are therefore unlikely to occur within the vicinity of the Curlew field (DTI, 2001; Thaxter *et al.*, 2012). However, some species may forage in excess of 200 km from their breeding sites and high densities of fulmar are present offshore from May to November; kittiwakes from November to March, and guillemots from July to October. Gannets are present at low densities all year round. These species have the potential to occur within the Curlew Field (Refer to Figure 5-15 and Table 5-6).

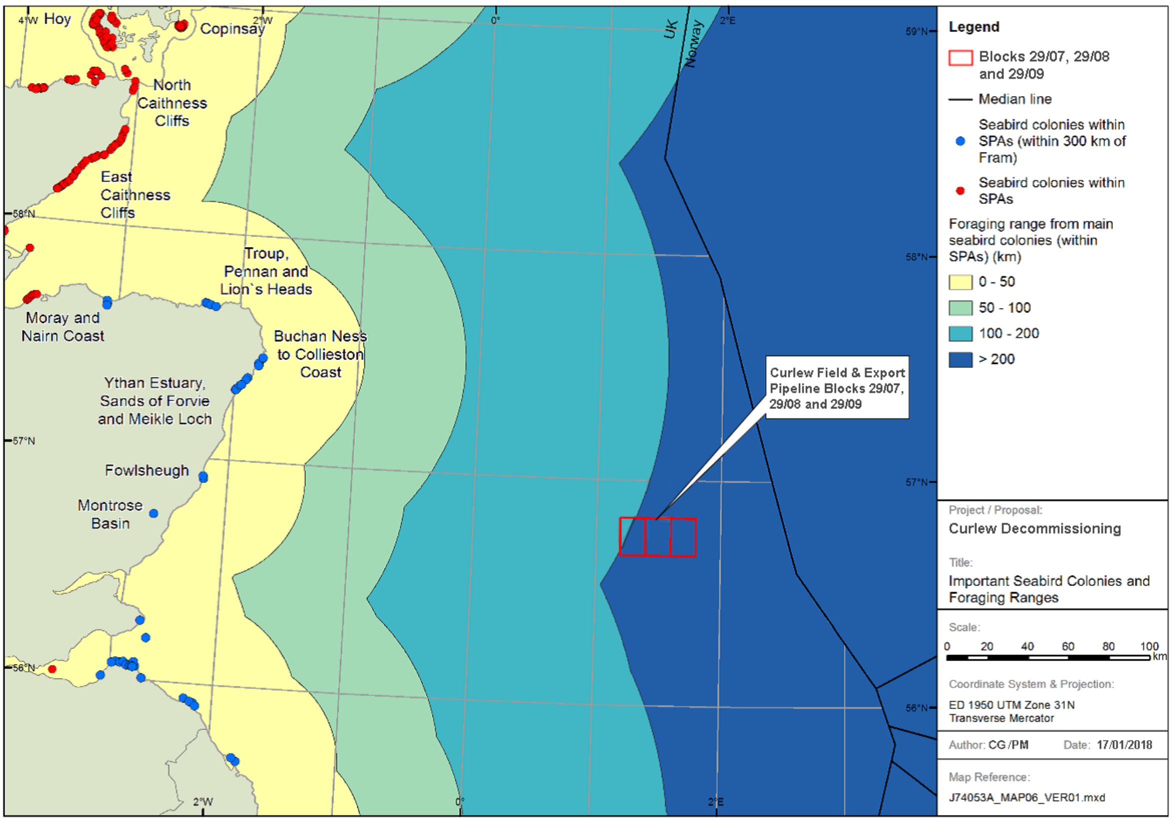


Figure 5-15 Seabird Foraging Ranges from East Coast SPAs during the Breeding Season (Thaxter *et al.*, 2012)

Table 5-6 Maximum Foraging Range of Breeding Seabirds from SPAs (Thaxter *et al.*, 2012)

Species	Mean Maximum Foraging Range (km)
Little tern (*Sterna albifrons*)	6
Shag (*Phalacrocorax aristotelis*)	14
Common tern (*Sterna hirundo*)	15
Roseate tern (*Sterna dougallii*)	17
Arctic tern (*Sterna paradisaea*)	24
Cormorant (*Phalacrocorax carbo*)	25
Razorbill (*Alca torda*)	43
Sandwich tern (*Thalasseus sandvicensis*)	49
Kittiwake (*Rissa tridactyla*)	60
Herring gull (*Larus argentatus*)	61

Table 5-6 Maximum Foraging Range of Breeding Seabirds from SPAs (Thaxter *et al*, 2012) (Continued)

Species	Mean Maximum Foraging Range (km)
Guillemot (*Uria aalge*)	85
Puffin (*Fratercula arctica*)	105
Lesser black-backed gull (*Larus fuscus*)	141
Gannet (*Morus bassanus*)	230
Fulmar (*Fulmarus glacialis*)	400

Birds are vulnerable to oiling from surface oil pollution, which can cause direct toxicity through ingestion, and hypothermia as a result of the birds' inability to waterproof their feathers. During the moulting season, certain species (e.g. guillemot, razorbill and puffin) become flightless and spend a large amount of time on the water surface, making them particularly vulnerable to surface oil pollution (DTI, 2001). However, seabirds are not normally affected by planned offshore O&G operations (DTI, 2001). Although locally important numbers of birds have been directly killed by oil spills, such spills have primarily been associated with the transportation of oil, and little or no direct mortality of seabirds has been attributed to exploration, production or decommissioning activities in the North Sea (DTI, 2004).

Seabird vulnerability to surface pollution varies throughout the year, with peaks in late summer after breeding when the birds disperse into the North Sea, and during the winter months with the arrival of over-wintering birds. OGUK has commissioned HiDef, a consultancy specialising in a digital aerial video and image analysis, to produce the SOSI, a tool designed to aid planning and emergency decision making with regards to oil pollution (Webb *et al.*, 2016). SOSI identifies sea areas with highest likelihood of seabirds becoming sensitive to oil pollution. It is derived from 1995 to 2015 seabird survey data, extending beyond the UKCS, and is based upon the following factors (Certain *et al.*, 2015):

- Habitat flexibility (an ability of species to relocate to alternative feeding ground)
- Adult survival rate
- Potential annual productivity
- Proportion of the biogeographical population in the UK

The seabird sensitivity to oil pollution in Blocks 29/7, 29/8 and 29/9 (where the Curlew cluster and export pipeline are located), and in surrounding blocks was very low throughout the year, with the exception of June when sensitivity was medium in Block 29/9, and September when sensitivity was very high in one of the surrounding blocks (refer to Table 5-7). No data is available for April, May, October, November or December. The period of very high sensitivity can be attributed to moulting of some of the species and foraging or feeding behaviour (JNCC, 1993).

Table 5-7 Seabirds Sensitivity to Oiling In and Around Blocks 29/7, 29/8 and 29/9

Seabirds Sensitivity to Oil Pollution (OGUK 2016a)

BLOCK	J	F	M	A	M	J	J	A	S	O	N	D
29/1	5	5	5			5	5	5	5			
29/2	5	5	5			5	5	5	5			
29/3			5			5	5	5	5			
29/4		5	5			5	5	5	5			
29/5		5	5			5	5	5	5			
29/6	5	5	5			5	5	5	5			
29/7	5	5	5			5	5	5	5			
29/8	5	5	5			5	5	5	5			
29/9		5	5			4	5	5	5			
29/10		5	5			5	5	5				
29/11	5	5	5			5	5	5	2			
29/12	5	5	5			5	5	5	5			
29/13	5	5	5			5	5	5	5			
29/14	5	5	5			5	5	5	5			
29/15		5	5			5	5	5				

Key

Seabirds Sensitivity	
1	Extremely High
2	Very High
3	High
4	Medium
5	Low
	No data
	Observations within Blocks of Interest

Source: Webb et al. (2016)

5.4. Conservation

The UKCS supports a wide variety of nationally and internationally important species and habitats. Key to maintaining this diversity is the designation and management of protected sites. In the UK, there are currently 99 Special Areas of Conservation (SACs) with marine components, 102 Special Protection Areas (SPAs) with marine components, 50 MCZs and 30 NCMPAs. Sites of Special Scientific Interest with marine components and Ramsar sites also contribute to the existing UK Marine Protected Area (MPA) network. This network will continue to grow as additional SPAs and MPAs are identified in the future. Figure 5-16 provides the locations of protected areas closest to the Curlew field.

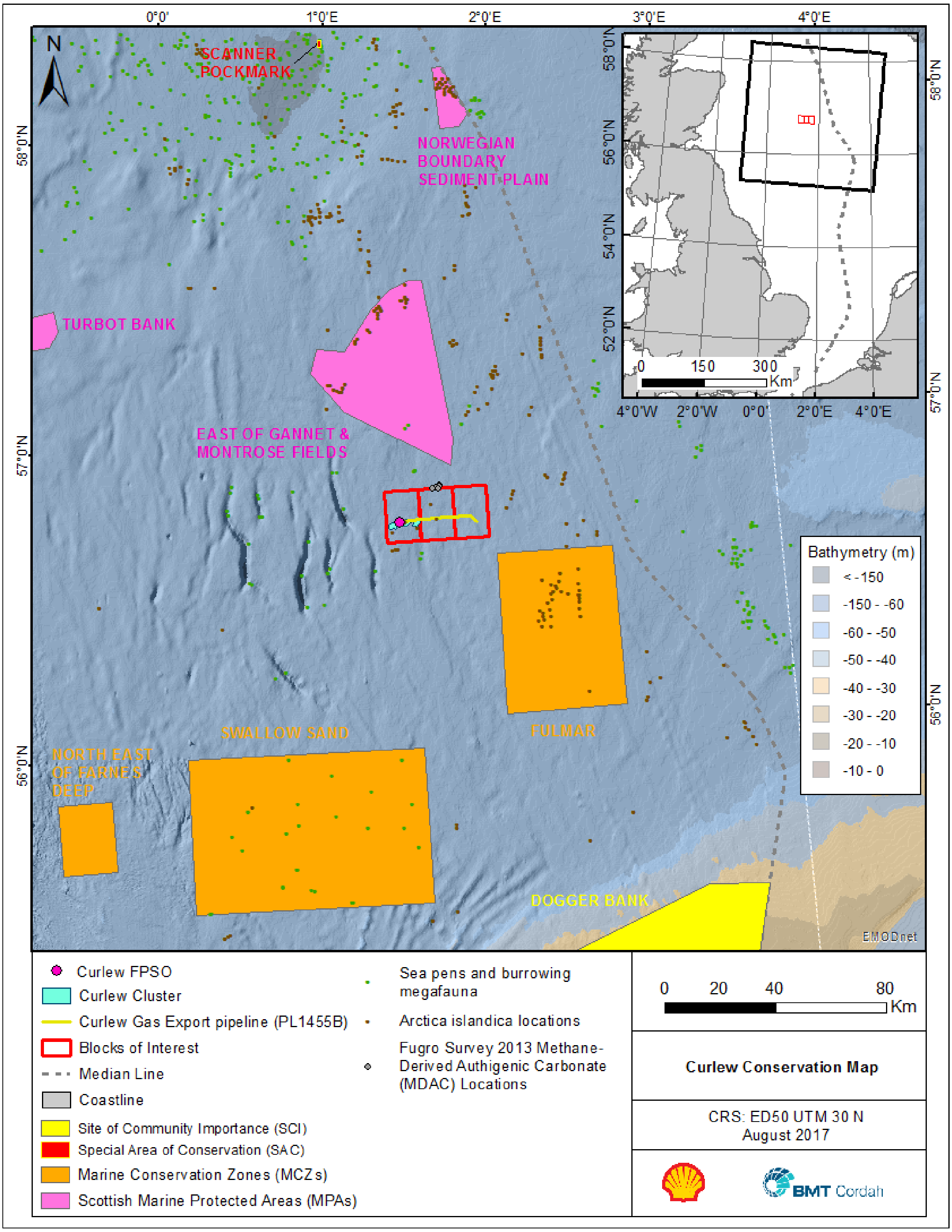


Figure 5-16 Protected Areas in Relation to the Curlew Field

5.4.1. Offshore Conservation Areas

The East of Gannet and Montrose fields are located approximately 20 km north of the gas export pipeline and 27 km northeast of the Curlew cluster (refer to Figure 5-16). The NCMPA comprises an area of 1,839 km^2, designated for the protection of both ocean quahog (*Arctica islandica*) aggregations, including their supporting sands and gravel habitats, and offshore deep sea muds. The conservation objectives for the East of Gannet and Montrose NCMPA are to maintain natural conditions so that:

- The quality and extent of *A. islandica* habitat is stable or increasing
- The population structure of *A. islandica* allows numbers to be maintained or increased
- Offshore deep sea mud extent is stable or increasing
- Offshore deep sea mud structures and functions, its quality, and the composition of its characteristic biological communities are such as to ensure that it is in a condition which is healthy and not deteriorating (JNCC, 2015a)

The Fulmar MCZ is located approximately 15 km southeast of the gas export pipeline and 35 km southeast off the Curlew cluster (refer to Figure 5-16). The Fulmar MCZ is an area of designated protection for subtidal sand, mud and mixed sediment habitats and the presence of *A. islandica*.

5.4.2. Potentially Sensitive Habitats and Species

Potentially sensitive habitats and species in the vicinity of the project area are outlined in Table 5-8.

Table 5-8 Potentially Sensitive Habitats and Species in the Vicinity of the Curlew Field

Species/Habitat	Legislation	Description	Designation/Status
Ocean quahog (*A. islandica*) (Section 5.4.2.1)	OSPAR T&D	Long-lived species of bivalve with a very slow growth rate	OSPAR threatened and/or declining species
	Marine (Scotland) Act Marine and Coastal Access Act	Ocean quahog	Scottish PMF low or limited mobility species Species Features of Conservation Importance (FOCI)
Mud habitats in deep water (Section 5.4.2.2)	UK Post-2010 Biodiversity Framework	Mud habitats in deep water	UK BAP habitat
	Marine (Scotland) Act	Offshore deep sea muds Burrowed mud	Scottish PMF habitat
	OSPAR T&D	Sea pens and burrowing megafauna communities	OSPAR threatened and/or declining habitat
Submarine structures made by leaking gases (Section 5.4.2.3)	EC Habitats Directive	Rocks, pavements and pillars of carbonate cement	Annex I habitat
	Marine (Scotland) Act	Submarine structures made by leaking gases	Scottish PMF habitat
Stony reefs (Section 5.4.2.4)	EC Habitats Directive	Stony reefs	Annex I habitat
Cetaceans (Section 5.3.6.1)	EC Habitats Directive	All cetaceans	Annex II species/EPS
	Marine (Scotland) Act		Scottish PMF mobile species

Table 5-8 Potentially Sensitive Habitats and Species in the Vicinity of the Curlew Field (Continued)

Species/Habitat	Legislation	Description	Designation/Status
Pinnipeds (Section 5.3.6.2)	EC Habitats Directive	Grey seals/harbour seals	Annex II Species
	Marine (Scotland) Act		Scottish PMF mobile species
Finfish (Sections 5.3.4 and 5.3.5)	Marine (Scotland) Act	Anglerfish, herring, mackerel, blue whiting, Norway pout, sand eels, whiting	Scottish PMF mobile species
	Marine (Scotland) Act	Cod	Scottish PMF mobile species
	OSPAR T&D		OSPAR threatened and/or declining species

Notes:

Annex I and Annex II Habitats

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

European Protected Species

EPS are species of plants and animals (other than birds) protected by law throughout the EU whose natural range includes any area in the UK.

Priority Marine Features

SNH and the JNCC have, together with MS, developed a priority list of marine habitats and species in Scotland's seas, known as PMFs. PMFs are habitats and species which are considered to be marine conservation priorities in Scottish waters.

UK Biodiversity Action Plan (UK BAP)

The UK BAP describes the biological resources of the UK and provides detailed plans for conservation of these resources

OSPAR list of threatened and/or declining species

The OSPAR Biological Diversity and Ecosystems Strategy sets out that the OSPAR Commission will assess which species and habitats need to be protected. This OSPAR list of threatened and/or declining species and habitats has been developed to fulfil this commitment.

Features of Conservation Importance

FOCI are species and habitats which may be more sensitive to pressures and hence need targeted protection.

5.4.2.1. *Ocean Quahog (Arctica islandica)*

The ocean quahog (*Arctica islandica*) is listed on the OSPAR (2017) 'List of threatened and declining habitats and species' and has subsequently been listed as a species for which Scottish MPAs and English/Welsh MCZs may be selected under UK legislation.

Adult *A. islandica* are adapted to cold temperate waters and display tolerance to oxygen depletion and high concentrations of hydrogen sulphide. *A. islandica* display slow and variable growth rates, and do not reach sexual maturity until the age of 13.1 years for males and 12.5 years for females (FAO, 2017). Adult *A. islandica* can reach lengths of 13 cm across and show exceptional longevity, with lifespans estimated up to 400 years. The slow growth and maturation rates of *A. islandica*, its low fecundity and sporadic recruitment suggest vulnerability to impacts by a number of human activities.

The East of Gannet and Montrose Fields NCMPA, designated for the protection of offshore deep sea mounds and ocean quahog (*Arctica islandica*), is located approximately 20 km north of the gas export pipeline and 27 km northeast of the Curlew cluster (refer to Figure 5-16). Several ocean quahog sites have been recorded within the vicinity of the Curlew cluster (refer to Figure 5-16).

The Fulmar MCZ, designated for the protection of subtidal sand, subtidal mud, subtidal mixed sediments and ocean quahog is located approximately 15 km southeast of the gas export pipeline and 35 km southeast of the Curlew cluster (refer to Figure 5-16).

During the 2016 Curlew pre-decommissioning environmental survey *A. islandica* juveniles (< 10 mm diameter) were observed at all grab sampling stations, with the exception of one (Fugro, 2016). Juveniles were present within the majority of subsamples with an average of three juveniles per subsample, with the greatest concentrations of 17 individuals per subsample recorded at two sampling stations. The variation in abundance of *A. islandica* juveniles did not appear to be influenced by particle size distribution, overall infaunal abundances or pollutant level (Fugro, 2016).

During the 2006 Curlew C environmental baseline survey, a total of two juvenile specimens were recorded from two separate sampling stations (Gardline, 2006).

A. islandica records in the vicinity of the Curlew field are shown in Figure 5-16. This data was collected by the Department for Environment, Food and Rural Affairs (DEFRA) and shows that *A. islandica* is found commonly in both the area surrounding the Curlew field and the wider CNS (DEFRA, 2010).

5.4.2.2. *Sea Pens and Burrowing Megafauna*

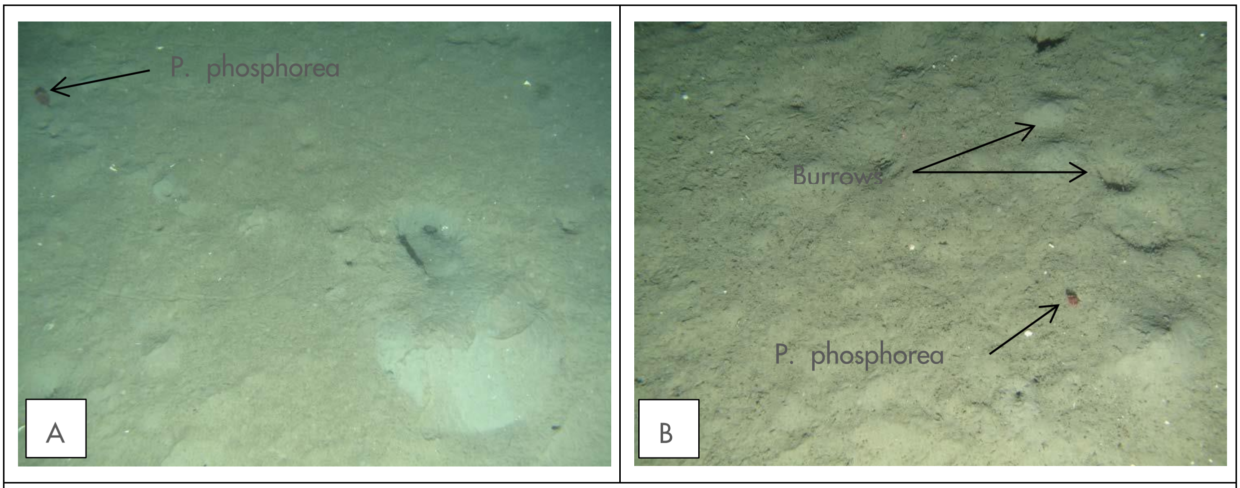
Sea pen and burrowing megafauna community habitats can be defined as 'plains of fine mud (in this instance sandy mud), at water depths ranging between 15 and 200 m, which are heavily bioturbated by burrowing megafauna. Burrows may form a prominent feature of the sediment surface with conspicuous populations of sea pens. The burrowing activity of megafauna creates a complex habitat, providing deep oxygen penetration (OSPAR, 2010b). The habitat is listed within the OSPAR List of Threatened and/or Declining Species and Habitats (Region II – North Sea, Region III – Celtic Sea) (JNCC, 2015c).

The JNCC (2014) guidance for the analogous Habitat FOCI suggests that burrowing megafauna are the main prerequisite for classifying this habitat. While sea pens may occur, their presence is not mandatory. Burrows must occur in abundances of at least 'frequent' (0.1 to 0.9/m^2) to classify the habitat as 'Sea pen and burrowing megafauna communities'.

Pre-decommissioning Environmental Survey (Fugro 2016)

The density of megafaunal burrows and sea pens *Pennatula phosphorea* and *Virgularia mirabilis* within the 2016 pre-decommissioning environmental survey led to the conclusion that all survey stations had areas which represent the OSPAR habitat 'sea pen and burrowing megafauna communities' (Fugro, 2016).

All stations and the camera transect had areas of frequent, common (1 to 9 per m^2) or abundant (10 to 99 per m^2) burrow densities, with megafaunal burrows generally recorded as 'common' at the majority of drop-down camera locations (refer to Figure 5-17). The sea pen *Pennatula phosphorea* was relatively dense across the survey area, with sporadic individuals of *Virgularia mirabilis* also observed. *P. phosphorea* was found at 31 of the 35 camera drop-down locations, and present during the camera transect. The greatest abundance of *P. phosphorea* was recorded at 4.2 individuals per m^2. The sea pen *V. mirabilis* was recoded in lower numbers than *P. phosphorea* and was recorded as common at five drop-down camera locations and occasionally along the camera transect.



Picture A: Sandy mud. Faunal burrows and Sea pen, *Pennatula phosphorea*

Picture B: Sandy mud. Sea pen, *Pennatula phosphorea*

Figure 5-17 Sea Pen and Burrowing Megafauna Communities (Fugro 2016)

Curlew C (2006) and Curlew A (2013) Surveys

The Curlew C survey undertaken in 2006 showed characteristics of 'Sea pen and Burrowing Megafauna Communities' at the majority of survey stations. The Curlew A habitat survey undertaken in 2013 also showed characteristics of this habitat, with sea pens (primarily *Pennatula phosphorea*) sparsely distributed throughout the survey area along with infaunal burrows. Furthermore, the Fram to Curlew habitat investigation undertaken in 2013 also displayed characteristics of this habitat type.

Classification

Clarification with JNCC was provided regarding the classification of the habitat in the vicinity of Curlew following the pre-decommissioning survey results (Fugro, 2016). JNCC provided the following clarification:

*"JNCC notes that the sea-pens and burrowing megafauna communities (OSPAR T&D)/burrowed mud (PMF) habitat (Robson, 2014) occurs predominantly in fine mud sediments. However, some examples of this habitat have been identified in areas of sandy muds. As such, where there is clear evidence of the relevant biological assemblages (burrowing megafauna and in some examples, sea-pens), such habitats can be classified as 'Sea-pen and burrowing megafauna communities' regardless of the grain size composition of the sediment. "*The seabed habitat in the vicinity of the Curlew field can therefore be considered to represent the sea-pens and burrowing megafauna communities (OSPAR T&D)/burrowed mud (PMF) habitat.

5.4.2.3. *Submarine Structures Made by Leaking Gases (Pockmark Associated Structures)*

The Annex I habitat 'submarine structures made by leaking gases' comprises rocks, pavements and pillars made of carbonate cement. Such cement is mostly made by microbial oxidation of Methane (CH_4) and is commonly known as MDAC. MDAC forms within the sediment at the sulphate-methane transition zone (SMTZ), within a few metres of the seabed (Judd, 2005).

MDAC concretions in the form of crusts or slabs may then be brought up to the surface by natural movements of surficial sediments. These exposed lumps can have an effect on the local benthos, by providing hard substratum and shelter in an otherwise soft sediment environment. Within UK waters this habitat is predominantly associated with pockmarks in the northern and CNS, as well as part of the Irish Sea (Jackson & McLeod, 2000).

The Curlew infrastructure is situated in an area where fluid seeps have the potential to exist (Annex I feature 'submarine structures made by leaking gases'), however no evidence of this habitat was revealed from surveys in the area of the Curlew field.

MDAC was identified approximately 1.21 to 1.32 km from the Curlew field during the 2013 Fram to Curlew pipeline route survey (Fugro, 2013). Ground truthing of additional MDAC potential areas, identified in historic surveys, during the pre-decommissioning environmental survey (Fugro,2016) did not identify any MDAC.

5.4.2.4. *Fish*

Information relating to fish in the area of the Curlew field is provided in Sections 5.3.4 and 5.3.5.

The designation of fish species requiring special protection in UK waters is receiving increasing attention, with particular consideration being paid to large slow growing species such as sharks and rays. A number of international laws, conventions and regulations as well as national legislative Acts have been implemented which provide for the protection of these species. They include:

- The UK BAP priority fish species (JNCC, 2016)
- The OSPAR List of Threatened and/or Declining Species & Habitats (OSPAR, 2017)
- The International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN, 2017)
- The Wildlife and Countryside Act 1981 (which consolidates and amends existing national legislation to implement the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) and the Birds Directive in Great Britain) The Wildlife and Countryside Act makes it an offence to intentionally kill, injure, possess or trade any animal listed in Schedule 5 and to interfere with places used by such animals for shelter or protection
- The European Commission (EC) Habitats Directive (transposed into UK law through the Conservation of Habitats and Species Regulations 2010 in England and Wales and also the 1994 Regulations in Scotland)

Species of fish that are listed under the protection measures of the above legislation are shown in Table 5-9.

Table 5-9 Designation of Fish Species in the Vicinity of Curlew

Species	Latin Name	UK BAP	OSPAR	IUCN	Bern Convention	Habitats Regulations
Allis shad	*Alosa alosa*	✓	✓	Least Concern	✓	✗
Twaite shad	*Alosa fallax*	✓	✗	Least Concern	✓	✗
Angel shark	*Squatina squatina*	✓	✓	Critically Endangered	✓[1]	✗
Atlantic salmon	*Salmo salar*	✓	✓	Not Listed	✓[2]	✗
Common skate	*Dipturus batis*	✓	✓	Critically Endangered	✗	✗
Basking shark	*Cetorhinus maximus*	✓	✗	Least Concern	✓	✗
Porbeagle shark	*Lamna nasus*	✓	✓	Vulnerable	✓	✗

[1] *Mediterranean only*

[2] *Not applicable to marine waters*

5.4.2.5. *Marine Mammals*

Information relating to marine mammals in the area of the Curlew field is provided in Section 5.3.6.

Four marine mammal species listed under Annex II of the Habitats Directive may be found in high abundance in UK offshore waters:

- Grey seal (*Halichoerus grypus*)
- Common seal (*Phoca vitulina*)
- Bottlenose dolphin (*Tursiops truncatus*)
- Harbour porpoise (Phocoena phocoena)

The bottlenose dolphin and harbour porpoise, like all the cetacean species found in UK waters, also have EPS status, along with several other marine mammals found in UK waters.

5.4.3. Priority Marine Features

In addition to the list of features of nature conservation importance for which it is deemed appropriate to use area-based mechanisms (MPAs) as a means of affording protection (as part of the Scottish MPA Project), SNH and JNCC have compiled a separate list of 80 habitats and species, termed PMFs which are considered to be of particular importance in Scotland's seas. The purpose of this list is to guide policy decisions regarding conservation in Scottish waters (SNH, 2014).

The following PMFs are assessed to be of relevance to the Curlew area:

Habitats:

- Sea pen and burrowing megafauna communities

Species:

- Atlantic mackerel
- Atlantic herring
- Blue whiting
- Whiting
- Sand eels
- Norway pout
- Atlantic white-sided dolphin
- Harbour porpoise
- Minke whale
- White-beaked dolphin

5.5. Socio-Economic Sensitivities

This section focuses on the broader socio-economic considerations of the existing baseline in relation to Curlew decommissioning activities. Attention is given to the potential impact on the fishing (UK and non-UK fishing in the area) and shipping industries as well as any potential impact on other users of the sea, such as military activity and activity within the renewable energy sector. The existence of submarine cables, historic wrecks and other O&G Installations is also considered.

5.5.1. Commercial Fisheries

An assessment of the fishing industry in the Curlew area has been derived from ICES fisheries statistics, provided by the MS Science Division. Offshore O&G operations, including decommissioning activities have the potential to interfere with fishing activities, for example as a result of the exclusion of fishing vessels from around an area of operation (CEFAS, 2001).

For management purposes, ICES collates fisheries information for individual rectangles measuring 30 by 30 nautical miles. Data was obtained for ICES rectangle 42F1, which contains the Curlew cluster and export pipeline.

Data on the economic value of the fishing industry in this area have been produced based on UK catches and landings between the years 2011 and 2015 (Scottish Government, 2016). The overall value of different fisheries by area (financial yield per ICES rectangle) is an indication of the differential worth of areas and is used as a method of expressing commercial sensitivity (Coull *et al.*, 1998).

Species found in the water column (pelagic species) are fished using techniques that do not interact with the seabed, whereas demersal and shellfish species are generally fished on or near the seabed. Both finfish, such as cod, whiting, haddock and flatfish, and shellfish species, such as *Nephrops*, which are found on or near the bottom, are caught by demersal gear. Demersal trawling methods interact with the seabed, and may interact with the existing infrastructure on the seabed and historical seabed anomalies created by O&G activities, including disturbance from subsea structures left in situ such as footings, pipelines, rock placement or concrete mattresses left or buried in the sediment.

A description of the fishing catch and value 2011 to 2015 is provided in Table 5-10. 150 tonnes of fish were landed in 2015 (£391,674), with *Nephrops* contributing to over 80% of value of landed fish. In 2014 almost 1,000 tonnes more fish were landed (1,112 tonnes), with majority of this increase attributed to herring. Herring and *Nephrops* were the most lucrative fisheries in this ICES rectangle in 2014, with values of £360,904 and £333,233, respectively. In 2013 105 tonnes of fish were landed, mainly haddock and *Nephrops* (41 and 23 tonnes, respectively), amassing a value of £94,505 and £38,366, respectively.

Table 5-10 Total Landings (Te) of Demersal, Pelagic and Shellfish Species Caught in ICES Rectangle 42F1 by UK and Foreign Vessels 2011 to 2015 (Source Scottish Government, 2016)

Species Type	Live Weight (Te)					Value (£k)				
	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
Demersal	175	143	81	72	66	319	201	87	92.1	70.3
Pelagic	-	236	2	959	0.3	-	64.9	3.20	366	362
Shellfish	140	140	23	81	83	722	666	94.8	334	321
Total	315	519	105	1112	150	1041	933	185	79	392

The annual value of landings for fish and shellfish in each ICES rectangle in and around the development area for the years 2011 to 2015 by value (£) is shown in Figure 5-18. Annual variation can be seen with shellfish contributing the majority of catch value within 42F1. The average weight landings of pelagic, demersal and shellfish species in 42F1 was 107, 239 and 93 tonnes respectively. Overall total landings contributed to 0.07% of the average total recorded UK landings 2011 to 2015 suggesting the fishing ground is of relatively low importance to the UK fishing industry.

