Mariner Area Development

Environmental Statement

DECC Project reference: D/4145/2012

Statoil

Nautical Petroleum

eni

INFORMATION PAGE

Project name:	Mariner Area Development		
DECC Project reference:	D/4145/2012		
Type of project:	Field Development		
Undertaker Name:	Statoil (UK) Limited		
Address:	One Kingdom Street London W2 6BD		
Licensees/Owners:		**Block 9/11a**	**Block 9/11b**
	Statoil (UK) Limited	65.1111%	92%
	ENI ULX Limited	20.0000%	8%
	ENI AEP Limited	6.6667%	-
	ENI UKCS Limited	2.2222%	-
	Alba Resources Limited (Nautical Petroleum)	6.0000%	-
Short description:	Statoil and its licence partners propose to develop the Mariner and Mariner East fields that are located in Quadrant 9 of the UK northern North Sea. The overall development proposal includes 50 wells and 92 sidetracks at Mariner field and 4 wells at Mariner East, the installation of a production, drilling and quarters (PDQ) platform, a floating storage and offloading unit (FSU), a subsea drilling template, a Pipeline End Manifold, six Pipeline End Terminations, and associated infield, import and export pipelines. Wells at the Mariner field will be drilled from the PDQ platform and from a jack-up drilling rig located alongside for a period of 4 to 5 years, while the Mariner East wells will be drilled using a semi-submersible drilling rig. Oil from the Mariner Area Development will be separated from gas and water on the PDQ platform. Produced water from the development will be re-injected back into the reservoir. The oil will be exported to and stored in the FSU, and from there transferred to shuttle tankers for transport to shore. Produced gas will be used to fuel the turbines on the PDQ, with additional gas imported via a connection from the existing Vesterled pipeline.		
Anticipated commencement of works:	2015		
Date and reference number of any earlier Statement related to this project:	Not applicable		
Significant environmental impacts identified:	None		
Statement prepared by:	Statoil (UK) Limited and BMT Cordah Limited		

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ABBREVIATIONS

Abbreviations	
3LPP	3-layer Polypropylene Coating
µPa	Micropascals
AHV	Anchor Handling Vessel
ALARP	As Low As Reasonably Practicable
AOR	Asset Owner Representative
API	American Petroleum Institute
Ba	Barium
BAP	Biodiversity Action Plan
$BaSO_4$	Barium Sulphate
BAT	Best Available Technique
bbl/day	Barrels per day
bbls	Barrels
BC	Background Concentration
BCLT	Business Case Leadership Team
BEP	Best environmental practice
BGS	British Geological Survey
BMIT	Bottom Mounted Internal Turret
BOD	Biological Oxygen Demand
BOP	Blow-out Preventer
BSI	British Standard Institute
CaCl	Calcium Chloride
CCS	Carbon Capture and Storage
Cd	Cadmium
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CFCs	Chlorofluorocarbon gases
CH_4	Methane
CHARM	Chemical Hazard Assessment & Risk Management
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CoP	Cessation of Production
CPA	Coastal Protection Act
Cr	Chromium
Cu	Copper
CVP	Capital Value Process
dB	Decibels
DECC	UK Government’s Department of Energy and Climate Change

Abbreviations	
DEFRA	Department of Environment, Food and Rural Affairs
DES	Drilling Equipment Set
DG1	Decision Gate (1, 2, 3,.. etc.)
DLE	Dry Low Emission
DMA	Dead Man Anchor
DNV	Det Norse Veritas
DP (vessel)	Dynamic Positioning / Dynamically Positioned
DPI EA	Development and Production International, Europe and Asia
DQ	Drilling Quarters
DSM	Drilling Support Module
DSV	Dive Support Vessel
DTI	Department of Trade and Industry
DWT	Dead Weight Tonnage
EC	European Commission
EDU	Energy Development Unit
EEA	European Environment Agency
EEC	European Economic Community
EEMS	Environmental Emissions Monitoring System
EIA	Environmental Impact Assessment
EMS	Environmental Management System
EMT	Environmental Management Team
ENVID	Environmental Impact Identification
EPRA	Early Phase Risk Assessment
EPC	Engineering, Procurement and Construction
EPS	European Protected Species
ERT	Emergency Response Team
ES	Environmental Statement
ESA	Environmentally Sensitive Areas
ESP	Electric Submersible Pump
EU	European Union
ETS	Emissions Trading Scheme
EUNIS	The European Nature Information System
FBE	Fusion Bonded Epoxy
FEED	Front End Engineering Design
FEPA	Food and Environment Protection Act
FLAGS	Far North Liquids and Associated Gas System (pipeline)
FLO	Fisheries Liaison Officer
FPSO	Floating, Production, Storage and Offloading

Abbreviations	
FSL	Fugro Survey Limited
FSU	Floating Storage Unit
FUKA	Frigg UK (pipeline)
GBS	Gravity Based Structure
GRT	Gross Register Tonnage
H_2S	Hydrogen Sulphide
HASS	High Activity Sealed Source
HAZID	Hazard Identification Study
HCFCs	Hydrochlorofluorocarbon gases
Hg	Mercury
HLV	Heavy Lift Vessel
HOCNS	Harmonised Offshore Chemical Notification Scheme
HP	High Pressure
HSE	Health and Safety Executive
HSE (Policy)	Health, Safety and Environment
HTV	Heavy Transport Vessel
Hz	Hertz
IBA	Important Bird Areas
ICES	International Council for the Exploration of the Sea
IMO	International Maritime Organisation
IoP	Institute of Petroleum
IOPP	International Oil Pollution Prevention Certificate
IPPC	Integrated Pollution Prevention and Control
ISO	International Standards Organisation
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
KCl	Potassium Chloride
kHz	kilohertz
KISKA	Kingfisher Information Service Cable Awareness
LAT	Lowest Astronomical Tide
LCP	Large Combustion Plant
LNR	Local Nature Reserve
L_R	Received Sound Level
L_S	Source Sound Level
LSA	Low Specific Activity
LTOBM	Low Toxicity Oil Based Mud
LWD	Logging While Drilling
MARPOL	The International Convention for the Prevention of Pollution from Ships

Abbreviations	
max	Maximum
MCA	Maritime and Coastguard Agency
MCAA	Marine and Coastal Access Act
MCZ	Marine Conservation Zone
MDAC	Methane Derived Authigenic Carbonate
min	Minimum
MMO	Marine Management Organisation
MoD	Ministry of Defence
MPA	Marine Protected Area
MS	Marine Scotland
MSA	Marine (Scotland) Act
MW	Mega Watt
MWD	Measurement While Drilling
N/A	Not Applicable
N_2O	Nitrous Oxide
NaCl	Sodium Chloride
ND	Not Detected
NER	New Entrants Reserve
nm	Nautical mile
NNR	National Nature Reserve
NNS	Northern North Sea
NO	No Data
NO_x	Oxides of nitrogen
NO_2	Nitrogen dioxide
NORBRIT	Norway-UK Joint Contingency Plan
NORM	Naturally Occurring Radioactive Materials
NSA	National Scenic Area
NSTF	North Sea Task Force
OBF	Oil Based Fluid
OBM	Oil Based Mud
OCNS	Offshore Chemical Notification Scheme
OIM	Offshore Installation Manager
OPEP	Oil Pollution Emergency Plan
OPF	Organic Phase Fluids
OPPC	Oil Pollution Prevention and Control
OPRC	Oil Pollution Preparedness, Response and Co-operation
OSCAR	Oil Spill Contingency and Response model
OSPAR	Oslo and Paris Conventions for the protection of the marine environment of

Abbreviations	
	the North-East Atlantic
OVI	Offshore Vulnerability Index
Pa	Pascals
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCB	Poly Chlorinated Biphenyls
PCZ	Preferred Conservation Zones
PDQ	Production Drilling Quarters
PEXA	(Military) Practice and Exercise Area
PLEM	Pipeline End Manifold
PLET	Pipeline End Termination
PON	Petroleum Operations Notice
POPA	Prevention of Oil Pollution Act
PPC	Pollution, Prevention and Control
PPD	Public Participation Directive
ppb	Parts per Billion
ppm	Parts per Million
ppt	Parts per Thousand
PTS	Permanent Threshold Shift (to hearing)
PW	Produced Water
PWA	Pipeline Works Authorisation
PWRI	Produced Water Re-Injection
Q	Annual Quarter
RA	Reference Areas
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
ROV	Remotely Operated Vehicle
SAC	Special Area of Conservation (c-candidate, d-draft, m-marine, p-possible)
SAGE	Scottish Area Gas Evacuation
SAST	Seabirds at Sea Team
SBF	Synthetic Based Fluid
SBM	Synthetic Based Muds
SCANS	Small Cetaceans Abundance in the North Sea and Adjacent waters
SCI	Sites of Community Importance
SCOS	Special Committee on Seals
SDS	Stern Discharge System
SEA	Strategic Environmental Assessment
SEL	Sound Exposure Level
SEPA	Scottish Environment Protection Agency

Abbreviations	
SFF	Scottish Fishermans Federation
SMRU	Sea Mammal Research Unit
SNH	Scottish Natural Heritage
SO_2	Sulphur Dioxide
SOE	State of the Environment
SOPEP	Shipboard Oil Pollution Emergency Plan
SOSREP	The Representative of the Secretary of State for Energy and Climate Change
SO_x	Oxides of Sulphur
SPA	Special Protection Area
SPL	Sound Pressure Level
spp.	Species (plural)
SS	Suspended Solids
SSCV	Semi-submersible Crane Vessel
SSIV	Subsea Isolation Valve
SSSI	Sites of Special Scientific Interest
STL	Submerged Turret Loading
tan	Tangent (function)
THC	Total Hydrocarbon Concentration
TPD	Technology, Projects and Drilling
TR	Technical Requirement
UB	Undersea Boat
UHB	Upheaval Buckling
UKCS	United Kingdom Continental Shelf
UKHO	United Kingdom Hydrographic Office
UKOOA	United Kingdom Offshore Operators Association
UKOPP	UK Oil Pollution Prevention
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States
VMR	Voluntary Marine Reserves
VMS	Vessel Monitoring System
VOC	Volatile Organic Compound
VSP	Vertical Seismic Profiling
WBM	Water Based Mud
WEEE	Waste Electrical and Electronic Equipment Directive
WHS	World Heritage Site
WWI	World War I
WWII	World War II

GLOSSARY

GLOSSARY	
Benthic fauna	Organisms that live on, near, or in the bottom sediments of the seabed.
Benthos	See ‘Benthic Fauna’.
Biogeographic area	An area of the Earth as defined by the flora and fauna found there.
Block	A North Sea acreage sub-division measuring approximately 10km x 20km forming part of a quadrant, e.g. Block 21/05 is the 5th block of Quadrant 21.
Blow-out preventer	System of valves connected to the wellhead while drilling, which can be closed over the wellhead to prevent uncontrolled, sometimes explosive release of hydrocarbons from the wellbore.
Centre for Environment, Fisheries and Aquaculture Science	The government agency which approves chemicals for offshore use (amongst other functions).
Cetaceans	Aquatic mammals e.g. whales, dolphins and porpoise.
Cephalopods	A class of mollusc characterised by bilateral body symmetry, reduction and internalisation of the shell and modification of the foot into tentacles. Examples include squid, cuttlefish, octopus and nautilus.
Copepods	Small crustaceans whose adult stage usually includes a single eye in the centre of the head. The free living marine species form a vital part of many marine food webs.
dBHT	A measure of the level of sound above the animal’s hearing threshold, or its “perception level”.
Demersal	The zone that is the part of the sea or ocean (or deep lake) comprising the water column that is near to (and is significantly affected by) the seabed.
DTI	Historically the regulatory authority for the offshore oil and gas industry, this agency has been dissolved and its energy-related responsibilities now fall to DECC.
Diatoms	A group of eukaryotic algae that secrete characteristic cell walls consisting of two separate halves with an overlap between them. Diatoms reproduce by binary fission and often exist as single cells, but some species form colonies of chains.
Dinoflagellates	A diverse group of eukaryotic algae that often have two protruding flagellae used for propelling and directing the cell.
Dispersant	An agent added to a suspension to improve the separation of particles. Dispersants added to spilled oil can help the oil break up into smaller droplets, increasing the exposed surface area and increasing the rate of degradation.

GLOSSARY	
Dynamic Positioning	A system of sensors and thrusters on a vessel which allows it to maintain position using satellite telemetry to adjust thrusters' direction and power.
Ecosystem	The physical environment and associated organisms that interact in a given area. There is no defined size for an ecosystem.
Environmental Impact Assessment	A process to identify and assess the impacts associated with a particular activity, plan or project.
Environmental Management System	A formal system which ensures that a company has control of its environmental performance.
Environmental Statement	A report setting out the findings of an assessment of a project's environmental impacts.
European protected species	Species that are listed in Annex IV of the habitats directive, and are therefore protected from harm or disturbance by European law.
Epibiotic	An organism that lives on the surface of another organism.
Epifauna	Fauna inhabiting the surface of rocks, sediment or other fauna/flora.
European Commission	Body made up of commissioners from each EU country, responsible for representing the common European interest, with the power to instigate and apply changes in European law to all EU countries.
Fauna	Animal life.
Floating Storage Unit	A ship that is either purpose-built or heavily modified to receive hydrocarbons from offshore wells and store them until they are offloaded onto tankers for shipping ashore.
Flora	Plant life.
Infauna	Fauna that lives within sediments.
Krill	Shrimp-like marine animals, found in all oceans of the world.
Marine Scotland	A government consultee and a lead marine management organisation in Scotland, bringing together the functions of the Fisheries Research Services (Marine Scotland Science), the Scottish Fisheries Protection Agency (Marine Scotland Compliance) and the Scottish Government Marine Directorate.
Manifold	The branch pipe arrangement which connects the valve parts of multiple pipes
Meroplankton	Plankton consisting of organisms at a certain life cycle stage (in particular larvae) that do not spend other stages of their lifecycles as plankton.
Motile	Organisms that are able to propel themselves from one place to another.
Niche	An environment that is different from the surrounding area and that

GLOSSARY	
	requires the organisms exploiting it to be specialised in ways not generally found in the surrounding area.
Notice to Mariners	Admiralty Notice to Mariners contain all the corrections, alterations and amendments for the UK Hydrographic Office worldwide series of Admiralty Charts and Publications, published weekly as booklets, which are despatched directly from the UKHO.
Organic	Compounds Containing Carbon and Hydrogen.
Pelagic	Any water in the sea that is not close to the bottom or near to the shore. Marine animals that live in the water column of coastal, ocean and lake waters, but not on the bottom of the sea or the lake.
Photic zone	In this context defined as the upper 20 m of the water column which receives enough light for photosynthesis to occur.
Phytoplankton	Planktonic organisms that obtain energy through photosynthesis.
Risk	The combination of the probability of an event and a measure of the consequence.
Salinity	The salt content, in this case of a body of water.
Sedentary	Organisms that are essentially fixed in one location, and unable to move.
Semi-diurnal	Occurring twice daily.
Stratification	Separation of a body of water into two or more distinct layers due to differences in density or temperature.
Sublittoral	The area between the low water line and the edge of the continental shelf.
Substrate	In this context, any surface which could provide a habitat for an organism to live, i.e., a rock outcropping or area of sand.
Surge	A rise in water level above that expected due to tidal effects alone; the primary causes are wind action and low atmospheric pressure.
Thermocline	An area in the water column where there is a rapid temperature change with increasing depth. This is due to stratification between warmer, well mixed, less dense water in the surface layer and deeper, colder water below.
Tie-Back	Tie-backs connect new oil and gas discoveries to existing production facilities.
Topography	The surface features of the seabed.
Transient	In this context, animals that tend to move through areas rather than stay in a given area for a long period of time.
UKCS	United Kingdom Continental shelf. Waters in which the UK Government has jurisdiction over oil and gas activity

GLOSSARY	
Umbilical	Subsea pipe or cable connecting structures such as wellheads and subsea distribution units. Can be used to carry chemicals, hydraulic fluids and electricity supply.
Water column	A theoretical column through a body of water from the surface to the sediments. This concept can be helpful when considering the different processes that occur at different depths.
Christmas tree	A structure fixed to the seabed which comprises a system of valves to control flow from a well into production flowlines.
Zooplankton	Broadly defined as heterotrophic (deriving energy from organic matter) planktonic organisms, although some protozoan zooplankton species can derive energy both from sunlight and by feeding on organic matter.

NON-TECHNICAL SUMMARY

Introduction

This non-technical summary outlines the findings of the environmental impact assessment conducted by Statoil (UK) Limited (Statoil) for the proposed Mariner Area Development. The detailed assessment is presented within the Environmental Statement.

The Mariner Area Development covers the Mariner field located in part Block 9/11a of the UK northern North Sea, together with the smaller nearby Mariner East field in part Block 9/11b (**Figure i**). The Mariner Area Development is located approximately 130 km from the nearest UK coastline and approximately 40 km northwest from the UK/Norway median line.

The concept for the Mariner Area Development comprises (**Figure ii**):

- Installation and operation of a fixed steel jacket platform at the Mariner field. The jacket will be secured by 24 piles hammered into the seabed;
- Installation and operation of a ship-shaped floating storage and offloading unit (FSU) at the Mariner field for the storage and transfer of crude and diluents. The FSU will be secured to the seabed by 12 to 16 suction piles or anchors;
- Two drilling centres. One drilling centre at the Mariner field, drilled via a platform-mounted drilling unit plus a jack-up drilling unit. The other at the Mariner East field, drilled using a semi-submersible drilling rig;
- Fifty active wells and 92 sidetracks at the Mariner field, comprising 76 production wells, 64 produced water re-injectors, a make-up water well and a waste disposal well;
- Four production wells at the Mariner East field;
- A diluent import pipeline connecting the FSU to the Mariner platform;
- A crude export pipeline connecting the Mariner platform to the FSU;
- A gas import pipeline connecting the Mariner platform to the existing Vesterled pipeline;
- Six pipeline end terminals connecting subsea structures to each other;
- A pipeline end manifold connecting the gas import pipeline to the existing Vesterled pipeline;
- A subsea template at the Mariner East field;

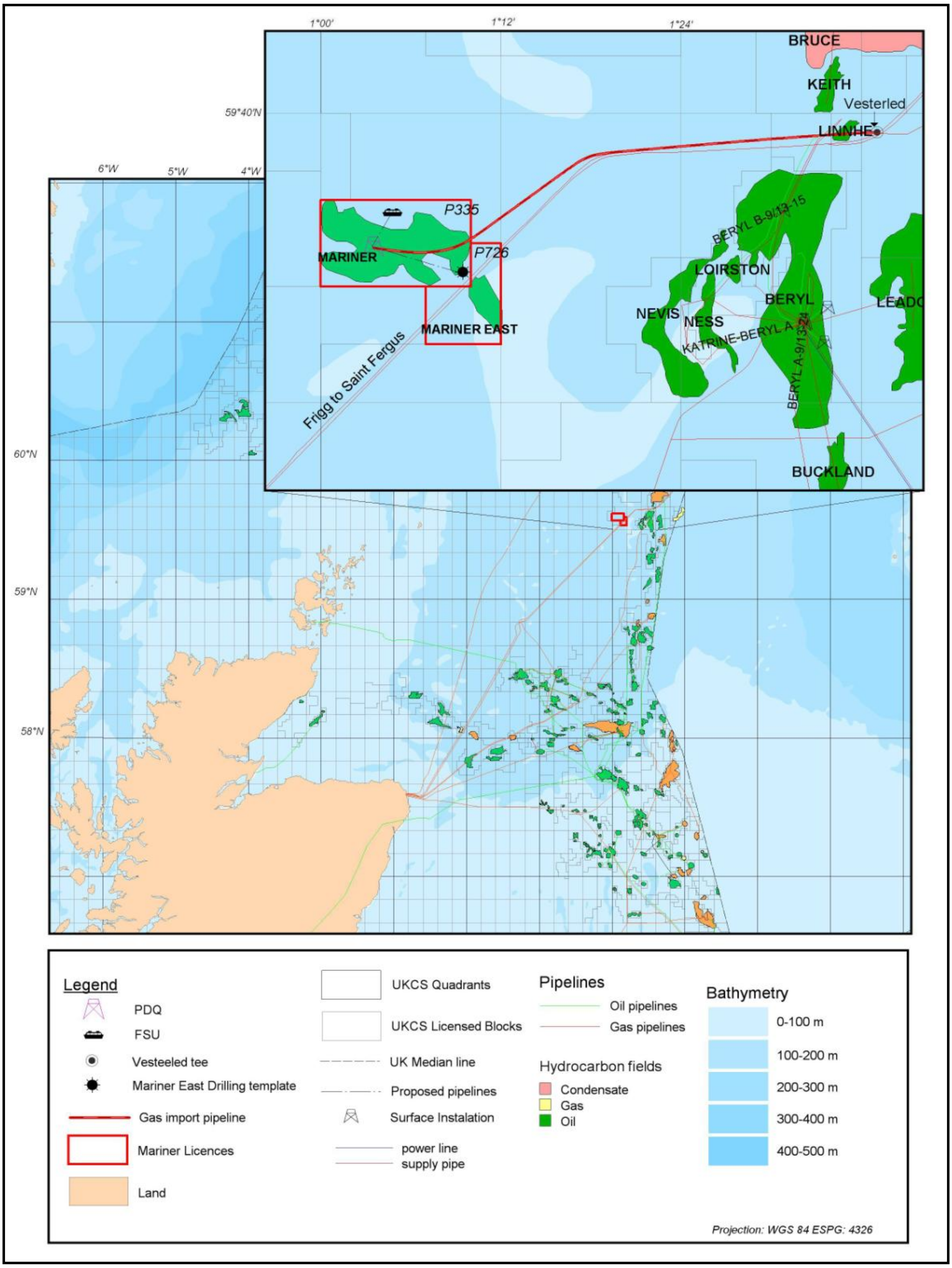


Figure i: Location of the Mariner Area Development in the northern North Sea

- A crude export pipeline connecting the Mariner East subsea template to the Mariner platform;
- A power and utility umbilical connecting the Mariner East subsea template to the Mariner platform;
- A 73 km fibre optic communication cable connecting the Mariner platform to the existing Heimdal platform on the Norwegian continental shelf;
- A subsea isolation valve (SSIV) in the gas import pipeline, close to the Mariner platform; and
- Various supporting offshore vessels.

Statoil plan to commence activities at the Mariner Area Development in Q3 2015, with first oil from the Mariner field expected in Q1 2017 and first oil from the Mariner East field in 2019. The Mariner Area Development is expected to have a field life of 40 years.

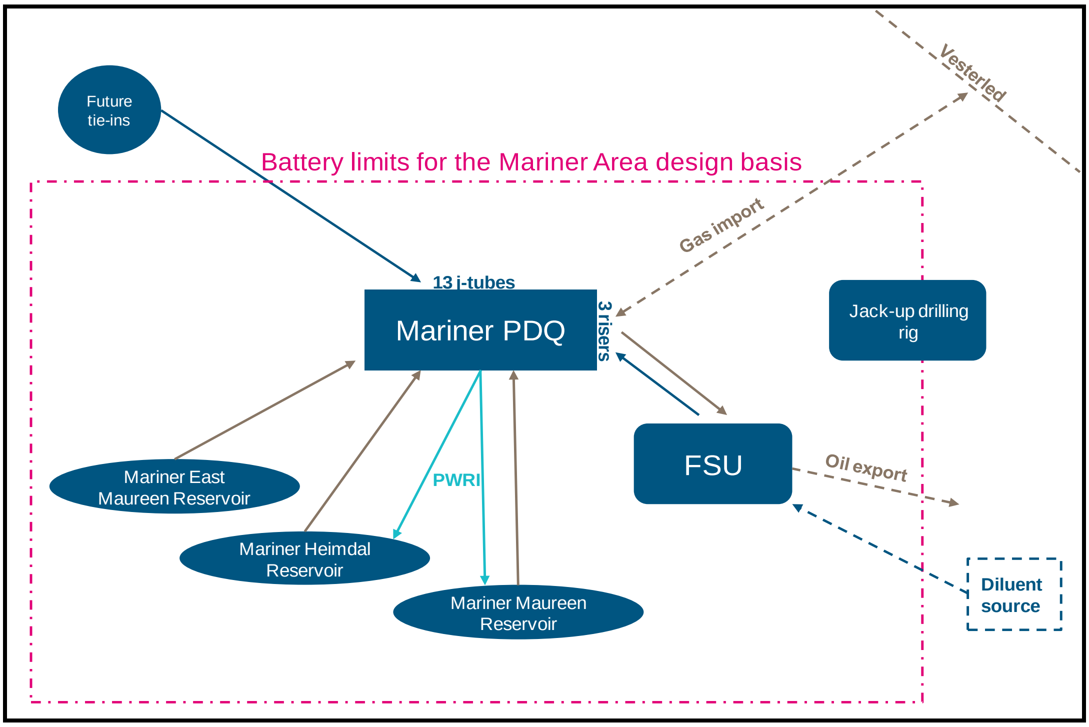


Figure ii: Schematic of the proposed Mariner Area Development

The environmental impact assessment and the Environmental Statement have been prepared by Statoil in accordance with The Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999 (as amended), which require the evaluation of projects likely to have a significant effect on the offshore environment. Additionally, the ES is formally required under these regulations because Mariner and Mariner East will be two new field developments.

The aim of the environmental impact assessment is to assess the potential environmental and socioeconomic impacts that may arise from the proposed Mariner Area Development and to identify measures that will be put in place during design, construction and operations to prevent or minimise these impacts. The Environmental Statement summarises the environmental impact assessment process and outcome. The scope of the environmental impact assessment was developed and agreed during a scoping consultation process.

Consultation has been an important part of the environmental impact assessment process. During the course of the environmental assessment, Statoil consulted with stakeholders potentially having an interest in the proposed Mariner Area Development. The relevant stakeholders were identified and contacted at an early stage to enable them to provide input into the environmental assessment and project design. Any concerns or comments raised during the consultations have been included and addressed within the Environmental Statement.

Project Summary

The proposed Mariner Area Development includes the installation of a new steel jacket platform at the Mariner field, with a permanent drilling rig on the jacket structure (**Figure iii**). A jack-up drilling rig positioned alongside the platform will assist drilling operations at Mariner for a period of 4 to 5 years.

Statoil propose to drill a total of 50 wells and 92 sidetracks at the Mariner field. There are two reservoir formations at Mariner: one in the Maureen sands and one in the overlying Heimdal sands. The Maureen reservoir will be drilled and produced first, via single production wells and single produced water injector wells. The Heimdal reservoir will be drilled and produced later, with dual and single production wells and single produced water injectors.

The Mariner East field will be developed by drilling 4 wells from a semi-submersible drilling rig, through a subsea template located 5 km south-east of the Mariner platform. Drilling at Mariner East will occur concurrently with drilling at the Mariner field.

All the Mariner and Mariner East wells will be equipped with screens for sand control and with electric submersible pumps for lifting the heavy crude from the reservoirs.

The top-hole sections of the wells will be drilled using seawater and high viscosity sweeps and subsequent sections will be drilled with water-based mud (WBM) and low-toxicity oil-base mud (LTOBM). Statoil currently have two options under consideration for the disposal for the LTOBM mud and cuttings generated from the reservoir sections; containment offshore with disposal onshore, or thermal treatment offshore.

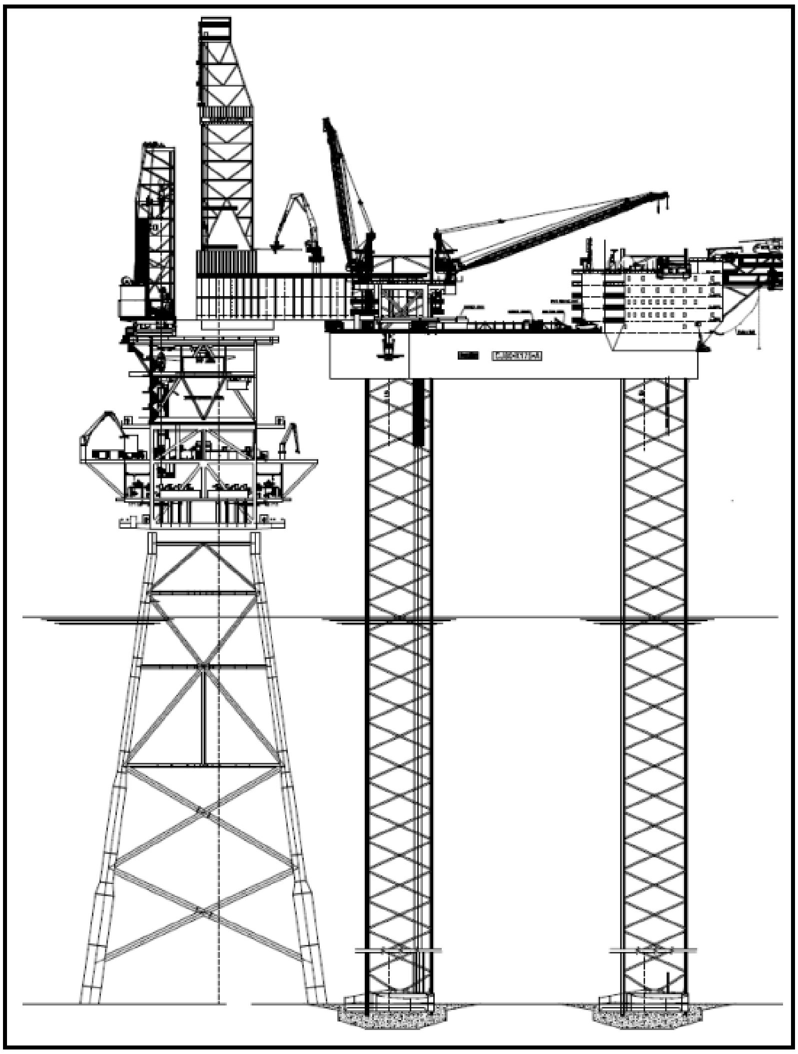


Figure iii: Illustration of the Mariner platform and jack-up drilling rig

All the pipelines and umbilicals installed at the Mariner Area Development will be trenched and backfilled. Concrete mattresses and rock-dump will be used to protect the subsea infrastructure as required.

The Mariner and Mariner East crude oil will be stabilised at the Mariner platform and transferred by pipeline to a ship-shaped Floating Storage and Offloading Unit, before being offloaded to shuttle tankers for transport to shore. A diluent will be used to reduce the crude oil viscosity and density. This diluent will be imported by shuttle tanker, stored on the FSU, transferred by pipeline to the Mariner platform and injected upstream of the electrical submersible pumps or upstream of the process for flow-assurance and separation purposes.

Water produced from the reservoirs will normally be re-injected for pressure support and water flooding. During periods when produced water re-injection is not possible, the produced water will be treated to the required oil in water level and disposed overboard to sea. Produced gas will primarily be used for fuel, but will be insufficient to meet all of the platform’s energy demands. Additional fuel gas will be imported from the Vesterled pipeline. Some produced gas will be flared.

The Mariner Area Development is expected to produce a maximum of 76,000 bbls / calendar day of crude oil, with a total oil and diluents capacity of approximately 80,000 bbls/day. The Mariner East field will produce a maximum of 22,000 bbls/ calendar day of crude oil, but at a time when Mariner production is below plateau rates, such that the combined development production rate will not exceed 76,000 bbls/day of crude or 80,000 bbls / day of oil plus diluent.

Environmental Sensitivities

The Mariner Area Development is located in an area that is typical of the offshore regions of the northern North Sea where hydrographical, meteorological, geological and biological characteristics are relatively uniform over large areas. A summary of the environmental sensitivities in the vicinity of the Mariner Area Development are presented in **Table i**. Users of the area are mainly associated with oil and gas exploration and development, shipping and fishing.

Table i: Summary of environmental sensitivities in the vicinity of the Mariner Area Development

Physical environment
Bathymetry: Seabed topography is flat with a gentle downward slope to the west. Water depths range between 97 and 112 m.
Water masses, currents and meteorology: Typical current and wave patterns for the northern North Sea.
Salinity and Temperature: Water column prone to stratify in the summer between June and September at depths of thermocline up to 50 m. Salinity relatively uniform at all depths.
Sediments type and features: Sediments are sand to muddy sand with occasional patches of coarser sediment and boulders.
Chemical environment
Seabed chemistry: There are no elevated levels of THC, PAH or heavy metals.
Biological environment
Plankton: Typical plankton community and seasonality for the northern North Sea.
Benthic Fauna: Studies in the vicinity of the Mariner Area Development indicate that the benthos in the area is typical of benthic species for this part of the northern North Sea. No species or habitats of conservation importance were recorded during environmental baseline surveys.

Table i (continued): Summary of environmental sensitivities in the vicinity of the Mariner Area Development

Biological environment (continued)											
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Finfish and Shellfish Populations: The proposed development is located in spawning grounds of demersal species cod (Jan- Apr); haddock (Feb-May); whiting (Feb -June); saithe (Jan-Apr); Norway pout (Mar- May); *Nephrops* (throughout the year with peak Apr to Jun) and sandeel (Nov - Feb). The proposed development coincides with nursery areas for haddock, whiting, Norway pout, *Nephrops*, blue whiting, mackerel, European hake, ling, anglerfish, sandeels and herring.											
▓	▓	▓	▓	▓	▓	░	░	░	░	▓	▓
Marine Mammals Harbour porpoise, minke whale, killer whales and white- beaked dolphin have been recorded as present in the area with low to medium densities. The most sensitive periods for marine mammals in the area are from February to March, from June to September and in October when abundance of marine mammals in the area ranges from medium to very high.											
░	█	▨	░	▨	░	▓	▨	▓	ND	▨	░
Seabirds: The most sensitive times of the year for seabirds are October to November when the seabird vulnerability is “very high”, and in January and July when the vulnerability is “high”.											
▓	░	▨	▨	░	░	▓	░	░	█	█	░
Habitats Directive: Annex I Habitats: No Annex I habitats or species of conservation concern have been found in the area such as Annex I Submarine structures made by leaking gases, pockmarks, MDAC derived outcrops, bubbling reefs and Annex I Reef such as stony, bedrock or biogenic reefs.											
░	░	░	░	░	░	░	░	░	░	░	░
Habitats Directive: Annex II Species: Harbour porpoise is the only Annex II species which has been sighted in the surroundings of the proposed development with very high abundance in February and high abundance in July.											
░	█	ND	░	░	░	▓	▨	▨	ND	ND	░

Key :										
	░	**Low**	▨	**Moderate**	▓	**High**	█	**Very High**	ND	**No Data**

Assessment of potential impacts

An assessment of the potential impacts associated with the Mariner Area Development was conducted through identification of the key environmental issues during workshops and stakeholder consultation; evaluation of mitigation and management measures to reduce or remove negative environmental impacts; detailed assessment of key issues; and determination of residual impacts.

The following potential impacts were identified as having the greatest significance to the environment:

- localised disturbance to the seabed;
- discharges to sea;
- underwater noise;
- long-term physical presence;
- atmospheric emissions; and
- accidental hydrocarbon release.

Localised disturbance to the seabed

The Mariner Area Development will result in disturbance to the seabed during from the placement of the platform jacket structure and the jack-up drilling rig on the seabed, the mooring system of the FSU, the subsea infrastructure, the pipeline installation vessels and the various support vessels.

These operations will result in a short-term increase in water column turbidity as sediment is disturbed and could result in disturbance to fish and other organisms that live on or spawn on the seabed, through resuspension of sediment, and disturbance to benthic organisms and seabed spawning fish.

Drilling rig operations are expected to have a short-term impact on approximately 0.032 km^2 of seabed. Once the semi-submersible drilling rig anchors and the jack-up drilling rig spud cans are removed, the seabed areas disturbed by these operations are expected to recover naturally through the physical processes of sediment redistribution and biological processes of immigration and reproduction.

The subsea infrastructure and the FSU moorings will remain on the seabed for the duration of the Mariner field life and represent a longer-term impact to the seabed. The estimated total area of impact is 3.2 km^2.

Seabed disturbance as a result of the Mariner Area Development will represent an additional impact. However, the majority of the seabed disturbance will result from the short-term operations of anchoring, trenching and backfill from which physical and biological recovery is expected to be rapid.

Discharges to sea

The Mariner Area Development will result in discharges to sea during the drilling (mud, cuttings and cement), installation and commissioning (leak testing of pipelines), and operational (produced water, production chemicals, deck drainage and ballast water) stages.

Drilling

Drilling of the Mariner Area Development wells will generate drill cuttings containing both water based muds and oil-based muds. The water-based mud and cuttings from the top sections will be discharged overboard and/or to the seabed. Statoil are considering either thermal treatment offshore, or containment and shipment back to shore for the low-toxicity oil based mud and cuttings from the lower well sections. If thermally treated the fine particles will be discharged to sea or shipped to shore.

The main environmental issues arising from the discharge of the water based and thermally treated low-toxicity oil based muds and cuttings are likely to be smothering of benthic fauna on the seabed and fish spawning grounds. This may result in mortality to some benthic (seabed) organisms and temporary alteration to and loss of their benthic habitat. However, this habitat is likely to recover over time as a result of dispersion, dilution and breakdown of drilling chemicals, spreading and dispersion of cuttings, re-working of the sediment by burrowing organisms and recolonisation of cuttings by seabed benthic organisms typical of the Mariner area.

There were no Annex I habitats identified in the area, with the nearest identified potential Methane Derived Authigenic Carbonate MDAC location situated approximately 100 km from the proposed development. The results of cuttings dispersion modelling indicate that mud and cuttings could extend to 0.5 km from the discharge point, therefore the discharge of mud and cuttings is highly unlikely to have an impact on any Annex I habitats.

There could be localised disturbance to seabed spawning species, of which the demersal living and spawning species *Nephrops* and sandeel potentially occur in the development area.

Nephrops and sandeel spawning habitat may be smothered by cuttings, resulting in mortality or disturbance to these species. However, the sediment type in the development area is not optimal *Nephrops* habitat and it is unlikely that large areas of *Nephrops* habitat are present. Although the sandy sediments at the development area can provide a suitable sandeel habitat, a widespread distribution of sandeels over the

North Sea would mean only a small fraction of the population is potentially affected by the development. Consequently, it is unlikely that there would be a significant impact on the *Nephrops* and sandeel populations.

Installation and commissioning

The permitted discharge of chemicals to the marine environment is a routine part of subsea installation operations. The quantities and types of chemicals to be used and discharged will be determined during the detailed design and will be selected in order to minimise hazards to the environment in accordance with the chemical permits obtained under Offshore Chemical Regulations 2002 (as amended). Where practicable Statoil will give priority to the selection and use of low dosage, low risk chemicals and will minimise the total volume of discharges.

During pipeline testing and commissioning, inhibited seawater may be released into the water column, with potential impacts on marine organisms in the immediate vicinity. Organisms most at risk would include planktonic and sessile organisms. The short-term permitted release of this water is not likely to have a significant impact on marine organisms but this will be fully risk-assessed when the specific chemical constituents and release locations are determined.

Operations

The discharge of produced water has the potential to impact upon marine organisms in the water column and on the seabed. The principal route for disposal of the treated produced water from the Mariner wells will be by re-injection. However, during periods when the produced water reinjection system is unavailable (e.g. during start up), produced water will be disposed of to sea. Before disposal, water will be treated to the regulatory oil-in-water standard of less than 30 mg/l.

A range of chemicals will be used in the operation of the process and utilities systems. Chemicals will be stored within closed systems but will also be present in low concentrations within systems such as the oil and water phase of the process system.

Underwater noise

Underwater noise has the potential to affect marine mammals including cetaceans, several species of which are known to occur in the area. The Mariner Area Development will generate underwater noise from, for example, drilling, piling, vessels and helicopter operations, as well as production operations.

A detailed impact assessment of this noise, carried out according to Joint Nature Conservation Committee guidelines, indicates that cetaceans and other marine mammals are unlikely to be significantly affected, and there will be no injury to cetaceans from any associated noise source.

Drilling and vessel noise is not predicted to cause more than minor disturbance to individual cetaceans. The most significant source of underwater noise is expected to be the piling of the platform jacket structure to the seafloor. Piling involves repeated impact of a pile using a hydraulic hammer in order to drive the pile to the desired depth.

It is predicted that a small number of cetaceans may be disturbed during these piling operations but are likely to return to the area once piling has ceased. The zone of disturbance may extend to 64 km. The piling operations will last between a few hours to several days, so it is not expected this activity will cause significant negative impacts on cetacean populations. Statoil will apply best practice mitigation measures to minimise any risk of disturbance, including the use of marine mammal observers, passive acoustic monitors and soft-starts (slow increase in power) of the piling.

Noise generated by vessels and drilling will contribute to the existing ambient noise already generated by vessels, shipping and construction in this well developed area of the North Sea. Therefore, there is unlikely to be a transboundary or global impact from the noise generated by the proposed development.

Long-term physical presence

The temporary and long term physical presence of the Mariner Area Development platform, FSU, drilling rigs, pipelines, subsea infrastructure, and various support vessels have the potential to interfere with commercial fishing and other users of the sea.

The development pipelines and umbilical will be trenched and buried. Once trenched and buried, the pipelines and umbilical are unlikely to represent a hazard to fishing gear. Statoil only plans to use spot (localised) rockdump as required along the length of the pipelines to protect against upheaval buckling. There may be a slightly increased risk of fishing gear interaction with areas of spot rockdump but the risk will be minimised by careful planning of trenching and backfilling operations to minimise the quantity of rock required. The profile of rockdump will be contoured to ensure that trawl gear can pass over it.

The pipeline end manifold, pipeline end terminals, and Mariner East subsea template will all have fishing friendly protective structures designed to mitigate the potential for fishing gear interaction, and will be recorded on Admiralty charts and notified via

'Kingfisher' reports. The platform and FSU will be surrounded by 500 m exclusion zones.

Significant impacts on other users of the sea are not expected as fishing effort and value in the area are medium, shipping activity is low and the area is not important for military training.

Atmospheric emissions

During installation and start up activities, there will be gaseous atmospheric emissions from consumption of diesel fuel by vessels, helicopters and the drilling rigs. Helicopters will also consume helifuel.

Operational emissions will arise from fuel consumption on the platform, drilling units and FSU, venting from tanker loading periodic venting and flaring, and fugitive emission sources.

These emissions will cause short-term deterioration of local air-quality within a few metres of the point of the discharge. The exposed offshore conditions will promote the rapid dispersion of emissions, which are not expected to have a significant impact on any biological receptors in the area.

From a global perspective, gaseous atmospheric emissions have the potential to contribute to greenhouse gas emissions and climate change. An assessment quantifying the significant sources of emissions associated with the Mariner Area Development concluded that the development will represent a small proportion of emissions typically arising from UK offshore oil and gas production. Statoil is committed to reducing emissions to as low as reasonably practicable from all sources by using Best Available Technology and managing operations to maximise efficiency and, minimise fuel consumption .

Accidental events

Accidental spills of hydrocarbons are recognised as potentially damaging to the environment, although accidental events that could cause large-scale spillage of oil are unlikely to occur. Statoil will ensure that appropriate measures are in place during all phases of the development to reduce the risk of hydrocarbon spills to as low as reasonably practicable.

Oil spill modelling has been conducted for the potential worst case spill scenarios, being a vessel collision with the FSU and a catastrophic event involving the FSU leading to loss of a majority of the oil inventory.

The spatial extent of the resulting slick will vary depending on the loss scenario. The location of the Mariner Area Development, combined with the circulatory nature of prevailing currents, results in a low probability of oil reaching a shoreline. However, the worst case scenarios that have been modelled do have a possibility of causing oil beaching on Shetland or along the Norwegian coastline.

The potential receptors that could be significantly impacted from an accidental spill event include seabirds and environmentally sensitive coastal areas.

The potential risk to seabirds from oil and diesel pollution is through damage to feathers resulting in loss of mobility, buoyancy, insulation and waterproofing. Birds may also be at risk from toxicity through ingestion of hydrocarbons and may face starvation through depletion of food sources. Overall, the seabird vulnerability to oil pollution within the development area is ‘high’ to ‘moderate’.

Several marine mammal species occur regularly in the development area, although only a few individuals are ever present at any one time. It is unlikely that the viability of any species would be impacted in the event of an accidental hydrocarbon spill associated with the Mariner Area Development.

Fish species found within the area occur throughout the North Sea and no significant threat to fish populations from accidental hydrocarbon spill would be expected. Although fisherman and other sea users may be impacted by an oil spill, the impacts will likely only last while there is oil on the sea surface, which may temporarily restrict access. It is unlikely that there will be any long term socioeconomic impacts on these industries.

An accidental release of chemicals could result in a localised impact around the discharge point. All chemicals will have been approved for use under the relevant chemical permit and so would be unlikely to present a significant environmental risk.

Statoil will prepare Oil Pollution Emergency Plans to cover the Mariner and Mariner East operations in accordance with current DECC guidelines. Statoil’s prevention measures, mitigation measures and contingency plans will consider all foreseeable spill risks and will ensure that the spill risk is reduced to as low as reasonably practicable. The contingency plans will ensure that an appropriate response is made to any spill in order to minimise any impact on the environment.

A worst case release of crude and diesel oil from the total loss of FSU inventory would be likely to have a transboundary impact. However, an incident of this magnitude would have a very low probability of occurrence.

Environmental Management

Statoil has an Environment Management System which is fully compatible with the recognised environmental management standards including to ISO 14001.

Statoil are committed to minimising the environmental impact of its activities. The activities associated with the Mariner Area Development will be conducted in accordance with Statoil's Environmental Management System. Continuous improvement in environmental performance is sought through effective project planning and implementation, emission reduction, waste minimisation, waste management, and energy conservation. Statoil, as the licence operator of the Mariner and Mariner East fields, retains ultimate liability and accountability for the field. Specific commitments for the Mariner Area Development are presented in the Environmental Statement.

Conclusions

The Mariner Area Development is not expected to result in significant environmental effects. The proposed development is very limited in extent and is located in an area which is typical of the northern North Sea in terms of habitat and marine life.

The controls on operations have been designed to ensure that robust environmental safeguards will be put in place and preventative measures have been designed to minimise any potential environmental risks. Statoil believe that the measures that will be taken to minimise the environmental effects associated with the Mariner Area Development represent an appropriate balance between protecting the environment and securing the economic benefits of the proposed project.

1 INTRODUCTION

1.1 Project Background and Purpose

This Environmental Statement (ES) presents the findings of an Environmental Impact Assessment (EIA) for the proposed development of the Mariner Area Development which consists of the Mariner field, located within Block 9/11a, and the Mariner East field, located within Block 9/11b, both in the UKCS northern North Sea. As the licence operator of these blocks, Statoil (UK) Limited (Statoil) and their commercial partners are proposing to develop the Mariner and the Mariner East discoveries. **Table 1.1** provides a breakdown of the commercial interests in Blocks 9/11a and 9/11b.

Table 1.1: Summary of block interests

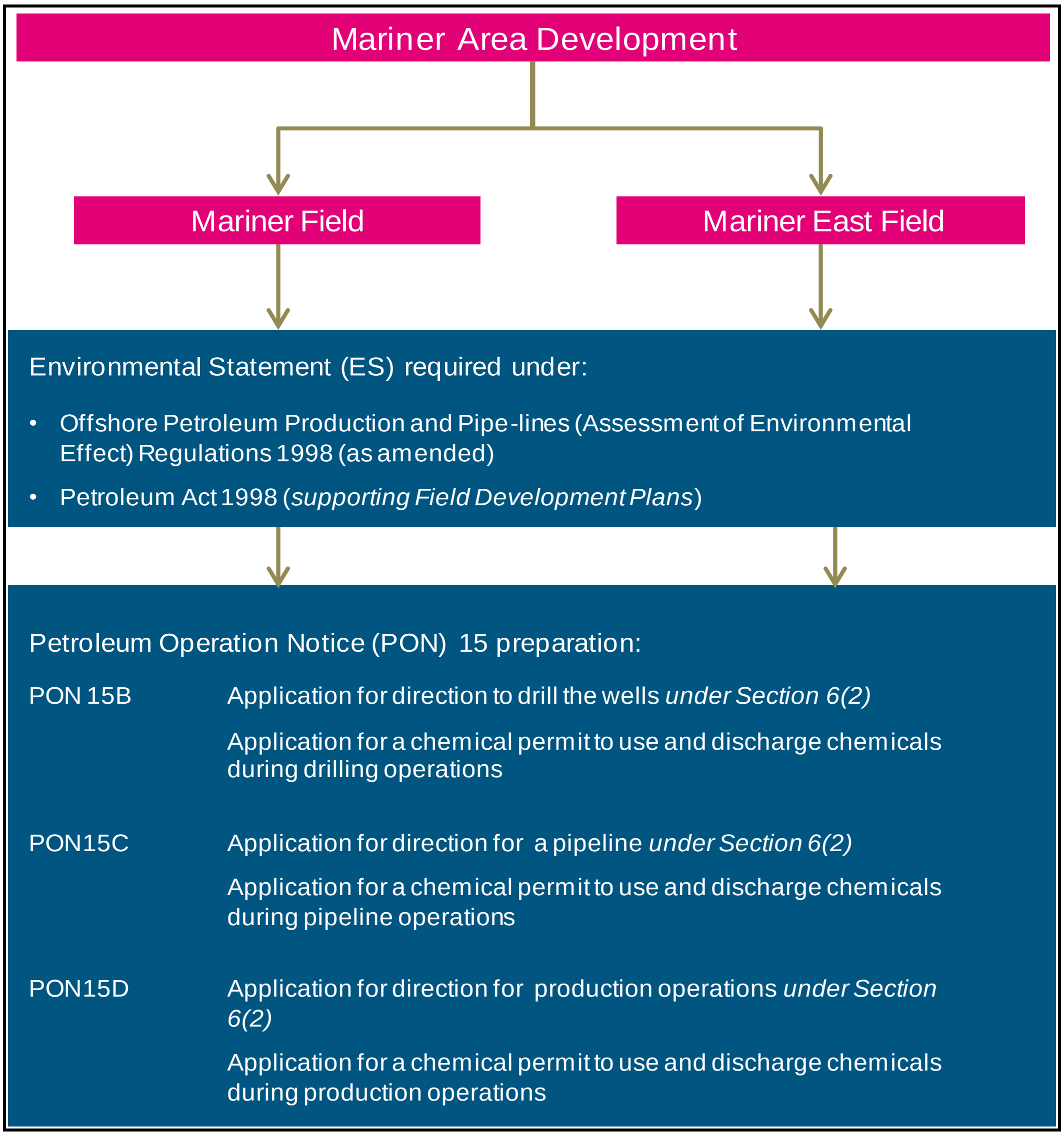
Company	Block 9/11a	Block 9/11b
Statoil (UK) Limited	65.1111%	92.0%
ENI ULX Limited	20.0000%	8.0%
ENI AEP Limited	6.6667%	-
ENI UKCS Limited	2.2222%	-
Alba Resources Limited (Nautical Petroleum)	6.0000%	-

1.2 Purpose of the Environmental Statement

This ES has been prepared by Statoil (UK) Limited (Statoil) in conjunction with BMT Cordah Limited. An ES is a means of submitting to the regulatory authority, statutory consultees, non-government organisations and the wider public the findings of an assessment of the likely effects on the environment of the proposed activity. The Mariner Area Development ES is a key management document for the Mariner Area Development Project and has been prepared in line with Statoil's HSE Policy.

Submission of an ES to the Department of Energy and Climate Change (DECC) is a legal requirement for projects designed to produce 500 tonnes (3,750 bbls) or more per day of oil, or 500,000 cubic metres or more of gas per day, under the Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1998 (as amended).

The ES is also prepared in support of the Field Development Plans for the Mariner and Mariner East fields. In addition to the ES, Statoil will prepare Petroleum Operation Notices (PONs) 15Bs, 15Cs and 15D for submittal to DECC for chemical use and discharge during the initial stages of the proposed operations at the Mariner Area Development. These will be prepared once details of chemical usage and discharge have been finalised. **Figure 1.1** illustrates the EIA process and PON requirements for the Mariner Area Development.



Environmental Statement (ES) required under:

- Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effect) Regulations 1998 (as amended)
- Petroleum Act 1998 (*supporting Field Development Plans*)

Petroleum Operation Notice (PON) 15 preparation:

PON 15B	Application for direction to drill the wells *under Section 6(2)* Application for a chemical permit to use and discharge chemicals during drilling operations
PON15C	Application for direction for a pipeline *under Section 6(2)* Application for a chemical permit to use and discharge chemicals during pipeline operations
PON15D	Application for direction for production operations *under Section 6(2)* Application for a chemical permit to use and discharge chemicals during production operations

Figure 1.1: EIA and PON requirements for the initial stages of the Mariner Area Development

An EIA is an important management tool used by Statoil to ensure that environmental considerations are incorporated into all project-planning and decision-making. At the heart of the EIA is a hazards and effects management process that comprises five main stages:

- characterisation of the receiving environment;
- identification of potential environmental impacts associated with the project;

- assessment of the significance of potential impacts from planned activities;
- assessment of the significance of potential impacts from accidental or unplanned events; and
- development of controls to eliminate or reduce the severity of identified impacts, and plans to avoid or reduce the likelihood of accidental or unplanned events.

In conducting the EIA, consideration was given to potential local, regional, cumulative and transboundary effects from the offshore development operations.

The EIA is an evaluation process which enables those responsible for the project, other interested parties (referred to as stakeholders) and the statutory authorities to understand the significant environmental impacts and risks (potential impacts), the methods of managing risk and the benefits that are likely to occur. This allows the stakeholders to contribute to the decisions that are taken about the project.

The EIA also helps those responsible for the project to select the plans, programmes, designs, technologies, management practices, contractors and personnel that are appropriate for the project and the environment in which the project occurs. In cases where oil and gas projects impinge upon a potential candidate Special Area of Conservation (cSAC), an ‘Appropriate Assessment’ may be required under The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended).

1.3 Scope of the Environmental Assessment

Statoil are planning to develop the Mariner (Heimdal and Maureen reservoirs) and Mariner East fields as the Mariner Area Development.

The Mariner field is located in Block 9/11a while the Mariner East field is located within Block 9/11b, both within the UK northern North Sea (**Figure 1.2**). The Mariner field lies approximately 5 km north west of Mariner East field. The nearest oil production facility to the Mariner and Mariner East fields is the Beryl oil field in Block 9/13, located approximately 18 km to the east (**Figure 1.2**).

The Mariner field will be developed by installing a new steel jacket platform, with 60 well slots, a maximum of 50 simultaneously active wells and 92 sidetrack wells, drilled via a jack-up drilling rig and the new platform, and installing a new gas import pipeline. The Mariner East field will be developed by drilling 4 wells from a semi-submersible drilling rig, through a subsea template.