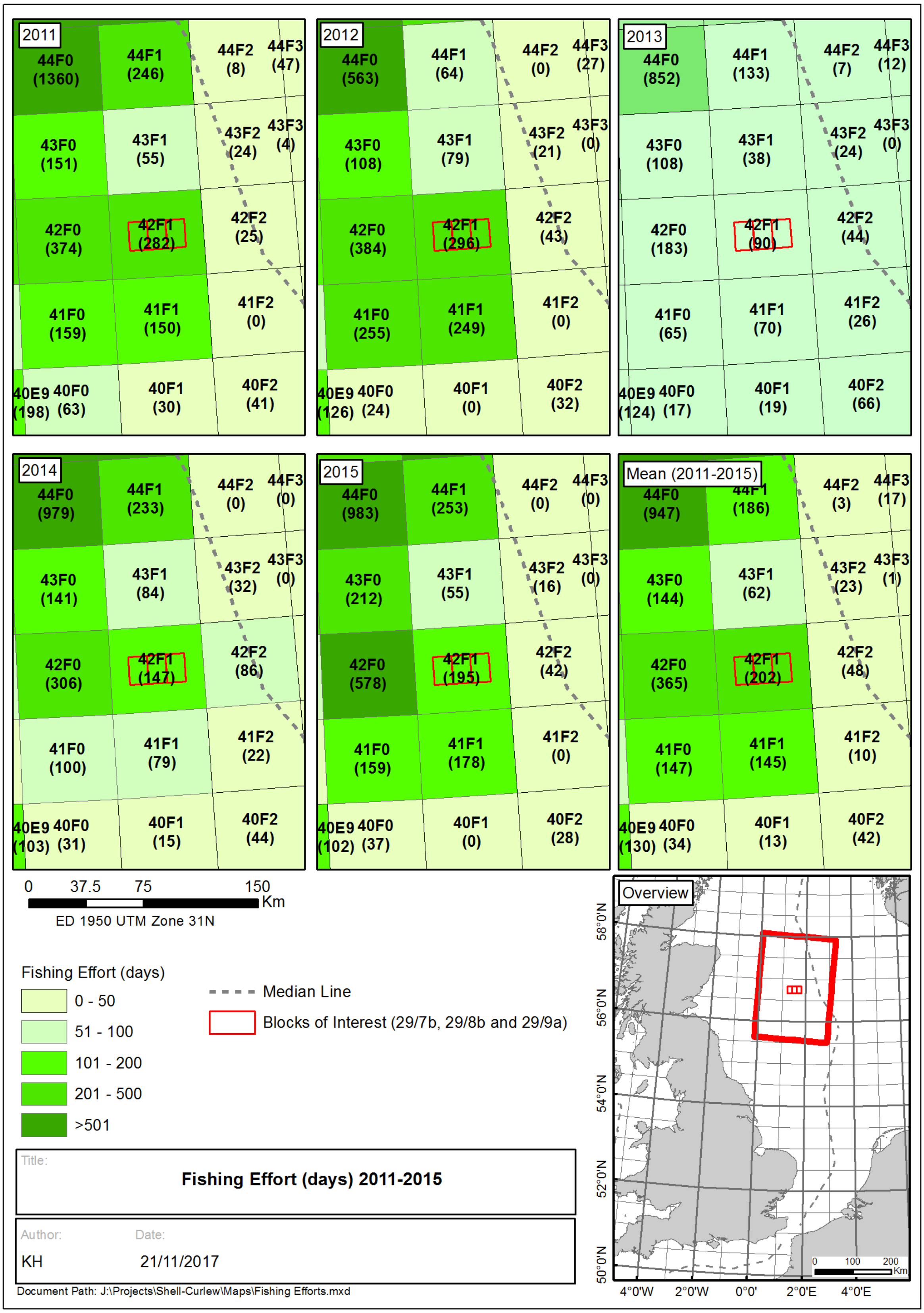


Figure 5-18 Fishing Effort Surrounding Blocks 29/7b, 29/8b and 29/9a (2011 to 2015)

Source – Scottish Government (2016)

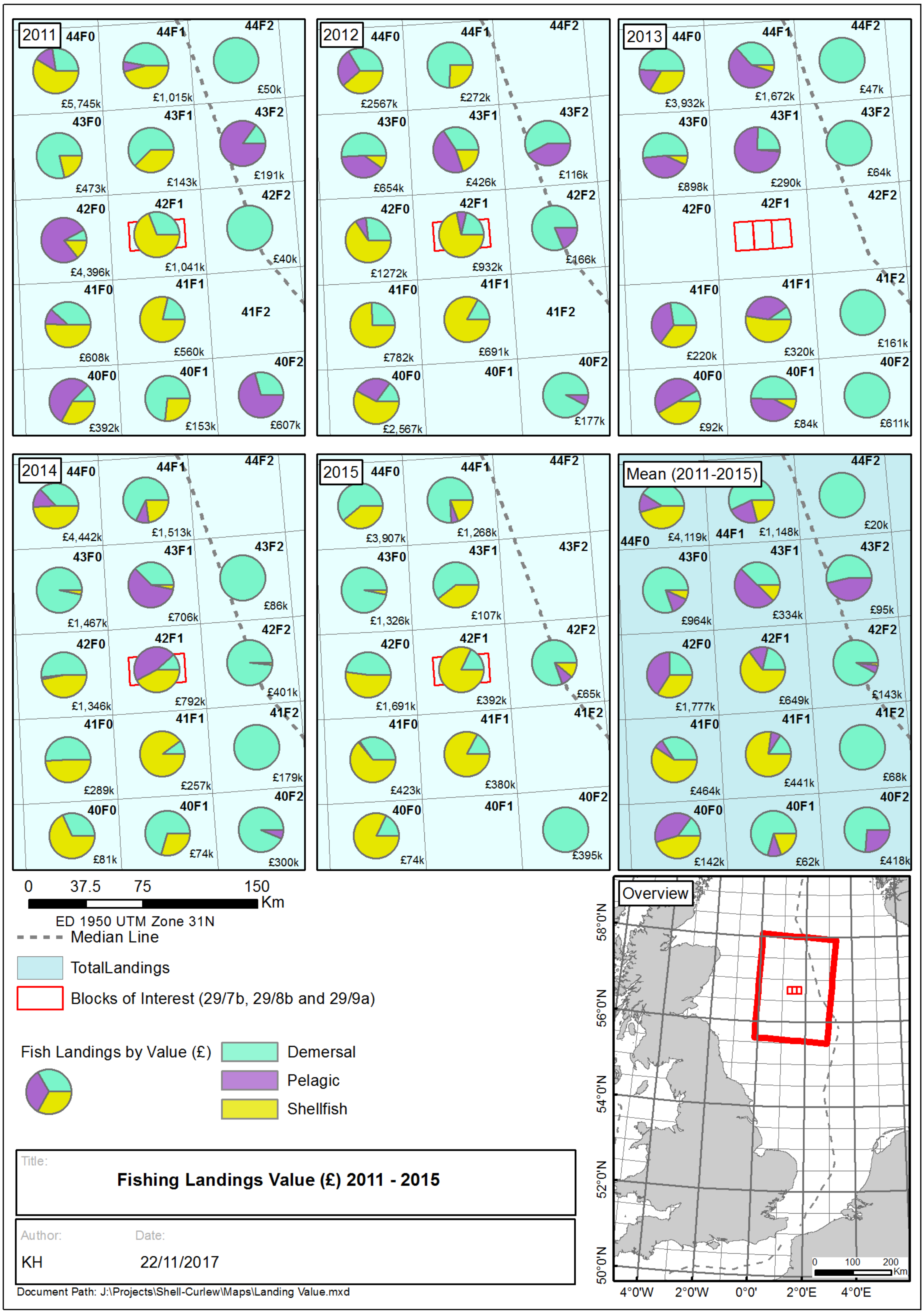


Figure 5-19 2011 – 2015 Fisheries Landings (£k) by Species Type ICES Rectangle 42F1 and Surrounding Area (Scottish Government, 2016)

5.5.1.1. *Vessel Monitoring System*

Scotland's seas support diverse commercial fisheries, including both bigger vessels (length ≥15 m) and smaller vessels (length <15 m). The bigger vessels are covered by Vessel Monitoring Systems (VMSs). VMS data for all UK registered commercial fishing vessels for the period 2007 to 2011 have been combined with landings information to develop Global Information System layers describing the spatial patterns of landings of the Scottish offshore fleet from within the Scottish zone of the UK fishing limits (200 nm) (Kafas *et al.*, 2012). Figure 5-20 shows the fishing intensity of fishing vessels ≥15 m in length.

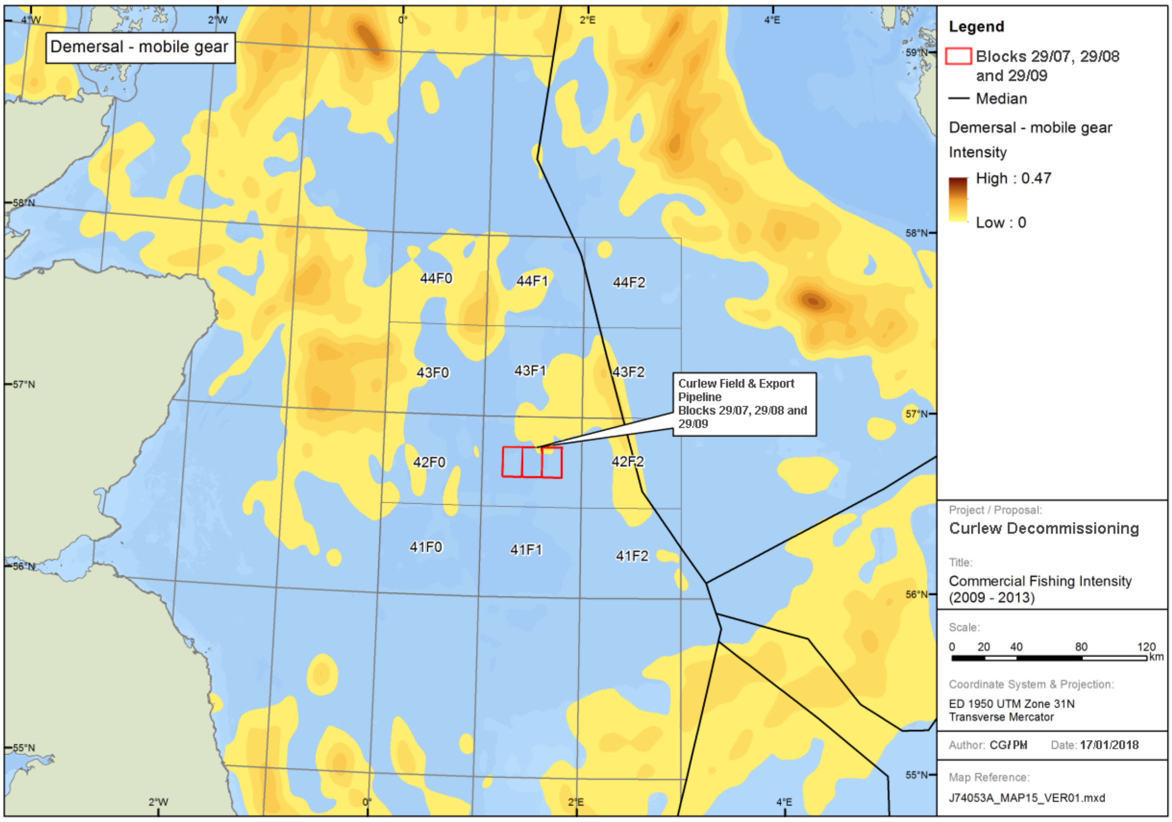


Figure 5-20 VMS Data in the Curlew Decommissioning Area 2013 to 2015

5.5.1.2. *Automatic Identification System*

Since 31 May 2014, all fishing vessels of overall length 15 metres and above are required to carry Automatic Identification System (AIS) by EU directive.

Anatec (2016) was commissioned by Shell to produce a Fishing Risk Assessment for the Curlew project area. AIS data of all fishing vessels in a 10 nautical miles radius is shown in Figure 5-21. Active fishing vessels within this area are presented in Figure 5-22. This shows that active vessels generally maintain a safe distance from the Curlew FPSO but do actively trawl over the pipeline location.

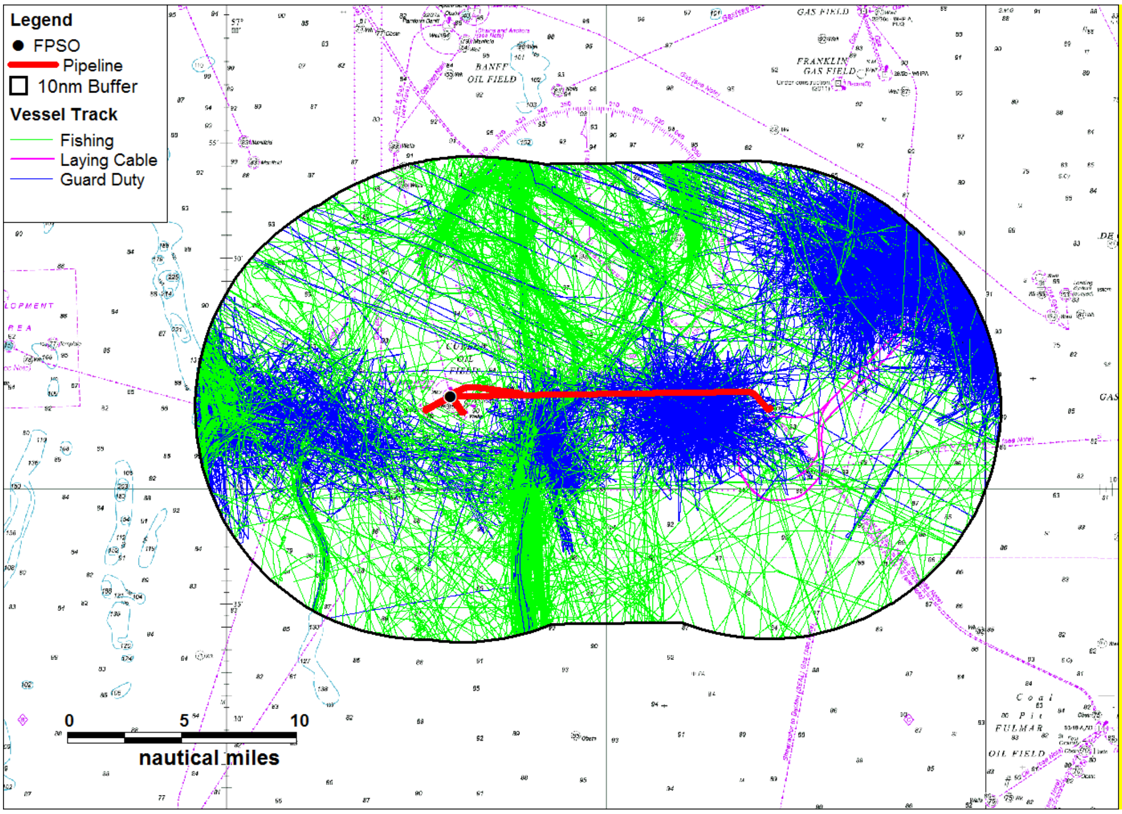


Figure 5-21 All Fishing Vessels 2015/2016 Source Anatec 2016

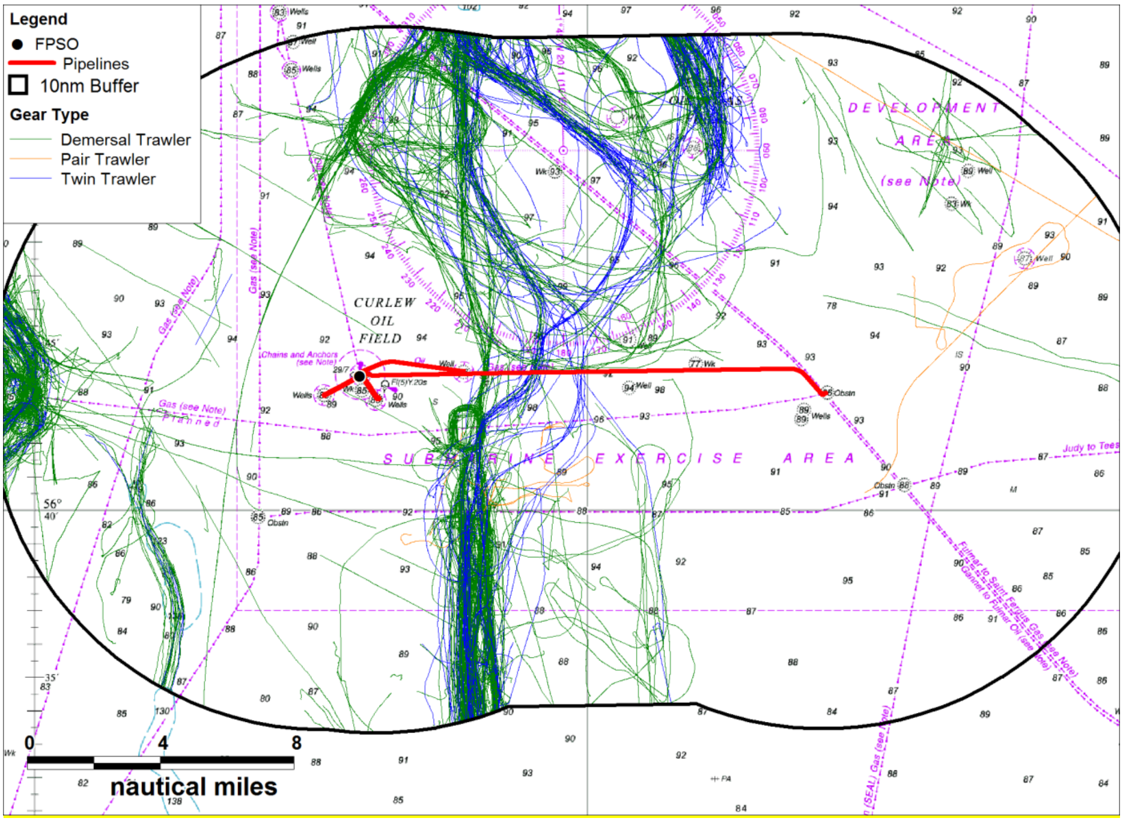


Figure 5-22 Active Fishing Vessels 2015/2016 Source Anatec 2016

5.5.2. Commercial Shipping

Shipping activities in the North Sea are categorised by the OGA (2016) to have very low, low, moderate, high or very high shipping density. Figure 5-23 shows the level of shipping activity is very low in Blocks 29/07 and 29/08, and moderate in Block 29/09. Data from the Marine Management Organisation (MMO) shows the annual average shipping density around the Curlew area was generally moderate to very low in 2014 (refer to Figure 5-24) (MMO, 2016).

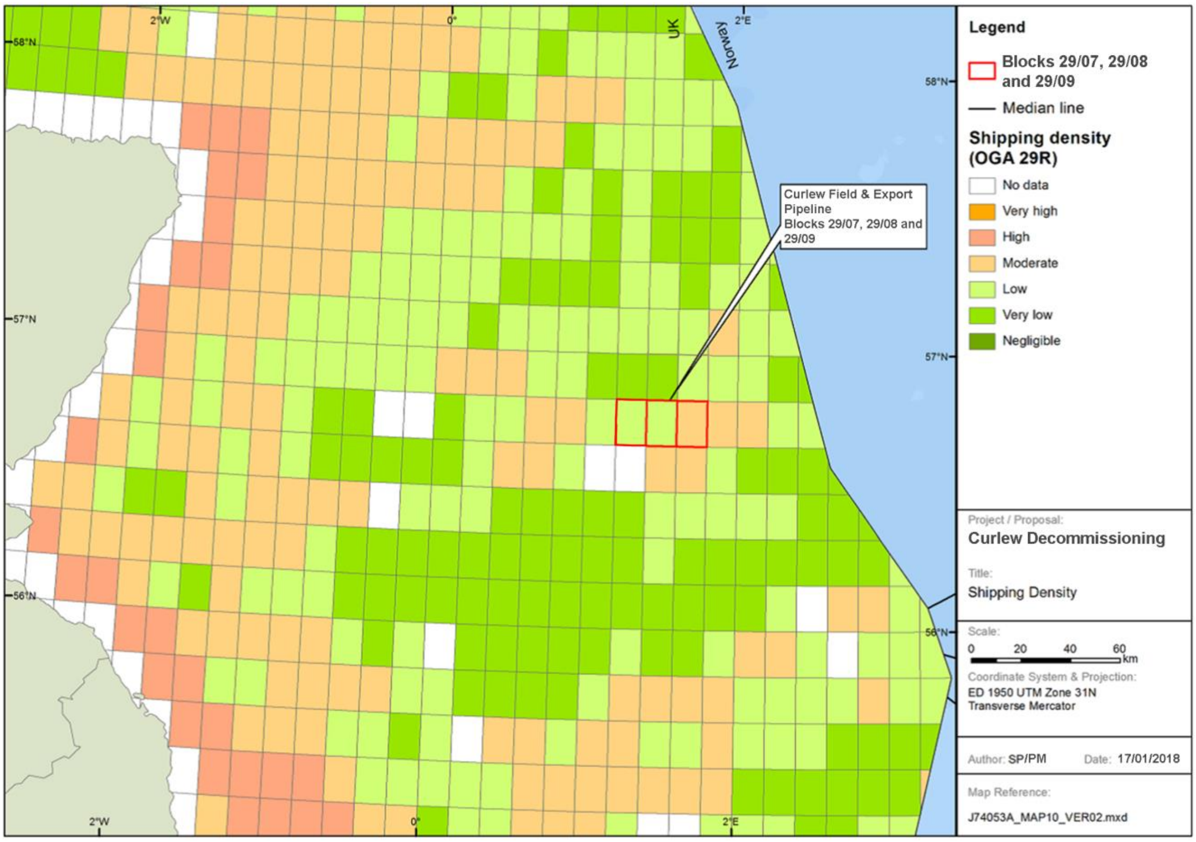


Figure 5-23 OGA Shipping Density

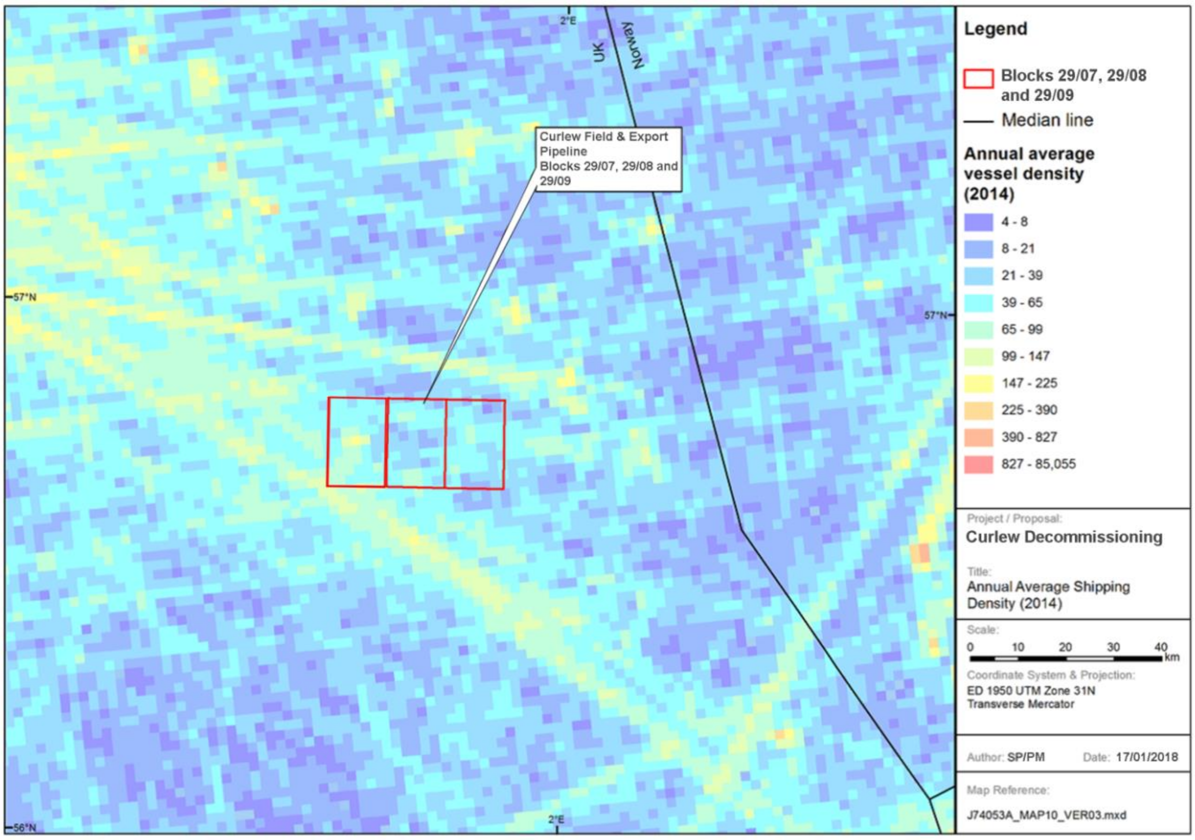


Figure 5-24 MMO Shipping Density

5.5.2.1. *Oil and Gas Activity*

O&G development in this region of the North Sea is relatively intensive. There are several O&G developments close to the Curlew cluster and gas export pipeline route. The closest platforms and pipelines, located within 30 km of the Curlew infrastructure, are listed in Table 5-11.

Table 5-11 Oil and Gas Infrastructure Located within 30 km from Curlew

Infrastructure*	Distance and Direction	Measured From	Operator
Banff FPSO	29 km N	From Curlew FPSO	CNRI
Banff FSU	30 km N	From Curlew FPSO	CNRI
Stella SAL System loading buoy	25 km NE	From Gas Export Pipeline	Ithaca
West Franklin wellhead platform	25 km N	From Gas Export Pipeline	Total
Catcher Gas Export Pipeline PL-3759	1.8 km S	From Curlew FPSO and Gas Export Pipeline (ties in at FGL deep gas diverter FGL). Runs near Curlew Gas Export Pipeline PL-1455B (approx. 60 m))	Premier
Fulmar A to St. Fergus Gas Pipeline PL208	25 km E	From Curlew FPSO (crossed by Curlew Gas Export Pipeline PL-1455B at 6 288 314.00 m N, 605 023.56 m E)	Premier
Kyle South Drill Centre to Curlew FPSO pipeline PL-1798	0.3 km N	From Curlew FPSO (near Curlew gas lift and production riser (approximately 10 m))	Shell

Table 5-11 Oil and Gas Infrastructure Located within 30 km from Curlew (Continued)

Infrastructure*	Distance and Direction	Measured From	Operator
Judy Export Pipeline PL-977	7.6 km S	From Curlew FPSO and Gas Export Pipeline (runs near Curlew D wellheads (approx. 13 km S))	Conoco Phillips
Everest to Teesside (Cats Trunkline) PL774	5.7 km W	From Curlew FPSO (runs near Curlew B wellhead (approx. 3.5 km W))	Antin
Langeled Pipeline PL-2071	12 km W	From Curlew FPSO	Gassco
Shearwater to Bacton	8 km E	From Gas Export Pipeline	Shell
Greater Stella 10 inch Gas Export PL-3078	19 km N	From Gas Export Pipeline	Ithaca

*Notes: *Umbilicals and other subsea infrastructure are not included in this table*

Source: UK Oil & Gas Data (2017)

5.5.3. Renewable Energy Activity

There are currently no renewable energy developments or extraction activities in the Blocks 29/07, 29/08 or 27/09 (Crown Estate, 2016).

5.5.4. Submarine Cables

Currently there is one submarine cable, Cantat-3 telecommunication cable, passing 10 km southeast from the Curlew infrastructure (NMPi, 2016).

5.5.5. Military Activities

There are no recorded military training or disposal sites located within Blocks 29/7, 29/8 and 29/9; with the closest military practice area located 115 km west from Curlew cluster (MMO, 2017).

5.5.6. Marine Archaeology and Wrecks

No dangerous wrecks or designated sites of archaeological interest occur in the blocks of interest or in the surrounding area. However, there are two potential non-dangerous or undesignated wrecks within the blocks of interest. One in Block 29/7a approximately 900 m from the FPSO which is unidentified but has some associated floating debris attached and one in Block 29/8b, approximately 300 m north of the export line which is potentially a submarine (Wrecksite, 2017).

6. PROCESS AND METHODOLOGY OF IMPACT ASSESSMENT

The IA process begins with identification of potential environmental, social and community health 'aspects', defined as interactions between project decommissioning activities and sensitive receptors. This was achieved through an ENVironmental (Social and Community Health) impact IDentification (ENVID) workshop involving the Shell project team and the IA contractor team. The Shell Curlew ENVID identified all aspects and activities over the lifecycle of the decommissioning project that may impact upon valued environmental, social and community health attributes. A summary of the findings of the ENVID workshop and scoping process is presented in Appendix A.

Section 6.1 provides a description of the process and methodology used during this EIA to identify and assess potential impacts and risks. Sections 7 to 13 then assess the environmental, social and community health impacts and risks for offshore project aspects. Section 14 provides a qualitative summary of the potential impacts and risks associated with the onshore activities and the proposed candidate dismantling yards for the FPSO.

6.1. Impact Identification and Assessment

Potential negative impacts/risks are evaluated using a methodology developed by Shell and the EIA contractor team. Positive impacts are not given a magnitude descriptor.

Early on in the project cycle, Shell first undertook an internal screening exercise. Following subsequent engagement of the EIA contractor team, the next step was to further identify environmental, social and community health impacts/risks in an ENVID workshop (held on 23 March 2017). The ENVID assessed initial impact 'significance' for planned and unplanned activities (refer to Section 6.1.1). Then unplanned events were also assessed against their 'likelihood' (refer to Section 6.1.2).

The same method was used in the next phase of the EIA, described in this ES.

6.1.1. Significance of Impacts

The significance of an impact is determined based on the magnitude of the impact and sensitivity of receptors identified to be affected by an aspect.

Magnitude

The magnitude of an impact or predicted changes takes into account the following key elements:

- Area of influence, potential for transboundary and cumulative impacts
- Duration and frequency of an impact
- Extent of contamination/degradation
- Degree of socio-economic change, level of community concern

Table 6-1 shows how the magnitude of an impact is quantified for different receptors (i.e. land, air, water, biodiversity/conservation).

[This page is intentionally blank]

Table 6-1 Impact Magnitude Matrix

Magnitude	Area of Influence	Land (Soil/Seabed)	Air	Water	Waste	Biodiversity/Conservation
No effect (0)	Not measurable above background					
Slight (1)	Measurable above background. No contribution to transboundary or cumulative effects. Highly localised to immediate vicinity of the Asset. (e.g. within 500 m zone). Confined within 10,000 m^2 area and/or fence line of site.	Physical disturbance, short-term or localised impacts not affecting usage.	Measurable deterioration of ambient air quality at specific area and fence line community. No odour or irritation to fence line community caused by the deterioration of air quality.	Slight degradation of quality or reduction of volume of groundwater. Slight contamination of aquatic ecosystem.	Primarily household and recyclable waste. Disposal at local waste facility.	Slight impact on localised species and habitat. Effects are unlikely to be discernible or measurable
Minor (2)	Unlikely to contribute to transboundary or cumulative effects. Impacts from activities may be felt at the field level. Extending over 100,000 m^2 area.	Localised physical disturbance and/or chemical pollution which may affect user. Effect will remediate naturally in a short period (<1 year).	Measurable deterioration of ambient air quality on the local level Minor odour and irritation to local community caused by deterioration of air quality.	Minor degradation of groundwater quality or reduction of its volume. Minor contamination of aquatic ecosystem.	Non-hazardous industrial waste. Handling facilities capable of dealing with industrial waste (to its designed capacity)	Changes to habitats or species which can be seen and measured but is at same scale as natural variability
Moderate (3)	Minor transboundary and cumulative effects. Impacts limited in their effect at the region level, over 1 km^2 area.	Physical disturbance and/or chemical pollution resulting in limitations to the use of the area. Effect/impact can be for a period of years, but does not require remediation/mitigation.	Measurable deterioration of ambient air quality on a regional level. Considerable odour and irritation to neighbouring community caused by deterioration of air quality.	Considerable degradation of groundwater quality or reduction of its volume. Considerable contamination of aquatic ecosystem.	Hazardous/special, radioactive and non-hazardous waste. Facility fully licensed for hazardous/special, radioactive and non-hazardous waste treatment and disposal (to the designed capacity).	Widespread change in habitats or species beyond natural variability.
Major (4)	Transboundary effects or major contributor to cumulative effects. Widespread effects which reach outside of the area of interest but can be contained to neighbouring environment. Extending over 10 km^2 area.	Physical disturbance and/or chemical pollution resulting in limitations in the use of the area. Remediation/mitigation measures needed.	Measurable deterioration of ambient air quality on a national level. Acute impact from odours on local receptors.	Major degradation of groundwater quality or reduction of its volume. Major contamination of aquatic ecosystem.	Hazardous/special, radioactive and non-hazardous waste. Facility only licensed for some of the waste received and generated. Non-permitted wastes must be transported to offsite treatment and disposal facilities.	Widespread degradation to the quality or availability of habitats or species.
Massive (5)	Major transboundary and cumulative effects. Widespread, Regional impact, multiply stakeholders effected. Extending over. 100 km^2 area.	Physical disturbance and/or chemical pollution resulting in restricted use of the area. Remediation is difficult, costly and over an extended period.	Measurable deterioration of ambient air quality on an international level. Severe acute impact on the receptor(s) (human and living thing) potentially leading to fatality.	Catastrophic degradation of groundwater quality or reduction of its volume. Catastrophic contamination of aquatic ecosystem.	Hazardous/special, radioactive and non-hazardous waste. Facility not licensed for hazardous/special or, radioactive waste.	Widespread degradation to the quality or availability of habitats and species that cannot be readily rectified.

[This page is intentionally blank]

Sensitivity of Receptor

Sensitivity criteria of receptors are provided in Table 6-2, based on the following key factors:

- Importance of the receptor at local, national or international level – for instance, a receptor will be of high importance at international level if it is categorised as a designated protected area (such as Ramsar site or SAC). Areas that may potentially contain e.g. Annex I habitats are of medium importance if their presence/extent has not yet been confirmed
- Sensitivity/vulnerability of a receptor and its ability to recover – for instance, certain species could adapt to changes easily or recover from an impact within a short period of time. The IA will consider immediate or long-term recovery of a receptor from identified impacts. It will also consider if the receptor is under stress already
- Sensitivity of the receptor to certain impacts – for instance, emissions can cause significant air quality impacts, but will not affect other receptors such as seabed

Table 6-2 Sensitivity Criteria of Receptors for Planned Events

Sensitivity	Definition
Not sensitive (A)	Not sensitive to activities
Low (B)	Receptor with low value or importance attached to them, e.g. habitat or species, which is abundant and not of conservation importance. and/or Immediate recovery and easily adaptable to changes.
Medium (C)	Receptor of importance e.g. recognised as an area/species of potential conservation significance for example, Annex I habitats and Annex II species. and/or Recovery likely within 1 to 2 years following cessation of activities, or localised medium-term degradation with recovery in 2 to 5 years.
High (D)	Receptor of key importance e.g. recognised as an area/species of potential conservation significance with development restrictions for example SACs, NCMPAs. and/or Recovery not expected for an extended period (5 to 10 years) following cessation of activity or that cannot be readily rectified.
Very high (E)	Receptor of key importance e.g. recognised as an area/species of potential conservation significance with development restrictions for example SACs, NCMPAs. and/or Recovery not expected for an extended period >10 years following cessation of activity or has permanent deleterious effects.

The magnitude of the impact and sensitivity of receptor is then combined (Table 6-3) to determine the impact significance of such an event occurring. Mitigation measures will then be identified to reduce the significance of an impact, in order to determine residual significance.

Table 6-3 Impact Significance Matrix

		Sensitivity				
		A	B	C	D	E
Impact Magnitude	No effect (0)	No effect				
	Slight (1)	Negligible	Negligible	Minor	Minor	Minor
	Minor (2)	Negligible	Minor	Minor	Moderate	Moderate
	Moderate (3)	Minor	Minor	Moderate	Moderate	Major
	Major (4)	Moderate	Moderate	Moderate	Major	Major
	Massive (5)	Major	Major	Massive	Massive	Massive

6.1.2. Likelihood Criteria of Unplanned Events

For unplanned events, the likelihood of such an event occurring also requires consideration. For example, based on magnitude and sensitivity alone a hydrocarbon spill would be classed as having major impact significance, however the likelihood of such an event occurring is very low. In addition, the mitigation measures for such impacts focus on reducing the likelihood of the impact occurring, as opposed to reducing the effects of the impact itself. Thus unplanned events also require assessment in terms of environmental 'risk'.

As with planned activities, the potential impacts of unplanned events are identified, and their magnitude and sensitivity defined and combined to determine the impact significance.

The significance of the impact is then combined with the likelihood of the event occurring (refer to Table 6-4) in order to determine its overall environmental 'risk' (refer to Table 6-5). Mitigation measures are then identified to reduce the risk of such an event occurring in order to determine residual risk.