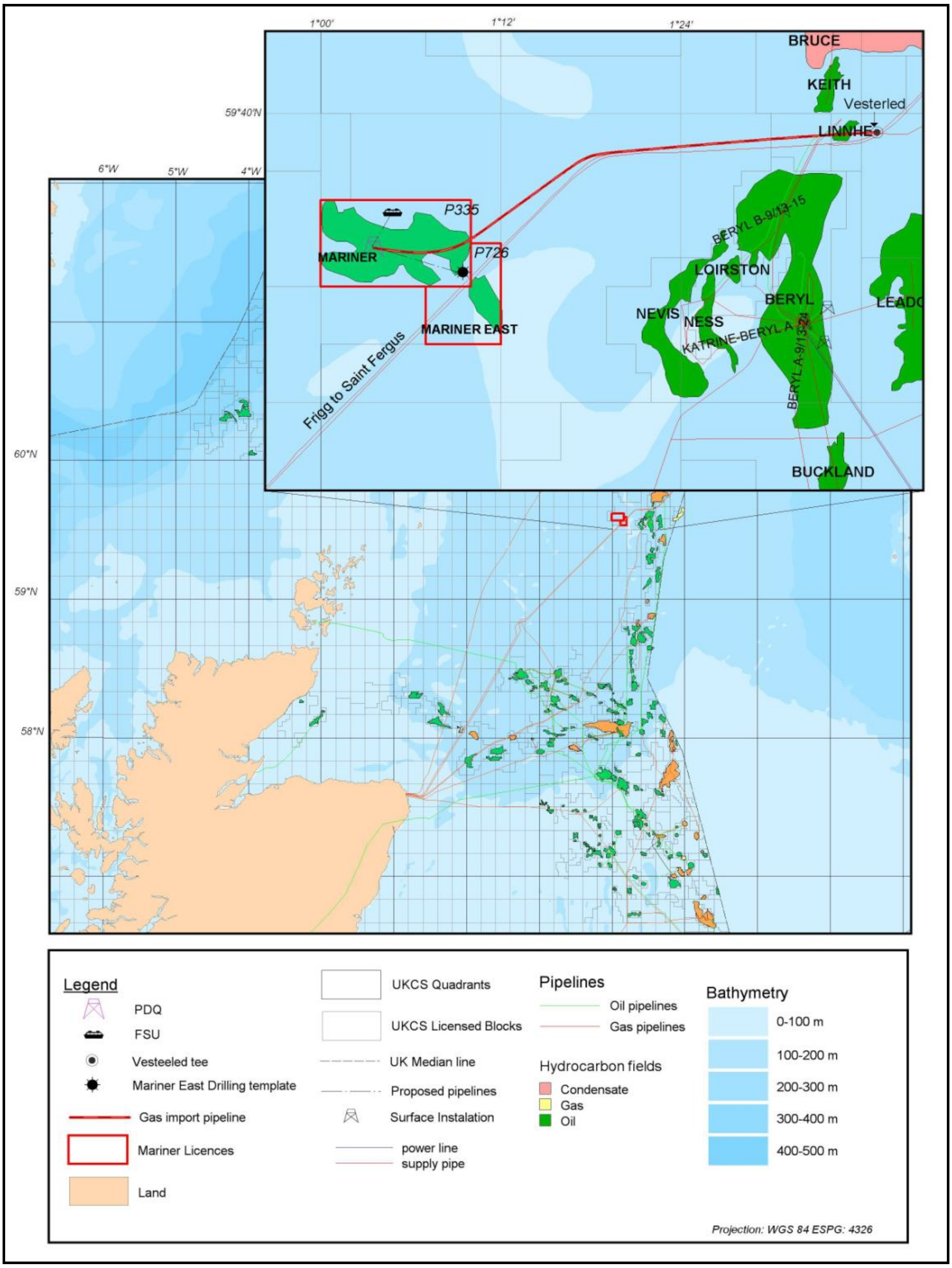


Figure 1.2: Location of the Mariner Area Development in the northern North Sea

Drilling, production and processing at the Mariner field will be undertaken by an integrated Production Drilling Quarter (PDQ) platform, in addition to a separate jack-up drilling rig positioned next to the platform. Statoil envisage the jack-up drilling rig will be required at the Mariner field to assist with the proposed drilling programme for a period of 5 years. Drilling at the Mariner East field will be undertaken by a semi-submersible drilling rig positioned over a subsea template.

The Mariner and Mariner East crude oil will be stabilised and transported to a ship-shaped Floating Storage Unit (FSU), before being offloaded to shuttle tankers for transport to shore. A diluent will be used at the Mariner Area Development to reduce the Mariner crude oil viscosity and density. This diluent will be stored on the FSU and injected upstream of the electrical submersible pumps (ESP) or upstream of the process for flow-assurance and separation purposes.

Water produced from the Mariner Area Development will be, after treatment, re-injected into the Mariner reservoirs for pressure support. Alternatively, when injection is not possible, the produced water will be treated to required oil in water level and disposed to sea. Produced gas will be used for fuel, however, it will be insufficient to meet all the facility’s energy demands, so a source of gas import is required. Supplemental gas for fuel will be imported from the Vesterled pipeline. The Mariner FSU and risers have a design life of 30 years.

Key environmental UK legislation applicable to the Mariner Area Development is listed below and summarised in **Appendix A**.

- Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999 (as amended).
- Petroleum Act 1998 (in support of the Field Development Plans).
- Offshore Chemicals Regulations 2002 (as amended).
- Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended).
- Department of Energy and Climate Change (DECC) Guidance Notes 2009.

1.4 Structure of the Environmental Statement

The ES is structured in the following manner:

Non-Technical Summary: An Executive Summary of the EIA presented in non-technical language.

Section 1 Introduction: An introductory discussion of the policy, legal, and regulatory framework within which the EIA is carried out.

Section 2 Methodology: A description of the methods used to complete the EIA.

Section 3 Project Description: A brief description of the project alternatives, and selected design including the drilling, construction and operational phases, a description of the production processes and an explanation of how the project will modify the existing environment.

Section 4 Environmental Baseline: A description of the current state of the physical and biological offshore environment of the Mariner Area Development, including in particular the components that are likely to be affected (climatic factors, air, water, seabed, flora, fauna, human activities and culture).

Section 5 Socioeconomic Environment: A description of commercial fisheries, shipping, oil and gas activities, communication cables, wrecks, dredging and military activities in the Mariner Area Development.

Section 6 Consultation: A summary of the informal consultation that was held between Statoil and the statutory and non-statutory stakeholders, and the issues raised or discussed.

Section 7 Environmental Risk Assessment: The methodology adopted for predicting and assessing likely positive and negative impacts from planned operations, a list screening the significance of impacts associated with the project, and a quantitative description of the significant residual negative impacts of the proposed project on the environment. The section also presents the methodology adopted for assessing the effects of accidental or unplanned events, and an assessment of the potential significance of selected example accidental or unplanned scenarios.

Section 8 Assessment of Potential Impacts: A description of the potential sources of significant impact from the project, an indication of the increase in those sources due to the modification of existing installations, and an estimate of the scale of the emissions, discharges, wastes and disturbance factors connected with the project.

Section 9 Environmental Management: An outline of the arrangements that will be put in place to ensure that the mitigation and control measures identified in the environmental statement are implemented. The section also states Statoil’s environmental commitments for the lifetime of the Mariner Area Development project.

Section 10 Conclusions: A summary of the findings of the EIA.

Appendices: Supporting information and studies relevant to the EIA.

2 METHODOLOGY

The EIA methodology systematically identifies the significant environmental impacts and risks (potential impacts) of the proposed project, assesses the requirement for risk-reduction measures and provides an Environmental Management Plan to facilitate the adoption of these measures throughout the project. This assessment aligns with the requirements set out in the Schedule to the Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999 (as amended), and associated Guidance Notes on the interpretation of the regulations (DECC, 2011b). **Figure 2.1** illustrates the principal stages in the EIA process.

In the present context, a significant impact or risk can be defined as one requiring management action to be taken to:

- avoid or minimise potentially adverse consequences for the environment, the public or the project;
- resolve the concerns of stakeholders; and/or
- fulfil the requirements of environmental legislation and company policy.

Management actions will include:

- controls, i.e. methods for reducing the likelihood of the events that will lead to environmental impact (e.g. vessel collisions causing oil spills);
- mitigation, i.e. methods for eliminating or reducing adverse environmental consequences (e.g. oil spill clean-up and response techniques); and
- other actions (e.g. awareness and training).

The approach has been adapted from the British Standard BS8800 (BSI, 1996), the Oil and Gas UK Guidelines on Risk Assessment (UKOOA, 1999 and 2000) and the international environmental management standard BS EN ISO 14001 (BSI, 2004).

The sections in the remainder of the ES provide individual method statements for the processes used in the EIA for data gathering and interpretation, consultation, risk assessment, evaluation of significant impacts and mitigation, and the evaluation of the environmental management framework to be used throughout the project lifecycle.

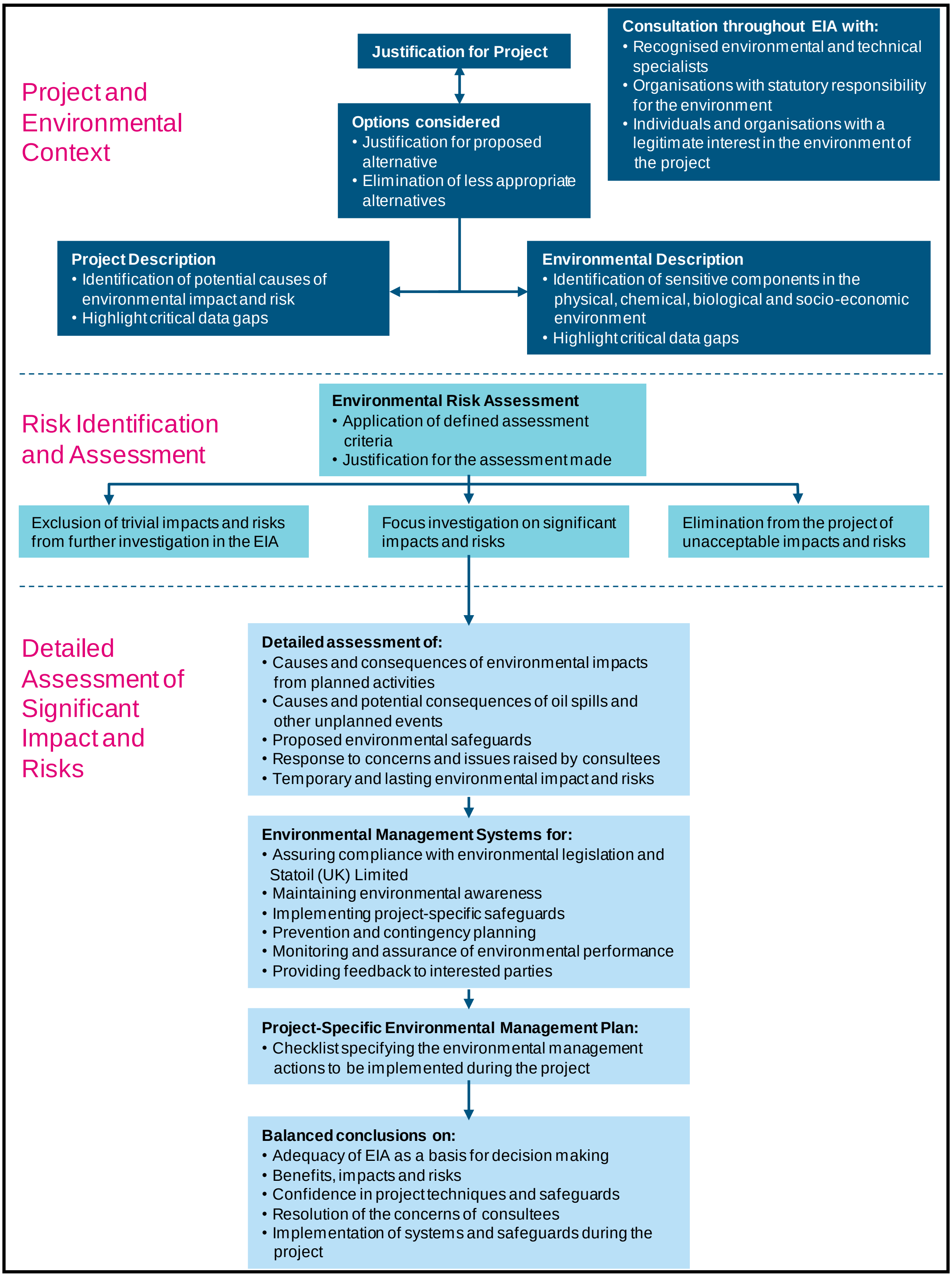


Figure 2.1: Principal stages in the Environmental Impact Assessment process

3 PROJECT DESCRIPTION

The Mariner Area Development will produce oil from the Mariner oil field and from the smaller nearby Mariner East oil field.

Each of these fields comprises two shallow reservoirs, one in the Maureen formation and one in the overlying Heimdal formation. These reservoirs are characterised by dense, highly viscous oils, the Maureen oil having an API gravity of approximately 14.2 and the Heimdal oil having an API gravity of approximately 12.1. Production of these dense, viscous crudes will require use of down-hole pumps for artificial lift, plus blending with a light oil (“diluent”) to assist fluid flow.

In the case of Mariner, oil will be produced from both reservoirs, but only the Maureen reservoir will be produced at Mariner East.

3.1 Project Location and Overview

The two oil fields are located in the UK northern North Sea, the Mariner field being in part-Block 9/11a and the Mariner East field in part-Block 9/11b approximately 5 km to the south east (**Figure 3.1**). The nearest existing oil production facility is on the Beryl oil field in Block 9/13, located approximately 18 km to the east.

The Mariner field will be operated by Statoil under Licence P.335 (see **Figure 3.2**), with joint ownership between Statoil (65.1111%), ENI (28.8889%) and Alba Resources (Nautical Petroleum) (6%). The Mariner East field will be operated by Statoil under Licence P.726, with joint ownership between Statoil (92%) and ENI (8%).

Since the oil accumulations were first discovered in 1981, 4 exploration and 10 appraisal wells have been drilled in Block 9/11. Including side-tracks there have been 19 reservoir penetrations in total.

The Mariner field is expected to produce a maximum of 76,000 bbls/calendar day of crude oil, and the Mariner East field is expected to produce a maximum of 22,000 bbls/calendar day of crude oil. Mariner East will produce at a time when Mariner field production is off plateau, such that the combined total production from the Mariner Area Development is not expected to exceed 76,000 bbls/calendar day of crude oil.

The production systems will be designed for 76,000 bbls/day of crude oil, 80,000 bbls/day of crude oil plus diluent, and 320,000 bbls/day of total fluids (being crude oil, diluent and produced water combined).

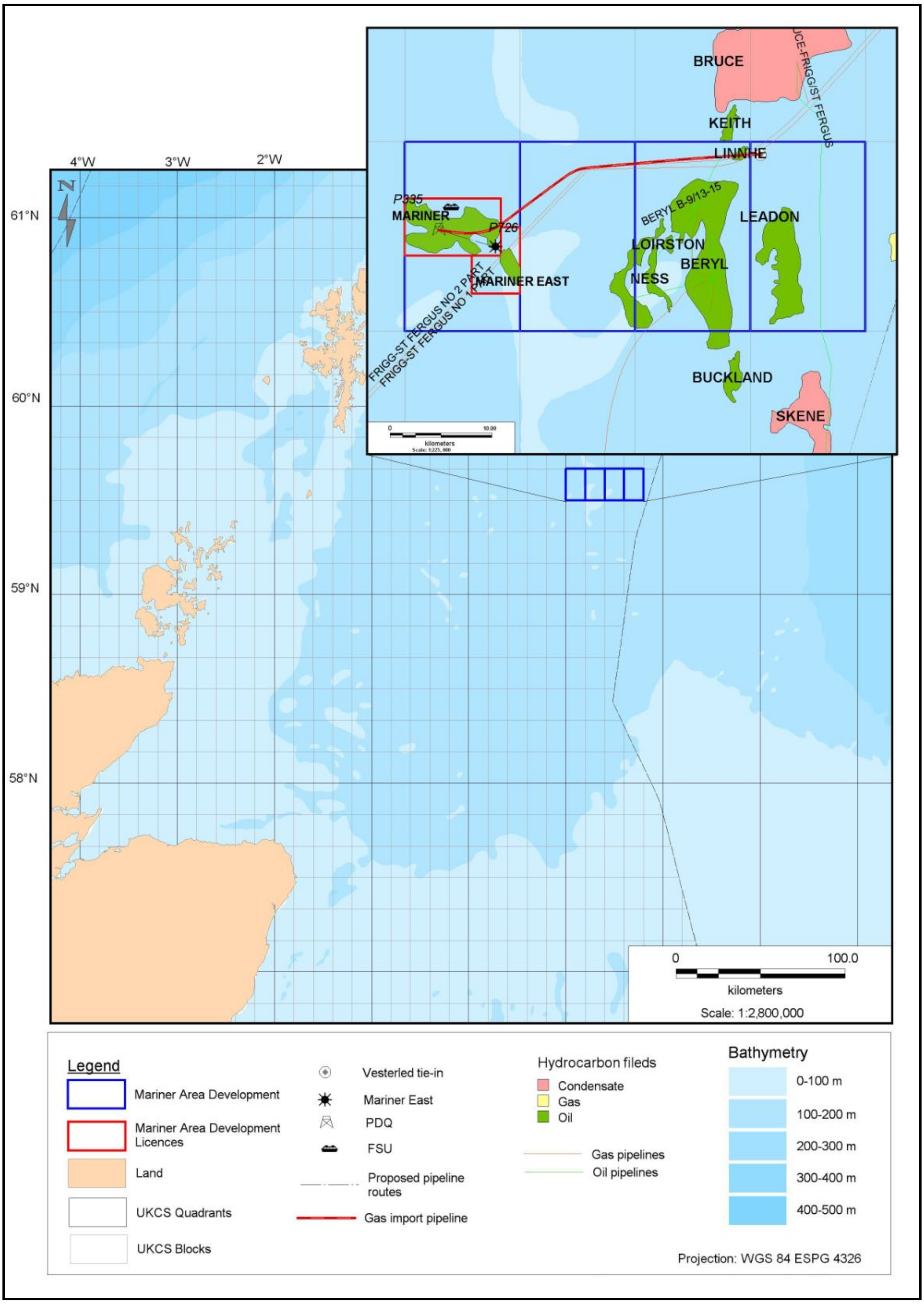


Figure 3.1: Location of Mariner and Mariner East within the northern North Sea

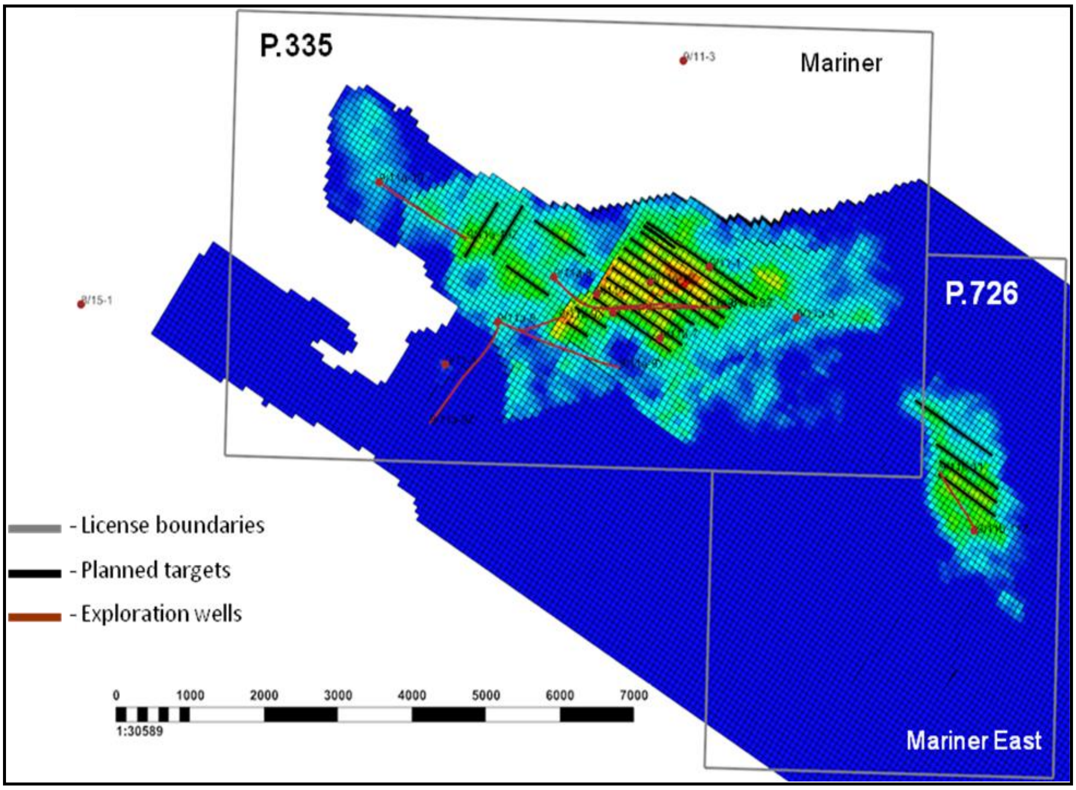


Figure 3.2: Schematic of the Mariner and Mariner East reservoirs, possible targets and previous wells

3.2 Concept Selection Process

3.2.1 Statoil's Capital Value Process

The Capital Value Process (CVP) is Statoil's decision process for investment projects. It is described in the Statoil Book, and in the Statoil governing document FR05 "Functional Requirements – Project Development". The CVP is as shown diagrammatically in **Figure 3.3**. Statoil became operator of the Mariner licence area in late 2007 following a process of acquisitions and mergers. The main path of the CVP was entered at the "business planning" stage. This and subsequent stages of the CVP may be explained as follows:

Business Planning ("Feasibility")

The work in this phase frames the business case and develops the business objectives. It also identifies a technically and operationally feasible investment project concept, and verifies through economic and stakeholder analysis that further development is justified. Decision Gate (DG)1 is an approval to further mature the investment project in the concept planning phase.

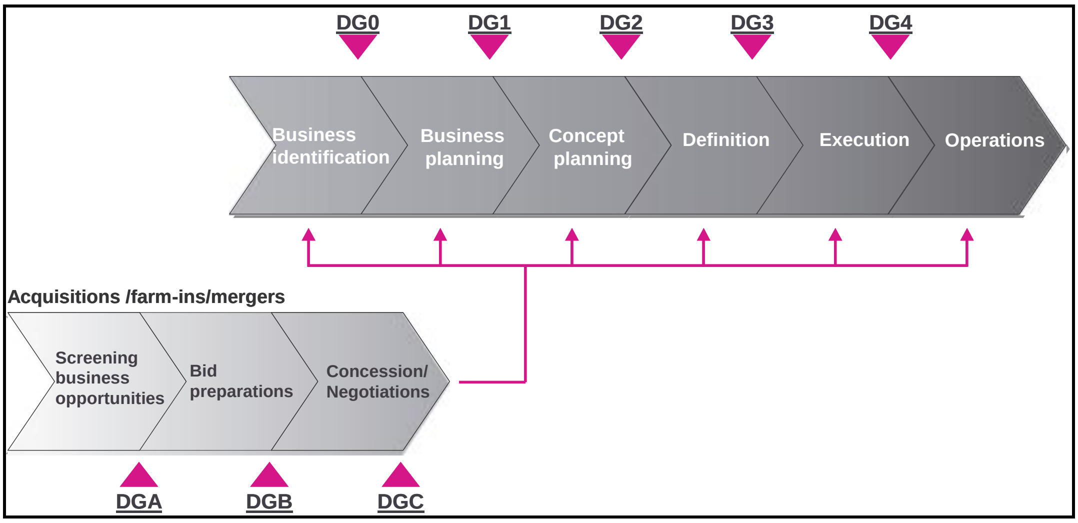


Figure 3.3: The Statoil Capital Value Process

Concept Planning

The work in this phase establishes a clear basis for the investment project, selects a preferred commercial and technical development concept, and matures the business case to the required level for DG2. DG2 is the main decision gate before significant external resources are involved, and is the approval to take the project into the definition phase.

Definition

The main focus in this phase is to mature the project to the required level for a final investment decision to be made. This phase includes Front End Engineering Design (FEED) of the facilities. DG3 represents the sanction of the investment project.

Execution

The purpose of the execution phase is to realise the business case through detailed design, fabrication, installation and commissioning. DG4 will be passed once the facilities are ready to start operation, and the receiving asset accepts that the facilities are ready for hand-over.

3.2.2 Quality Assurance within the CVP

Extensive quality processes are incorporated into the CVP. In particular, FR05 specifies an organizational structure for projects, the activities that must be conducted during each project phase, and a programme of meetings and reviews.

Organisation

The relevant business area – which in the case of Mariner is Development and Production International, Europe and Asia (DPI EA) – delegates responsibility and provides the necessary mandate to an “Asset Owner”.

Responsibilities for the asset owner are to:

- establish the business case objectives;
- establish a steering committee and a project organisation;
- establish quality assurance and company assistance;
- establish risk management processes for the project;
- establish relevant project benchmarks;
- establish the decision documentation;
- prepare a decision memo; and
- recommend that the project either pass a decision gate or ceases.

The asset owner appoints an “Asset Owner Representative” (AOR) to deliver these outcomes on his or her behalf. Reporting to the AOR is a Business Case Leadership Team (BCLT) comprising the heads of the three sub-projects - petroleum technology, drilling and wells and facilities - together with the functions of quality and risk management, integration and HSE/Authority Liaison. Facilities sub-project includes a team dedicated to health, safety and environment (HSE) in facilities design.

Discipline engineers within the sub-projects are drawn from the Technology, Projects and Drilling (TPD) division of Statoil. These engineers conduct the detailed technical work according to the Statoil governing documents known as “Technical Requirements”, TRs.

Review Processes

At the beginning of each phase a meeting between key internal stakeholders is held to discuss the business case and business drivers, and give key forward-looking directions for the project.

A Steering Committee acts as an advisory group for the asset owner. It meets regularly to secure alignment between business areas regarding definition, context and scope of the business case.

During their execution of the detailed technical work within each project phase, the project engineers are guided by a peer process involving the Competence Ladder within their corresponding discipline within TPD division.

As each DG is approached, there is in addition a formal process of review against the requirements of the governing documents and against best practice. This is known as the Investment Arena review (**Figure 3.4**).

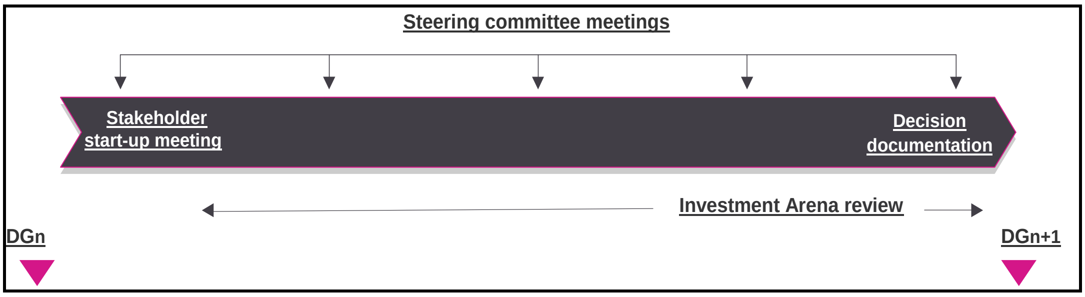


Figure 3.4. The Steering Committee and Arena Process

Documentation

The Decision documentation, which forms the basis for each DG approval, includes:

- the Decision memo itself;
- reports from the quality review (Arena) processes; and
- the detailed Project documentation developed during the phase.

3.3 The Mariner Development Concept

Mariner oil field comprises two reservoirs. One reservoir is in the Maureen sands and contains oil of API gravity 14.2 and viscosity (at reservoir conditions) of 67 cP. The other reservoir is in the Heimdal channel sands and contains oil of API gravity 12.1 and viscosity 508 cP.

Both reservoirs are shallow - between 1,400 and 1,500 metres below sea level for the Maureen and around 1,200 metres below sea level for the Heimdal. Both reservoirs are at relatively low temperatures, at around 46 °C and 38 °C respectively, and are at hydrostatic pressure. The gas-oil ratios also are low, being 33 m^3/m^3 and 24.5 m^3/m^3. The reservoir sands are, however, highly porous.

As such, the Mariner oil field development concept has been constrained at all stages by the following requirements:

- A high number of wells, because each well would only be capable of draining hydrocarbon from a small section of the reservoir before excessive water breakthrough occurred;

- Artificial lift of the reservoir fluids, because natural well flow rates would be very low, given that the reservoirs are at hydrostatic pressure, the reservoir oil density is close to that of water, and the reservoir fluids are highly viscous;

- Platform wells / dry trees, because of the expected requirement to frequently side-track wells or reuse slots as wells water-out. Use of platform wells / dry trees would also enable ready change-out of down-hole pumps;

- Large capacity process systems, relative to the oil production rate, to accommodate high water cut. Also, large separation vessels to maximum fluid residence time;

- Import of fuel gas, due to the low levels of associated gas;

- Reinjection of produced water, to achieve water-flooding and enhance oil recovery;

- Oil export by tankers, to avoid fluid flow problems with the dense viscous oils, and to maximize oil market options; and

- Extended field life due to the low expected rate of oil recovery.

3.3.1 Business Planning (“Feasibility”) Phase

The concept adopted for the feasibility phase of Mariner project was a large integrated-facilities (PDQ - production, drilling and quarters) topsides on a steel jacket, with produced oil transferred to a floating storage unit for export by shuttle tankers.

At this stage the PDQ platform design was closely based on that of the existing Grane production facility that is operated by Statoil on the Norwegian Continental Shelf. The Grane facility produces a moderately heavy oil of API gravity approximately 18, and was therefore seen as providing a good basis for initial design of the Mariner PDQ.

This concept was as shown in **Figure 3.5**.

Figure 3.5: Initially proposed Steel Jacket, Integrated-Facilities Platform at DG1

Qualitative consideration of health, safety and environmental issues, e.g. through use of the Statoil method “Early Phase Risk Assessment” (EPRA) indicated that there were no unmanageable HSE risks or impacts. This was supported by the more detailed HSE assessments that had previously been conducted on the Grane development itself.

DG1 was passed in late 2008 based on this concept.

3.3.2 Concept Planning Phase

During the feasibility phase a number of alternate concepts to the base case were also considered, but these had not been adopted as the base case due to the lack of a recent analogue on which to base the outline design.

However, these alternate concepts were subsequently reconsidered in more detail during the concept phase. The principal such alternate concepts that were considered were as tabulated and illustrated in **Table 3.1**.

Table 3.1: Development options considered during Concept phase

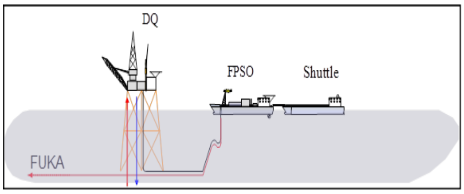
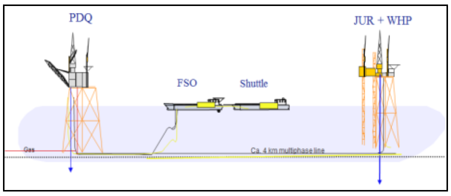
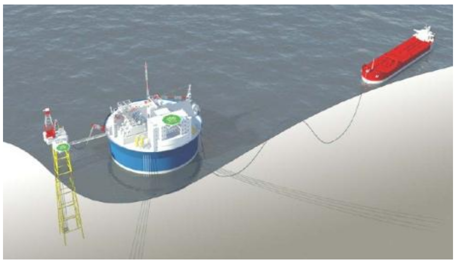
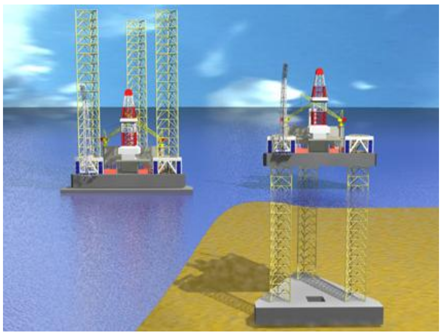
Option	Illustration
Fixed steel jacket platform – BASE CASE A concept closely based on the one Statoil had previously developed for the Grane production facility on the Norwegian Continental Shelf, which produces a moderately heavy oil of API gravity approximately 18. This concept comprises a large integrated-facility PDQ topsides on a steel jacket. The Mariner Development would require a floating storage and offloading (FSU) vessel to enable oil export by shuttle tanker.	
Wellhead platform plus ship-shaped FSU This option was seen to not be cost-competitive with the base case solution. It was also seen to have marginally higher health and safety risks and environmental emissions (although these were not so great that they could not have been overcome).	
Twin drill centres Concepts based on two drill centres were considered, but as design of the wells progressed it was seen that most of the reserves could be reached from a single Mariner location, and this option was then no longer cost effective.	
Wellhead platform plus circular FPSO Initially this option appeared favourable, but as more studies were carried out the predicted capital costs increased. This was also recognized to be a novel solution with significant technical and commercial risks, as well as new HSE challenges. As such it was rejected.	
TPG-500 self-installing jack-up platform The TPG-500 was found to be unable to support more than 36 wellheads, which was considered insufficient to deliver and maintain an economic rate of production. The concept was also not considered proven for an extended field life that might exceed 40 years. Finally, the concept included a gravity base for oil storage, which presented a greater problem with respect to final decommissioning.	

Table 3.1 (continued): Proposed feasibility phase development options

Option	Illustration
Integrated facilities, gravity-based structure In order to have a sufficient number of wells to deliver the required production rates, the structure requires two or three shafts (the figure shows just one), the cost of which was found to be too high. Also, concrete gravity structures are not preferred under international agreements adopted by UK, due to the difficulties of decommissioning, and are only permitted if necessary for technical or safety reasons.	

On the basis of the above, the Base Case (a development based on a steel-jacketed integrated facilities platform plus FSU) was carried forward. The other concepts were all found to be unacceptable for cost and/or environmental reasons. Variations that were considered within the context of this chosen concept included the following:

- *Reservoir drainage strategy*. A large number of options were explored regarding the strategy for drainage of the two reservoirs. The preferred strategy was finally determined to be production of the Maureen reservoir initially, continuously drilling until all Maureen targets were drilled, and then to drill into the Heimdal reservoir, progressively replacing all the Maureen wells Maureen wells would be horizontal with single or dual completions. Heimdal wells would be drilled to an inverted 9 spot pattern, and again would be single or dual completions.

- *Slot numbers and pre-drilling*. Various sensitivities on slot numbers were assessed, but it soon became apparent that the most economic cases were those with maximum practical slot numbers, typically in the range 40 to 60. To maximize initial slot use and hence initial production rates, consideration was also given to the pre-drilling of some wells. However, this was not found to give any economic advantage.

- *Platform rig numbers*. Consideration was given to options involving either one or two platform-mounted drilling units. At the higher slot numbers, the dual rig option showed economic advantages, although it was recognized that this might create a need for operational restrictions due to the increase in simultaneous operations. Note: This is in addition to a unit dedicated to pulling and replacement of the ESPs.

- *Artificial lift*. Three options were studied for artificial lift of reservoir fluids – gas lift, hydraulically driven down-hole pumps, and electrically driven down-hole pumps. Of these, the down-hole pump options were preferred, as it was not clear that gas-lift was suitable for these high viscosity well fluids. Of the two down-hole pump options, the hydraulic system was rejected because the volume of hydraulic fluids required were significant, and these would result in increased process train sizes beyond what was considered practical. It was recognized that the ESP option would likely require frequent well intervention to replace failed pumps, but nonetheless this was considered to be the best option.

- *Oil dilution – using a light oil or condensate*. In order to improve fluid flow properties and oil/water separation, it was suggested that a lighter oil, such as the condensate from Asgard, be blended with the Mariner reservoir fluids so as to create a blend with properties close to that of the crude at the successful Grane Development. The light oil would be imported by shuttle tanker and stored on the FSU.

- *Gas Import – to supplement low associated gas*. During most of the field life, the volume of associated gas produced at Mariner will be insufficient to meet all the facility's energy demands, so a source of gas import is required. Various existing gas pipelines were reviewed for their suitability to provide this gas, in particular Vesterled, FUKA, FLAGS and SAGE (**Section 3.3.5**). The Vesterled option was selected, as it provides the most secure gas supply in the long term.

- *Fluid capacities*. A range of process train capacities was considered. The optimum was found to be 320,000 barrels (bbls) per day total fluids (oil, water and diluent), 60,000 bbls per day of oil (subsequently increased to 76,000 bbls/day), and 0.4 million m^3 of gas.

3.3.2.1 Short-listing

As a result of the above process, a short-list of concept options was finally determined.

The options all comprised a large, integrated-facilities topside on a steel jacket, with 60 well slots, oil dilution, artificial lift using electrical submerged pumps, a single processing train of high capacity, and a living quarters for 160 people.

The short-list comprised variations of that case, as follows:

- Single or dual platform-based drilling rigs. In both cases there would be a pulling-unit for the ESPs in addition.

- Circular or ship-shaped FSU. The circular FSU would be moored close to the PDQ and bridge-linked to it. The ship-shaped FSU would be turret-moored approximately 2.5 km from the PDQ and linked to it by pipeline.

3.3.3 Definition Phase

Definition phase, including Front End Engineering Design, commenced after DG2 was passed in November 2011. The concept selected was as follows, based on the short-list, but with some modifications:

- a steel jacket PDQ platform with 60 well slots (of which only 50 would be considered “active”), a single high-capacity production process train plus a test separation system, and a living quarters for 160 persons;
- a single platform-mounted drilling unit, together with an enhanced ESP pulling unit known as an Intervention and Completion Unit, ICU;
- supplementary drilling for the first 5 years using a large jack-up drilling unit stationed alongside the PDQ;
- dilution of the reservoir crude oil with an imported diluent. Blending of the diluent would occur upstream of the production process, either down-hole or topsides;
- oil storage on a conventional ship-shaped floating storage unit, turret moored approximately 2.5 km from the PDQ.

The concept is illustrated in **Figures 3.6 and 3.7**.

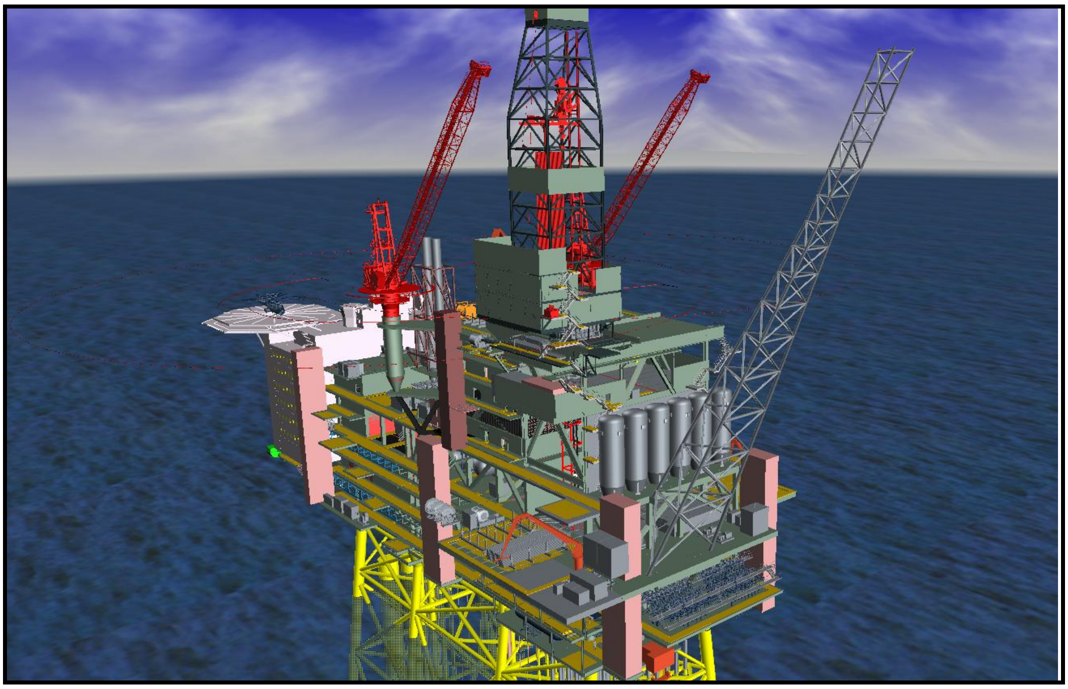


Figure 3.6: Concept Adopted for Definition Phase – Integrated facilities PDQ

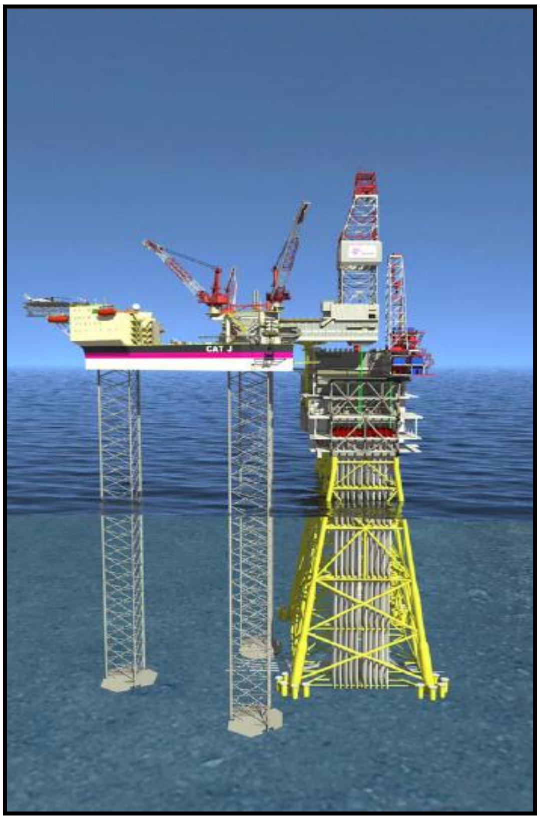


Figure 3.7: Concept Adopted for Definition Phase – Jack-Up drilling assist

FEED activities completed in June 2012, and the results of this work will form part of the proposal to be taken to DG3, for sanction, in December 2012. If sanctioned, the jacket will be installed in 2015, the topsides and FSU will be installed in early summer 2016, and the facilities will be commissioned to achieve DG4 and first oil in the first quarter of 2017.

The Environmental Statement has been written in-line with this final concept.

3.3.4 Mariner East field options

The Mariner East field cannot be reached by drilling from the Mariner field facilities. Accordingly, Mariner East will be developed by tie-back of a sub-sea system to the Mariner PDQ. A range of different well configurations was studied, and the optimum solution was found to a sub-sea development of four production wells, all into the Maureen reservoir. The production wells would have dual electrical down-hole pumps. There would be no water injection wells. Diluent would not be used. Overall, the development would be as shown below (**Figure 3.8**).

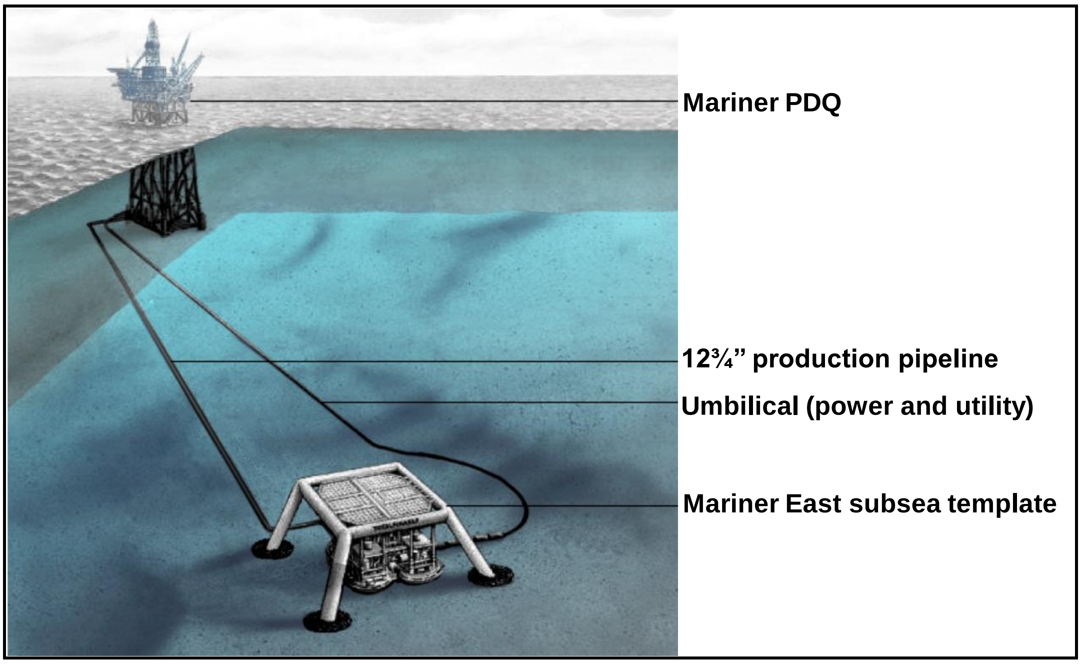


Figure 3.8: Schematic of the proposed Mariner East tie-back to the Mariner PDQ

3.3.5 Mariner Area Development gas pipeline route options

The Mariner Area Development requires the import of gas for power generation on the platform, although when the field is at peak production there may be a slight excess of gas. In addition to the various facilities concept options for the Mariner field, Statoil also considered a number of options for gas import. The four alternative gas pipeline route options that were considered were:

- A new pipeline tied-in to the existing 32” Vesterled pipeline.
- A new pipeline tied-in to the existing 32” FUKA pipeline.
- A new pipeline tied-in to the existing 36” FLAGS pipeline.
- A new pipeline tied-in to the existing 30” SAGE pipeline from the Beryl area.

Capital costs, tie-in method and long-term gas availability were considered for each of these options, in addition to relevant environmental factors.

Statoil concluded that there was little difference between the options in environmental terms - although the Vesterled option involved more interaction with existing infrastructure (e.g. pipeline crossings), the other options required longer pipelines and would have more impact on the seabed and on fishing activity.

As a result of this assessment, Statoil selected the 32” Vesterled pipeline as the host pipeline and the source for importing gas for the Mariner Area Development.

A 6”, 35 km pipeline will connect the Mariner Area Development to the 32” Vesterled pipeline, via a T-connection. A new tie-in spool for the Mariner Area Development will be installed at the Vesterled pipeline for the future tie-in of Statoil’s Bressay field.

Initially, when a circular FSU was still being considered, which would have been moored alongside the PDQ, the gas import pipeline was routed with a southerly approach towards the platform to avoid conflict with the proposed FSU mooring system. However, once the circular FSU option was rejected in favour of a ship-shaped FSU to be located 2.5 km NNE of the PDQ (**Section 3.3.2.1**), a more direct pipeline approach to the PDQ was possible, and is now adopted (**Figure 3.9**).

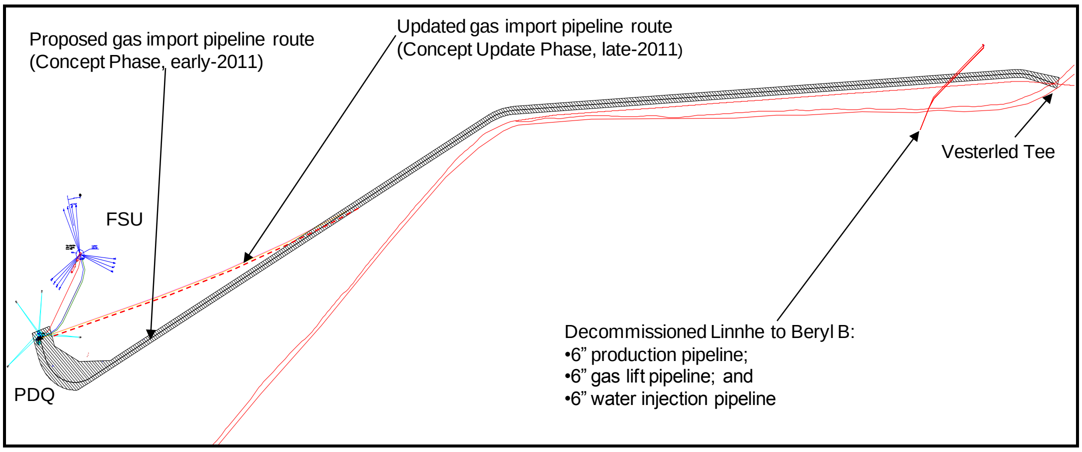


Figure 3.9: Schematics illustrating the proposed Concept Phase and Concept Update Phase gas import pipeline routes

3.4 Project Overview

Summarising the selected option (**Figure 3.10**), Statoil are planning to progress the Mariner Area Development by installing a new large steel jacket platform plus floating storage unit and associated pipelines, etc.

There will be a maximum of 50 simultaneously active wells at Mariner, with 92 sidetracks. These wells will be drilled from a rig permanently mounted on the PDQ platform, and from a jack-up rig located alongside the platform for the first 5 years of operations.

The Mariner East field will be developed by drilling 4 wells from a semi-submersible drilling rig, through a subsea template.

The PDQ platform, jack-up drilling rig, semi-submersible drilling unit and the FSU will be powered independently. Produced gas will be used for fuel at the PDQ. However, this will be insufficient to meet all the facility's energy demands, and supplemental gas will be imported from the Vesterled pipeline via a new gas import connection.

The primary production mechanism at the development will be the use of ESPs. In addition, a diluent will be used at Mariner to reduce the crude oil viscosity and density.

The crude oil will be stabilised and pumped to the ship-shaped FSU, before being offloaded to tankers for transport to shore.

Produced water will mostly be re-injected. In periods where injection is not possible, the produced water will be treated to the required oil in water level and disposed of to sea.

The co-ordinates for the proposed facilities are summarised in **Table 3.2**.

Table 3.2: Proposed locations for the Mariner Area Development

Location	Longitude	Latitude
PDQ platform	01° 03' 25.350"E	59° 35' 20.770"N
FSU	01° 04' 41.000"E	59° 36' 31.891"N
Mariner East template	01° 09' 21.6936"E	59° 34' 27.0156"N

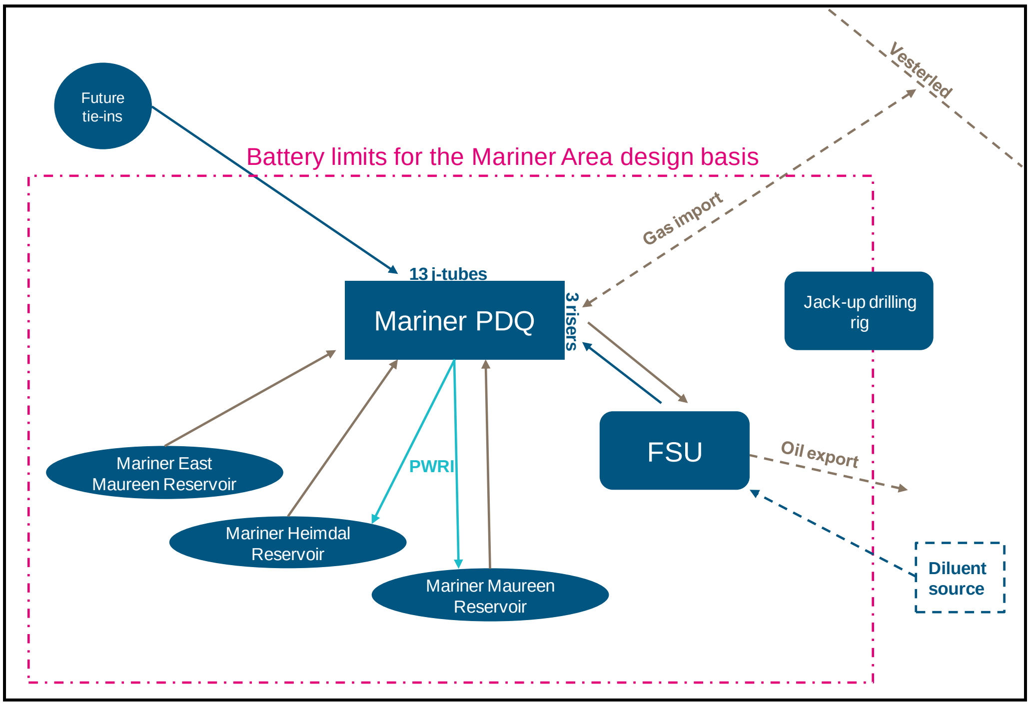


Figure 3.10: Schematic illustrating the proposed Mariner Area Development

3.5 Project Schedule

Installation of the platform jacket is currently scheduled to commence in Q3 2015, while installation of the topside modules is currently scheduled to commence in Q2 2016. Drilling activities at the Mariner field are expected to commence in Q3 2016, with drilling at the Mariner East field to commence in 2018. Statoil expect first oil from the Mariner field in Q1 2017 and first oil from the Mariner East field in 2019. Subsea operations (pipeline installation and commissioning) are anticipated to begin in Q2 2015, with activities expected to finish in Q4 2016. The Mariner Area Development is expected to have a field life of 40 years (**Table 3.3**).

The proposed timings of activities are summarised in **Table 3.3** and are based on current planning, but may be subject to change as the project reaches its final stages of design.

Table 3.3: Proposed project schedule for the Mariner Area Development

Development activity	Proposed Start	Duration
Drilling: • *Mariner* • *Mariner East*	Q3 2016 2018	30 years 2019
Jack-up installation (Mariner)	Q3 2016	5 years
PDQ platform installation: • *Jacket* • *Topside*	*Q3 2015* *Q3 2016*	*5 weeks* *5 weeks*
FSU mooring system (including anchors)	*Q2 2015*	1 month
FSU installation and hook-up	Q2/Q3 2016	2 weeks
Pipeline installation (*Mariner*)	Q2 2015	5 months
Fibre optic communication cable	Q2 2015	1 month
Pipeline and umbilical installation (*Mariner East*)	2018	2019
Flotel (hook-up and commissioning operations)	Q2 2016	6 months
Hook-up, commissioning and tie-in (*Mariner*)	Q2 2016	6 months
Hook-up, commissioning and tie-in (*Mariner East*)	2018	2019
First Oil: • *Mariner* • *Mariner East*	Q1 2017 2019	40 years 5 years
Field Life	Q1 2017	40 years

3.6 Drilling

Drilling at the Mariner Area Development will target two fields, the Mariner field and the Mariner East field. The development of the Mariner field will involve 60 well slots, a maximum of 50 simultaneously active wells and 92 sidetrack wells, drilled via the PDQ platform and the jack-up drilling rig. Development of Mariner East will involve drilling of 4 wells through a sub-sea template using a semi-submersible drilling unit.

3.6.1 Drilling Programme

The 60 well slots, 50 simultaneously active wells and 92 sidetrack wells to access the Mariner Maureen and Mariner Heimdal reservoirs, and the 4 wells to access the Mariner East Maureen reservoir will comprise (**Figure 3.11**):

- 80 production wells;
- 64 produced water re-injectors;
- a make-up water well; and
- a waste disposal well.

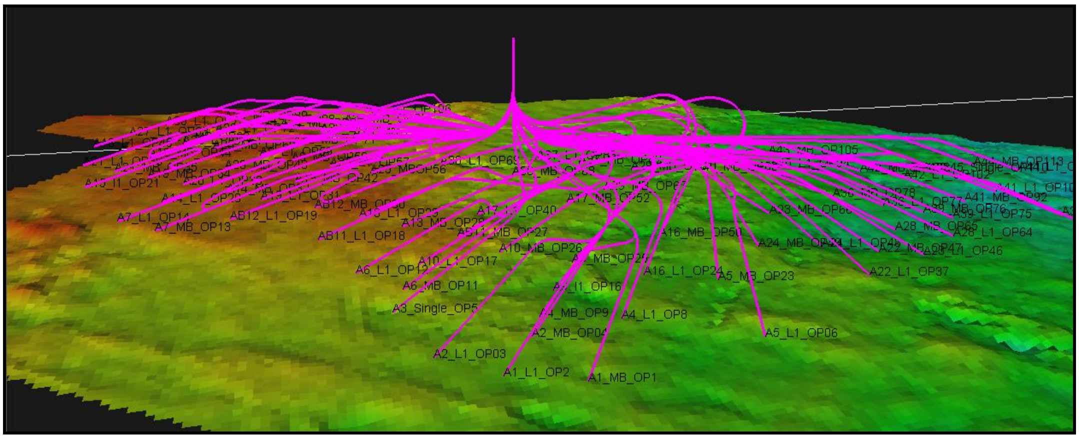


Figure 3.11: Indicative schematic of the proposed wells for the Mariner field

The proposed schedule for the wells is illustrated in **Figure 3.12**.

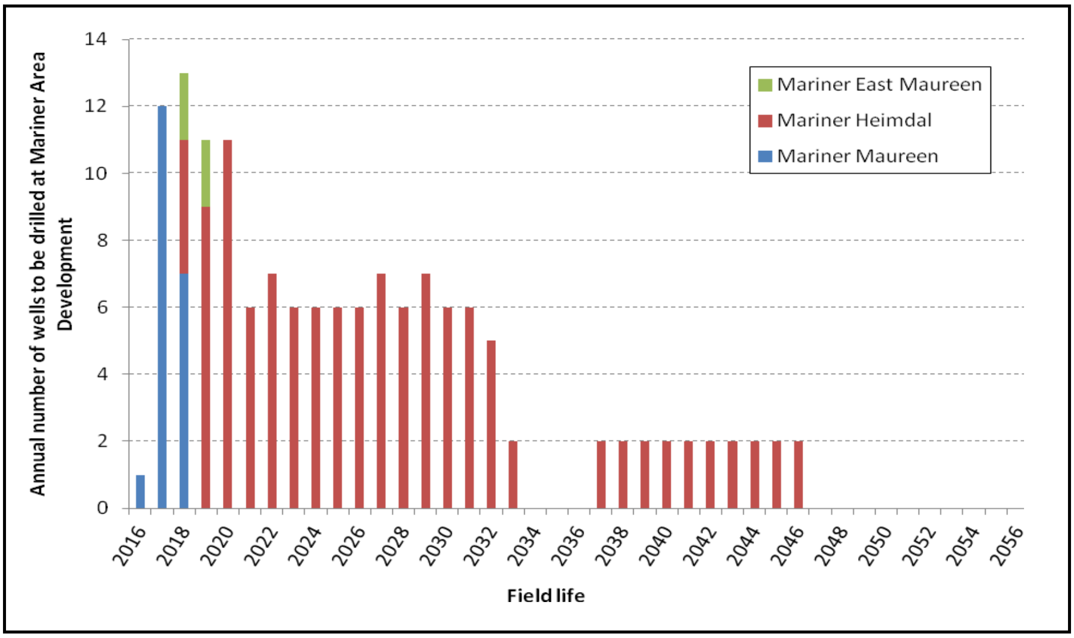


Figure 3.12: Indicative schedule for drilling of the development wells

The Maureen reservoir will be drilled first to build an early and high production plateau. Re-injection of produced water (PWRI) and additional makeup water will be required to enhance production from the Mariner Maureen producing wells only.