Table 6-4 Likelihood Criteria for Unplanned Events

Likelihood	Definition
Improbable (A)	Never heard of happening in O&G industry. $<10^{-5}$ per year
Remote (B)	Incident/impact has never occurred during company's activities, including non-operator projects. Or incidents/impacts have occurred in the O&G industry. $10^{-5} – 10^{-3}$ per year
Occasional (C)	Incidents/impacts have occurred during company's activities, including non-operator projects. $10^{-3} – 10^{-2}$ per year
Probable (D)	Incidents/impacts happen multiple times a year during company's activities, including non-operator projects. $10^{-2} – 10^{-1}$ per year
Frequent (E)	Incidents/impacts happen multiple times a year at one operational site in companies group. $10^{-1} – >1$ per year

Table 6-5 Evaluation of Environmental Risk (Unplanned)

		Likelihood				
		A	B	C	D	E
Impact Significance	No effect (0)	No effect				
	Slight (1)	Negligible	Negligible	Minor	Minor	Minor
	Minor (2)	Negligible	Minor	Minor	Moderate	Moderate
	Moderate (3)	Minor	Minor	Moderate	Moderate	Major
	Major (4)	Moderate	Moderate	Moderate	Major	Major
	Massive (5)	Major	Major	Massive	Massive	Massive

6.1.3. Elimination or Reduction of Significant Environmental Impacts/Risks

Measures (sometimes referred to as project controls or included mitigation) to reduce or eliminate the impact/risk of an activity have already been included in the project design. This is the design assessed in the ENVID and the IA process.

If during this phase of the assessment, impacts are considered unacceptable or the impact has not been reduced to ALARP, additional mitigation measures are then identified, evaluated for their effect and it is assessed whether they can be implemented in the project design. If a significant change in design occurs then the impacts are re-assessed. This cycle of redesign can be repeated until either (a) impacts are acceptable or (b) no further design changes are possible or practical.

Where an impact cannot be reduced to acceptable levels, compensation (for impacts to humans) or offsets are considered. Once all necessary, practical and possible mitigation is included in the design, the resulting impact/risk of that design is termed the 'residual' impact/risk. This is what is documented in the ES.

Mitigation measures can include but are not limited to, the following:

- Modification of the project design
- Alteration of the timing/scheduling of the project implementation
- Operational management (e.g. waste management)
- Behavioural (e.g. training and competency)

6.1.4. Residual Impacts/Risks

A residual negative impact/risk is that remaining after the implementation of proposed project controls, safeguards and mitigation measures.

The EIA process provides the basis for determining if further mitigation, monitoring and/or management measures are required. Residual impacts/risks will be incorporated into the Environmental, Social and Health Management Plan and monitored to see if additional mitigation is required.

7. SEABED DISTURBANCE

The potential short and long-term environmental impacts associated with seabed disturbance during Curlew decommissioning activities are presented in this section. The measures taken or planned by Shell to minimise these impacts are also discussed.

7.1. Sources of Potential Impact

There are perceived to be two main types of impact regards seabed disturbance:

- Primary impacts as a direct result of removal, excavation, jetting, trenching and overtrawl surveys
- Secondary impacts associated with resuspension and redistribution of sediment

The following activities have been identified as the sources of these potential impacts:

- FPSO decommissioning activities
  - Temporary deposition of mooring lines on the seabed
  - Temporary deposition of the risers on the seabed
  - Removal of the mooring system, including the suction anchor piles
  - Remediation of the mooring trenches
- Pipeline and umbilical decommissioning activities
  - Rock-placement
  - Excavation/Re-burial (trench and bury)
  - Overtrawl surveys
- Additional subsea infrastructure decommissioning activities
  - Cutting operations and removal of infrastructure
  - Temporary seabed storage of subsea infrastructure
  - Removal of mattresses, grout bags and debris

Any activities within the decommissioning process which require work below, at, or near the seabed, may result in disturbance to seabed sediments and background sediment concentrations. Impacts can be classified as either short- or long-term, as discussed in the following sections.

Short-term impacts are generally temporary in nature and it is envisioned that the seabed will recover over a period of time (usually less than 10 years). These impacts could be comparable in nature to natural impacts e.g. storm events.

Long-term impacts are generally considered permanent or requiring several decades to recover, for example the introduction of new substrate which is different than that naturally present e.g. rock-placement in a movable sediment environment.

7.1.1. FPSO Decommissioning Activities

As per the operational description discussed in Section 2, removal of the mooring lines, remediation of associated trenches, suction pile anchors with rock placement, and overtrawl surveys to establish clear seabed conditions for other sea users will disturb the seabed, with the potential for both short and long-term impacts equating to 24.2 km^2 of seabed (refer to Table 7-1).

The basis of the area assessment for the overtrawl trials associated with the FPSO location will cover:

- Safety Zones: the 500 m (radius) will be subject to overtrawl trails in order to receive the Clear Seabed Certificate. To achieve this, SFF have advised an additional 400 m turning circle (in the direction of travel) and trawls in an east/west and north/south direction, are required. This results in the impacted area covering two1,800 m x 1,000 m boxes centred over the three wellheads
- Anchor chain trenches: these will be subject to overtrawl perpendicular to their length and will result in the impacted area covering three boxes (one per group of trenches) of 100 m x 860 m
- Suction anchor piles: the base case for the suction anchor piles is full removal via reverse installation, which is likely to result in a small seabed depression around each pile. These depressions will be subject to an overtrawl trial to ensure any depressions do not pose snagging risks to other sea users. As the seabed impact of the reverse installation of the piles is uncertain, a highly conservative, worst-case approach has been taken to assume the same overtrawl footprint as for the safety zones

The aforementioned describes a conservative estimate of seabed disturbance taking into account the turning circle required for the overtrawl gear. All efforts will be made to minimise the area affected.

Table 7-1 Structures and Materials Associated with Curlew FPSO Decommissioning with the Potential to Impact the Seabed

Infrastructure	Quantity and Dimensions	Seabed Impact (km^2)	Perceived Nature of Impact
Mooring lines deposited on seabed (temporary storage)	Mooring lines – 9 x 290 m length with a diameter of 0.15 m	0.0004	Short term
Risers deposited on the seabed (temporary storage)	Risers – 2,600 m in total for 8 riser sections. Assumed an average diameter of 0.25 m	0.0007	Short term
Overtrawl surveys of safety zones, anchor piles and mooring trenches	3 x [(1,800 m x 1,000 m) + (1,800 m x 1,000 m)] box centred on each drill centre 3 x (100 m x 860 m) for each mooring trench cluster 3 x [(1,800 m x 1,000 m) + (1,800 m x 1,000 m)] box centred on each suction anchor pile cluster.	24.18	Short term
Mooring trenches remedial rock placement	9 x 100 m length, 10 m width (filled with rock)	0.009	Long-term
Suction anchor pile decommissioning (remedial work placement)	3 x 7 m diameter piles (rock berm footprint of 10 m diameter)	0.0002	Long term
	6 x 5 m diameter piles (rock berm footprint of 8 m diameter)	0.0003	Long-term
Total		**24.19**	

7.1.2. Pipelines and Umbilical Decommissioning Activities

Following the removal of approximately 25 m of pipeline from each cut end, the remaining Curlew pipelines will be decommissioned in situ. Seabed disturbance associated with decommissioning activities for the pipelines can be considered as (i) displacement and redistribution of existing sediment through jetting or dredging to access pipeline ends; and (ii) overtrawl surveys of pipelines left in situ.

Disturbance to the seabed to access pipeline ends and overtrawl surveys of the in situ pipelines will result in a short-term impact. Rock placement over the depression created by the ends removal will result in a long-term impact. Water quality also has the potential to be temporarily impacted, through an increase in Suspended Sediment Concentration (SSC), which in turn may have a short-term impact on planktonic/pelagic species.

100 m either side of the pipeline will be subject to overtrawl trails in order to receive the Clear Seabed Certificate. To achieve this, SFF have advised an additional 300 m turning circle parallel to the pipeline is required. The width of impacted seabed associated with the overtrawl trails of the infield pipelines was therefore assumed to be a maximum of 800 m along the entire length of the pipelines (based on 400 m on each side of the line).

In total, the estimated impact to the seabed from the overtrawl trails of the pipelines and umbilicals decommissioned in situ, and the removal of the pipelines ends is estimated as 29.1 km^2 (refer to Table 7-2).

Table 7-2 Potential Seabed Impact from Decommissioning Pipelines and Umbilicals

Infrastructure	Dimensions	Seabed Impact (km^2)	Nature of Impact
Overtrawl Surveys			
PL-1455B Gas Export Pipeline	800 m x 26,600 m	21.28	Short term
PL-1450 Curlew B Production Pipeline	800 m x 2,400 m	1.92	
PL-1451 Curlew B Umbilical			
PL-2523 Curlew C Production Pipeline	800 m x 5,700 m*	4.56	
PL-2524 Curlew C Gas Lift Pipeline			
PLU-2525 Curlew C UTA Umbilical			
PL-1452 Curlew D Production Pipeline 1	800 m x 1,600 m	1.28	
PL-1453 Curlew D Production Pipeline 2			
PL-1454 Curlew D Umbilical			
Pipeline Ends with Rock-Placement			
18 pipeline ends	2 ends – 460 m^2 each 6 ends – 1,380 m^2 each 10 ends – 3,000 m^2 each	0.039	Long term
Total		**29.079**	

** Curlew C pipelines and umbilicals are all placed in the same trench. It was assumed that the length of the trench equals the length of the shortest line.*

7.1.3. Additional Subsea Infrastructure Removal

Cutting operations and removal activities associated with the decommissioning of the subsea structures will result in a short-term impact to approximately 0.0015 km^2 of the seabed and temporary redistribution of sediment.

The full suite of subsea structures to be removed as part of the project and the approximate seabed area of disturbance is presented in Table 7-3.

Table 7-3 Subsea Infrastructure and Associated Materials with the Potential to Impact the Seabed

Infrastructure	Quantity and Dimensions*	Seabed Impact (km^2)	Nature of Impact
MWA	1 x (12 m x 8.5 m x 3.8 m)	0.000102	Short term
Curlew D Manifold	1 x (8 m x 6 m x 4.9 m)	0.000048	Short term
Curlew D SDU	1 x (10.6 m x 9.1 m x 2.9 m)	0.000096	Short term
SSIV	1 x (15.4 m x 7.6 m x 2.6 m)	0.000117	Short term
Spools and Jumpers	Export – 10 x 0.31 m x 290 m	0.000899	Short term
	C – 4 x 0.20 m x 50 m 4 x 0.08 m x 108 m	0.000075	
	D – 7 x 0.15 m x 186 m 1 x 0.08 m x 130 m	0.000206	
	B – no jumpers/spools	0.00	
Total		**0.001543**	

** External diameter were used in the calculations*

7.1.4. Stabilisation Materials

Currently there is approximately 60,300 tonnes of rock placement, 480 concrete mattresses and approximately 3,000 grout bags within the Curlew field, which have been deployed throughout the field life to act as stabilisation material to subsea infrastructure. The rock placement already present in the Curlew field takes approximately 0.13 km^2 of seabed (based on conservative evaluation of 7 m width and 18 km length of existing berms across all fields).

In order to decommission the Curlew subsea infrastructure, additional rock cover will be required, including rock placement in/over mooring trenches and anchor piles (as shown in Table 7-1), pipeline ends (as shown in Table 7-2), and pipeline left in situ (refer to Table 7-4). It is estimated that for the remediation of pipelines left in situ 0.005 km^2 of seabed will be subject of additional rock cover (based on known exposures). In total, 0.05 km^2 of seabed will be affected by rock placement for remediation of all elements (i.e. mooring trenches, anchor piles, pipeline ends and pipeline left in situ), which equates to circa 46,000 tonnes of additional rock.

The base case is for all exposed mattresses and grout bags to be removed, subject to their integrity. Lifting of the mattresses and grout bags will result in a short-term disturbance to approximately 0.008 km^2 of seabed.

The area and nature of impacts from the placement of additional rock and removal of grout bags and mattresses are summarised in Table 7-4.

Table 7-4 Stabilisation Materials with Potential to Impact the Seabed

Infrastructure	Quantity and Dimensions	Seabed Impact (km^2)	Nature of Impact
Additional rock cover at Curlew B	4 x (0.6 m high x 4.6 m wide x 100 m long)	0.00184	Long term
Additional rock cover at Curlew D	10 x (0.6 m high x 4.6 m wide x 50 m long)	0.00230	Long term
Additional rock cover at gas export line	2 x (0.6 m high x 4.6 m wide x 50 m long)	0.00046	Long term
Mattresses removal	480 x (5 m long x 3 m wide)	0.00720	Short term
Grout bags removal	3000 x (0.5 m x 0.5 m x 0.5 m)	0.00075	Short term
Total		0.0126	

Dimensions of rock berms and quantities of protective materials required will be site-specific and dependent upon requirements once activities have been completed. Worst-case estimates are used to ensure that a worst-case impact is presented.

Assessment of the seabed impact from grout bags removal assumed the grout bags to be laid side by side, while in practice some are piled on top of each other and therefore this is a conservative estimate.

7.1.5. Temporary Seabed Storage of Wellheads

During well P&A activities (which are not included in this EIA process), Shell will be removing the Xmas trees. Potentially six Xmas trees, indulging the tree caps, may require temporary storage on the seabed, to be recovered alongside the other subsea infrastructure, due to vessel lifting and storage capacity. Table 7-5 provides a summary of the perceived impact footprint from potential temporary storage of Xmas trees and the tree caps.

Table 7-5 Summary of the Total Seabed Impact from Temporarily Stored Infrastructure

Infrastructure	Dimensions	Seabed Impact (km^2)	Perceived Nature of Impact
4 x Curlew Xmas trees and tree caps	3.63 m x 4.42 m x 3.18 m 2.1 m x 2.6 m x 0.93 m	0.00004 0.000007	Short term
2 x Xmas Trees and tree caps	4.0 m x 4.14 m x 3.60 m 1.96 m x 1.68 m x 1.42 m	0.00003 0.000005	Short term
Total		0.000082	

7.2. Summary of Seabed Impact

Table 7-6 provides a summary of the total expected seabed disturbance from the Curlew cluster decommissioning activities, which equates to approximately 53.3 km^2. The majority of the seabed disturbance area (greater than 95%) is associated with the overtrawl trails, demonstrating safe and clear seabed for other users of the sea.

Table 7-6 Summary of the Total Seabed Impact from Curlew Decommissioning Activities

Decommissioned Element	Seabed Impact (km^2)
FPSO (Table 7-1)	24.19
Pipelines and umbilicals (Table 7-2)	29.08
Additional subsea infrastructure (Table 7-3)	0.002
Stabilisation materials (Table 7-4)	0.0126
Temporary seabed storage of wellheads (Table 7-5)	<0.001 (0.00008)
Total	**53.286**

7.3. Impact on Sensitive Receptors

In order to determine the significance of impacts resulting from seabed disturbance there is a requirement to understand the sensitivity of receptors. A discussion of these receptors is presented in the following sections.

7.3.1. Short-term Impacts

This section presents the potential short-term impacts of the Curlew decommissioning activities. It is estimated a worse-case seabed footprint of short-term impacts would equate to approximately 53.3 km^2.

The Curlew cluster is located in a predominantly fine sediment environment (muds and sands), with no seabed features recorded within the surveys (refer to Section 5.2.5). The sediment type, in addition to the absence of such features, indicates a relatively benign seabed environment, supported by the current burial status of the pipelines, with no recorded exposure or scour.

The magnitude of the local effect will ultimately depend upon the sediment release rate. Of note here is that planned operations are not scheduled to occur at the same time. The proposed excavation, cutting and overtrawl operations will physically disturb the sediment in the local area. This disturbance will result in an initial increase in suspended sediment, but will be short-term and localised.

Whilst the seabed currents are relatively benign, once disturbed and in suspension the sediment will be transported with ambient tidal currents, and will then be subject to the general processes of dispersion and deposition. The natural settling of suspended sediments is such that the coarser fraction (sands) will quickly fall out of suspension, with the less dense material (muds) being the last to settle. This natural process will ensure that all the suspended sediment is not deposited in one location.

A change in local Suspended Sediment Concentration (SSC) levels does not necessarily imply an effect if receptors sensitive to the change are not present.

Following the cessation of any seabed disturbance activities, SSC will revert to background levels and any of the deposited material will be subject to natural processes of suspension, dispersion and deposition. As a result, the residual impact is expected to be slight to minor; although measurable over background levels, the impacts are expected to be highly localised with some impacts to species and habitats being measurable, but only on a similar scale to natural variability.

7.3.1.1. *Faunal Disturbance*

The proposed activities will cause some direct physical impact to fauna living on and in the sediments, including the OSPAR habitats. This disturbance will be both short term in duration and highly localised. Mortality is more likely in non-mobile benthic organisms such as sea pens and burrowing megafauna (e.g. *A. islandica).* Mobile benthic organisms may be able to move away from the disturbed area and return once operations have ceased.

It is expected that, upon completion of subsea decommissioning activities, re-deposited sediment will be quickly recolonised by benthic fauna typical of the area. This will occur as a result of natural settlement by larvae and plankton and through the migration of animals from adjacent undisturbed benthic communities (Dernie *et al.*, 2003).

Although there will be the potential to cause mortality to a small number of *A. islandica* in the direct footprint of some of these decommissioning activities, this species is quite widespread in the North Sea. The worst-case estimated footprint of the decommissioning activities is circa 53.3 km^2, which represents a very small fraction of the total available habitat within which *A. islandica* can be found in the North Sea.

Overtrawling of the site is expected to impact species such as sea pens. The scale of the direct impact from this activity is expected to be similar to single pass impacts from fishing trawls such as beam trawling or other bottom contact gear. Troffe *et al.* (2005) found no significant difference in the density of some sea pen species following beam trawling. This was mainly due to the species (*Virgularia mirabilis*) present having the ability to retract the majority of their bodies into the sediment, therefore reducing the risk of impact. However, other comparative studies have indicated that continued fishing pressure can reduce the ability for sea pens to recover following fishing interaction (NAFO, 2011).

The two species of sea pen identified in the region, *Virgularia mirabilis* and *Pennatula phosphorea*, have the ability to retract into the sediment. This will therefore limit the risk of impact from overtrawling activity. In addition to the footprint this would result in a minimal direct impact to these species.

In a series of large-scale field experiments, Dernie *et al.*, (2003) investigated the response to physical disturbance (sediment removal down to 10 cm) of marine benthic communities within a variety of sediment types (clean sand, silty sand, muddy sand and mud). Whilst it was concluded that the recovery rate was strongly correlated to sediment infilling, which is typically slower in areas where finer material predominates such as the Curlew area, the small area of disturbance (refer to Table 7-5) is such that effects are unlikely to detrimentally impact faunal communities found in this area of the North Sea. This is supported by the literature, where seabed dredging studies have shown that faunal recovery times are generally proportional to the spatial scale of the impact (Foden *et al.*, 2009). This area of impact is also significantly smaller than that affected by commercial fishing activities which are a comparable activity to the overtrawl survey work.

As the impact is a one-off event, providing larvae are seeding from a neighbouring area of the North Sea, It would be expected that *A. islandica* or sea pens directly removed through impacts from decommissioning activities would be replaced and re-established within 10 to 15 years (MarLIN 2018).

Sea pen recoverability is not well understood; however, recruitment is expected to occur annually to every few years (NAFO, 2011); areas subjected to continual fishing pressure require several consecutive years of low fishing pressure to recover (MarLIN, 2018). Recoverability is dependent on sufficient seeding populations being present in the surrounding area and the degree of continued pressure on the region from factors such as commercial fishing.

An experimental study looking at the effect of the Nephrops creel fishery in Loch Broom, Scotland found that the three sea pens present; *Virgularia mirabilis, Pennatula phosphorea* and *Funiculina quadrangularis*, were able to re-anchor themselves, provided the basal peduncle remained in contact with the sediment surface, and mortality rates following experimental creel disturbance were very low (Kinnear *et al.* 1996).

Commercial fishing activity is currently relatively low in the immediate vicinity of the infrastructure, primarily due to the safety zones being in place. This, in conjunction with the low risk of direct impact due to the species' ability to retract into the sediment, should allow good survivability of individuals prior to any potential increase in fishing effort once the safety zones are removed, post decommissioning.

A small number of demersal and pelagic fish and their spawning grounds might also be temporarily disturbed by seabed disturbance activities. The Curlew facilities are within the spawning ground for cod, lemon sole, mackerel, Norway pout and sand eels (Aires *et al.*, 2014; Coull *et al.*, 1998; Ellis *et al.*, 2012) (refer to Section 5.3.4).

7.3.2. Long-term Impacts

This section presents the potential long-term impacts of the Curlew decommissioning activities, created by the introduction of additional stabilisation material. It is estimated a worse-case seabed footprint of long-term impact would equate to approximately 0.053 km^2.

7.3.2.1. *Habitat Change*

The introduction of hard substrate (rock placement) into a predominantly soft substrate environment will result in habitat change and associated faunal change.

Although the Curlew area is not located within a protected area (5.4.1), similar consideration has been given when discussing impacts towards present sensitive habitats and associated species. Therefore, the potential exists for any placement of rock substrate to directly impact these sensitive receptors. There is a total of 60,300 tonnes of rock already placed on the seabed within the Curlew cluster covering an area of around 0.13 km^2. Shell currently proposes a worst-case scenario of 46,000 tonnes of additional rock, with a footprint of 0.05 km^2 to be placed on the seabed. This will be in combination to the already deposited rock within the field, bringing the combined footprint of rock-placement to 0.18 km^2.

Juvenile *A. islandica* have been observed in proximity to the Curlew facilities (near the FPSO). There will be direct impact on a small area of habitat suitable for this species, resulting in direct losses of individuals under the initial deposits. However, these are juveniles would be expected to be replaced over time.

The existing hard substrate will already be populated by organisms associated with such substrate and as such the additional rock placement may also provide habitats for crevice-dwelling fish (e.g. ling, conger eels and wolf fish) and crustaceans (e.g. squat lobsters and crabs), in addition to attracting fish species to the site (Lissner *et al.*, 1991).

Whilst the commercial fishing effort for the area in 2016 was relatively low, there exists the potential for the fishing industry to be impacted by the increased presence of rock berms. As previously stated, the total seabed area impacted by the additional rock-placement is relatively small (0.05 km^2). The profile of the protective and stabilisation material over the pipeline and on the seabed will allow fishing nets to trawl over the berms unobstructed. If remedial rock cover is required, suitably graded rock will be used to minimise the risk of snagging fishing gear.

There is the potential for a positive impact with some of the infrastructure being removed and the removal of safety zones, resulting in additional areas of the seabed being opened to commercial fishing interests.

7.3.2.2. *Seabed Morphological Change*

The existing seabed has no notable morphological features. There are no recorded locations of scour pits or wakes associated with the current known state of the Curlew infrastructure. The additional placement of rock material or the decommissioning in situ is not expected to significantly affect the present seabed mobility regime within the area.

7.4. Transboundary and Cumulative Impacts

Given the distance to the median line, in addition to the predominance of localised nature of seabed activities there are no transboundary impacts anticipated.

Shell are currently planning the development of the Fram field with planned operation expected to commence in 2019, however these activities are over 20 km from the Curlew field and its proposed decommissioning activities. Furthermore, the seabed activities planned for the Curlew facilities have been shown to predominately result in localised effects. As such, there are no cumulative or in-combination impacts anticipated.

7.5. Mitigation Measures, Safeguards and Controls

Standard industry practice and legislative requirements:

- A combination of diver and diverless techniques will be used for cutting and lifting operations to ensure accurate placement of equipment and reduction of seabed sediment impacts
- An overtrawl survey will be undertaken to ensure clear seabed conditions following decommissioning activities and to establish whether any additional mitigation is needed
- The rock mass will be carefully placed over the designated areas of the pipelines and seabed by ROV and/or a controlled fall pipe, equipped with cameras, profilers, pipe tracker and other sensors as required. This will control the profile of the rock covering, thus ensuring rock is only placed within the planned footprint with minimal spread over adjacent sediment, minimising seabed disturbance
- Minimisation of rock volume and footprint
- The profile of the protective and stabilisation material over the pipeline and on the seabed will allow fishing nets to trawl over the rock unobstructed. If rock is used, suitably graded rock will be used to minimise the risk of snagging fishing gear

No project-specific mitigation measures have been identified as necessary.

7.6. Impact Assessment Summary Statement

The assessment of impacts from seabed disturbance is calculated to have a residual impact significance of minor to moderate.

Although measurable over background levels, the impacts are expected to be highly localised; some impacts to species and habitats will be measurable but only on a scale similar to natural variability. The deposition of rock is a permanent change to the seabed morphology, but this has been limited where possible, resulting in a total rock footprint of only 0.053 km^2 post decommissioning.

[This page is intentionally blank]

8. DISCHARGES TO SEA

Potential and planned discharges to sea associated with Curlew decommissioning operations are discussed within this section. Those strategies, which will be adopted by Shell to prevent/limit potential impacts from such discharges, are also presented. Those potential impacts to seabed sediments, including associated benthic fauna, are reviewed in Section 7. Any unplanned discharges during accidental events are presented in Section 13.

The types of releases considered within this section are:

- Chemical releases (permitted) from umbilical cores, which cannot be flushed
- Release of contaminants from disturbed drill cuttings deposits
- Potential release of contaminants from wax deposits in Curlew C production pipeline
- Contaminants released from infrastructure left in situ

8.1. Approach

The potential sources of discharges to sea resulting from Curlew decommissioning activities have been identified through an ENVID, a scoping phase of the IA process and stakeholder consultation. All of those discharges to sea, which were assessed to result in minor or moderate impacts during the scoping phase, have been considered within this section (refer to Appendix A). There were three releases identified as resulting in a negligible impact and as such are not included here.

8.2. Chemical Release from Umbilical Cores

The majority of the chemical cores in the umbilicals supporting the Curlew fields will be flushed and displaced by seawater, before being decommissioned in situ as per the outcome of the CA. There are, however, a number of cores which cannot be cleaned due to being blocked or due to their location and lack of access to them. These include the following:

- Curlew B Field: Four spare cores filled with control fluid Oceanic BTC-491 (OCNS Group A with a substitution warning). These cannot be flushed because they all terminate within the umbilical at the base of the dynamic section. There is no access to these terminations to allow their content to be flushed. The combined maximum core volume is estimated at 95 litres
- Curlew C Field: one umbilical core containing wax inhibitor, Clariant Flotreat DF-3159 (OCNS Group GOLD). The core is blocked and cannot be flushed. The maximum core volume is estimated at 779 litres
- Curlew D Field: One umbilical core containing scale inhibitor, FX-2443 (OCNS Group GOLD). The core is blocked and the maximum volume is estimated at 58 litres

During disconnection, these cores will be cut and their content is anticipated to be released to the water column over time. The potential environmental impacts associated with these releases were assessed using Osborn Adam (OA) toxicity model and their results are discussed as follows.

The discharges of fluids from disconnection of the umbilical will be covered by relevant permits.

8.2.1. Short-term Impacts

Immediately following any cutting activities, it is anticipated that chemicals in the aforementioned cores will be slowly released. The system at that time will be at ambient pressure, hence there will be no drive for active discharge. The discharges will be of fixed and limited volume as stated previously; as they will be disconnected from the FPSO, hence there will not be a supply of new quantities.

When released, the chemicals will cause temporary and localised water quality deterioration. As a worst-case, the total volumes described previously could be released to sea instantaneously. An OA risk assessment was completed to understand the potential environmental impacts of an instantaneous release of these chemicals. The assessment concluded that the refreshment rate of the water column will prevent the discharge from reaching a concentration at which it could have a negative adverse environmental effect. On this basis, it is expected that an instantaneous release of a reduced volume (since cutting of the ends of lines would not be likely to result in the release of the entire inventory) or a release of the entire inventory over the period of time will not result in a negative adverse environmental effect.

8.2.2. Long-term Impacts

The umbilicals are to be decommissioned in situ, and as such following cleaning and cutting, small quantities of contaminants may remain. These will be released gradually after throughwall corrosion occurs and integrity progressively fails. Any failure is anticipated to begin to occur over a long period (i.e. >60 years) (HSE, 1997). Pathways from the umbilicals to the receptors would be via the interstitial spaces in seabed sediments, overlying rock placement where applicable, and the water column. Release would therefore be gradual and intermittent over an extended period of time, such that the effects on the receiving marine environment are considered to be negligible based on the OA modelling mentioned in Section 8.2.1.

A consideration of the potential impact of these released fluids (hydrocarbons and chemicals) upon sensitive receptors has not been considered given the predicted negligible effects.

8.3. Discharges from Drill Cuttings Deposits

8.3.1. Curlew Drill Cuttings Deposits

Organic phase drilling fluids i.e. OBMs discharged to the seabed are subject to OSPAR Recommendation 2006/5 on the Management Regime for Offshore Cuttings Piles (OSPAR, 2006). A pile is defined as 'an accumulation of cuttings on the seabed, which has been derived from more than one well' (OSPAR, 2006). Following this definition, only the cuttings associated with the drill centre at Curlew D are considered a 'cuttings pile'.

Cuttings from the oil-based synthetic mud sections of Curlew D P1 and P2 wells drilled in 1996 were discharged to sea. Bathymetry data (Fugro, 2013) identified a small physical pile with a height of approximately 3.5 m adjacent to the Curlew D P2 well. Results from the core sampling of this pile are discussed in Section 5.2.5.3 and concluded that the cuttings deposits in the area of seabed around Curlew D are relatively shallow, being typically less than 10 cm in depth.

Although the core sampling indicates that cuttings are restricted to the top layer of the pile, the cores were unable to penetrate further than approximately 40 cm in to the pile to confirm if cuttings were present. Therefore, a conservative approach has been taken where the potential size of the cutting pile volume and area have been calculated on the basis of the bathymetry survey giving a footprint of 3,540 m^2 (above mean seabed), a maximum depth of 3.5 m and a volume of 671 m^3 (Shell, 2016b). Even with this conservative approach, the Curlew D drill cutting deposits are significantly smaller than many within the North Sea. For example, the Ninian North drill cuttings pile is reported to be 11.93 m high and have a volume of 33,144 m^3 (CNRI, 2017) whilst the NW Hutton pile was recorded to have a volume of 30,000 m^3 and cover a seabed area of 20,000 km^2 (BP, 2006).

OSPAR Recommendation 2006/5 Stage 1 requires that the following properties of the drill cuttings pile should be assessed:

- The rate of oil loss should be assessed on the basis of the quantity of oil lost from the cuttings pile to the water column over time. The unit used should be tonnes per year (tonnes/yr)
- The persistence should be assessed on the basis of the area of the seabed where the concentration of oil remains above 50 mg/kg and the duration that this contamination level remains. The unit used should be square kilometre years (km^2yrs)

This rate of oil loss from the cuttings pile has been calculated as 0.67 tonnes per year using the UKOOA leaching rate (UKOOA, 2003), which is significantly below the threshold of 10 tonnes per year in OSPAR Recommendation 2006/5.

All of the pre-decommissioning environmental survey stations at 100 m from Curlew D had a THC of less than 50 mg/kg; however the core samples exceeded 50 mg/kg out to 62 m (Fugro, 2016). Taking a conservative approach, it has therefore been assumed that the 50 mg/kg contamination extents out to 100 m from Curlew D. Using the UKOOA (2005) conversion factor gives a persistence of drill cuttings contamination of 2.22 km^2years. This is significantly below the threshold of 500 km^2years in OSPAR Recommendation 2006/5.

As the cuttings pile falls below both OSPAR thresholds, the OSPAR recommendation 2006/5 that the cuttings pile should be left in place to degrade naturally. The UKOOA drill cuttings initiative found that the potential environmental impact of a cuttings pile is not considered to be significant if the pile characteristics fall below the two OSPAR thresholds (UKOOA, 2002).

8.3.2. Disturbance of Cuttings Piles

The disturbance of drill cuttings piles during decommissioning may be unavoidable if infrastructure is to be removed and overtrawl surveys are to be undertaken. Infrastructure removal and overtrawl operations will interact with the seabed and disturb surficial contaminated sediments, including the drill cutting pile at Curlew D.

Trawling is a key mechanism of seabed sediment disturbance, resulting in suspension of material in a cloud of particles in the wake of the fishing/debris clearance gear. This can lead to the release of nutrients, pore water, hydrocarbons and metals from the sediment into the water column. However, a number of independent studies have found that fishing gear typically re-suspend the equivalent of 1 mm depth of seabed sediment. The contaminant content of the top (approximately 100 mm) layer of a cuttings pile is often relatively low, having leached into the water column over time and biodegraded. This suggests that the release of contaminants into the water column by overtrawling of cuttings pile is unlikely to be significant (OSPAR 2009 and update to OIC 2014 (Genesis, 2014)).

Through environmental monitoring it is documented that effects on the seabed are mainly found within 100 to 200 m distance from the cuttings disposal area, while small particles (e.g. barite) can drift for a couple of kilometres or so before they settle (DNV, 2017).

A study undertaken by the Fisheries Research Service (FRS, 2000) using a heavy monkfish trawler to disturb a cuttings pile in the outer Moray Firth, concluded that although contamination was spread, it was not in amounts or at rates likely to pose serious wider contamination or toxicological threats to the marine environment. The act of spreading will encourage, albeit at a slow rate, increased aeration of deposited material which will enable its further degradation by natural processes.

This research was incorporated in to the 2009 OSPAR assessment (2009) of impacts of offshore O&G activities in the North-East Atlantic which concluded that disturbance of cuttings piles does not result in significant impacts on the marine environment as no significant effects on the seabed have been observed, although there may be a temporary effect on the water and sediment quality near the site of disturbance. Contamination of the water column is expected to be limited to during and immediately following the disturbance and the local seabed is expected to return, if undisturbed, to its prior status within a few years. In 2016, OSPAR confirmed their conclusions from 2009 about environmental effects from disturbance of drill cuttings (OSPAR, 2016). As the Curlew cuttings pile is relatively small, it is therefore considered that fishing gear interactions with the pile would be unlikely to result in an impact to the sediments and wider environment.

8.3.2.1. *Societal*

Once decommissioning has been completed, there is the potential for fishing gear to tow through the drill cuttings deposits, which may result in low-level contamination of either fishing gear or the catch therein.

Vessels operating demersal gear have the highest risk associated with interaction with the drill cuttings deposits due to the nature of their activity. The majority of fishing activity in the vicinity of Curlew is associated with demersal fishing. There is also potential for pelagic and fixed gear to be exposed to the same risks. However, these risks are considered to be lower than demersal gear due to the nature of the activities and the relatively low level of this fishing activity occurring within the vicinity of Curlew.

Studies conducted by UKOOA have shown that catches close to the cutting piles have about the same level of hydrocarbons and other contaminants in their tissues as catches from those away from the platforms (UKOOA, 2002). In contrast, SFF have reported that decommissioning trawl sweeps undertaken over the Hutton Tension Leg Platform (TLP) cuttings pile resulted in the gears and doors (starboard and port) being covered in a muddy substance with a very strong oily smell (Goodlad, 2003).

8.4. Potential Contaminant Release from Wax Deposits

The 5.7 km 8 inch Curlew C production pipeline was operated without wax inhibition and below the wax appearance temperature of the Curlew C fluids; therefore wax deposition is anticipated to have occurred.

No samples are available for any potential wax deposition within the pipeline as no wax was ever seen on the topside. However, the wax content of the Curlew C hydrocarbon fluid and its potential to precipitate out of solution was assessed from a sample of Curlew C well fluids. The carbon number distribution from the sample comprised of long chain hydrocarbons >C_{26}, with >96%wt being in the C_{38} toC_{60} range. Flow assurance modelling predicted a maximum deposit thickness of 13.7 mm with an average 9 mm thickness over the 5.7 km pipeline with a total volume predicted of <33 m^3.

8.4.1. Wax Environmental Impacts

There is little scientific literature available on the potential impact of long chain hydrocarbon wax on the marine environment; therefore an independent study on the potential fate of long chain hydrocarbon waxes (C_{38} to C_{60}) in the marine environment has been undertaken (Genesis, 2016). A summary of the main conclusions from the study are given as follows:

- The wax will initially be contained within the pipeline where it has no potential to impact the environment; The pipeline will corrode over the course of a number of years/decades, after which the wax will remain in situ, buried below the seabed for an indeterminate period of time (at least decades) without causing harm to the environment
- The solubility of the long chain hydrocarbon wax in water is low and release of hydrocarbons from the wax, following corrosion of the pipeline, into subsurface pore water is anticipated to be very slow

- Water left in the pipeline at decommissioning will also be released once the pipeline has corroded. The concentration of wax in the pipeline water is limited by their low solubility and so release of the pipeline water is not expected to cause measurable concentrations of hydrocarbons in the water column
- Long chain hydrocarbons are considered to be non-toxic. This is likely to be due to both a lack of biochemical functionality and low bioavailability
- Long chain hydrocarbons are inherently biodegradable although rates of environmental degradation are expected to be low due to impediments to bioavailability resulting from low solubility and poor transport across cell membranes

Based on the aforementioned conclusions, it is anticipated that the potential for environmental impact from the long chain hydrocarbon wax predicted to be present in the Curlew C flowline is considered to be negligible, were it to be left in situ.

8.4.2. Potential Entrained Contaminants

There is the potential that components, present in the Curlew C hydrocarbon fluid, could have become entrained in the predicted wax deposition. As no samples are available to quantify the potential entrainment, concentrations have been assumed based on experience from other Assets that typically show well fluids and contaminants, could be trapped in the wax, up to an additional 50% of wax weight. Therefore, a volume of 13 t of Curlew C hydrocarbon has been assumed to be entrained in the potential wax. In addition to sand, scale and asphaltenes, the heavy metals, mercury, nickel and vanadium may also be present. As per the wax, the release of the hydrocarbon fluid and formation water with the trace amounts of metals that may be present in the wax is also expected to be slow. Dispersion and biodegradation within the water column are expected to result in limited potential for any buildup of concentrations in the water column or through bioaccumulation. However, the predicted metals concentrations have been compared against the OSPAR Co-ordinated Environmental Monitoring Programme (CEMP) assessment criteria (OSPAR, 2009).

OSPAR recommends the use of effects range values developed by the US Environmental Protection Agency as sediment quality guidelines to protect against the potential for adverse biological effects on organisms. The ERL value is defined as the lower tenth percentile of the data set of concentrations in sediments which were associated with biological effects. Adverse effects on organisms are rarely observed when concentrations fall below the ERL value, and the Effects Range-Median (ERM). Table 8-1 shows that predicted concentrations of the predicted metal contaminants would be orders of magnitude below those that might be considered to cause adverse effects on marine organisms (ERL and ERM).

Table 8-1 Comparison of Estimated Metals Concentrations against OSPAR Environmental Assessment Criteria

Metal	Concentration ($\mu g g^{-1}$)		
	Potentially entrained in Curlew C wax	OSPAR guidance criteria for contaminants in sediment	
		ERL	ERM
Mercury	4.89×10^{-7} (1)	0.15	0.71
Nickel	<0.00125	20.9	51.6
Vanadium	<0.00125	N/A	N/A

(1) Based on concentration of mercury in oil until 2016, then mercury in water until 2019 for worst case.

In the unlikely event that chronic toxicity levels are reached within the interstitial spaces of the sediments or in close proximity to the pipelines, heavy metals act as enzyme inhibitors, adversely affect cell membranes, and can damage reproductive and nervous systems. Changes in feeding behaviour, digestive efficiency and respiratory metabolism can also occur. Growth inhibition may also occur in crustaceans, molluscs, echinoderms, hydroids, protozoans and algae (Kennish, 1997). It is expected that any toxic levels will be short lived and localised with minimal potential to impact populations of marine species in the vicinity of the Curlew C pipeline.

The metal concentrations trapped within the Curlew C wax are therefore likely to have negligible environmental impact.

8.5. Contaminants Released from Infrastructure Left In Situ

Once the Curlew pipelines and umbilicals have been cleaned and flushed, where possible, Shell intends to leave this infrastructure in situ in line with the CA conclusions. This may result in the slow release of contaminants over time as the infrastructure slowly degrades. The Curlew pipeline and umbilicals components contain a range of contaminants, as listed in Table 8-2.

Table 8-2 Pipeline and Umbilical Inventory

Material	Materials Associated with Pipelines and Umbilicals within Clusters			
	Export Pipeline	Curlew B	Curlew C	Curlew D
Anodes (aluminium)	✓	✓	✓	✓
Carbon Steel Pipe	✓		✓	
Flanges	✓		✓	✓
Cathodic Protectors (Aluminium)	✓			
Paint	✓			
Durapol 0.4 mm	✓		✓	
Polypropylene Corrosion Coating (3-layer)	✓		✓	
Plastic Sheath		✓	✓	✓
PF Foam Coating (5-layer; 54.3 mm)			✓	
Syntatic PU (41 mm)			✓	

The primary degradation products, which have the potential to result in an environmental impact, are:

- Steel
- Sacrificial anodes
- Plastic

The rate of external corrosion of an abandoned pipeline can vary significantly due to the many factors, which must be present for corrosion to take place. Corrosion of subsea buried pipelines will occur through an electrochemical reaction that involves the loss of metal in one location (called the anode) through the transfer of the metal ions to another location on the pipeline (called the cathode). The anodes will corrode preferentially to the pipeline material. However, once these are depleted, the pipeline material will corrode. The rate of metal ion transfer depends on a number of factors such as the quality of the pipeline coating (DNV, 2006).

The external corrosion of coated pipelines is normally restricted to those localised areas where there are defects or damage in the coating, or where the coating has become disbonded from the pipe. Disbondment of the coating may be the result of damage during installation, impacts from trawl boards and dropped objects, abrasion, etc. Corrosion can be expected to be almost negligible in areas, where the coating integrity is intact. Pipeline corrosion is therefore expected in most cases to occur as localised pits, which will eventually result in random perforations throughout the pipeline length.

Structural degradation of the Curlew pipelines will be a long-term process caused by corrosion and the eventual collapse of the structures under their own weight and that of any overlying structures and sediment. During this process, degradation products derived from the exterior and interior of the pipe will break down and potentially become bio-available to benthic fauna in the immediate vicinity. Pathways from the pipelines to the receptors would be via the interstitial spaces in seabed sediments, overlying rock placement, where applicable, and the water column (DNV, 2006).

8.5.1. Heavy Metals from Steel and Anodes

Heavy metals have a relatively high density or a high relative atomic weight and will be slowly released into both the sediments and water column during the breakdown of the components of the pipeline steel and sacrificial anodes.

The assumed chemical components of the carbon steel in the pipelines found are shown in Table 8-3. The bulk constituent of the steel is likely to be Fe.

Table 8-3 Typical Pipeline Steel Components

Element	Composition (Maximum %)
Iron (Fe)	up to 97.7
Manganese (Mn)	1.85
Carbon (C)	0.22
Phosphorus (P)	0.025
Sulphur (S)	0.015
Titanium (Ti)	Combined <0.15
Niobium (Nb)	
Vanadium (V)	

An estimation of the degradation rate for buried coated pipelines to any degree of accuracy is not possible due to the number of variables involved. Furthermore, any degradation will not be uniform over the pipeline length. Evidence indicates that the internal surface of pipeline in contact with stagnant seawater is likely to have a very slow corrosion rate of 1 to 2 mm per century, due to the low dissolved oxygen content of the seawater (OGUK, 2013). Following the removal of protective coating, degradation rates for the external surface are likely to be of the order of 0.01 to 0.02 mm per annum. The release of degradation products is expected to occur at a slow rate and therefore expected to have a minimal impact on the surrounding environment (OGUK, 2013).

The pipelines are cathodically protected with sacrificial anodes. The cathodic protection system operates on the principle that the anodes will decay in preference to the pipeline material. The typical composition of an Aluminium (Al) anode used in the North Sea is provided in Table 8-4.

Table 8-4 Typical Aluminium Anode Components

Element	Composition (Maximum %)	Estimated Weight (Te)
Aluminium (Al)	up to 95.3	8.5
Zinc (Zn)	4.5 to 5.5	0.5
Copper (Cu)	0.0003	trace
Silicon (Si)	0.08 to 0.12	0.02
Iron (Fe)	0.09	0.01
Other metals	0.04	<0.01

Source: MCPS (2017)

The heavy metal input from the anodes is relatively minor when compared to the inputs from the steel; with the exception of Al and Zn, the majority of other components are only present in trace quantities. The estimated depletion time for anodes is between 30 to 50 years (HSE, 2005). Given the preferential decay of these components, it is likely that this material is already partially degraded and as such many of the chemicals associated with these anodes will have already been released into the surrounding environment.

Of those listed in the previous tables, Cu and Zn are potentially the most environmentally hazardous materials identified in North Sea pipelines (MPE, 1999). Above a threshold, these metals are toxic to marine organisms and can bio-accumulate. The concentration of these metals is dependent on variables in the environment including the release rate (determining the concentration in the surrounding water), the temperature and salinity of the water, presence of other metals and the bioavailability of a metal (which depends strongly on its chemical speciation).

Metals are chemical elements, which will not degrade further once discharged to seawater. As free cations, the natural states of metals in seawater have almost indefinite solubility and will quickly dilute to non--toxic concentrations. Metals may also complex with inorganic constituents of seawater, such as sulphate. Corrosion and degradation depends on a multitude of variables and as such it is not possible to predict the rate of release of metals or other contaminants to the environment. Prediction of the rates of corrosion is further complicated by the unknown durability of their anticorrosion and coating systems.

Given the characteristics of these metals in the marine environment and the quantities (refer to Table 8-4) within the anodes, it is unlikely that any significant effects will occur.

8.5.2. Plastic

Plastics contain phthalamates, softeners, which biodegrade easily in aerobic conditions but, according to some studies biodegrade slowly in anaerobic environments. Since there are small amounts of plastics in use, and since phthalamates leach out mainly from new pipes and biodegradability in the anaerobic environment is low, it can be assumed that the environmental effect of leaving the plastic is negligible (MPE, 1999).

8.5.2.1. *Short-term Impacts Contaminants from Infrastructure Left In Situ*

As presented within this section, the degradation of any infrastructure decommissioned in situ will be gradual and more likely to occur over longer timescales. Any release of contaminants from the degradation of the infrastructure left in situ will be slow and intermittent, rather than instantaneous. Therefore, it can be considered that any potential impacts over the short-term will be negligible.

8.5.2.2. *Long-term Impacts*

Long-term impacts will be dependent upon numerous factors including the degradation rates of the infrastructure left in situ and this is likely to be at slow rate (refer to Section 8.5.1).

Laboratory and enclosure research has reported that the composition and toxicity of contaminated water varies greatly. However, high dispersion rates mean that toxicity in receiving waters is rarely observed (DTI, 2001).

The toxicity of a given metal will vary between marine organisms for many reasons, including their ability to take up, store, remove or detoxify these metals (Kennish, 1997). Metals concentrations are not expected to exceed acute toxicity levels at any time, although chronic toxicity levels may be attained for short periods within the sediment's interstitial spaces or in close proximity to the pipelines. At these levels, heavy metals act as enzyme inhibitors, adversely affect cell membranes, and can damage reproductive and nervous systems. Changes in feeding behaviour, digestive efficiency and respiratory metabolism can also occur.

Growth inhibition may also occur in crustaceans, molluscs, echinoderms, hydroids, protozoans and algae (Kennish, 1997). Any toxic levels are expected to be temporary and localised, with minimal potential to impact populations of marine species. The potential for uptake and concentration of metals would also be limited to the local fauna; due to the slow release of these chemicals it is not likely to result in a significant transfer of metals into the food chain.

Along buried pipeline corridors, there may be accumulations of heavy metals within the sediments. These sediments are also likely to form bonds with these metals, making them less bioavailable to marine organisms (MPE, 1999). The slow release of the metals associated with the pipeline steel is expected to have a negligible impact on the local environment. Failure of the pipelines due to throughwall degradation would only begin to occur after many decades (i.e., 60 to 100 years) (HSE, 1997). The area that could be biologically impacted would likely be limited to a few metres on either side of the pipeline.

The polypropylene rope that is used to bind the individual concrete blocks constituting the concrete mattress matrix can degrade over time. However, the principal route of degradation is by Ultraviolet (UV) radiation absorbed from sunlight. Due to the depth at which the mattresses are located and the fact that a number of these mattresses are buried or partially buried, the effect of UV radiation on the polymer plastics will be minimal, resulting in extremely low degradation rates.

The secondary route of degradation is through abrasive wear. However, the mattresses are not suspended and therefore not subjected to significant abrasive forces from the attached concrete blocks. Therefore, this is not expected to be a significant contributor to the degradation of this material. As a result, any negligible release of polypropylene fibres will be insignificant to the marine environment.

8.5.2.3. *Impacts Upon Sensitive Receptors*

The short and long-term environmental consequences of any contaminants released from infrastructure left in situ have been presented previously. Releases are shown to be slow and intermittent in response to the degradation of the infrastructure. Consequently, these impacts have been concluded to be negligible and as such impacts upon any sensitive receptors have not been considered further.

8.6. Transboundary, Cumulative and In-Combination Impacts

8.6.1. Chemical Release

The predicted small release of contaminated fluids from blocked umbilicals has been identified as the only potential short-term or immediate impact during the decommissioning process. Given the nature of the release, there is minimal risk for cumulative impacts.

Previous monitoring programmes in regions with high densities of offshore Installations and significant volumes of entrained water discharges, have confirmed the presence of constituent compounds around the offshore Installations. They have not however identified any negative environmental effects (Bakke *et al.*, 2013). In the North Sea, surveys of contaminants in fish tissue have not revealed elevated levels of contaminants from entrained fluids (OSPAR, 2009). Similar results have been found for the Gulf of Mexico (OGP, 2005).

8.6.2. Discharges from Drill Cutting Deposits

Given the relative isolation of the Curlew cuttings deposits, the relatively small total volume of all cuttings present within the Curlew field and low concentrations recorded within the pile sediments, it is considered that cumulative effects will be limited.

Shell considers that these decommissioning activities will not present a measurable cumulative impact to the local environment for the following reasons:

- Regulatory requirements ensure that discharges to sea are limited, with thresholds similar to those applied during production periods, i.e. they are permitted activities
- Operators are required to reduce the opportunity for discharges to enter the marine environment to ALARP
- The distances both spatial and temporal, between operations and the dilution factors recorded for released contaminants will prevent cumulative impacts

As all identified impacts would be localised and within UK waters, no transboundary impacts are anticipated for either short term or long term impacts.

8.6.3. Potential Contaminants Release from Wax Deposits

The long-term cumulative effects have also been considered, to account for the degradation and eventual collapse of the Curlew C pipeline decommissioned in situ. As wax has a low solubility in water, any hydrocarbon and contaminant release following exposure to the marine environment will be gradual and intermittent such that the effects on the receiving marine environment are considered to be negligible.

8.6.4. Contaminants Released from Infrastructure Left In Situ

Any contaminant release from pipeline degradation and eventual collapse has been considered. It is not anticipated that these will lead to a significant cumulative impact, as release rates will be over a long period (several decades to centuries), of small volumes or amounts, and potentially locked within the surrounding sediments, if the pipelines remain buried over time.

8.7. Mitigation Measures, Safeguards and Controls

Standard industry practice and legislative requirements:

- Cleaning of pipelines and umbilicals during the decommissioning activities to ALARP
- Debris clearance from drill cuttings deposits using ROV
- Shell consider that leaving the cuttings pile in situ is the most environmentally justified method for decommissioning, compared with methods that involve extensive disturbance of the cuttings pile and re-suspension of OBM contaminated sediments into the marine environment

Project specific mitigation measures:

- Capping of Curlew C pipeline at both ends to contain both the wax and any entrained contaminants.

8.8. Impact Assessment Summary Statement

The discharges to sea assessment identified three main sources of potential impact:

- Chemical releases from umbilical cores
- Discharges from drill cuttings deposits
- Potential contaminant release from wax deposits

The residual impacts for all of the above have been assessed individually. It is recognised that small volumes of contaminants will be released over a long period of time, and these contaminants do have the potential to persist in the environment for longer than 1 year. However, due to the actual volumes involved and the very slight contamination risk these volumes pose to the marine environment, the impact has been assessed to be of minor significance.

[This page is intentionally blank]

9. UNDERWATER NOISE

Sound is important for many marine organisms. Marine mammals, fish and certain species of invertebrates having developed a range of complex mechanisms for both the emission and detection of sound (Richardson *et al.*, 1995). Cetaceans (whales, dolphins and porpoises) use sound for navigation, communication and prey detection. Anthropogenic underwater noise therefore has the potential to significantly impact marine mammals (Southall *et al.* (2007); Richardson *et al.* (1995)).

Underwater noise may influence and alter animal behaviour, affecting activities such as feeding, mating, socialising, resting or migration. This in turn may impact the body condition and reproductive success of individuals or populations (Southall *et al.* (2007); Richardson *et al.* (1995)). Feeding may also be affected indirectly if noise disturbs prey species (Southall *et al.* (2007); Richardson *et al.* (1995)). The introduction of the additional anthropogenic sound in extreme cases can even injure local wildlife.

During the proposed decommissioning of the Curlew cluster, noise is primarily associated with increased vessel usage, cutting operations and rock placement. These sources will emit low frequency noise both in the air and within the water column.

This section will consider the noise and potential impact generated during the proposed Curlew decommissioning activities. A dedicated noise IA was carried out to inform this section.

9.1. Regulatory Context

Under Regulations 41(1) (a) and (b) of the Conservation (Natural Habitats &c.) Regulations 1994 (as amended) and 39(1) (a) and (b) in the Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007 (amended 2009 and 2010), it is an offence to:

- Deliberately capture, injure or kill any wild animal of an EPS; and/or
- Deliberately disturb wild animals of any such species

Disturbance of animals is defined under the Regulations and includes, in particular, any disturbance that is likely to impair the ability to:

- Survive, breed, rear or nurture their young
- Hibernate or migrate (where applicable); and/or
- Significantly affect the local distribution, or abundance of the species to which they belong

In a marine setting, EPS includes all the species of cetaceans (whales, dolphins and porpoises) (JNCC, 2011). As underwater noise has the potential to cause injury and disturbance to cetaceans, an assessment of underwater noise generated by the activities associated with a development is required in line with guidance provided by the JNCC (JNCC, 2010).

9.2. Approach

There is a potential for certain Curlew decommissioning activities to produce underwater noise resulting in impacts. In conjunction with an understanding of the sensitivity of receptors, an assessment of the significance of impacts has been undertaken.

The approach undertaken within this assessment incorporates the following steps:

- Identification of potential noise sources
- Evaluation of their levels and frequencies
- Introduction to relevant underwater noise propagation pathways and the appropriate assessment model
- IA

- Comparison of assessment results against relevant values from the literature, addressing both behavioural impacts to and injury of the target species
- Evaluation of identified potential issues with respect to transboundary and cumulative impacts

Generally, sound can be categorised as continuous noise (where there are no sudden rises or falls in pressure) or impulsive noise.

The European Marine Strategy Framework Directive (MSFD) (2008/56/EC) suggested measures to assess underwater sound. The findings were analysed for BEIS (Genesis, 2011) to help inform on compliance with this MSFD Directive. Descriptor 11, relating to underwater noise, states that the measure of anthropogenic sound sources will be for low and mid frequency *impulsive* underwater sounds, within the frequency range of 10 Hz to 10 kHz.

It is worth noting that the FPSO has been operating in the area since 1997, with ongoing helicopter and vessel support during this time. Due to this baseline condition, potentially affected species such as marine mammals are likely to have become habituated to the anthropogenic noise present during these operations. Any additional noise from decommissioning activities is assessed further in the following sections.

9.3. Sources of Potential Impact

Sources of underwater noise during the proposed decommissioning operations include:

- Use of vessels for transportation and to carry out decommissioning operations, dynamic positioning thrusters and onboard equipment
- Use of underwater tools for cutting and water jetting
- Side-scan sonar or multibeam echo sounder to carry out surveys in the immediate vicinity of the Curlew cluster
- Helicopters for transportation of personnel

Shell does not anticipate the use of explosives to cut any of the subsea equipment.

The typical level and frequency of sound generated by each source was obtained from published studies (reviewed by Genesis, 2011; Table 9-1). In order to model the worst-case scenario, it has been assumed that a maximum of four vessels will be operating at any one time in the vicinity. In reality, this may not happen and thus source levels are likely to be lower than predicted within this assessment.

Table 9-1 Summary of Modelled Activities and Parameters used in the Noise Assessment

Parameter	Value
Decommissioning Activities	■ Removal and recovery of pipelines (including cutting operations) ■ Removal and recovery of subsea infrastructure ■ Removal of mooring system ■ Rock placement ■ Pre/post-decommissioning surveys
Location	■ Block 29/07 ■ 210 km from nearest coastline (Aberdeenshire)
Scheduled timing	■ Activities occur throughout the year
Water depth	■ Approximately 93 m
Mixed layer depth	■ Approximately 50 m
Seabed substrate	■ Muddy sand

Table 9-1 Summary of Modelled Activities and Parameters used in the Noise Assessment (Continued)

Parameter	Value
Absorption coefficient in seawater (↑ in dB/km)	▪ Varies with frequency, temperature, salinity and pH – sourced from NPL online calculator using S = 35, T = 8°C and pH = 8[1]
Near-field anomaly (dB)	▪ Varies with frequency, substrate (sand or mud) and sea state[2]
Attenuation factor (dB)	▪ Varies with frequency, substrate (sand or mud) and sea state[2]
Frequency range	▪ Vessels[3]: 0.005 to 16 kHz; highest noise levels from 0.125 to 1.25 kHz
Source level	▪ Varies with frequency ▪ Vessel[3]: maximum ~180 dB re 1 μPa m (zero-to-peak) at 0.08 kHz ▪ Ambient[4]: maximum ~110 dB re 1 μPa m (rms) at 0.0004 kHz
Marine mammal species potentially present	▪ Minke whale ▪ Long-finned pilot whale ▪ Common dolphin ▪ White-beaked dolphin ▪ White-sided dolphin ▪ Harbour porpoise

Key: dB re1 μPa m – unit of sound pressure level extrapolated to 1 m range from source

[1] http://resource.npl.co.uk/acoustics/techguides/seaabsorption

[2] Urick (1983); [3]Hallett (2004); [4]DEWI (2004)

In the case of the Curlew cluster, sound propagation from the source (Ls) was determined using the Marsh-Schulkin model (Schulkin & Mercer, 1985). This model is valid for acoustic transmission in shallow water (up to 185 m) and represents sound propagation loss (transmission loss) in terms of sea state (wave height), substrate type (bottom loss), water depth, frequency and the depth of the mixed layer.

9.3.1. Vessels

The majority of O&G decommissioning activities are typically dominated by vessel noise, which is continuous and thus not captured within the MSFD descriptor for loud, low and mid-frequency impulsive sounds. Broadband source levels for these activities rarely exceed about 190 dB re 1 μPa m and in reality are typically much lower (Hannay and MacGillivray (2005); Genesis (2011)). Whilst continuous noise can mask biologically relevant signals such as echolocation clicks, the Sound Levels (SLs) are below the threshold levels for Temporary Threshold Shift (TTS) in cetaceans according to the Southall *et al.* (2007) criteria (Genesis, 2011).

The level and frequency of sound produced by vessels is related to vessel size and speed, with the larger vessels typically producing lower frequency sounds (Richardson *et al.*, 1995). Noise levels depend on the operating status of the vessel and can therefore vary considerably during a single operation. Vessels typically produce noise within the range 100 Hz to 10 kHz.

The subsea noise levels generated by surface vessels used during the decommissioning phase are unlikely to result in physiological damage to marine mammals. Depending on ambient noise levels, sensitive marine mammals may be locally disturbed by vessel noise in its immediate vicinity; however, the impact is not expected to be significant. The types and size of decommissioning vessels are not different from the supply vessels that have been visiting the FPSO for years. It is likely that potentially affected marine mammals will have moved location or become habituated.

Various combinations of vessels will be on site during the decommissioning operations. As a worst-case scenario, an assumption of four vessels at any one time has been assessed. Source levels resulting from a study giving the average of ten merchant ships (lengths 89 to 320 m, average 194 m) during entry or exit to port were used as a basis for this assessment (Hallett (2004); note that the standard deviation was given as 5 to 10 dB). These data are more conservative than many of the published examples for specific construction and support vessels.

For continuous sound such as shipping noise, it is typical to use a measure of the total sound intensity of a signal (rms). However, the larger zero-to-peak values have been used in the modelling to illustrate the worst-case scenario.

9.3.2. Helicopters

Helicopter activities related to the decommissioning operations will occur throughout the year for transportation of personnel.

The potential impacts resulting from helicopters' noise will mainly occur at the sea surface. These will be short-term due to the movement of the helicopters and duration of activities. Helicopter flights in the project area have been common for many years. No significant increase will occur due to Curlew decommissioning, with no major disturbance to marine species expected. They will therefore not be considered further.

9.3.3. Underwater Tool Use including Cutting

The main underwater tool used during decommissioning operations will be for pipeline cutting. For example, cutting tools will be required to sever the pipeline ends.

Several different underwater cutting methods have the potential to be used as part of the decommissioning operations, including:

- Abrasive water jetting – using a high-pressure jet of water and a sand and grit mix directed onto the item to be cut
- Diamond wire cutting – using a continuous loop of diamond wire mounted onto a pulley system, which enables a continuous, clean cut to be carried out
- Hydraulic shear – used for cuttings smaller braces up to 1.4 m diameter

There is currently little published data on the sound generated by underwater cutting or other tools. Peak source levels of 148 to 180 dB re 1 μPa are reported for a range of diver operated tools including drills, saws, grinders, water jetters, rock breakers, wrenches and cutters with most energy in the frequency range 200 to 1000 Hz (Anthony *et al.*, 2009). Consequently, tool use is generally within the hearing range of most cetaceans. As the episodes of tool use are typically intermittent and of limited duration, it will not be considered further within this assessment.

9.3.4. Side-Scan Sonar/Multibeam Echo Sounder

Following decommissioning operations, vessels operating side-scan sonar and/or multibeam echo sounder will be used to conduct post-decommissioning surveys of the seabed and subsea infrastructure. The sound generated by side-scan sonar and/or multibeam echo sounder is at frequencies outside the main hearing range of all cetacean species likely to occur in the area. Hence, JNCC considers side-scan sonar to be of negligible risk of causing injury or disturbance to marine mammals (JNCC, 2010); therefore, it is not discussed further in this assessment.

9.4. Impact on Sensitive Receptors

In order to determine the significance of impacts resulting from underwater noise, there is a requirement to understand those receptors sensitive to this parameter. Underwater noise can affect the behaviour of, or may cause injury to, several different marine taxa, in particular fish and marine mammals such as pinnipeds and cetaceans.

9.4.1. Fish

The Curlew cluster lies within spawning grounds for cod, lemon sole, mackerel, sand eels and Norway pout; and within nursery grounds for anglerfish, blue whiting, cod, European hake, haddock, herring, Norway pout, ling, mackerel, plaice, sand eels, spurdog and whiting (Section 8; Aires *et al.*, 2014; Ellis *et al.*, 2012; Coull *et al.*, 1998).

Many species of fish use sound for location of prey, avoidance of predators and for social interactions. The inner ear of fish, including elasmobranchs (sharks, skates and rays), is very similar to that of terrestrial vertebrates, and hearing is understood to be present among virtually all fish (NRC, 2003). The majority of fish species detect sounds from below 50 Hz up to 500 to 1500 Hz. A small number of species can detect sounds to over 3 kHz, while a very few species can detect sounds to well over 100 kHz. Fish with the narrower bandwidth of hearing are often referred to as “hearing generalists” or hearing “non-specialists”, while fish with a broader range are often called “hearing specialists”. The difference between hearing generalists and specialists is that the latter usually have specialised anatomical structures that enhance hearing sensitivity and bandwidth (Popper and Hastings, 2009).

Hearing generalists include salmonids, cichlids, tunas and numerous other species. Hearing specialists include all the *Otophysi* and *Clupeiformes*, and some representatives in a wide range of other fish groups such as few *Holocentrids*, *Sciaenids,* etc. The fish known to have the widest hearing frequency bandwidth are limited to the members of the *Clupeiform* genus Alosa (Popper and Hastings, 2009). The fish species found in the project area are mainly generalists, except some species such as herring, which are considered a specialist.

Certain fish exhibit avoidance reactions to vessels and it is likely that radiated underwater noise is the cue. For example, noise 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). These reactions include diving, horizontal movement and changes in tilt angle (De Robertis and Handegard, 2013).

A comprehensive review by Popper and Hastings (2009) on the effects of anthropogenic sound on fish concluded that there are substantial knowledge gaps that need to be filled before meaningful noise exposure criteria can be developed. De Robertis and Handegard (2013) mentioned that further research is needed to identify the stimuli fish perceive from approaching vessels and to what extent fish perceiving these stimuli will react, before further recommendations to reduce vessel avoidance reactions can be made.

9.4.2. Pinnipeds

The Curlew cluster is located approximately 210 km from the nearest coastline; therefore it is unlikely that grey and harbour seals would be found in its vicinity (Jones *et al.*, 2015). Offshore noise resulting from decommissioning activities is not expected to disturb any pinnipeds.

9.4.3. Cetaceans

Minke whale, long-finned pilot whale, common dolphin, white-beaked dolphin, white-sided dolphin and harbour porpoise have been recorded as present in Quadrant 29 and the wider area (Section 5.3.6; Reid *et al.*, 2003; UKDMAP, 1998; DECC, 2016; Hammond *et al.*, 2017).

9.4.3.1. *Characterisation of Hearing Sensitivities*

Data and studies indicate that not all marine mammal species have equal hearing capabilities, in terms of absolute hearing sensitivity and the frequency band of hearing (US National Oceanic and Atmospheric Administration (NOAA), 2015). Consequently, vulnerability to impact from underwater noise differs between species. Southall *et al.* (2007) classified the "hearing types" of different marine mammal species (Table 9-2).

Table 9-2 Functional Cetaceans Hearing Groups

Cetacean Functionality Hearing Group	Estimated Auditory Bandwidth	Species Sighted in the Curlew Area
Low frequency	7 Hz to 25 kHz	▪ Minke whale ▪ Long-finned pilot whale
Mid frequency	150 Hz to 160 kHz	▪ White-beaked dolphin ▪ White-sided dolphin ▪ Common dolphin
High frequency	200 Hz to 180 kHz	▪ Harbour porpoise

Sources: *Southall et al. (2007); UKDMAP (1998); NOAA (2015)*

9.4.3.2. *Threshold for Injury and Disturbance to Marine Mammals*

The noise level perceived by an animal (the "received noise level") depends on the level and frequency of the sound when it reaches the animal and the hearing sensitivity of the animal. In the immediate vicinity of a high SL source, noise can have a severe effect causing a Permanent Threshold Shift (PTS) in hearing; leading to hearing loss and ultimately, with increasing exposure, to physical injuries which are occasionally fatal.

However, at greater distance from a source the noise decreases and the potential effects are diminished (Nedwell & Edwards (2004)); possibly causing the onset of only a temporary shift in hearing thresholds (TTS-onset). Hearing sensitivity varies with species, in terms of the range of frequencies and SLs that can be perceived, and the minimum level of sound that a species is able to detect (the "hearing threshold") varies with frequency (Nedwell *et al.* (2007); Southall *et al.* (2007)).

Southall *et al.* (2007) undertook a review of the impacts of underwater noise on marine mammals and used this to define criteria for predicting the onset of injury and behavioural response in marine mammals with different hearing characteristics, when subjected to different types of noise. The estimated bandwidths have been revised recently by the NOAA (2015). This distinction between noise types is required as single and multiple noise exposures at different levels and durations differ in potential to cause injury to marine mammals. Noise types associated with Curlew decommissioning are provided in Table 9-3.

Table 9-3 Noise Types and Activities Associated with the Curlew Cluster

Noise Type	Definition	Activities
Single pulse (not expected at Curlew)	*Brief, broadband, atonal, transient, single discrete noise events; characterised by rapid rise to peak pressure.*	*No single pulse sources planned e.g. explosives.*
Multiple pulse	Multiple pulse events within 24 hours.	Side-scan sonar/multibeam echo sounder
Non-pulse	Intermittent or continuous, single or multiple discrete acoustic events within 24 hours; tonal or atonal and without rapid rise to peak pressure	Vessels, water jetting, general underwater tool use, underwater cutting

Sources: *Southall et al. (2007)*

Note: *Highlighted sections are not expected within the scope of the proposed activities.*

9.4.3.3. *Zone of Injury or Disturbance*

The proposed precautionary thresholds for zero-to-peak sound pressure levels and sound exposure levels that are likely to lead to injury and disturbance to marine mammals for different noise types are described in Table 9-4 (Southall *et al.*, 2007). Southall *et al.* (2007) proposed precautionary criteria for the level of single pulse sound that would lead to a behavioural response in marine mammals. However, none of the activities associated with the proposed DPs will generate noise classified as single pulse.

Table 9-4 Precautionary Threshold for Injury or Disturbance to Cetaceans

Cetacean Functional Hearing Group	Sound Measure[1]	Injury Threshold for Different Sound Types			Disturbance Threshold for Single Pulse Sounds[2]
		Single Pulse	Multiple Pulse	Non-pulse	
Low-frequency	SPL	230	230	230	224
	SPL	198	198	215	183
Mid-frequency	SPL	230	230	230	224
	SPL	198	198	215	183
High-frequency	SPL	230	230	230	224
	SPL	198	198	215	183

[1] SPL – zero-to-peak Sound Pressure Level in dB re 1 μPa

[2] Southall et al. (2007) did not define thresholds for disturbance from multiple pulse and non-pulse sounds.

Note: Grey highlighted sections are not expected within the scope of the proposed activities.

Southall *et al.* (2007) recommend assessing whether a noise from a specific source could cause disturbance to a particular species by comparing the circumstances of the situation with empirical studies reporting similar circumstances. JNCC (2010), in their guidance on how to assess and manage the risk of causing "injury" or "disturbance" to a marine EPS as a result of activities at sea, suggests that disturbance to a marine mammal is likely to occur from sustained or chronic behavioural response with a severity scoring of five or above according to the scale of Southall *et al.* (2007).