The Heimdal wells will be drilled to maintain plateau production once most of the Maureen wells have been drilled and completed. Production from the Heimdal reservoir is critically dependant on the injection of produced water, requiring extensive water injection for sweep and pressure support.

Additionally, artificial lift will be required for production from the Mariner Maureen and Heimdal and the Mariner East production wells. The Maureen wells will produce at high liquid rates with high water cuts for approximately six to seven years. The Heimdal wells will produce at lower rates, with a gradually increasing water cut (up to 98%). The Mariner Heimdal and Maureen wells are designed for 20 years.

Statoil plan to commence drilling operations (Q3 2016) once most of the hook-up operations at the Mariner field are completed. The jack-up drilling rig will be positioned adjacent to the PDQ platform, and after pre-loading, the drilling derrick will be moved out over the platform to the required location. Drilling operations from the jack-up drilling rig will commence after all hook-up operations on the PDQ have been completed.

A semi-submersible drilling rig will be positioned at the Mariner East location after the subsea template has been installed on the seabed. Drilling operations at the Mariner East field are scheduled to commence in 2018 for a period of 8 months.

3.6.2 Rig specifications

The layout and positioning of the PDQ facilities and a jack-up drilling rig are illustrated in **Figures 3.13**.

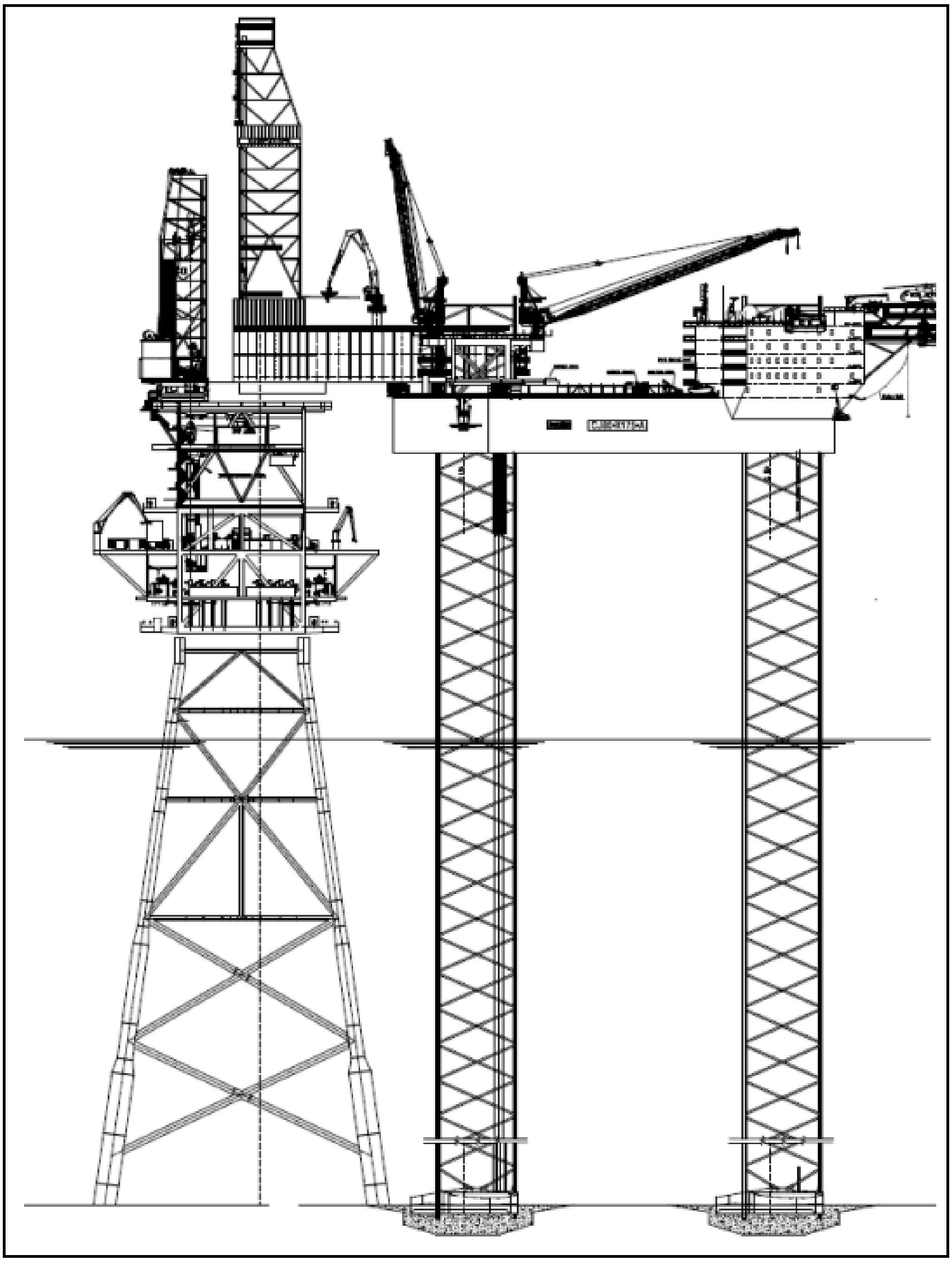


Figure 3.13: Sideview illustration of the proposed PDQ and jack-up drilling rig

3.6.2.1 The PDQ platform

The PDQ drilling facilities will be an integrated part of the topside. They will comprise:

- a PDQ Drilling Equipment Set (DES);
- a Drilling Support Module (DSM) with dedicated pipe-deck for the DES;
- access and interfaces to the jack-up drilling unit;
- a well intervention deck; and
- an intervention and completion unit with associated platform interfaces.

The integrated DES and DSM module will be designed for offshore installation and removal by use of a heavy lift crane/vessel. The DSM will be designed as a five level offshore module, and will be supported directly on the main trusses of the platform deck structure (**Figure 3.14**). The DES unit will have a conventional design consisting of a skid-base skidding north-south on the DSM, and the drillfloor with a derrick skidding east-west on top of the skid-base. The pipe-deck is an integrated part of the DSM, located on top of the DSM. Two platform Pedestal cranes are also integrated into the DSM module.

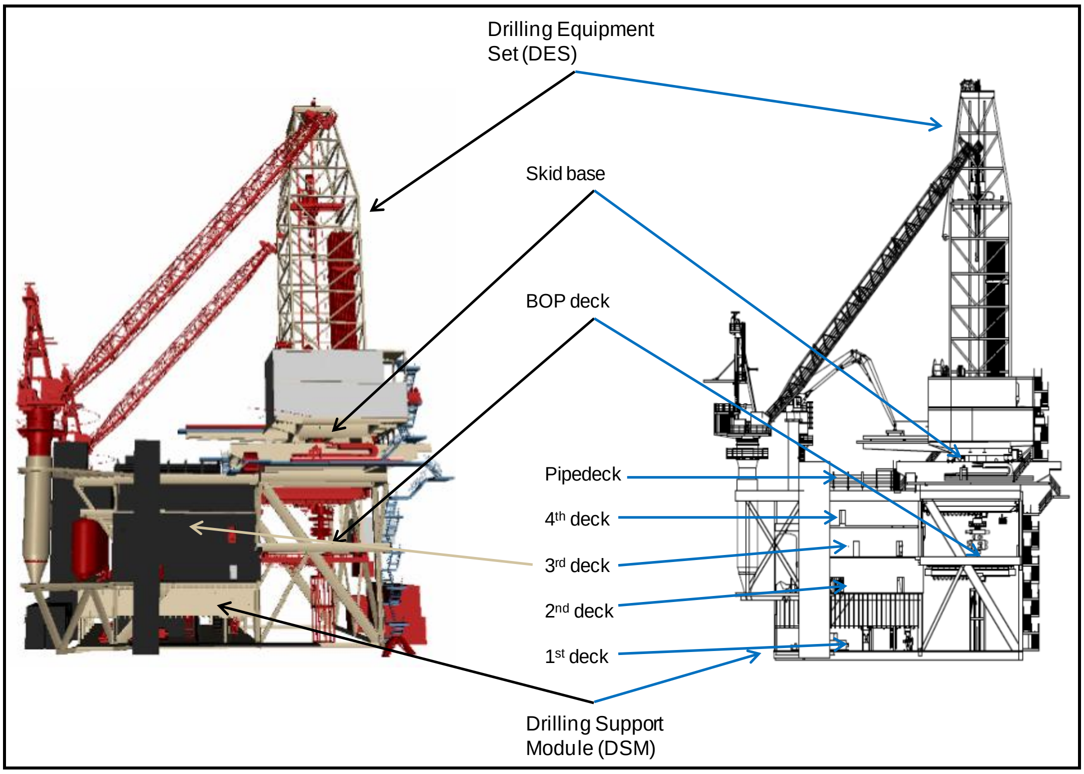


Figure 3.14: Illustration of the proposed DSM and DES structural arrangement

3.6.2.2 Mariner and Mariner East jack-up drilling rigs

At this stage, it is not known which drilling contractor and specific mobile drilling facilities will be used at Mariner and Mariner East. Generic rig types are currently assumed.

The jack-up drilling rig to be used at the Mariner field will be a large, harsh environment unit in line with a typical CJ70 rig design. The drilling rig will have the ability to operate in water depths of up to 150 m, with a high variable deck load and a higher operating efficiency compared to previous jack-up generations. A standard semi-submersible drilling rig will be used at the Mariner East field.

Statoil will ensure that the drilling rigs are fully compliant for use in the North Sea and designed for drilling in the appropriate water depth. Statoil will undertake technical, safety and environmental audits as part of the rig tendering process and will ensure that the crew are provided with environmental awareness training. The ability of the rigs and drilling contractors to manage well control scenarios will also be assured.

Once the FSU is in operation and initial hook-up work has started, the jack-up rig will arrive on location to start drilling the Mariner wells. During jack-up installation, mooring / positioning lines will be required to winch the jack-up drilling rig in position close to the PDQ. The semi-submersible drilling rig for the Mariner East wells will arrive on location after the subsea template has been installed and will remain on site for a period of eight months.

3.6.2.3 Layout and structural interface between the PDQ and Mariner jack-up drilling rig

The Mariner field jack-up drilling rig and the PDQ platform will have no structural interfaces, however, a gangway / access tower will link the jack-up drilling rig to the PDQ. The jack-up drilling rig will be connected to the wells via the wellhead area in the PDQ through low pressure and high pressure risers. These risers are not planned to be in contact with the structural steel of the PDQ.

The minimum distance between the PDQ jacket and jack-up legs at seabed, will be approximately 5 m, with minimum distance of 20 m between the jack-up main deck and the PDQ.

3.6.3 Mobilisation and vessel requirements for drilling

The jack-up drilling rig for the Mariner field will either be towed to location by tugs or will be shipped on the back of a large barge. The semi-submersible for the Mariner East field will be towed out to location by tugs, and may require anchor handling vessels onsite if it is not a dynamically positioned vessel. In addition, Statoil will have a stand-by vessel and dedicated supply vessel on-site throughout both drilling operations. Statoil are also considering joining an area-based emergency response.

The 500 m safety zone will be maintained during the drilling programme and thereafter for the life of the field around the platform itself. Local shipping traffic will be informed of its position and the standby vessel will monitor shipping traffic at all times. Prior to any rig moves, a warning will be issued to the appropriate authorities, as required by the Health and Safety Executive (HSE) Operations Notice 6 (HSE, 2002). A “Notice to Mariners” will also be issued by the Hydrographer of the Navy for the establishment of a rig-on-location and will be maintained throughout drilling operations.

3.6.4 Positioning and anchoring of the rig

The Contractor’s Rig Safety Case and the Marine Operations Manual will detail the procedures for jacking-down and jacking-up operations, which include ballasting and mooring operations.

The location will be reviewed by the drilling contractor to assess its suitability. Borehole data has already been obtained to assess the soil conditions at the site. This data will be reviewed, and, if deemed necessary, additional boreholes will be installed to determine the soil conditions at each leg position. Gravel dumping (maximum 3,000 tonnes) may be required if the soil conditions are determined to be unsuitable for the jack-up foundations. Statoil understand that any material added for rig stabilisation purposes will constitute a potential change to the local seabed habitat. Consequently, Statoil will only consider such measures if the soil conditions at the seabed are unsuitable to support the rig.

The Mariner field drilling rig will be manoeuvred close to the platform and positioned adjacent to it in a predetermined configuration. To position the drilling rig, the legs will be jacked-down and the rig will be jacked-up until clear of the sea. The ballast tanks located around the rig will be filled with seawater to settle the rig in position. This ballast loading will be held for approximately one hour before being discharged back to the sea.

Following this “pre-loading” stage, the drilling derrick on the Mariner field drilling rig will be moved out over the platform to the required location above the well so that drilling can begin. The jack-up drilling rig will be located on the north side of the PDQ platform.

Once the drilling rig is in position, an ROV will be used to monitor for evidence of scour around the legs. Scour is caused by strong currents near to the seabed, due to tidal and/or storm surge currents, and additional measures are sometimes required to prevent scour and ensure that the rig remains stable on the seabed.

3.6.5 Disposal of liquid and solid drilling waste

Under the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL) and as implemented by UK legislation, it is a legislative requirement that all discharges and wastes from the rig and attendant vessels are managed.

Where required, machinery, chemicals, fuel and lubrication oil storage areas on each rig will be bunded in order to contain drips and spills, and minimise the risk of overboard discharge. For safety reasons, however, it is usually required that any spillage of aviation fuel during the refuelling of helicopters on the rig, will be directed to sea, where it will rapidly disperse and evaporate.

Engine room machinery space containing quantities of waste oil will drain to the bilge. The contents of the bilge are passed through an oil/water separator. The separated oil is then stored in an oily waste tank and back-loaded to shore for recycling. The separated water is discharged to sea at oil concentrations of less than 15 ppm, in accordance with regulatory requirements.

The drill floor is a fully contained area and all oily discharges will drain to a pollution tank. Liquid waste at the Mariner field will be disposed of via a dedicated waste injection well (**Section 3.6.17**).

Non-hazardous wastes (e.g. packaging, scrap metal and galley waste) and special wastes (e.g. chemicals, out-of-date medicines, contaminated dressings from the sick bay, and chemical and lubrication oil containers) will be categorised and segregated on board the rig and then back-loaded to a dedicated waste reception terminal for disposal by recycling, incineration or landfill onshore according to “Duty of Care” requirements of waste management legislation. Sewage and “grey water” will be treated on board the rig before being discharged to the sea in accordance with regulatory requirements.

The disposal of the low toxicity oil based mud (LTOBM) mud and cuttings are detailed in **Section 3.6.10**.

3.6.6 Simultaneous operations

Routine lifts from supply vessels will be conducted while drilling operations are undertaken at the drilling rig and the PDQ platform. A dropped objects risk assessment study will be conducted to avoid damage to any installed subsea facilities as a result of subsequent well drilling operations, where applicable. There is the potential for the Mariner Area Development pipe-lay vessel, the PDQ platform and drilling rig to undertake simultaneous operations (**Table 3.3**). When assessing simultaneous operations, Statoil will take into consideration well shut-in requirements.

Drilling operations on the jack-up drilling rig will commence when most of the hook-up operations on the PDQ have been completed. The following simultaneous drilling / operations will occur at the Mariner Area Development between the PDQ drilling module and the jack-up drilling rig:

- setting of conductors;
- drilling of complete well into well target; and
- well completions.

3.6.7 Hazardous materials

The storage and use of hazardous materials on the drilling rig will be carefully controlled. Storage will only be allowed in designated areas and a detailed inventory of hazardous materials will be kept.

Hazardous materials will be likely to include:

- Diesel fuel, lubricants and base-oil supplied by boat using clearly marked hose connections, or in dedicated containers.
- Aviation fuel for refuelling helicopters, stored in a dedicated, clearly marked, helifuel tank; refuelling will only be carried out by trained personnel.
- Limited quantities of compressed gases (oxygen, nitrogen and acetylene), stored separately in well-ventilated, clearly marked locations, away from any heat sources.
- Radioactive materials used for well logging which will be stored in special handling containers located in a clearly-marked position and normally bolted or welded to the rig structure; handling will be closely monitored and undertaken only by specially trained staff.

- Paint and thinners will be stored in a dedicated locker.
- Drilling chemicals which will be held in tanks, or dedicated hopper and sack storage areas. They will be handled and used strictly according to approved procedures; handling and use will be closely monitored and undertaken by dedicated staff.

Detailed guidelines on the containment of oil and chemicals, and on procedures for the transfer of hydrocarbons and chemicals, will be given in the rig contractor's Environmental Management System (EMS). In line with Statoil's Drilling Management System, Statoil will undertake technical, safety and environmental audits as part of the drilling rig tendering process and acceptance, which include the drilling rig contractor's EMS. Implementation of the EMS will be reviewed as part of ongoing management of the drilling rig contractor.

3.6.8 Well designs

Drilling at the Mariner Area Development will target the Maureen and Heimdal reservoirs. Statoil propose to target the Mariner field (Maureen and Heimdal reservoirs) by 60 well slots, with 50 simultaneously active wells. Approximately 92 geological sidetracks will be needed to ensure optimal production from the well slots towards the end of the programme to access all the reservoir targets. Four wells will be drilled at the Mariner East field (Maureen reservoir).

Once all available well slots at the Mariner field have been utilised, the sidetracks will be drilled. The Maureen and Heimdal production wells at the Mariner field will be designed for an operating life of 10 years before they are sidetracked to target the reservoirs further.

To access each reservoir, Statoil are proposing to drill short wells, medium wells, long wells, extended reach wells and sidetracks for the production wells and the produced water re-injection (PWRI) wells. In addition, the production wells for the Heimdal and Maureen reservoirs will have separate designs to optimise the recovery of the reservoirs. The designs as diagrammed in **Figure 3.15** are:

- Mariner Maureen production wells will be single drains wells;
- Mariner Heimdal production wells will be single and dual drain wells; and
- Mariner East Maureen production wells will be single drain wells.

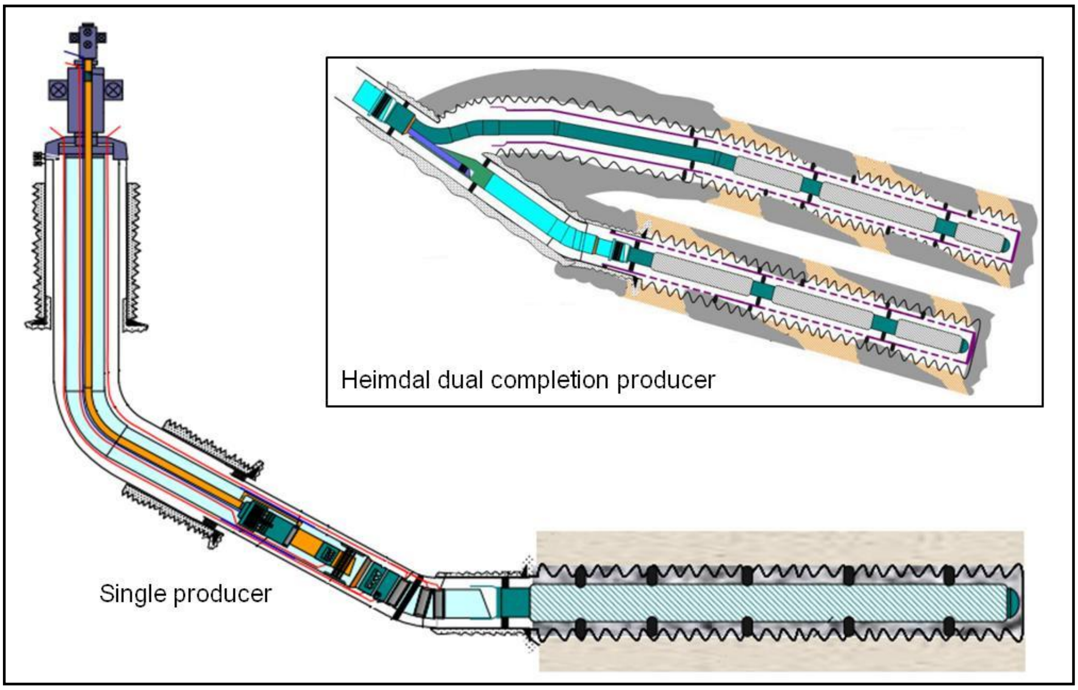


Figure 3.15: Schematics of the proposed Maureen, Heimdal and Mariner East producer wells

The proposed well designs for the Mariner (Heimdal and Maureen) and Mariner East (Maureen) production and PWRI short, medium, long and extended reach wells and sidetracks are provided in **Appendix B**. The wells will be of a simple design within proven industry practice, and will be based on lessons learned from previous wells drilled in the vicinity of the Mariner field.

Statoil have designed the Mariner (Maureen and Heimdal) and Mariner East (Maureen) wells to:

1. optimise and fulfil the well objectives at a minimum risk and cost;
2. optimise use of reliable and field proven equipment and completion techniques;
3. apply their experience from similar completions;
4. ensure simplicity and functionality; and
5. ensure use of environmentally friendly fluids and chemicals.

Under all the different well designs LTOBM will be required to drill the 12¼” and 9½” sections and sidetrack sections (**Appendix B**). Under the long well designs the 17½” will also be drilled using LTOBM. LTOBM will be used for these sections because:

- Drilling risks, resulting from the long sections, will be reduced. If water-based mud (WBM) was utilised then there is a significantly higher risk that the casing could not be run to the correct target depth due to sticky chemically sensitive shales.

- The likelihood of differential sticking due to the large pressure differences between formations will be reduced.

- Drilling torque and drag will be reduced. The use of LTOBM, therefore, significantly reduces the risks potentially associated with drilling and completing the well only using WBM.

Applicable permit applications and notifications will be submitted to the DECC prior to the commencement of drilling operations and will identify, quantify and assess the risks associated with drilling operations. The preliminary well design that will be applied for both the Mariner and Heimdal wells is presented in **Tables 3.4a** to **3.4c.**

3.6.9 Drilling mud

Drilling mud is used to lubricate and cool the drill bit, maintain well pressure stability and remove drill cuttings from the bottom of the well as it is drilled. Different mud formulations are required at different stages in the drilling operation because of variations in pressure, temperature and the physical characteristics of the rock being drilled. The mud formulation will be finalised during detailed well design and the appropriate permit application for the proposed operations will be submitted to the DECC prior to drilling.

Contingency chemicals are the chemicals that will be kept on the drilling rig but used only if specific problems occur during drilling. The most common problems encountered are:

- Stuck pipe – fluid is required to help free the drill pipe if it becomes stuck in the well bore.

- Loss of circulation – fibrous, granular and flaked material is added to the mud to reduce losses through porous or fractured formations penetrated by the well bore.

- Bridging – the flow of drilling mud in the annulus is blocked due to an excess of solid material.

- Side-tracking – contingency plans are enacted if the well trajectory is misaligned or the reservoir target is not encountered.

In the UK, chemical use is administered under the Offshore Chemicals Regulations 2002 (as amended). These regulations require that the chemicals or products to be used during the drilling operations are assessed for their environmental risk prior to use and discharge. This chemical risk assessment will be carried out as part of the chemical permit and drilling applications for the production wells. The risk assessment applies for both routine and contingency chemicals in the mud formulation.

3.6.10 Drill cuttings

The top-hole (28") sections of each Maureen, Heimdal and Mariner East well slots, regardless of well design, will be drilled with seawater / WBM; (**Tables 3.4a** to **3.4e; Appendix B**). Drilling each 28" section will result in 70.7 tonnes of seawater / WBM cuttings discharged directly onto the seabed (**Tables 3.4a** to **3.4f; Appendix B**). Drilling the 28" sections at 50 out of the 60 well slots at the Mariner field would result in approximately 3,536 tonnes of seawater and WBM cuttings discharged directly onto the seabed (**Table 3.4f**). Drilling the 28" sections from the 4 Mariner East production wells would result in an additional 283 tonnes of seawater / WBM cuttings discharged directly onto the seabed at a separate location, approximately 6.5 km from the Mariner PDQ (**Appendix B**).

Table 3.4a: Preliminary design for Maureen, Heimdal and Mariner East short well designs

Hole section	Mud system	Fate of cuttings
28"	Seawater / WBM	Discharged to seabed
26"	WBM	Discharged overboard to sea
17½"	WBM	Discharged overboard to sea
13½"	LTOBM	Thermally treated fine particles discharged to seabed
9½"	LTOBM	Thermally treated fine particles discharged to seabed or skip and shipped to shore
Sidetrack sections to access the additional reservoir from the short well		
13½"	LTOBM	Thermally treated fine particles discharged to seabed
9½"	LTOBM	Thermally treated fine particles discharged to seabed or skip and shipped to shore

Note: WBM – water-based mud; LTOBM – Low-toxicity oil based mud

Table 3.4b: Preliminary design for Maureen and Heimdal medium well designs

Hole section	Mud system	Fate of cuttings
28”	Seawater / WBM	Discharged to seabed
26”	WBM	Discharged overboard to sea
17½”	WBM	Discharged overboard to sea
13½”	LTOBM	Thermally treated fine particles discharged to seabed
9½”	LTOBM	Thermally treated fine particles discharged to seabed or skip and shipped to shore
Sidetrack sections to access the additional reservoir from the medium well		
13½”	LTOBM	Thermally treated fine particles discharged to seabed
9½”	LTOBM	Thermally treated fine particles discharged to seabed or skip and shipped to shore

Note: WBM – water-based mud; LTOBM – Low-toxicity oil based mud

Table 3.4c: Preliminary design for Maureen and Heimdal long well designs

Hole section	Mud system	Fate of cuttings
28”	Seawater / WBM	Discharged to seabed
26”	WBM	Discharged overboard to sea
17½”	LTOBM	Thermally treated fine particles discharged to seabed
13½”	LTOBM	Thermally treated fine particles discharged to seabed
9½”	LTOBM	Thermally treated fine particles discharged to seabed or skip and shipped to shore
Sidetrack sections to access the additional reservoir from the medium well		
13½”	LTOBM	Thermally treated fine particles discharged to seabed
9½”	LTOBM	Thermally treated fine particles discharged to seabed or skip and shipped to shore

Note: WBM – water-based mud; LTOBM – Low-toxicity oil based mud

Table 3.4d: Preliminary design for the make-up water well (based on the short, Maureen water injection well)

Hole section	Mud system	Fate of cuttings
28”	Seawater / WBM	Discharged to seabed
26”	WBM	Discharged overboard to sea
17½”	LTOBM	Thermally treated fine particles discharged to seabed
13½”	LTOBM	Thermally treated fine particles discharged to seabed
9½”	LTOBM	Thermally treated fine particles discharged to seabed or skip and shipped to shore

Note: WBM – water-based mud; LTOBM – Low-toxicity oil based mud

Table 3.4e: Preliminary design for the waste disposal well (based on the long, Maureen water injection well)

Hole section	Mud system	Fate of cuttings
28”	Seawater / WBM	Discharged to seabed
26”	WBM	Discharged overboard to sea
17½”	LTOBM	Thermally treated fine particles discharged to seabed
13½”	LTOBM	Thermally treated fine particles discharged to seabed
9½”	LTOBM	Thermally treated fine particles discharged to seabed or skip and shipped to shore

Note: WBM – water-based mud; LTOBM – Low-toxicity oil based mud

Table 3.4f: Estimated cuttings volumes for the Mariner field wells and Mariner East wells

Mud system	Disposal method	Mariner field	Mariner East field
		Amount of cuttings (tonnes)	
Tophole section drilled with seawater	Discharged directly to seabed	3,536	283
WBM drilled sections	Discharged overboard to sea	70,796	4,652
LTOBM	Thermally treated fine particles discharged to seabed	54,183	1,597
LTOBM (reservoir sections)	Thermally treated fine particles discharged to seabed or skip and shipped to shore	20,582	595

The 26” section of each short, medium and long well will be drilled with WBM, while the 17½” section of only the short and medium wells will be drilled with either a WBM or a LTOBM. The Mariner East wells will be of a short well design, while the Mariner wells will be of short, medium and long well design (**Tables 3.4a** to **3.4e**).

3.6.10.1 Water-based mud (WBM)

If WBM is used to drill the 26” and 17½” sections, the cuttings will be brought to the rig via the riser from the well. The WBM and cuttings will then be processed onboard the drilling rig to remove the majority of the mud and the cuttings will be discharged overboard. Drilling the 26” sections (and 17½” sections in the short and medium wells) with WBM at the Mariner field would result in the overboard discharge of approximately 70,796 tonnes of mud and cuttings (**Tables 3.4f**). Drilling the 26” sections and 17½” sections in the Mariner East wells with WBM would result in the overboard discharge of approximately 4,652 tonnes of mud and cuttings (**Tables 3.4f**).

3.6.10.2 Low-toxicity oil based mud (LTOBM)

The 17½” sections of the long wells, and the 13½” and 9½” hole sections in all Mariner and Mariner East wells and sidetracks will be drilled using LTOBM. The use of LTOBM in these sections will produce approximately 74,765 tonnes of mud and cuttings from the Mariner wells and approximately 2,192 tonnes of mud and cuttings from the Mariner East wells (**Tables 3.4f**).

The raw LTOBM cuttings, which will comprise a mix of drilled rock solids, drilling muds and water, will be retrieved to each drilling rig. The contaminated LTOBM mud and cuttings will be returned to the jack-up drilling rig and the PDQ through the mud return line. Due to the high flash point of the Mariner crude, Statoil currently have two options under consideration for the disposal for the LTOBM mud and cuttings generated from the 9½” reservoir sections; disposal via containment and disposal of the cuttings onshore or the use of a thermal cuttings treatment unit offshore.

Thermal treatment of LTOBM cuttings offshore

The use of a thermal cuttings treatment unit offshore would use thermo-mechanical desorption to clean the LTOBM cuttings. Due to the properties of the heavy oil from the reservoirs, cuttings produced from the reservoir sections may have to be offloaded for treatment onshore.

Thermo-mechanical desorption treats the raw cuttings waste, reducing it to its constituent parts of water, oil and dry rock powder. The LTOBM cuttings treated and cleaned offshore by thermo-mechanical desorption will result in oil-on-cuttings less than 1%. These cuttings would be disposed of overboard in compliance with UK. environmental regulations. By using a thermo-mechanical desorption unit, the extensive storage of hazardous waste, long transportation by boat and hazardous waste treatment onshore will be avoided.

The purpose of a thermo-mechanical desorption unit is to convert hazardous oily waste into useful products. The advantages of this system include simplified logistics for offshore waste management, reduced environmental impact, improved safety and reduced costs.

Typical drilling waste from thermo-mechanical desorption will contain 70% mineral solids, 15% water and 15% oil. The cuttings are loaded into a feed hopper where a dual piston pump transports the waste into the next process step. The key component in the thermo-mechanical desorption is the process hammer mill. In the hammer mill kinetic energy is transformed to heat by friction created in the waste itself.

Before the process starts there are only dry solids in the vessel. The system will be pre-heated. An electrical drive sets a series of shaft mounted hammer arms in motion inside a barrel shaped process chamber (also referred to as the hammer mill or just the mill). The solid particles are forced towards the inner wall of the process chamber where the kinetic energy from the rotating arms will be transformed to heat by friction. When the unit has reached a preset temperature cuttings waste is automatically fed into the reaction chamber. The waste is heated by the already heated dried solids. The oil and water will be heated and evaporate instantly. The unit can run continuously as frictional heat is constantly created by the hammering and motions.

The liquids evaporate and leave the chamber, new waste is pumped in, and solids are discharged through a cell valve. The hottest spot in the process is the waste itself, and the base oil is under influence of high temperature for a maximum of a few seconds. The oil can be reused as a component in new OBM.

The solids are discharged from the chamber through a discharge valve and transported by a screw conveyer, cooling the solids to an acceptable temperature. A small amount of solids will be carried by the vapours out of the process mill for that reason the vapours will pass through a cyclone where most of the solids are taken out.

To secure maximum quality of the oil, the vapours will also pass through an oil scrubber where the remainder of solid particles are separated from the vapour stream. The next step is a condenser for the oil where the oil vapours condense to a high quality liquid oil. Afterwards the water vapour is condensed to a liquid. A small percentage of the oil, the lighter fractions, which are not condensed in the oil condenser will be removed from the water in a traditional water / oil separator. The water phase will be routed to the slop treatment unit.

The solids produced will be mixed with seawater during processing and pumped overboard for disposal. The seawater used is the spent cooling water which has been utilised for cooling the mill. The discharge point recommended is 15 m below sea level. The discharge caisson for drill cuttings on the PDQ will be located on the North West side and the slurrified WBM cuttings and the powdered OBM cuttings will be discharged through a hose connected to the caisson 50 m away from the platform to avoid conflicts with seawater intake and reduce piling and spreading.

Containment and onshore disposal

If Statoil select the disposal of LTOBM mud and cuttings via containment and disposal of the cuttings onshore, the contaminated LTOBM mud and cuttings from the reservoir sections (9½” sections) will be returned to the jack-up drilling rig and the PDQ through the mud return line and will be processed by a series of solids control equipment. The solids control equipment will separate drilled solids from liquid mud; the drilled solids/cuttings are then contained and shipped to shore for processing. The recovered mud will be drained back into the mud pits on the jack-up drilling rig and on the PDQ and will be recycled back down the hole by the mud pump. The circulating system is a closed loop system; the mud is continually recycled throughout the drilling programme. The PDQ drilling rig will be designed to store 400 tonnes of cuttings and treat 8 tonnes per hour. When there is capacity, drill cuttings from the drilling rigs can be stored and treated on the PDQ.

Constituents will be added to make up for losses to formation, adjust the mud’s properties or overcome difficult conditions (e.g. a stuck drill pipe).

In alignment with company policy and legislative requirements, all LTOBM-contaminated cuttings will be totally contained throughout the closed loop system and the cuttings will be collected and returned for treatment and disposal onshore, via enclosed skips filled on the rig. Once onshore, the cuttings will be treated to remove residual oil to very low levels before being transported to a licensed landfill disposal site. The recovered oil will be recycled and whole LTOBM will be returned to the suppliers for treatment and reuse.

3.6.11 Cementing

In order to anchor the well casing within the hole, cement will be pumped down via the casing and then up the outside to fill the annulus between the casing and the wall of the hole. The well design will incorporate practices to minimise the use and discharge to sea of cement and additive chemicals. During well planning, data from previous wells in the area will be reviewed to provide estimates of the size of the hole and therefore the amount of cement required.

Between each cementing operation there may be a small discharge of chemicals when the cementing unit is cleaned. It is anticipated that the majority of the cement will be mixed and used as required, and as a result there should be limited discharges of cement mix water or spacers. The cement formulation will be finalised during well design and the appropriate permits will be submitted to DECC for approval before drilling operations begin.

3.6.12 Well control procedures

Well control will be maintained through the use of drilling fluid at a density that will maintain the hydrostatic pressure greater than the pore pressure of the formations being drilled. A minimum amount of barite (a weighting agent) will be stored on the rig to enable the density of the active mud system to be increased as necessary.

A blow-out preventer (BOP) will be installed for secondary well control. The BOP is a series of powerful sealing elements (or valves) located on the BOP deck (**Figure 3.14**). In the event of an influx of oil, gas or water into the well, the BOP closes-off the annular space between the pipe and the hole through which the mud normally returns to the surface. This forces the mud and / or formation fluids to flow through a controllable choke which allows the pressure to be controlled and a balanced system to be restored. The BOP would be tested immediately after installation and approximately every three weeks thereafter. Responsibilities during a BOP closure would be documented in the Well Control Manual. All relevant staff would be fully trained and competent in its operation.

3.6.13 Logging

Electric logs will be run in the production wells to fully evaluate the formation. During drilling operations Measurement While Drilling (MWD) tools will be used to provide directional and formation information. The primary data collection will be by Logging While Drilling (LWD) tools, but wireline logs may also be run depending on the data acquisition requirements of each well. MWD, LWD and wireline logging evaluation will include the use of several types of downhole instruments to log the well and determine hole and formation conditions. A combination of resistivity, natural gamma ray and sonic measurements will be taken. LWD and wireline tools may also include neutron, density, formation pressure, borehole calliper and imaging logs, and formation fluid and pressure sampling. Vertical Seismic Profiling (VSP) logs may also be required. The safe use of these tools, including radioactive sources, is covered by the relevant statutory, Statoil and contractor procedures.

3.6.14 Well bore clean-up

After drilling operations for each well have been completed, Statoil will undertake a well bore clean-up. This involves displacing the LTOBM from the cased well bore with clean-up pills and circulating the well with seawater at a fast pumping rate. The wastewater generated will be of two types: visibly oily and visibly clean. These will be kept separate and disposed of appropriately.

The clean-up pills and any contaminated seawater returns (visibly oily seawater and any residual cuttings solids) will be fully contained and routed to a designated pit. All solids from the clean-up will be disposed of via skips and shipped to controlled onshore disposal sites. Seawater will continue to be circulated into the well until it is considered clean (i.e. no visible oil is present) at which point returns from the well will be discharged to the sea. Samples of discharged water will be taken at regular intervals for analysis in accordance with OPPC regulations.

After each well has been drilled and completed, the mud in each well will be removed and replaced with an inhibited completion fluid. The completion fluid is likely to consist of NaCl / CaCl / KCl brine, containing small quantities of chemicals to protect the well. These chemicals will include a corrosion inhibitor, an oxygen scavenger and a biocide. The exact chemicals and work programme will be included in the detailed chemical risk assessment within the chemical permit application which will be submitted to DECC at least 28 days prior to commencement of drilling activities as required by the Offshore Chemicals Regulations 2002 (as amended).

Following completion, each production well will be flowed to clean the well bore and establish a sand free production rate prior to hook-up to the production facilities. A final clean-up and flow test will be required to remove mud, debris and loose sand particles from the well bore. Data on productivity will also be gathered. Production fluids from each production well will be routed through the test separator on the PDQ. Any interface fluid produced will be captured on the PDQ and injected down the waste well.

3.6.15 Electrical Submersible Pumps

Electrical Submersible Pumps (ESPs) will be required throughout the Mariner Area Development life to artificially lift oil from the production wells back to the PDQ. The ESPs will be fitted to each production well to provide a method of artificial lift at the development.

3.6.16 Produced water re-injection (PWRI)

Water injection is a method of maintaining reservoir pressure by injecting treated water back into the reservoir, thereby maximising the percentage of hydrocarbons that would naturally be recovered from the reservoir and maintaining the production rate of a reservoir over a longer period of time. Typically water is injected to support reservoir pressure to displace the oil from the reservoir and push it towards the well.

Statoil anticipate that the Mariner Area Development will require water to be injected into the Maureen and Heimdal reservoirs, to maintain pressure following initial production start-up. Statoil anticipate a total of 50,000 m^3/day of water will need to be injected into the Maureen and Heimdal reservoirs until the end of field life. No produced water re-injection will be required at the Mariner East wells.

Initially the injected water will consist of chemically treated, filtered and de-aerated seawater, and over time the re-injection of inhibited produced water will be used in preference to the seawater.

3.6.17 Waste disposal well

There are two main areas of waste streams emanating from drilling operations at the Mariner field; cuttings from the drilling process and waste liquids. The waste liquids come from two main sources, rain / washdown water from the rig drains and other liquids that primarily come from well related operations. These liquids are commonly collected together and disposed of as waste often referred to as “slop”. They cannot be disposed of to sea without further treatment since these streams commonly contain hydrocarbons.

Statoil plan to dispose of these liquid wastes, firstly by treating the fluids to segregate as much free water as possible; then once they have been tested to be within regulatory limits, this free water will be disposed of to sea in accordance with existing permits. The remainder of the liquid waste at the Mariner field will be disposed of via a dedicated waste injection well.

This waste injection well at the Mariner field will be drilled to an already identified target in the Maureen sandstone, north of the PDQ. The well will be completed as a dedicated waste injection well and is not intended to have any other use. The target zone in the Maureen sandstone is in a segment completely segregated by faulting from the main Maureen reservoir to prevent potential contamination.

This solution has been selected since it is believed to be the most environmentally sound long-term option for the field. The only other viable alternative would be to contain and ship this waste to shore for further treatment and disposal. This alternative would only be used where the waste well was inoperable for whatever reason and would be considered as a temporary solution.

3.6.18 Make-up water well

The Mariner field is expected to require water injection from an early stage in its development to maintain pressure and reservoir drive. It is expected that some of the production wells will produce water early on, but it is uncertain when water will be produced and whether the volumes will be sufficient for injection needs. A source of water is therefore necessary from the point when the first water injection well is drilled. This is expected to be in year one of production or early year two at the latest. Studies have shown that using treated seawater for water injection can prove detrimental to the reservoir in the longer term, therefore, a water production well will be necessary early in the life of the field.

A very large aquifer has been identified in the Dornoch formation, which lies above both main reservoirs. This will be the primary target for the water production or “make up water well”. The well will be drilled to an already identified target to the east of the PDQ. This is planned to be a relatively short and simple well, which will be completed with an Electrical Submersible Pump (ESP) to provide for water production. It is not known at this stage for how long the well will be required to be in service. However, once sufficient water is being produced with the oil producers, the requirement for this well will gradually subside.

3.7 Pipelines and Subsea Infrastructures

Subsea facilities associated with the Mariner Area Development comprise:

- a 6 ⅝” (denoted by 6”), ~33 km gas import pipeline connecting the PDQ to the 32” Vesterled pipeline (Vesterled Tee);
- a 6⅝” (denoted by 6”), ~2.4 km diluent import pipeline connecting the FSU to the PDQ;
- a 10¾” (denoted by 10”), ~2.6 km crude export pipeline connecting the PDQ to the FSU;
- a PLET and spool to connect the 6” diluent import pipeline to the PDQ;
- a PLET to connect the 6” diluent import pipeline to the flexible risers at the FSU;

- a PLET and spool to connect the 10” crude export pipeline to the PDQ;
- a PLET to connect the 10” crude export pipeline to the flexible risers at the FSU;
- a PLET and spool to connect the 6” gas import pipeline to the PDQ;
- a PLET to connect the 6” gas import pipeline to the PLEM at the Versterled tie-in location;
- a PLEM, to connect the 6” gas import pipeline to the 32” Vesterled pipeline (Vesterled Tee);
- a 12¾” 6.5 km crude export pipeline connecting the Mariner East template to the PDQ;
- a 6.5 km umbilical (power and utility) to connect the Mariner East template to the PDQ;
- a 73 km fibre optic communication cable is to be installed between the PDQ and the Heimdal platform;
- a subsea isolation valve (SSIV) close to the PDQ, remotely controlled from the PDQ.

Additionally, risers will be installed within the jacket of the PDQ for the 6” gas import pipeline, the 6” diluents import pipeline and the 10” oil export pipeline.

The subsea facilities will be designed so that they can be inspected, maintained and repaired *in situ*, as necessary. All key components of the production system will have a protection philosophy which will consider fishing activity, dropped objects, anchoring and simultaneous operations consistent with reducing safety and environmental risk.

The Mariner Area Development pipeline specifications and design criteria are shown in **Table 3.5.**

Table 3.5: Mariner Area Development pipeline specifications

Pipeline specifications	Pipeline service			
	Gas import	**Diluent**	**Oil export**	**Multiphase flowline***
Diameter	6”	6”	10” (*Mariner*)	12¾” (*Mariner East*)
Length	~33 km	~2.4 km	~2.6 km	6.5
Design rate (max)	0.4x10^6 m^3/day	[3,180 m^3/day	12,720 m^3/day	3,500 m^3/day
Design rate (normal)	0 - 0.4x10^6 m^3/day	60 – 2,400 m^3/day	1,700 – 11,800 m^3/day	3,500 m^3/day
Design pressure (max)	164 barg at 26 m above MSWL	130 bara	130 bara	190 barg at MSL+30m
Operating pressure (normal)	70 – 142 barg	40 bara	40 bara	50 bara
Design Temp. (max)	50°C	65°C	65°C	65 °C
Operating temp. (normal)	5 - 8°C	45°C	45°C	50°C
Flowline material	Carbon steel	Carbon steel	Carbon steel	Carbon steel
Anti Corrosion material	3LPP	5LPP	5LPP	5-layer FBE

**The Mariner East values will be optimized further during later phases and may change accordingly*

3.7.1 Mariner East subsea template

The subsea template at the Mariner East field, from which the four production wells will be drilled through, will be approximately 20 m by 30 m in dimension and with a footprint area of 600 m^2. Statoil anticipate that the subsea template will be a gravity based structure, secured to the seabed by four suction anchors. The template will be designed to carry out a number of functions like launching and receiving pigs in connection with pipeline de-watering, drying and product-filling. Several vessels will be required during the installation programme, with diver assisted tie-in operations.

The subsea template will have an anti-corrosion protection provided by:

- a painted epoxy coating; and
- sacrificial aluminium-zinc-indium alloy anodes.

3.7.2 Gas import pipeline

Produced gas recovered from the Maureen and Heimdal and Mariner East reservoirs will be used for fuel on the PDQ. Statoil have not designed for export gas. Supplemental fuel gas will be imported from the existing 32” Vesterled pipeline located approximately ~33 km routing length from the Mariner Area Development.

A 6” carbon gas import pipeline will be installed, to connect the PDQ to the Vesterled pipeline, via a T-connection. **Figure 3.9** provides an illustration of the proposed pipeline route. The gas import pipeline will have a subsea isolation valve (SSIV), located on a separate structure, assumed to be located between 100 and 300 m away from the PDQ. The pipeline will be trenched to a sufficient depth for protection against third parties and trawling activities. Typical trench depth will be approximately 1 m with backfill.

3.7.3 Pipelines between PDQ and FSU

Two pipelines will be installed between the PDQ and the FSU (**Figure 3.16**). The two carbon steel pipelines will be a 6” diluent import line, and a 10” crude export lines, and will be installed with a southerly approach to the FSU. Both pipelines are assumed to be trenched to approximately 1 m and backfilled for protection against third parties and trawling activities.

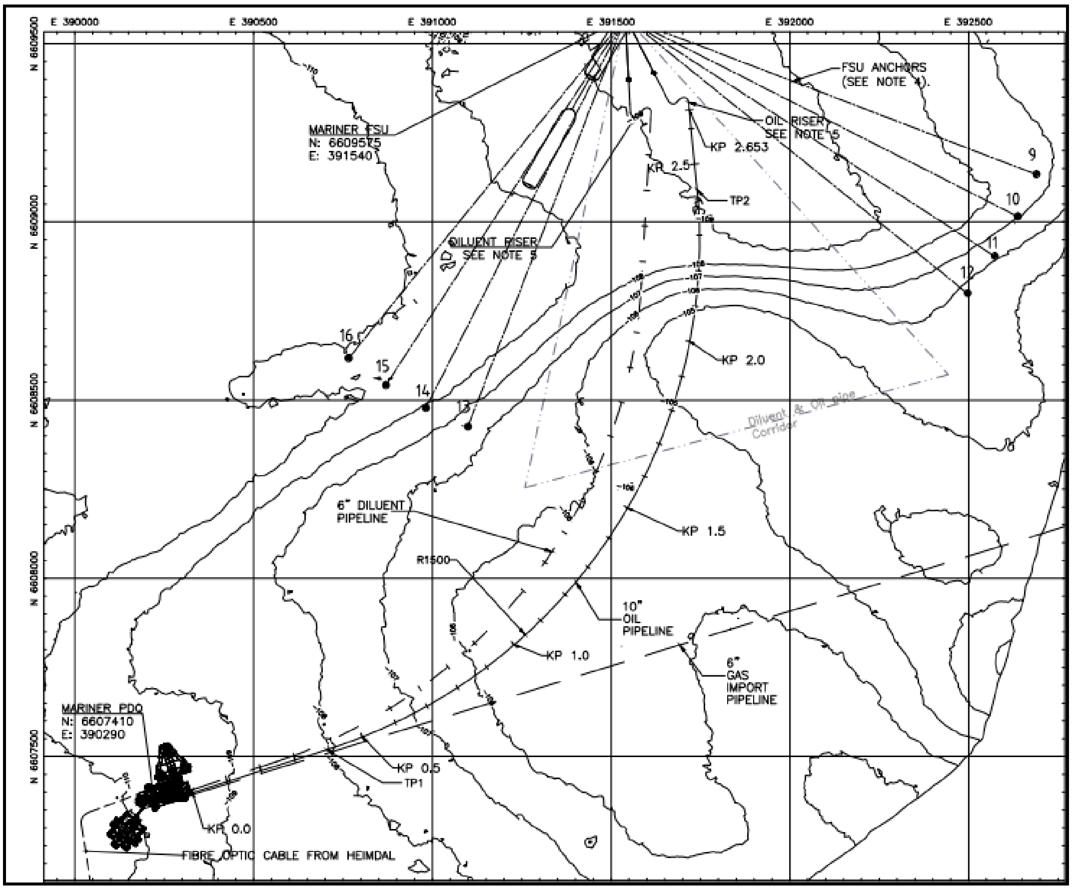


Figure 3.16: Proposed pipeline routes between PDQ and FSU

3.7.4 Pipelines/cable between Mariner East and the PDQ

One pipeline and one umbilical will be installed between the Mariner East subsea template and the PDQ. The carbon steel pipeline will be a 12¾" crude export line, exporting crude from the Mariner East reservoir to the PDQ. The umbilical will be a combined power and communication cable providing the subsea template with power and utilities from the PDQ. The pipeline will be trenched to an approximate depth of 1 m and backfilled for protection against third parties and trawling activities.

3.7.5 Pipeline End Manifolds (PLEM) and Pipeline End Terminations (PLETs)

A pipeline end manifold (PLEM) will be installed at the tie-in location at the Vesterled Pipeline to provide the connection point for the tie-in spools from the gas import pipeline and the existing spool for the Vesterled Tee. The PLEM will be connected to the Vesterled Tee by utilising an existing cross over spool on the Vesterled pipeline, where an existing tie-in system connection is available. A new spool will bridge between the Mariner gas import pipeline PLEM and the existing cross over spool (**Figure 3.17**).

There is currently an ongoing study to determine if the existing cross over spool and tie-in locations is in a suitable working condition. If the cross over spool is not in condition, Statoil use a back-up tie-in location at the same Tee utilising the existing cross over spool. If the tie-in location is not in condition, Statoil will use a hot-tap to Vesterled.

A total of six Pipeline End Terminations (PLETs) will be installed at the Mariner Area Development. A PLET will be installed at either end of the 10", ~2.6 km oil export pipeline connecting the PDQ to the FSU, at either end of the 6", ~2.4 km diluent import pipeline connecting the PDQ to the FSU, and at either end of the 6", ~33 km gas import pipeline connecting the PDQ to the Vesterled pipeline. The PLETs will provide a connection point for the tie-in spools at the PDQ and flexible risers at the FSU from each pipeline.

The PLETs will be approximately 4 m by 3 m in dimension and with a footprint area of 12 m^2. The PLEM will be approximately 10 m by 15 m, giving a footprint area of approximately 150 m^2. Statoil anticipated that the PLEM and PLETs will be gravity based structures, where the PLEM skirt will penetrate into the seabed. The PLEM and PLETs will have been designed to carry out a number of functions like launching and receiving pigs in connection with pipeline de-watering, drying and product-filling. Fishing friendly protection covers will be installed over the PLEM and PLETS and the new spools. Several vessels will be required during the installation programme, with tie-in operations undertaken by either remotely operated vehicles (ROVs) or diver assisted.

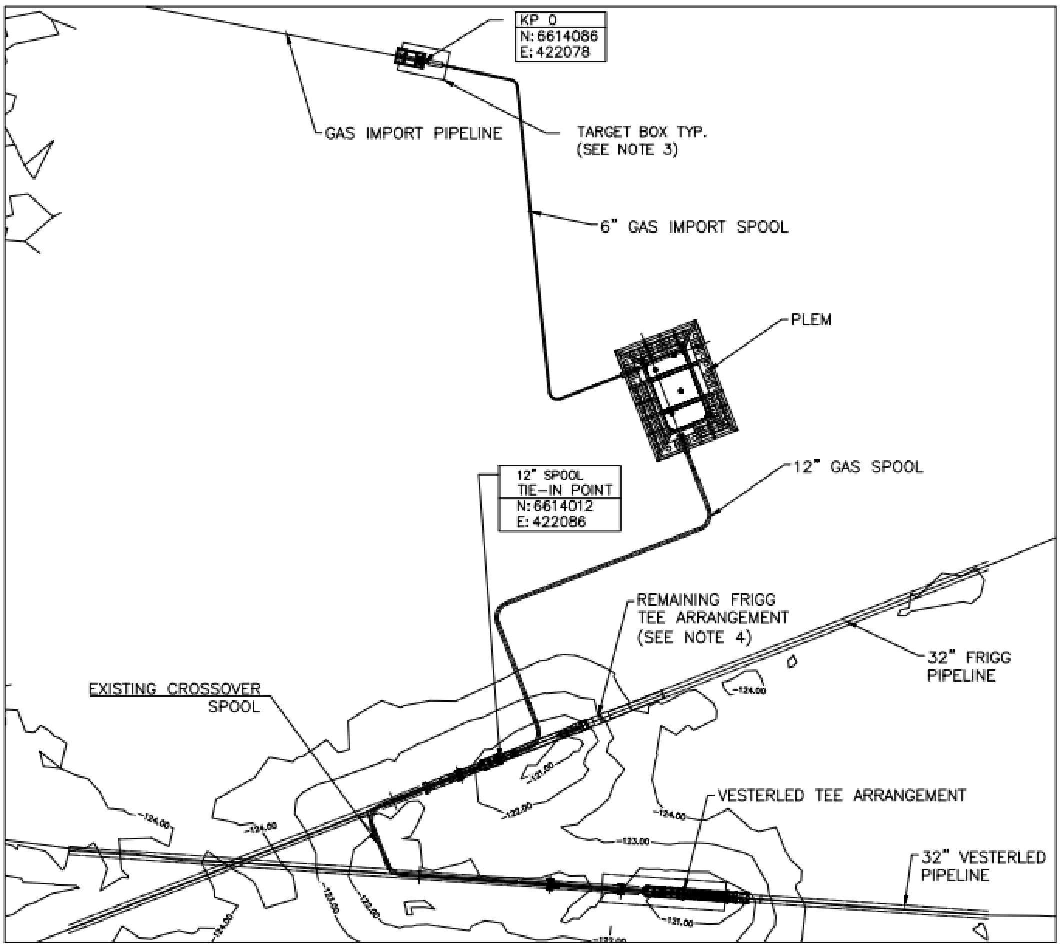


Figure 3.17: Illustration of the Mariner gas import pipeline PLEM at the Vesterled Tee

Protection against corrosion for the PLEM and PLETs will be provided by coatings, such as a 3-layer polypropylene coating (3LPP), and by sacrificial aluminium-zinc-indium alloy anodes placed in the form of bracelets around the pipes and at the structures, with spacing intervals to be determined. The anodes will be suitable for long term continuous service in seawater, saline mud or alternating seawater and saline mud environments. The exact number and locations of anodes have not been determined at this early stage of Front-End Engineering Design (FEED) but will be during later stages of detailed engineering.

Rockdump, varying in size, (**Section 3.7.10**) will be laid on the seabed to level the seabed prior to the placement of the PLEM and the PLETs. Statoil estimate that approximately 10,000 m^2 of rockdump will be laid onto the seabed for the PLEM and the six PLETs.

3.7.6 SSIV

A subsea isolation valve (SSIV) will be installed on the seabed close to the PDQ and will be remotely controlled from the PDQ. The design of the SSIV has yet to be finalised, however, the dimensions of the SSIV would be expected to be approximately 9 x 7 x 4 m. The SSIV will require a protective structure and will be located within the 500 m zone of the PDQ.

Like the PLEM and PLETs, the SSIVs will be designed with dimensions and weights to enable installation by diving support vessel (DSV). The SSIV will be gravity based and therefore there is no requirement to pile these structures.

3.7.7 Subsea cables

A 73 km fibre optic communication cable is to be installed towards the Heimdal platform. This cable will as base case be trenched along the 73 km route (**Figure 3.18**). The fibre optic communication cable will cross 12 existing pipelines and one cable, a proportion of which will be within Norwegian waters and therefore will be subject to permits from the relevant Norwegian Authorities (**Figure 3.18).**

3.7.8 Pipeline installation

The method of pipe-lay and the installation contractor will be selected by Statoil during the detailed engineering phase of the project. The selected contractor will submit a detailed method statement for approval to Statoil at that time.

At this stage it is not known whether the Mariner Area Development pipelines will be installed by an anchored lay vessel, a dynamically positioned (DP) reel-lay vessel or a DP S-lay vessel. Given the proposed size and length of the pipelines (**Section 3.7**), any of the methods can be used at the Mariner Area Development.

- *Anchored lay vessel*. An anchored lay barge maintains its location or position by the vessel's anchoring system, supported by anchor handling vessels (AHVs). If an anchored lay barge were to be used to install the pipeline, it would be moved forward by deploying, tensioning and re-deploying between 10 and 14 anchors, which would be positioned on the seabed in a pre-determined 'anchor pattern'. This type of lay barge requires up to three AHVs to manoeuvre the anchors, and supply vessels to maintain the supply of pipe sections. The pipeline installation method would be the same as that for a DP lay barge.

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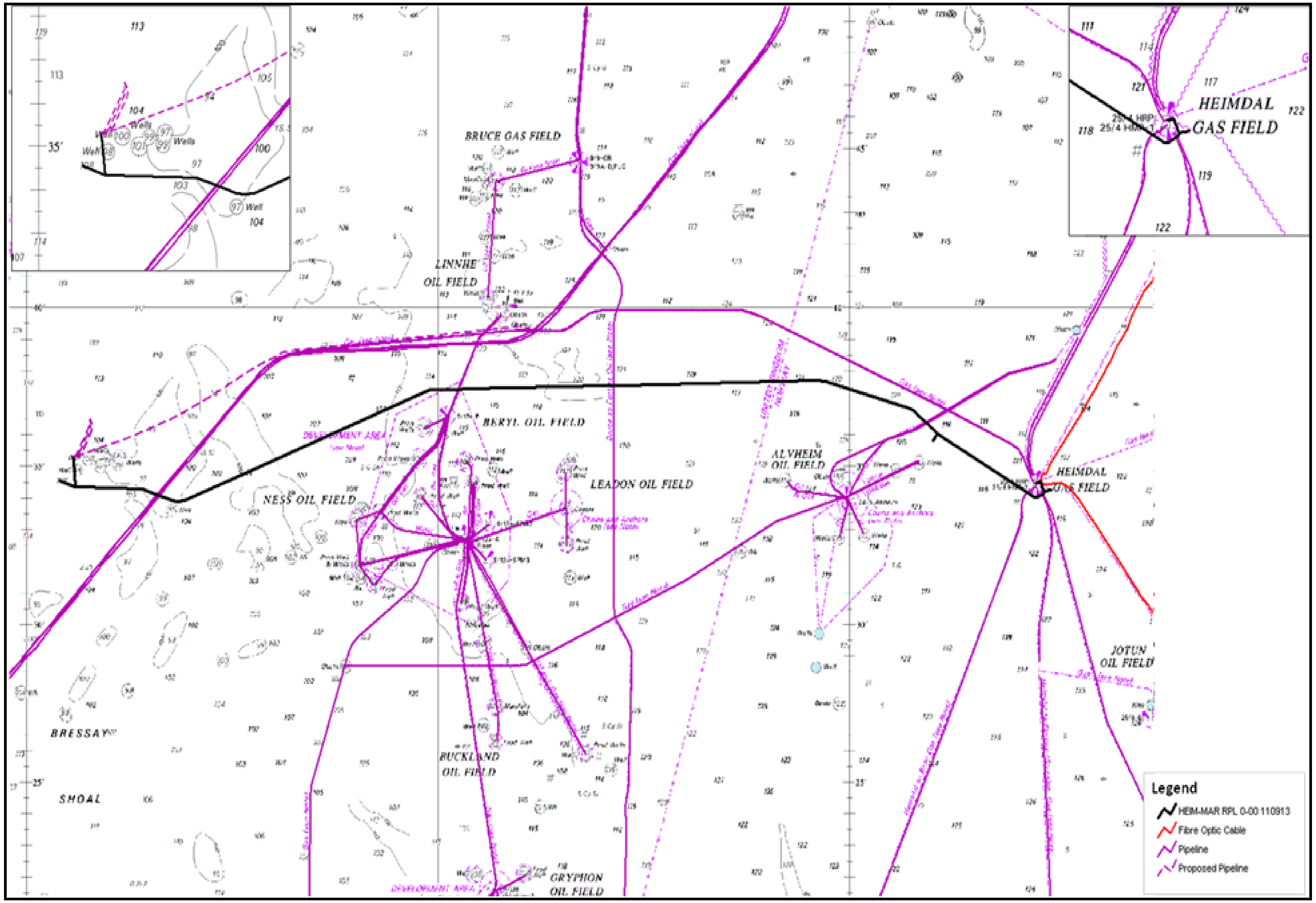

Figure 3.18: Illustration of the proposed fibre optic communication cable route

- *DP reel-lay vessel.* A DP reel-lay vessel maintains its location or position by the vessel's propulsion and station-keeping (dynamic positioning) system. Reel-lay vessels are self-propelled and deploy the pre-fabricated pipeline by unreeling the pipeline from a large drum onboard the vessel. Guard vessels would be required to alert fishing vessels about the pipeline and pipe-laying operations and would remain onsite should the reel vessel return to shore.

- *DP S-lay vessel.* A DP S-lay barge / vessel maintains its location or position by the vessel's propulsion and station-keeping (dynamic positioning) system. During installation, pre-fabricated sections of pipeline would be welded together on the lay barge, and the welded joints would be coated. The pipeline would be deployed into the sea via a 'stinger' (guide frame) and the pipe-laying rate would correspond to the forward speed of the vessel, restricted by the time needed for welding and curing of field-joint coating.

The installation of the gas import pipeline, the diluent import pipeline and the oil export pipeline will utilise a dead man anchor (DMA) to initialise the pipe-lay at the PDQ. The pipeline for the diluents and crude oil pipeline will be laid towards the FSU with the tie-in for the gas import pipeline laid from the PDQ towards the Vesterled. The pipelines will be initialised against the DMA with a PLET welded on the end. The DMA will be recovered post installation. After completing the pipe-lay operations, the pipelines will be tied-in to the risers at the PDQ jacket using a spool. At the FSU there will be direct tie-in to the flexible risers. It is anticipated that installation, tie-in and commissioning operations for the import and export pipelines will take approximately four months depending upon installation method selected.

The fibre optic communication cable will be tied-in by the use of J-tube pull. The direction of laying the fibre optic communication cable has not been decided. The cable may be laid from the Heimdal platform or from the Mariner PDQ.

There is no declared exclusion zone around the installation operations for the pipelines. Installation vessels will be responsible for guarding any operation that could potentially result in snagging of fishing gear, such as the installation of concrete mattresses and rock-dumping or at the lay-down head.

The pipe-lay vessel will have a Fisheries Liaison Officer (FLO) onboard if required and daily notifications will be issued as are required by the conditions of the DECC Pipeline Works Authorisation (PWA). Both the pipe-lay and trenching operations will be assisted by a survey vessel to ensure that the pipeline is laid in the correct location and that trenching activities are performed satisfactorily. Guard vessels will also be used to guard the un-trenched pipelines and the exposed pipeline ends prior to tie-in and the installation of permanent protection.

3.7.9 Trenching and backfilling operations

After the pipelines have been laid on the seabed, they will be trenched and backfilled in order to protect them from damage by third parties, to prevent interactions with fishing gear and to provide stability against upheaval buckling. This is the industry-preferred approach to pipelines less that 16” diameter.

3.7.10 Crossings

Based on the latest pipeline route selection, Statoil anticipate there will be one pipeline crossing as a result of the Mariner Area Development; the crossing of the abandoned Linnhe to Beryl B pipeline cluster which includes a six inch production, six inch gas lift and six inch water injection pipelines, by the proposed six inch gas import pipeline. The six inch gas import pipeline will be installed in 2015, between the PDQ and the 32” Vesterled pipeline.

The fibre optic communication cable will cross the following 12 pipeline routes and cable (**Table 3.6**).

Table 3.6: Summary of the pipelines and cable to be crossed by the fibre optic communication cable

Pipeline / Cable	Owner	Status	Burial status
18” Grane pipeline	unknown	In service	Unknown (presumed surface laid)
36” Statpipe	unknown	In service	Unknown (presumed surface laid)
8” PL301 Heimdal to Brae	unknown	In service	Unknown (presumed surface laid)
Umbilical Vilje-Alvheim	unknown	In service	Unknown (presumed surface laid)
12” production Vilje-Alvheim	unknown	In service	Unknown (presumed surface laid)
6” gas injection Vilje-Alvheim	unknown	In service	Unknown (presumed surface laid)
24” PL815 Bruce - Forties	unknown	In service	Unknown (presumed surface laid)
PL663	unknown	In service	Unknown (presumed surface laid)
PL662	unknown	In service	Unknown (presumed surface laid)
PL659	unknown	In service	Unknown (presumed surface laid)
PL6N (32”)	unknown	In service	Unknown (presumed surface laid)
Pl7N (32”)	unknown	In service	Unknown (presumed surface laid)
Gassled	unknown	In service	Unknown (presumed surface laid)

Statoil intend the crossings to be similar to other crossings in the North Sea by using rockdump and concrete mattresses to support, separate and protect the abandoned pipelines from the gas import pipeline. The communication cable may utilise “snap-on” external protection to avoid physical contact with other pipelines and cables, followed by post-laid rock-dumping.

3.7.11 Rock-dumping and mattresses

A number of concrete mattresses of standard industry design will be laid on the seabed and over existing pipelines, to support, separate and protect these pipelines from the gas import pipeline. The mattresses planned for use are likely to be of standard density concrete with dimensions of 10 m x 3 m (30 m^2).

The final number of mattresses required for the crossing of the gas import pipeline over existing infrastructure will be determined during the detailed design phase, but approximately four mattresses will be installed over pipelines PL 659, PL662 and PL 667 (**Table 3.6**). This will result in the use of a total of 12 mattresses, giving a total area of 360 m^2.

The base case for the fibre optic communication cable is to use “snap on” protection at the crossings followed by post-lay rock-dumping, rather than mattresses. If owners of the pipelines and cable do not allow the use of “snap on” protection, two concrete mattresses will be installed at each crossing. Assuming all 12 pipelines and cables require mattresses, a total of 26 mattresses will be required (footprint area of 780 m^2).

Statoil anticipate spot rock-dumping will required along the lengths of the pipelines to mitigate against upheaval buckling (UHB). Statoil anticipate a maximum of 60,000 m^3 of rockdump would be required for upheaval buckling and free-span, at the pipeline ends (transition zones), and at pipeline crossings. In addition, approximately 10,000 m^3 of rockdump will be laid on to the seabed for the PLEM and the six PLETs.

However, under a worst case scenario, rock-dumping may be required along the entire lengths of the pipelines and fibre optic cable for protection and to mitigate against UHB and free-span (pipeline). Under this scenario, Statoil anticipate a maximum volume of 200,000 m^3 of rockdump would be required for the pipelines and 300,000 m^3 of rockdump would be required for the fibre optic communication cable.

Graded crushed rock (1” to 5” in diameter) will be used for rock-dumping. Controlled placement of the graded rock at the proposed locations will be achieved by using a dedicated rock-dumping vessel equipped with a fall pipe. The graded rock will be fed into the fall pipe using a hopper system and the length of the fall pipe will be varied to suit the water depth at the site, with the end of the fall pipe positioned nominally within 5 m of the seabed. The hopper system will control the rate at which the rock is fed into the fall pipe and the operation will be monitored by ROV to confirm the correct positioning of the rock.

All rock-dumping will be consented under a Marine and Coastal Access Act (MCAA) licence, which will be applied for prior to installation.

3.7.12 Corrosion protection

All pipelines will be protected by use of corrosion coating. In addition, cathodic protection against corrosion will be provided by sacrificial aluminium-zinc-indium alloy anodes placed in the form of bracelets around the pipes, with spacing intervals to be determined. The anodes will be suitable for long term continuous service in seawater, saline mud or alternating seawater and saline mud environments.

3.7.13 Tie-in and connection operations

Tie-in and connection operations will be conducted from a Dive Support Vessel (DSV) equipped with ROVs and divers. Base case will be for some diver assistance at the Vesterled tie-in along with the use of ROVs.

After completion of the spool piece tie-in, rockdump will be placed over the top of the exposed part of the pipelines in the transition zone to buried conditions to provide protection from impacts by dropped objects and/or fishing gear. Spools and structures will be protected by means of protection covers. The tie-ins will be located within the 500 m exclusion zones around the Mariner PDQ and FSU, Vesterled Tess and the Mariner East subsea template.

3.7.14 Leak testing and dewatering operations

After a survey of the installed pipelines has confirmed that no excessive free-spans (areas where the flowline bridges depressions or hollows in the seabed) exist on the seabed, flooding and leak-testing operations will be performed. The pipelines will be flooded with inhibited seawater.

The flooding water will be chemically treated with oxygen scavengers, biocide and corrosion inhibitors to mitigate the risks of corrosion or bacterial growth. An ultraviolet-fluorescent dye will also be added to assist in leak detection subsea. Such chemicals will be diluted within the line-fill at concentrations typically ranging from 100 parts per million (ppm) to 500 ppm, depending on the manufacturer’s specifications and the required residence time within the pipelines. Following testing operations the inhibited seawater will be discharged subsea.

After completion of the flooding operation, a hydrostatic leak test will be performed to verify the integrity of the tie-in connection points. The pipelines will be pressurised to 1.1 times their maximum operating pressure. The pressure will be monitored, and if necessary an ROV will carry out a visual inspection to ascertain the integrity of the tie-in joints. Dye will again be used and will be subject to the same statutory approval process as the line-fill treatment. On completion of the testing programme the pressurisation fluid (treated seawater) will be discharged to the sea. The production pipelines will be commissioned by introducing the hydrocarbons into the line.

Chemical products approved for use on the UKCS under the Harmonised Offshore Chemical Notification Scheme (HOCNS) cannot be used or discharged without prior statutory approval. Prior to the installation of the pipelines PON15Cs will be submitted to DECC under the Offshore Chemicals 2002 (as amended), which will identify, quantify and assess the environmental risks associated with chemical use and discharge while installing the pipelines and umbilical.

3.7.15 Pipeline maintenance

No further planned hydrostatic testing of the pipelines is scheduled during the operational phase. Since the design life of the pipeline systems (40 years) will be the same as the expected design field life (40 years), no maintenance is planned other than routine inspections such as checking for lack of cover, free-spans and evidence of interaction with fishing. Any potential problems such as upheaval buckling and anchor snags will be avoided by correct pipeline design, trenching and careful installation.

The pipelines will be designed to accommodate ‘intelligent pigging’ inspection if necessary, whereby a remote sensing ‘pig’ will be conveyed through the pipeline to undertake checks on and confirm pipeline integrity and condition.

3.7.16 Flotel

A flotel will be on location at the Mariner Area Development during the hook-up, commissioning and tie-in operations, to provide additional personnel space (**Table 3.3**). At this stage, it is not known which flotel will be used by Statoil. The flotel would likely be positioned on location, approximately 50 m south or southwest of the PDQ, by DP or 12 to 16 anchors. Statoil anticipate the flotel will remain on location for 5 to 6 months, with accommodation for 350 to 500 personnel. The flotel will either be towed to location by several tugs or will transport itself to the Mariner Development area.

A 500 m safety zone will be maintained around the flotel during operations. Local shipping traffic will be informed of its position and the standby vessel will monitor shipping traffic at all times. Prior to any moves, a warning will be issued to the appropriate authorities, as required by the Health and Safety Executive (HSE) Operations Notice 6 (HSE, 2002). A "Notice to Mariners" will also be issued by the Hydrographer of the Navy for the establishment of the flotel's location and will be maintained throughout operations.

3.8 Mariner PDQ and Ship-shaped FSU

The integrated PDQ steel jacket platform will provide services for the reception of reservoir fluids, processing and offloading of crude for the Mariner Area Development. The PDQ platform will be supported by a FSU that will have the capacity to store quantities of crude and light oil. Light oil (diluent) will be used at the Mariner Area Development to dilute the crude oil, reducing its viscosity and density. The diluent will be supplied by shuttle tankers and stored onboard the FSU, and will then be transferred from the FSU into the production stream up-stream of the ESPs and as needed into the process on the PDQ platform (**Figure 3.19**).

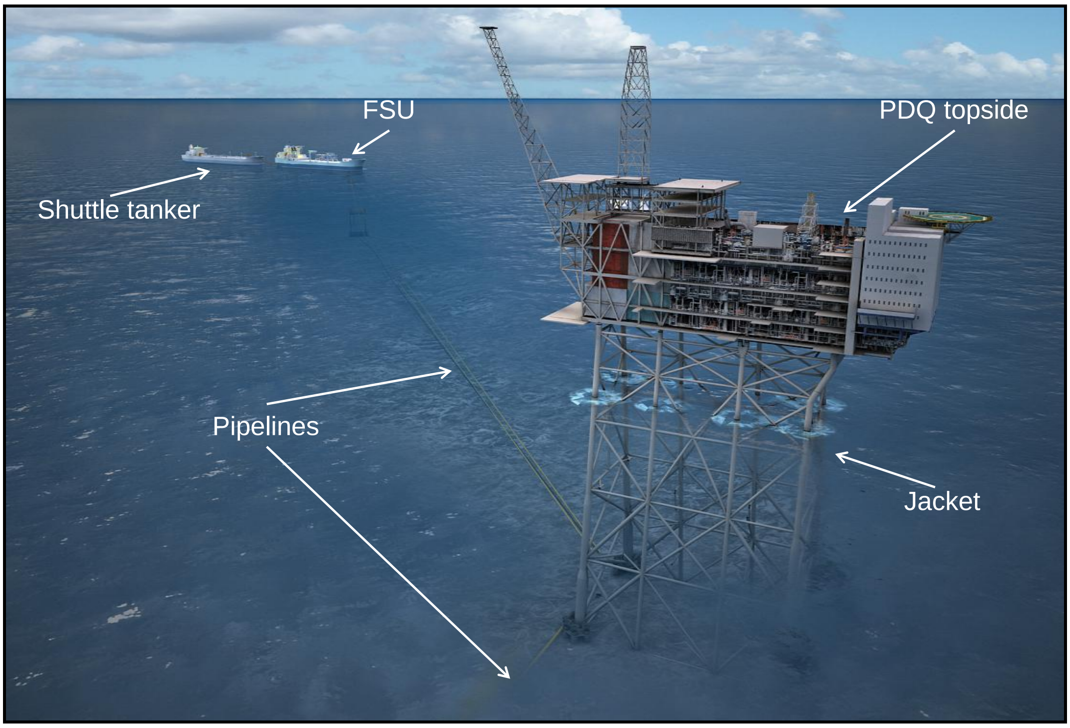

Figure 3.19: Illustration of the proposed PDQ and FSU layout

The FSU will be procured, owned and operated by Statoil. Diluent will be imported by shuttle tanker and stored on the FSU. The diluent will be transferred from a DP shuttle tanker to the selected FSU through an offloading hose, an ESD valve and the metering station to the diluent storage tanks on the FSU. The capacity of the diluent import system will be a maximum 5,000 to 8,000 m^3/h.

The FSU will offload the blended crudes (crude and diluent) and load diluents via a DP shuttle tanker, via a hose reeled out from the FSU. The hose to the shuttle tanker will be arranged in a floating “U” shape and when out-reeled the hose length will be approximately 90 to 100 m to the shuttle tanker.

Fuel gas will be imported to the PDQ, when the field becomes fuel gas deficit, via the gas import pipeline and Vesterled pipeline. The gas import system will be designed to supply the PDQ with necessary gas for power generation and as needed for other process and utilities systems. This system will be fully operated and controlled from the PDQ.

Following treatment, produced water will be re-injected into the Maureen and Heimdal reservoirs, for pressure support. During periods where PWRI is not possible, the produced water will be treated to required oil-in-water levels and will be disposed to sea. PWRI will not be required at the Mariner East wells.

3.8.1 PDQ Overview

The Mariner PDQ platform will have the following main characteristics:

- production wells with ESP’s;
- PWRI wells;
- end bay drilling;
- integrated Drilling Support Module (DSM) and Drilling Equipment Set (DES);
- well Intervention deck;
- oil export to FSU;
- diluent import from the FSU;
- gas import from the Vesterled pipeline; and
- living quarters for 160 personnel.

The topsides layout for the PDQ platform consists of a large integrated deck, supporting the Utility and Process modules, the Drilling Support Module (DSM) and the Drilling Equipment Set (DES) (**Figure 3.20**). The drilling facilities on the PDQ platform will be an integrated part of the topside facilities. The living quarters will be a separate module supported from the utility module deck structure. The well intervention structure is incorporated into the main deck primary structure. The topside structure will be approximately 110 m in length, 28 m in width, 52 m high and weigh approximately 30,500 tonnes.

The topside structure will have a long narrow deck, allowing greater freedom in the placement of equipment, running of piping and providing the maximum distance between the hazardous area and the living quarters (**Figure 3.20**). The platform supports two cranes which will transfer general supplies from the supply boats to the platform and service pipe-decks (**Figure 3.20**). The positioning of the cranes allows the supply boats to come to either side of the platform for pick-up.

Figure 3.20: Illustration of the proposed PDQ topside

The PDQ topside will be supported upon an eight legged jacket (**Figure 3.21**). The jacket will be designed with well bay area for 60 well slots and space for 60 conductors, well heads including space for manifold areas (**Figure 3.21)**. The jacket structure will be 133.5

m in height, 88 m in length and 62 m in width (at seabed), and as a whole will weigh approximately 18,000 tonnes.

The jacket will be secured to the seabed by 6 piles at each of the four corners (**Figure 3.21**). Each pile will be 2.438 m (96”) in diameter, and will be piled to a penetration depth of 60 m.

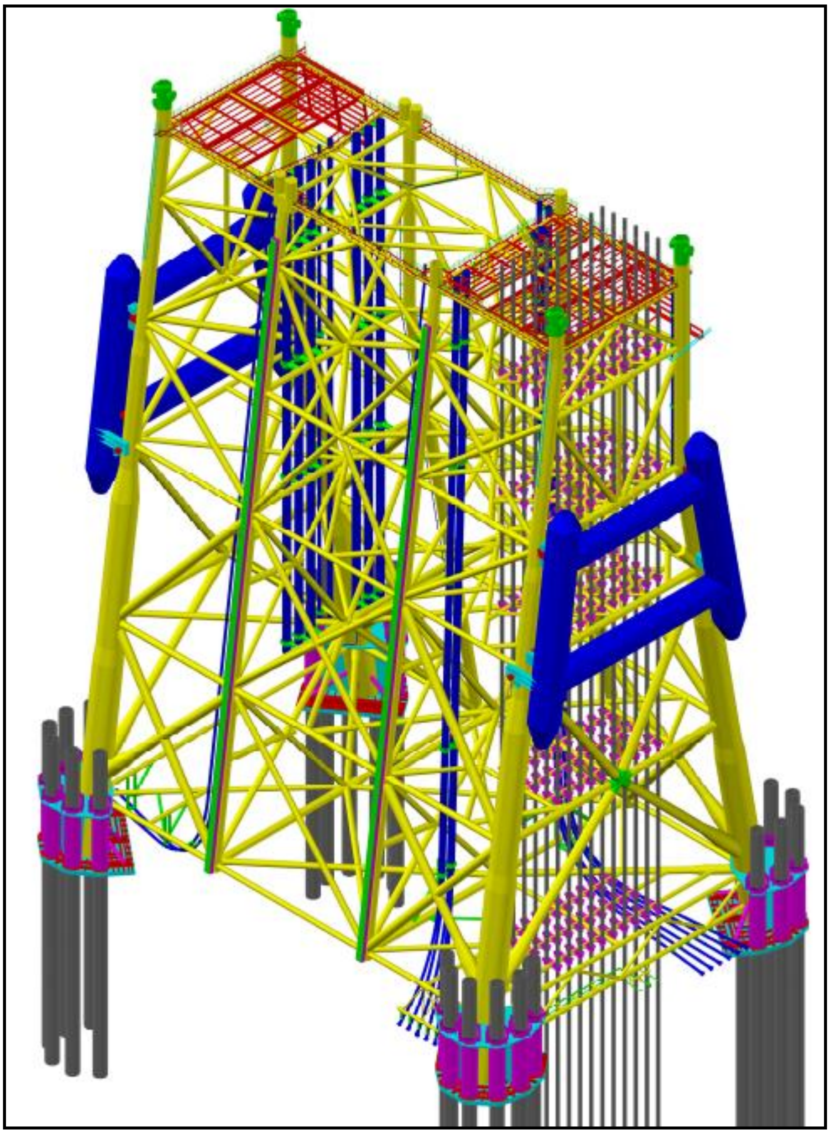

Figure 3.21: Illustration of the proposed PDQ jacket

3.8.2 FSU overview

The FSU will be located approximately 2.5 km north of the PDQ, and will be connected to the PDQ via two pipelines. The FSU will be procured, owned and operated by Statoil. **Table 3.7** shows the indicative main dimensions of a ship-shape FSU for the Mariner Field. The FSU will be powered by onboard diesel generators.

The PDQ and the FSU will both have separate control rooms, with the PDQ control room permanently manned and acting as a control centre for the entire field. The FSU will also be permanently manned.

To operate at the Mariner Area Development, the selected FSU will be capable of the following services:

- to receive diluent from a shuttle tanker at a maximum rate of 5,000 to 8,000 m^3/h, via a stern discharge system (SDS);
- to store diluent;
- to export diluent to the production unit at a rate of >3,200 m^3/day (20,000 bbls/day);
- to receive diluted crude from the PDQ at a rate of >12,700 m^3/day (80,000 bbls/day);
- to store the diluted oil;
- to keep the diluted crude oil at the require temperature; and
- to export the diluted crude oil to a shuttle tanker via a stern discharge system (SDS) at a rate of approximately 6,500 m^3/h.

Table 3.7: Indicative main dimensions and capacities of a ship-shape FSU for the Mariner field

Attribute	Dimension
Length (m)	249
Breadth (m)	44
Depth (m)	28
Dead Weight Tonnage (DWT) (tonnes)	137,000
Personnel on board (maximum)	25
Total cargo storage (crude and diluent) in 20 tanks	138,600 m^3 / 871,600 bbls
Total diesel / gas oil storage in 3 tanks	3,450 m^3 / 21,700 bbls
Total ballast water	79,500 m^3 (54% of DWT)

The FSU for the Mariner Area Development will have the class classification of "Clean Design" and will be designed with the following capacities / features:

- a service life of 30 years;
- a full-bodied and simple mono-hull design, with double sides and double bottom for ballast water throughout the entire vessel length;
- a turret system with mooring lines and risers to ensure free weather vaning while staying passively and permanently moored on location. Risers for diluent and crude will be hung off from the turret bottom;
- accommodation for operational and additional personnel;
- VOC recovery unit, metering skid;
- a helideck; and
- two thrusters to assist the vessel during offloading and material handling to/ from the FSU.

3.8.3 Transportation and Installation

3.8.3.1 PDQ

Jacket

Statoil plan to install the jacket structure in July 2015 (**Section 3.5**; **Table 3.3**). Operations to install the jacket structure are expected to take approximately two months. Due to the size and weight of the jacket, the jacket will need to be installed by launch installation rather than by crane vessels. Launch installation will require the jacket to be loaded out and transported offshore on a barge. The load out method of the jacket onto the launch barge will depend on the fabrication yard selected by Statoil.

At this stage, it is not known which barge will be used by Statoil to transport the jacket out to the development location. Typically the jacket will be skidded onto the launch barge by means of a pulling system consisting of tension wires and hydraulic centre hole strand jacks connected between jacket and the anchors onboard the barge. Transportation of the jacket will be done in a traditional manner.

The jacket structure would be fitted with two clusters of buoyancy tanks, with launch runners on the centre rows of the jacket (approximately 34 m apart). After being launched the jacket will be up-ended and set down on the seabed at the development location, with assistance from a heavy lift vessel. Once the jacket has been placed at the correct location, the four corners of the jacket will be piled into the seabed.

The jacket structure (88 m in length and 62 m in width, at seabed) will be secured to the seabed via a total of 24 vertical skirt piles, 6 piles in each corner (**Figure 3.21**). Each pile will be 2.438 m (96") in diameter, and will be piled to a penetration depth of 60 m.

Before the jacket structure is secured to the seabed, it will be temporarily supported on mud mats surrounding each leg and pile sleeve. The mud mats will also act as the lower yoke plate of the pile cluster, once secured.

Topside

The PDQ topside structure will be installed in Q2 2016, a year after the jacket structure has been secured to the seabed. Installation operations are expected to take two months (**Table 3.3**). All modules will be loaded out onto barges or heavy transport vessels by use of trailers, and will be performed by use of SSCV. The modules will arrive at the offshore location in sequence ready for the heavy lift vessel to perform the installation. Statoil estimate that six major offshore lifts and several minor lifts will be required to install the topside sections of the PDQ to the jacket structure. The installation of the topside structure will be broken down into the following sequence (**Figure 3.22)**.

1. Utility Module
2. Process Wellhead module
3. Living Quarter
4. Wellhead Extension Module
5. Drilling
6. Flare Boom

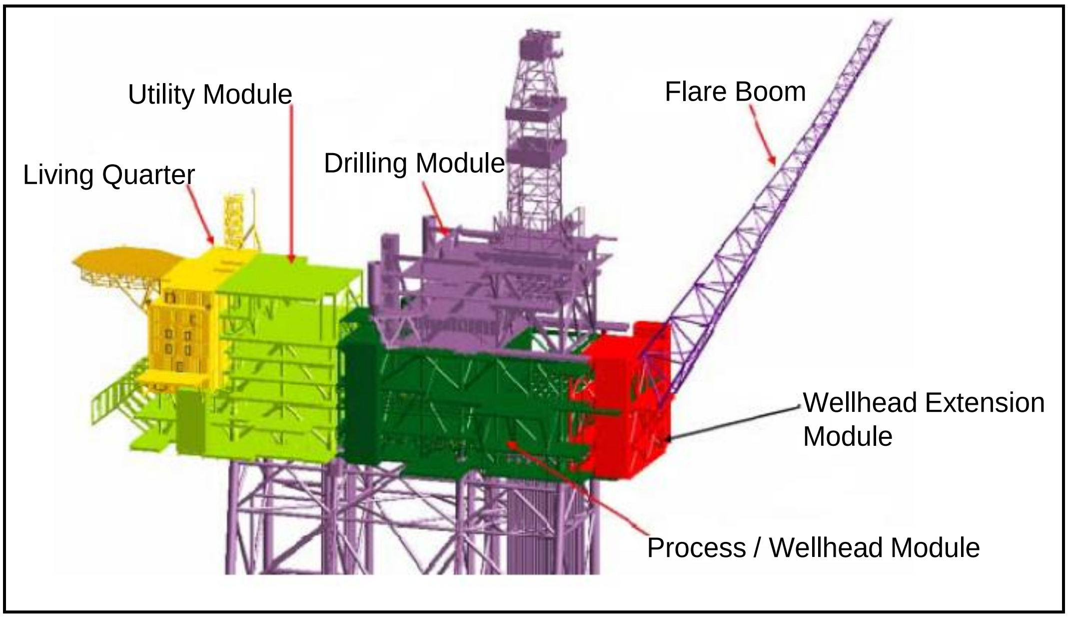

Figure 3.22: Topside components for heavy offshore lifts

3.8.3.2 FSU

The FSU will be installed in Q2/Q3 2016. Installation and hook-up operations are expected to take two weeks (**Section 3.5**; **Table 3.3**).

Statoil are currently evaluating two alternative turret system designs for the selected FSU. One alternative is a submerged turret loading (STL) system, which will consist of a STL buoy with turret, mooring system, risers and equipment in the STL room. The Mariner Area Development will then pre-install the buoy, complete with mooring lines and risers before the FSU arrives. The second alternative will be to select a bottom mounted internal turret (BMIT) system, which does not include a submerged buoy.

The mooring system for the FSU at the Mariner Area Development could either comprise 12 mooring lines in three separate clusters or 16 mooring lines in four separate clusters, depending on conclusion of design. The normal distance between the STL centre and the anchor centre is typically >1,232 m. The mooring lines at the Mariner Area Development will be a combination of chain and wire segments, and would be expected to range from 1,350 to 1,370 m in length. Mooring lines can be attached to the seabed by either 12 to 16 anchors or 12 to 16 suction piles. The type of anchor or suction anchor has not been decided. The mooring lines would be installed by a dive support vessel (DSV) and a support vessels would also be present.

Figure 3.23 presents a schematic of the proposed FSU layout (including moorings) in relation to the PDQ and jack-up drilling rig.

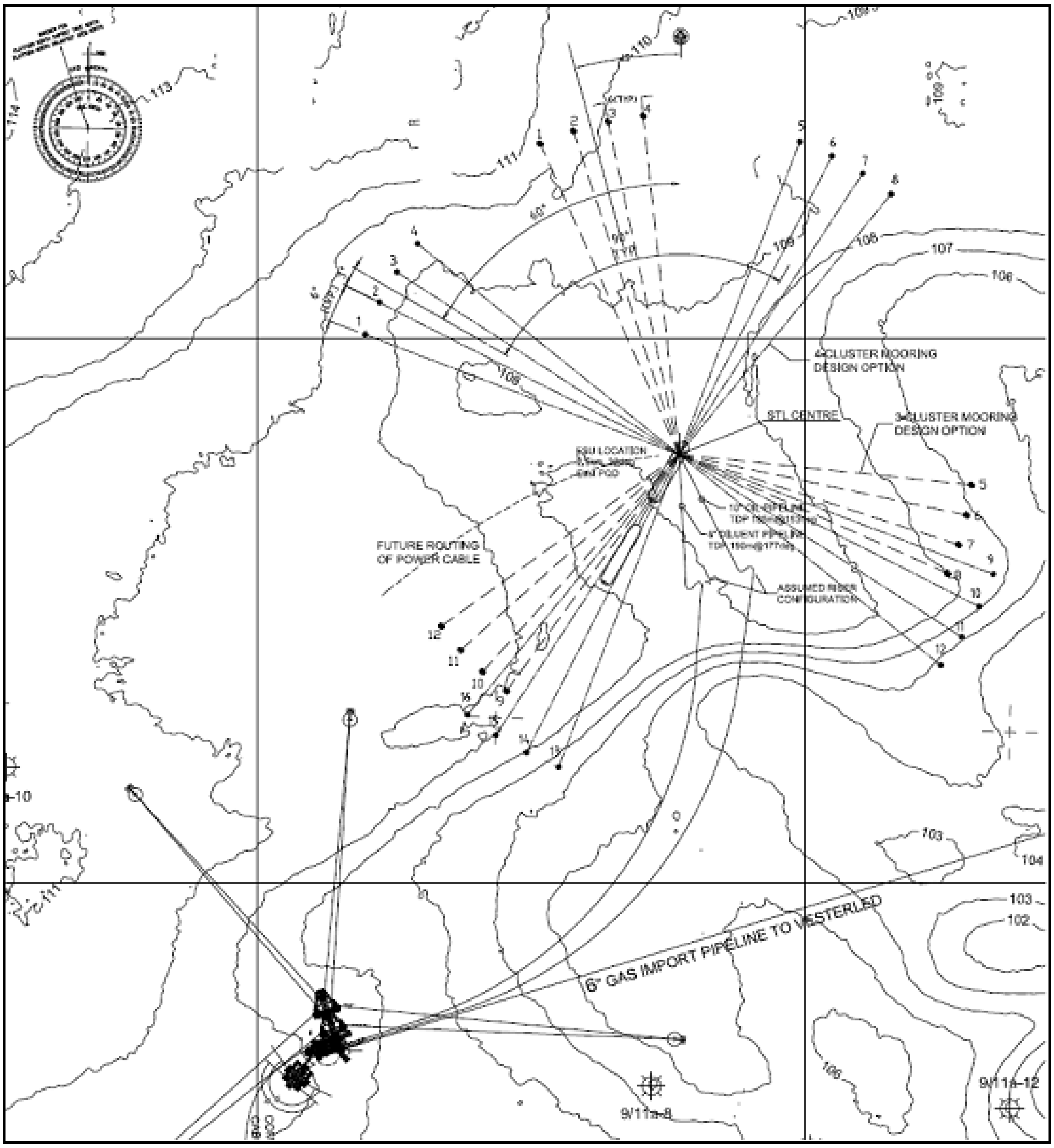

Figure 3.23: Schematic of the proposed FSU layout in relation to the PDQ and drilling rig

3.8.4 Process facilities

Figure 3.24 presents a schematic of the Marine Area Development process system. Processing of the Mariner and Mariner East hydrocarbons will occur on the PDQ.

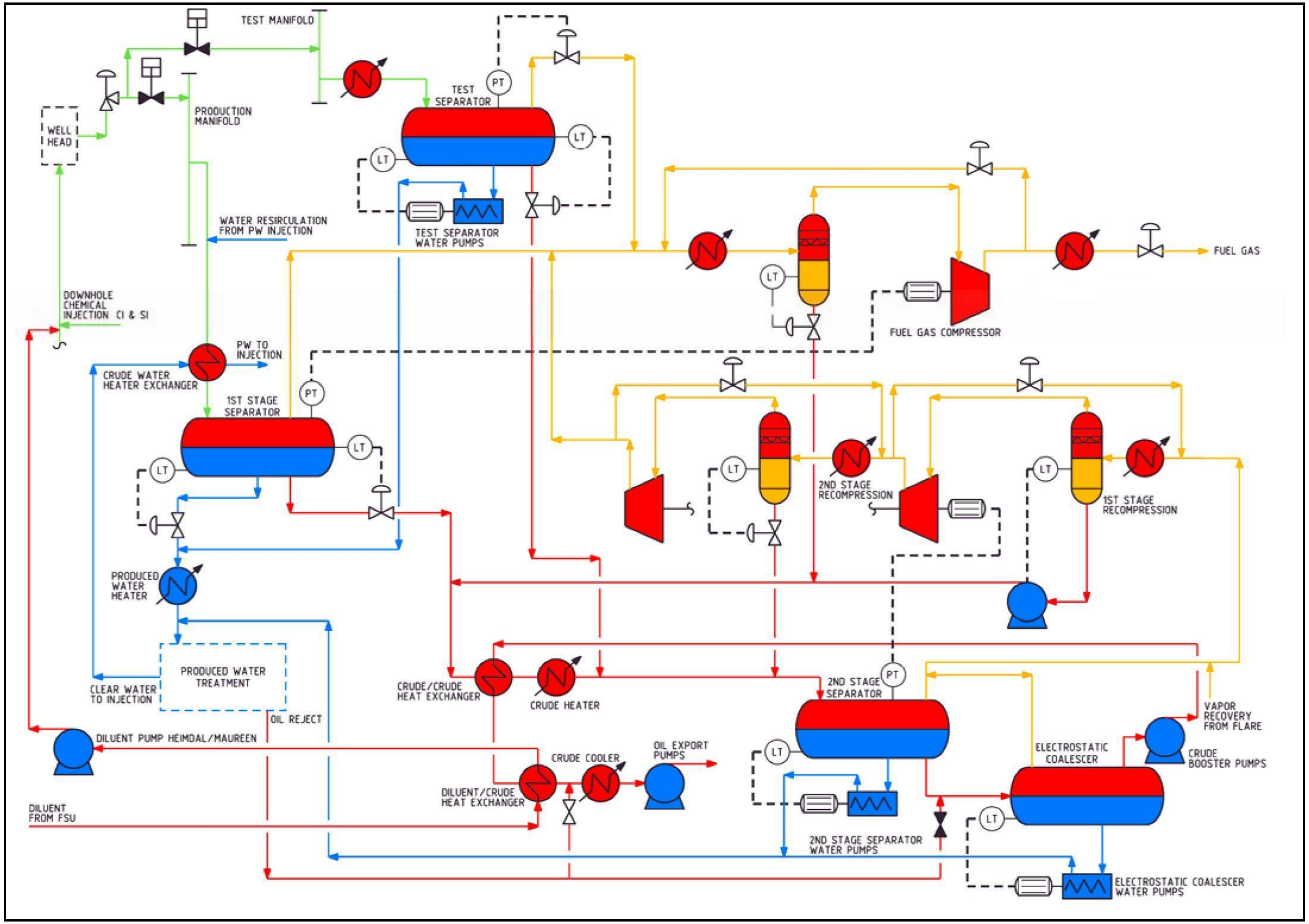

Figure 3.24: Process diagram for the PDQ

3.8.4.1 Oil production and well test system

The well stream from each production well at the Mariner Area Development will be routed to a production manifold or a test manifold on the PDQ prior to transfer to the 1st Stage Separator or test separator respectively (**Figure 3.24**).

Before entering the 1st stage separator, the hydrocarbons are heated to improve separation capabilities and the treatment of the produced water. Degassing of the oil and bulk oil/water separation occurs in the 2nd stage separator. The crude stream from the 1st stage separator will be heated before entering the 2nd Stage Separator.

The test separator will be designed to handle maximum production from a single well, and will be used for well clean-up, start-up and testing of wells. The separator can be operated both in parallel to the 1st stage separator, with the same pressure, and at a lower pressure (similar to the 2nd stage separator pressure).

Diluent stored on the FSU will be received at the PDQ via a dedicated import line, where it will be injected downhole into the production wells via the slim tubing used for installing the ESP. Back-up injection points will be installed in the topside process.

3.8.4.2 Gas compression

Gas from the 2nd stage separator is recompressed in two stages, for mixing with gas from the 1st stage separator (**Figure 3.24**). After mixing with the gas from the 1st stage separator, the total amount of associated gas is then further compressed and used as fuel gas. Due to a deficiency in the amount of produced gas expected at the development, the import of additional fuel gas will be required throughout most of the Mariner field life.

3.8.4.3 Produced water treatment

The 1st stage oily water treatment will consist of a hydrocyclone package. The oil-in-water concentration from the hydrocyclones will be dependent on the selected contractor, however Statoil expect it to range from 75 to 200 mg/l. To meet the overboard disposal specification of <29 mg/l, produced water will be routed to a CFU package with parallel single-stage vessels (**Figure 3.24**). The number of parallel single-stage vessels will be dependent on the selected contractor. The treated produced water from the CFUs will then be routed to a surge drum before it is re-injected into the reservoir.

A degasser surge drum will then be used for entrained oil polishing and to remove any dissolved gases. The surge drum will be connected to the closed flare system. During normal operations the dissolved gases will be recovered and not vented to the atmosphere. To allow for this, the surge drum cannot be atmospheric. If the water injection equipment or wells are out of service, then the treated produced water would be discharged to sea. This may be necessary during periods when one main power generator is out of service, as a result of load shedding. In a discharge situation, some gas will be discharged with the produced water (operating conditions for the surge drum is approximately 2.5 bara and 60°C).

3.8.4.4 Sand treatment

Sand carried within the production fluids can form deposits within larger production vessels such as the separators. It can also cause erosion in the pipe-work, seals, pumps and other types of equipment. Finer particles can be transported by produced water into downstream systems causing, for example, damage to the PWRI system.

Sand production at the development is expected to be 10 ppm (w/w) with grain sizes less than 100 micron during start-up and 5 ppm (w/w) with grain sizes less than 40 micron during normal production. The Maureen production wells will be completed with open hole gravel packs to assist with sand control, while the Heimdal production wells will have slotted liners with screens and open hole gravel packs. The primary solution for produced sand is by cleaning, where a produced water desanding skid will be designed to remove particles down to 40 microns, to protect the produced water re-injection system. Under normal operations, cleaned sand will be discharged to sea via a discharge caisson, however under back-up operations, sand will be collected in containers and sent onshore for further treatment.

3.8.5 Utility systems

The following utility systems will be provided on the PDQ and the selected FSU.

3.8.5.1 Flare and vent systems on the PDQ and the FSU

PDQ

Statoil considered three alternative solutions to flaring gas at the Mariner Area Development (**Section 3.9.3.2**). Produced gas from the Mariner Area Development will be used to fuel the PDQ power generators (**Section 3.7.2**). The PDQ will not be equipped with a gas export system, therefore, Statoil plan to flare all excess gas. Excess gas is only expected at the Mariner field during 2017 and 2018. Flaring of excess gas will provide the safe disposal of hydrocarbon gas in controlled shutdown, emergency conditions and pressure relief events.

The PDQ will have a single, closed high pressure (HP) flare system to allow for the safe collection and disposal of hydrocarbons from the process and utility systems. A closed flare is regarded as the best available technique (BAT). The design of the HP flare system will ensure full availability and safe operation across all anticipated operating conditions of pressure, temperature, flow rates and fluid characteristics. The flared gas will be metered, consistent with regulatory requirements.

The reclaimed oil sump, which acts as a closed drain tank, is vented to the atmospheric vent system.

FSU

Intermittent venting emissions will occur on the FSU from filling the storage tanks. The location of the atmospheric vents will ensure adequate dispersion and avoid potential hazards to personnel, helicopter / marine operations or air-ingesting equipment. A VOC recovery unit is proposed for the FSU.

3.8.5.2 Drainage systems on the PDQ and the FSU

PDQ

The selected PDQ will have an open drains system to allow the collection of rain water, spill water and firewater from decks and drip trays, for segregation into hazardous and non-hazardous systems and to ensure their safe disposal. The open drains will be gravity drained to the slops tanks for settling and separation. The Open Drain System will be divided into three systems:

1. *Non-polluted open drain*. This sub-system collects drain water from the helicopter deck and possibly other areas where pollution is very unlikely. Non-polluted drain areas are also classified as non-hazardous. No treatment is required and the collected water will be routed directly to sea.

2. *Hazardous open drain*. This sub-system collects drain water in the process, wellhead and drilling areas. Drain headers will collect liquid from the drain boxes and gullies. Seal pots will be located on all drain headers where they cross over from one fire area to another. Drains from the process area will be routed to the Open Drain Caisson. This caisson is used to discharge drain liquids to sea. It will also separates hydrocarbons from the drain water by means of gravity. Long retention time and baffle plates will aide the separation process. A skimming pump will be used to pump the hydrocarbon top layer floating in the caisson to oil export. The caisson will be continuously purged with inert gas and the vent routed to a safe location. Overflow from certain storage tanks such as the diesel tanks will also be routed to the Open Drain Caisson. Drainage from areas where drilling fluid is present, is segregated from other areas as particles in the drilling fluid might compromise the integrity of the open drain system. Hazardous drains from the wellhead areas are therefore not routed to the Open Drain Caisson, but to the Wash Down Tank instead. The wash down tank is purged continuously with inert gas and the vent is routed to safe location. The liquid collected in the Wash Down Tank is pumped to Drilling Drain Tanks which are part of

the Drilling Support Module.There, the drain liquid is treated along with liquid from the DSM. The normal open drain arrangement is not sized for a fire water deluge scenario. All seal pots and the Wash Down Tank are equipped with overflows to sea. Drain headers are however not sized for deluge and additional overflows are therefore included from drain boxes/gullies.

3. *Non-hazardous open drain*. This sub-system is very much similar to the hazardous open drain system, but seal pots will not berequired. Drain water from the utility module will be routed to the Open Drain Caisson; the outlet is however will be submerged to a level below the hazardous open drain. This will effectively segregate hazardous from non-hazardous areas.

A closed drains system on the PDQ will collect hydrocarbon liquid due to drainage of platform equipment, piping and instruments and return the captured fluids to the process where required. The closed drain system will consist of:

- Reclaimed oil sump
- Reclaimed oil sump oil heater
- Reclaimed oil sump water heater
- Reclaimed oil sump pumps
- Reclaimed oil sump water pumps

The reclaimed oil sump will be an in-deck drain/storage tank, with an internal baffle that allows the separation of oil and water phases. Water from the reclaimed oil sump will be routed to the produced water treatment system or to the slop tank, located in the drilling area, by means of two reclaimed oil sump water pumps.

Oil from the reclaimed oil sump will be routed to the FSU, via the Crude Booster Pumps, or to the 2nd Stage Separator.

The reclaimed oil sump is connected to atmospheric vent for venting and is continuously purged with inert gas.

FSU

A small drain tank will be integrated in the ballast tank structure on each side of the selected FSU. Any water within the drain tanks will be monitored, prior to discharge overboard. Oil spills on the FSU will be pumped to the slop tanks. Oil drains from equipment and deck piping will be collected in containers and pumped to the drain slop tank.

3.8.5.3 Produced water system on the PDQ

Following the initial commissioning period, Statoil propose to re-inject the Mariner Area Development produced water. In the event that the water injection system is not available the produced water will be directed overboard via a dedicated caisson.

The produced water system will be designed to remove sand and residual oil from the produced water to a maximum level of 30 mg/l, as required by the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005.

3.8.5.4 Seawater system on the PDQ and the FSU

PDQ

Seawater will be used on the PDQ to cool the process coolers; cooling of motors and power generators; supply to the heat; ventilation and air conditioning system; drilling; fresh water maker; and for maintaining the pressure in the firewater ring main. Seawater will be lifted by seawater lift pumps which will incorporate marine growth prevention methods at the seawater inlet.

FSU

Seawater will be used on the FSU to supply the central coolers for cooling medium; the inert gas generator; the inert gas deck water seal; and the VOC plant cooler.

3.8.5.5 Water and chemical injection systems on the PDQ

Water injection at the Mariner Area Development will primarily use produced water re-injected via the PDQ. To prevent scale deposition, chemicals will be injected at the PDQ as appropriate.

The chemical injection system on the PDQ will store, distribute and inject chemicals into the wells and topside production systems and to miscellaneous utility consumers. The system comprises storage tanks, injection pumps and a distribution system to supply the chemicals. The well designs for the Mariner wells will include two dedicated down-hole injection lines for chemicals.

3.8.5.6 Fuel gas on the PDQ

The fuel gas treatment system on the PDQ will remove liquids from the produced gas in a gas / liquid separator vessel, supplying clean, dry fuel gas for power generation, heating and purging requirements. The system will comprise scrubbers, filters and heaters to provide the quality of fuel specified for the gas turbine requirements.

The main power generators on the PDQ are gas driven, dual fuel generators, which will use diesel during periods when fuel gas is unavailable. The fuel gas system on the PDQ will have a design capacity of 400,000 m^3/day. Except for some excess gas during 2017 and 2018, all associated gas from the oil production will be used as fuel gas. As discussed previously, the amount of associated gas from the Mariner Area Development over the proposed 40 year field life will be insufficient, and additional gas will be imported via the Vesterled pipeline.

3.8.5.7 Diesel system on the PDQ and the FSU

Statoil will use ultra-low sulphur, winter-grade diesel oil at the PDQ and the FSU which will be bunkered onto the FSU and the PDQ from a supply boat.

PDQ

The diesel oil system on the PDQ will supply diesel to the dual-fuel fired gas turbine generators, the emergency generator day-tank and firewater diesel generators day tanks. In addition, diesel may be used for equipment on the PDQ drilling module.

FSU

The FSU will be powered by diesel generators. The selected FSU will have a diesel storage capacity of approximately 4,000 m^3.

3.8.5.8 Ballast water on the FSU

The ballast systems on the FSU will ensure acceptable stability, draught, freeboard, heel and tilt and safety against down-flooding during all loading conditions. The system will be sub-divided to ensure that the FSU can comply with the required intact, damage and flooded compartment stability criteria. The FSU will have segregated ballast tanks and ballasting operations will meet IMO requirements.

3.8.6 Power Generation

The following sections describe the power generation on the PDQ and the FSU, with **Tables 3.10** to **3.12** providing a summary of the estimated annual power generation emissions from the PDQ and FSU over the field life.

At this stage, it is not known which drilling contractors or specific drilling rigs (jack-up and semi-submersible) will be used to drill the wells at the Mariner and the Mariner East fields. **Tables 3.9b** and **3.9c** estimate the atmospheric emissions that may arise during drilling operations based on fuel consumption estimates for a typical jack-up drilling rig and semi-submersible drilling rig.

PDQ

Main electrical power at the Mariner Area Development PDQ will be generated using turbine generators. Statoil propose to use high-efficiency, low NO_x and low CO_2 emission type turbines employing Dry Low Emission (DLE) technology at the Mariner Area Development, which is regarded as BAT. Power management systems will be provided which will ensure that the overall system operation is optimised such that the use of fuel will be minimised for best energy efficiency and lowest environmental emissions.

Power generation at the PDQ will be supplied by two gas generators, which will be a dual-fuel fired turbine generators to ensure that full production and offloading can be maintained and to minimise the potential for environmental discharges in the event of the main generator failing. The two turbines on the PDQ will be able to use produced gas and imported gas for fuel, however, they will also be able to use diesel during periods when fuel gas is unavailable.

The gas turbine generators will each have a power output of 28.6 MW. For approximately 16 days a year, Statoil anticipate that one of the gas turbines will be unavailable. During this 16 day period, one gas turbine will be used in addition an essential five MW diesel fired generator. The diesel fired generator will have a thermal efficiency of 42%, and a NO_x emission factor of 47 kg/tonnes of diesel. It is predicted that two gas turbines will be unavailable for an extra 16 days a year, compared to using three gas turbines, due to scheduled and unscheduled maintenance.

FSU

Power at the selected FSU will be independent of the PDQ, with power supplied by diesel generators. The diesel generator will utilise an average of 7,332 tonnes (8,625 m^3) of diesel per year.

Power management systems will be provided which will ensure that the overall system operation is optimised such that the use of fuel will be minimised for best energy efficiency and lowest environmental emissions. In the event that the diesel generators are shutdown, an emergency power generator will provide enough power to keep a basic level of operation of key utilities and all life support requirements. In addition to BAT, Statoil will meet requirements that satisfy MARPOL.

3.8.7 Offloading

The produced crude oil will be mixed with approximately 5% to 25% diluent (depending on reservoir composition and diluent type). The diluent / crude blend will be exported to the Mariner FSU via a turret system at a maximum rate of 12,700 m^3/day (80,000 bbl/day). The selected FSU will have a storage capacity of 850,000 bbls (135,000 m^3) for diluent and diluted cargo storage. The diluent / crude blend for export between the FSU and shuttle tankers will have a maximum transfer rate of 6,500 m^3/hour (41,000 bbl/hour).

The transfer of the diluted crude oil for export from the FSU to the shuttle tanker and the import of the diluent from the shuttle tanker to the FSU will be performed in tandem mode. Tandem offloading is widely used offshore by Statoil in the North Sea. The crude oil will be transferred from the FSU to the shuttle tanker through an offloading system installed on the FSU. The shuttle tankers for exporting the crude and importing the diluent will be held in position by dynamic positioning systems, approximately 80 to 100 m from the FSU.

3.9 Potential Atmospheric Emissions from the Mariner Area Development

3.9.1 Sources of atmospheric emissions from drilling activities

Atmospheric emissions may arise during drilling operations and potential sources are given in **Table 3.8**.

Table 3.8: Sources of atmospheric emissions during drilling activities

Source of Emission	Type of Equipment	Pollutants Released
Combustion	Diesel engines; Emergency generators; Heaters	CO_2, CO, NO_x, N_2O, SO_2, CH_4, VOC
Flaring oil and gas	Flare boom	CO_2, CO, NO_x, N_2O, SO_2, CH_4, VOC
Venting	Vent boom	CH_4, VOC
Fugitive emissions	Mud pits	CH_4, VOC, dust
Refrigeration	Refrigeration units	HCFCs
Storage and handling of dry chemicals	Bulk Storage Tanks; Sack Room	Chemical dusts

Refrigerants will only be released if accidental leakage occurs from refrigeration units. Levels will be checked during routine maintenance allowing effective detection of any leaks. Mud pits will be covered in order to reduce fugitive emissions.

3.9.2 Atmospheric emissions from vessels during drilling and subsea installation operations

The emissions released during drilling and subsea installation operations at the Mariner Area Development can be evaluated based on fuel consumption estimates and the number of days of each operation. These are shown in **Tables 3.9a** to **3.9h**.