These sound thresholds are compared with the predicted SLs generated by the decommissioning operations to estimate a distance from the activities within which disturbance may occur.

9.4.3.4. *The Nedwell et al. (2007) dBht (Species) Alternative Approach*

Nedwell *et al.* (2007) suggests that all species with well-developed hearing are likely to proactively avoid sound when the level exceeds 50 to 90 dB above their hearing threshold, and receive damage to hearing organs at 130 dB above their hearing threshold. Species-specific audiograms are used to filter received noise levels according to the hearing ability of a species, giving SLs in dBht (species). The distance from the centre of operations to the points at which 130 dBht (species) and 90 dBht (species) are exceeded represent an estimate of the limits within which injury (PTS) and likely avoidance, respectively, might be expected.

9.5. Noise Modelling Impact Assessment

In accordance to JNCC guidelines, the Marsh-Schulkin model (Schulkin and Mercer, 1985) was used to predict the distance from the activities beyond which the SL would be too low for injury under the Southall criteria (Southall *et al.*, 2007). The Nedwell dBht (species) was then applied to determine both injury and avoidance zones for specific species.

9.5.1. Prediction of Injury and Behavioural Avoidance Zones

To compare the Southall criteria to predicted vessel operation noise levels, the non-pulse injury threshold was applied. The threshold for injury to cetaceans of 230 dB re 1 μPa m is higher than the model output Sound Pressure Level (SPL) of 191 dB re 1 μPa m. Therefore, the threshold for cetacean injury is not predicted to be exceeded for any of the decommissioning operations. Southall *et al.*, (2007) does not provide non-pulse threshold recommendations for disturbance and therefore this method cannot be applied to determine disturbance zones.

The results of the alternative dBht method indicate that the threshold for a likely avoidance reaction (90 dBht (species)), may be exceeded for harbour porpoises and minke whales within a maximum radius of approximately 30 and 7 m respectively, for activities involving a maximum of four vessels at once (refer to Table 9-5).

Table 9-5 Precautionary Threshold for Injury or Disturbance to Cetaceans

Species[1]	Hearing Threshold in Range (dB)	Source Level Max[2] (dB)	Source Level (dBht (species))[2]	Frequencies Causing Greatest Effect[2] (kHz)	Maximum Radii of Injury Zone[2] (m)	Maximum Radii of Likely Avoidance Zone[2] (m)
Harbour porpoise	52	175	116	8	N/A	30
White-beaked dolphin[3]	69			16 to 20		
Minke whale	90	191	101	0.1	N/A	7

[1] No audiograms are available for common dolphin. Cetacean presence data is given in Section 0.

[2] Propagation model output

[3] Of note is that the SL and radius for the white-beaked dolphin was not calculated due to the fact that the hearing range of this species is on the limit of the SL calculated.

9.5.1.1. *Potential Disturbance to Marine Mammals*

Areas of the SCANS III survey (SCANS III, 2017) and densities derived from UKDMAP (1998) have been used to estimate the number of animals of each species potentially experiencing behavioural disturbance from the decommissioning operations (refer to Table 9-6). UKDMAP (1998) densities have been used for the calculations and represent a worst-case scenario in terms of densities. The modelling indicates that it is unlikely that any marine mammals will be affected by the decommissioning activities.

Table 9-6 Estimated Number of Animals Potentially Experiencing Behavioural Disturbance from the Decommissioning Activities

Species[1]	Highest Density in the Area (animals/km^2)	Estimated Number of Animals that may Experience Behavioural Disturbance[1]
Harbour porpoise	0.60	<1
White-beaked dolphin	0.49	<1
Minke whale	0.19	<1
Common dolphin	0.09	<1

[1] Calculation method based on Southall et al. (2007) as recommended by JNCC (2010), abundance given to the nearest whole animal.

Source: *SCANS III (2017) for area; UKDMAP (1998) for densities*

Of note is that the methods applied within this study provide an overestimation of the number of animals disturbed by the proposed decommissioning activities. This assessment indicates that it is unlikely any marine mammals will be impacted. There is no clear relationship between received SPL and likely behavioural response and so this analysis conservatively uses the lowest reported SPL likely to cause behavioural response. Additionally, in reality marine mammals are likely to be sparsely located, whether as individuals or groups of individuals, and move over large areas. There may be no individuals within the estimated zone of disturbance at the time of the decommissioning operations.

9.6. Transboundary, Cumulative and In-Combination Impacts

The Curlew facilities are located, approximately 55 km west from the UK/Norway median line. At this distance, noise levels associated with the decommissioning activities would attenuate to a level lower than that likely to cause injury or disturbance to any cetacean species and hence there are unlikely to be any transboundary impacts.

O&G development in this region of the North Sea is relatively intensive. There are several oil developments within a 30 km radius of the Curlew cluster.

Therefore, whilst there is a potential for cumulative noise impact due to the Curlew decommissioning vessel operations, the number of vessels anticipated to be present in the area due to these developments is small.

Given the localised nature of the proposed decommissioning works, no cumulative impacts are anticipated with other O&G Installations or fields. Although the Fram development project is anticipated to be underway in 2019, as it is approximately 20 km away from the Curlew field, this leads to the conclusion that no in combination effects will be anticipated.

9.7. Mitigation Measures, Safeguards and Controls

Standard industry practice and legislative requirements:

- Machinery and equipment will be in good working order and well maintained
- The number of vessels utilising dynamic positioning would be minimised where possible

No project-specific mitigation measures have been identified as necessary.

9.8. Impact Assessment Summary Statement

The modelling undertaken for this EIA indicates it is unlikely that any marine mammals will be adversely affected by Curlew decommissioning activities. Noise levels generated by surface vessels, even when combined, are unlikely to result in physiological damage to marine mammals in the project area. In addition, marine mammals move over large areas and are likely to be sparsely located. There may be no individuals within the estimated zone of disturbance at the time of decommissioning operations.

The types and size of decommissioning vessels to be used for Curlew are not different from the supply vessels that have been visiting the FPSO for years. It is likely that potentially affected marine mammals will have moved location or become habituated.

Noise generated by Curlew decommissioning activities has been determined to have a significance of minor to negligible.

10. ENERGY USE AND ATMOSPHERIC EMISSIONS

This section provides quantitative estimates of the E&E from the decommissioning operations and endpoints for the Curlew cluster. The potential for environmental impact and mitigation measures to minimise emissions and optimise energy use is also assessed.

10.1. Approach

This assessment is based on the Institute of Petroleum (IOP) Guidelines for the Calculation of Estimates of Energy Use and Gaseous Emissions in the Decommissioning of Offshore Structures (IOP, 2000). The assessment includes:

- Establishment of materials inventory for each structure to be decommissioned
- Identification of all operations associated with the decommissioning options
- Identification of all endpoints associated with decommissioning each structure, where endpoints are defined as the final states of the materials at the cessation of the decommissioning operations, including the presence of material in landfill sites or on the seabed. If the endpoint results in an otherwise recyclable material being removed from the chain of utility, e.g. steel left in situ on the seabed or disposed of in landfill, this is accounted for by a theoretical cost for remanufacture of the material, with consequent E&E attributed to the decommissioning process
- For each operation and endpoint, the identification of associated activities that will be a source of E&E
- Selection of conversion factors and subsequent calculation of E&E
- Calculation of the E&E based on these factors

In accordance with the IOP (2000) guidelines, alternative factors may be used where specific equipment is considered to have a significantly different fuel use from that presented in the IOP database. Appendix B details the factors used for the E&E calculations associated with the manufacture of new materials, recycling of materials, general fuel consumption and vessel fuel use.

10.2. Sources of Potential Impact

This section reports the findings of the E&E assessment, which considered, where appropriate, the following sources for each stage of the decommissioning process for the Curlew cluster:

- Vessels for transportation and offshore operations
- Vessels for towing the FPSO to cleaning and dismantling yards
- Manufacture or sourcing of new items (e.g. rock placement and temporary steel work) required for the decommissioning operations
- Recycling of recovered material
- New manufacture to replace recyclable materials decommissioned in situ at sea or disposed of in landfill

10.3. Assumptions and Calculation Factors

The following subsections outline the assumptions applied to the E&E for the project.

10.3.1. General Assumptions

For the calculation of the E&E, the following assumptions were made. These are applicable to all the components of the Curlew cluster decommissioning operations:

- The estimates of E&E will contain an inherent uncertainty; IOP (2000) reports a typical inherent uncertainty of approximately 30 to 40%. However, the primary function of the IOP approach is to compare decommissioning options rather than to obtain absolute estimates of E&E
- E&E calculations for vessel use are based on a worst-case scenario of type of vessel used for the operations (i.e., where a number of vessels are being considered, the vessel with the highest fuel consumption has been assessed). Therefore E&E for vessel use may be conservative and represent a worst-case scenario
- Recovered material is assumed to be landed at shore and subsequently taken to recycling and/or landfill sites. As the contract for waste management has not been confirmed, the transport from landing port to a disposal site is excluded from current assessment
- A theoretical replacement value is calculated for recyclable material decommissioned in situ or disposed of in a landfill site. However, it should be noted that the replacement of otherwise recyclable material is a theoretical activity designed to account for materials left in situ. In reality, it is unlikely that this activity will take place. This will therefore represent a conservative estimate of E&E
- The E&E associated with recycling and the manufactures of new materials are calculated for all materials for which standard factors are available (refer to Appendix B for details). Where materials are grouped, the highest energy factors for materials from the group are used to represent the worst-case scenario
- In this assessment, 100% of concrete recovered is to be sent to landfill, while 100% of materials classed as hazardous or NORM contaminated will be sent to authorised disposal sites for treatment and landfill disposal. The E&E values are greater for disposal and remanufacture to replace landfilled materials, and therefore this is likely to generate an overestimation, which will provide a worst-case scenario assessment
- Only one post-decommissioning survey has been accounted for in the E&E calculations as the final monitoring programme has not yet been agreed with BEIS

10.3.2. FPSO Topside Assumptions

The following assumptions apply specifically to the decommissioning of the FPSO topsides:

- No material is decommissioned in situ
- Post-CoP operations of Curlew topside (i.e. normal power generation, flaring, venting, etc.) have not been included in the E&E assessment
- It has been assumed here, as a worst-case scenario, that FPSO will be decommissioned as a whole. It will be transported first from the Curlew location for cleaning at an audited and authorised site in the UK, then to one of the proposed dismantling sites. For the purposes of this assessment, the site with the greatest distance was chosen to provide a worst-case scenario
- All recovered material, where practical, will be re-used or recycled and any remaining material will be sent to landfill
- Recyclable material sent to landfill has been accounted for under "New manufacture to replace recyclable materials decommissioned in situ or taken to landfill"
- The IOP energy factors for Zn have been used to represent any unidentified non-ferrous metals
- Wait on Weather (WOW) contingency is not applied to vessels involved with the FPSO removal
- Standby and guard vessels are not included in the calculations

- Helicopter use is excluded from the assessment as decommissioning is not expected to result in a significant increase in flights in the area
- Onshore transportation and onshore dismantling are not included in the calculations

10.3.3. Subsea Infrastructure Assumptions

The following assumptions apply to subsea infrastructure decommissioning:

- Subsea infrastructure decommissioning includes risers, umbilicals, pipeline ends, jumpers, spools, manifolds, trees, protection structures, mattresses, debris, mooring lines and suction anchor piles. These are assessed as one entity, and therefore the energy use and gaseous emissions values for the subsea infrastructure represent all of these elements. Where more than one option is available for the decommissioning of an element, the option with the greatest E&E has been used to represent a worst-case scenario and may therefore generate an overestimation
- Flushing, disconnection operations and associated vessel use are included in the subsea infrastructure calculations
- A WOW contingency is not applied to all vessels involved with the subsea infrastructure decommissioning
- 100% of concrete associated with subsea infrastructure is to be sent for landfill disposal; this is to take into account the worst-case scenario option for recovered mattresses. The E&E values are greater for disposal and remanufacture to replace landfilled materials, and therefore this is likely to generate an overestimation
- Standby and guard vessels are not included in the calculations
- Onshore transportation and onshore dismantling are not included in the calculations

10.4. Materials and Operations Inventories

Table 10-1 provides details on the assumptions used in the calculations of E&E.

Table 10-1 Assumptions Used to Calculate E&E

Source	Value
Vessel Use During Topside Decommissioning	
Station keeping vessel tug	30 days
Towing vessel	96 days
Vessel Use During Subsea Infrastructure Decommissioning	
Dive support vessel	236 days
Rock placement vessel	67 days
ROVSV vessel	17 days
Post-Decommissioning Activities	
Overtrawl survey (fishing vessel)	50 days
Debris removal – ROVSV	20 days
Debris removal – DSV	20 days
Post-decommissioning survey vessel	14 days

Table 10-1 Assumptions Used to Calculate E&E (Continued)

Source	Value
Material Brought to Shore from FPSO	
Steel, Cu and Al to be recycled	▪ Steel – 25,194 tonnes ▪ Al – 29 tonnes ▪ Cu – 130 tonnes ▪ Other non-ferrous – 695 tonnes
Material Brought to Shore from Subsea Infrastructure	
Steel and Cu to be recycled	▪ Steel – 732 tonnes ▪ Cu – 47 tonnes

10.5. Energy Use and Atmospheric Emissions from Curlew Decommissioning

This section details the estimated E&E values for the components of the Curlew cluster.

10.5.1. Topsides Decommissioning

Estimated E&E during the decommissioning of the Curlew topsides are detailed within Table 10-2 and Table 10-3, respectively.

Table 10-2 Total Energy Use for the Decommissioning of the Curlew Topsides

Decommissioning Activity	Energy Use (GJ)	Percentage (%) contribution of activity to CO_2 emissions
Vessel use (including towing FPSO to a dismantling yard)	206,900	44
Recycling topsides	237,800	51
New manufacture to replace recyclable materials left in situ or sent to landfilled	21,700	5
Total*	**466,400**	

**Total values are rounded to nearest whole number.*

Table 10-3 Total Atmospheric Emissions for the Decommissioning of the Curlew Topsides

Decommissioning Activity	Emissions (tonnes)				Percentage (%) Contribution of Activity to CO_2 Emissions
	CO_2	NOx	SO_2	CH_4	
Vessel use (including towing FPSO to cleaning and dismantling yards)	15,400	285	19	1	37
Recycling	24,600	41	113	ND*	59
New manufacture to replace recyclable materials left in situ or sent to landfilled	1,500	3	5	0	4
Total**	**41,500**	**329**	**137**	**1**	

** "ND" indicates that no data is available to enable a conversion to be made between a particular operation and the resulting gaseous emissions*

***Total values are rounded to nearest whole number.*

10.5.2. Subsea Infrastructure Decommissioning

The E&E for the decommissioning of subsea infrastructure are calculated here for the worst-case option from the considered decommissioning scenarios. For subsea infrastructure, those include:

- Pipelines (leave in situ)
- Pipeline ends (leave in situ with rock placement/cut and remove with rock placement to fill the excavation pit)
- Spools, jumpers and mattresses (remove)
- Mooring trenches (fill with rock)
- Suction anchor piles (worse case – piles cut at seabed level with remedial rock placement if full removal is not feasible)

The results of this analysis are detailed within Table 10-4 (energy use) and Table 10-5 (atmospheric emissions).

Table 10-4 Total Energy Use for the Decommissioning of the Curlew Subsea Infrastructure

Decommissioning Activity	Energy Use (GJ)	Percentage (%) Contribution of Activity to CO_2 Emissions
Manufacture of new components or materials required for decommissioning	4,600	1
Vessel use	293,100	96
Recycling	7,900	3
New manufacture to replace recyclable materials left in situ or landfilled	700	<1
Total*	**306,400**	

**Total values are rounded to nearest whole number.*

Table 10-5 Total Atmospheric Emissions for the Decommissioning of the Curlew Topsides

Decommissioning Activity	Emissions (tonnes)				Percentage (%) Contribution of Activity to CO_2 emissions
	CO_2	NOx	SO_2	CH_4	
Manufacture of new components or materials required for decommissioning	231	ND*	ND*	ND*	1
Vessel use	21,800	400	28	1	96
Recycling	700	1	8	ND*	3
New manufacture to replace recyclable materials left in situ or landfilled	40	<1	<1	ND*	<1
Total**	**22,800**	**400**	**36**	**1**	

** "ND" indicates that no data is available to enable a conversion to be made between a particular operation and the resulting gaseous emissions.*

*** Total values are rounded to nearest whole number*

10.5.3. Summary

Table 10-6 provides a summary of the E&E for decommissioning all components and associated activities of the Curlew cluster.

Table 10-6 Total Energy Use and Atmospheric Emissions for the Curlew Decommissioning

Decommissioning Activity	Energy (GJ)	Emissions (tonnes)			
		CO_2	NOx	SO_2	CH_4
Manufacture of new components or materials required for decommissioning*	4,600	200	0	0	0
Vessel use	500,000	37,100	689	46	2
Recycling	245,700	25,300	43	121	0
New manufacture to replace recyclable materials decommissioned in situ or landfilled	22,400	1,600	3	5	0
Total*	**772,800**	**64,200**	**735**	**172**	**2**

**Total values are rounded to nearest whole number.*

The operations for Curlew decommissioning are predicted to use a total of 772,800 GJ of energy (refer to Figure 10-1). Approximately 65% of this total can be attributed to vessel use offshore and for transport of the FPSO to the cleaning and dismantling yards.

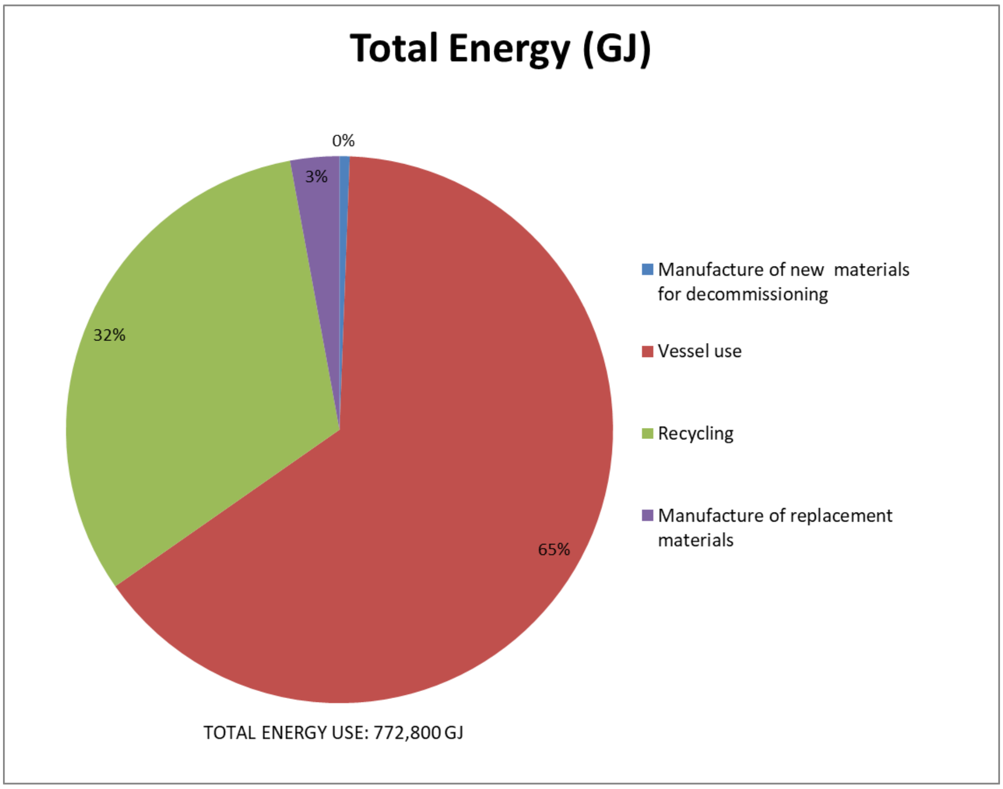


Figure 10-1 Total Energy Use (GJ) from Curlew Decommissioning Activities

The highest contributor to Carbon Dioxide (CO_2) emissions is represented by vessel use offshore and for transportation of the FPSO to the cleaning and dismantling yards, which represents approximately 58% of total emissions (refer to Figure 10-2). New manufacture, to replace otherwise recyclable materials left in situ or sent to landfill and recycling, contributes approximately 3% and 32%, respectively of total energy use, and 2 and 40% respectively of CO_2 emissions.

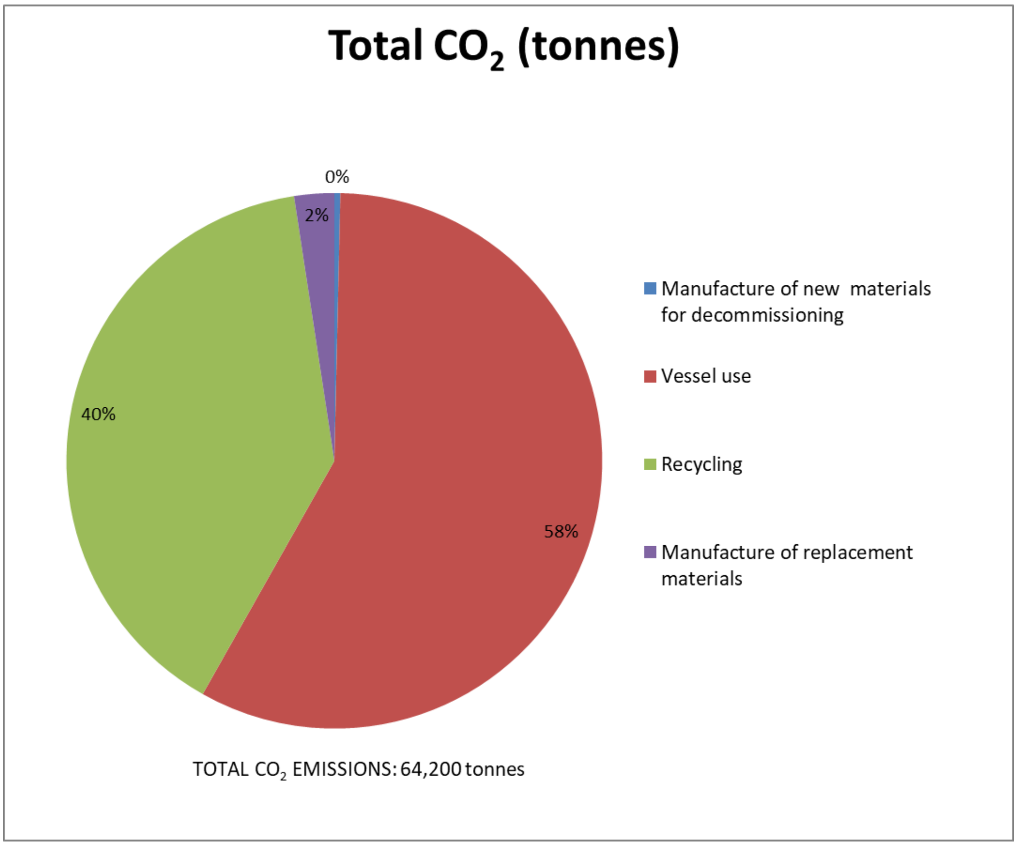


Figure 10-2 Total CO_2 Emissions (tonnes) from Curlew Decommissioning Activities

10.6. Impacts on Sensitive Receptors

Atmospheric emissions of the Curlew DP will include CO_2, CH_4, Nitrogen Oxides (NOx), Sulphur Oxides (SOx) and Volatile Organic Compounds (VOCs).

Potential impacts include a reduction in air quality affecting local sensitive receptors, contribution to global climate change and regional acidification (acid rain).

Emissions of gases such as CO_2 and CH_4 (CH_4 has 21 times the global climate change potential of the main greenhouse gas CO_2 (IPCC, 2007)) contribute to global climate change.

Additional effects of NOx, SOx and VOCs emissions include the formation of tropospheric Ozone in the presence of sunlight. Tropospheric ozone is a toxic secondary pollutant, which in abnormally high concentrations can cause serious health issues and impact the environment. By-products of ozone formation include nitric and sulphuric acid, contributing to acid rain, and the dry deposition of nitrate particulates.

As the Curlew cluster is located approximately 210 km east of the nearest UK coastline, it is unlikely that offshore decommissioning operations will impacted on any designated coastal or onshore conservation sites. In addition, the total annual CO_2 emissions from offshore O&G UKCS operations during 2015 were 13.2 million tonnes. The estimated CO_2 emissions released during Curlew decommissioning represent less than 0.5% of this total (OGUK, 2016b).

With respect to offshore receptors, only one Annex II marine mammal species (harbour porpoise) has been sighted in the vicinity of the Curlew cluster. In the open conditions that prevail offshore, any atmospheric emissions generated would be quickly dispersed. Outside the immediate vicinity of decommissioning activities, all released gases would only be present in low concentrations and are unlikely to have any effect on receptors such as marine mammals.

10.6.1. Onshore Emissions

Dependent on existing onshore air quality, onshore emissions to air associated with decommissioning are likely to have negligible impact significance. Emissions to air from towing vessels will be largely away from the coast, and when near the coast will be transient.

10.7. Transboundary, In-Combination and Cumulative Impacts

The Curlew cluster is located approximately 55 km west of the UK/Norway median line. Emissions from the offshore decommissioning activities are unlikely to be present in any measurable concentrations across the median line.

The Curlew cluster is located in a region of relatively intensive O&G activity; however the closest platforms are located between 25 and 30 km from the cluster. The shipping traffic around the cluster is classed as low (refer to Section 5.5.2). Emissions from Curlew decommissioning activities are not expected to result in notable cumulative or in-combination effects to the local environment.

10.7.1. Transit of FPSO and Recycling Yard

As a worst-case scenario, it is assumed that the FPSO will be towed from the Curlew location to the UK yard for cleaning and then on to a dismantling yard.

For each of these legs (to UK and then to dismantling yard) it is planned to use multiple vessels. The in-combination and cumulative impacts from the emissions produced by these three vessels are not expected to substantially increase the impact to the receiving environment.

10.8. Mitigation Measures, Safeguards and Controls

Standard industry practice and legislative requirements:

- Vessels will be audited as part of selection and pre-mobilisation
- All generators and engines will be maintained and operated to the manufacturers' standards to ensure maximum efficiency
- Vessels will use ultra-low sulphur fuel in line with MARPOL requirements
- Work programmes will be planned to optimise vessel time in the field
- Fuel consumption will be minimised by operational practices and power management systems for engines, generators and other combustion plant and maintenance systems

No project-specific mitigation measures have been identified as necessary.

10.9. Impact Assessment Summary Statement

This assessment has identified that the E&E associated with the decommissioning activities will have an impact significance of negligible to minor.

Although the emissions will be detectable, these are only a small fraction of the total North Sea emissions anticipated to be present during the period of decommissioning. As the decommissioning activities are only temporary and primarily associated with moving vessels, this further reduces the significance.

[This page is intentionally blank]

11. WASTE

The activities undertaken in the decommissioning of the Curlew cluster will generate quantities of controlled waste, defined in Section 75 (4) of the Environmental Protection Act 1990 as 'household, industrial and commercial waste or any such waste'. The sequence and quantities of controlled waste generated at any one time depend on the processes of dismantling, such as offshore deconstruction, and the subsequent treatment and disposal methods of the waste itself.

There are three key challenges associated with waste management for the Curlew cluster:

- Generation of large quantities of controlled waste within short timeframes. This will require detailed planning to manage the logistics associated with transporting waste to shore, its temporary storage and the onward treatment/disposal of materials
- Potential for "problematic" materials, generated due to cross–contamination of non-hazardous waste with substances that have hazardous properties, which results in the material being classified as hazardous waste. Hazardous waste is defined as material that has one, or more, properties that are described in the Hazardous Waste Directive (91/689/EEC) as amended by Council Directive 94/31/EC
- Problems associated with materials with unknown properties at the point of generation. These quantities of 'unidentified waste' require careful storage and laboratory analysis to determine whether they are hazardous or non-hazardous waste

In accordance with the Petroleum Act 1998 Guidance Notes (DECC, 2011), the disposal of O&G infrastructure should be governed by the precautionary principle. Shell will assume the worst-case scenario, especially in the consideration of hazardous and unidentified wastes, and select waste treatment options which aim to result in the lowest environmental impact.

11.1. Regulatory Context

The designation of whether a material or substance is 'waste' is determined by EU law. The EU Waste Framework Directive (2006/12/EC) defined 'directive waste' as "any substance or object in the categories set out in Annex I of the Directive which the holder discards or intends or is required to discard".

Responsibility for waste management lies with the producer or Dutyholder, including the decision on which materials are to be treated as waste. The action of removal and transfer of redundant Installations and infrastructures to shore falls within the legal definition of waste. Having determined the substance or object is waste, subsequent labelling, storage, handling, transfer and treatment of the waste generated is then governed by specific regulations.

Shell will ensure compliance and adherence to requirements of all applicable regulations. If the selected disposal yard is in a country outside of the UK, the waste will be dealt with in line with the receiving country's waste legislation and will be subject to the approval of a Transfrontier Shipment of Waste application, as per UK regulations.

Shell will engage with the relevant waste regulator as appropriate.

As a 'waste producer' under UK legislation, Shell has a Duty of Care to ensure that waste is properly transported and disposed of. In order to meet this obligation, Shell will:

- Ensure waste is appropriately segregated, labelled, stored and transported
- Ensure applicable permits are in place, including Transfrontier Shipment, and their conditions are met
- Use only licensed carriers and disposal sites

11.2. Approach – Waste Management

The BEIS Guidance Notes (DECC, 2011) require decommissioning decisions to be consistent with the waste hierarchy. For the decommissioning activities relating to the Curlew cluster, Shell will follow the principles of the waste hierarchy (refer to Figure 11-1) to minimise waste production. The Shell HSSE&SP CF includes a Waste Manual and associated guidance, which details how Shell meets the basic requirements of the relevant internal standards, the application of the waste hierarchy and Shell's duty of care with respect to waste (Shell, 2016a & b).

As per the requirement of the Waste Manual of the Shell HSSE&SP CF, a Waste Management Plan (WMP) for the project has been developed to ensure compliance with relevant legislations and Shell internal requirements, including the waste hierarchy (refer to Figure 11-1). Via implementation of the WMP, waste materials will be tracked to the recycling endpoint. Those materials that cannot be reused or recycled will be tracked to landfill disposal.

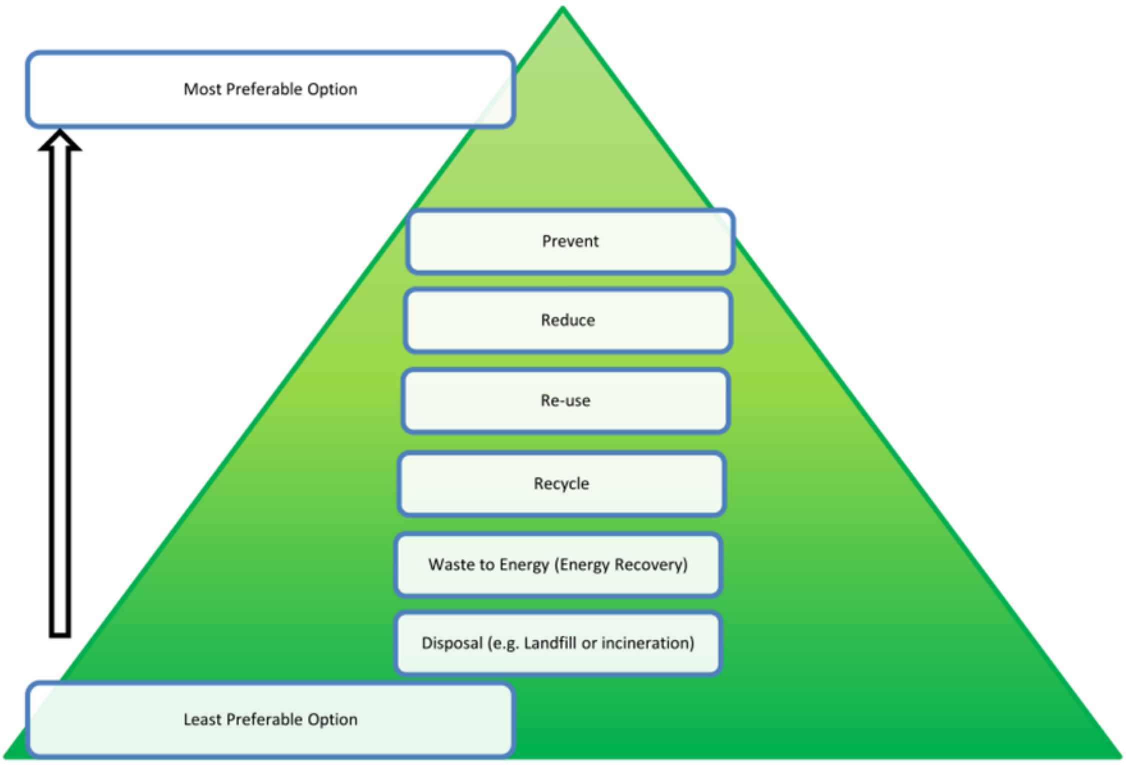


Figure 11-1 The Waste Hierarchy (Shell, 2017b)

11.3. Sources of Potential Impact – Waste Generation

Typical non-hazardous waste will include scrap metals, plastics and wood that is not cross-contaminated with hazardous waste and can therefore be removed or recovered for re-use, recycling or landfill. Hazardous wastes generated will include oil-contaminated materials and chemicals. Many types of hazardous or 'special' waste identified during the decommissioning process are routinely generated during production and maintenance of offshore Installations. However, the decommissioning process may generate significantly greater quantities of both non-hazardous and hazardous waste when compared to routine operations and, as such, requires appropriate management.

Table 11-1 details the total inventory tonnage planned to be decommissioned in situ (10%) and those planned to be recovered to shore (90%). For the inventory to be left in situ, it accounts for pipelines and umbilicals only, which are currently trenched and buried, as well as several structural piles, which will be cut to certain depth and partially left in the seabed.

Table 11-1 Inventory Disposition

Inventory	Total Inventory Tonnage	Planned Tonnage to Shore	Planned Left In Situ
Installations			
Curlew FPSO and B and D Installations	30,708	30,398	310
Curlew C Installations	110	70	40
Total	30,818	30,468	350
Pipelines			
Curlew B and D (including Gas Export)	5,961	2,873	3,088
Curlew C	1,357	932	425
Pipelines Total	7,318	3,805	3,513

An estimate of the different types and quantities of materials which constitute the Curlew B, C and D, inventories to be decommissioned are detailed in Table 11-2.

Table 11-2 Curlew Material Inventory (Including FPSO)

Material	Weight (Te)	% of Total
B and D Installations (inc. FPSO)		
Carbon Steel*	25,479	83.4
Stainless Steel	1,276	4.2
Non-ferrous Metal	880	2.9
Concrete	0	0
Plastics	121	0.4
Hazardous Materials/NORM	182	0.6
Other Non-hazardous	2,608	8.5
Installations Total	**30,504**	**100**
B and D Pipelines		
Carbon Steel	4,049	65.9
Non-ferrous Metal	9	0.2
Concrete	1,945	31.7
Plastics	137	2.3
Hazardous Materials/NORM	0	0
Other Non-hazardous	4	0.07
Pipelines Total	**6,144**	**100**

Table 11-2 Curlew Material Inventory (Including FPSO) (Continued)

Material	Weight (Te)	% of Total
C Installations		
Carbon Steel	108	96.2
Non-ferrous Metal	<1	0.9
Concrete	0	0
Plastics	<1	0.9
Hazardous Materials/NORM	0	0
Other Non-hazardous	2	2.0
Installations Total	**113**	**100**
C Pipelines		
Carbon Steel	659	48.6
Non-ferrous Metal	<2	0.1
Concrete	639	47.1
Plastics	31	2.3
Hazardous Materials/NORM	0	0
Other Non-hazardous	26	1.9
Pipelines Total	**1,357**	**100**

** Includes steel associated with the FPSO*

An estimated 1,905 Te (wet weight) of marine growth is listed as a constituent of the 'Other Non-hazardous' material associated with the FPSO. The marine growth associated with the other subsea infrastructure equates to 23.5 Te. Most of this weight represents water. Some marine growth will dislodge, die off or mummify during transit and onshore. This loss of weight due to drying of the marine growth is estimated to be in the region of 80%. As a result, a much smaller dry weight of biological waste will require disposal, and will be disposed of in accordance with the regulations in force at the disposal site, following the site operator's licences and procedures. It is likely that the marine growth will be disposed of by land farming or to landfill.

11.3.1. Radioactive Waste

Radioactive wastes, including nucleonic sources used as level control sources on vessels, and NORM, for example from pipework and sand from vessels, will be managed in line with the Radioactive Substances Act 1993 Amendment (Scotland) Regulations 2011, which regulates the handling, storage, transfer and disposal of such waste.

Shell has outlined the actions they will undertake in the management of radioactive wastes in the Waste Management Strategy (WMS) (Shell, 2017d). The local rules for working with radioactive materials will be adhered to in order for the appropriate removal and transportation of radioactive materials during decommissioning, including through consultation with the Scottish Environment Protection Agency (SEPA). In preparation for the decommissioning of the Curlew cluster, Shell has compiled inventories of hazardous materials prior to recycling conforming to the requirements of the WMS (Shell, 2017b; Sea2Cradle, 2016).

11.3.2. Waste Generation and Management – FPSO

Post CoP, before transit to a yard, the topside of the FPSO will be subject to DFPV. Unopened chemicals containers will be shipped onshore for either re-use on a different Installation, returned to producer (if feasible) or appropriately disposed of. Produced water remaining in the system will be discharged overboard, if within permitted levels, to minimise volume of fluids returned to shore for disposal. Nucleonic sources will be disconnected, removed and shipped onshore to a specialised contractor for their appropriate disposal. These activities will be undertaken in accordance with applicable permits.

Once the DFPV has been completed, a NORM quantification survey will be completed by independent third-party contractor to confirm location of radioactive material and provide an estimate of its mass and activity level. IHM will be repeated post-DFPV to confirm type, location and quantities of waste present onboard the vessel, prior to arrival at a yard.

Both the NORM quantification survey and IHM will be made available to the cleaning/dismantling yard and any contractors involved in cleaning and dismantling activities.

If the Curlew FPSO is to be cleaned first, before being moved to a recycling yard, the vessel will be taken to a berth, where third-party companies contracted by Shell will undertake cleaning of the topside. This will include removal of the fluids remaining on the ship's tanks, and cleaning and removal of NORM to a level required by the dismantling yard. All waste will be managed by existing processes and will be handled by licensed sites.

The selection of an onshore dismantling site will be made on the basis of a commercial tender, taking into account technical suitability (i.e. water depth), HSE management system and the yard's track record in management and handling of waste. Site audits have been performed and Shell will only consider sites that are licensed to receive the types and quantities of materials identified in the Materials Inventory. The dismantling site operator will have established arrangements with facilities that recycle steel, Cu, Al and other materials. Information provided in the Inventory will be used by a selected dismantling yard to generate a ship- specific Ship Recycling Plan, as per the requirement of the IMO Hong Kong Convention on Safe and Environmentally Sound Ship Recycling. The Ship Recycling Plan will outline process of dismantling a ship, controls applied during recycling, and management of waste including sites and method of disposing them. A Duty of Care Audit will be carried by Shell on the selected yard to ensure management of waste during the recycling process, including sub-contractors, is sufficient and robust.

At the arrival to a dismantling yard, a Port Authority will enter the vessel to survey its content and status against the Inventory of Hazardous Waste. Dismantling activities will not be able to commence without permission of the Port Authority. Prior to commencement of any recycling activities, trained personnel of the dismantling yard will mark locations of hazardous materials. If required, samples of fluids might be taken to confirm their composition to inform appropriate disposal. Following this survey, removal activities will commence. A Shell Rep will be present at the yard to ensure that recycling activities, waste management and disposal are undertaken as per the agreed Ship Recycling Plan.

Shell will only use a licensed yard which complies with requirements of the IMO Hong Kong Convention. This ensures that safety controls, fluids containments and proper waste management (segregation, storage and transport) are in place. Prior to transit outside of the UK, all necessary transfrontier shipments for waste, if required, will be obtained.

11.3.3. Waste Generation and Management – Subsea Infrastructure

Table 11-3 presents the options and disposal route (if applicable) for subsea Installations and stabilisation features. When removed from the seabed, the equipment will be transported to a decommissioning contractor's onshore yard, where different types of material will be segregated with a view to optimising re-use and recycling. The recycling yard for the subsea Installations has not been selected yet, but recycling and disposal of these materials will be carried out in accordance with current established processes and applicable legal requirements.

11.3.4. Subsea Installations and Stabilisation Features

Table 11-3 Subsea Installations and Stabilisation Features

Subsea Installations and Stabilisation Features	Number	Option	Disposal Route
Gas export riser SSIV	1	Full recovery	Return to shore for recycling
Manifold and SDU structures at Curlew D drill centre	2	Full recovery	Return to shore for recycling
Curlew C pipeline and umbilical protection structures	2	Full recovery	Return to shore for recycling
Curlew B and D, C trees including protection frames	6	Full recovery	Return to shore for recycling
Concrete mattresses	2,400 tonnes	Full recovery	Return to shore for recycling [1]
Grout bags	75 tonnes	Full recovery	Return to shore for disposal[2]
Rock	60,300 tonnes[3]	Leave in situ	N/A

[1] It is intended that all mattresses will be removed to shore; however, in the event of practical difficulties (e.g. poor integrity or fully covered with rock), BEIS will be consulted.

[2] The exact distribution of grout bags (rock covered or exposed) is not known, however it is that all exposed bags will be recovered to shore.

[3] This is the existing rock that is estimated as being present at time of CoP.

11.3.5. Drill Cuttings

Drill cuttings are to be decommissioned by being left in situ. Further details relating to drill cuttings are contained in the 'Discharges to Sea' (refer to Section 8) section of this document.

11.4. Contractor Management

Waste management activities include:

- Handling
- Storage and treatment of waste offshore
- Transfer of waste to a waste treatment or dismantling yard for further storage/handling
- Treatment as appropriate and then further transfer to the final disposal or treatment point

Contractors and sub-contractors will conduct many of these activities on Shell's behalf. In these instances, although Shell may not be undertaking the operations directly, the legal liability, i.e. Duty of Care, for all waste generated from decommissioning remains with Shell

The Shell HSSE&SP CF stipulates the overarching requirements for contractor Health, Safety, Security and Environment (HSSE) management. The selection and management of contractors by Shell will be carried out in line with the requisite contractor control processes and procedures within the Framework.

Specific actions to support the management and minimisation of waste generated by contactors during decommissioning will include:

- Ensuring that waste management issues are included during the contract procurement process, for example, consideration of a contractor's past HSSE performance
- Ensuring that waste management issues are covered within the contractor interface documents
- Engaging with contractors to identify effective technical solutions that support waste minimisation with the reuse and recycling of waste, where possible

11.5. Transboundary and Cumulative Impacts

Transboundary impacts, such as the cleaning and dismantling of the Curlew infrastructure overseas, will be evaluated and managed by Shell or the appropriately appointed contractor. As outlined in Shell's WMS, the transboundary impacts and relevant legislation are taken into consideration in the event of the Curlew FPSO travelling overseas for decommissioning operations (Shell, 2017d).

11.6. Mitigation Measures, Safeguards and Controls

Measuring and monitoring performance is an important element of an Environmental Management System (EMS) and Shell has a number of mechanisms in place to do this outlined in their WMS (Shell, 2017d). With respect to the management and minimisation of waste during the decommissioning of the Curlew infrastructure, the key areas for action are:

- Monitoring legislative compliance
- Measuring performance against stated targets

A range of methods will be used to ensure effective monitoring of waste management activities including, for example, auditing of contractors and disposal sites, monthly waste statistic summaries and the routine inspection of waste handling facilities, and provision of waste reports.

MITIGATION MEASURE, SAFEGUARDS AND CONTROLS

Standard industry practice, legislative requirements and project-specific controls:

- WMP in place, including management of NORM contaminated fluids and equipment, prior to decommissioning
- Shell will ensure the principles of the Waste Management Hierarchy are followed during all activities to increase reuse/recycling and minimise landfill disposal
- Onward transportation agreements will be in place
- Ship Recycling Facility Plan (SRFP) in place for the dismantling yard
- Use of designated licensed sites only approved waste treatment/disposal facilities
- Compliance with country's waste legislation and duty of care
- Permits and traceable chain of custody for waste management, shipment, treatment and onshore disposal
- Duty of Care Audit(s) to be conducted on the selected yard to verify Curlew-specific Ship recycling Plan
- Verify competence of personnel with waste management responsibilities
- Ensure subcontractor management process in place for third-party disposal sites
- Contract in place that adequately describes waste management requirements

Project-specific mitigation measures identified:

- Pre-qualification audits and site visits of potential dismantling yards
- Compliance with Corporate Framework Manual Waste guidance
- Shell Representative present at a selected dismantling yard ensuring recycling and waste management being carried out in accordance with Ship Recycling Plan
- Direct transfer of ownership of the Curlew FPSO from Shell to a selected yard to avoid potential reselling of the vessel and its dismantling in location with lesser controls

11.7. Impact Assessment Summary Statement

Although the decommissioning activities will produce some waste streams, Shell intends to recycle the majority of the material constituting the combined materials inventory of the Curlew cluster infrastructure.

Shell will follow the principles of the waste hierarchy and apply controls as per the Curlew Decommissioning Project WMP. The resulting significance of impacts associated with waste is assessed to be minor.

12. MARINE ALIEN INVASIVE SPECIES

Decommissioning of the Curlew FPSO will require transport of the vessel to a recycling yard located at a port either on the North Sea or Mediterranean Sea. The hull of the FPSO is covered with marine growth and may contain species that are alien (non-native) and invasive to the recycling yard location, which may have negative impacts to the marine environment.

An alien invasive species is one which has been introduced by human activity to a new geographic area or ecosystem outside of its natural distribution range and upon establishment, can threaten the ecosystems, habitats and/or other species. Furthermore, there is a potential to cause economic and/or environmental damage, or harm to human health.

Non-native marine species can be introduced into new geographic areas in a variety of ways as identified by analysis undertaken by Molnar *et al*. (2008). This study showed that for the 329 marine invasive species considered, shipping and vessel movement were the most common pathway of introduction (69%). For species introduced via shipping, 39% were introduced by hull-fouling, 31% via ballast water and the remainder by both.

There is potential for introduction of alien invasive species or further contributions to existing populations of alien invasive species with the transit of the Curlew FPSO to the location of a recycling yard, which is yet to be selected.

12.1. Regulatory Context

12.1.1. EU Regulation 1143/2014 on the Prevention and Management of the Introduction and Spread of Invasive Alien Species

The Regulation entered into force in the EU Member States on 1 January 2015. It introduces one co-ordinated approach to invasive species on the European level, to protect native biodiversity and ecosystem services, minimise and mitigate the human health and/ or economic impacts that invasive species present.

This Regulation introduced a list of species deemed to be of concern across all Member States. 'The list of Invasive Alien Species of Union Concern' includes species which represent a threat to native plants and animals in Europe. The species should not be introduced, transported, placed on the market, offered, kept, grown or released into the environment. The Regulation requires EU Member States to analyse the pathways of introduction and spread of invasive alien (non-native) species of concern. It also requires the establishment of surveillance systems (particularly at EU borders) and action plans to manage priority pathways (for instance biofouling) and limit the introduction and spread of these species.

12.1.1.1. *International Conventions*

IMO International Convention for the Control and Management of Ships' Ballast Water and Sediments (2017)

The Convention came into force on 8 September 2017. It introduces standards and procedures for the management and control of ships' ballast water and sediments to prevent the introduction and spread of invasive species. These include:

- Standard D1 for ballast water exchange, which specifies the volume of water to be replaced, i.e. requires the activity to be undertaken at least 200 nautical miles from nearest land and in waters at least 200 metres deep

- Standard D2 covers approved ballast water treatment systems and specifies levels of viable organisms left in water after treatment
- Requirements for ships to carry a Ballast Water Management Plan and a Ballast Water Record Book for recording and reporting ballast exchange operations

IMO 2011 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Species (2011)

The Guidelines provide a globally consistent approach to the management of biofouling. They advise on practices which can assist with reducing the risk of the transfer of invasive aquatic species via biofouling. The Guidelines recommend implementation of biofouling management measures such as but not limited to:

- A Biofouling Management Plan
- A Biofouling Record Book
- An Anti-fouling System and its management
- In-water inspection, cleaning and maintenance

12.1.1.2. *Regional Convention*

As a dismantling yard might be located in the Mediterranean, the following Regional Convention is relevant to the proposed activities.

Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention, 2004).

The Convention entered into force on 9 June 2004 and contains seven Protocols addressing specific aspects of Mediterranean environmental conservation, including, among others, "Specially Protected Areas and Biological Diversity Protocol".

Article 10 of the Convention states that "The Contracting Parties shall, individually or jointly, take all appropriate measures to protect and preserve biological diversity".

12.2. IMPACT ASSESSMENT

The Curlew Decommissioning Project will include a transit of the FPSO to a recycling yard location, which might be located in the North Sea or the Mediterranean Sea, and therefore there is potential for introducing and/or further contributing to existing populations of alien invasive species. The risk, however, depends on the location of the decommissioning yard, as the species-receiving environment may not be suitable for colonisation by these species. Seawater temperature and salinity, human activities, etc. play a crucial role in the colonisation and survival of the species and therefore are site specific. Current distribution and invasive potential of a species are also important considerations when evaluating potential impacts.

Consequently, once the recycling yard is selected, an IA will be undertaken for the potential introduction and/or further contribution to existing populations of alien invasive species via hull fouling and ballast water exchange to ensure the potential impacts are managed to ALARP.

12.3. Mitigation Measures, Safeguards and Controls

Standard industry practice and legislative requirements:

- All vessels (including the towed FPSO) follow the requirements of the IMO Convention for the Control and Management of Ships' Ballast Water and Sediments
- Application of the IMO 2011 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Species

Projects-specific:

- Carry out IA of potential introduction and/or further contributions to existing populations of alien invasive species via ballast water exchange and hull fouling once the recycling yard is selected

12.4. Impact Assessment Summary Statement

Once the yard is selected, IA will be undertaken to determine the significance of potential impacts.

[This page is intentionally blank]

13. ACCIDENTAL EVENTS

Three types of accidental events during decommissioning activities may lead to impacts:

- Unplanned liquid hydrocarbon (oil) release
- Unplanned chemical release
- Dropped object(s)

This section describes these events, their potential consequences and presents strategies which will be adopted by Shell to prevent/limit potential impacts. Shell recognises that minor spills, for example fluid loss from hoses, may occur. These will be managed using onsite implementation of Shell's approved safety procedures.

13.1. Approach

The potential sources of accidental events resulting from Curlew Decommissioning activities were identified through the Curlew IA ENVID workshop. All accidental events resulting in minor and moderate risks have been considered within this section. There were no risks classed higher than moderate. A full description of the impacts which were identified is provided in Appendix A.

The Curlew Field System Offshore Oil Pollution Emergency Plan (OPEP) (Shell, 2015) has been used to support this assessment.

13.2. Sources of Potential Impact

Potential sources of impact are presented in the following sections, and include a review of the sensitive receptors that may be affected. In many cases, both impacts and receptors have been detailed in the hydrocarbon release section. Where the chemical release impacts differ from those described in the hydrocarbon release section, further detailed discussion is given.

The following scenarios have been identified and the sources of potential impacts listed:

- Liquid hydrocarbon (oil) release:
  - Vessel (supporting and FPSO) collision
  - Loss of (control) FPSO under tow
- Chemical spill:
  - Resulting from FPSO cleaning activities (i.e. cargo tanks, ballast tanks)
  - Vessel (supporting and FPSO) collision resulting in chemical spillage
  - Loss of (control) FPSO under tow
- Dropped object(s):
  - From supporting vessels

13.3. LIQUID HYDROCARBON (OIL) RELEASE

An accidental hydrocarbon release can result in a complex and dynamic pattern of pollution distribution and impact in the marine environment. There is a large range of both natural (i.e. metocean conditions) and anthropogenic (i.e. intervention) factors that could influence behaviour and consequences an accidental spill. Therefore, each spill is unique. The long-term effects resulting from such an event have been reported in the literature as ranging from none detected (e.g., after the Ekofisk blowout in 1977) to chemical contamination but no acute biological effects detectable (e.g., after the Braer wreck in 1993) (DTI, 2001). The extent of a spill's environmental impact is dependent upon several factors including:

- Location and time of the spill
- Spill volume
- Hydrocarbon properties
- Prevailing meteorological/metocean conditions
- Environmental sensitivities
- Efficacy of the contingency plans

The hydrocarbons used in or produced by the Curlew field include crude, marine diesel and aviation fuel. The Curlew crude has a specific gravity of 0.819, and is classified as an International Tanker Owners Pollution Federation (ITOPF) Group II oil. This indicates the oil will remain afloat on the sea surface in the event of a spill to sea. In addition, Group II or can lose up to 40% by volume through evaporation but, because of their tendency to form viscous emulsions, there is an initial volume increase as well as a curtailment of natural dispersion (ITOPF, 2012).

Both marine diesel and aviation fuel have very high levels of volatile components, evaporating quickly on release. The low asphaltene content in these fuels prevents emulsification, reducing their persistence in the marine environment. Diesel characteristics and subsequent behaviour when released means that it may not represent a significant threat to the environment when compared to a Curlew crude oil spill.

Oil spill modelling has been undertaken for the Curlew field and reported in the offshore OPEP (Shell, 2015). Two scenarios were modelled; the blowout of the curlew DP3 well and loss of full hydrocarbon inventory of the FPSO. The failure of the FPSO hydrocarbon stock (instantaneous loss of 90,949 m^3) is considered the worst-case event under the scenarios considered in this assessment.

The modelling results for the worst-case accidental event predict that released crude could only reach the UK coastline during spring (March to May). However, this spring scenario had only a 1% probability of occurrence. Dependent upon the prevailing weather conditions, this could occur approximately 14 days after the release, and with a value less than 0.02 m^3 predicted to impact the coastline. In addition, the most likely times for the spilt hydrocarbon to reach the median line were winter and spring (0 to 20% probability), for no less than 42 hours following release. Refer to Figure 13-1 and Figure 13-2 for the results of the oil spill modelling.

Oil spill modelling for a diesel spill has not been modelled under the Curlew Field OPEP. An accidental release of diesel would result in much smaller volume being lost (less than 2,000 m^3 assuming 100% capacity of all fuel tanks on board) and a reduced impact on the marine environment due to the characteristics of diesel (high volatility; low persistence). Therefore, it is estimated that the impacts to marine species and habitats would be lower in comparison to the OPEP scenario, localised and those impacted likely subjected to toxic short-term non-persistent effects.

Of note, CoP and final crude oil offload will have occurred prior to decommissioning activities and thus only a limited hydrocarbon volume will actually be present on the FPSO. Therefore, it can be assumed that the OPEP modelling volumes greatly exceed the potential loss from the FPSO. The likelihood of a large hydrocarbon release is therefore greatly reduced, and the risk much lower.

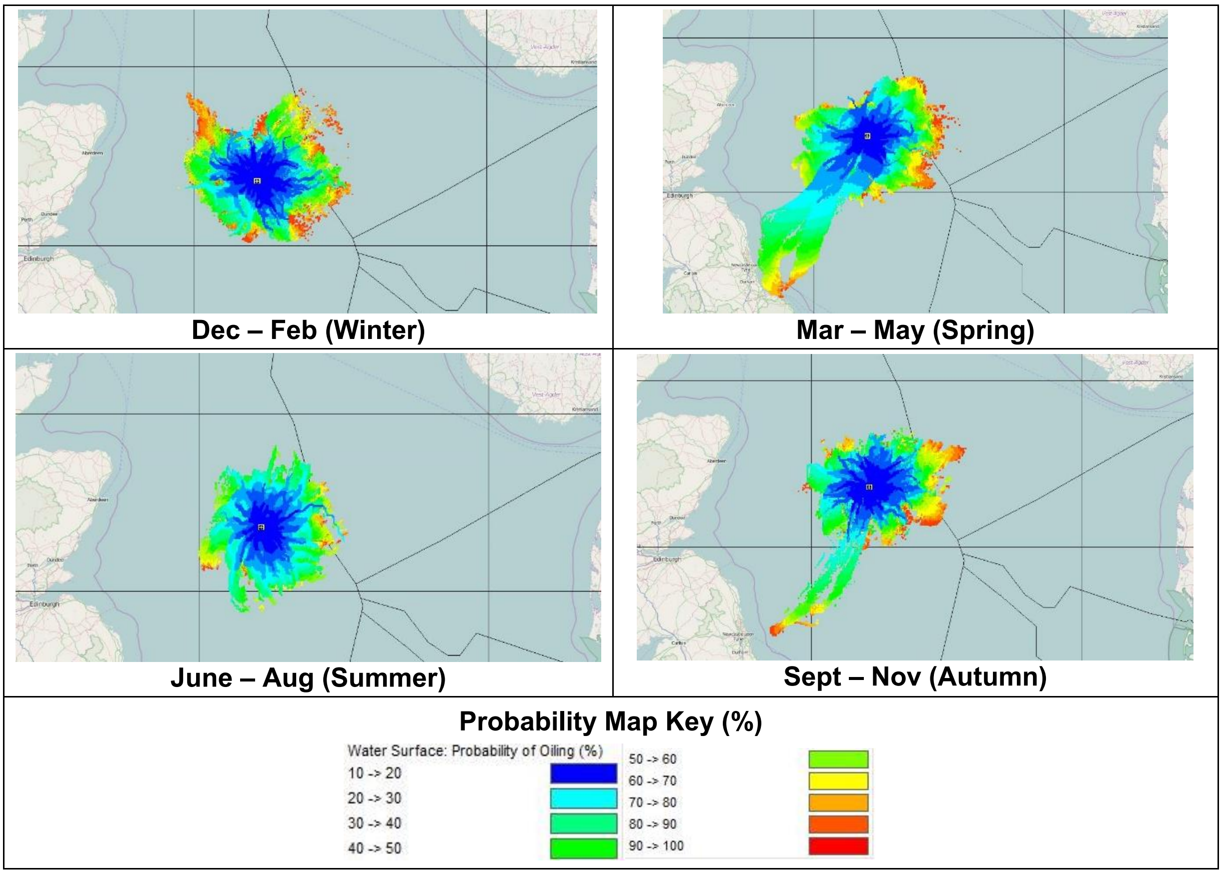


Figure 13-1 Seasonal Arrival Time Plot following an Instantaneous Release from Curlew FPSO

13.3.1. Impact on Sensitive Receptors

The potential for short-term and long-term impacts are assessed for the major taxonomic groups relevant to the CNS marine environment, to determine the potential scale of interaction within the vicinity of an accidental oil spill. Socioeconomic and shoreline impacts are also described below.

13.3.1.1. *Biological Receptors*

Whilst there is only a small likelihood of an accidental hydrocarbon release during the Curlew decommissioning activities, there exists a potential risk to organisms in the immediate marine environment if a spill were to occur. Table 13-1 highlights the biological receptors that may be impacted from a potential oil spill incident.

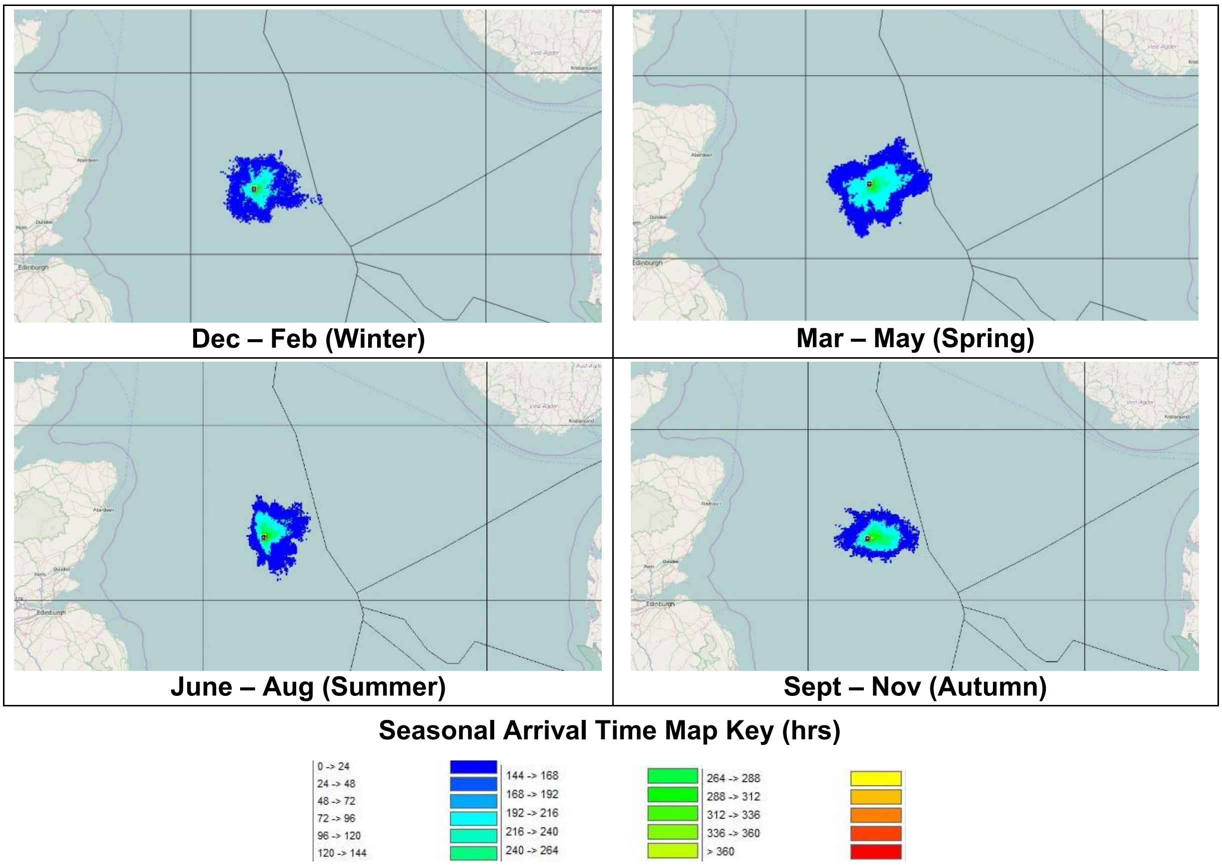


Figure 13-2 Probability of Oil Beaching and Crossing the Median Line following an Instantaneous Release from the Curlew FPSO

Table 13-1 Summary of Potential Impacts to Biological Receptors

Biological Receptor	Potential Risks
Plankton	Localised effects due to toxicity. Impacts on communities are unlikely due to natural variability, high turnover and seasonal fluctuation.
Benthos	The impact to benthic species/seabed will be localised. The 2016 survey indicates the presence of very fine sand, with a EUNIS biotype of offshore circalittoral sandy mud (Fugro, 2016). The macrofauna were dominated by polychaetes and molluscs. OSPAR threatened and/or declining habitat 'sea pens and burrowing mega fauna' indicated to be present although no protected area is designated. Those benthic communities may be affected by gross contamination, with recovery taking several years. Mortality would be dependent on oil sensitivity, potentially leading to structural change in the community. Surface release of hydrocarbons from the FPSO and marine diesel from both the FPSO and support vessels is unlikely to impact the benthic community; therefore the risk is considered minimal.

Table 13-1 Summary of Potential Impacts to Biological Receptors (Continued)

Biological Receptor	Potential Risks
Fish (spawning and nursery)	Curlew is located within spawning grounds for cod, lemon sole, mackerel, Norway pout, and sand eels and within nursery grounds for anglerfish, blue whiting, cod, European hake, haddock, herring, ling, mackerel, Norway pout, plaice, sand eels, spurdog and whiting (Aires *et al*, 2014; Ellis *et al.*, 2012; Coull *et al.*, 1998). Adult fish are expected to avoid the affected area, but if affected, hydrocarbons may result in tainting of the fish, and hence in a reduction of commercial value. Whilst eggs and larvae may be affected, such effects are generally not considered ecologically important because eggs and larvae are distributed over large sea areas. Demersal species may be influenced by habitat pollution.
Seabirds	Block 29/07 has a low sensitivity to oil pollution throughout the year. In surrounding blocks, the most sensitive time of year is September and June when vulnerability to oil pollution is reported as "very high" and "medium", respectively. No data is available for November and from some blocks in December. The period of very high sensitivity can be attributed to moulting of some of the species and foraging or feeding behaviour (Certain *et al.*, 2015). Physical fouling of feathers, damage to eyes and toxic effects of ingesting hydrocarbons can result in direct and indirect fatalities. Effects would depend on species present, their abundance, reliance on particular prey species and the time of year. Diving birds such as auks and gannets are particularly susceptible. Species most affected may be guillemots, razorbills and puffins that spend large periods of time on the water, particularly during the moulting season when they become flightless (DTI, 2001).
Marine mammals	The predominant marine mammal species occurring in the project area are minke whale, common dolphin, white-beaked dolphin and harbour porpoise, with most sightings occurring between June and October (Reid *et al.*, 2003; UKDMAP, 1998). Potential effects may include inhalation of toxic vapours, eye/skin irritation and bioaccumulation. Ingestion of oil can damage the digestive system or affect liver and kidney function. Loss of insulation through fouling of the fur of young seals increases the risk of hypothermia. Oil contamination can impact food resources directly through prey loss or indirectly through bioaccumulation. However, it is expected that marine mammals would most likely avoid the area if a spill were to occur.
Protected habitats and species	There are no known Annex I habitats in the immediate vicinity (within a 50 km radius) of the Curlew field. Of the Annex II species, the harbour porpoise is the only species sighted within the decommissioning area. It was observed in low numbers in July and October with medium numbers reported in September and December (UKDMAP, 1998). OSPAR threatened and/or declining habitat 'sea pens and burrowing mega fauna' indicated to be present although no protected area is designated.

Table 13-1 Summary of Potential Impacts to Biological Receptors (Continued)

Biological Receptor	Potential Risks
Shore line	The results of the oil spill modelling predict that spilt crude oil is only likely to reach the English coast (Durham/Yorkshire) during Spring (Shell, 2015). However, the probability of beaching is less than 1%. The modelling does not predict beaching along other North Sea coastlines. Based on its low persistency in the marine environment and the distance of the main activities from shore, it is unlikely that a surface diesel spill might have an impact on the shoreline.

13.3.1.2. *Socioeconomic Receptors*

An accidental release may influence a number of socioeconomic receptors, summarised in Table 13-2.

Table 13-2 Summary of Potential Impacts to Socioeconomic Receptors

Socioeconomic Receptor	Potential Risks
Fisheries	Fishing is one of the primary economic activities in the EU and it supports other shore-based activities including fish processing and boat construction. The impacts to offshore fishing are limited for the period that oil remains on the surface as access to fishing grounds would be limited. There is the potential for fish that come into contact with oil to become tainted precluding sale. There is no UKCS evidence of any long-term effects of oil spills on offshore fisheries. During 2016, the total number of days' effort in the Curlew area (ICES rectangle 42F1) was relatively moderate with 518 days. The fishing effort between 2011 and 2016 was dominated by trawls (Scottish Government, 2016). *Nephrops* made up 38% of the catch composition in 42F1 in 2016. Previous years were dominated by both *Nephrops* and herring (Scottish Government, 2016).
Tourism	Coastal tourism can be adversely affected by oil pollution events owing to reduced amenity value. Impact can be further influenced by public perception and media coverage.
Shipping	The overall vessel traffic in the Block 29/07 is low, and moderate in one of the adjacent blocks (BEIS, 2016b). Shipping lanes are used by shuttle tankers, supply and standby vessels serving the offshore oil Installations in the area. Although all of the aforementioned may potentially be impacted by an oil spill, the impacts will likely last only whilst there is oil on the sea surface, as this may restrict access. However, it is unlikely that there will be any long-term socioeconomic impacts upon this sector.

13.3.2. Transboundary, In-Combination and Cumulative Impacts

Numerical modelling for the purposes of a production OPEP predicts that the Curlew hydrocarbons spill will cross the Norwegian median line (after 42 hours in winter and spring (less than 20% probability)). In the event of an oil spill entering Norwegian waters, it may be necessary to implement the Norway-UK Joint Contingency Plan (NORBRIT) Agreement. The NORBRIT Agreement sets out command and control procedures for pollution incidents likely to affect both parties, as well as channels of communication and available resources. The Marine and Coastguard Agency Counter Pollution and Response Branch also have agreements with equivalent organisations in other North Sea coastal states, under the Bonn Agreement 1983.

Cumulative effects arising from the Curlew decommissioning activities have the potential to combine with those from other O&G activity, including both existing activities and new activities, or to combine with those of other human activities (e.g., fishing and marine transport of crude oil and refined products). Following consideration of the likely volumes of any spilt oil, it is anticipated that accidental discharge would disperse rapidly in the immediate environment without the potential to combine with other discharges from concurrent incidents. Given that any cumulative impacts are dependent upon previous disturbances or future accidental releases at other locations, it becomes difficult to predict whether the impacts from an oil spill to the marine ecology of the affected area would be cumulative. Cumulative effects of overlapping "footprints" for detectable contamination or biological effects should therefore be considered to be unlikely.