Table 3.9a: Estimated gaseous emissions from vessels during the installation of the PDQ

Mariner Area Development activity	Days	Fuel consumption		Emissions (tonnes)						
		tonnes / day	tonnes	CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
Marine diesel factors (t/t)[1]				*3.2*	*0.008*	*0.059*	*0.00022*	*0.004*	*0.00027*	*0.0024*
Transportation and installation of PDQ										
Tow jacket on launch barge to location for installation by 1 tug										
Towing of launch barge from fabrication yard from north of Europe	5	50	5,850	18,720	46.8	345.15	1.29	23.4	1.58	14.04
Heavy lift vessel (HLV) / semi-submersible crane vessel (SSCV) for jacket installation and driving of 24 piles										
Mob / demob for jacket installation	4	20	80	256	0.64	4.72	0.0176	0.32	0.0216	0.192
On location / working	28	50	1,400	4,480	11.2	82.6	0.308	5.6	0.378	3.36
Tug for towing of pile barge, jacket installation and piling jacket to seabed (1 tug)										
Mob / demob of barge at yard for piling installation	7	5	35	112	0.28	2.065	0.0077	0.14	0.00945	0.084
working	49	50	2,450	7,840	19.6	144.55	0.539	9.8	0.6615	5.88
Installation of topside modules by HLV/SSCV										
Mob /demob	5	20	100	320	0.8	5.9	0.022	0.4	0.027	0.24
Transit & installation	41	50	2050	6,560	16.4	120.95	0.451	8.2	0.5535	4.92
Module delivery - installation of topside modules on location by heavy transport vessel (HTV x4)										
HTV transportation from fabrication yard	240	50	12,000	38,400	96	708	2.64	48	3.24	28.8
Loadout at EPC yard / demob	60	20	1,200	3840	9.6	70.8	0.264	4.8	0.324	2.88
Installation	12	50	600	1920	4.8	35.4	0.132	2.4	0.162	1.44
Module delivery - installation of topside modules on location by barge, towed by 1 tug										
Mob/demob of barge at yard for module installation	4	50	200	640	1.6	11.8	0.044	0.8	0.054	0.48
Mob / demob	28	5	140	1,280	3.2	23.6	0.09	1.6	0.11	0.96
Installation	3	50	150	208	0.52	3.84	0.01	0.26	0.02	0.16
Anchor handling vessel (AHV) / support vessel per HTV (4) – module delivery										
Mobilisation and anchoring	12	50	600	1,920	4.8	35.4	0.132	2.4	0.162	1.44
Total vessel atmospheric emissions from PDQ transportation and installation operations				**67,552**	**168.88**	**1,245.50**	**4.64**	**84.44**	**5.70**	**50.67**

Source: [1]*UKOOA (2002)*

Table 3.9b: Estimated gaseous emissions from vessels during the drilling operations for the Mariner wells

Mariner Area Development activity	**Days**	**Fuel consumption**		**Emissions (tonnes)**						
		tonnes / day	**tonnes**	**CO_2**	**CO**	**NO_x**	**N_2O**	**SO_2**	**CH_4**	**VOC**
Marine diesel factors (t/t)[1]				*3.2*	*0.008*	*0.059*	*0.00022*	*0.004*	*0.00027*	*0.0024*
Drilling of the Mariner field wells										
Jack-up drilling rig (5 year drilling campaign)										
Drill and complete wells	1,825	10	18,250	58,400	146.00	1,077	4.02	73.00	4.93	43.80
Drill rig positioning (3 tugs)										
Mob / demob to PDQ location	9	5	45	144	0.36	2.66	0.01	0.18	0.01	0.11
Installation operations	21	50	1,050	3,360	8.40	61.95	0.23	4.20	0.28	2.52
Standby vessel (present during drilling operations)										
Mob / demob to PDQ location	4	10	40	128	0.32	2.36	0.01	0.16	0.01	0.10
Working at development location	5,840	5	18,250	58,400	146	1,077	4	73	5	44
Total vessel atmospheric emissions from drilling operations				**120,432**	**301.08**	**2,220.47**	**8.28**	**150.54**	**10.16**	**90.32**

Source: [1]UKOOA (2002)

Table 3.9c: Estimated gaseous emissions from vessels during the drilling operations for the Mariner East wells

Mariner Area Development activity	**Days**	**Fuel consumption**		**Emissions (tonnes)**						
		tonnes / day	**tonnes**	**CO_2**	**CO**	**NO_x**	**N_2O**	**SO_2**	**CH_4**	**VOC**
Marine diesel factors (t/t)[1]				*3.2*	*0.008*	*0.059*	*0.00022*	*0.004*	*0.00027*	*0.0024*
Drilling of the 4 Mariner East wells										
Semi-submersible drilling rig										
Drill and complete 4 wells	240	30	7,200	23,040	57.60	424.80	1.58	28.80	1.94	17.28
Drill rig positioning (3 tugs)										
Mob / demob to PDQ location	12	50	600	1,920	4.80	35.40	0.13	2.40	0.16	1.44
Standby vessel (Mariner field standby vessel will be onsite for the Mariner East well)										
Total vessel atmospheric emissions from drilling operations				**24,960**	**62.40**	**460.20**	**1.71**	**31.20**	**2.10**	**18.72**

Source: [1]UKOOA (2002)

Table 3.9d: Estimated gaseous emissions from helicopter operations during drilling and installation operations

Mariner Area Development activity	**Days**	**Fuel consumption**		**Emissions (tonnes)**						
		tonnes / day	**tonnes**	**CO_2**	**CO**	**NO_x**	**N_2O**	**SO_2**	**CH_4**	**VOC**
Aviation fuel factors (t/t)[1]				*3.2*	*0.0052*	*0.0125*	*0.00022*	*0.004*	*0.000087*	*0.0008*
Helicopter operations										
Helicopters (10 flights per week for the first 5 years of drilling campaign)										
Helicopters	2,600	1.96*	5,096	16,307	26.50	63.70	1.12	20.38	0.44	4.08
Helicopters (6 flights per week for the remainder of drilling campaign – 25 years)										
Helicopters	7,800	1.96*	15,288	48,922	79.50	191.10	3.36	61.15	1.33	12.23
Total atmospheric emissions from helicopter operations				**65,229**	**106**	**254.8**	**4.48**	**81.53**	**1.77**	**16.31**

**Based on a helicopter flight duration of 3.75 hours and a fuel consumption rate of 615 litres / hour (0.523 tonnes / hour)*

Source: [1]UKOOA (2002)

Table 3.9e: Estimated gaseous emissions from vessels during the installation of the FSU

Mariner Area Development activity	**Days**	**Fuel consumption**		**Emissions (tonnes)**						
		tonnes / day	**tonnes**	**CO_2**	**CO**	**NO_x**	**N_2O**	**SO_2**	**CH_4**	**VOC**
Marine diesel factors (t/t)[1]				*3.2*	*0.008*	*0.059*	*0.00022*	*0.004*	*0.00027*	*0.0024*
Transportation and installation of FSU										
Tow FSU from fabrication yard (tugs x2)	180	50	9,000	28,800	72	531	1.98	36	2.43	21.6
Tugs onsite	40	50	2,000	6,400	16	118	0.44	8	0.54	4.8
FSU installation – installation vessels (x2)										
Mob / demob	6	22	132	422	1.06	7.79	0.03	0.53	0.04	0.32
Installation	50	18	900	2,880	7.20	53.10	0.20	3.60	0.24	2.16
FSU installation – anchor handling vessel										
Mob / demob	6	5	30	96	0.24	1.77	0.01	0.12	0.01	0.072
Installation	14	50	700	2,240	5.6	41.3	0.15	2.8	0.19	1.68
Total vessel atmospheric emissions from FSU transportation and installation operations				**40,838**	**102.10**	**752.96**	**2.81**	**51.05**	**3.45**	**30.63**

Source: [1]UKOOA (2002)

Table 3.9f: Estimated gaseous emissions from vessels installation and operation of the flotel

Mariner Area Development activity	Days	Fuel consumption		Emissions (tonnes)						
		tnnes / day	tonnes	CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
Marine diesel factors (t/t)[1]				*3.2*	*0.008*	*0.059*	*0.00022*	*0.004*	*0.00027*	*0.0024*
Installation and operation of the flotel										
AHTV (mob/demob)	6	5	30	96	0.24	1.77	0.01	0.12	0.01	0.07
Flotel onsite	150	0.02	3	9.6	0.02	0.18	0.00	0.01	0.00	0.01
Total vessel atmospheric emissions from flotel installation and operation				**105.60**	**0.26**	**1.95**	**0.01**	**0.13**	**0.01**	**0.08**

Source: [1]UKOOA (2002)

Table 3.9g: Estimated gaseous emissions from vessels during subsea installation operations

Mariner Area Development activity	Days	Fuel consumption		Emissions (tonnes)						
		tonnes / day	tonnes	CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
Marine diesel factors (t/t)[1]				*3.2*	*0.008*	*0.059*	*0.00022*	*0.004*	*0.00027*	*0.0024*
Mariner subsea installation, hook-up and commissioning operations										
Support vessel (spool and tee installation and pipeline commissioning)										
Mob / demob	5	10	50	160	0.4	2.95	0.01	0.2	0.01	0.12
Working	23	5	115	368	0.92	6.79	0.03	0.46	0.03	0.28
Pipe-lay vessel (gas and diluent / oil pipeline installation)										
Mob / demob	9	8	48	154	0.38	2.83	0.01	0.19	0.01	0.12
Working	27	15	450	1,440	3.6	26.55	0.10	1.8	0.12	1.08
Anchor handling vessel (pipeline trenching, ploughing and rock-dumping)										
Mob / demob	2	5	10	320	0.8	5.9	0.02	0.4	0.03	0.24
Working	20	50	1000	320	0.8	5.9	0.02	0.4	0.03	0.24
Anchor handling vessel (fibre cable laying)										
Mob / demob	5	5	25	80	0.2	1.48	0.28	0.1	0.01	0.06
Working	14	50	700	2240	5.6	41.3	0.15	2.8	0.19	1.68
Cable lay vessel (fibre cable laying)										
Mob / demob	6	18	108	346	0.864	6.37	0.02	0.43	0.03	0.26
Working	15	22	330	1056	2.64	19.47	0.07	1.32	0.09	0.79
Rock-dumping vessel										
Mob / demob	5	18	90	58	0.144	1.06	0.00	0.07	0.00	0.22
Working	15	26	390	83	0.208	1.53	0.01	0.10	0.01	0.94
Installation / construction vessel (spool, riser, tee installation – 3 vessels)										
Mob / demob	35	18	630	2016	5.04	37.17	0.14	2.52	0.17	1.51
working	106	22	2,332	7462	18.656	137.59	0.51	9.33	0.63	5.60
Total vessel atmospheric emissions from subsea operations				**16,035**	**40.09**	**295.65**	**1.37**	**20.04**	**1.36**	**13.07**

Source: [1]UKOOA (2002)

Table 3.9h: Estimated gaseous emissions from all vessels during drilling and installation of the Mariner Area Development

Mariner Area Development activity	Emissions (tonnes)						
	CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
Total vessel atmospheric emissions from PDQ transportation and installation operations	67,552	168.88	1,245.50	4.64	84.44	5.70	50.67
Total vessel atmospheric emissions from the Mariner drilling operations	120,432	301	2,220	8	151	10	90
Total vessel atmospheric emissions from the Mariner East drilling operations	24,960	62.4	460.2	1.71	31.2	2.10	18.72
Total vessel atmospheric emissions from FSU transportation and installation operations	40,838	102.1	752.96	2.81	51.05	3.45	30.63
Total vessel atmospheric emissions from flotel installation and operation	106	0.26	1.95	0.01	0.13	0.01	0.08
Total vessel atmospheric emissions from subsea operations	16,035	40.09	295.65	1.37	20.04	1.36	13.07
Total atmospheric emissions from helicopter operations	65,229	106	254.8	4.48	81.53	1.77	16.31
Total drilling and installation gaseous emissions from Mariner Area Development	**335,152**	**780.81**	**5,231.52**	**23.30**	**418.93**	**24.56**	**219.81**

3.9.3 Sources of atmospheric emissions from production operations

3.9.3.1 Power generation

As discussed in **Section 3.8.6** power generation at the PDQ will be supplied by two dual-fuel fired turbine generators. The two turbines on the PDQ will be able to use produced gas and imported gas for fuel, however, they will also be able to use diesel during periods when fuel gas is unavailable.

Diesel will be used for the essential generator (plus emergency generator) and the dual fuel power generators. The amount of diesel that will be required to fuel the essential, emergency and duel fuel power generators is unknown at this time. However, Statoil estimate that 100 tonnes of diesel per year will be required at the Mariner Area Development over field life to fuel these generators for testing and additional operations. **Table 3.10** provides a summary of the estimated annual atmospheric emissions resulting from the operation of the diesel generators.

Table 3.10: Summary of the predicted annual diesel power generation emissions (diesel) at the Mariner Area Development PDQ over the field life

Diesel required for power generation (per year)	Emissions (tonnes)						
	CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
Diesel turbine factor (te/te)	*3.2*	*0.00092*	*0.0135*	*0.00022*	*0.004*	*0.0000328*	*0.000295*
100 tonnes	320	0.092	1.35	0.022	0.4	0.003	0.03

Source: EEMS (2008)

Table 3.11 provides a summary of the estimated annual power generation emissions (gas) at the Mariner Area Development PDQ over the field life. Power generation is expected to peak in 2022 (production year 7), utilising approximately 113 x10^6 m^3 of gas per year to power the gas turbines (**Table 3.11**). Following peak production at the Mariner and Mariner East fields, power generation at the PDQ is expected to decrease, utilising approximately 65 x10^6 m^3 of gas per year to power the gas turbines until end of field life (**Table 3.11**).

Table 3.11: Summary of the predicted annual power generation emissions (gas) at the Mariner Area Development PDQ over field life

Year	Fuel (10 m^3) required for power generation (per year)	Emissions (tonnes)						
		CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
	Gas turbine factors (te/te)[1]	*2.86*	*0.003*	*0.0061*	*0.00022*	*0.0000128*	*0.00092*	*0.000036*
2016	5,181	14,818	15.544	31.61	1.14	0.07	4.77	0.19
2017	71,599	204,773	214.80	436.75	15.75	0.92	65.87	2.58
2018	88,053	251,831	264.16	537.12	19.37	1.13	81.01	3.17
2019	106,651	305,021	319.95	650.57	23.46	1.37	98.12	3.84
2020	110,824	316,956	332.47	676.02	24.38	1.42	101.96	3.99
2021	110,817	316,935	332.45	675.98	24.38	1.42	101.95	3.99
2022	112,894	322,877	338.68	688.66	24.84	1.45	103.86	4.06
2023	107,562	307,629	322.69	656.13	23.66	1.38	98.96	3.87
2024	104,307	298,318	312.92	636.27	22.95	1.34	95.96	3.76
2025	103,464	295,907	310.39	631.13	22.76	1.32	95.19	3.72
2026	102,716	293,767	308.15	626.57	22.60	1.31	94.50	3.70
2027	101,912	291,470	305.737	621.67	22.42	1.30	93.76	3.67
2028	100,674	287,929	302.02	614.11	22.15	1.29	92.62	3.62
2029	99,490	284,543	298.47	606.89	21.89	1.27	91.53	3.58
2030	102,156	292,166	306.47	623.15	22.47	1.31	93.98	3.68
2031	101,290	289,690	303.87	617.87	22.28	1.30	93.19	3.65
2032	97,620	279,194	292.86	595.48	21.48	1.25	89.81	3.51

Year	Fuel (10 m^3) required for power generation (per year)	Emissions (tonnes)						
		CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
	Gas turbine factors (te/te)[1]	*2.86*	*0.003*	*0.0061*	*0.00022*	*0.0000128*	*0.00092*	*0.000036*
2033	95,540	273,244	286.62	582.79	21.02	1.22	87.90	3.44
2034	94,465	270,171	283.40	576.24	20.78	1.21	86.91	3.40
2035	64,494	184,453	193.48	393.41	14.19	0.83	59.33	2.32
2036	64,096	183,313	192.29	390.98	14.10	0.82	58.97	2.31
2037	63,736	182,284	191.21	388.79	14.02	0.82	58.64	2.29
2038	63,547	181,746	190.64	387.64	13.98	0.81	58.46	2.29
2039	63,568	181,805	190.71	387.77	13.99	0.81	58.48	2.29
2040	63,486	181,570	190.458	387.27	13.97	0.81	58.41	2.29
2041	63,427	181,402	190.28	386.91	13.95	0.81	58.35	2.28
2042	63,656	182,055	190.97	388.30	14.00	0.81	58.56	2.29
2043	63,605	181,910	190.82	387.99	13.99	0.81	58.52	2.29
2044	63,643	182,018	190.93	388.22	14.00	0.81	58.55	2.29
2045	63,588	181,862	190.76	387.89	13.99	0.81	0.00	2.29
2046	63,572	181,817	190.72	387.79	13.99	0.81	58.49	2.29
2047	64,012	183,075	192.037	390.48	14.08	0.82	58.89	2.30
2048	64,250	183,755	192.75	391.93	14.14	0.82	59.11	2.31
2049	64,100	183,326	192.30	391.01	14.10	0.82	58.97	2.31
2050	64,352	184,046	193.06	392.55	14.16	0.82	59.20	2.32
2051	64,561	184,643	193.68	393.82	14.20	0.83	59.40	2.32
2052	64,672	184,963	194.02	394.50	14.23	0.83	59.50	2.33
2053	65,184	186,426	195.55	397.62	14.34	0.83	59.97	2.35
2054	65,667	187,808	197.00	400.57	14.45	0.84	60.41	2.36
2055	65,652	187,764	196.96	400.48	14.44	0.84	60.40	2.36

Source: [1]EEMS (2008)

The FSU will be powered independently from the PDQ, with the power generation on the FSU generated by diesel generators. Statoil estimate the diesel generators on the FSU will utilise an average of 7,332 tonnes of diesel per year over field life. **Table 3.12** provides a summary of the estimated annual power generation emissions at the Mariner Area Development FSU.

Table 3.12: Summary of the predicted annual power generation emissions (diesel) at the Mariner Area Development FSU

Fuel required for power generation (per year)	Emissions (tonnes)						
	CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
Diesel turbine factors (te/te)[1]	*3.2*	*0.00092*	*0.0135*	*0.00022*	*0.004*	*0.0000328*	*0.000295*
7,332	23,462.40	6.75	98.98	1.61	29.33	0.24	2.16

Note: [1]EEMS (2008);

Statoil will apply for a Pollution, Prevention and Control (PPC) Permit for the Mariner Area Development FSU under the Offshore Combustion Installations (Prevention and Control of Pollution) (Amendment) Regulations 2007, and all atmospheric emissions produced at the Mariner Area Development from power generation operations will be monitored and reported as per the requirements of the PPC permit.

3.9.3.2 Flaring

Flaring of excess gas is not normally regarded as BAT. Accordingly, the following alternative solutions to flaring were considered:

- including a gas export module on the PDQ, and exporting the surplus to the Vesterled line. This option has a high cost, and certain safety risks, that cannot be justified relative to the relatively small volumes of gas requiring to be flared;
- re-injection of the excess gas, using dedicated gas injection wells. Again, the costs and risks could not be justified for the relatively low volumes of gas to be flared;
- re-injection of the excess gas into the water injection wells, using multi-phase pumps. This option was found to have risk of reservoir damage and was therefore rejected;

On this basis, because there is a relatively small quantity of gas requiring to be flared, over a relatively short period, all alternates were seen as being unacceptable. The current proposal is therefore to flare the excess gas. However, Statoil is currently evaluating the use of excess production gas for power generation limiting periods of flaring to periods of process upsets (safety flaring).

Table 3.13 provides an annual breakdown of the amount of excess gas that Statoil anticipate will be flared from the PDQ over the first two main years of production.

Table 3.13: Summary of the predicted annual excess gas flaring emissions from the Mariner Area Development, over the first two years of production

Production year	Flared gas (10^6 m^3)	Emissions (tonnes)						
		CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
Gas emission factors (te/te)[1]		*2.8*	*0.0067*	*0.0012*	*0.000081*	*0.0000128*	*0.045*	*0.005*
2017	33.9	79,068	189.20	33.89	2.29	0.36	1,271	141.19
2018	51.3	119,652	286.31	51.28	3.46	0.55	1,923	213.66

Source: [1]UKOOA (2002)

In addition, it is assumed that 2% of produced gas will be flared over the remaining field life due to process upset conditions. **Table 3.14** presents the total estimated flaring emissions that will occur over the field life of the development, including both the excess gas flaring and the 2% safety flaring.

Table 3.14: Summary of the predicted annual flaring emissions from the Mariner Area Development over the field life

Production year	Flared gas (10^6 m^3)	Emissions (tonnes)						
		CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
Gas emission factors (te/te)[1]		*2.8*	*0.0067*	*0.0012*	*0.000081*	*0.0000128*	*0.045*	*0.005*
1	0.046	107.29	0.26	0.05	0.00	0.00	1.72	0.19
2	33.9	79,068	189.20	33.89	2.29	0.36	1,270.74	141.19
3	51.3	119,652	286.31	51.28	3.46	0.55	1,922.98	213.66
4	3.587	8,366	20.02	3.59	0.24	0.04	134.46	14.94
5	3.161	7,373	17.64	3.16	0.21	0.03	118.49	13.17
6	2.816	6,568	15.72	2.81	0.19	0.03	105.56	11.73
7	2.841	6,626	15.86	2.84	0.19	0.03	106.49	11.83
8	3.180	7,417	17.75	3.18	0.21	0.03	119.20	13.24
9	3.551	8,282	19.82	3.55	0.24	0.04	133.11	14.79
10	3.409	7,951	19.03	3.41	0.23	0.04	127.79	14.20
11	3.314	7,730	18.50	3.31	0.22	0.04	124.23	13.80
12	3.054	7,123	17.04	3.05	0.21	0.03	114.48	12.72
13	2.905	6,776	16.21	2.90	0.20	0.03	108.89	12.10
14	2.924	6,820	16.32	2.92	0.20	0.03	109.61	12.18
15	2.630	6,134	14.68	2.63	0.18	0.03	98.59	10.95
16	2.120	4,945	11.83	2.12	0.14	0.02	79.47	8.83

Production year	Flared gas (10^6 m^3)	Emissions (tonnes)						
		CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
Gas emission factors (te/te)[1]		*2.8*	*0.0067*	*0.0012*	*0.000081*	*0.0000128*	*0.045*	*0.005*
17	1.731	4,037	9.66	1.73	0.12	0.02	64.89	7.21
18	1.468	3,424	8.19	1.47	0.10	0.02	55.03	6.11
19	1.281	2,988	7.15	1.28	0.09	0.01	48.02	5.34
20	1.143	2,666	6.38	1.14	0.08	0.01	42.85	4.76
21	1.034	2,412	5.77	1.03	0.07	0.01	38.76	4.31
22	0.951	2,218	5.31	0.95	0.06	0.01	35.65	3.96
23	0.901	2,102	5.03	0.90	0.06	0.01	33.77	3.75
24	0.850	1,983	4.74	0.85	0.06	0.01	31.86	3.54
25	0.807	1,882	4.50	0.81	0.05	0.01	30.25	3.36
26	0.774	1,805	4.32	0.77	0.05	0.01	29.01	3.22
27	0.735	1,714	4.10	0.73	0.05	0.01	27.55	3.06
28	0.707	1,649	3.95	0.71	0.05	0.01	26.50	2.94
29	0.680	1,586	3.80	0.68	0.05	0.01	25.49	2.83
30	0.650	1,516	3.63	0.65	0.04	0.01	24.37	2.71
31	0.642	1,497	3.58	0.64	0.04	0.01	24.07	2.67
32	0.628	1,465	3.50	0.63	0.04	0.01	23.54	2.62
33	0.605	1,411	3.38	0.60	0.04	0.01	22.68	2.52
34	0.592	1,381	3.30	0.59	0.04	0.01	22.19	2.47
35	0.581	1,355	3.24	0.58	0.04	0.01	21.78	2.42
36	0.569	1,327	3.18	0.57	0.04	0.01	21.33	2.37
37	0.562	1,311	3.14	0.56	0.04	0.01	21.07	2.34
38	0.572	1,334	3.19	0.57	0.04	0.01	21.44	2.38
39	0.561	1,309	3.13	0.56	0.04	0.01	21.03	2.34
40	0.554	1,292	3.09	0.55	0.04	0.01	20.77	2.31
41	0.531	1,239	2.96	0.53	0.04	0.01	19.90	2.21
42	0.519	1,211	2.90	0.52	0.04	0.01	19.45	2.16

Source: [1]UKOOA (2002)

3.10 Production Period

The Mariner Area Development production wells will target the oil in the Mariner field (Heimal and Maureen reservoirs) and the Mariner East field (Maureen reservoir only). To assist in the extraction of the oil reserves at the Mariner field, water injection wells will be required and each production well will require artificial lift (**Sections 3.3**). The Mariner

East wells will not require water re-injection or the injection of diluent. All Mariner and Mariner East wells will require ESPs to artificially lift the crude.

3.10.1 Oil production

Production at the Mariner Area Development is scheduled to commence in early 2017, with a field life of 40 years. **Table 3.15** and **Figure 3.25** illustrate the expected oil production from the Mariner field and the Mariner East field**.**

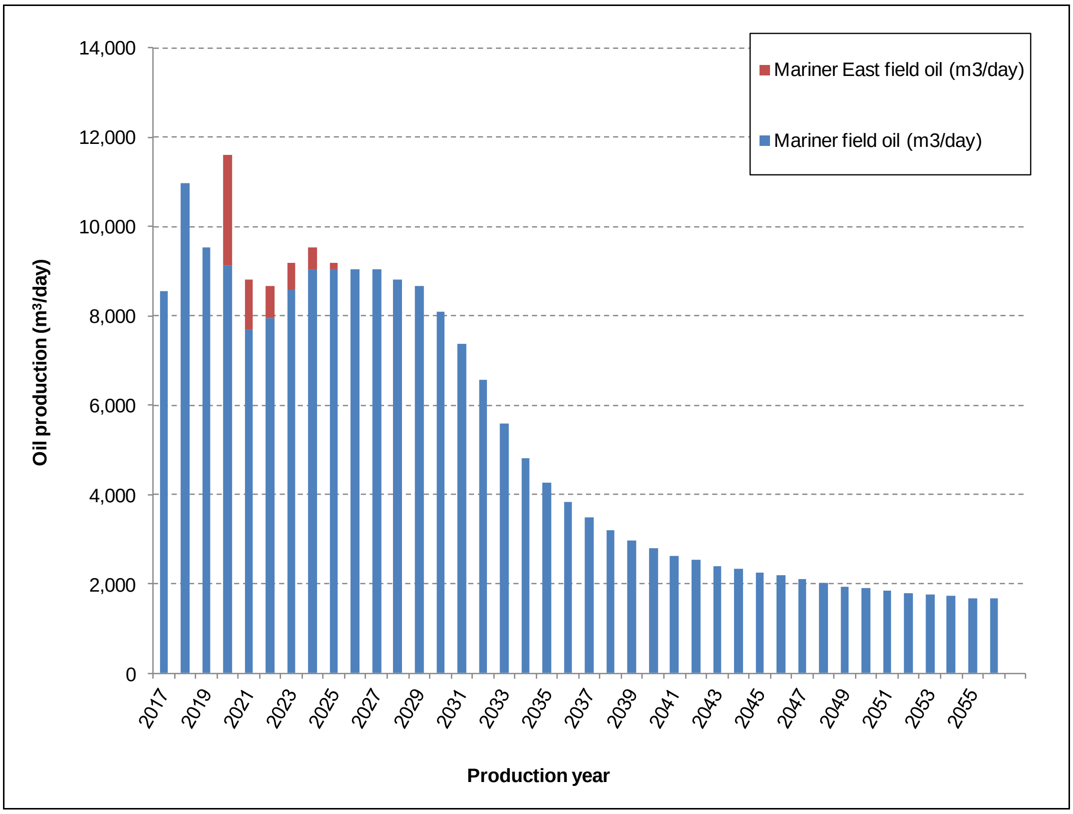

Figure 3.25: Expected oil production rates at the Mariner Area Development

Production will peak in 2018, once the majority of the Maureen wells have been drilled, and will decline as these Maureen wells water-out and are progressively replaced by Heimdal wells. Production rates will then increase again from around 2022 onwards, as more Heimdal wells are brought on-line, peaking in the period 2024 to 2027. Following this secondary peak in production, production decreases until predicted end of field life.

Mariner East production will occur at a time when production from the Mariner field is off plateau, as this is constrained by the production system capacity. Statoil currently predict that Mariner East production will commence in 2019 and will continue until 2024 (**Table 3.15; Figure 3.25**).

Table 3.15: Maximum predicted daily production over field life

Production year	Production rates at Mariner Area Development					
	Oil (m^3/day)			Gas (10^6 m^3/day)	Produced water (m^3/day)	Diluent (m^3/day)
	Mariner	Mariner East	Mariner Area			
2017	8,544	-	8,544	0.27	2,189	449
2018	10,962	-	10,962	0.34	17,202	792
2019	9,527	2,482	12,009	0.28	34,489	1,014
2020	9,120	1,133	10,253	0.25	39,394	1,233
2021	7,695	741	8,436	0.21	40,007	1,152
2022	7,940	610	8,550	0.18	39,634	1,445
2023	8,576	479	9,055	0.18	37,707	1,690
2024	9,043	131	9,174	0.19	37,306	2,022
2025	9,058	-	9,058	0.16	38,197	2,154
2026	9,056	-	9,056	0.16	38,357	2,217
2027	9,052	-	9,052	0.15	38,721	2,263
2028	8,823	-	8,823	0.13	39,373	2,206
2029	8,679	-	8,679	0.13	39,192	2,170
2030	8,082	-	8,082	0.12	39,866	2,020
2031	7,387	-	7,387	0.11	40,331	1,846
2032	6,582	-	6,582	0.10	40,702	1,646
2033	5,577	-	5,577	0.09	41,161	1,394
2034	4,825	-	4,825	0.08	40,455	1,206
2035	4,256	-	4,256	0.07	41,024	1,064
2036	3,839	-	3,839	0.07	41,555	960
2037	3,490	-	3,490	0.07	41,801	872
2038	3,212	-	3,212	0.06	42,068	803
2039	2,981	-	2,981	0.06	42,299	745
2040	2,792	-	2,792	0.05	42,601	698
2041	2,635	-	2,635	0.05	42,656	659
2042	2,537	-	2,537	0.05	42,743	634
2043	2,406	-	2,406	0.05	42,874	601
2044	2,324	-	2,324	0.05	43,070	581
2045	2,237	-	2,237	0.05	43,053	559
2046	2,184	-	2,184	0.04	43,096	546
2047	2,104	-	2,104	0.04	43,176	526
2048	2,024	-	2,024	0.04	43,370	506
2049	1,942	-	1,942	0.04	43,348	485
2050	1,895	-	1,895	0.03	43,385	474

Production year	Production rates at Mariner Area Development					
	Oil (m^3/day)			Gas (10^6 m^3/day)	Produced water (m^3/day)	Diluent (m^3/day)
	Mariner	Mariner East	Mariner Area			
2051	1,849	-	1,849	0.03	43,431	462
2052	1,794	-	1,794	0.03	43,600	448
2053	1,752	-	1,752	0.03	43,538	438
2054	1,721	-	1,721	0.03	43,559	430
2055	1,675	-	1,675	0.03	43,605	419
2056	1,667	-	1,667	0.02	43,726	417

3.10.2 Gas production

Gas production at the Mariner field is predicted to peak in 2018 (**Table 3.15** and **Figure 3.26**).

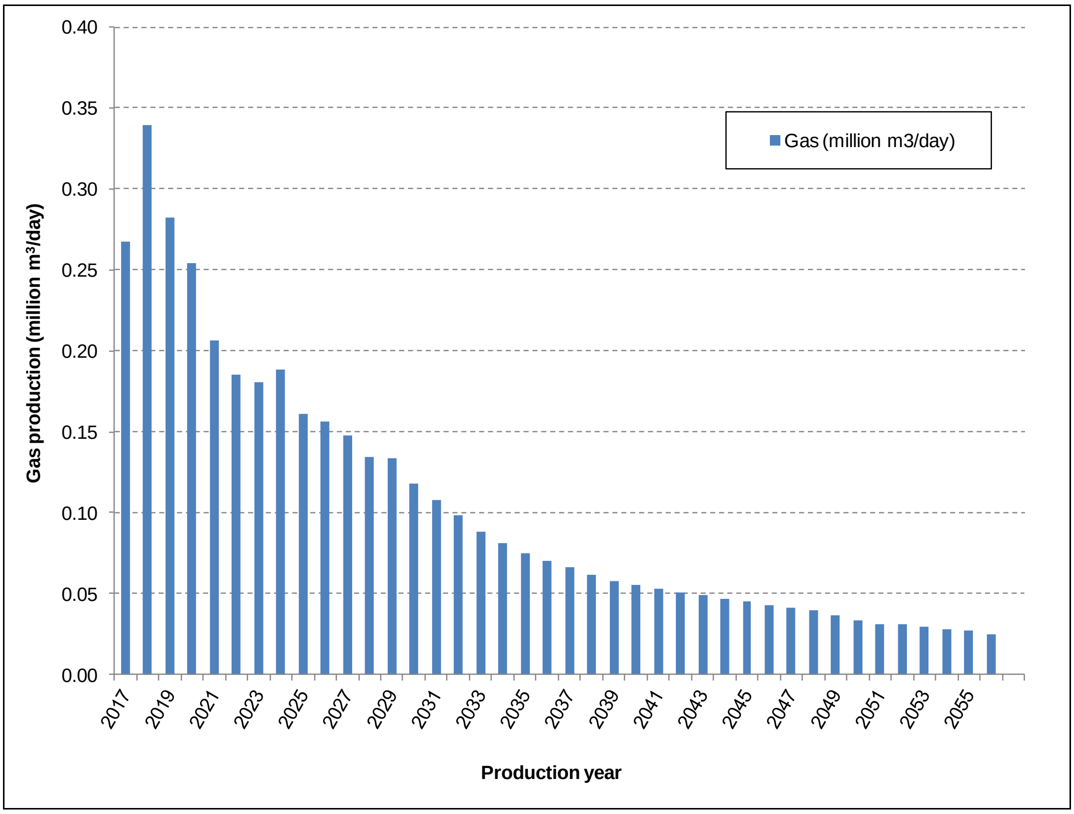

Figure 3.26: Expected gas production rates at the Mariner Area Development

Following this peak, gas production is expected to decrease as field life continues. Produced gas will be used for fuel on the PDQ, supplemented by imported gas when necessary. During 2017 and 2018 some excess gas will be produced, that most likely will be flared.

3.10.3 Produced water discharges

The production of gas and oil is associated with the generation of produced water sourced either from water vapour in the reservoir or from the aquifer. Condensate water is produced as water vapour in the reservoir condenses as a function of pressure and temperature and formation water can be produced as it breaks through into the wellbore.

Produced water from the Mariner Area Development will be re-injected back into the reservoir, via the water re-injection wells at the Mariner field (**Section 3.6.16**). The design specification of the produced water re-injection system is to achieve at least 95% availability, equating to 18 days per year, on average, when water may be discharged overboard. During contingency periods when the PWRI system is unavailable (e.g. equipment downtime) produced water will be disposed to sea via a dedicated caisson. Before disposal, water will be treated to the required oil-in-water standard. Produced water will be subject to secondary treatment (i.e. de-oiling hydrocyclones) in combination with dissolved gas floatation to achieve the required oil in water standard. Produced water equipment will be regularly maintained to ensure operational capability. Sampling and monitoring will be carried out in line with OPPC requirements.

Produced water volumes are forecast to increase initially peaking in 2021, then following a dip in 2023 and 2024, produced water rates will increase again remaining relatively constant as field life increases, (**Table 3.15 and Figure 3.27**).

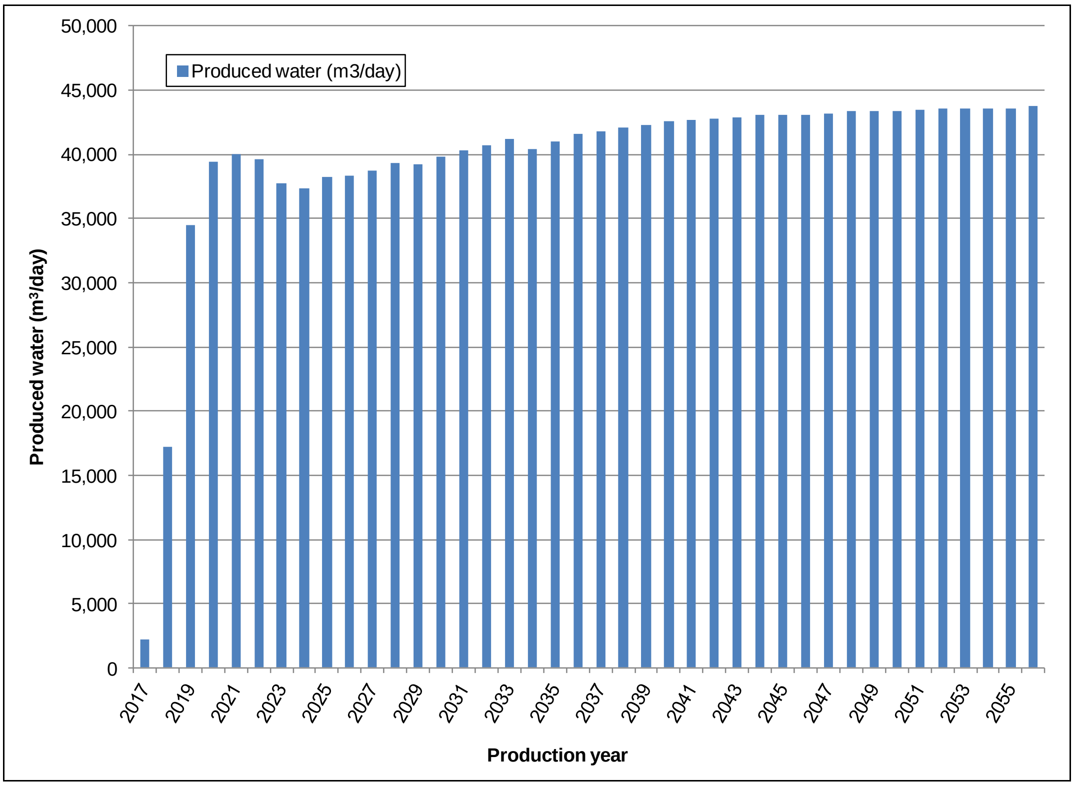

Figure 3.27: Expected produced water rates at the Mariner Area Development

3.10.4 Tanker Offloading

Tanker offloading will result in volatile organic compounds (VOC) emissions. Loading losses occur as a consequence of organic vapours in “empty” cargo tanks being displaced to atmosphere by liquid being loaded into the tanks. The vapours released will be a composite of:

- vapours formed in the empty tank by evaporation of residual product from the previous load; and
- vapours generated in the tank as the new product is being loaded

The quantity of evaporative losses from loading operations is therefore a function of the following parameters:

- physical and chemical characteristics of the cargo;
- method of unloading the cargo; and
- method of loading the cargo.

Tanker offloading emissions can be mitigated by a VOC recovery system on the selected FSU and on the export shuttle tanker. However, the loss of VOC vapours to the atmosphere during tanker offloading operations has been assumed as the worst case scenario. The FSU will have the class classification of “Clean Design”.

Emission factors for methane and VOCs for tanker loading are taken from the UKOOA Guidelines on Atmospheric Emissions Inventory (2002) and have been used to calculate emissions (**Table 3.16**).

Table 3.16: Predicted VOC emissions from tanker offloading

Production year	Daily production	Annual oil production	Annual oil production	Annual VOC emissions
	m^3/day	m^3	Tonnes*	Tonnes**
2017	8,544	3,118,453	2,951,579	5,903
2018	10,962	4,001,255	3,787,141	7,574
2019	12,009	4,383,266	5,054,710	10,109
2020	10,253	3,742,503	3,955,635	7,911
2021	8,436	3,079,054	3,184,589	6,369
2022	8,550	3,120,777	3,176,379	6,353
2023	9,055	3,305,009	3,303,053	6,606
2024	9,174	3,348,557	3,217,070	6,434
2025	9,058	3,306,092	3,129,177	6,258
2026	9,056	3,305,375	3,128,498	6,257

Production year	Daily production	Annual oil production	Annual oil production	Annual VOC emissions
	m^3/day	m^3	Tonnes*	Tonnes**
2027	9,052	3,303,969	3,127,168	6,254
2028	8,823	3,220,531	3,048,195	6,096
2029	8,679	3,167,783	2,998,269	5,997
2030	8,082	2,949,864	2,792,012	5,584
2031	7,387	2,696,325	2,552,040	5,104
2032	6,582	2,402,308	2,273,756	4,548
2033	5,577	2,035,566	1,926,640	3,853
2034	4,825	1,761,097	1,666,857	3,334
2035	4,256	1,553,609	1,470,473	2,941
2036	3,839	1,401,274	1,326,290	2,653
2037	3,490	1,273,713	1,205,554	2,411
2038	3,212	1,172,351	1,109,616	2,219
2039	2,981	1,088,090	1,029,865	2,060
2040	2,792	1,019,222	964,682	1,929
2041	2,635	961,625	910,167	1,820
2042	2,537	926,079	876,523	1,753
2043	2,406	878,305	831,306	1,663
2044	2,324	848,095	802,712	1,605
2045	2,237	816,564	772,868	1,546
2046	2,184	797,026	754,375	1,509
2047	2,104	767,943	726,849	1,454
2048	2,024	738,642	699,116	1,398
2049	1,942	708,815	670,885	1,342
2050	1,895	691,799	654,780	1,310
2051	1,849	674,936	638,819	1,278
2052	1,794	654,808	619,768	1,240
2053	1,752	639,653	605,424	1,211
2054	1,721	628,203	594,587	1,189
2055	1,675	611,347	578,633	1,157
2056	1,667	608,586	576,020	1,152

Note:

**Based on Mariner / diluent blend API 18 / Density 0.946488294*

***Based on VOC emission factor 0.002*

3.10.5 Pipeline maintenance

No hydrostatic testing of the pipelines is expected during the operational phase. No maintenance is planned other than routine inspections such as checking for lack of cover, free-spans and evidence of interaction with fishing. Any potential problems such as upheaval buckling and anchor snags will be avoided by correct pipeline design, trenching and careful installation.

The production pipelines will be designed to accommodate ”pigging operations” if necessary, whereby a remote sensing “pig” will be conveyed through the flowline to undertake checks on flowline integrity and condition.

3.10.6 Operational chemicals

Production chemicals will be required for the normal operation of the Mariner Area Development. Planned chemical use specific to the operations of the Mariner Area Development are summarised in **Table 3.17**, however these will be finalised during detailed design and included in the PON15D application.

The quantities of chemicals to be used and discharged will be subject to the Mariner Area Development PON 15D permit, and approval will be sought from DECC as required under the Offshore Chemicals Regulations 2002 (as amended).

Table 3.17: Expected operational chemical requirements

Chemical	Location
Hydrate inhibitor	Hydrate inhibitor (methanol) will be required to be intermittently injected to reduce the potential for hydrate formation inside the production/ injection systems.
Scale inhibitor	Scale inhibitor will be required to reduce the potential for calcium carbonate scale build-up inside the production/ injection systems.
Demulsifier	The Mariner crude has the potential to form very viscous water-in-oil emulsions. A demulsifier will be injected upstream, to break water-in-oil emulsions.
Antifoam	Antifoam chemical will be injected upstream of the 1st stage separator, and test separator to break the foam and prevent liquid carry-over, and maximise gas breakout.
Oxygen scavenger	Oxygen scavenger will be injected at the outlet of the seawater de-oxygenation system to manage potential corrosion problems and reservoir souring issues.

3.11 Decommissioning

3.11.1 General

The Mariner Area Development has been designed for a field life of 40 years. At Cessation of Production (CoP) the Mariner Area Development infrastructure will be decommissioned in compliance with applicable legislation at that time and other agreements with the DECC and relevant regulatory bodies.

A full decommissioning plan will be developed at the time of CoP and will be designed to ensure that potential effects on the environment resulting from the decommissioning of the facilities will be minimised.

The main considerations of the decommissioning process will be safety of navigation, the prevention of marine pollution and the prevention of damage to the marine environment. The ultimate intention is to leave the seabed in the development area in a condition that will pose no harm to the marine environment.

Decommissioning options and the final method will be discussed and agreed with the statutory authorities and will adhere to governmental policies and regulations in force at the time. It is anticipated that the decommissioning programme for the Mariner Area Development will likely include the following.

3.11.2 Pipeline and subsea structures

Pipelines will be disconnected from the structures, with all pipelines being flushed and capped for abandonment in the seabed. Any manifold structures (i.e. PLEM) will be retrieved by DSV and a seabed clearance campaign conducted. Any piles at the structure will be cut off below the seabed level for retrieval.

In accordance with current legislation, the manifolds and subsea structures will be removed from the seabed and returned to shore for reuse, recycling, or disposal.

3.11.3 Wells

All producing and water injection wells will be plugged and permanently abandoned in accordance with the UKOOA Guidelines for Suspension and Abandonment of wells (or applicable guidance at that time). All well programmes will have been reviewed by the HSE Offshore Safety Division as required under the Design and Construction Regulations.

On completion of the well abandonment programme each conductor and internal tubing will be cut below the seabed. The subsea wellheads will then be recovered at location utilising either a DSV or semi-submersible mobile drilling unit.

3.11.4 PDQ

It is anticipated that the PDQ Platform will be removed in the reverse order to the original installation sequence.

Wherever possible the original lifting points for each of the separately lifted platform components will be designed to be retained during the field life, so that they may be used for the final lifts for platform removal.

As the final method of jacket removal is not known, all lifting attachments shall be designed for current installation conditions.

Each component piece of the topsides will be lifted from the platform with a HLV and transported by barge to a disposal site for reuse wherever possible, or dismantling and recycling/safe disposal.

The jacket will be cut free and lifted in one or more pieces onto transportation barges for subsequent disposal, recycling etc. The piles will be cut off below the mudline level using high powered sand and water jets. If grout plugs are used during pile installation, the top of the grout plug will be no higher than 10 m below mudline.

3.11.5 FSU

Statoil intend to float the selected FSU off the field and remove subsea infrastructure. However, prior to the decommissioning process, reuse and recycling alternatives will be considered where feasible. In advance of the decommissioning process an inventory of all project equipment will be made and an examination for further reuse will be carried out.

Surveys around installations to establish the environmental baseline will be performed prior to decommissioning. The precise decommissioning methodology will depend upon operating conditions. Discussion on what may be required in an individual case will be held with DECC’s Offshore Decommissioning Unit before commencing.

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4 ENVIRONMENTAL SETTING AND DESCRIPTION

The purpose of this section is to describe the baseline environmental setting of the proposed Mariner Area Development and to identify those components of the physical, chemical and biological environment that might be sensitive to the impacts that could arise as result of the proposed development in this location. An understanding of the environmental sensitivities informs the assessment of the environmental impacts and risks associated with the proposed development activities.

The proposed Mariner Area Development will be located in UKCS Blocks 9/11 and 9/12 in the northern North Sea. The Mariner field is located in Block 9/11a while the Mariner East field is located within Block 9/11b. The Mariner field lies approximately 5 km north west of the Mariner East field. The proposed gas import pipeline will cross from the Mariner field through Blocks 9/12 and 9/13 and into the western edge of Block 9/14.

The Mariner Area Development is located approximately 40 km north west from the nearest UK/Norway median line and approximately 130 km from the nearest Shetland coastline.

4.1 Mariner Area Development Field Surveys

Statoil have conducted four surveys within the Mariner Area Development. These are:

1. A detailed **ROV survey** undertaken by Subsea 7 Norway on behalf of Statoil, between 6th and 15th March 2011. This survey covered a 1 km x 1 km area centred on the Mariner PDQ / FSU location and a 200 m (±100 m) wide pipeline route corridor along the proposed gas import pipeline route from the PDQ to the Vesterled tie-in location. The survey utilised multibeam echo sounder, side scan sonar and sub-bottom profiler. The scope and objective of the detailed ROV survey was to conduct visual identification of any significant side-scan targets, an anchor cluster and mooring survey, identify the shallow soil conditions, and any potential obstructions along the route of the survey (Subsea 7, 2011).

2. Mariner regional survey was conducted in Block 9/11 by Gardline (Gardline, 2009). The survey was conducted over an area nominally measuring 11.2 km x 9.3 km encompassing the Mariner and Mariner East fields. The survey utilised single and multi-beam echo sounder, sidescan sonar, hull mounted pinger, mini airgun and high resolution 2D seismic equipment. The objectives of the survey were to identify any hazards, obstructions and anchoring conditions to the emplacement of a semi-submersible drilling rig and to provide shallow gas assurance for the subsequent drilling programme (Gardline, 2009).

3. A site and pipeline route survey was undertaken by Fugro Survey Limited (FSL) between February and March 2008 covering the area from the Bressay field (Block 3/28a) to the Broch field (9/14). The Bressay to Broch route survey captured the proposed pipeline route between the Mariner field and Mariner East field. The objective of the survey was to acquire multi-beam echo sounder data, single beam echo sounder data, hull-mounted pinger data and side scan sonar data and to identify sub-seabed conditions, bathymetry, obstructions, anchoring conditions and installation constraints. The multi-beam echo sounder covered a survey corridor approximately 500 m wide, whilst the side scan sonar data covered a survey corridor approximately 200 m wide (FSL, 2008).

4. An environmental baseline survey was undertaken by Det Norske Veritas (DNV) on behalf of Statoil during June 2011, which covered the area of the Mariner field. The objective of the survey was to acquire information about the physical/chemical properties and to establish a baseline for the contamination status of the local sediments; and to determine the diversity and the level of dominance of the local benthic environment. The sampling stations were aligned on 250 m, 500 m, and 1000 m downstream direction from the proposed Mariner PDQ site, lying on a sampling axis cross oriented to the south east due to the prevailing direction of the subsea current conditions (sampling points MA). Samples were taken in the vicinity of old wells and a number of reference stations were sampled.

4.2 Physical environment

4.2.1 Bathymetry

The seabed across the Mariner Area Development is generally flat with a gentle downward slope to the west of the area (FSL, 2008; Subsea 7, 2011). In the northwest, the seabed is generally smooth with water depths increasing to the northwest. For the central, eastern and southern areas, the seabed is highly irregular; forming mounds several metres high and a distinct shoal 12 m high (Gardline, 2009). The seabed gradient across the development area varies from less than 0.1° to 2.9°. The water depth ranges from 94.8 m LAT in the north-east of the development area to 116.5 m LAT the north-west of the development area (Gardline, 2009; Subsea7, 2011; DNV, 2011).

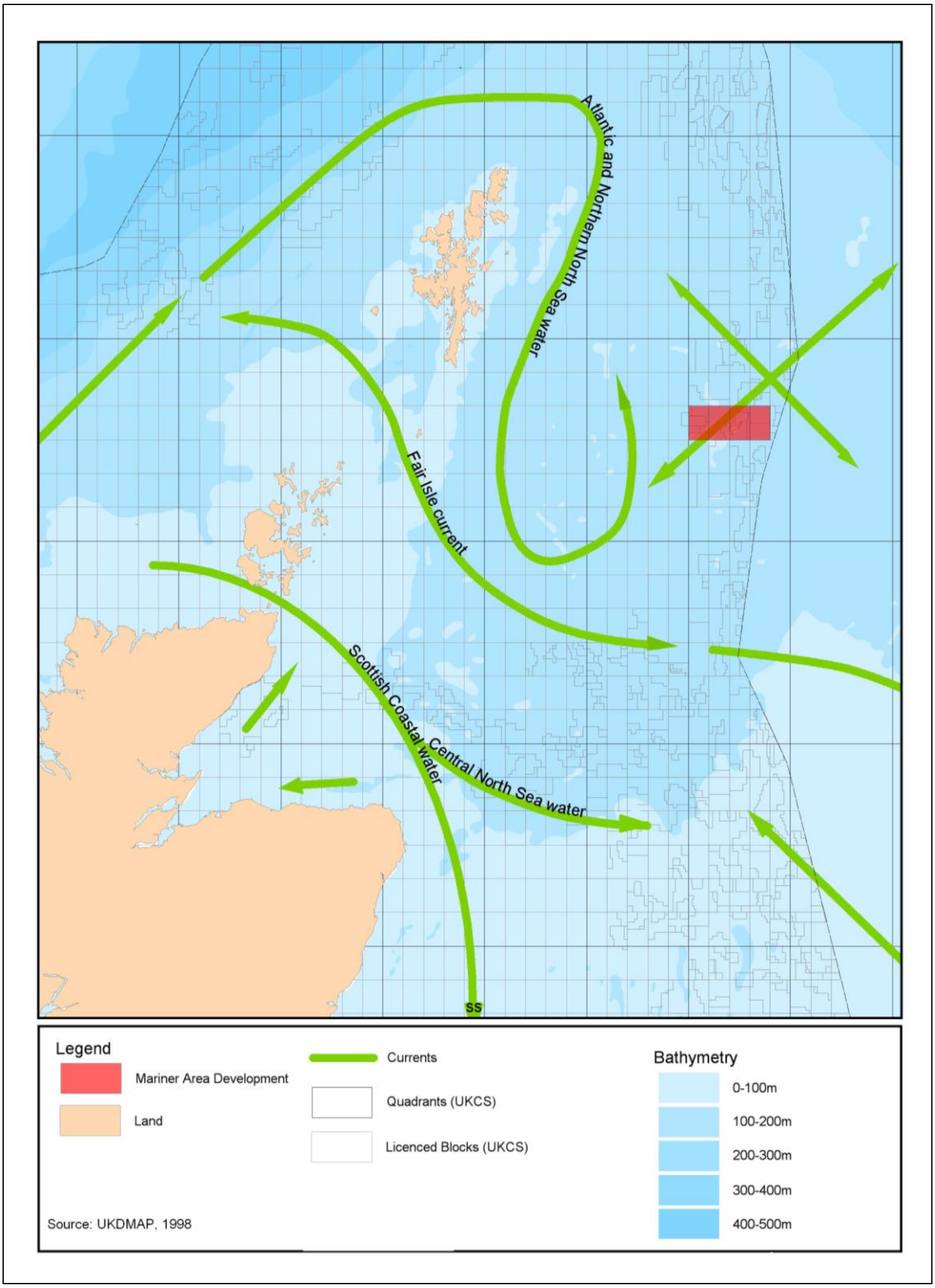
Along the proposed Mariner to Mariner East pipeline route, the seabed irregularly undulates reaching a maximum depth of 108 m with a maximum gradient of 0.9° (FSL; 2008) (**Appendix C; Figure C.1**). Along the gas import pipeline route between the PDQ and the Vesterled tee location, no significant features were observed and the seabed appeared to be relatively flat with gentle regular undulations (Subsea 7, 2011).

4.2.2 Water Masses, Currents and Tidal Streams

The speed and direction of water currents have a direct effect on the transport, dispersion and ultimate fate of any discharges during offshore installation work and operation. In regions where strong directional water currents occur, greater dispersal of these discharges will take place. Mixing in the water column intensifies with increased current speed. Current speeds decrease with proximity to the seabed, often becoming weak and variable. The circulation of water masses in the North Sea is driven by a combination of winds, tidal forcing and topographically-steered inflows. **Figure 4.1** shows the pattern of current driven water movement in the northern North Sea in relation to the proposed development.

The movement of water masses around the Mariner Area Development location is influenced by a circulation of Atlantic water, the Fair Isle Current from the north and variable and wind driven near-surface inflows from the south-east. The current energy at the Mariner Area Development is high (>1.16 Newton m^2) and the wave energy ranges from low (<0.21 Newton m^2) to moderate (>0.21-1.2 Newton m^2) (EUSeaMap, 2011).

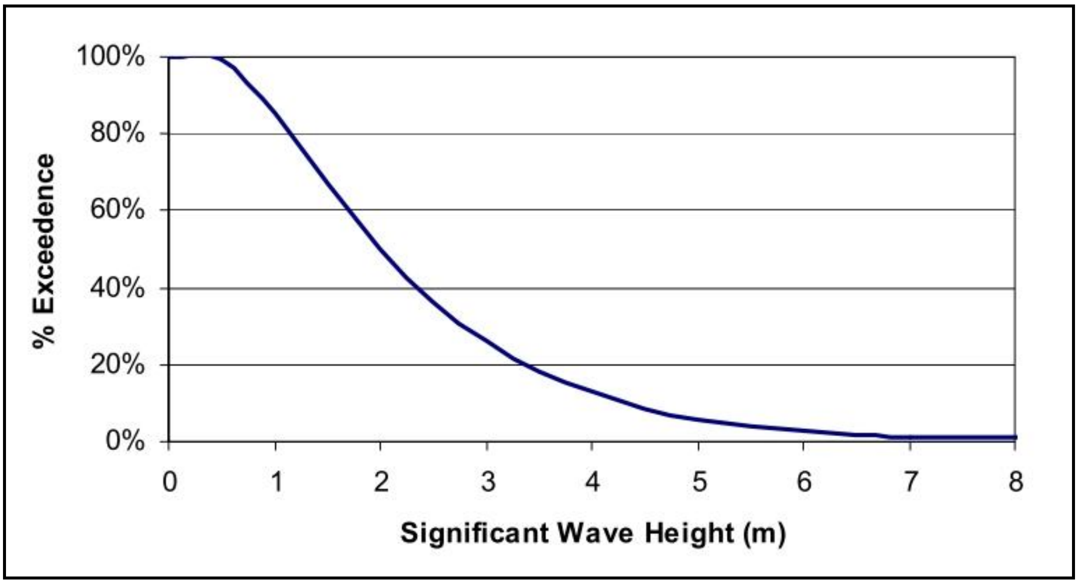
Semi-diurnal tidal currents are relatively weak in the offshore northern North Sea (DTI, 2001). At the proposed development area the maximum tidal current speeds during mean spring tides are low and ranges between 0.25 m/s to 0.38 m/s (UKDMAP, 1998). The mean spring tidal amplitude recorded in 2008, was about 80 cm with maximum value of 88.3 cm during March (StatoilHydro, 2008). The highest astronomical tide at the Mariner Area Development has been reported to be 92 cm above the mean sea level (StatoilHydro, 2010).