13.4. Chemical Spill

An accidental chemical release can result in a complex and dynamic pattern of pollution distribution and impact to the marine environment. As described for a hydrocarbon release, the number of factors that could influence an accidental spill renders each spill unique. Those specific for a chemical spill are:

- Spill volume
- Chemical toxicity
- Chemical solubility
- Environmental persistence in the environment
- Biodegradability of the compound
- Potential for bioaccumulation in the food chain
- Partitioning of individual components

Technical failure remains the predominant cause of chemical spills within the North Sea. Spills of hydraulic fluids or chemicals are the primary sources of loss into the marine environment. The potential sources of accidental chemical spills from the Curlew decommissioning activities have been identified from the ENVID as the permitted release of residual contents and will be justified in the associated permit and justification documents on the Portal Environmental Tracking System portal. As such, this potential activity was scoped out from a detailed IA with a summary provided in the following sections.

13.4.1. Biological Receptors

Due to the rapid dispersion and dilution of the chemical upon discharge or release, few biological receptors are noticeably impacted. The most sensitive receptors are the planktonic communities. Plankton (phytoplankton, zooplankton and fish larvae) are likely to come into direct contact with discharged chemicals, with zooplankton appearing to be the most vulnerable, particularly at the early stages of development. However, the impact of a chemical spill is not likely to impact beyond the immediate vicinity of the discharge point because:

- The likely credible maximum volume of chemicals that may be subject to a spill event would be very low
- Discharge is likely to be dispersed and diluted rapidly by the receiving environment
- Many of the compounds will be volatile or soluble and thus removed from the water by evaporation and dilution
- Biological oxygen demand is likely to be within the capacity of ambient oxygen levels

13.4.2. Socioeconomic Receptors

The main socioeconomic receptors relevant to a chemical spill can be considered similar to those impacted by an accidental hydrocarbon release. Dispersion and dilution, combined with the likely small volumes spilt will result in localised impact areas. The socio-economic risks foreseen for fisheries, tourism, O&G and/or shipping are therefore considered minor.

13.4.3. Transboundary, In-combination and Cumulative Impacts

The majority of chemical spills are unlikely to result in an environmental impact due to a combination of rapid dispersion, dilution and the likely low volume spilt. This, in conjunction with the depth (93 m) and distance from shore of the area of activity (210 km) will result in a minor contributory risk to residual, cumulative or transboundary impacts.

13.5. Dropped Object(s)

Dropped objects can vary in size, from small tools to large sections of topside infrastructure. Efforts will be made to remove dropped objects where feasible, therefore the potential impact is derived from the impact an object may have on any habitat or species it is dropped on or any damage caused to subsea infrastructure which may result in an unplanned release.

The likely worst-case consequential risk which imposes the greatest environmental and socioeconomic impact would be the loss of a large section of topside during the removal phases of the project. This type of event may cause localised effects in the water column, on the seabed or to the benthos. The extent and severity of these effects would depend on the object lost and the amount of seabed and consequently, sediment disturbed.

13.5.1. Biological Receptors

Whilst the impact of a dropped object on the immediate drop zone may be significant, the effect is considered localised. In the event of a dropped object, the dominant receptors are the infaunal and epibenthic communities within the drop zone. The most recent seabed survey (Fugro, 2016) indicates that the benthic community within the Curlew area is typical of this area of the CNS. Therefore, it is likely that the impact of a dropped object would have no significant impact on the wider community. No other biological receptors would be impacted by a dropped object.

13.5.2. Socio-economic Receptors

Shell intends to recover any dropped objects, where safe and practical to do so, during the decommissioning operations. Once the decommissioning activities have completed, an independent seabed clearance survey and overtrawlability survey will be conducted. This will verify that a safe seabed has been left (excluding any infrastructure permitted to remain in place).

No impacts relating to other socio-economic receptors have been identified from dropped objects.

13.5.3. Transboundary, In-combination and Cumulative Impacts

In the case of potential dropped objects during the decommissioning process, the impacts will be both localised and temporary. No residual effects are anticipated and it is considered that this accidental event will not contribute to cumulative or transboundary impacts.

13.6. Mitigation Measures, Safeguards and Controls

Standard industry practice and legislative requirements:

- Approved OPEP in place for decommissioning activities post-CoP and before the transit of the FPSO
- Shell have specialist oil spill response services provided by OSRL and are members of the Oil Pollution Operator's Liability (OPOL) Fund
- Local shipping traffic would be informed of proposed decommissioning activities and a standby/ support vessel would monitor traffic continually during operations
- Outwith the 500 m exclusion zone and in the event of an accidental release to sea, vessels will implement their SOPEP
- All operations will be undertaken in a controlled manner, by trained personnel and using approved equipment
- Observed leaks will be dealt with immediately by competent personnel and reported to the appropriate authorities
- During decommissioning operations, items will be secured to prevent loss wherever practicable
- Where practicable and safe to do so, any dropped objects will be retrieved from the seabed
- Once the decommissioning activities are completed, an independent seabed clearance survey and overtrawl survey will be undertaken
- Tow plan and towing procedure in place

Project specific mitigation measures identified as necessary:

- Inventories will be minimised prior to removal and transfer of the FPSO
- Offload of crude inventory before removal and sail away of the FPSO
- Multiple towing vessels will be deployed for the transit of the FPSO

13.7. Impact Assessment Summary Statement

The EIA has identified three avenues of risk from accidental events occurring during the proposed decommissioning activities:

- Hydrocarbon release
- Chemical spills
- Dropped objects

Impact significance associated with a hydrocarbon or chemical release would potentially be classed as moderate, depending on the volume released. However, due to the mitigation measures put in place the likelihood of these events happening is remote. This results in an assessed risk of Minor.

The potential impact significance from dropped objects is slight, with a remote likelihood of occurrence. If these did occur, the dropped object would be retrieved where feasible. The risk from dropped objects is considered negligible.

14. ONSHORE IMPACT ASSESSMENT

There is the potential for the onshore phase of decommissioning to have an impact on the environment and communities in the vicinity of a dismantling yard. Potential onshore/nearshore socio-economic effects may include but are not limited to: an increase in road traffic, elevated noise and dust in the vicinity of the site, and light and odour impacts. Environmental impacts may include water contamination, atmospheric emissions and waste generation. Shell is currently in the process of evaluation and selection of a dismantling yard for the Curlew FPSO. The proposed sites are located in the UK, Europe and Mediterranean Region. Whether in the UK or abroad, dismantling activities will be undertaken by an experienced contractor at an established yard, which will have a suitable management system and permits in place and therefore the potential impacts to the environment and nearby communities will be appropriately controlled.

Although a specific yard has not been selected yet, this section provides an overview of potential impacts, how they will be managed and the process of yard assessment undertaken by Shell to ensure HSSE&SP risks during onshore dismantling activities are managed to ALARP.

14.1. Applicable Legislation and Standards

Multiple yards are being considered as a potential final destination for the FPSO. These are currently being assessed by Shell to ensure they meet the IMO Hong Kong International Convention 2009 for safe and environmentally sound recycling of ships, and that they meet legal requirements of the EU Regulation No 1257/2013 on ship recycling.

14.1.1. The Hong Kong International Convention

The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships (the Hong Kong Convention) was agreed at a diplomatic conference held in Hong Kong in May 2009. It was developed with input from IMO Member States and non-governmental organisations, and in cooperation with the International Labour Organisation and the parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

It is intended to address all the issues around ship recycling, including the fact that ships sold for scrap may contain environmentally hazardous substances such as asbestos, heavy metals, hydrocarbons, accumulations of NORM and (ODSs). It also addresses concerns about working conditions and environmental sensitivities in many of the world's ship recycling facilities.

The aim of the Convention is to ensure that ship recycling at the end of operational life does not pose any unnecessary risk to human health and safety or to the environment. Many European and non-EU countries have signed up to the Convention, but it has yet to be ratified (come into force). This is expected in the coming few years but dates are not yet fixed.

The Convention requires that ships flagged by states which have ratified the Convention must only be dismantled in countries that have ratified the Convention, and that facilities in states party to the Convention do not recycle ships which are flagged with non-party countries.

Under the convention, ship recycling yards are required to provide an SRFP to provide an overview of how the yard is managed e.g. in relation to hazardous waste, environmental and health impacts from their operations. Once a contract is in place to recycle a specific vessel, the yard produces a recycling plan which specifies the details for that contract/vessel.

14.1.2. EU Ship Recycling Regulation 2013

EU Regulation 1257/2013 regulates approved recycling facilities and transboundary movement of waste. When this legislation is fully in force (at the latest 31 December 2018), EU flagged ships are only allowed to be recycled at approved EU facilities. EU facilities are being placed on the list by the individual members of the EU. EU facilities without a Ship Facility Recycling Plan (SFRP) can be on the approved list because the individual member of the EU might approve a facility even if it has no SRFP. Facilities which wish to be on the EU approved list but are outside of the EU are subject to having an SRFP approved by the EU.

14.1.3. UK Ship Recycling Legislation

14.1.3.1. *The Ship Recycling Facilities Regulations 2015*

In Great Britain, The Ship Recycling Facilities Regulations 2015 (Great Britain) implement EU Regulation No 1257/2013 on ship recycling, which itself implements the Hong Kong International Convention for the safe and environmentally sound recycling of ships.

Ships over 500 gross tonnes, unless military or owned by the state for non-commercial purposes, must be recycled at authorised facilities. Facilities must gain authorisation through application to the Environment Agency, SEPA or Natural Resources Wales as relevant. An SRFP must be submitted as part of this application, meeting the requirements of the EU Regulation.

Similarly, in Northern Ireland, The Ship Recycling Facilities Regulations 2015 (Northern Ireland) implement EU Regulation No 1257/2013 on ship recycling.

Facilities must gain authorisation through application to the Department of the Environment and the Health and Safety Executive Northern Ireland.

14.1.3.2. *Implication of the EU Referendum (BREXIT)*

On 23 June 2016, the UK voted to leave the EU. Until exit negotiations are concluded, the UK remains a full member of the EU and all the obligations of EU membership remain in force. During this period, the Government will continue to negotiate, implement and apply EU legislation. The outcome of these negotiations will determine what arrangements apply in relation to EU legislation in future once the UK has left the EU.

14.2. Overview of Ship Dismantling Process

The FPSO will be towed to a selected yard. On arrival, the vessel will be checked to confirm that its inventory is aligned with what was specified in the Hazardous Material Inventory.

Prior to commencement of any deconstruction operation, the yard's personnel will survey the vessel to confirm the type and quantities of material on board, specifically focusing on the areas of hazardous material like asbestos, remaining hydrocarbons, heavy metals, PCBs, ODS, etc. If necessary, samples might be taken to confirm composition of the fluids/material to minimize potential risks of exposure to the personnel and the environment. Afterwards, deconstruction of the vessel will commence.

There are various methods of ship recycling. Yards considered by Shell follow the recommendations of the IMO Hong Kong Convention 2009 and use either dry dock, floating containment along the quay side or paved slipway with built-in drainage and effluent collection system.

First, soft materials are removed, followed by structural deconstruction. Depending on the yard's arrangements, dismantling might be either undertaken from top to bottom, with the carcass of the ship's hull being lifted to a quay side, or from back to front with cutting and decontamination activities taking place within a containment area. The structure of a ship is first cut into smaller pieces, which are transferred to a secondary laydown area for further processing and waste segregation. No freefall methods are used at any of the proposed yards.

All waste generated by these activities is transported to a dedicated laydown area, where they are segregated and properly stored. Regular reports are generated by the yard to a client to update on the progress of the dismantling and waste management. At the end of the recycling process, the yard issues certificate(s) of a ship being fully recycled.

14.3. Noise

There will be noise associated with the onshore dismantling of the Curlew FPSO. The cutting itself is not thought to be particularly noisy, although the noise caused by the increased industrial activity may potentially result in elevated noise levels. However, the noise generated by the dismantling work will not be higher than would normally occur onsite; it is expected to be intermittent, and will be assessed and managed as part of the yard established controls. Moreover, each site is approved and permitted to undertake dismantling activities with specific requirements on noise management if required. Overall, the noise impacts are considered to be minor.

14.4. Light

Operations at a dismantling yard might take place 24 hours a day. However, any activities carried out by a yard will not be of unusual scope and therefore there will be no additional light above and beyond what is already emitted regularly from a site. Moreover, each site is approved and permitted to undertake dismantling activities with specific requirements on light management if required. Overall, the light impacts are considered to be minor.

14.5. Odour from Marine Growth

Marine growth is identified as potentially producing an odour, which may impact immediate neighbours and nearby local communities. Environmental conditions such as prevailing wind direction and temperature will also determine the severity and area impacted by any such odour. The main source of odour is thought to be due to the disturbance of low-oxygen layers and removal of putrefying organisms.

Around 1,905 Te (wet weight) of marine growth is estimated to be present on the hull of the FPSO. Some marine growth is likely to be dislodged or die off during the tow to a yard; however, some volume will be brought onshore for disposal after cleaning the structure. Odour from storing the remaining quantities of the marine growth might potentially be detectable for a number of weeks or months. However, each site is experienced in decommissioning either of ships and subsea structures or O&G offshore platforms and they have processes in place to deal with the potential odour pollution. Mitigation measures may include rapid removal of marine growth and spraying of odour suppressants. With these measures in place, the impact from marine growth is assessed as minor.

14.6. Road Transport

Waste generated by the dismantling activities will have to be transported to their relevant end locations. Dismantling of the Curlew FPSO will not be an additional workscope to the normal operations of the yards considered by Shell. Any transport of waste from a site will be as part of regular operating conditions of the location.

14.7. Fluids Containment and Management

The Curlew FPSO will arrive to a dismantling yard with fluids present in its cargo and slops tank, unless cleaning of the vessel is undertaken in an interim berth yard. These fluids will be a mixture of produce water, seawater, remaining hydrocarbons and chemicals. In addition, despite DFPV and flushing of pipework being before sail away of the FPSO, residual fluids are expected to be present in topside pipework and tanks. During dismantling operations, these fluids will require appropriate containment measures in place to minimise potential risks of accidental releases and contamination of water (groundwater and surface water bodies) and soil.

Yards considered by Shell have controls and practices in place to manage fluids during the recycling process. These include gravity dock, dry dock, slipway and paved laydown areas with a built-in environmental protection drainage system, and an effluent collection and water treatment system consisting of an interceptor tank, with regular sampling and monitoring of discharges. In addition, the site's operations are subject to permit conditions issued by the relevant authority and have systems in place for monitoring and reporting planned discharges and emissions. Furthermore, each yard has an Emergency Preparedness and Response Plan, including storm water and debris pollution prevention.

14.8. Waste Management

Dismantling of the Curlew FPSO will result in a significant amount of waste being generated. This will include non-hazardous and hazardous waste including NORM, hydrocarbons and asbestos. Any waste will have to be properly identified, stored and transported to minimise the risks of cross- contamination, exposure to human health and pollution to the environment. In addition, tracking and recording of waste streams being generated during the recycling will be critical to ensure compliance with Duty of Care.

Yards considered by Shell have established practices and disposal routes in place to sufficiently manage waste aspects during recycling. As per the requirement of the 2009 IMO Hong Kong Convention, each site has a Ship Facility Recycling Plan in place outlining methods of handling, storing, transporting and disposing waste. Moreover, for individual projects, a dedicated Ship Recycling Plan will be generated by the selected yard, based on the inventory of the ship, which will specifically outline waste management for waste streams present onboard the ship. This Plan will be subject of review and approval by Shell. Furthermore, Shell will provide a Company Representative to be present at the selected yard for the entire duration of the recycling process to ensure that activities are being completed as per the Ship Recycling Plan and in accordance with procedures and management systems outlined in the Ship Facility Recycling Plan. All dismantling yards are experienced in recycling operations and have established controls and systems to manage waste. This includes procedures, a dedicated waste storage area with separate areas for handling hazardous substances such as NORM, heavy metals and/or hydrocarbons. Finally, each site is subject to regulatory permit approval.

14.9. Assessment of Dismantling Yards

Shell, with help of independent third-party company, have carried out evaluation of a dismantling yard so that potential technical and HSSE&SP risks are minimized to ALARP during the dismantling process of the Curlew FPSO.

A multi-stage assessment was undertaken, consisting of a pre-qualification questionnaire, site audits and a Social Performance and Community Health questionnaire. The objectives of the evaluation process were:

- Provide assurance to Shell that risks associated with Asset recycling are being managed to ALARP
- To assess whether shipyards are developing and documenting a systematic approach to safety and environmental management, designed to ensure compliance with the all applicable laws and to achieve continuous improvement

- Assess whether the safety and EMS will be effective in managing the risks of operations at the yard to ALARP
- Verify that procedures, and practices available provide suitable and sufficient controls
- To seek agreement on corrective actions

The pre-qualification checklist was sent to the yards where Shell has had no previous experience. This step was to eliminate yards that did not meet the minimum technical and safety standards. Following the preliminary screening, site audits were conducted to confirm management processes and controls are implemented in practice as specified in the initial questionnaire and/or documents provided. During the site visits, the checklist within the International Association of Oil and Gas Producers (IOGP) Report 423, 'HSE management guidelines for working together in a contract environment', was utilised. The audits focused on technical capabilities of a yard to recycle the Curlew FPSO, and on critical HSE aspects (for instance HSE management system, personal and process safety controls, risk management, environmental permits and compliance, performance monitoring and reporting, workers welfare, emergency system, transportation, waste management, etc.). Following the site visits, a Social Performance & Community Health Questionnaire was issued to yards to check whether facilities have systems in place to manage social and community impacts of their operations.

As a result of the assessment process, a number of yards have been shortlisted for tender. Evaluation was undertaken for facilities considered to be in compliance with Shell safety standards and the 2009 Hong Kong Convention on the Safe and Environmentally Sound Recycling of Vessels, which provides the minimum industry best practices of ship recycling in a safe and environmentally sound manner. The key requirements of the Convention include, but are not limited to, an Inventory of Hazardous Waste to be carried out; surveys to be undertaken before recycling process begins; and a Ship Recycling Plan to be generated by a dismantling yard to specify the manner in which each individual ship will be recycled, depending on its particulars and inventory. The Convention also addresses issues regarding working and environmental conditions at recycling location, such as appropriate personal protective equipment. As a result, dismantling methods such as beaching and freefall deconstruction are not practiced at compliant yards, and therefore potential personnel and environmental risks are minimised. All shortlisted yards have as a minimum:

- Policies ensuring workers' safety and the protection of human health and the environment
- Programmes for providing appropriate information and training of workers for the safe and environmentally sound operation of the Ship Recycling Facility
- Emergency preparedness and response plans
- Performance monitoring and record keeping systems
- Systems for reporting discharges, emissions, incidents and accidents causing damage, or with the potential of causing damage to workers' safety, human health and the environment
- Systems for reporting occupational diseases, accidents, injuries and other adverse effects on workers' safety and human health

Due to recent events, in order to minimise the risk of vessel being resold and then recycled in locations with less robust regulatory controls, Shell plans to carry out the transfer of ownership directly at the yard to ensure that the FPSO arrives at the agreed locations.

14.10. Mitigation Measures, Safeguards and Controls

Standard industry practice and legislative requirements:

- All shortlisted yards are compliant with either the 2009 IMO Hong Kong Convention on the Safe and Environmentally Sound Recycling of Vessels, and/or with the 2014 EU Regulation
- SRFPs in place for all considered yards
- All facilities are established and licensed yards with appropriate permits in place (e.g. Discharge Permit, Emission Permit, NORM Permit, Waste Permit, etc.)
- Update to the Hazardous Material Inventory post-CoP and prior to arrival at the selected yard
- Duty of Care and ongoing monitoring of waste management during the recycling process

Project-specific mitigation measures identified as necessary:

- Shell Representative being present at the dismantling yard during the duration of the recycling activities to ensure operations are carried out in accordance with agreed methods and practices
- Thorough, multi-stage assessment process of the potential recycling yards

14.11. Impact Assessment Summary Statement

The proposed sites are located in the UK, mainland Europe and the Mediterranean. Dismantling activities will be undertaken by an experienced contractor at an established yard, which will have suitable management systems and permits in place. The potential negative impacts to the environment and nearby communities will be appropriately controlled.

15. CONCLUSIONS

An EIA forms an integral part of the Shell project management process, ensuring that adequate environmental, social and community health considerations are incorporated into the design of the Curlew DP. This ES presents the findings of the EIA for the recommended options for the decommissioning of the Curlew infrastructure, providing sufficient information to enable a robust evaluation of the potential impacts/risks of the proposed decommissioning activities, both offshore and during onshore disposal. This document provides an assessment of a number of worst-case assumptions, affording flexibility to Shell to allow the project to develop under the ready to react principle, should the FPSO need to move off station prior to 2019.

The approach taken to identify and assess the potential impacts associated with the decommissioning of the Curlew cluster can be summarised by the following:

- Key environmental, social and community health considerations were identified through an ENVID workshop and stakeholder consultation
- A series of mitigation and management measures have been identified to eliminate or reduce as far as reasonably practicable any negative impacts
- A detailed assessment of impacts/risks to both environmental or societal receptors and determination of any residual impacts/risks posed

15.1. ENVIRONMENTAL AND SOCIETAL EFFECTS

The Curlew infrastructure is located in a marine environment that is typical of this part of the CNS. Shell has considered there are certain times of the year when populations of seabirds, life stages of fish, marine mammal presence and commercial fishing interests are more susceptible to potential impacts/risks.

This EIA has considered the interactions that decommissioning activities pose to the local environment and its sensitive species or habitats. The EIA identified some species (e.g. *Arctica islandica*, sea pens and other burrowing megafauna), which represent examples of OSPAR threatened and/or declining species/habitats. However, the overall footprint of the project on the seabed is small (53.3 km^2) and the majority of the impact within this area is temporary in nature, comparable to impacts that may occur after large storms, and significantly less than impact that may arise from other permitted activities (e.g. dredging and fishing).

The proposed decommissioning activities are likely to have a long-term impact to the seabed over an area of no more than 0.05 km^2. This is primarily in relation to the placement of additional hard substrate in the form of rock to prevent any snagging risk to other users of the sea.

The project has assessed potential impacts and risks associated with decommissioning the majority of the subsea pipework in situ. In situ decommissioning poses the minimal environmental and societal impact/risk, as the pipelines are predominantly buried and will degrade slowly over a number of decades. Entrained material will be released to the sea/seabed in small, discrete amounts, over a long period of time. These contaminants do have the potential to persist in the environment for longer than 1 year. However, due to the actual volumes and the very slight contamination involved, the impact is of minor significance.

The project intends to decommission the drill cuttings deposits in situ, however evidence suggests these are small in size and below OSPAR thresholds. The size and contamination levels are expected to degrade further as time passes, through natural and biological degradation, and will continue to be distributed by natural causes (currents/storms) and occasional commercial fishing activities. Measures will be taken to highlight the location of these cutting deposits on shipping charts to minimise any risk of any minor contamination to fishing gear in the near future.

It is unlikely that any marine mammals will be adversely affected by Curlew decommissioning activities. Noise levels generated by surface vessels (even when combined) are unlikely to result in physiological damage to marine mammals in the project area. In addition, marine mammals move over large areas and are likely to be sparsely located. There may be no individuals within the estimated zone of disturbance at the time of decommissioning operations.

Other than a minor contribution to the overall emissions, decommissioning activities are not anticipated to cause any transboundary impacts. The local impact is minimal when compared to emissions from general vessel traffic in the North Sea and at the decommissioning yard.

As this is a decommissioning project, waste management has been included in the IA as a potential ongoing source of impacts throughout the duration of the dismantling/decommissioning process. Waste generation will include special (hazardous), non-hazardous and recyclable wastes. Wherever practical, Shell and its contractors will recycle or re-use material rather than disposing to landfill. Due to the nature of some of the waste streams, however, disposal to landfill may be the only viable option. In this case suitably licenced facilities will be used. A project-specific WMP will be implemented.

The transient loss of access for vessels during the decommissioning activities is unlikely to have a significant impact on other users of the sea (i.e. commercial shipping and fishing). In addition, there is the potential for a positive impact with some of the infrastructure being removed and the removal of safety zones, resulting in additional areas of the seabed being opened to commercial fishing interests.

Shell is currently in the process of evaluation and selection of a dismantling yard for the Curlew FPSO. Although a specific yard has not been selected yet, potential impacts and risks associated with onshore dismantling of the Curlew FPSO were assessed in the EIA. Yards considered by Shell are approved and permitted to undertake dismantling activities, with established standards and processes to mitigate potential environmental and social impacts.

Shell's HSSE Management System encompasses all activities associated with the decommissioning of the Curlew cluster, including services provided by its contractors. It provides the decommissioning project with a robust framework detailing Shell's environmental and societal objectives/targets and how it manages potential impacts and monitors its achievement of its targets. The system ensures effectiveness through continual monitoring, review and compliance, and if required, provides opportunities for the development of operational improvements throughout the project.

The options for the Curlew Decommissioning Project have been robustly selected through a formal CA process, developed in compliance with BEIS and OGUK guidelines, presented to and discussed with key stakeholders.

Mitigation measures, safeguards and controls to reduce impacts have been identified. These will be captured in the project's Environmental, Social and Community Health Management Plan, which will include roles and responsibilities for their implementation.

It is the conclusion of this EIA that the recommended options presented for the decommissioning of the Curlew infrastructure can be completed without causing unacceptable adverse impact on the environment, including cumulative and transboundary effects.

15.2. Mitigation Measures, Safeguards and Controls

Table 15-1 provides a summary of all mitigation measures, safeguards and controls for the project.

Table 15-1 Mitigation Measures, Safeguards and Controls for the Curlew Decommissioning Project

1.	SEABED DISTURBANCE
■	A combination of diver and diver-less techniques will be used for cutting and lifting operations to ensure accurate placement of cutting and lifting equipment and minimise seabed sediment impacts
■	An overtrawl survey will be undertaken to ensure clear seabed conditions following decommissioning activities and establish whether any additional mitigation is needed
■	The rock mass will be carefully placed over the designated areas of the pipelines and seabed by ROV and/or controlled fall pipe equipped with cameras, profilers, pipe tracker and other sensors as required
■	Optimisation of rock volume and footprint
■	The profile of the protective and stabilisation material over the pipeline and on the seabed will allow fishing nets to trawl over the rock unobstructed
2.	DISCHARGES TO SEA
■	Cleaning of pipelines and umbilicals to ALARP
■	Debris clearance from drill cuttings deposits using ROV
■	Shell consider that leaving the cuttings pile in situ is the most environmentally justified method for decommissioning, compared with methods that involve extensive disturbance of the cuttings pile and re-suspension of OBM-contaminated sediments into the marine environment.
■	Capping of Curlew C pipeline at both ends to contain both the wax and any entrained contaminants
3.	UNDERWATER NOISE
■	Machinery and equipment will be in good working order and well maintained
■	The number of vessels utilising DP would be minimised where possible

Table 15-1 Mitigation Measures, Safeguards and Controls for the Curlew Decommissioning Project (Continued)

4. ENERGY USE AND ATMOSPHERIC EMISSIONS
▪ Vessels will be audited as part of selection and pre-mobilisation
▪ All generators and engines will be maintained and operated to the manufacturers' standards to ensure maximum efficiency
▪ Vessels will use ultra-low sulphur fuel in line with MARPOL requirements
▪ Work programmes will be planned to optimise vessel time in the field
▪ Fuel consumption will be minimised by operational practices and power management systems for engines, generators and other combustion plant and maintenance systems
5. WASTE
▪ WMP in place, including management of NORM-contaminated fluids and equipment, prior to decommissioning
▪ Shell will ensure the principles of the Waste Management Hierarchy are followed during all activities to increase re-use/recycling and minimise landfill disposal
▪ Onward transportation agreements will be in place
▪ SRFP in place for the dismantling yard
▪ Compliance with country's waste legislation and duty of care
▪ Permits and traceable chain of custody for waste management, shipment, treatment and onshore disposal
▪ Duty of Care Audit(s) to be conducted on the selected yard to verify Curlew-specific Ship Recycling Plan
▪ Verify competence of personnel with waste management responsibilities
▪ Ensure subcontractor management process in place for third-party disposal sites

Table 15-1 Mitigation Measures, Safeguards and Controls for the Curlew Decommissioning Project (Continued)

■	Contract in place that adequately describes waste management requirements
■	Pre-qualification audits and site visits of potential dismantling yards.
■	Compliance with Corporate Framework Manual Waste guidance
■	Shell representative present at a selected dismantling yard, ensuring recycling and waste management being carried out in accordance with the SRFP
■	Direct transfer of ownership of the Curlew FPSO from Shell to a selected yard to avoid potential reselling of the vessel and its dismantling in location with lesser controls
6.	MARINE GROWTH
■	All vessels, including the towed FPSO, to follow IMO Convention for the Control and Management of Ships' Ballast Water and Sediments requirements
■	Application of the IMO 2011 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Species
■	Carry out IA of potential introduction and/or further contributions to existing populations of alien invasive species via ballast water exchange and hull fouling once the recycling yard is selected
7.	ACCIDENTAL EVENTS
■	Approved OPEP in place for decommissioning activities post-CoP and before the transit of the FPSO
■	Shell have specialist oil spill response services provided by OSRL and are members of the OPOL Fund
■	Local shipping traffic would be informed of proposed decommissioning activities and a standby/support vessel would monitor traffic continually during operations
■	Outwith the 500 m exclusion zone and in the event of an accidental release to sea, vessels will implement their Shipboard OPEP
■	All operations will be undertaken in a controlled manner, by trained personnel and using approved equipment
■	Observed leaks will be dealt with immediately by competent personnel and reported to the appropriate authorities

Table 15-1 Mitigation Measures, Safeguards and Controls for the Curlew Decommissioning Project (Continued)

■ During decommissioning operations, items will be secured to prevent loss wherever practicable
■ Where practicable and safe to do so, any dropped objects will be retrieved from the seabed
■ Once the decommissioning activities are completed, an independent seabed clearance survey and overtrawl survey will be undertaken
■ Tow plan and towing procedure in place
8. ONSHORE IMPACTS/YARDS
■ All shortlisted yards are compliant with the 2009 IMO Hong Kong Convention on the Safe and Environmentally Sound Recycling of vessels, and/or with the 2014 EU Regulation
■ SRFPs in place for all considered yards
■ All facilities are established and licensed yards with appropriate permits in place (e.g. Discharge Permit, Emission Permit, NORM Permit, Waste Permit, etc.)
■ Update to the Hazardous Material Inventory post-CoP and prior to arrival at the selected yard
■ Duty of Care and ongoing monitoring of waste management during the recycling process
■ Shell Representative being present at the dismantling yard during the duration of the recycling activities to ensure operations are carried out in accordance with agreed methods and practices
■ Thorough, multi-stage assessment process of the potential recycling yards

16. CONTACTING SHELL

If you have any views, concerns, comments or questions about the Curlew Decommissioning Project, you can contact the Shell Project Team by email:

Contact: Rob Jansen, Head of Projects Decommissioning Strategy

SUKEP-Shell-Decommissioning-Correspondence@shell.com@shell.com

[This page is intentionally blank]

17. REFERENCES

ABPmer. (2016). ABP Marine Environmental Research Ltd 2014 V1.0. [Accessed April 2017].

Aires, C, Gonzalez-Irusta, J.M., Watret, R. (2014). Updating Fisheries Sensitivity Maps in British Waters. Scottish Marine and Freshwater Science Report, Volume 5, No. 10. ISSN: 2043-7722. Marine Scotland Science. December 2014.

Anatec. (2016). Curlew Pipeline Decommissioning Fishing Risk Assessment. 16th December 2016. Rev. 01. Reference: A3880-SHE-RA-1.

Anthony, T. G., Wright, N. A., & Evans, m. A. (2009). Review of diver noise exposure. Report by QinetiQ for the Health and Safety Executive. Research Report No. RR735. (No. RR735).

Bakke, T., Klungsoyr, J., and Sanni, S. (2013). Environmental impacts of produced water and drilling waste discharges from the Norwegian offshore petroleum industry. Marine Environmental Research 92, 154 – 169.

BEIS. (2016a). Guidance notes for preparing Oil Pollution Emergency Plans For Offshore Oil and Gas Installations and Relevant Oil Handling Facilities. Accessed 2017: www.hse.gov.uk/osdr/assets/docs/guidance notes opeps rev1 may 2015.pdf.

BEIS. (2016b). 30th Round information. Accessed October 2017: https://www.ogauthority.co.uk/licensing consents/licensing rounds/offshore licensing rounds.

BMT Cordah. (1998). UKCS 18th Round Environmental Screening Report. Area II Central North Sea. UKOOA.BP, 2006. North West Hutton Decommissioning Programme.

BMT Cordah (2004). Environmental Statement in support of the De-commissioning of the North West Hutton Facilities, Report No. BPX067/ES/2003, June 2004

BODC (British Oceanographic Data Centre). (1998). United Kingdom Digital Marine Atlas, Third Edition.

BP (2006) North West Hutton Decommissioning Programme.

CEFAS. (2001). North Sea Fish and Fisheries. Technical report TR_003 produced for Strategic Environmental Assessment – SEA 2.

Certain, G., Jørgensen, L.L., Christel, I., Planque, B. & Bretagnolle, V. (2015). Mapping the vulnerability of animal community to pressure in marine systems: disentangling pressure types and integrating their impact from the individual to the community level. ICES Journal of Marine Science, 13pp.

CNRI,(2017). Ninian Northern Platform Late Life & Decommissioning Project; Environmental Statement; Report Number: P0005-BMT-EN-REP-00006; February 2017.

Colebrook, J. M. (1982). Continuous plankton records: seasonal variations in the distribution and abundance of plankton in the North Atlantic Ocean and the North Sea. Journal of Plankton Research. 4 (3): 435 – 462.

Coull, K.A., Johnstone, R., and Rogers, S.I. (1998). Fisheries Sensitivity Maps in British Waters. UKOOA Ltd.

Crown Estate. (2016). Energy and infrastructure shapefiles. Accessed October 2017: http://www.thecrownestate.co.uk/energy and infrastructure/downloads/.

De Robertis, A. and Handegard, N. O. (2013). Fish avoidance of research vessels and the efficacy of noise reduced vessels: a review. ICES Journal of Marine Science 70(1):34 45.

DECC. (2011). Guidance notes for decommissioning of offshore oil and gas Installations and Pipelines under the Petroleum Act 1998 (as amended). Version 6. March 2011.

DECC. (2016). UK Offshore Energy Strategic Environmental Assessment Future Leasing/Licensing for Offshore Renewable Energy, Offshore Oil & Gas, Hydrocarbon Gas and Carbon Dioxide Storage and Associated Infrastructure. OES Appendix 1a.7 Marine and Other Mammals.

DEFRA. (2010) Distribution of Arctica islandica in the United Kingdom and Isle of Man. Available online at: http://portal.oceannet.org/search/full/catalogue/dassh.ac.uk__MEDIN_2.3__26d6fce44e95d4516c0016420f4130f2.xml.

Dernie, K.M., Kaiser, M.J., and Warwick, R.M. (2003). Recovery rates of benthic communities following physical disturbance. Journal of Animal Ecology.

DEWI. (2004). Standardvefahren zur Ermittlung und Bewertung der Belastung der Meeresumwelt durch Schallimmissionen von Offshore Windenergieanlagen. (pp. 123): Deutsches Windenergie Institut. Abschlussbericht zum Forschungs vorhaben.

DNV. (2006). Monitoring, characterization and profiling of selected drill cuttings piles. Report Number 20060653.

DTI. (2001). Department of Trade and Industry, Strategic Environmental Assessment of the Mature Areas of the Offshore North Sea – SEA 2. Consultation Document. Report to the Department of Trade and Industry, September 2001.

DTI (2004). Strategic Environmental Assessment of parts of the Northern and Central North Sea to the east of the Scottish mainland, Orkney and Shetland. Sea 5.

DNV, (2017). Drill Cuttings Piles Management and Environmental Experiences. DNV Report No. 2017-4056, Rev. 01.

EEA. (2015). European Environmental Agency Status of marine fish stocks from: http://www.eea.europa.eu/data and maps/indicators/status of marine fish stocks 2/assessment.

Ellis, J. R., Milligan, S. P., Readdy, L., Taylor, N. and Brown, M. J. (2012). Spawning and nursery grounds of selected fish species in UK waters. Sci. Ser. Tech. Rep., Cefas Lowestoft, 147: 56 pp.

FAO. (2017). Arctica islandica Species Fact Sheets. Accessed September 2017: http://www.fao.org/fishery/species/3534/en.

Foden, J., Rogers, S.I., Jones, A.P. (2009) Recovery Rates of UK Seabed Habitats After Cessation of Aggregate Extraction. Marine Ecology Progress Series, 390, 15 26.

Fowler et al. (2004). Plan of Action for the Conservation and Management of Sharks in UK Waters. JNCC Report No.360. August 2004. ISSN 0963 8091.

FRS. (2000). Fishing gear interference with cuttings piles beneath oil installations after their decommissioning – the consequences for contamination spread. Fisheries Research Services Marine Laboratory Aberdeen (unpublished draft report finalised in 2000).

Fugro. (2013). Pipeline route survey UKCS Block 29/3, 29/7 & 29/8 Fram to Curlew. Habitat Investigation Results Volume 2 of 2. FRM2 PT GEN HE 7180 00002.

Fugro. (2016). Fugro Emu Limited. Curlew Pre Decommissioning Environmental Survey UKCS Block 29/7, 21 July to 23 July 2016. Fugro job No. 160788.

Gardline. (1997) Post-drill environmental survey of the sediments around the exploration Curlew-B, P1 well. Report number: 4950

Gardline (1998) Repeat Environmental Survey of the sediments around the exploration Curlew-B, P1 well. Report Number: 5212.

Gardline. (2006). Pipeline and umbilical route survey UKCS Block 29/7 Curlew C – Curlew FPSO: Environmental Survey 15th – 16th October 2006. Volume 1. Shell EPE Report ED 2006 033. Gardline Report No. 6994 Final Version.

Gatliff, R. R. (1994). United Kingdom Offshore Regional Report: The Geology of the Central North Sea. British Geographical Survey. HMSO.

Genesis. (2011). Review and Assessment of Underwater Sound Produced from Oil and Gas Sound Activities and Potential Reporting Requirements under the Marine Strategy Framework Directive. Genesis Oil and Gas Consultants Report for DECC, J71656.

Genesis,(2014) Assessment of possible effects of releases of oil and chemicals from disturbance of cuttings piles. Summary of supporting information.

Genesis. (2016). Curlew C flowline residual wax fate. Document no J74102A Y TN 24000/D2.

Goodlad I. (2003). Hutton T.L.P. Decommissioning Trawl Sweeps MV "Steadfast IV" FR443, SFF.

Hallett, m. A. (2004). Characteristics of merchant ship acoustic signatures during port entry/exit. Paper presented at the ACOUSTICS 2004, Gold Coast, Australia. 3 5 November 2004.

Hammond, P.S., Berggren, P., Benke, H.M. Borchers, D.L., Collet, A., Heide Jorgensen, M.P., Heimlich, S., Hiby, A.R., Leopold, M.F. and Oien, N. (2002). Abundance of Harbour Porpoise and Other Cetaceans in the North Sea and Adjacent Waters. Journal of Applied Ecology, Volume 39, No.2. April 2002. pp.361 376.

Hammond, P.S., Lacey, C., Gilles, A., Viquerat, S., Börjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M.B., Scheidat, M., Teilmann, J., Vingada, J., Øien, N. (2017). Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. Available online: https://synergy.st-andrews.ac.uk/scans3/category/researchoutput/.

Hannay, D. E., and MacGillivray. A. (2005). Comparative environmental analysis of the Piltun Astokh field pipeline route options: Sakhalin Energy Investment Company Ltd.

HSE (Health and Safety Executive). (1997). The abandonment of offshore pipelines: Methods and procedures for abandonment. Offshore technology report. HSE Books, Norwich. ISBN 7176 1421 2.

HSE (2005). The Hazardous Waste (England And Wales) Regulations 2005.

IOP. (2000). Guidelines for the calculation of estimates of energy use and emissions in the decommissioning of offshore structures.

IPCC. (2007). Intergovernmental Panel on Climate Change The Physical Science Basis. Contribution of working Group I to the fourth assessment report of the International Panel on climate change [Solomon, S., D. Quin, m. Maning., K.B. Averyt, m. Tignor and H.L. Miller (Eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996p.

ITOPF. (2012). International Tanker Owners Pollution Federation Limited, Response to Marine Oil Spills. 2nd Edition.

IUCN. (2017). International Union for the Conservation of Nature and Natural Resources, The IUCN Red List of Threatened Species. Accessed 2017: http://www.iucnredlist.org.

Jackson, D. and Mcleod, C. (2000). Handbook on the UK status of EC Habitats Directive interest features; provisional data on the UK distribution and extent of Annex I habitats and the UK distribution and population size of Annex II species. Revised 2002, s.l.: JNCC Report No. 312, pp. 180.

JNCC (1993). Seabird concentrations in the North Sea. An atlas of vulnerability to surface pollutants. Joint Nature Conservation Committee, Aberdeen.

JNCC. (2010). The Protection of marine European Protected Species from Injury and Disturbance. Guidance for the Marine area in England and Wales and the UK Offshore Marine area.

JNCC (2011). European Marine Protected Species. Internet: http://jncc.defra.gov.uk/page 5473. Accessed November 2016

JNCC (2014) JNCC Clarification on the habitat definitions of two habitat Features of Conservation Importance: Mud Habitats in deep water, and Sea-pen and burrowing megafauna communities.

JNCC (2015a). East of Gannet and Montrose Fields MPA, Available from http://jncc.defra.gov.uk/page-6478: [Accessed June 2017]

JNCC. (2015b). UK BAP priority marine features. Accessed June 2017 http://jncc.defra.gov.uk/page 5167.

JNCC. (2015c). Sea pen and burrowing megafauna communities. Available: http://jncc.defra.gov.uk/page 6028. Last accessed 31/08/2017.

JNCC. (2016). UK BAP priority species. Available at: http://jncc.defra.gov.uk/page-5717.

Johns D. and Reid m. (2001). Plankton Report for Strategic Environment Assessment Area 2. SAHFOS, Plymouth Marine Laboratory.

Johnston CM, Turnbull CG & Tasker ML. (2002). Natura 2000 in UK Offshore Waters. JNCC Report 325 http://jncc.defra.gov.uk/PDF/JNCC325 full.pdf.

Jones, E.L., McConnell, B.J., Smout, S., Hammond, P.S., Duck, C.D., Morris, C.D., Thompson, D., Russel, D.J.F., Vincent, C., Cronin, m., Sharples, R.J. and Matthiopoulos, J. (2015). Patterns of space use in sympatric marine colonial predators reveal scales of spatial partitioning. Marine Ecology Progress Series. 534: 235 249. DOI: 10.3354/meps11370.

Judd, A.G. (2005). The distribution and extent of methane-derived authigenic carbonate. Strategic Environmental Assessment, Area 6 (SEA6). Technical Report, s.l.: s.n.

Kafas, A., Jones, G., Watret, R., Davies, I. and Scott, B. (2012). Representation of the use of marine space by commercial fisheries in marine spatial planning. ICES CM I:23.

Kennedy, A. D. and Jacoby, C. A. (1999). Biological indicators of marine environmental health: Meiofauna A neglected benthic component? Environmental Monitoring and Assessment, 54 (1): 47 68.

Kennish, M. J. (1997) Pollution Impacts on Marine Biotic Communities. CRC Press LLC, USA, ISBN 0-8493-8428-1.

Kinnear, J.A.M., Barkel, P.J., Mojseiwicz, W.R., Chapman, C.J., Holbrow, A.J., Barnes, C., and Greathead, C.F.F. (1996). Effects of Nephrops creels on the environment. Fisheries Research Services Report No. 2/96.

Klinowska, M. (1991). Dolphins, Porpoises and Whales of the World. The IUCN Red Data Book. Gland, Switzerland, IUCN: 1-429.

Lissner, A.L., Taghon, G.L., Diener, D.R., Schroter, S.C. AND Dixon, J.D. (1991). Recolonisation of Deep Water Hard Substrate Communities: Potential Impacts from Oil and Gas Development. Ecological Applications 1:258–267. http://dx.doi.org/10.2307/1941755.

MacLeod, K., Simmonds, M.P., and Murray, E. (2003). Summer Distribution and Relative Abundance of Cetacean Populations off North-West Scotland. Journal of the Marine Biological Association of the United Kingdom 83, 1187-1192.

MAFF. (1981). Atlas of the Seas Around the British Isles. Directorate of Fisheries Research.

MarLIN. (2018). The Marine Life Information Network, Species lists. http://www.marlin.ac.uk/species/detail/1519#policy_legislation. Accessed January 2018.

Mitson, R. B. and Knudsen, H. P. (2003). Causes and effects of underwater noise on fish abundance estimation. Aquatic Living Resources 16:255 263.

MMO. (2016). Vessel Density Grid 2014. Accessed May 2017: https://data.gov.uk/dataset/vessel-density-grid-2014.

MMO. (2017). Marine Information System. Interactive marine plan mapping tool. Accessed April 2017: http://defra.maps.arcgis.com/apps/webappviewer/index.html?id=2c2f6e66c0464fa99d99fd6d8822ddef.

Molnar, J L, R L Gamboa, C Revenga, and m Spalding. (2008). Assessing the global threat of invasive species to marine biodiversity. Front. Ecol. Environ., 2008:6.

MPE (Ministry Of Petroleum And Energy), (1999). The final disposal of disused pipelines and cables. Summary of the findings of a Norwegian Assessment Programme. Oslo, December, 1999.

NAFO. (2011). Development of Encounter Protocols and Assessment of Significant Adverse Impact by bottom Trawling for Sponge Grounds and Sea Pen Fields in the NAFO Regulatory Area. E. Kenchington, F.J. Murillo, A. Cogswell, C. Lirette. December 2011.

Nedwell, J. R., & Edwards, B. (2004). A Review of Measurements of Underwater Man Made Noise Carried out by Subacoustech Ltd, 1993 – 2003. Subacoustech Ltd Report Ref 534R0109.

Nedwell, J.R., Turnpenny, A.W.H., Lovell, J., Parvin, S.J., Workman, R., Spinks, J.A.L. and Howell, D. (2007). A validation of the dBht as a measure of the behavioural and auditory effects of underwater noise. Subacoustech Report Reference: 534R1231, Published by Department for Business, Enterprise and Regulatory Reform.

Nielsen, T. G. and Richardson, K. (1989). Food chain structure of the North Sea plankton communities: seasonal variations of the role of the microbial loop. Marine Ecology Progress Series. 56: 75-87.

NMPi (2016). National Marine Interactive Planning Tool. Accessed April 2017: http://marinescotland.atkinsgeospatial.com/nmpi/.

NOAA. (2015). National Oceanic and Atmospheric Administration. Draft Guidance for Assessing the Effect of Anthropogenic Sound on Marine Mammal hearing. Underwater Acoustic Threshold Levels for Onset of Permanent and Temporary Threshold Shifts. July 23, 2015.

North Sea Task Force. (1993). North Sea Quality Status Report 1993. Oslo and Paris Commissions. Fredenborg, Denmark: Olsen and Olsen. development on the feather microstructure of pelagic seabirds. Marine Pollution Bulletin. 60(5):672-8.

Northridge, S.P., Tasker, M.L., Webb, A. and Williams, J.M. (1995). Distribution and relative abundance of harbour porpoise (Phocoena phocoena L.), white-beaked dolphins (Lagenorhynchus albirostris Gray), and minke whales (Balaenoptera acutorostrata Lacepede) around the British Isles. ICES Journal of Marine Science 52, 55-56.

NRC. (2003). National Research Council. Ocean Noise and Marine Mammals. (No. National Research Council of the National Academies, Washington DC).

OESEA3. (2016). UK Offshore Energy Strategic Environmental Assessment. OESEA3 Environmental Report. March 2016.

OGA. (2016). Oil and Gas Authority. Shipping Density. Accessed May 2017: https://www.ogauthority.co.uk/media/1419/29r_shipping_density_table.pdf.

OGP. (2005). Fate and effects of naturally occurring substances in produced water on the marine environment. Report No. 364. February 2005. OGP (International Association of Oil and Gas Producers).

OGUK. (2013). Oil & Gas UK. Long-term Degradation of Offshore Structures and Pipelines Decommissioned and Left in situ, Oil and Gas UK. February 2013.

OGUK. (2015). Oil and Gas UK's Guidelines for Comparative Assessment in Decommissioning Programmes.

OGUK. (2016a). Sensitivity of offshore seabird concentrations to oil pollution around the United Kingdom: Report to Oil & Gas UK. Prepared for Oil & Gas UK by HiDef Arial Surveying Limited. Document number: HP00061 701. 01 April 2016.

OGUK. (2016b). Environmental Report 2016. Accessed October 2017: https://oilandgasuk.co.uk/product/oil gas uk environment report 2016/.

OSPAR. (2006). Recommendation 2006/5 on a Management Regime of Offshore Cuttings Piles. OSPAR 06/23/1 E, Annex 16. Meeting of the Offshore Industry Committee (OIC), Stockholm: 26 30 June 2006. Internet: http://www.ospar.org/documents/dbase/decrecs/recommendations/06 05e_Rec%20drill%20cuttings%20regime.doc.

OSPAR. (2009). Assessment of impacts of offshore oil and gas activities in the North East Atlantic. OSPAR Commission. 2009.

OSPAR. (2010a). Plankton Quality Status Report 2010 Impacts of climate change on the North-East Atlantic ecosystem. Available at: http://qsr2010.ospar.org/media/assessments/P00463_supplements/13_plankton.pdf.

OSPAR. (2010b). Background Document for Seapen and Burrowing megafauna communities. Biodiversity Series.

OSPAR. (2014). Levels and Trends in Marine Contaminants and their Biological Effects – CEMP Assessment Report 2013. Monitoring and Assessment Series. OSPAR Commission London. Publication No. 631/2014.

OSPAR, (2016). Impacts of Certain Pressure of the Offshore Oil and Gas Industry on the Marine Environment – Stocktaking Report.

OSPAR. (2017). List of Threatened and/or Declining Species & Habitats. Available at: https://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats.

Popper, A. N., & Hastings, m. C. (2009). The Effects of Anthropogenic Sources of Sound on Fishes. Journal of Fish Biology, 75(3), 455 489.

Reid, J.B., Evans, P.G.H. and Northridge, S.P. (Eds.). (2003). Atlas of cetacean distribution in north west European waters. JNCC, Peterborough.

RF (2003). UKOOA phase III – Task 3. Joint report on factors determining future pile characteristics. Report to DNV for UKOOA drill cuttings initiative phase II. Rogaland Research Report RF-2001/220

Richardson, W. J., Greene Jr., C. R., Malme, C. I., & Thomson, D. H. (1995). Marine mammals and noise. Academic Press, San Diego.

Robinson, G. (1970). Continuous Plankton Records: Variations in the Seasonal Cycle of Phytoplankton in the North Atlantic. Bull. Mar. Ecol, 6, 33-345.

Robson, L. (2014). JNCC clarifications on the habitat definitions of two habitat Features of Conservation Importance Mud habitats in deep water, and; Sea-pen and burrowing megafauna communities.

Rogers, S. & Stocks, R. (2001). North Sea Fish and Fisheries, Technical Report produced for Strategic Environmental Assessment SEA2: CEFAS.

SCANS III. (2017). Small Cetaceans in the European Atlantic and North Sea. Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS III aerial and shipboard surveys, May 2017. SCANS III. Accessed October 2017: https://synergy.st andrews.ac.uk/scans3/2017/05/01/first results are in/.

Schulkin, m., & Mercer, J. A. (1985). Colossus revisited: A review and extension of the Marsh Schulkin shallow water transmission loss model (1962). (No. APL UW 8508).

Scottish Government. (2016). Fishing Effort and Quantity and Value of Landings by ICES Rectangle. Accessed June 2017: http://www.gov.scot/Topics/Statistics/Browse/Agriculture Fisheries/Rectangle Data.

Sea2Cradle. (2016). Final Inventory of Hazardous Materials Prior to Recycle – FPSO Curlew. July 2016. Prepared by Sea2Cradle B.V.

Shell. (2008) Initial Screening Assessment of UKCS Cuttings Piles. Prepared by Aquatera Ltd. P254, February 2007. Rev. 1.1.

Shell. (2013). Pipeline route survey UKCS Block 29/3, 29/7 and 29/8. Fram to Curlew. Survey Period 05 – 16 October 2013. Shell UK Limited Report No.: ED-2013-068. FSLTD Report No.: 131105.2V1.1

Shell. (2015). Curlew Field System Offshore Oil Pollution Emergency Plan.

Shell. (2016a). Waste Guide: Shell HSSE & SP Control Frameork. Environment Manual, Version 1. March 2016.

Shell. (2016b). CDP – Curlew C pipeline cleaning report.

Shell. (2017a). Subsea Comparative Assessment Methodology Report (Document Number EOFL PT S QA 6050 00001).

Shell. (2017b). Fram 2 Field Development. Environmental Statement.

Shell. (2017c). Curlew decommissioning project: Exchange of Correspondence, Revision A.01. Doc no CDP-PT-S-AA-6179-00001, 27 October 2017.

Shell. (2017d). Waste Management Strategy, Projects and Technology UK & Ireland Operated Projects: End of Field Life Projects. Document Number: CDP PT S HX 5980 00003. July 2017.

SMRU. (2001). Sea Mammal Research Unit Background Information on Marine Mammals Relevant to SEA 2. Technical Report produced for Strategic Environmental Assessment – SEA 2. Technical Report TR_006.

SNH. (2014). Scottish Natural Heritage. Priority Marine Features in Scotland's seas. http://www.snh.gov.uk/protecting-scotlands-nature/priority-marine-features/priority-marine-features/. [Accessed July 2017].

SNH. (2017). Invasive non-native species. Internet: https://www.snh.scot/professional-advice/safeguarding-protected-areas-and-species/protected-species/invasive-non-native-species. Accessed November 2017.

Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene, C. R., et al. (2007). Marine Mammal Noise Special Issue: Exposure Criteria: Initial Scientific Recommendations Aquatic Mammals.

Thaxter, C.B., Lascelles, B.L., Sugar, K., Cook, A. S. C. P., Roos, S., Bolton, M., Langston, R. H. W. and Burton, N. H. K. (2012). Seabird foraging ranges as preliminary tool for identifying candidate marine protected areas. Biological Conservation. 156: 53-61.

Troffe, P.M., Levings, C.D., Piercey, G.E. and Keong, V. (2005). Fishing gear effects and ecology of the sea whip (Halipteris willemoesi (Cnidaria: Octocorallia: Pennatulacea)) in British Columbia, Canada: preliminary observations. Aquatic Conservation: Marine and Freshwater Ecosystems, 15: 523-533.

UKDMAP. (1998). United Kingdom Digital Marine Atlas – An Atlas of the Sea around the British Isles. 3rd Edition Software by the British Oceanographic Data Centre, Birkenhead.

UKOOA. (2001). An Analysis of UK Offshore Oil and Gas Environmental Surveys 1975 to 1995. A study carried out by Heriot-Watt University at the request of UKOOA. pp. 132 and appendices.

UKOOA. (2002). Drill Cuttings JIP Task 6. Drill Cuttings Recovery Project. Final Report.

UKOOA, (2005). UKOOA JIP 2004 Drill Cuttings Initiative Phase III: Final Report. Report for Submission to DTI. Report number 20132900, 26 January 2005

Urick, R. J. (1983). Principles of Underwater Sound (3rd ed.). New York: McGraw-Hill.

Webb, A., Elgie, m., Irwin, C., Pollock, C. and Barton, C. (2016). Sensitivity of offshore seabird concentrations to oil pollution around the United Kingdom: Report to Oil & Gas UK. Document No HP00061701.

Wrecksite. (2017). UK Wreck information. Accessed June 2017: http://www.wrecksite.eu/.

APPENDIX A. ASPECTS SCOPED OUT OR CARRIED FORWARD FOR IMPACT ASSESSMENT

Table A1 Aspects Scoped out from Further Assessment or Carried Forward for Further Assessment

Category	Assessment Outcome				
	Negligible		Minor		Moderate
	Proposed to be Scoped out from Further Assessment	Carried Forward for Further Assessment	Proposed to be Scoped out from Further Assessment	Carried Forward for Further Assessment	Carried Forward for Further assessment
Release/discharge of chemicals	Hazardous drains (machinery space drainage) on vessels – potential discharge into the water around the discharge point (permitted activity) Release of contaminated fluids in the marine environment from the disconnection of pipeline systems and umbilicals (permitted activity) Overboard disposal of the fluids associated with decommissioning activities from the FPSO waters flushed through treatment systems on the FPSO – potential release of chemicals and/or NORM contaminants into the water column (permitted activity)		Release of contaminants from the subsea structures and risers as they are lifted from the seabed to the supporting vessels and transported to shore – loss of residual contents (permitted activity)	Release of chemicals from blocked umbilical cores – potential deterioration of water quality leading to environmental impact (permitted activity) Drill cuttings pile and deposits (leave in situ) – slow release of small volume of contaminated material	
Ecological impact				Rock placement in connection with in situ infrastructure and pipeline route length – placed on the seabed to fill the hole created by the dredging operation and cover the pipeline ends (as above) – change of habitat type and therefore benthic community Cleaning FPSO cargo tanks, ballast tanks and slops tanks etc., water treatment system – ecological effects to marine species from chemical contamination of land, sea and air	
Marine Invasive Species	Ballast management on vessels (FPSO, tow vessel, supply vessel etc.) – potential introduction of non-native species			Marine growth on subsea structures – potential introduction/movement of non-native or protected species	Marine growth on supporting vessels – potential introduction of non-native species Transit of the FPSO to recycling onshore location – potential introduction of non-native species
Noise		Underwater noise associated with cutting operations – avoidance behaviour in sea mammals and fish		Underwater noise associated with vessel engines, dynamic positioning thrusters and onboard equipment. Underwater noise associated with the use of sonar and other acoustic survey equipment. Noise associated with the dismantling activities of the FPSO – potential limited disturbance on human populations	
Seabed disturbance		Seabed disturbance from decommissioning mooring system of the FPSO – seabed disturbance from mooring chain and pile trenches		Dredging operations of pipeline and sub-seabed structures being exposed (including leave in situ, partial removal and full removal). – direct impact to benthic communities and species from displacement and redistribution of seabed sediments Reburial (trench and bury) – displacement and redistribution of seabed sediments Drill cuttings disturbance (pile and deposits) from removal of subsea equipment/structures – localised seabed disturbance Cutting and removal of subsea structures – alteration of sediment structure	

Table A1 Aspects Scoped out from Further Assessment or Carried Forward for Further Assessment (Continued)

Category	Assessment Outcome				
	Negligible		Minor		Moderate
	Proposed to be Scoped out from Further Assessment	Carried Forward for Further Assessment	Proposed to be Scoped out from Further Assessment	Carried Forward for Further Assessment	Carried Forward for Further assessment
Energy use and atmospheric emissions		E&E from vessels – to be carried through to the Decommissioning and Energy and Emissions Study E&E from helicopters		E&E from the onshore dismantling activities and recycling of the FPSO – emissions resulting in deterioration to surrounding air quality	
Waste	Solid waste produced from supporting vessels – use of landfill facilities				Waste management from dismantling of the FPSO including fluid disposal onshore – potential for exceeding local waste disposal resources, and possible NORM waste from the pipelines Waste management from removal, recycling and disposal pipelines and associated contaminated materials onshore – potential for exceeding local waste disposal resources, and possible NORM waste from the pipelines
Societal				Wet tow of FPSO to dismantling onshore location outside of North Sea – local community concerns FPSO crew deployment – low morale, potential livelihood issues Dismantling of FPSO – potential visual and noise impacts to local residents and potential release of contamination Transport of steel and other materials to recycling and waste disposal sites – potential disturbance from increase road traffic	
Physical presence			Physical increased presence of vessels during decommissioning activities (in transit to decommissioning site and out with the 500 m exclusion zone) Wet tow of FPSO to dismantling onshore location outside of North Sea – increased risk of collision to commercial users	Subsea equipment (for example: mattresses, grout bags, spool pieces etc.) left in situ – potential snagging hazard for commercial fisheries resulting in loss of gear and catch. Drill cuttings pile and deposits (leave in situ) – fishing catch and gear contamination leading to loss of livelihood or additional cost to fishermen	
Water Quality		Bracelet anodes located around the pipelines to prevent corrosion left in situ – potential deterioration of water quality Long-term impact from residual contaminants from the degradation of pipelines, umbilicals and other subsea equipment left in situ – corrosion of pipelines and subsea structures leading to release of contaminants and metals into the marine environment			

Table A1 Aspects Scoped out from Further Assessment or Carried Forward for Further Assessment (Continued)

Category	Assessment Outcome				
	Negligible		Minor		Moderate
	Proposed to be Scoped out from Further Assessment	Carried Forward for Further Assessment	Proposed to be Scoped out from Further Assessment	Carried Forward for Further Assessment	Carried Forward for Further assessment
Accidental Events				Accidental release of fuel from supporting vessels – from vessel collision leading to potential hydrocarbon release Accidental releases of chemicals from supporting vessels from vessel collision leading to chemical release Accidental dropped objects and debris from supporting vessels – loss of fishing grounds from obstruction to commercial fishing area All accidental events will be taken forward to the next stage of the assessment and will be covered in the IA reports in a specific chapter.	Accidental leak of hydrocarbons or chemicals from oil storage tanks during transport and/or dismantling of FPSO – potential vessel collision leading to spill of diesel or chemicals into the marine environment Loss of FPSO under tow – potential collision or grounding of vessel with release of hydrocarbons Loss of control of tow – potential collision or grounding and loss of vessel with release of hydrocarbons
Release Discharge of chemicals	Hazardous drains (machinery space drainage) on vessels – potential discharge into the water around the discharge point (permitted activity) Release of contaminated fluids in the marine environment from the disconnection of pipeline systems and umbilicals (permitted activity) Overboard disposal of the fluids associated with decommissioning activities from the FPSO waters flushed through treatment systems on the FPSO – potential release of chemicals and/or NORM contaminants into the water column (permitted activity)		Release of contaminants from the subsea structures and risers as they are lifted from the seabed to the supporting vessels and transported to shore – loss of residual contents (permitted activity)	Release of chemicals from blocked umbilical cores – potential deterioration of water quality leading to environmental impact (permitted activity) Drill cuttings pile and deposits (leave in situ) – slow release of small volume of contaminated material	
Ecological impact				Rock placement in connection with in situ infrastructure and pipeline route length – placed on the seabed to fill the hole created by the dredging operation and cover the pipeline ends (as above) – change of habitat type and therefore benthic community Cleaning FPSO cargo tanks, ballast tanks and slops tanks etc., water treatment system – ecological effects to marine species from chemical contamination of land, sea and air	
Marine Growth/Invasive Species	Ballast management on vessels (FPSO, tow vessel, supply vessel etc.) – potential introduction of non-native species			Marine growth on subsea structures – potential introduction/movement of non-native or protected species	Marine growth on supporting vessels – potential introduction of non-native species Wet tow of FPSO to dismantling onshore location outside of the North Sea – potential introduction of non-native species
Noise		Underwater noise associated with cutting operations – avoidance behaviour in sea mammals and fish		Underwater noise associated with vessel engines, dynamic positioning thrusters and onboard equipment. Underwater noise associated with the use of sonar and other acoustic survey equipment. Noise associated with the dismantling activities of the FPSO – potential limited disturbance on human populations	

Table A1 Aspects Scoped out from Further Assessment or Carried Forward for Further Assessment (Continued)

Category	Assessment Outcome				
	Negligible		Minor		Moderate
	Proposed to be Scoped out from Further Assessment	Carried Forward for Further Assessment	Proposed to be Scoped out from Further Assessment	Carried Forward for Further Assessment	Carried Forward for Further assessment
Seabed disturbance		Seabed disturbance from decommissioning mooring system of the FPSO – seabed disturbance from mooring chain and pile trenches		Dredging operations of pipeline and sub-seabed structures being exposed (including leave in situ, partial removal and full removal) – direct impact to benthic communities and species from displacement and redistribution of seabed sediments Reburial (trench and bury) – displacement and redistribution of seabed sediments Drill cuttings disturbance (pile and deposits) from removal of subsea equipment/structures – localised seabed disturbance Cutting and removal of subsea structures – alteration of sediment structure	
Energy use and atmospheric emissions		E&E from vessels – to be carried through to the Decommissioning and Energy and Emissions Study E&E from helicopters		E&E from the onshore dismantling activities and recycling of the FPSO – emissions resulting in deterioration to surrounding air quality	
Waste	Solid waste produced from supporting vessels – use of landfill facilities				Waste management from dismantling of the FPSO including fluid disposal onshore – potential for exceeding local waste disposal resources, and possible NORM waste from the pipelines Waste management from removal, recycling and disposal pipelines and associated contaminated materials onshore – potential for exceeding local waste disposal resources, and possible NORM waste from the pipelines
Societal				Wet tow of FPSO to dismantling onshore location outside of North Sea – local community concerns FPSO crew deployment – low morale, potential livelihood issues Dismantling of FPSO – potential visual and noise impacts to local residents and potential release of contamination Transport of steel and other materials to recycling and waste disposal sites – potential disturbance from increase road traffic	
Physical presence			Physical increased presence of vessels during decommissioning activities (in transit to decommissioning site and outwith the 500 m exclusion zone) Wet tow of FPSO to dismantling onshore location outside of North Sea – increased risk of collision to commercial users	Subsea equipment (for example: mattresses, grout bags, spool pieces etc.) left in situ – potential snagging hazard for commercial fisheries resulting in loss of gear and catch. Drill cuttings pile and deposits (leave in situ) – fishing catch and gear contamination leading to loss of livelihood or additional cost to fishermen	

Table A1 Aspects Scoped out from Further Assessment or Carried Forward for Further Assessment (Continued)

Category	Assessment Outcome				
	Negligible		Minor		Moderate
	Proposed to be Scoped out from Further Assessment	Carried Forward for Further Assessment	Proposed to be Scoped out from Further Assessment	Carried Forward for Further Assessment	Carried Forward for Further assessment
Water Quality		Bracelet anodes located around the pipelines to prevent corrosion left in situ – potential deterioration of water quality Long-term impact from residual contaminants from the degradation of pipelines, umbilicals and other subsea equipment left in situ – corrosion of pipelines and subsea structures leading to release of contaminants and metals into the marine environment			
Accidental Events				Accidental release of fuel from supporting vessels – from vessel collision leading to potential hydrocarbon release Accidental releases of chemicals from supporting vessels from vessel collision leading to chemical release Accidental dropped objects and debris from supporting vessels – loss of fishing grounds from obstruction to commercial fishing area All accidental events will be taken forward to the next stage of the assessment and will be covered in the IA reports in a specific chapter.	Accidental leak of hydrocarbons or chemicals from oil storage tanks during transport and/or dismantling of FPSO – potential vessel collision leading to spill of diesel or chemicals into the marine environment Loss of FPSO under tow – potential collision or grounding of vessel with release of hydrocarbons Loss of control of tow – potential collision or grounding and loss of vessel with release of hydrocarbons

[This page is intentionally blank]

APPENDIX B. ENERGY AND EMISSIONS FACTORS

Table B1 Energy Consumption and Gaseous Emissions Factors Used in the Calculations of the Recycling of Materials

Materials	Energy (GJ/tonne)	Emissions (kg/tonnes)				Source
		CO_2	NOx	SO_2	CH_4	
Standard steel	9	960	1.6	3.8	ND	IOP (2000)
Plastics	3.6	ND	ND	ND	ND	IOP (2000)
Aluminium	15	1080	1.3	1.7	ND	IOP (2000)
Copper	25	300	1.3	120	ND	IOP (2000)
Zinc	10	148	1.3	1.7	ND	IOP (2000)

ND = No data available for the conversion

Table B2 Energy Consumption and Gaseous Emissions Factors Used in the Calculations of the Manufacture of New Materials

Materials	Energy (GJ/tonne)	Emissions (kg/tonnes)				Source
		CO_2	NOx	SO_2	CH_4	
Standard steel	25	1889	3.5	5.5	ND	IOP (2000)
Plastics	77	ND	ND	ND	ND	IOP (2000)
Aluminium	215	3589	4.1	24.9	ND	IOP (2000)
Copper	100	7175	20	200	ND	IOP (2000)
Zinc	65	24	0.3	3.7	ND	IOP (2000)

ND = No data available for the conversion

Table B3 Energy Consumption and Gaseous Emissions Factors Used in the Calculations for Fuel Use

Fuel type	Energy (GJ/tonne)	Emissions (kg/tonnes)				Source
		CO_2	NOx	SO_2	CH_4	
Marine diesel	43.1	3,200	59.4	4	0.180	EEMS (2008)

ND = No data available for the conversion

Table B4 Energy Consumption and Gaseous Emissions Factors Used in the Calculations for Vessel use

Vessel	Rate of Fuel Consumption (tonnes/day)				Source/Comments
	In port	In transit	Working	Waiting on Weather	
Overtrawl vessel and heading support vessel	2	26	18	9	IOP (2000) values Multi- support vessel (MSV)
Station-keeping vessels	1	10	17	17	IOP (2000)for cargo barge tug
Station-keeping and towing vessel	2	50	5	30	(IOP, 2000) for anchor handling vessel
DSV (and ROV Support vessel)	3	22	18	10	IOP (2000)for Diving Support Vessel (DSV)
Rock vessel	2	8	15	15	IOP (2000) values for rock dump vessel