Source: UKDMAP, 1998

Fig 4.1: Location of the proposed development in the northern North Sea showing the bathymetry and the general current circulation in the North Sea.

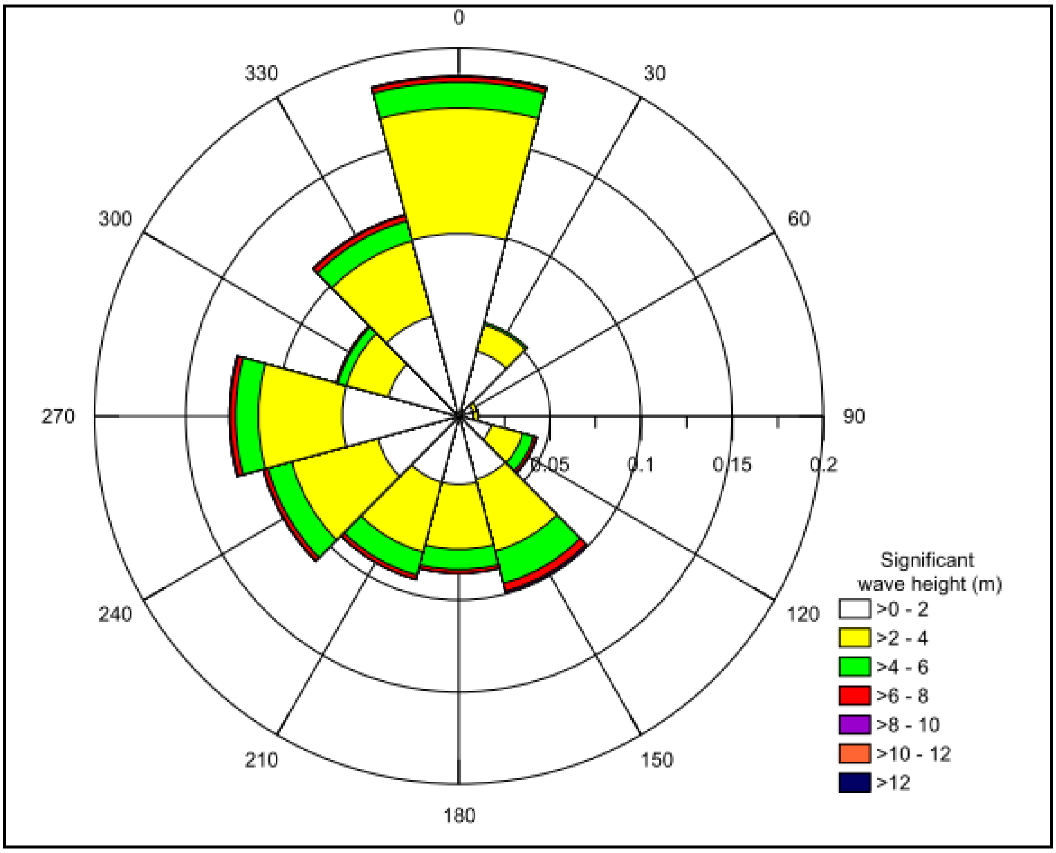
The elevation of the water level with a return period of 50 years, at the proposed Mariner Area Development is approximately 0.75 m (UKDMAP, 1998). Surge and wind-driven currents, caused by changes in atmospheric conditions, can be much stronger and are generally more severe during winter. Storm events may also generate near-bed, wave-induced currents sufficient to cause sediment mobilisation (DTI, 2001). However, such events are unlikely given the deep offshore location of the proposed development. The significant wave height that exceeds 10% of the year in the proposed development area is between 4 to 5 m (**Figure 4.2;** Anatec, 2010).



Source: Anatec (2010)

Figure 4.2: Annual wave height exceedance frequency in the Mariner Area Development.

Figure 4.3 presents the annual wave regime recorded in the proposed development area, and illustrates that the significant wave heights ranging from 0 to 4 m dominate throughout the year, with the distribution of the waves originating predominantly from the north to the south (StatoilHydro, 2008, 2010).



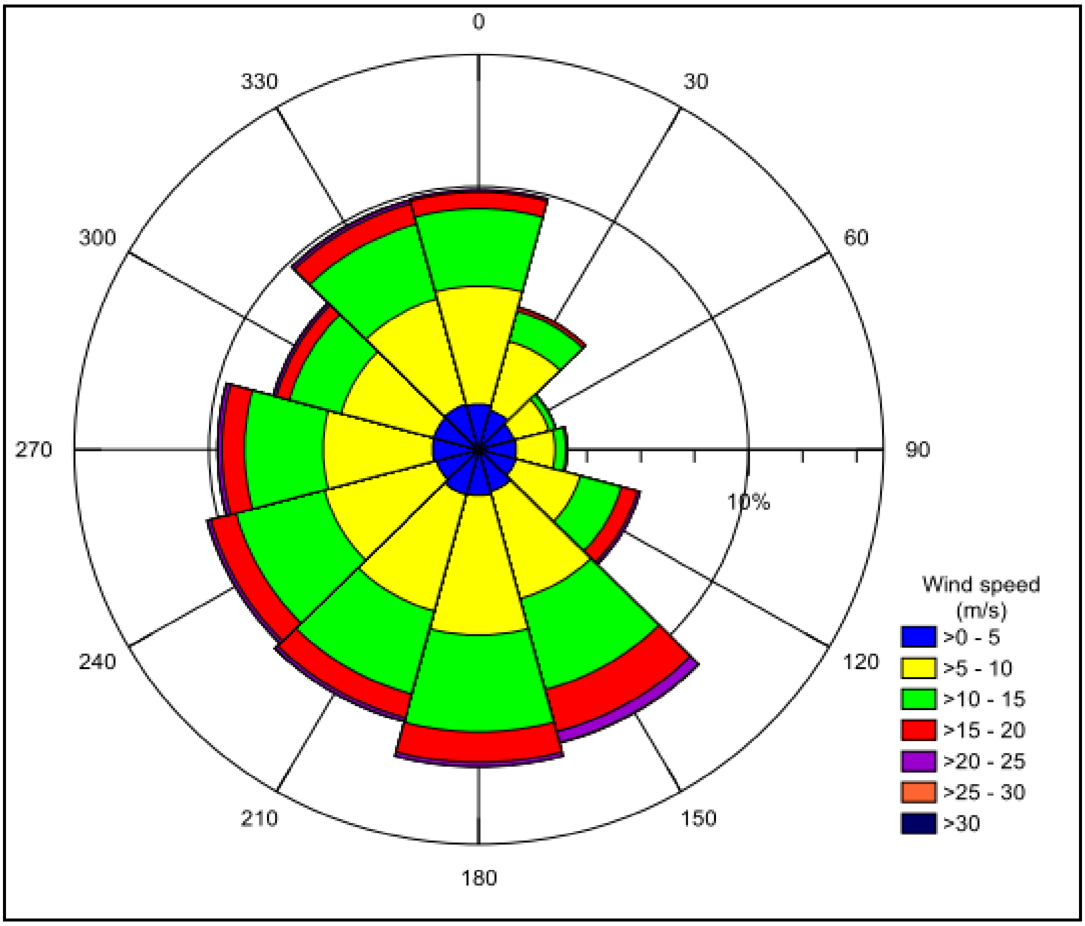
Source: StatoilHydro (2010)

Figure 4.3: Annual wave rose in Mariner Area Development [59.81° N, 01.20° E] for the period 1958 to 2009.

4.2.3 Meteorology

Wind data in the vicinity of the Mariner Area Development [data collected at grid point at 59.81º N, 01.20º E] were recorded for the period of 1958 to 2009 (StatoilHydro, 2010). Winds originating from a south to south-westerly direction were found to predominate during the winter months (October to March; **Appendix C Figures C.2**). Between April and September (summer months), winds were observed to originate from any direction, predominately from a northerly or southerly direction (**Appendix** C, **Figures C.2**). High winds (<15 m/s) were observed to occur during the winter months (StatoilHydro, 2008, 2010).

Figure 4.4 presents the annual wind rose for the Mariner Area Development.



Source: StatoilHydro (2010)

Figure 4.4: Annual wind rose for the Mariner Area Development, for the period of 1956 to 2009

4.2.4 Temperatures and salinity

The temperature of the sea affects both the properties of the seawater and the fates of discharges and spills to the environment. The temperature and salinity conditions in the area define the tendency of the water column to stratify and form water fronts (thermoclines) with different conditions at the surface and the bottom. Temperature is also important in determining the distribution and occurrence of marine organisms (Patin, 1999).

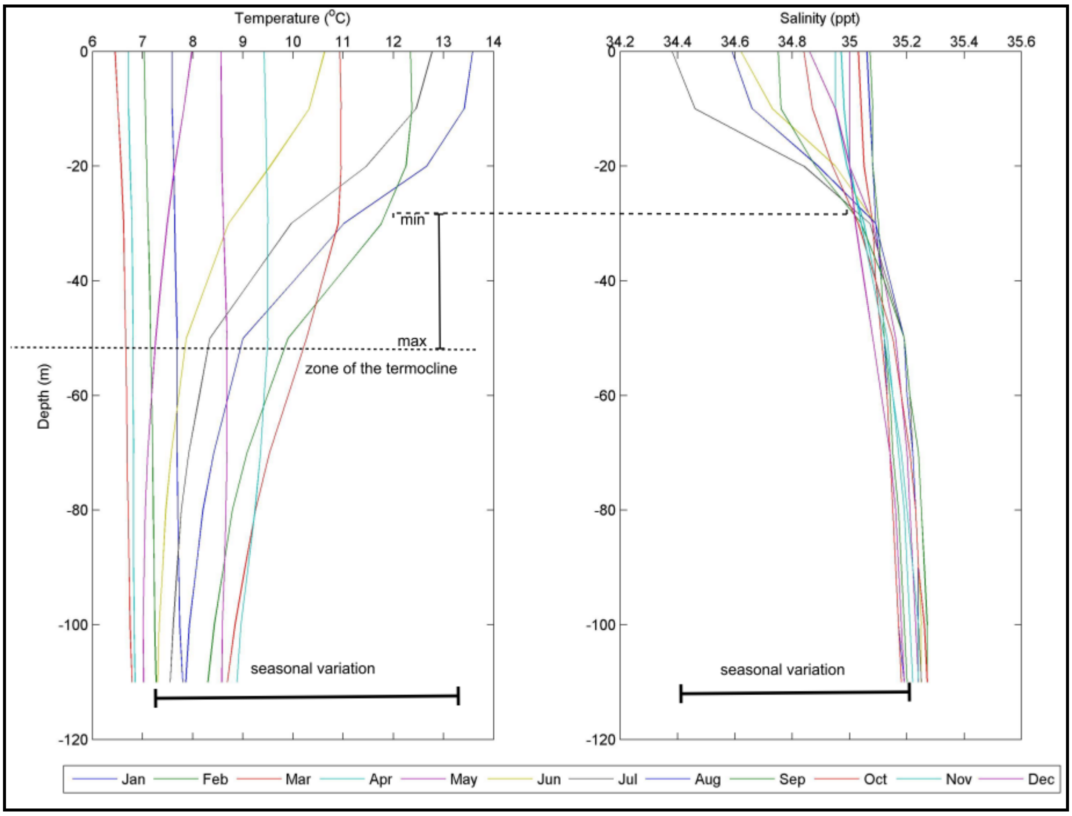
The seasonal variation in the sea temperature and salinity conditions in the proposed development area is provided in **Table 4.1**. Water temperature is relatively uniform through the water column during the winter months. Over the summer months, however, the increase in solar heat can result in a thermocline, which separates a heated and less dense surface layer from the denser layer of cooler water in the rest of the water column. The strength of the thermocline is determined by the intensity of the input of solar heat and turbulence generated by wind and tides. The depth at which the thermocline occurs increases from May to September and is typically between 25 and 50 m during June and September, with a thermocline in August being at maximum values (**Figure 4.5**; StatoilHydro, 2008, 2010).

Table 4.1: Typical values of sea temperature and salinity in the Mariner Area Development.

Season	Mean Temperature (°C)		Mean Salinity (ppt)	
	Sea Surface	Seabed	Sea Surface	Seabed
Winter	7	6.5	35.3	35.2
Summer	14	7	34.75	35.25

Source: UKDMAP (1998)

Fluctuations in salinity are largely caused by the addition or removal of water through natural processes such as rainfall and evaporation. Salinity varies with season and changes in ocean currents.



Source: StatoilHydro (2008 and 2010)

Figure 4.5: Temperature and salinity annual profiles in the Mariner Area Development.

4.2.5 Seabed Sediments

The characteristics of the local sediments and the amount of sediment transport within a development area are important in determining the potential effects of possible future developments (drill cuttings, installation of pipelines, anchor scouring) on the local seabed environment. Particles of various types and sizes, notably the silt / clay fraction, can absorb petroleum hydrocarbons from sea water and through this pathway, hydrocarbons become incorporated into the sediment system. Organic matter within the sediment matrix is also likely to absorb hydrocarbons and heavy metals, providing a means of transport and incorporation into sediments. The bioavailability of contaminants that are adsorbed to sediment or organic matters is poorly understood, but in general terms prolonged contact between hydrocarbons and sediment may result in stronger bond formation and a subsequent reduction in bioavailability (van Brummelen *et al.,* 1998). This phenomenon is referred to as 'ageing', and is especially important for sediments with historic contamination such as prolonged discharge of drill cuttings.

The nature of the local seabed sediments also plays a very important role in determining the flora and fauna present. Seabed sediments provide habitats and a food source for benthic infauna which, in turn, are preyed upon by other species such as demersal fish and shellfish. Whilst gravelly sediments are important to bottom-spawning fish species, muddy sediments are favoured by burrowing shellfish species such as Norway lobster (*Nephrops norvegicus*) (Rees *et al.,* 2007).

The distribution of seabed sediments within the northern North Sea results from a combination of hydrographic conditions, bathymetry and sediment supply (OSPAR, 2000). Broadscale sediment distribution maps indicate that the area of the proposed development is dominated by deep circalittoral sand and muddy sand with patches of deep circalittoral coarse sediment (EUSeaMap, 2011). Most of the sediment in this area of the northern North Sea is fine to coarse sands (Künitzer *et al*., 1992), with an approximate silt fraction of 5% and an organic fraction of 3% (Basford *et al*., 1989).

The grain size distribution across the proposed Mariner Area Development is comprised of fine sand (93.8%-99.4% - following Buchanan classification) with silt and clay contents ranging between 2.2% to 6.2% across the sampled stations (DNV, 2011). A weak relationship was observed between depth and fine particle content (DNV, 2011). Across the Mariner field, the seabed sediments were classified as comprising medium to dense sand to clayey or silty sand (Subsea 7, 2011).

The seabed sediments across the Mariner Area Development can be sub-divided into two broad areas:

- In the northwest, the seabed was found to be generally smooth with sediments being generally featureless and comprising a veneer of fine sand. Occasional exposures with distinct mounds occurred though the area where underlying Cape Shore Formation comprised of thick dense sand and clay was outcropping from the surface veneer fine sand.

- In the far southeast of the area, a series of linear depressions were recorded associated with small exposures of underlying dense sand of the exposed Cape Shore Formation (Gardline, 2009).

Along the Mariner to Mariner East pipeline route, the seabed sediments comprise medium to dense sand with presence of numerous elongated gravel patches, localised clay layers and occasional boulders (FSL, 2008). Shallow soil geology along the proposed Mariner to Mariner East pipeline route was reported with an underlying layer of sandy muds associated with the Cape Shore Formation (or Holocene veneer) (FSL, 2008; Subsea 7, 2011). The overlaying sediments of the Viking Bank Formation were very thin or absent, approximately 0.5 to 1 m in depth with some areas up to 2 m thick. Viking Bank Formations in the northern North Sea have been associated with the formation of shallow gas chimneys and shallow water flow, presence or absence of which will be confirmed in future site specific surveys (FSL, 2008).

The sediment type along the gas import pipeline route was derived by the interpretation of bathymetry data, side scan sonar data, pinger data and aligned for interpretation with BGS published information. Along the entire pipeline route, sediments are medium to dense sand with localised areas of gravelly sand and clayey sand with occasional cobbles and boulders (Subsea 7, 2011).

4.2.6 Seabed features and shallow seabed conditions

A number of seabed features have been identified and mapped in the Mariner Area Development predominantly associated with previous human activities (e.g. trawling and historical drilling) (FSL, 2008; Gardline, 2009; Subsea7, 2011).

A number of wells are present within the Mariner Area Development and were confirmed on the bathymetry data (**Section 4.3.1**; **Appendix C**; **Figure C.2**) as being marked by small mounds up to 30 cm high (Gardline, 2009). Evidence of anchor and trawling associated scars have been mapped across the surveyed area and the debris ROV survey has documented a number of large metal fabrications, fishing nets and debris, cables and tyres. Around the plugged and abandoned well 9/11a-1, a large metal basket and fabrication have been found (Subsea 7, 2011). A historical drill cutting pile has been recorded around the abandoned well 9/11a-8 with fishing deris and gear entangled on the remaining wellhead (Gardline, 2009; Subsea7, 2011).

The two 32" Gas Frigg to St Fergus pipelines cross the south-eastern quarter of the survey area from the northeast to the southwest (Gardline, 2009).

No significant geohazards are expected within the survey area, such as shallow water flow or shallow gas seeps (Gardline, 2009). No specific boulder problems were reported at the tie wells for which information was made available. Therefore the risk of encountering boulders within the shallow section is negligible (Gardline, 2009).

No pockmarks or Annex I habitat protected features associated with MDAC were observed in the Mariner Area Development during the ROV debris clearance survey (Subseas7, 2011) or pipeline route surveys (FSL, 2008; Subsea 7, 2011). The Scanner Pockmark offshore SAC in Block 15/25 is located more than 150 km south-east from the proposed development, whilst the Breamar Pockmark SAC in Block 16/3 is located approximately 100 km south-east from the Mariner Area Development.

4.3 Chemical environment

Chemical analysis of the seabed (concentrations of metals and hydrocarbons) provides an indication of the condition of seabed sediments in the area of the proposed project. Sediment chemistry is an important factor in ecological investigations, with areas of fine sediments acting as sinks which have the potential to release their contaminant load following disturbance.

The principal sources of hydrocarbons in the marine environment are anthropogenic (McDougall, 2000); however, contamination of the marine environment with crude oils is not a recent phenomenon, nor solely attributable to anthropogenic activities (Douglas *et al*., 1981).

Due to the complex and variable composition of oil in marine sediments, quantification of total hydrocarbons, groups of hydrocarbons and individual hydrocarbons is required to allow identification of the source of oil within the sediments, be it anthropogenic, biogenic or geochemical. The results of the chemical analysis of the sediments are summarized in **Table 4.2**

Table 4.2: Sediment contamination status of the Mariner Area Development

Location	**THC (µg/g)**	**PCB (µg/kg)**	**PAH (µg/g)**	**Cu (µg/g)**	**Zn (µg/g)**	**Cd (µg/g)**	**Hg (µg/g)**	**Ba (µg/g)**	**Pb (µg/g)**	**Cr (µg/g)**
Mariner Area Development chemical concentrations (highest value detected)										
Mariner Area Development baseline survey 2011	<1-4	ND	0.016	0.6-4.5	4-17	<0.03	<0.01	3-40	4.3	8.1
LO1 reference station	0.016	ND	0.01	0.1	4	ND	<0.01	4	0.1	0.1
LO4 reference station	0.01	ND	<0.01	<0.01	0	ND	<0.01	2	0.1	0.6
LO5 reference station	0.006	ND	<0.01	0.2	1	ND	<0.01	6	0.1	0.2
MAR reference station	2	ND	0.171	1.4	9	<0.03	0.3	27	3.4	7.8
Reference background concentrations (range or average)										
Estuaries (1)	ND	6.8-19.1	0.2-28							
Coast (1)	ND	2								
Offshore (1)	17-120	<1	0.2-2.7	3.96	20.87	0.43	0.16			
Oil & Gas Installations (1)	10-450	1,917	0.02-74.7	17.45	129.74	0.85	0.36			
UKOOA, 2001 (2)	10.82 (20.32)		0.123 (0.341)	3.57 (5.40)	12.14 (13.00)	ND	ND	332.38 (637.50)	7	17.14
OSPAR, 2005 (3) (BC)				20	90	0.2	0.05		25	60

Key: ND - Not detected due to values below detection limits
Blank - no data

Source: (1) CEFAS (2001a); (2) UKOOA(2001); (3) OSPAR(2005) (BC- background concentration); DNV (2011)

4.3.1 Total Hydrocarbons (THC)

Total hydrocarbons (THC) gives an indication of the total oil in the sediment, but does not indicate the source of contamination (UKOOA, 2001). Hydrocarbon concentrations recorded during the Mariner field baseline survey were considered representative of fine sandy sediments of the northern North Sea, with THC found to be low across the site ranging from <1 µg/g at the sampling stations close to the abandoned wells to 4 µg/g at the stations downstream from the Mariner field (DNV, 2011; **Table 4.2**). These reported THC values are well below the reported background concentrations found in the northern North Sea (CEFAS, 2001a; UKOOA, 2001).

4.3.2 Polycyclic Aromatic Hydrocarbons (PAH)

Polycyclic aromatic hydrocarbons (PAHs) and their alkyl derivatives are ubiquitous in marine environments; however, sources of elevated PAHs in marine sediments are often associated with anthropogenic activities, particularly fossil fuel combustion (Neff, 2005). Another source of PAHs is the use of oil-based muds during drilling operations and the subsequent discharge of these cuttings on the seabed (Breuer *et al*., 2004). This is no longer practised as the discharge of cuttings contaminated with more than 1% oil based fluids was eliminated under OSPAR Decision 2000/3. This requirement came into effect on 16 January 2001 and is implemented under the Offshore Chemical Regulations 2002 (as amended). The occurrence and concentration of PAHs in the environment is of concern since many possess mutagenic, carcinogenic or otherwise toxic properties (McDougall, 2000; Neff, 2005). However, the concentrations at which individual PAHs produce toxic effects vary widely and are dependent on their chemical type and bioavailability (Long *et al.,* 1995).

Total PAHs in the Mariner field ranged from 0.008 to 0.0.016 µg/g. However, these results were redrawn from only two stations located within the Mariner field (Station MA4 and MA5 on **Figure 4.1-** DNV, 2011). The total PAH concentrations recorded in the reference stations ranged from 0.01 µg/g to 0.171 µg/g and were well below the values expected for sediments considered as background (e.g. CEFAS, 2001a; UKOOA, 2001; **Table 4.2**.), and therefore it is unlikely to cause any discernible effect on faunal community structure.

4.3.3 Metal concentrations

Many metals are generally persistent and most are toxic to varying degrees. Many essential metals such as copper, zinc and chromium are readily bio-accumulated, meaning that they are capable of causing lethal and sub-lethal toxic effects in benthic organisms even when found in apparently low amounts (Neff, 2005).

Metals typical of contamination of the sediment with drilling muds or cuttings are barium, zinc, chromium, and lead (Neff, 2005). Barium and zinc have low bioavailability in marine sediments. By far the most abundant metal in most drilling muds is barium, found in the form of barite ($BaSO_4$). Generally, contamination by metals extends no further than 500 m from production platforms, but elevated concentrations of barium can be found from 500 m to 1,000 m (CEFAS, 2001a). Monitoring sediment barium concentrations can provide information on the extent to which drill cuttings have been transported from their point of origin.

There was little variation in metal concentrations across the Mariner field, and these concentrations were generally below the reported background concentrations for this area of the northern North Sea (CEFAS, 2001a; UKOOA, 2001). A slight increase in the concentration of Copper (Cu) was observed at station MA6 (**Table 4.2**), with slightly elevated concentration levels of heavy metals (barium (Ba), chromium (Cr), lead (Pb), zinc (Zn) and Cu) observed in reference station MAR (DNV, 2011). The elevated Ba, Cr, Pb, Zn and Cu levels were still considered to be within background levels for 95% of stations sampled in the region (DNV, 2011). The concentrations of chromium and lead across the Mariner Area Development were observed to be significantly lower, compared to the background concentrations for this region of the northern North Sea (**Table 4.2;** DNV, 2011). Metal levels correlated well with sediment characteristics, where finer particles tend to accumulate higher concentrations of hydrocarbons and heavy meals, indicating that any variation is likely to be natural and related to minor changes in the sediment and not a point source anthropogenic pollution from historical drilling.

4.4 Biological Environment

4.4.1 Plankton

Plankton is comprised of microscopic plants (phytoplankton) and animals (zooplankton) that drift with the oceanic currents. These organisms form the basis of food chains and many species of larger animals such as fish, birds and cetaceans are dependent upon them. The distribution of plankton therefore directly influences the abundance and distribution of other marine species (DECC, 2009).

Plankton may be vulnerable to human activities associated with elevated concentrations of chemicals or hydrocarbons in seawater as a result of planned or accidental releases. Subsea activities interacting directly with the seabed, such as anchoring, trenching/ backfilling and jetting of sediments across the proposed development are expected to generate suspended solids (SS) within the water column and may result in increased sediment deposition on the seabed in close proximity to the work areas (Jusoh, 1999). Elevated SS (and turbidity) reduces light penetration, lowers the rate of photosynthesis by phytoplankton (primary productivity) and thus lowers the rate of oxygen production in the water column (Jusoh, 1999). Other potential interactions can emerge during both the construction phase (discharge of sewage from vessels leading to organic enrichment and increased oxygen demand) and operational phase where the discharge of produced water could have potential toxic effect on plankton.

Although planktonic communities are generally not considered to be highly vulnerable, due to their capacity to recover quickly to the continual exchange of individuals with those in surrounding waters (NSTF, 1993), changes in the distribution and abundance of planktonic communities could, however, result in secondary effects on organisms that depend on the plankton as a food source, including commercial fish species and marine mammals. It is also possible that pollutants that initially accumulate within plankton could bio-accumulate in higher trophic levels (Johns and Reid, 2001).

4.4.2 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 motile, may encompass a variety of feeding patterns (e.g. filter-feeding, predatory or deposit-feeding) and occupy a variety of different ecological 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 typically divided into various categories, principally according to size. The largest are the megafauna and this comprises animals, usually living on the seabed, which are large enough to be seen in bottom photographs and caught by trawl (e.g. brittle stars, sea urchins, sea cucumbers, sea spiders, sponges, corals). Macrofauna are defined as those animals with a lower size limit of around 0.5 µm. Meiofauna comprises the smaller interstitial animals (mainly nematode worms and harpacticoid copepods) with a lower size limit of between 0.045 µm and 0.063 µm (Kennedy and Jacoby, 1999).

Colonisation of sediments by different species is largely dependent on the type of sediment present and its characteristics. Both physical and biological factors are important in determining species abundance and distribution, including seabed depth, water movements, salinity, temperature and available oxygen. The species composition and relative abundance in a particular location provides a reflection of the immediate environment, both current and historical (Clark, 1997), as every benthic species has its own response and degree of adaptability to changes in the physical and chemical environment. Determination of sediment characteristics is, therefore, of particular importance in the interpretation of benthic environmental survey data.

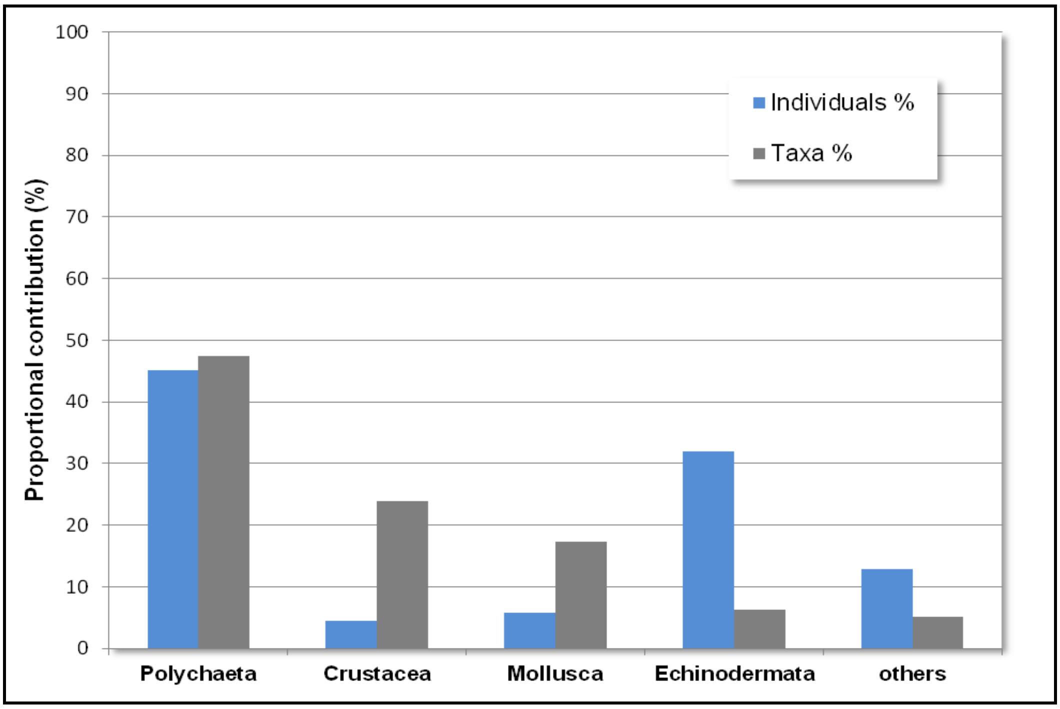
4.4.2.1 Benthic groups

During 1986, the whole of the North Sea was surveyed using standard techniques and equipment (Künitzer *et al*., 1992; Basford *et al*., 1990) and the benthic infaunal assemblages were determined by depth and by sediment type. According to the benthic classification scheme of Künitzer *et al*. (1992), the Mariner Area Development falls within category *IIIb* (fine sediment deeper than 100 m) (Künitzer *et al*., 1992; NSTF, 1993), and would be expected to be characterised by a deep-water infaunal assemblage, which typically has high densities (2,863±1,844 individuals per m^{-2}) and species richness (51±13 species) (Künitzer *et al.,* 1992). Indicator species of this benthic infaunal assemblage include the *Thyasira* spp. bivalve complex and the polychaetes *Minuspio cirrifera, Aricidea catherinae* and *Exogone verugera* (Künitzer *et al.,* 1992). Other indicator species found in the area's finer sediments were opportunistic bivalves from *Thyasira* spp., and on the coarser sediments the polychaetes *Ophelia borealis, Exogone hebes, Spiophanes bombyx* and *Polycirrus* spp. Species with restricted distribution almost exclusively in the northern North Sea are the brittlestar *Ophiura affinis* and the molluscs *Montacuta substriata* and *Antalis entails.* According to Künitzer *et al.,* 1992, the Mariner Area Development is located in an area with higher species diversity and characteristically lower biomass per assemblage in comparison with the southern North Sea shallows.

The infaunal work was complemented by epifaunal studies in the same areas (Basford *et al.,* 1989, 1990). Epifauna species identified in the area include the starfish *Astropecten irregularis* (starfish) and *Asterias rubens* (common starfish), the yellow sea potato *Echinocardium flavescens*, *Brissopsis lyrifera* (sea urchin), the gastropods *Neptunea antique*, *Colus gracilis* and *Scaphander lignarius*, tunicates and sponges (Basford *et al.,* 1989).

Mariner Area Development Baseline Survey

Figure 4.6 illustrates the number of individuals and taxa in the Mariner field distributed among the different taxonomic groups (DNV, 2011). In total, 175 juvenile species were sampled during the baseline survey. However, the survey concluded that the significance of the juvenile component on the adult benthic community was negligible and the population sampled at the time of the survey was representativee for the area.



Source: DNV (2011)

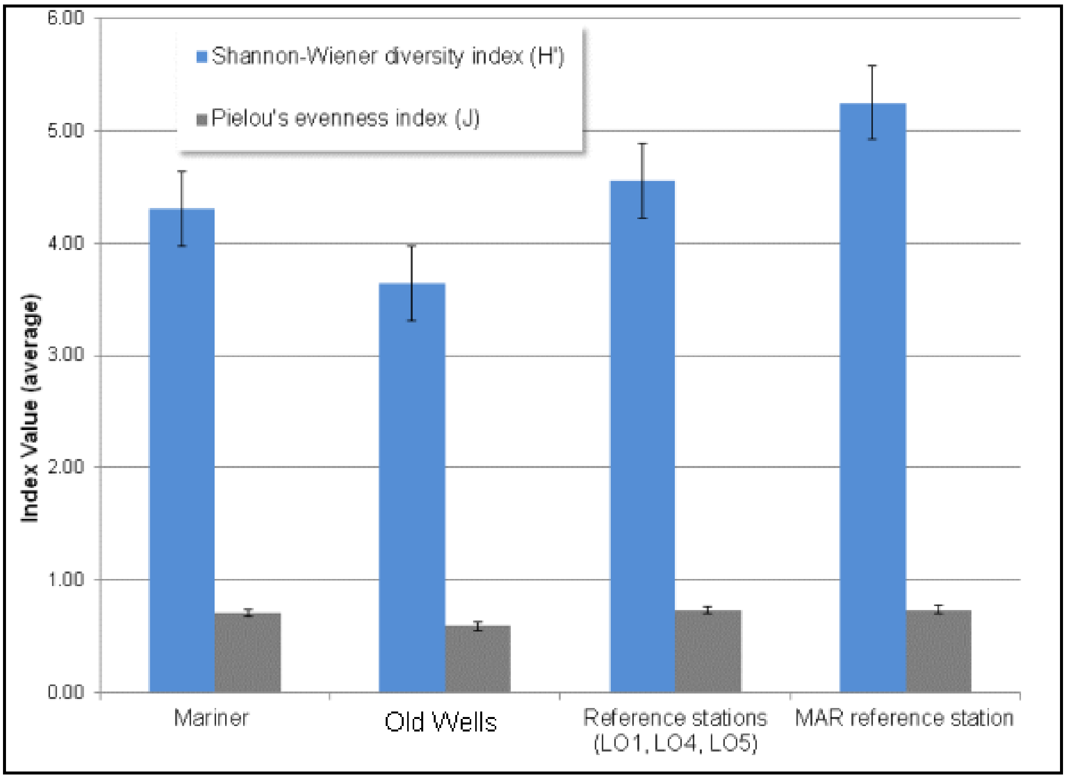
Figure 4.6: Macrofaunal composition in the Mariner Area Development.

The most prevalent benthic group found in the Mariner Area Development was comprised of polychaetes contributing 45% of the individuals and 47% across the taxa (**Figure 4.6**). The most common species found at all stations were the polychaete *Spiophanes bombyx* contributing between 9% and 32% of the total number of individuals across the stations (DNV, 2011). The second most abundant group in terms of proportion of individuals were Echinoderms, contributing 37% of individuals with a clear predominance of the brittle star *Ophiocten affinis* which contributed between 56% and 60% across the total individuals found (DNV, 2011). The polychaete *Paramphinome jeffreysii*, the suspension feeding horseshoe worm *Phoronis* spp., and the sensitive cnidarian *Cerianthus lloydii* are also among the most common species found across the sampled stations (DNV, 2011).

The sampled reference stations were found to be generally consistent with the benthic community found at the Mariner and Mariner East fields, with the exception of reference station MAR. Reference station MAR was located 10 km north-west from the Mariner Area Development, and comprised slightly finer sediments with high contents of silt and clay (**Section 4.3.5**) and different contamination status (**Section 4.4**) and herein the benthic community was found typically to comprise of benthic community with predominance of *Paramphinome jeffreysii* (DNV, 2011). *Paramphinome jeffreysii* is commonly found in sublittoral sands and muddy sands and is restricted to a deeper (>50 m) regions on the central and northern North Sea. This species is known to increase in density and is highly tolerant to hydrocarbon contamination (Olsgard and Gray, 1995), although it is intolerant of heavy metals (Rygg, 1985).

Despite the different community structure found at reference station MAR, there was no dominant community structure found across the Mariner Area Development (**Figure 4.8**; DNV, 2011). At the sampled points across the old wells, there were slightly lower diversity indexes and variation in the abundance of individuals, however at these stations there was still a lack of a dominance structure (**Figure 4.8**; DNV, 2011). This slight difference in the community structure between the Mariner PDQ sampling points and the abandoned wells site cannot be related to abiotic parameters, such as sediment characteristics, depth or levels of hydrocarbon and heavy metal contamination and the difference can only be regarded as natural variations (DNV, 2011).

Overall, there was no apparent influence on the diversity indices, with moderate Shannon-Wiener diversity index (H') and high Pielou's evenness index (J) also indicating a lack of a dominance structure in the faunal community across the Mariner Area Development (DNV, 2011).



Source: DNV (2011)

Figure 4.10: Statistical summary of faunal composition for Mariner and Mariner East Fields.

4.4.2.2 Habitat classification

Biotope types, based on the EUNIS classification system (JNCC, 2010a; EuSeaMap, 2011), in the Mariner Area Development were classified according to the nature and distribution of the sediment found in the area and related to the most prevalent species abundance obtained from the survey data (DNV, 2011). Dominant characteristic fauna were identified and matched to the EUNIS classification system to the most probable biotope rank, using the BioScribe database (BioScribe, 2011) In the EUNIS biotope classification system, initially abiotic habitats are defined at four levels. Biological communities are then linked to these (at two lower levels) to produce a biotope classification. The most probable biotopes identified within the Mariner Area Development are presented in **Table 4.3**.

Table 4.3: Hierarchical habitat classification in Mariner Development Area.

Location	Broad Habitat	Habitat	Biotope complex	Biotope
Mariner Area Development	A5 Sub littoral sediment	A5.4 Sublittoral mixed sediments	A5.44 Circalittoral mixed sediment	A5.445 *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment
				A5.443 *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment
		A5.3 Sublittoral mud	A5.35 Circalittoral sandy mud	A5.353 *Amphiura filiformis* and *Nuculoma tenuis* in circalittoral and offshore sandy mud

Source: DNV (2011); BioScribe (2011)

4.4.3 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, with the following characteristics:

- **Pelagic species** spend most of their lives swimming in the water column, typically making extensive seasonal movements or migrations between sea areas. Pelagic species include herring, mackerel, blue whiting and sprat.
- **Demersal species** live on or near the seabed and include cod, haddock, plaice, sandeel, sole, and whiting.
- **Shellfish species** comprise demersal (bottom-dwelling) molluscs, such as mussels and scallops, and crustaceans, such as shrimps, crabs and Nephrops (Norway lobster).

Generally, there is little interaction between fish species and offshore oil and gas developments. Some fish and shellfish species are, however, vulnerable to offshore oil and gas activities and associated discharges to sea. The most vulnerable periods for fish species are the egg and juvenile stages. Fish that lay their eggs on the sediment (e.g. herring and sandeels) or live in intimate contact with sediments (e.g. sandeels and most shellfish) are susceptible to smothering by discharged solids. Other ecologically sensitive fish species include cod, most flatfish (including plaice and sole) and whiting because in the North Sea these stocks are considered to be outside ‘safe biological limits’ (EEA, 2011).

The industry-commissioned *Fisheries Sensitivity Maps in British Waters* and Strategic Environmental Assessment (SEA) 2 Technical Report on North Sea Fish and Fisheries (Coull *et al.,* 1998; CEFAS, 2001b), as well as the CEFAS led *Spawning and nursery areas of fish of commercial and conservation importance* (Ellis *et al.,* 2010); provide data illustrating fish spawning and nursery locations (**Figure 4.10**). The results of this work have been incorporated in **Table 4.4** to gain more understanding about when species spawn and develop within the Mariner Area Development.

Table 4.4 Spawning periods and nursery grounds in the Mariner Area Development.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Nursery
Cod[1]	S	S*	S*	S									
Haddock[2]		S*	S*	S*	S								N
Whiting[2]		S	S	S	S	S							N
Saithe[1]	S*	S*	S	S									
Norway pout[2]			S	S	S								N
Nephrops[2]	S	S	S	S*	S*	S*	S	S	S	S	S	S	N
Blue whiting[1,2]													N
Mackerel (North Sea) [1,2]													N
European hake[1]													N
Ling[1]													N
Anglerfish[1]													N
Sandeel	S	S									S	S	N
Herring[1]													N

Key	S	Spawning period
	N	Nursery period
	*	Peak of the Spawning

Source: [1]Ellis et al.(2010); [2]Coull et al. (1998);

Spawning and nursery grounds are dynamic features of fish life history and are rarely fixed in one location from year to year. The information provided in **Figure 4.10** 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.,* 2010). Spawning times represent the generally accepted maximum duration of spawning (Coull *et al.,* 1998).

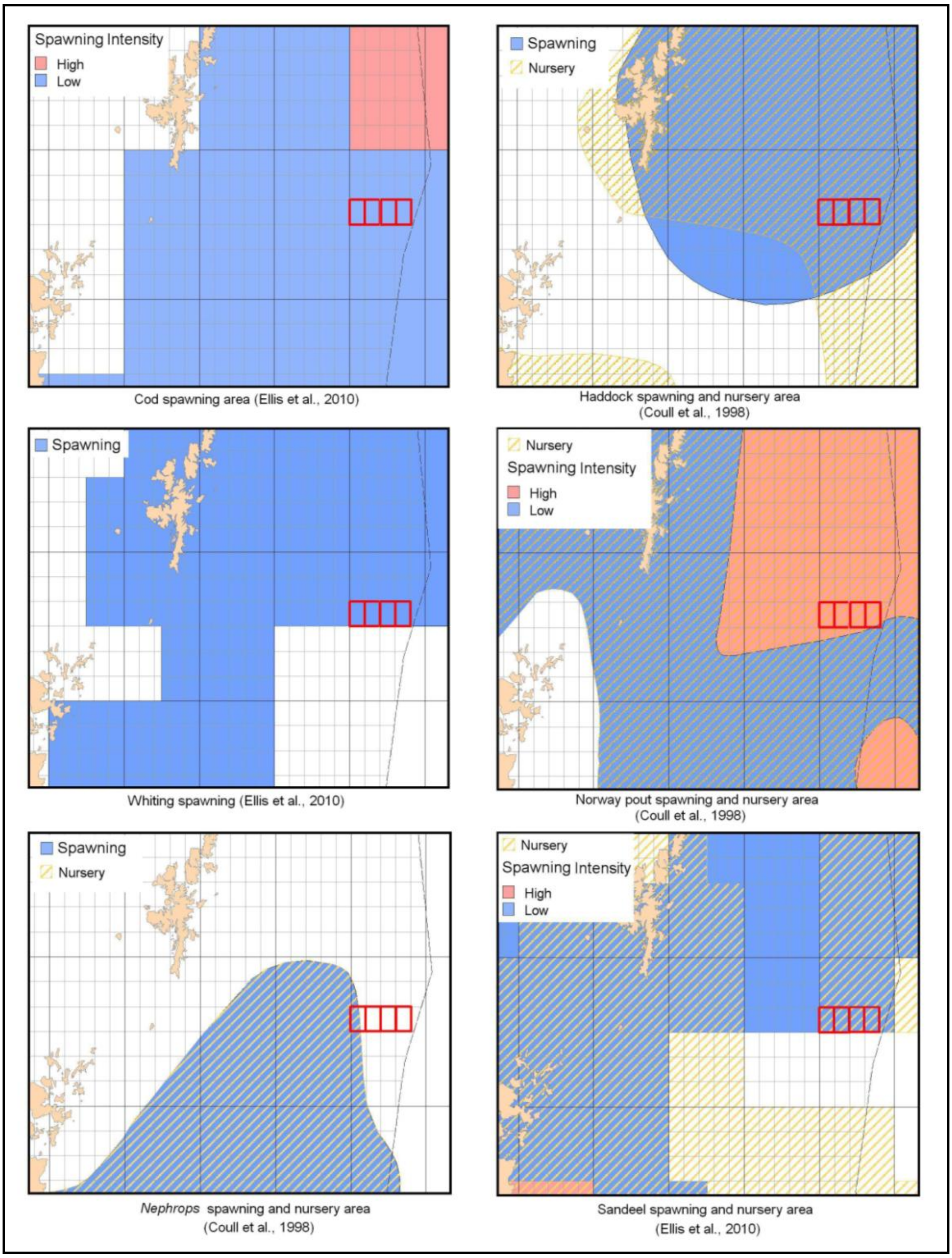
After spawning, fish hatch quickly from their eggs and many species remain in discrete areas (nursery grounds) in the water column or settle on the seabed as larvae, consuming microscopic organisms and gradually developing the body shape and behaviour patterns of adults. The prevailing water temperature and availability of food can alter the position of these nursery grounds from year to year and they can drift far from initial spawning location. As a result of these factors it is difficult to define precisely the limits of nursery areas. The maps in **Figure 4.10** 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).

4.4.3.1 Spawning and Nursery Areas

The Mariner Area Development coincides with spawning grounds of the demersal species cod (January to April, peaking February and March); haddock (February to May, peaking February to April); whiting (February to June), saithe (January to May, peaking January and February), Norway pout (March to May), *Nephrops* (throughout the year, peaking April to June) and sandeels (November to February) (Coull *et al.,* 1998; Ellis *et al.,* 2010). The proposed development area also occurs within the nursery areas of haddock, whiting, Norway pout, *Nephrops,* blue whiting and mackerel (Coull *et a*l., 1998) as well as European hake, ling, anglerfish and herring (Ellis *et al.,* 2010).

4.4.3.2 Potential interactions (risks) with the proposed Mariner Area Development activities

The majority of the fish species that are considered to spawn and recruit within the Mariner Area Development have demersal life style as adults, however they spawn in the pelagic environment and therefore they are sensitive to discharge of chemicals in the water column which might bear potential toxic effects. Although mackerel and herring are highly mobile schooling species, and therefore less sensitive to physical disturbance, they spawn in the water column which makes them sensitive to chemicals discharge. *Nephrops*, sandeel and anglerfish spent their entire life-cycle in the seabed and since the adults live in seabed and have a relatively sedentary lifestyle, they are vulnerable to smothering and disruption of seabed sediments which might occur during the construction and installation phase of the proposed development.



Cod spawning area (Ellis et al., 2010)

Haddock spawning and nursery area (Coull et al., 1998)

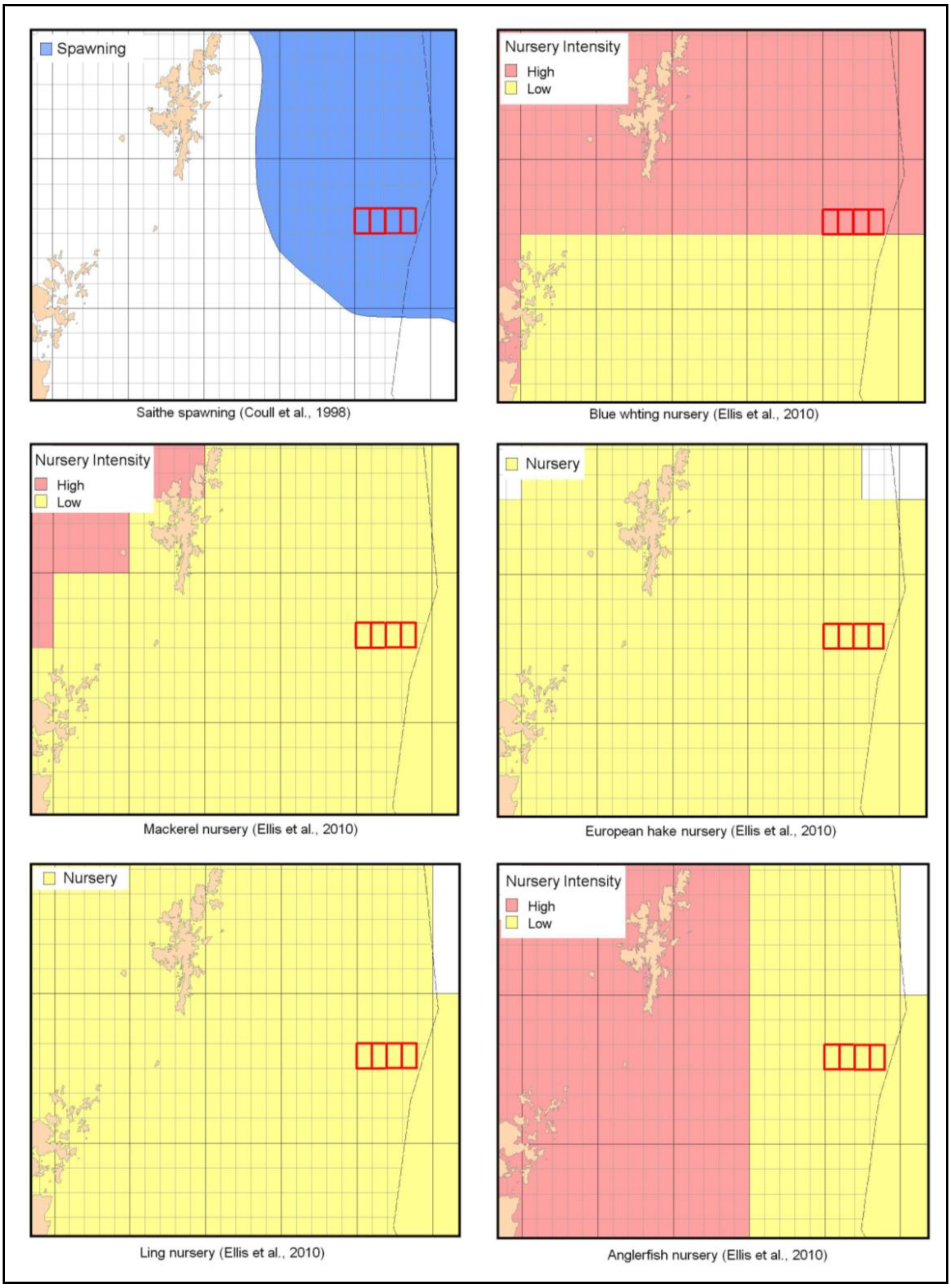
Whiting spawning (Ellis et al., 2010)

Norway pout spawning and nursery area (Coull et al., 1998)

Nephrops spawning and nursery area (Coull et al., 1998)

Sandeel spawning and nursery area (Ellis et al., 2010)

Figure 4.10: Fish Spawning and Nursery grounds in the Mariner Area Development.



Saithe spawning (Coull et al., 1998)

Blue whting nursery (Ellis et al., 2010)

Mackerel nursery (Ellis et al., 2010)

European hake nursery (Ellis et al., 2010)

Ling nursery (Ellis et al., 2010)

Anglerfish nursery (Ellis et al., 2010)

Figure 4.10 (*continued*): Fish Spawning and Nursery grounds in the Mariner Area Development.

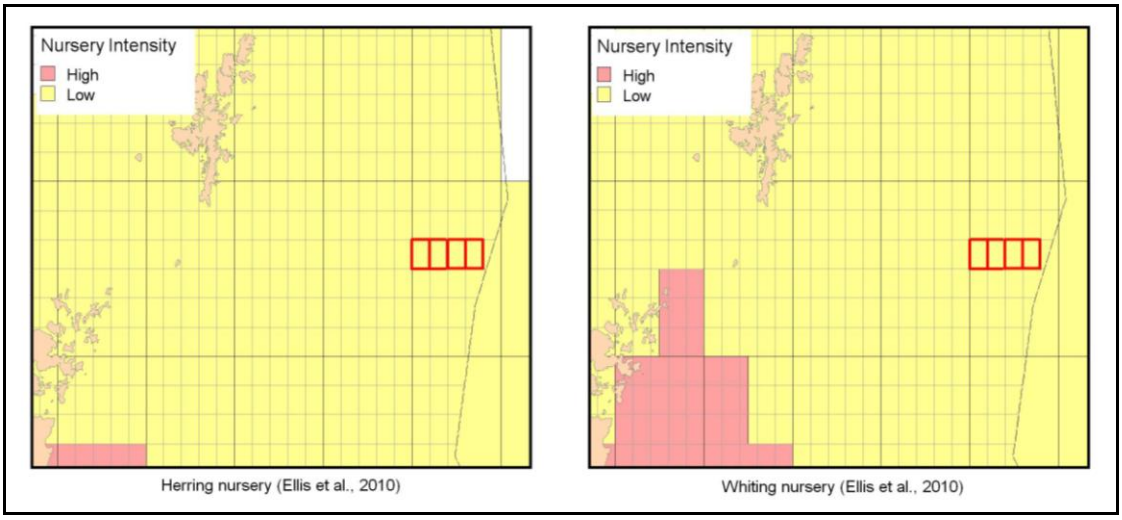


Figure 4.10 (*continued*): Fish Spawning and Nursery grounds in the Mariner Area Development.

4.4.4 Sharks, Rays and Skates (*Chondrichthyes* - Elasmobranches and Holocephali)

Chondrichthyans include sharks, rays and chimaeras, which have typically slow growing 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 dead man's fingers (soft coral) (Ellis *et al.,* 2004).

Work is underway for developing National Plans of Action for conservation and management of sharks in UK waters (Fowler *et al.,* 2004). UK BAP (Biodiversity Action Plan) 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, 2007).

The distribution of the chondrichthyans in the UKCS is not extensively documented. However from available literature (Ellis *et al.*, 2004) it can be concluded that the Mariner Area Development is located within an area where both the number of chondrichthyan species recorded and the relative abundance is low compared to other areas in the North Sea (Ellis *et al.,* 2004). The species which may be encountered in the 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 exception of spurdog and cuckoo ray juveniles which can be found further offshore (Ellis *et al.,* 2004). Available data suggest that in ICES rectangle 48F1, which coincides with the Mariner Area Development, there are no known nursery grounds for spurdog or other chondrichthyan species (Ellis *et al.*, 2010).

4.4.5 Seabirds

Seabird vulnerability to offshore surface pollution varies throughout the year with peaks in late summer after breeding when the birds disperse across the wider North Sea area, and during the winter months with the arrival of over-wintering birds. To assess the relative risk for different species, the Joint Nature Conservation Committee (JNCC) Seabirds at Sea Team (SAST) has developed an index to assess the vulnerability of bird species to the threat of oil pollution. This offshore vulnerability index (OVI) is derived by taking account of the following four factors (Williams *et al.,* 1994):

- the amount of time spent on the water;
- total biogeographic population;
- reliance on the marine environment; and
- potential rate of recovery.

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. The breeding season extends from May to June with birds arriving at the coastal colonies on Shetland from March onwards and feeding in the inshore waters. In July the seabird densities in the region are highest when birds leave the coastal colonies to feed in the offshore waters. Of the species commonly present offshore in the North Sea, gannet, skuas and auk species (Guillemot, Razorbill and Puffin) are considered to be most vulnerable to oil pollution, since after the post breeding period they undergo a complete post-breed moult during which they are flightless. Towards the end of July, seabirds begin to disperse to their wintering grounds, either heading south to the central North Sea or north towards the shelf break west of Shetland (DTI, 2001).

The seasonal vulnerability of the seabirds in the area of the proposed Mariner Area Development (UKCS Block 9/11, and its surroundings) is derived from the JNCC block-specific vulnerability data (JNCC, 1999; **Table 4.5**).

The most sensitive time of the year for seabirds in the area of the proposed Mariner Area Development and surrounding blocks are during October and November when seabird vulnerability is “very high”, and during January and July when the seabird vulnerability is “high” (**Table 4.5**). These increased vulnerabilities correspond to the periods when seabirds are leaving their coastal colonies in Shetland to feed in the offshore waters of the northern North Sea. Vulnerability ranges from “low” to “moderate” for the remainder of the year, with June being the period with the lowest vulnerability (JNCC, 1999) which corresponds to the breeding season when seabirds remain close to the coastal colonies and feed in the inshore waters.

Table 4.5: Seasonal seabird vulnerability to oil pollution in Mariner Area Development.

Block	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
8/10	2	4	2	3	3	4	2	4	3	1	1	2
8/15	2	4	3	3	3	4	2	4	3	1	1	2
8/20	2	2	3	3	3	4	2	3	3	1	1	2
9/6	2	4	3	3	4	4	2	4	3	1	1	3
9/7	2	4	3	3	4	4	2	4	3	1	1	3
9/8	2	4	3	3	4	4	2	3	3	1	1	3
9/9	2	4		3	4	4	2	3	3	1	1	
9/10	2	3		3	4	4	2	3	3	1	1	
9/11	2	4	3	3	4	4	2	4	3	1	4	3
9/12	2	4	3	3	4	4	2	4	3	1	4	3
9/13	2	4	3	3	4	4	2	3	3	1	3	3
9/14	2			3	4	4	2	3	3	1	3	
9/15	2			3	4	4	2	3	3	1	2	
9/16	2	4	3	3	4	4	2	4	3	1	3	2
9/17	2	4	3	3	4	4	2	4	3	1	3	2
9/18	2	4	3	3	4	4	2	3	3	1	3	2
9/19	2		4	3	4	4	2	3	3	1	3	
9/20	2		4	3	4	4	2	3	3	1	2	

KEY:

1	Very High vulnerability
2	High vulnerability
3	Moderate vulnerability
4	Low vulnerability
☐	Mariner Area Development

Source: JNCC (1999)

The northern North Sea offshore environment is characterised by peak densities of Fulmars (*Fulmarus glacialis*), Gannet (*Morus bassanus*), Auks, Herring Gulls during the winter months, Kittiwakes (*Rissa tridactyla*) throughout the year, and passages of Terns, Gannets, Razorbills (*Alca torda*), Puffins (*Fratercula arctica*) and Guillemots (*Cepphus grille*) distributed in the summer periods (DTI, 2001). Species likely to be encountered at the Mariner Area Development and approximate densities are given in **Table 4.6** (Stone *et al.,* 1995). In the Mariner Area Development, Fulmar, Gannet, Herring Gull, Great Black-backed Gulls, Guillemot, and Little Auk are present in different densities almost throughout the year. Other species which are recorded in lower numbers include the Storm petrel, Lesser black backed gull, Great Skua, Puffin, Arctic Skua, Common Tern and Arctic Tern (*Sterna hirundo and Sterna paradisaea*).

The closest bird breeding colonies to the Mariner Area Development are located on Shetland. Common seabird breeding colonies around Shetland include Fulmar, Gannet, Cormorant (*Phalacrocorax carbo*), Great Skua (*Catharacta skua*), Arctic Skua (*Stercorarius parasiticus*), Great Black-backed gull (*Larus marinus*), Kittiwake, Common and Artic tern, Razorbill, Puffin and Black Guillemot. Further details about the coastal SPA are given in **Section 4.7**.

The implications of seabird vulnerability to accidental operational events (e.g. oil spills) in the area around the Shetland and the proposed Mariner Area Development are discussed further in detail in **Section 8.**

Table 4.6 Annual distribution of commonly found seabirds around in the Mariner Area Development.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fulmar (*Fulmarus glacialis*)	░	░	█	█	░	░	░	█	█	█	█	░
Gannet (*Morus bassanus*)	░	░	░	░	░	░	░	░	▒	▒	░	░
Storm Petrel (*Hydrobates pelagicus*)	/	/	/	/	/	/	░	░	/	/	/	/
Lesser black backed gull (*Larus fuscus*)	/	/	/	░	░	░	/	/	/	/	/	/
Herring gull (*Larus argentatus*)	▓	▓	░	░	/	/	░	░	░	░	▓	▓
Great black backed gulls (*Larus marinus*)	▒	▒	░	░	/	/	/	/	/	/	▒	▒
Kittiwake (*Rissa tridactyla*)	█	█	█	░	░	▓	▓	▒	▒	▒	█	█
Guillemot (*Uria aalge*)	░	░	▒	▒	░	░	▓	█	░	░	░	░
Razorbill (*Alca torda*)	/	░	░	░	░	░	░	/	/	/	/	/
Puffin (*Fratercula arcica*)	░	/	/	░	░	░	░	/	/	░	░	░
Little auk (*Alle alle*)	▓	▓	░	░	░	░	░	░	░	░	▓	▓
Great skua (*Catharacta skua*)	/	/	/	/	/	░	░	░	/	/	/	/
Arctic and common terns **(***Sterna paradisaea/ S hirundo*)	/	/	/	░	░	░	▒	▒	▒	/	/	/

Key:	**Density Birds/km^2**			
/	░	▒	▓	█
No Birds	0.01-0.99	1.00-1.99	2.00-4.99	>5.00

Source: Stone et al. (1995)

4.4.6 Marine Mammals

Marine mammals include whales, dolphins and porpoises (cetaceans), and seals (pinnipeds). They may be vulnerable to the effects of oil and gas 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 (**Section 4.5.1**) and fish (**Section 4.5.3**), can be of prime importance in determining the abundance 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 currently not possible to predict the extent of any such changes (SMRU, 2001).

4.4.6.1 Cetaceans

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 prey capture. Cetaceans are widely distributed in UK waters and are recorded throughout the year (Reid *et al*., 2003). Twenty-eight cetacean species have been recorded in UK waters. Of these, the species that occur regularly in northern North Sea include the minke whale, fin whale, sperm whale, harbour porpoise, bottlenose dolphin, common dolphin, Atlantic white-sided dolphin and white beaked dolphin (JNCC, 2010b).

Cetacean distribution may be influenced by variable natural factors such as water masses, fronts, eddies, upwellings, currents, water temperature, salinity and length of day. A major factor likely to influence cetacean distribution is the availability of prey, mainly fish, plankton and cephalopods (Stone, 1997). Spatially and temporally, harbour porpoise, white-beaked dolphins and minke whales are the most regularly sighted cetacean species in the North Sea (Weir *et al.,* 2007).

In the Mariner Area Development (Quadrant 9) and the surrounding Quadrants, harbour porpoise, minke whale, and white- beaked dolphin have been recorded as present in the area, albeit with low to medium densities (UKDMAP, 1998; Reid *et al.,* 2003; **Table 4.7**). Harbour porpoise have been recorded as present almost throughout the year with very high densities in February in the area surrounding the Quadrant 9 (**Table 4.7**). Only harbour porpoise, minke whale, white-sided dolphins and killer whales have been recorded occurring within the Quadrant 9. White-sided dolphins have been also been sighted in low densities during the summer months in the area around the Mariner Area Development (UKDMAP, 1998; Reid *et al.,* 2003). Therefore, the most sensitive periods for marine mammals in the area are from February to March, from May to September and in November when the densities of marine mammals range from very high to moderate.

Table 4.7: Seasonal cetacean sightings within Mariner Area Development.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Harbour Porpoise	L	VH		L	L	L	H	M	H			L
Minke Whale						L	L					
White-beaked Dolphin		M	M			L	L	L			M	
White-sided Dolphin							L					
Killer Whale					M	L					L	

Key		No animals / No data
	L	Low densities (0.01 to 0.09 animals/km)
	M	Moderate densities (0.10 to 0.19 animals/km)
	H	High densities (0.20 to 0.49 animals/km)
	VH	Very high densities (>= 0.50 animals/km)
	🟧	Sightings within the proposed development Quadrant 9
	🟦	Sightings in the surrounding Quadrants

Source: UKDMAP (1998); Reid et al (2003); Gardline (2009)

A seismic site survey and marine mammal observation covering Blocks 3/27, 3/28, 9/2 and 9/3, was conducted by Statoil in June 2009 (Gardline, 2009). A line transect of 850 km in total was recording one minke whale and approximately 25 killer whales, which corresponded to 0.001 minke whales per km and 0.02 killer whales per km of a survey effort.

4.4.6.2 Pinnipeds (seals)

Both grey (*Halichoerus grypus*) and common seals (*Phoca vitulina*) have breeding colonies in Orkney and Shetland, and can travel considerable distances (up to 60 km or more, but this is relatively rare) from their haul-out sites on feeding trips (Harwood and Wilson, 2001; Hammond *et al.,* 2002). Grey and common seals are resident in UK waters and occur regularly over large parts of the North Sea (Stone, 1997; SMRU, 2001). Both species breed in the UK, with common seals pupping in June / July and grey seals pupping between September and December. British populations of grey and common seals represent approximately 40% and 5%, respectively, of the world populations of these species (SMRU, 2001).

Both species are found predominantly along the UK coastline but there are few data available on the distribution and abundance of seals when offshore. Tracking of seals suggests they make feeding trips lasting 2 to 3 days, normally travelling less than 40 km from their haul-out sites, and with the animal ultimately returning to the same haul-out site from which it departed (SMRU, 2001). Grey seals may spend more time further offshore than common seals. The proposed Mariner Area Development is over 135 km southeast from the nearest UK coastline (Shetland) so it is unlikely that grey and common seals would be regularly found in the vicinity of the proposed development.

Grey and common seals are listed in Annex II of the Habitats Directive (**Section 4.6.3**).

4.5 Offshore Conservation Areas

The European Commission (EC) Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Flora and Fauna (the Habitats Directive), and the EC Directive 2009/147/EC on the Conservation of Wild Birds (the Birds Directive), are the main instruments of the European Union (EU) for safeguarding biodiversity.

These Directives provide for the protection of animal and plant species of European importance and the habitats which support them, particularly through the establishment of a network of protected sites. The Habitats Directive includes a requirement to establish a European network of important high-quality conservation sites that will make a significant contribution to conserving the habitat and species identified in Annexes I and II of the Directive respectively. Habitat types and species listed in Annexes I and II are those considered to be in most need of conservation at a European level (Johnston *et al.,* 2002; JNCC, 2012).

The UK government, with guidance from JNCC and the Department of Environment, Food and Rural Affairs (DEFRA), has statutory jurisdiction under the EC Habitats Directive to propose offshore areas or species (based on the habitat types and species identified in Annexes I and II) to be designated as Special Areas of Conservation (SACs).

SACs are sites that have been adopted by the European Commission and formally designated by the government of each country in whose territory the site lies. Sites of Community Importance (SCIs) are sites that have been adopted by the European Commission but not yet formally designated by the government of each country.

- Draft SACs (dSACs) are areas that have been formally advised to UK government as suitable for selection as SACs, but have not been formally approved by government as sites for public consultation

- Possible SACs (pSACs) are sites that have been formally advised to UK Government, but not yet submitted to the European Commission.

- Candidate SACs (cSACs) are sites that have been submitted to the European Commission, but not yet formally adopted. Candidate SACs will be considered in the same way as if they had already been classified or designated and any activity likely to have a significant effect on a site must be appropriately assessed.

In relation to UK offshore waters, relative to the EC Habitats Directive four habitats from Annex I and four species from Annex II are under consideration for the identification of SACs in UK offshore waters (**Table 4.8**; Johnston *et al*., 2002, JNCC, 2012). Currently in UK offshore waters there are twelve offshore SACs (JNCC, 2012).

Table 4.8: Annex I habitats and Annex II species occurring in UK offshore waters.

Annex I habitats considered for SAC selection in UK offshore waters	Species listed in Annex II know to occur in UK offshore waters
• **Sandbanks** which are slightly covered by seawater all the time • **Reefs** (bedrock, biogenic and stony) – Bedrock reefs – made from continuous outcroppings of bedrock which may be of various topographical shape (e.g. pinnacles, offshore banks); – Stony reefs – these consist of aggregations of boulders and cobbles which may have some finer sediments in interstitial spaces (e.g. cobble and boulder reefs, iceberg ploughmarks); and – Biogenic reefs – formed by cold water corals (e.g. *Lophelia pertusa*) and the polychaete worm *Sabellaria spinulosa*. • **Submarine structure made by leaking gases** • **Submerged or partially submerged sea caves**	**Grey seal** (*Halichoerus grypus*) **Common (Harbour) seal** (*Phoca vitulina*) **Bottlenose dolphin** (*Tursiops truncates*) **Harbour porpoise** (*Phocoena phocoena*)

Source: Johnston et al (2002); JNCC (2012)

The Mariner Area Development is situated in approximately 100 km north-west from the Braemar SCI and approximately 150 km from the Scanner SCI (**Table 4.9**). The location of the Mariner Area Development in relation to the SACs areas in the northern North Sea is presented in **Figure 4.11**.

Table 4.9: List of Annex I conservation areas in UK waters.

Name / EU Code	Description	Site Location	Area (km^2)	Status	Approximate Distance to Mariner (km)
Braemar Pockmarks UK003057	Submarine structures made by leaking gas	58.99°N, 1.48°E	5.180	SCI/cSAC	70
Scanner Pockmark UK0030354	Seabed depression approx. 900 m by 450 m and 22 m deep	58.28°N, 0.97°E	3.350	SCI/cSAC	145
Pobie Bank	Stony and bedrock reef 70 km long and 21 km wide with seabed depth ranging from 70 m to 100 m	60°31'23″N, 0°17'34″W	1,011	pSAC	130

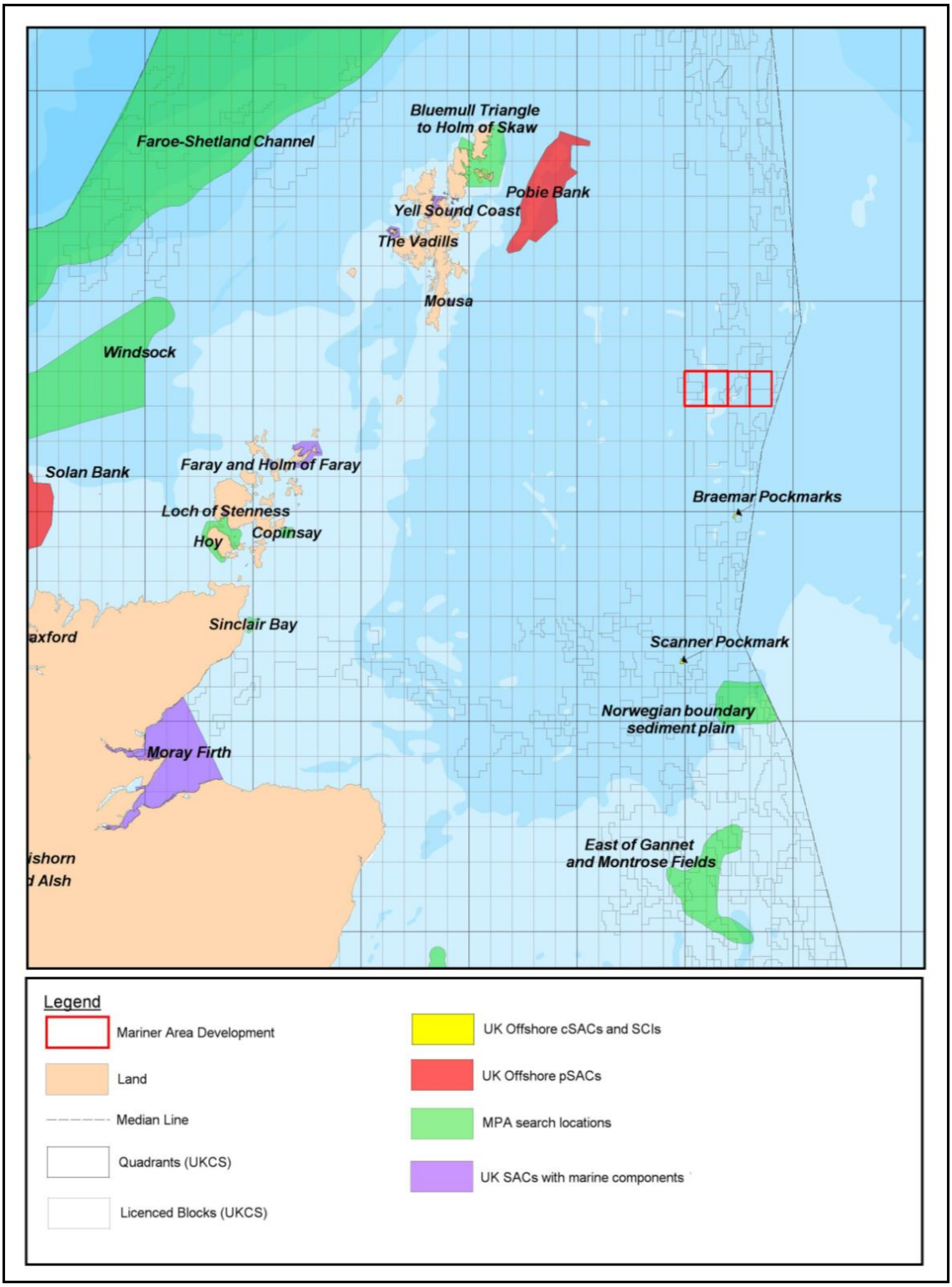


Figure 4.11: Location of Mariner Area Development in relation to offshore conservation areas.

The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (Amended 2007) apply the Habitats Directive and Birds Directive in relation to oil and gas plans or projects wholly or partly on the United Kingdom's Continental Shelf (UKCS) and adjacent waters outside territorial waters. These regulations extend to the seaward limits of territorial waters (12 nm offshore) (DECC, 2011b).

The Offshore Marine Conservation (Natural Habitats, & c.) Regulations 2007 (Amended 2009) transpose the Habitats Directive and Birds Directive in the marine offshore area, from 12 nm to 200 nm from the UK coast. Under these regulations it is an offence to deliberately disturb any listed species while it is within its SAC/SCI; capture, injure or kill any wild bird or any wild animal of a European Protected Species (EPS); and/or significantly disturb any EPS, whether it is within a protected site or not, in such a way as to significantly affect:

1. the ability of any significant group of animals to survive, breed, rear or nurture their young; or
2. the local distribution or abundance of that species.

EPS include all species of cetaceans (whales, dolphins and porpoises), all species of marine turtles, the sturgeon (*Acipenser sturio*) and the otter (*Lutra lutra*) (JNCC, 2012).

4.5.1 Marine Protected Areas (MPAs)

In Scottish waters, under the Marine (Scotland) Act 2010, Scottish Natural Heritage (SNH), JNCC and Marine Scotland (MS) have started work on identification of potential Nature Conservation Marine Protected Areas (MPAs) as part of the Scottish MPA Project. The Act includes new powers for Scottish Ministers to designate Marine Protected Areas (MPAs) in the seas around Scotland as part of a range of measures to manage and protect Scotland's seas for current and future generations.

Both the Marine (Scotland) Act 2010 and the UK Marine and Coastal Access Act 2009 contain new powers to designate MPAs. The legislation requires that a network of MPAs in UK seas is created to protect biodiversity and geodiversity. The network will contribute to an agreement with international partners to create an ecologically coherent network of well-managed MPAs in the northeast Atlantic (Scottish Government, 2012).

Marine Conservation MPAs are intended to complement existing site-based measures by protecting nationally important marine habitats, species and features of geological/ geomorphological interest; in the seas around Scotland that are not currently afforded protection through existing measures. The Scottish MPA network will therefore consist of

European Marine Sites (e.g. SACs and SPAs), the marine component of SSSIs and the new Nature Conservation MPAs (Scottish Government, 2012).

The development of the Marine Protected Area (MPA) network is being undertaken in collaboration with marine stakeholders and during workshops held throughout 2011, thirty MPA search locations were identified (Scottish Government, 2012). MPA search locations situated in proximity to the Mariner Area Development are listed in **Table 4.10**.

Table 4.10: MPA search locations in relation to the Mariner Area Development.

MPA search locations	Size (km^2)	Description	Designation	Distance to the Mariner Area Development (km)
East of Gannet field and Montrose field	1,224	Sandy sediment plain to the east of Scotland offshore waters. The location comprises primarily sandy sediments but also encompasses an area of offshore deep sea mud and ocean quahog aggregations.	MPA	160
Norwegian boundary sediment plain	51	Sandy and coarse sediment plain to the east of Scotland offshore waters The search location boundary incorporates northern and southern component, which contains offshore sub tidal sands and gravels and records of ocean quahog.	MPA	230

Source: NetGain (2011); Scottish Government (2012)

4.5.2 Annex I habitats

Of the Annex I habitats listed in the **Table 4.8**, only “Reefs’ and “Submarine structure made by leaking gases” Annex I habitats can potentially be found in the vicinity of the Mariner Area Development.

4.5.2.1 Submarine structures made by leaking gases

‘Submarine structures made by leaking gases’ in Annex I are defined as "spectacular sub-marine complex structures, consisting of rocks, pavements and pillars up to 4 m high. These formations are due to the aggregation of sandstone by carbonate cement resulting from microbial oxidation of gas emissions, mainly methane. The methane most likely originates from the microbial decomposition of fossil plant materials. The formations are interspersed with gas vents that intermittently release gas, and shelter a highly diversified ecosystem with brightly coloured species" (EC, 2003).

4.5.2.2 Pockmarks

Pockmarks are shallow seabed depressions generally formed in soft, fine-grained seabed sediments by the escape of fluids into the water column (Judd, 2001). In the North Sea, pockmarks range from less than 0.5 m to approximately 20 m in depth, and from 1 m to more than 1,000 m in length (Judd, 2001). Most pockmarks are relict features but a few continue to leak natural gas and may contain carbonate structures (Methane Derived Authigenic Carbonate (MDAC)) which provide a habitat for encrusting and other surface-living seabed animals (DTI, 2001).

Pockmarks alone are not considered to conform to any of the Annex I habitats, but the potentially important 'submarine structures' listed in Annex I are often associated with gas seeps and pockmarks. While MDAC concretions provide evidence of historical gas seeps, in the absence of bubbles or sulphate reducing bacterial mats they are not indicative of active gas seeps (Judd, 2001). Most North Sea pockmarks are shallow and currently inactive. Continuous or recent activity, with or without MDAC, is thought to be confined to unusually large pockmarks (Dando, 2001).

The proposed Mariner Area Development is located outside the Witch Ground Formation and any known gas seep areas. The Scanner Pockmark (cSAC) in Block 15/25 and Braemar Pockmarks (cSAC) in Block 16/3 are located approximately 150 km and 100 km, respectively from the proposed development (**Figure 4.11**).

4.5.2.3 Reefs

There are three main types of Annex I reef:

1. bedrock reef
2. stony reef
3. biogenic reef

Bedrock and stony reefs are both types of rocky reef. These occur where the bedrock or stable boulders and cobbles (generally >64 mm in diameter) arise from the surrounding seabed creating a habitat that is colonised by many different marine animals and plants. Rocky reefs can be very variable in terms of both their structure and the communities that they support. They provide a home to many species such as corals, sponges and sea squirts as well as giving shelter to fish and crustaceans such as lobsters and crabs.

Annex I reef habitats are defined as "submarine, or exposed at low tide, rocky substrates and biogenic concretions, which arise from the seafloor in the sublittoral zone, but may extend in to the littoral zone where there is an uninterrupted zonation of plant and animal communities". These reefs generally support a zonation of benthic communities of algae and animal species including concretions, encrustations and corallogenic concretions (EC, 2003;). Aggregations of species that form a hard substratum (biogenic concretions) which enable an epibiotic community to develop are also considered in this habitat category (JNCC, 2012).

Reef and reef building organisms may be found in proximity to the Mariner Area Development. Cold-water corals such as *Lophelia pertusa*, the horse mussel *Modiolus modiolus* and the ross worm *Sabellaria spinulosa*, create a biogenic reef structures and have been reported in the northern North Sea on manmade structures such as the Beryl and Brent platforms in this area (Bell & Smith, 1999). However, currently there is no evidence that these species has established large colonies of potential conservation interest in the North Sea, including the SEA2 area (DTI, 2001). The recent surveys conducted in the Mariner Area Development (FSL, 2008; Subsea 7, 2011; DNV, 2011) did not confirm the presence of cold water coral or other reef building organisms that could potentially indicate presence of Annex I reef habitats.

No bedrock, stony or biogenic reef species or habitats of conservation significance were observed during the Mariner Area Development surveys (FSL, 2008; Subsea 7, 2011; DNV, 2011) and therefore no Annex I reef habitats occur within the Mariner Area Development.

4.5.3 Annex II species

Annex II of the Habitats Directive lists species that are defined as “species of community interest whose conservation requires the designation of Special Areas of Conservation”. Four Annex II species are known to occur in UK waters for which selection of offshore SACs will be considered: grey seal, common seal, bottlenose dolphin and harbour porpoise (**Table 4.6**). As with all marine mammals these four species can be impacted by a number of activities associated with the activities of the offshore oil and gas industry (**Section 4.5.5**; DECC, 2009; SMRU, 2001).

All four species are typically wide-ranging, so it is difficult to identify specific areas which may be deemed essential to their life and reproduction, and which may, therefore, be considered for proposal as SACs (JNCC, 2002). Nonetheless, coastal SACs have already been designated in the UK to protect grey and common seal breeding colonies and their moulting and haul-out sites. Two coastal SACs have been designated for bottlenose dolphins within UK territorial waters. The UK currently has no proposed SACs for harbour porpoises.

4.5.3.1 Grey seal

Approximately half of the world’s population of grey seals occur in the northeast Atlantic, with approximately 40% of this total occurring in the UK. Major colonies are present on Shetland and the east coast of Scotland (DECC, 2009). The closest known colonies are in Faray and Holm of Faray islands SACs in northern part of Orkney located more than 220 km west from the Mariner Area Development. The islands support the second-largest breeding colony in the UK, contributing around 9% of annual UK pup production.

The majority of the grey seal population remains 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 at sea are likely to be lower during these periods (DECC, 2009).

For the remainder of the year, grey seals spend most of the time at sea and travel long distances between haul out sites and range widely in search of prey (DECC, 2009). Information on the distribution of British grey seals at sea, although limited, shows that they do occur offshore in SEA2 UKCS Blocks; the population as a whole, however, does not appear to spend significant time in these offshore areas (SMRU, 2001).

4.5.3.2 Common (Harbour) seal

Common seals haul out on tidally-exposed areas of rock, sandbanks or mud. They are widespread throughout coastal waters and their abundance at sea is constrained by the need to periodically return to shore. Pupping occurs on land between June and July; and the moult occurs between August and September (DECC, 2009). Data on the distribution of common seals at sea is even sparser than that for grey seals. Studies suggest, however, that they have a more inshore distribution than grey seals, and tend to forage within 75 km of haul-out sites (JNCC, 2002).

The following breeding colonies of common seals are located near the Mariner Area Development:

- Shetland (Mousa, Yell Sound Coast SACs), - approximately 135 km north-west of the development;
- Orkney (Sunday SAC) – approximately 210 km south-west of the development; and
- and around Moray Firth (Dornoch Firth and Morrich More SACs) – approximately 350 km south-west of the development.

The normal foraging distance common seals is 75 km offshore; however the Mariner Area Development is located 130 km from the nearest coast and any haul out sites. Therefore it is highly unlikely that common seals will be present in the development area.

4.5.3.3 Bottlenose dolphin (*Tursiops truncates*)

There are two main areas within UK territorial waters (Cardigan Bay and the Moray Firth) where there are semi-resident groups of bottlenose dolphin. Both sites have been designated as SACs for bottlenose dolphins. There are also smaller populations of dolphins off south Dorset, around Cornwall and in the Sound of Barra in the Outer Hebrides. Dolphins from all of these areas may occasionally move some distance from their apparent core range. Other dolphin groups, presumed to comprise of transients, are recorded further offshore in deeper water to the west of Scotland (Sea Watch Foundation, 2008).

In the North Sea, bottlenose dolphins are most frequently sighted within 10 km of land and they are rarely sighted outside coastal waters. For example, in the Moray Firth the population of dolphins is estimated to consist of approximately 129 individuals (95% confidence interval 110 to 174) (Wilson *et al.*, 1997). Although these dolphins are considered to be resident in the inner Moray Firth, numbers decrease during winter. Because sightings elsewhere around the coast do not increase accordingly, it is possible that animals from this population move offshore at this time of year (SMRU, 2001). Therefore it is possible that bottlenose dolphins may be present around the Mariner Area Development, although numbers are likely to be low and occurrence infrequent.

4.5.3.4 Harbour porpoise (*Phocoena phocoena*)

The harbour porpoise is widespread throughout the cold and temperate seas of north-west Europe, including the North Sea, the Skagerrak, Kattegat, Irish Sea, the seas west of Ireland and Scotland, northwards to Orkney and Shetland and off the coasts of Norway (JNCC, 2010c). Harbour porpoises are highly mobile and well-distributed around the UK (Reid *et al.,* 2003). In the North Sea, sightings from shipboard and aerial surveys indicate that harbour porpoises are widely and almost continuously distributed, with important concentrations in the central North Sea, along the Danish and northern German coasts (Hammond *et al.,* 2002; SCANS II, 2008).

The seasonal movements and migratory patterns of harbour porpoises in the North East Atlantic and North Sea are not well understood. Porpoises may reside within an area for an extended period of time, but onshore/offshore migrations and movements parallel to the shore are thought to occur (Bjørge & Tolley, 2002).

Harbour porpoises are generally described as a coastal species, however, they have been observed frequently in deep waters and offshore areas (Northridge *et al.,* 1995; Rogan & Berrow, 1996; Hammond *et al.,* 2002; MacLeod *et al*., 2003; SCANS II, 2008). The abundance of harbour porpoises in the area of the proposed Mariner Area Development coincides with area “T” of the SCANS II survey in the northern North Sea which was estimated at approximately 23,766 animals (SCANS II, 2008).

Based on currently available data for the Mariner Area Development, harbour porpoises have been observed throughout the year, with “very high” numbers recorded in February and “high” numbers in July (**Table 4.11**; UKDMAP, 1998). In Quadrant 9, which coincides with the Mariner Area Development, harbour porpoises have been sighted only in June and July with low abundance. Although harbour porpoises may be present in the area throughout the year, there appears to be a higher likelihood of their occurrence between June and September. The installation phase of the proposed Mariner Area development and the associated activities are planned to take a place throughout the year and would therefore coincide with “low” to “very high” abundances of the harbour porpoise in the area (**Table 4.11**).

Table 4.11: Recorded sightings of harbour porpoise in proximity of Mariner Area Development .

Quadrant	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2						L	L	L	L			
3		VH										
30 (Norwegian waters)							L	M				
25 (Norwegian waters)							L					
9						L	L					
16							M					
15	L	M					H	M				
8	L			L	L							L
15 (Norwegian waters)					L		M		M			
16 (Norwegian waters)					L		M		M			

Key	L	Low (0.01 to 0.09 animals/km)
	M	Medium (0.10 to 0.19 animals/km)
	H	High (0.20 to 0.49 animals/km)
	VH	Very High (>= 0.50 animals/km)
		Absent
		Quadrant of the proposed development

Source: UKDMAP (1998)

4.6 Coastal Conservation Areas

The eastern mainland coastline of the UK is highly varied with a variety of hard and soft substrates and sediments and numerous islands and skerries. Hard coastline consists of sheltered inlets, exposed headlands, caves, sea stacks and many kilometres of high sea cliffs. The soft coastline consists of voes, brackish tidal ponds, dune systems, sandy and shingle beaches and small areas of mudflat and sandflats (Barne *et al.,* 1997a & b; DTI, 2001). This multitude of habitats supports a variety of maritime vegetations and animal communities. Many of these coastal features are of geomorphological importance and have been designated as Sites of Special Scientific Interest (SSSI) (SNH, 2012b).

The European coastline is comprised of an equally diverse range of substrates and habitat types. Norway has a long, rugged coastline broken by fjords and thousands of islands which stretches over 2,500 km (SOE, 2010). The coastal scenery of southwest Norway is dominated by numerous fjords and valleys, with many islands and skerries, raised beaches, sand dune systems and adjoining wetlands and coastal meadows (DTI, 2001).

4.6.1 European site designations under international convention and EC directives

There are a large number of sites along the coastlines of the UK and Norway, that are designated as conservation areas under international legislation. Sites designated under international conventions to which these countries are contracted parties include:

Natura 2000 sites

Natura 2000 is the collective name given to Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) designated under the European Habitats and Birds directives, respectively (SNH, 2012b).

SACs are selected for threatened habitats and species listed in the Habitats Directive (92/43/EEC) on conservation of natural habitats and wild fauna and flora, including species listed as European Protected Species (EPS).

SPAs are selected under the Birds Directive (2009/147/EC) of the European Parliament and the Council on the conservation of wild birds, which protects all wild birds and their eggs, nests and habitats within the EC. The Directive gives member states the power and responsibility to classify sites as SPAs to protect rare, threatened or vulnerable birds, including migrants, listed in Annex I of the Directive.

Ramsar sites

Ramsar sites are areas of internationally important wetland designated under the Convention of Wetlands of International Importance adopted in Ramsar, Iran, in 1971 and signed by the UK in 1976. Compared to many countries, the UK has a relatively large number of Ramsar sites, but they tend to be smaller in size than many countries. The emphasis is on selecting sites of importance to waterbirds within the UK, and consequently many Ramsar sites are also SPAs classified under the Birds Directive (Wetlands International, 2010).

Important Bird Areas (IBA)

The Important Bird Areas (IBA) Programme is a worldwide initiative aimed at identifying and protecting a network of critical sites for the conservation of the world's birds (SNH, 2012b). IBAs are key sites for conservation, small enough to be conserved in their entirety and often already part of a protected area network. They do one (or more) of three things:

1. hold significant numbers of one or more globally threatened species;
2. are one of a set of sites that combined hold a suite of restricted-range or biome-restricted species; and
3. have exceptionally large numbers of migratory or congregatory species.

Biogenetic Reserves

Biogenetic reserves are a non-statutory designation made by the Council of Europe under resolutions 76(17) on the European Network of Biogenetic Reserves, and 79(9) concerning rules for the European Network of Biogenetic Reserves. The concept of biogenetic reserves arose from the Bern Convention on the Conservation of European Wildlife and Natural Habitats (ratified by the UK Government in 1983). Biogenetic reserves were first established to accommodate biological research; their purpose has since been overtaken by that of the National Nature Reserve network (SNH, 2012b).

Biosphere Reserves

Biosphere reserves are a non-statutory designation made by the United Nations Education, Science and Culture Organisation (UNESCO) under its 'Man and the Biosphere' ecological programme launched in 1970 (UNESCO, 2010; SNH, 2012b).

World Heritage Sites

A World Heritage Site is the highest and most prestigious accolade that can be given in recognition of an areas globally outstanding natural and/or cultural heritage. It is a non-statutory designation made by the United Nations Education, Science and Culture Organisation (UNESCO) under the Convention Concerning the Protection of the World Cultural and Natural Heritage, adopted in 1972 by the General Conference of UNESCO and ratified by the UK Government in 1984 (UNESCO, 2010).

4.6.2 Priority Species of Conservation Concern

The following section briefly describes sites which are important to sensitive and priority bird and mammal species of conservation interest.

4.6.2.1 Coastal Bird Populations

Shetland are particularly important for their cliff and island nesting birds, overwintering wildfowl, waders and divers. In the summer, the cliffs and adjacent coastal areas support large colonies seabirds, including Arctic Tern, Guillemot, Great Skua, Puffin, Shag (*Phalacrocorax aristotelis*), Storm Petrel (*Hydrobates pelagicus*) and Gannet populations of international importance and Leach's Petrel, Kittiwake, Razorbill, Fulmar and gull populations of national importance. Shetland contains key sites for divers and waders: 5% and 5.3% respectively of the UK Whimbrel (*Numenius phaeopus*) and Red-throated Diver (*Gavia stellata*) populations breed here. Also 1% of the UK population of Ringed Plovers breed at the Papa Stour SPA, representing the highest density in the UK and one of the highest in Europe (DTI, 2004; SNH, 2012b).

The Fair Isle supports up to 180,000 seabirds including 7% of the UK fulmar population and 4% of the UK Kittiwake population and also has an endemic species, the Fair Isle Wren (*Troglodytes troglodytes fridariensis*). Foula is also an extremely important island, supporting 250,000 seabirds, including 17% of the world's population and 29% of the UK's population of Great Skuas and 5% of the world's and 11% of the UK's Puffin population. (DTI, 2004; SNH, 2012b).

The east coast of Scotland has a combination of cliffs, rocky coastline, sandy beaches and estuaries. It is important for breeding seabirds, waders and divers and wintering ducks and geese, with several notable sites of international importance along the potentially affected coastline (SNH, 2012b). The Buchan Ness to Collieston Coast, designated as an SPA, SSSI and SAC contains a 15 km stretch of seacliffs that support colonies of almost 100,000 seabirds. They include around 6.2% of the UK Kittiwake population as well as nationally important Guillemot, Herring Gull, Shag and Fulmar populations (DTI, 2004; SNH, 2012b).

The Ythan Estuary, Sands of Forvie and Meikle Loch, designated as an SPA, SSSI and a Ramsar site provide an important breeding area for tern species, with nationally important breeding populations of Sandwich, Little and Common Terns representing 4.3%, 1.7% and 2.2% of the UK breeding populations, respectively. The estuary provides a wintering habitat for over 30 species, with up to 7.7% of the Eastern Greenland, Iceland and UK Pink-footed geese (*Anser brachyrhynchus*). Other important species wintering at Meikle Loch include Redshank (*Tringa totanus*), Lapwing (*Vanellus vanellus*) and around 6% of the UK Eider population (SNH, 2012b).

4.6.2.2 Coastal Marine Mammals

Marine mammals that are resident along the potentially affected coastlines are grey seals (*Halichoerus grypus*), common (harbour) seals (*Phoca vitulina vitulina*) and Eurasian otters (*Lutra lutra*). Other species occasionally occurring are the ringed seal (*Phoca hispida*), harp seal (*Phoca groenlandica*) and the hooded seal (*Cystophora crystata*) all of which are Arctic species and may travel south in search of food (SCOS, 2009).

Seals

The Scottish coast provides breeding habitat for internationally important numbers of grey seals, around 45% of the world's grey seals breed in the UK, 90% of which breed in Scotland. The main breeding areas of grey seals in Scotland are the Outer Hebrides, Orkney, Shetland and the north and east coasts of the mainland. The abundance of UK grey seals, estimated via pup counts, has steadily increased since the 1960s and is now levelling off. Female grey seals often return to the same colony to breed each year. Shetland and the Scottish mainland account for around 82% of the total UK grey seal population (SCOS, 2009).

Around 30% of the total population of European common seals breed in the UK, 85% of which occur in Scotland. The main areas of population in Scotland are the Hebrides, Shetland and Orkney, the Firth of Tay and the Moray Firth. Shetland accounts for around 15% of the Scottish common seal population. The Scottish common seal population has decreased by 50% since 2002 (SCOS, 2009).

Otter populations

The Eurasian otter are largely solitary, semi-aquatic mammals that depend on lochs, rivers and the sea for their habitat. Otters occur throughout the UK along the eastern UK coastline, but approximately 90% of the population (around 8,000 animals) occurs in Scotland (SNH, 2012a). Surveys of Scottish otter abundance were carried out by the Vincent Wildlife Trust between 1977 and 1994, and by the SNH from 2003 onwards (Strachan, 2007). These surveys have shown that otters have increased their population abundance and range over the survey period and are now ubiquitous throughout Scotland.

The Scottish otter population is unusual in that around 50% of the population dwells on the coast and feeds mainly in the sea (SNH, 2012a). Coastal otters are commonly active in the day, feeding on benthic fish, crustaceans and molluscs, and tend to favour shallow inshore rocky areas with dense seaweed cover.

4.7 Summary of the Environmental Sensitivities

The proposed Mariner Area Development is located in UKCS Blocks 9/11 and12 in the UK water of the northern North Sea. The key environmental settings and sensitivities arising from the review of the existing background environment are summarized in **Table 4.12**.

Table 4.12: Summary of environmental sensitivities in Mariner Area Development.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Physical environment											
Bathymetry: Seabed topography is flat with a gentle downward slope to the west. Water depths range between 97 and112 m.											
Water masses, currents and meteorology: Typical current and wave patterns for the northern North Sea.											
Salinity and Temperature: Water column prone to stratify in the summer between June and September at depths of termocline up to 50 m.											
Sediments type and features: Sediments are sand to muddy sand with occasional patches of coarser sediment and boulders.											
Chemical environment											
Seabed chemistry: There are no elevated levels of THC, PAH and heavy metals.											
Biological environment											
Plankton: Typical plankton community and seasonality for the northern North Sea.											
Benthic Fauna: Studies in the vicinity of the Mariner Area Development indicate that the benthos in the area is typical of benthic species for this part of the northern North Sea. No species or habitats of conservation importance were recorded during these surveys.											
Finfish and Shellfish Populations: The proposed development is located in spawning grounds of demersal species cod (Jan- Apr); haddock (Feb-May); whiting (Feb -June); saithe (Jan-Apr); Norway pout (Mar- May); *Nephrops* (throughout the year with peak Apr to Jun) and sandeel (Nov - Feb). The proposed development coincides with nursery areas for haddock, whiting, Norway pout, *Nephrops*, blue whiting, mackerel, European hake, ling, anglerfish, sandeels and herring.											
▓	▓	▓	▓	▓	▓	░	░	░	░	▓	▓
Marine Mammals Harbour porpoise, minke whale, killer whales and white- beaked dolphin have been recorded as present in the area with low to medium densities. The most sensitive periods for marine mammals in the area are from February to March, from June to September and in October when abundance of marine mammals in the area ranges from medium to very high.											
░	█	▨	░	▨	░	▓	▨	▓	ND	▨	░
Seabirds: The most sensitive times for seabirds of the year are October to November when the seabird vulnerability is "very high", and in January and July when the vulnerability is "high".											
▓	░	▨	▨	░	░	▓	░	░	█	█	░
Habitats Directive: Annex I Habitats: No Annex I habitats or species or conservation concern have been found in the area such as Annex I Submarine structure made by leaking gases, pockmarks, MDAC derived outcrops, bubbling reefs and Annex I Reef such as stony, bedrock or biogenic reefs confirmed in the area.											
░	░	░	░	░	░	░	░	░	░	░	░
Habitats Directive: Annex II Species: Harbour porpoise is the only Annex II species which has been sighted in the surroundings of the proposed development with very high abundance in February, and high abundance in July.											
░	█	ND	░	░	░	▓	▨	▨	ND	ND	░
Key :											
	░	**Low**	▨	**Moderate**	▓	**High**	█	**Very High**	ND	**No Data**	

5 SOCIOECONOMIC SETTING

This section focuses on the broader social and economical considerations within the Mariner Area Development area. Socioeconomics is a subset of the EIA that is concerned with the human dimensions of the environment, that seeks to identify the social and economic impacts on people and who benefits and loses (Morris and Therivel, 2009). For offshore oil and gas developments consideration is given to the potential impact on the fishing and shipping industries as well as any potential impact on other users of the sea, such as military organisations and activity within the renewable energy sector. The existence of submarine cables, historic wrecks and other oil and gas installations are also considered.

Socioeconomic considerations can also include changes in demographics and to communities, direct and indirect effects on employment, expenditures and incomes, and economic benefits to the wider area from the proposed development. However no attempt has been made to quantify these potential changes and social benefits and are only discussed in the context of potential economic impacts.

5.1 Commercial fisheries

Offshore oil and gas exploration and production operations have the potential to interfere with fishing activities, for example as a result of the exclusion of fishing vessels from around subsea wellheads, the area adjacent to platforms, and associated structures which require protection (CEFAS, 2001b). It is important to quantify the fishing activity and intensity in the Mariner Area Development area, to evaluate the potential impacts associated with the development on the fishing industry.

An assessment of the fishing activity in the Mariner Area Development area has been derived from International Council for the Exploration of the Seas (ICES) fisheries statistics, provided by Marine Scotland Science Division (Marine Scotland, 2011a, 2011b).

For management purposes, ICES collates fisheries information for individual rectangles measuring 30 nm by 30 nm. Data have been obtained for ICES rectangle 48F1 which coincides with the Mariner Area Development. Statistical data from ICES rectangles provide information on the UK fishing effort and live weight of demersal, pelagic and shellfish caught by all UK vessels between 2008 and 2010 (Marine Scotland, 2011b). Data on the economic value of fishing in this area have been produced based on UK catches and landings (Marine Scotland, 2011b). The reported catches and landings are directly related to the type of fishing gear and techniques used in the North Sea. The overall value of the different species 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).

The type of fishing gear and techniques deployed by fishermen depends on a variety of factors, such as:

- species fished, i.e., demersal, pelagic or shellfish;
- depth of water and seabed topography; and
- seabed characteristics.

Pelagic species (found in the water column) are fished using techniques that do not typically interact with the seabed, whereas demersal and shellfish species are generally fished on or near the seabed and therefore there is the potential for fishing gear to interact with structures placed on the seabed.

5.1.1 Fishing gear and effort

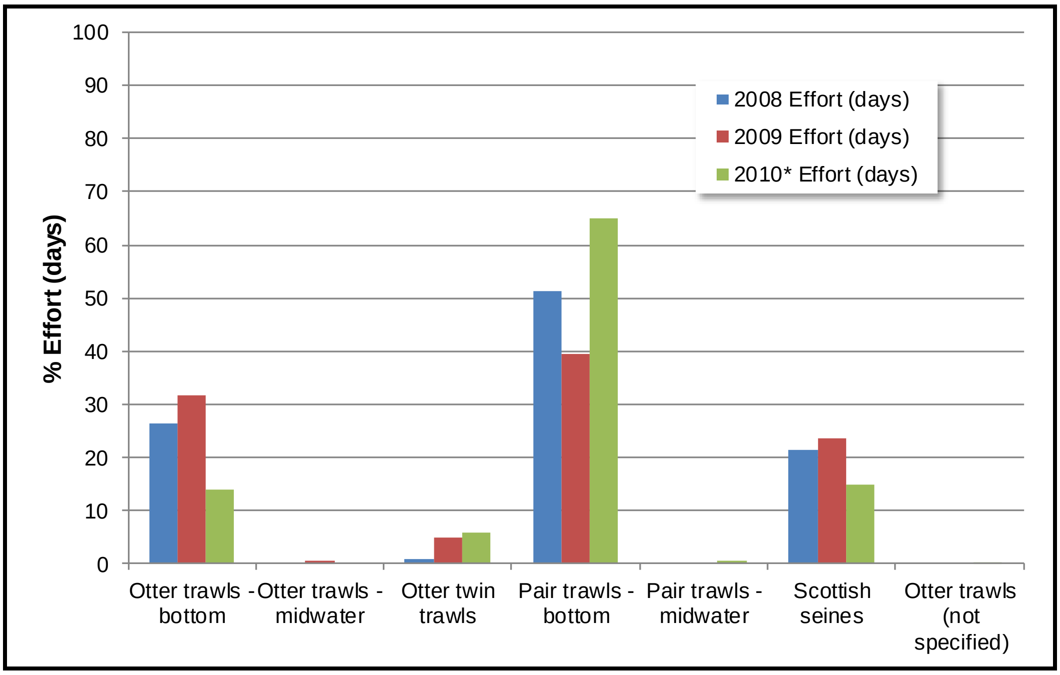
The relative fishing effort in ICES rectangle 48F1 for the period between 2008 - 2010 is considered to be 'very low' compared to the rest of the fisheries effort in the UK (**Table 5.1**). The relative fisheries effort for demersal gear compared to the rest of UK was medium, while there was very low effort for pelagic and *Nephrops* gears.

Table 5.1: 'Relative' fishing effort of commercial fisheries in ICES Rectangle 48F1 for 2010

Effort in 2010	ICES Rectangle 48F1 Days effort (Category)
Demersal gears	300-<800 (Medium)
Pelagic gears	<30 (Very low)
Nephrops gears	<300 (Very low)
Shellfish gears	None
Industrial gears	None
Other gears	None

Source: Marine Scotland (2011a)

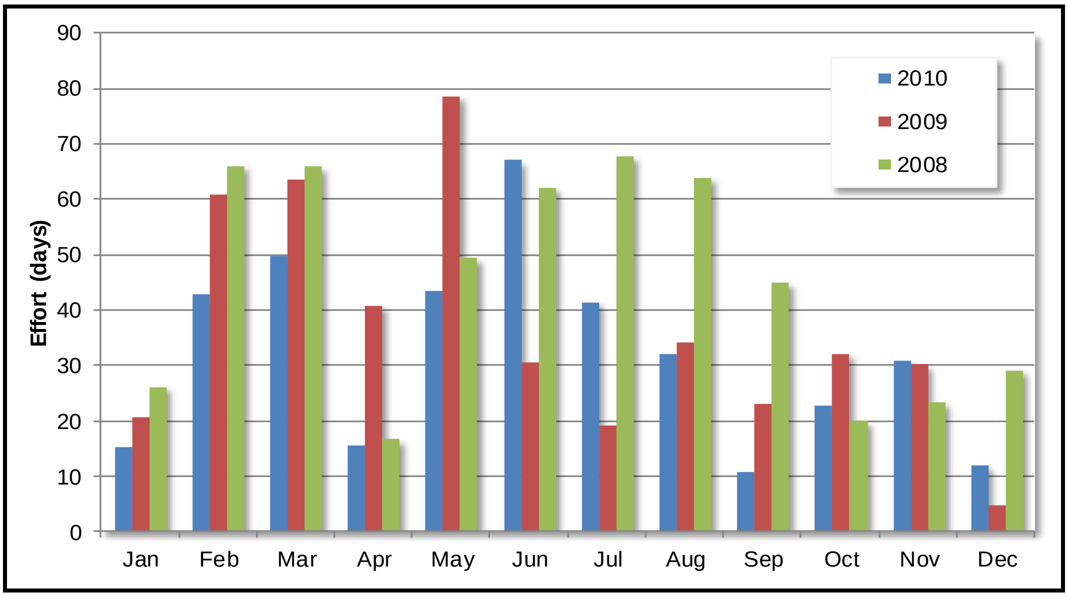
Demersal fishing methods, such as bottom otter trawling, pair trawling and Scottish saines, dominated the fishing effort in ICES rectangle 48F1 between 2008 and 2010 with pair trawling gear being the most common method comprising 50%, 40% and 65% of the total gear used in 2008, 2009 and 2010, respectively (Marine Scotland, 2011b **Figure 5.1**). The number of days for effort using mid-water otter trawls and pair trawls are close to zero for each year (**Figure 5.1**).



Source Marine Scotland (2011b) Note: 2010 data is provisional*

Figure 5.1: UK fishing effort by different gear types in ICES rectangle 48F1 in the period 2008 to 2010

The fisheries effort in ICES rectangle 48F1 appears to be variable throughout the year with peak times between February and March and during summer months from May to August (**Figure 5.2**).

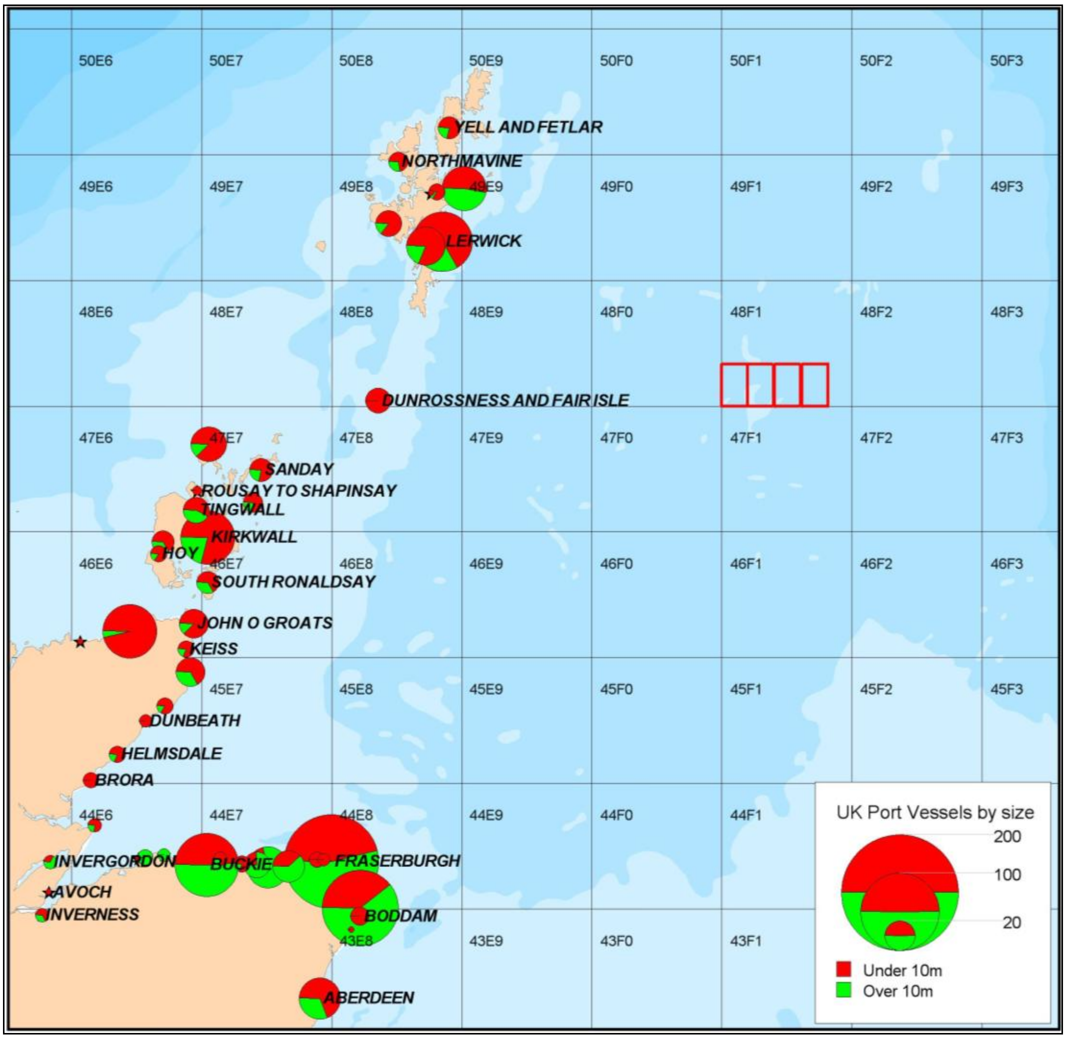


Source: Marine Scotland (2011b).

Figure 5.2: Fisheries effort by month for the period 2008 - 2010 in ICES rectangle 48F1

Demersal trawling methods interact with the seabed and may interact negatively with infrastructure placed on the seabed by oil and gas activities, including the disturbance caused by trenching, backfilling, or piling. **Section 8.4** discusses the implications of the physical presence of Mariner Area Development structures and inventory to the fishing activity in the area.

Analysis of the port distribution of the UK fishing vessels landings indicates that larger boats (over 10 m), which are more likely to be in the offshore areas around ICES 48F1. are located in Lerwick, Fraserburgh and Boddam (**Figure 5.3**). The remaining landings of the UK ports are dominated by smaller boats (under 10 m).

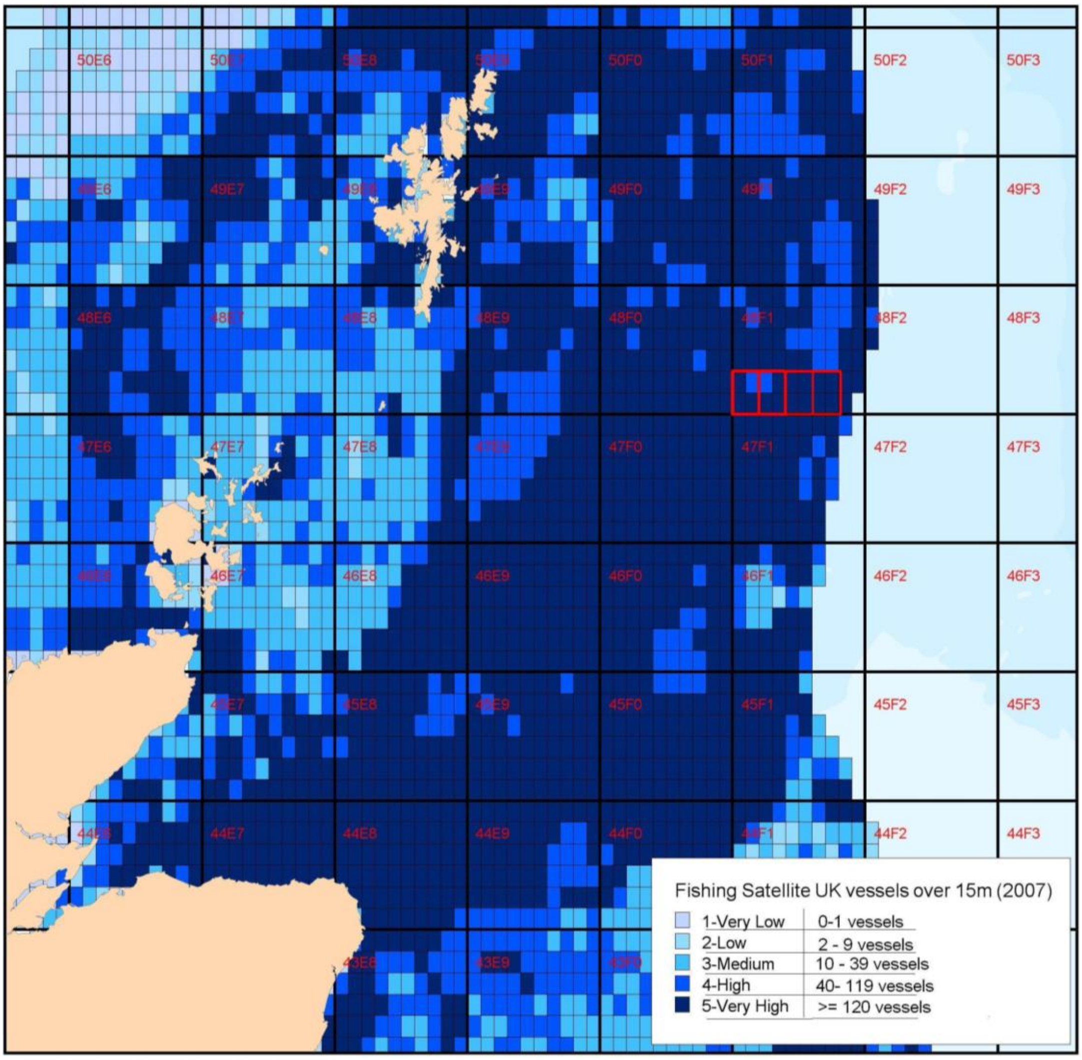


Source: Maritime Data (2012)

Figure 5.3: UK Ports and vessel distribution by size

Vessel Monitoring System data (VMS data), based on satellite data, allows for an understanding of the distribution of fishing vessels in the UK Sector of the North Sea. Data available from year 2007 for fishing boats over 15 m in length indicates that the

Mariner Area Development coincides with high to very high density of fishing vessels (**Figure 5.4**; Maritime Data, 2012).



Source: Maritime Data (2012)

Figure 5.4: UK Fishing Satellite data

5.1.2 Catch composition and economic value

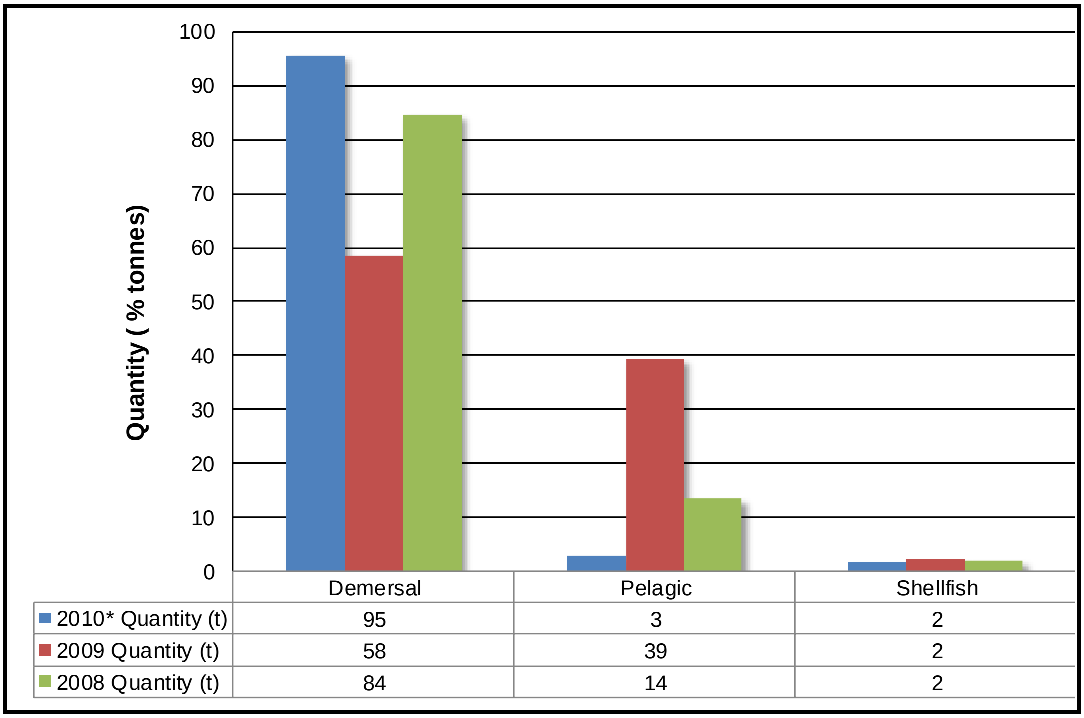
Marine Scotland (2011b) provides fisheries data for the "relative value" in 2010 of the demersal, pelagic, *Nephrops* and shrimp and shellfish fisheries, and for all species landed by UK vessels. For the Mariner Area Development (ICES rectangles 48F1) as compared to all areas fished around the UK, the "relative value" was "medium" for demersal fisheries and "very low" for pelagic, *Nephrops* and other shellfish species (**Table 5.2**.). Overall, taking into account all species, the 'relative value' for ICES 48F1 was "medium" in 2010 (Marine Scotland, 2011b).

Table 5.2: 'Relative' value of commercial fisheries in ICES rectangle 48F1 for 2010

Effort (2010)	ICES 48F1 Value m£ (Rank)
Demersal species	1500 - <3000 (Medium)
Pelagic species	<1500 (Very low)
Nephrops and shrimps	<500 (Very low)
Other Shellfish	<500 (Very low)
Total All species	1500 - <3000 (Medium)

Source: Marine Scotland (2011b)

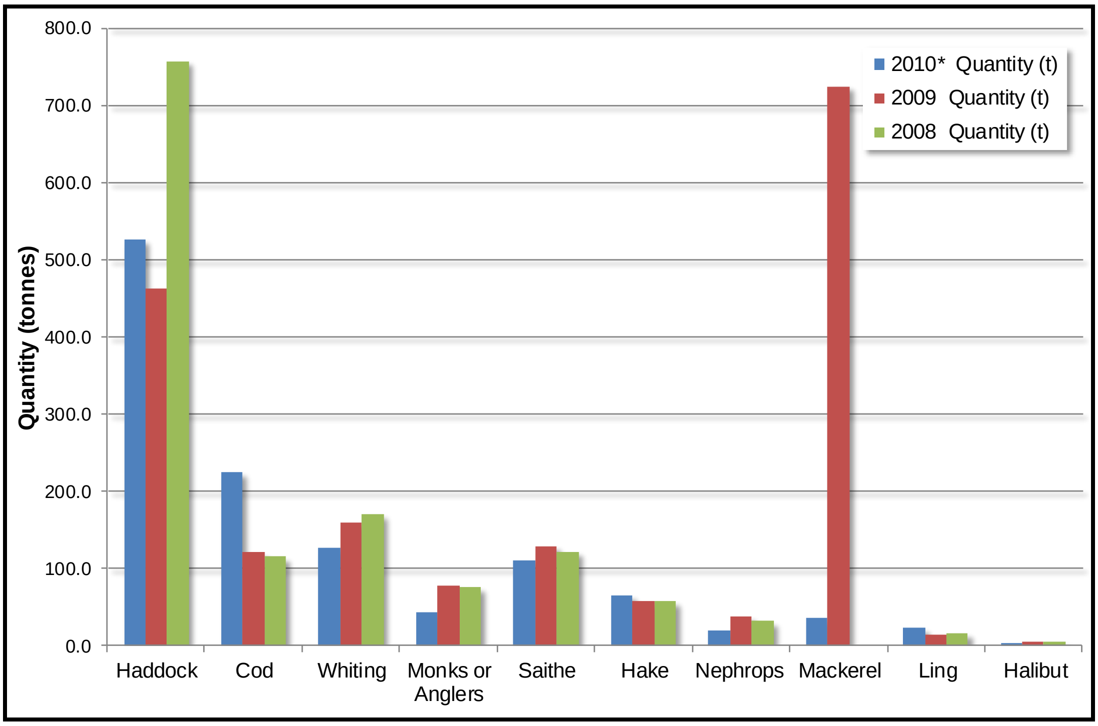
The fishery catch composition in the ICES rectangle 48F1 was dominated by demersal fisheries with demersal catch in 2010 comprising 95% of the total catch in the area. The pelagic fisheries are variable through the period between 2008 to 2010, with a maximum of 39% of the total catch in 2009 (Marine Scotland 2011b; **Figure 5.3**). The shellfish species caught in the ICES 48F1 accounted for only 2% of the total catch for the three years (**Figure 5.5**).



Source: Mariner Scotland (2011b)

Figure 5.5: Fishery catch composition in ICES 48F1.

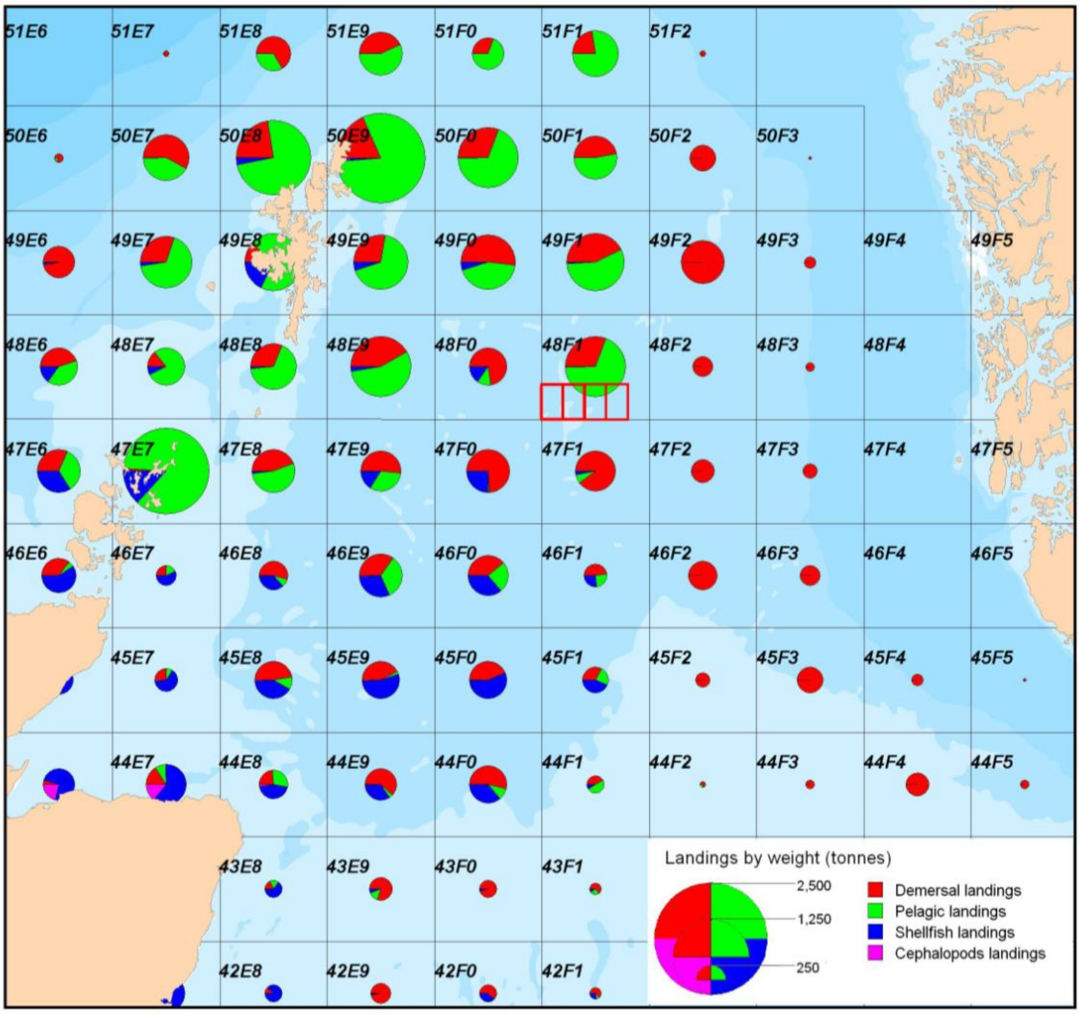
Haddock dominated the catch in ICES 48F1 for the entire period between 2008 to 2010, with the exception of mackerel, which was the only pelagic species, targeted in this area and comprised 724 tonnes in 2009 (**Figure 5.6**; Marine Scotland 2011b). However, mackerel did not account for any significant catch for the other years. The sporadic catch of mackerel is not unusual given the species' transitory behaviour. The catch of the other species in the area appear to be relatively constant with predominance of cod, whiting and saithe. *Nephrops* fishery did not account for significant catch in the ICES 48F1 (**Figure 5.6**; Marine Scotland 2011b).



Source: Marine Scotland (2011b)

Figure 5.6: Catch composition by species in ICES 48F1.

Fisheries landing data collected for the period between 2005 and 2007 indicate that the area of ICES rectangle 48F1 was dominated by pelagic landings comprising approximately 65% of the total landings of the fisheries from this rectangle, followed by demersal fisheries and a small proportion of shellfish landings (Maritime Data, 2012; **Figure 5.7**). The adjacent rectangles of the ICES 48F1 showed a predominance of demersal and shellfish landings.



Source: Maritime Data, 2012

Figure 5.7: Landings per ICES rectangle relative to the Mariner Area Development

5.2 Aquaculture

Coastal aquaculture sites could be susceptible to an offshore release of oil which then beaches along the Scottish coast. Finfish farms are usually mobile cages and shellfish are normally cultured on rafts or ropes and nets hung in the water column near shore and in sea lochs. There are a number of finfish and shellfish production sites in Orkney and Shetland. In the east of Shetland there are 15 finfish and 35 shellfish farms located on the coastal zone, while in northern Scotland and Orkney there are 10 finfish and 21 shellfish sites. Only one finfish farm is reported in the Morey Firth's Black Isle (Baxter *et al*., 2011). Scotland is one of the three largest producers of farmed Atlantic salmon in the world along with Norway and Chile and the largest in the EU. In 2009 144,000 tonnes of salmon were produced as well as Rainbow trout (2,620 t), brown trout (157 t), and halibut (69 t). Shellfish production in Scotland is dominated by blue mussels which in 2009 comprised

7,180 t production. Other species cultivated are Pacific oysters and Native oysters, as well as to a smaller extent King and Queen Scallops (Baxter *et al.,* 2011).

The provision of jobs in remote and rural areas is a key benefit. Salmon farming in Shetland and Orkney is reported to support about 874 full-time and 963 part-time jobs. Trout and other finfish production and processing support about 134 full-time and 183 part-time jobs with shellfish supporting about 169 full-time and 345 part-time jobs (Baxter *et al.,* 2011).

5.3 Shipping traffic

The North Sea has some of the busiest shipping lanes in the world. In 1996 alone there were 37,055 shipping movements transporting 48 million tonnes of cargo between the North Sea and the Baltic. The southern North Sea experiences relatively busy shipping traffic and this is highlighted by the number of main ports along the coast (DTI, 2001).

Statoil has conducted a shipping traffic study using ShipRoutes database (Anatec, 2010) to identify the shipping routes within ten nautical mile radius to the Mariner PDQ, estimate the shipping constrains/obstructions for navigation in relation to the drilling rigs and PDQ, and identify measures to minimise any risks to shipping (Anatec, 2010).

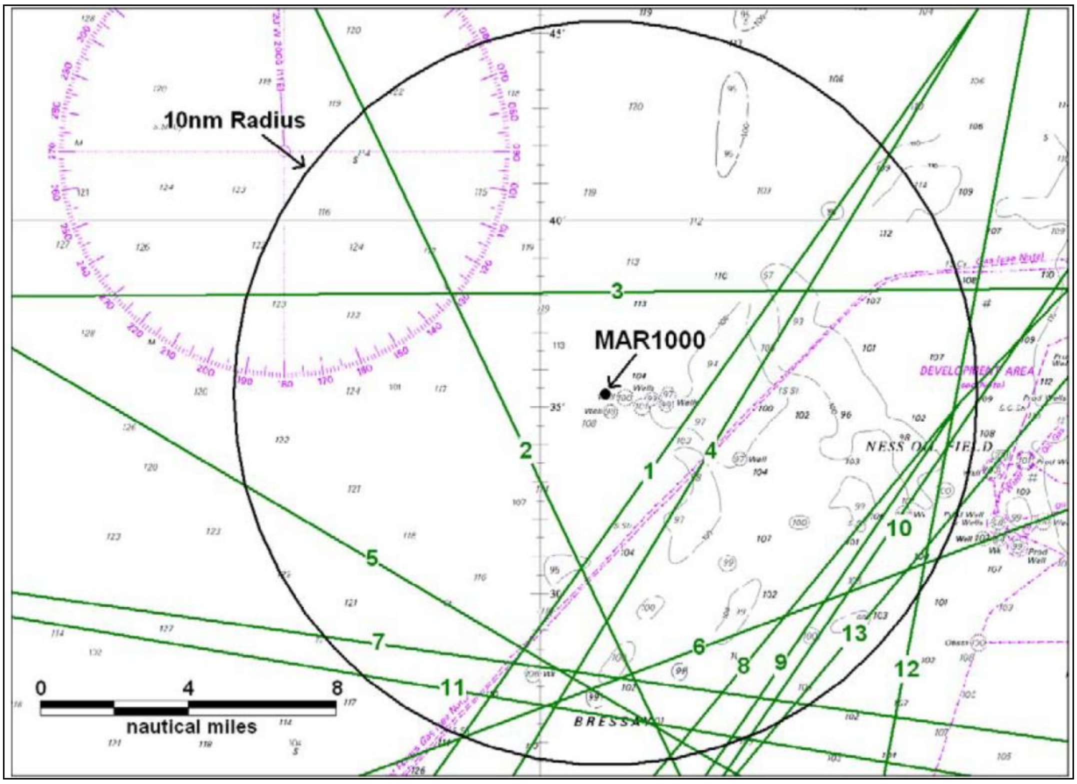
Table 5.3: Shipping routes within 10nm of the Mariner PDQ.

Route No.	Description	CPA (nm)	Bearing (°)	Ships/year	% Total
1	Aberdeen-Froysjoen	2.2	125	10	2
2	Sullom Voe-Hamburg*	2.6	245	35	7
3	Iceland-Bomlafjorden	2.7	360	25	5
4	Forth-Froysjoen	3.2	121	5	1
5	PolandE-Lerwick*	7.1	210	45	9
6	Beryl Term.-Mersey*	7.3	159	10	2
7	Boknafjorden-Iceland	7.5	188	25	5
8	Aberdeen-Bruce NNSb*	7.6	129	80	16
9	Aberdeen-Bruce NNS a *	8	124	120	24
10	Tay-Norway/Russia*	8.4	124	95	19
11	Boknafjorden-America	8.6	190	20	4
12	Humber-Statfjord	9.3	101	10	2
13	Beryl-Peterhead*	9.3	129	26	5
Total				506	100

** Where two or more routes have identical Closest Point of Approach (CPA) and bearing they have been grouped together. In this case, the description lists the sub-route with the most ships per year.*

Source: Anatec, 2010

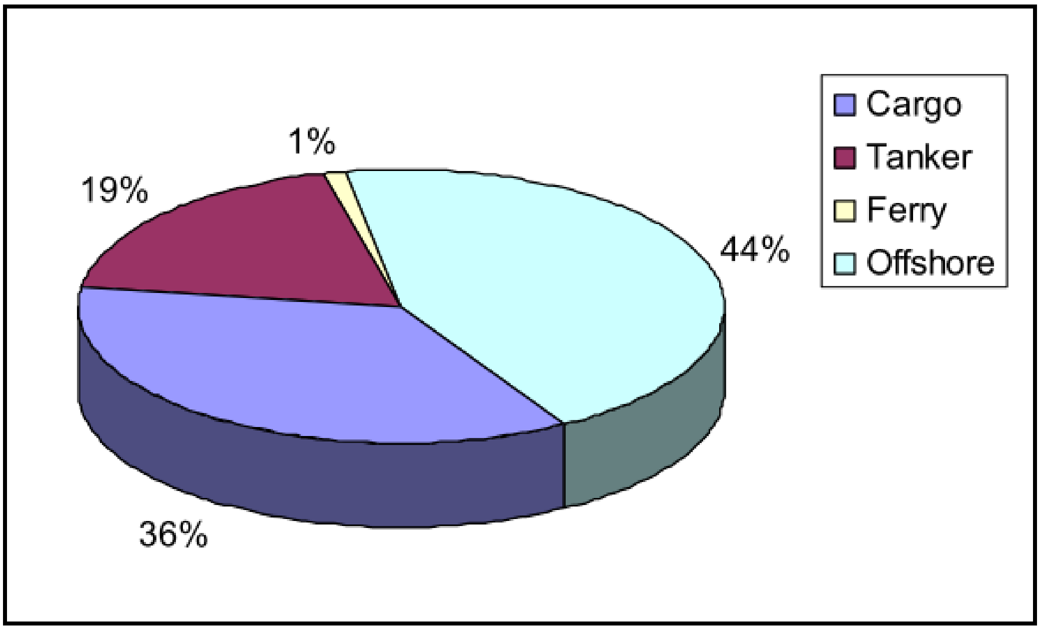
There are 13 shipping routes trafficked by an estimated 506 ships per year passing within 10 nm of the Mariner field (**Table 5.3; Figure 5.8**). This corresponds to an average of one to two vessels per day which is considered to be a low shipping density (Anatec, 2010; Maritime Data, 2012)



Note: MAR1000 is Mariner PDQ location
Source: Anatec, 2010

Figure 5.8: Shipping routes within 10nm of the Mariner field.

A breakdown of traffic by vessel type and size is presented in **Figure 5.9** and **Figure 5.10** respectively. It can be seen that the largest traffic constituent passing within 10 nm of the location comprised predominantly of cargo and offshore support vessels (**Figure 5.9**) in the size range of 1,500 to 5,000 DWT (**Figure 5.10**) (Anatec, 2010).



Source: Anatec, 2010

Figure 5.9: Distribution of vessel type within 10 nm of the Mariner field location.

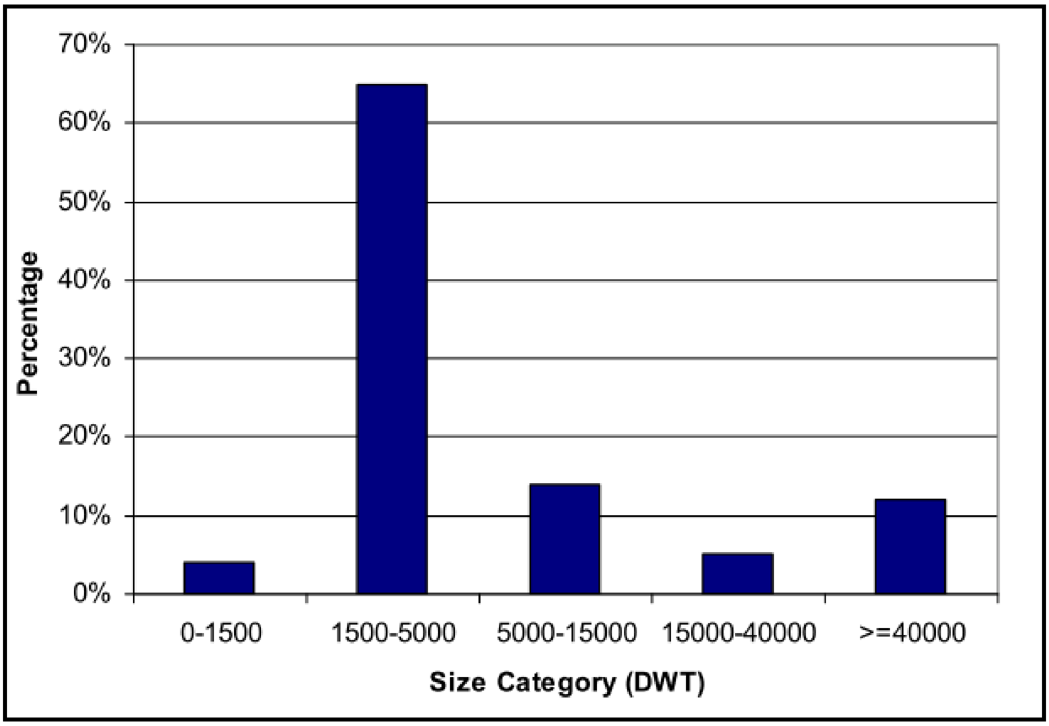


Figure 5.10: Size-frequency distribution of ships passing within 10nm of Mariner field.

Details of the three routes passing closest to the Mariner PDQ location (MAR1000, **Figure 5.8**) are summarised below (Anatec, 2010):

- Route No. 1 is used by an estimated 10 vessels per year between Aberdeen and Froysjoen in Norway. This route passes the location to the SE at a mean distance of 2.2 nm.
- Route No. 2 is used by an estimated 35 vessels per year between the Sullom Voe Oil Terminal and Hamburg. This route passes the location to the SW at a mean distance of 2.6 nm.
- Route No. 3 is used by an estimated 25 vessels per year between Iceland and Bomlafjorden in Norway. This route passes the location to the North at a mean distance of 2.7 nm. (Anatec, 2010).

The risk collision modelling estimates an annual ship collision frequency for a theoretical drilling ship vessel (Baucentaur) at the Mariner field is estimated to be 1.2 x 10^{-5}, corresponding to a collision return period of 83,000 years. This is below the historical average ship collision frequency for offshore installations on the UKCS (Anatec, 2010). The major shipping routes contributing to this frequency are routes number 1 and 2 (**Table 5.3 Figure 5.8**).

5.4 Oil and gas exploration activity and infrastructure

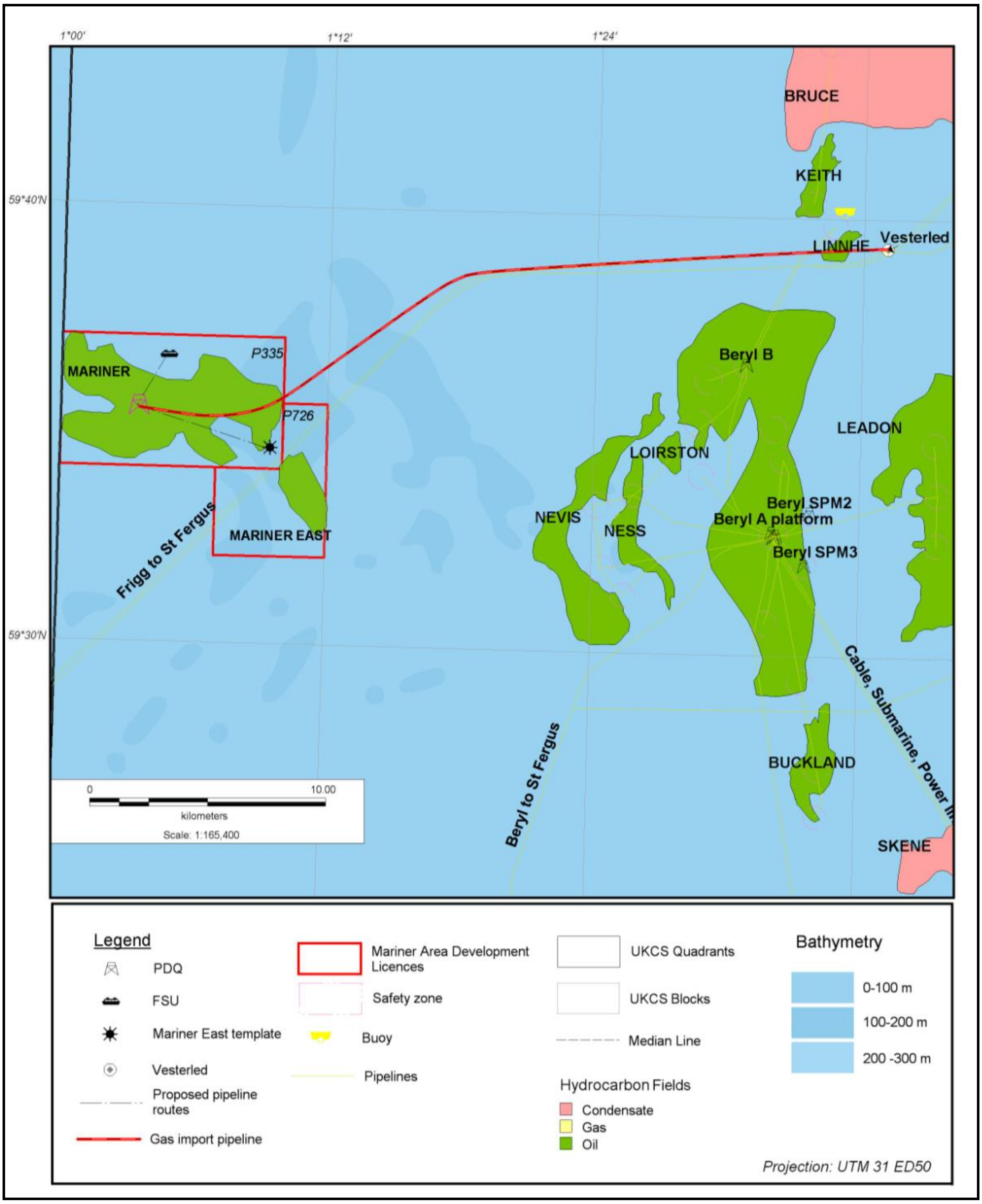
The Mariner Area Development is located in a well-developed oil and gas area of the northern North Sea. The nearest surface infrastructure in proximity to the proposed development location is as shown in **Table 5.4** the Beryl complex currently operated by Apache North Sea Ltd (**Figure 5.11**).

Table 5.4: Nearest oil and gas infrastructure to the Mariner Area Development.

Feature	Distance (nm)	Bearing (°)
Beryl B Platform	13.9	85
Beryl Flare Platform	14.7	100
Beryl A Platform	14.8	100
Beryl A Riser Platform	14.8	100

Source: UKDeal (2012); Anatec, 2010; Crown Copyright, © 2012

There are no oil and gas infrastructure developments to the west and south west of the proposed Mariner Area Development (**Figure 5.11**).



Source: Crown Copyright, © 2012

Figure 5.11: Oil and Gas infrastructure in relation to the Mariner Area Development.

5.5 Submarine cables and pipelines

In addition to the oil and gas infrastructure, a number of operational submarine (telecommunication) cables cross the SEA2 (Regional Sea 2) area. There has been a rising demand for telecommunications cable capacity with the increase in the use of the Internet and the growth in e-commerce and this may lead to further cables being installed in the future. It is expected that Statoil would be consulted if any future cables are proposed in the vicinity of the Marine Area Development.

Currently there are no subsea communication cables laid within the Blocks 9/11 and 9/12 of the Mariner Area Development (KISKA, 2012). The closest submarine cable to the Mariner PDQ is BT Telecom cable “Blaabjerg to 20 west” which is located approximately 40 km south west (KISKA, 2012).

Mariner Area Development lies within close proximity to two gas pipelines (FUKA and Vesterled Pipeline) which export gas from Frigg field to St Fergus gas terminal. The FUKA Pipeline is 100% owned by TOTAL E&P UK Ltd. The Vesterled Pipeline is owned by the GassLed Partners. The gas import pipeline route follows the route parallel to the FUKA and Vesterled pipeline system and the latter will supply the import gas to Mariner PDQ via a 34 km in length 6” gas import pipeline. The pipeline system to St. Fergus is located approximately 1 km from the Mariner East template.

5.6 Renewable energy activity

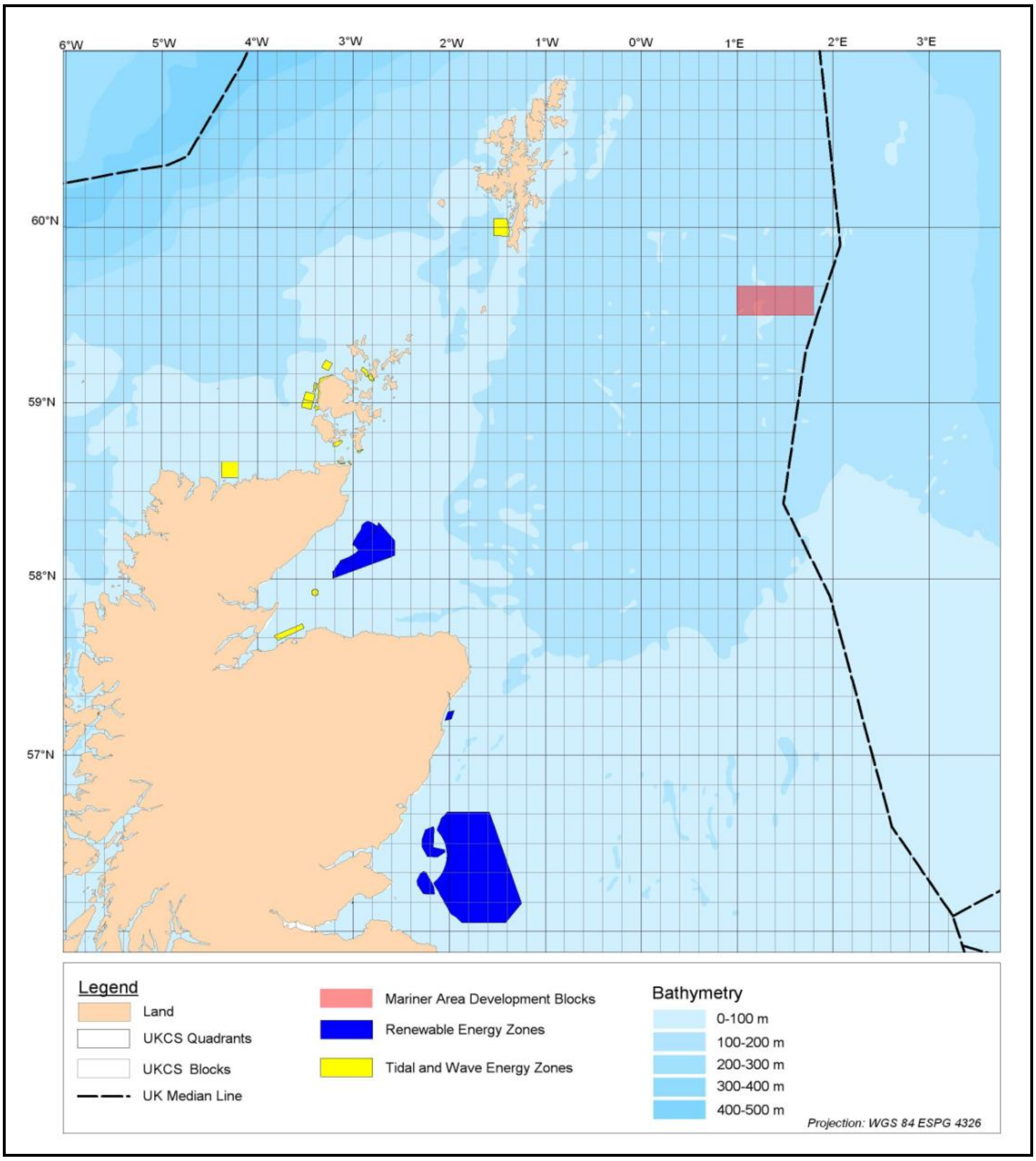
Wave and tidal

Tidal systems, which utilise the natural ebb and flow of tides and currents to power turbines, are believed to be one of the world’s greatest untapped energy resources. The UK has a particularly good marine current resource with at least 40 possible locations with suitable fast currents. Stingray, the world’s first large scale tidal stream generator system, was deployed in Yell Sound off the Shetland coast in 2002 for preliminary testing. The success of these tests has led to the redeployment of Stingray for additional testing, with plans for connecting the Stingray power station the local power network (DTI, 2004).

There are currently six wave and four tidal areas located on the western coast of Orkney. There are two tidal sites at the northern coast of Scottish mainland at Dunnet Head and two wave sites at the Moray Firth (Crown Estate, 2012; **Figure 5.12**). The closest tidal and wave energy zone to the Mariner Area Development is located more than 150 km north west and the closest renewable energy zone is located more than 270 km south west and therefore no interaction with the renewable energy sector is expected to occur as a result of the proposed development (**Figure 5.12**).

Wind

The Firth of Forth Renewable Energy Zone, one of the largest UK renewable energy zones, is located more than 350 km south west of the proposed Mariner Area Development. Moray Firth renewable zone area is adjacent to the Beatrice wind farm and is located more than 250 km south west of the proposed development. Both Moray Firth and Firth of Forth are designated under the Round 3 licensing programme (Crown Estate, 2012). The renewable energy operators within these zones are EDP Renovaveis and Sea Energy Renewables for the Moray Firth site and NPower Renewables Ltd, Sea Energy Renewables Ltd for the Fifthof Forth location (Crown Estate, 2012; **Figure.12**).



Source: Crown Estate, 2012

Figure 5.12 Crown estate areas of interest in relation to Mariner Area Development

5.7 Ministry of Defence Activities (MoD)

Military operations in Scottish waters include the triennial exercises run jointly by the Royal Navy and the Royal Air Force. These exercises include operations to the north and east of Scotland. Several areas of the inner and outer Moray Firth, including an extensive area to the east of Orkney, are utilised by the Air Force for activities which include radar training, high and low-angle gunnery and air to sea or ground firing. Areas in and around the Firth of Forth are predominantly used by the Navy for submarine exercises, mine countermeasures and minesweeping, and explosive trials (DTI, 2001).

The proposed development is located approximately 150 km north east of the Royal Air Force or Royal Navy military exercise areas (PEXAs) in the central and northern North Sea (Cordah, 2001; DECC, 2009).

There are no recorded historic military disposal sites, nor license conditions, applied to Block 9/11 by DECC on behalf of the MoD within, or close, to the Mariner Area Development.

5.8 Gas and Carbon Capture and Storage Activities

As a result of declining natural gas resources in the North Sea pressure is mounting for more investment in UK gas storage facilities to ensure integrity of supply. There is only one offshore gas storage facility currently in operation in the UK located in the southern North Sea: the Rough 47/8 Alpha facility. Other licences have been gratned such as ENI’s Debora field located in Block 48/29 in the Southern North Sea near Bacton terminal. However, currently there are no gas storage facilities in Scottish waters (Baxter *et al*., 2011). Use of existing storage features and infrastructure is likely to have negligible environmental impacts although the release of hyper saline water in the production of salt caverns may have some localised effects (UKMMAS, 2010).

Carbon Capture and Storage (CCS) is a new technology being developed to manage the emissions of CO_2 and reduce the contribution of fossil fuel emissions to global warming. If this alternative proves to be feasible and economically viable, CCS could capture approximately 80-90% of the CO_2 emissions produced by fossil fuel power plants and heavy industry, transport them in liquid form by pipeline or ship, and subsequently re-inject them into geological formations deep underground where they are stored permanently below the earth's surface (Baxter *et al*., 2011). CCS has the potential capability to store more than 200 years of Scotland’s current CO_2 output from its major fixed industrial sources (Baxter *et al.,* 2011).

Within UK territorial waters the suitable areas for CCS tend to coincide with locations of offshore oil and gas extraction because the reservoirs tend to be impermeable and suitable for CCS (UKMMAS, 2010). In Scottish waters, 26 hydrocarbon fields and 10 saline aquifers have been identified for potential use (Baxter *et al*., 2011). In 2011, an Environmental Statement was submitted to convert Shell's Goldeneye gas condensate field into a CCS storage site and included CO_2 transport, injection and storage. The proposed project was to occur in Blocks 14/29a and 20/4 in the central North Sea. Shell proposed to capture the CO_2 from the Longannet Power Station in Fife and transport it in a gaseous phase via the existing National Grid (NG) pipelines to the a new NG Black hill compressor facility at St. Fergus and subsequently pass it to the Goldeneye platform for injection subsurface (Shell, 2011).

The project is still to be approved. The Golden Eye platform is located approximately 205 km from the proposed Mariner PDQ location. No issues are expected to arise between the proposed Mariner Area Development and the CCS plans for that area of the North Sea.

5.9 Dredging and Aggregate extraction

Aggregates are mixtures of sand, gravel, crushed rock or other bulk minerals used in construction, principally as a component of concrete. Most UK dredging sites are located in the southern North Sea with the main region of aggregate extraction in the North Sea being the Humber Region (DTI, 2001). There are currently no marine aggregate application options or licensing sites in Scottish waters. The only licensed site is at Middle Bank in the Firth of Forth, which has not been dredged since its last (and only) usage in 2005 (Baxter *et al*., 2011; Crown Estate, 2012). .

5.10 Marine Archaeology and Wrecks

In the UK, submerged prehistoric sites and shipwrecks are not protected unless specific action has been taken to protect them. There are, however, two different acts under which wrecks that may be of archaeological interest may be designated, namely the Protection of Wrecks Act 1973 the Protection of Military Remains Act 1986. Designation of wrecks and submerged prehistoric sites is also possible under a third act, the Ancient Monuments and Archaeological Areas Act 1979, which applies to England, Scotland and Wales (DECC 2009).

The discovery of a single flint tool off the Viking Bank (150 km north-east of Lerwick) has been the only deep water prehistoric find close to the Mariner Area Development. The discovery is unique not just for its depth, but also for its distance from the shore. The probability is a low that prehistoric submarine archaeological remains occur in the area between the northern mainland coast and the UKCS median line (DTI, 2004).

Known submerged prehistoric sites in Orkney, Shetland, Viking Bank, show that such sites from the last 5-10,000 years can survive marine transgression. However, the strong current conditions in the northern North Sea area, the exposure to North Atlantic storms, the thin sediment cover in many places, and the large areas of exposed bedrock make the exposed areas of the shelf statistically poor prospects for the survival of prehistoric deposits *in situ,* other than in submerged caves and gullies (DTI, 2004).

The strategic importance of the northern North Sea area to the navy during WWI and WWII, the concentration of much of the North Sea fishing fleet in coastal ports, the importance of maritime trade routes in the area, and the treacherous nature of near shore waters has led to a large number of ship and aircraft wrecks in the area of northern North Sae and Shetland.

Statoil have conducted a detailed seabed survey using ROV (Subsea 7, 2011), sidescan and multi-beam sonar (FSL, 2008) around the Mariner Area Development. No features requiring further investigation such as obstructions, high reflective debris or shipwrecks have been identified within the area of the proposed development.

In relation to the Mariner Area Development, four wrecks and six potential obstructions have been identified from the UKHO database in proximity to the Mariner Area Development (**Table 5.5**; **Figure 5.13**).

Table 5.5: Summary of wrecks and obstructions identified in proximity to the Mariner Area Development

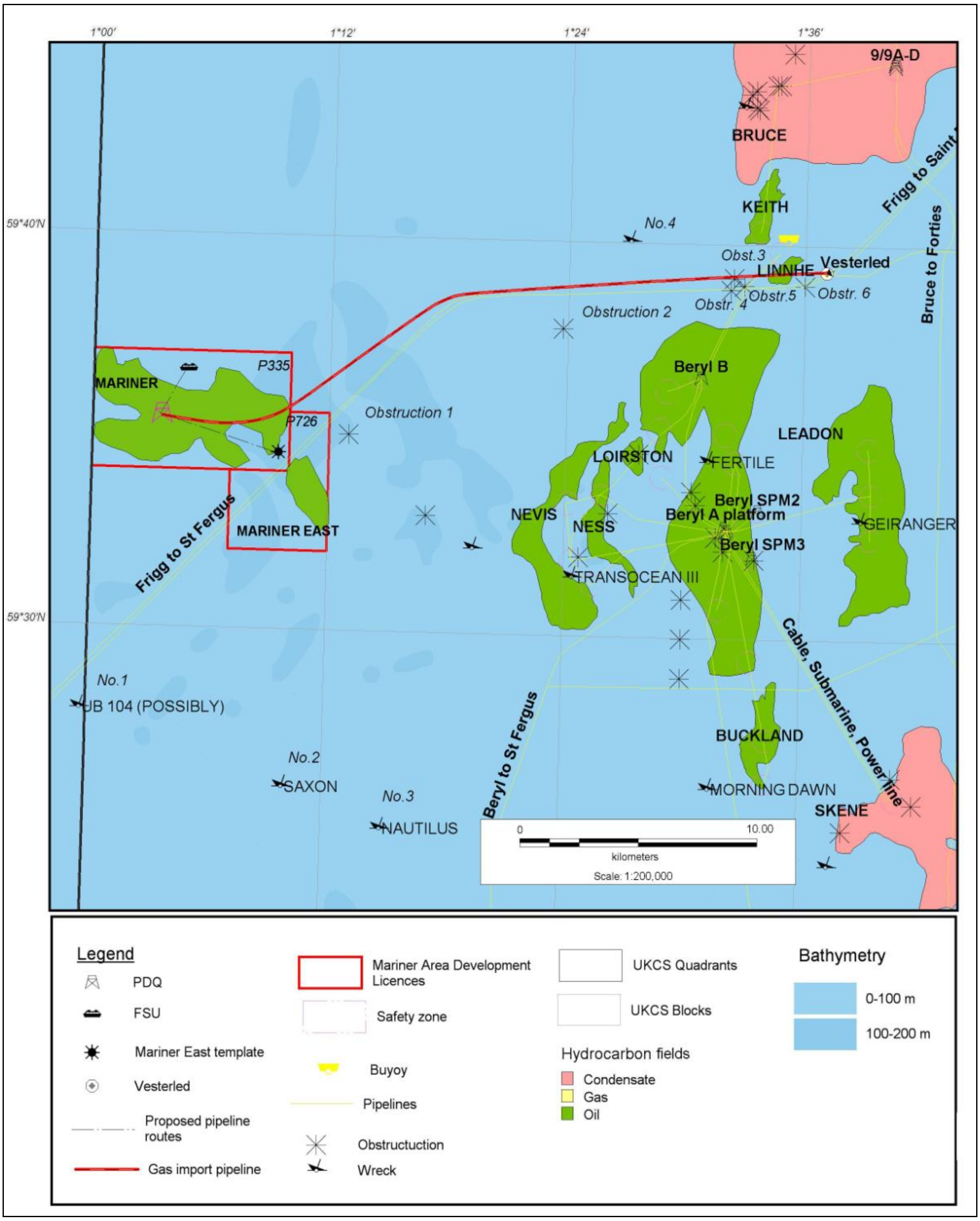
Wreck No.	Description	Wreck name	Nationality	Depth (m)	Approximate distance from PDQ (km) or pipelines
Wreck 1	Submarine (UB Class); Sunk: 1918/09/19; Length: 55.5m; Beam: 5.8m; Tonnage: 650	UB 104 (Possibly)	German	106	14.30
Wreck 2	SS; Sunk: 1918/05/07; Tonnage: 1595; Cargo: Carbide	Saxon	British	Unknown	18.30
Wreck 3	M Fishing; Sunk: 1972/01/01; Tonnage: 46	NAUTILUS	British	Unknown	21.90
Wreck 4	Unidentified wreck	N/A	N/A	Unknown	1.9 from gas import pipeline
Obstruction 1	Fishermens Fastener	N/A	N/A	Unknown	9
Obstruction 2	8 inch Hawser	N/A	N/A	Unknown	1.8 from gas import pipeline
Obstruction 3	Various debris	N/A	N/A	Unknown	0.06 from gas import pipeline
Obstruction 4	Metallic debris	N/A	N/A	Unknown	0.6 from gas import pipeline
Obstruction 5	Various debris	N/A	N/A	Unknown	0.4 from gas import pipeline
Obstruction 6	Fishermens Fastener	N/A	N/A	Unknown	0.6 from gas import pipeline

Source: Crown Copyright, © 2012

From the identified wrecks and obstructions only Wrecks 1 and 2 may potentially represent wreck sites of any importance for designation as they date back to WWI.

Wreck 1 is defined as possible UB-104 German submarine loss effectively a missing submarine, which went missing off Orkney on September 19 or 21, 1918. The Wreck 2 has been identified as Saxon` cargo boat, was sunk on May 7th, 1918, by the German submarine U-105, on a voyage from Odde to Leith with a cargo of carbide (WreckSiteEU, 2012).

Mariner Area Development is located a considerable distance (at least 9 km) from the nearest wreck site and therefore it is not expected that the proposed activities will have any interaction or impact to the wrecks in proximity.



Source: Crown Copyright, © 2012

Figure 5.13 Wrecks and obstructions around the Mariner Area Development

5.11 Economic benefits from the proposed development

According to the industry group Oil and Gas UK (OGUK, 2012), in the last four decades the oil and gas industry has invested a total of £468 billion (2010 money) in exploration, development and production of the UK's oil and gas reserves. Additional economic factors for this sector include:

- The largest industrial investor in 2011 spending £9.9 billion on exploration and new developments, with operating costs over £7 billion.
- Oil and gas production from the UKCS has contributed £293 billion (2010 money) in tax revenues over the last forty years.
- In 2011/12, the industry paid £11.1 billion in tax on production, which is 20% of total corporation taxes received by the Exchequer.
- The wider supply chain is estimated to have contributed another £6 billion in corporate and payroll taxes.
- In 2011, the UK's balance of trade in goods and services was boosted by oil and gas production by over £30 billion.

Within this context Statoil’s estimate of the total capital expenditure for the Mariner and Bressay heavy oil fields is almost £5 billion, well construction (drilling) costs are estimated at almost £3 billion, and annual operating costs would be of the order £200 million (**Table 5.6**). The project will require that a new operations office be established in the Aberdeen area, with a staff of 200-300. The long-term offshore workforce would number at least 500 (total for all shifts). Development of these oil fields will contribute to the economic wellbeing of the UK.

Table 5.6: Projected Mariner Area Development expenditures

Projected Expenditures	Mariner	Bressay
Facility Capex	£2.4 billion	£2.5 billion
Drilling Capex	£1.8 billion	£1.1 billion
Annual Opex	£102 million / year	£108 million / year

5.12 Summary of the socioeconomic receptors

Following the review of the socioeconomic environment in relation to the proposed Mariner Area Development planned to take a place in Blocks 9/11 and 9/12, the key potential receptors identified from the existing baseline are:

- Fisheries effort in the Mariner Area Development is classified as “low”, however satellite tracking in 2007 shows that fisheries fleet intensity is high to very high in the area of Blocks 9/11 and 9/12. Commercial fishing methods are dominated by demersal fishing gear predominantly using pair trawl nets targeting demersal species such as cod, haddock and whiting. The fisheries effort is variable throughout the years with highest effort in February to March and between May to October.

- The economy of the area taken as fisheries value was “medium” compared to the rest of the UK, with a value of £1.5 million to £3 million.

- Coastal aquaculture sites could potentially be vulnerable to an offshore release of oil which then beaches along Shetland and Orkney coasts, which is the major fish producing centre in the UK. Altogether 25 finfish sites and 56 shellfish sites are vulnerable to a potential oil spill reaching the shore.

- There is low shipping traffic in the area comprised predominantly of cargo and offshore support vessels in the size range of 1,500 to 5,000 DWT.

- Four wrecks and six potential obstructions have been identified in the area surrounding the proposed Mariner Area Development. Only two wrecks, one submarine and one cargo vessel, however have been identified as representing potential archaeological value since they date back to the period of WWI history.

- The Frigg to St Fergus gas export pipelines lies within a close proximity (1 km) to the Mariner East template. The third party pipelines are owned by Total E&P UK Ltd. and GassLed Partners.

- No interactions are expected to arise between the Mariner Area Development and the government’s and thirds parties’ proposals for renewable energy zones, marine aggregates, carbon capture and storage, natural gas storage or MoD activity.

- The project will result in a beneficial impact to the UK through new jobs, business opportunities and increased tax revenues.

6 CONSULTATION

Consultation with stakeholders is an important part of the EIA process, and enables stakeholders to provide feedback on the Mariner Area Development. Key feedback received to date has been recorded, addressed and communicated within the present ES. Where applicable, issues or concerns have been addressed within the project design, or will be acted upon during the subsequent planning and implementation phases of the project.

6.1 Purpose and Method

Upon assuming operatorship of the relevant licences Statoil has held regular meetings with the Department of Energy and Climate Change (DECC), Development and Production Team, in order to present their licensees' plans for appraisal and development of the oil-fields, and to better understand DECC's goals and requirements. These meetings have typically been held at six month intervals, and have usually also involved representatives of the DECC Environmental Management Team (EMT).

In addition, separate meetings have been held with the DECC EMT and stakeholders to discuss the possible environmental impacts of the development, preparation of the Mariner Area Development ES and DECC's expectations regarding control and management of potential impacts. At these meetings Statoil:

- informed the participants about the Mariner Area Development, including the options that had been, and were still being, considered;
- discussed any concerns DECC and the other stakeholders may have had regarding the possible environmental impacts of the project; and
- discussed possible methods of mitigating the potential environmental impacts that could arise from the Mariner Area Development activities.

Most recently, in May 2012 a consultation package was sent to DECC EMT, and to the organisations listed below, to enable them to communicate any specific concerns to Statoil prior to formal issue of this ES:

- Joint Nature Conservation Committee (JNCC)
- Marine Scotland (MS)
- Scottish Fishermen's Federation (SFF)
- Scottish Natural Heritage (SNH)
- Maritime and Coastguard Agency (MCA)
- Ministry of Defence (MoD)
- Sea Mammal Research Unit (SMRU)

Statoil has also consulted with the UK Health and Safety Executive, Offshore Safety Division, regarding safety and the working environment at the proposed development, and with the Marine and Coastguard Agency regarding the possible impacts on maritime safety. However, the topics discussed with these stakeholders, such as “major accident hazards”, and search and rescue, are outside of the scope of this ES.

6.2 Concerns and Issues

Table 6.1 summarises the main issues raised by the stakeholders during the consultation process and provides Statoil’s response on how their concerns were addressed.

Table 6.1: Summary of the Mariner Area Development consultations

Consultee	Consultee’s comments / concerns	Statoil’s response to comments / concerns
Comments in response to the ES scoping consultation meeting held with DECC, SFF, JNCC and Marine Scotland on 2 June 2010		
Department of Energy and Climate Change (DECC) Joint Nature Conservation Committee (JNCC) Scottish Fishermens’ Federation (SFF)	• Consultees confirmed that an ES that addressed both Mariner and Mariner East would be acceptable	A combined ES for the two developments has been prepared.
	• Consultees indicated that the ES should focus on the key issues, demonstrate that solutions are BAT and should avoid excessive theory.	ES focuses on a key project issues and BAT assessment outcomes are addressed in **Section 3.8.**
	• The ES should describe the basis for choice of the development option, and the range of alternatives that were considered.	This is addressed in **Section 3** of the ES.
	• The development described in the ES should represent the licensees’ final development proposal so far as possible..	Although study work continues in order to optimise the development, in particular to optimise recovery of reserves within the overall development concept, the ES so far as possible represents the licensees’ preferred option.
	• The ES should consider all development phases, up to and including decommissioning.	Installation, drilling, production and decommissioning phases are covered in this ES.
	• SFF indicated that a *Sevan* solution is not preferred by their members due to the large anchor pattern.	Concepts based on or including a *Sevan* style floating unit have been rejected.

Consultee	Consultee's comments / concerns	Statoil's response to comments / concerns
Comments in response to the ES consultation meeting held with DECC, JNCC and SFF on 31 October 2011		
Department of Energy and Climate Change (DECC) Joint Nature Conservation Committee (JNCC) Scottish Fishermens' Federation (SFF)	• Statoil to confirm whether they intend to trench the gas import pipeline.	Following the FEED phase for the Mariner Area Development Statoil has decided to trench and bury the gas import pipeline.
	• Consultees enquired if significant levels of H_2S are associated with the Mariner reservoir.	Statoil can confirm that there were no significant levels of H_2S recorded in the Mariner or Mariner East crudes.
	• Statoil to provide details of the required rock-dumping to stabilise the jack-up rig	Statoil foresees use of up to 3,000 tonnes of gravel for contingency use of stabilising the rig jacket is required in scour conditions.
	• Consultees enquired about the alternatives of overboard discharge of produced water (PW)	Statoil can confirm that the preferred water disposal route is reinjection. However, there will be some overboard disposal of produced water during periods when reinjection equipment and wells are not available. All discharged water will be treated to meet the legal quality limits, or better whenever possible. Zero discharge options were considered; these but gave no operational advantages but increased operational risks, and hence were not adopted. Dedicated water injection wells will be drilled.
	• Consultees enquired about using old abandoned wells for re-injection of PW.	Statoil has studied the status of the old abandoned wells at Mariner and Mariner East fields and can confirm that all of the old wells have been fully abandoned except well 9/11a-8Y which will be fully abandoned during Mariner installation phase. Statoil has no intention of reusing any of these wells. Dedicated water injection wells will be drilled.

Consultee	Consultee's comments / concerns	Statoil's response to comments / concerns
Comments in response to the ES consultation meeting held with DECC, JNCC and SFF on 31 October 2011		
Department of Energy and Climate Change (DECC) Joint Nature Conservation Committee (JNCC) Scottish Fishermens' Federation (SFF)	• Drill cuttings management issues shall be considered	Statoil has conducted studies for use of thermal desorption technology for treatment of drill cuttings and can confirm that the powdered by-product is suitable for overboard discharge. Other appropriate onshore and offshore disposal options have also been considered. Offshore drill cuttings disposal have been modelled and the results are presented in the ES.
	• Statoil shall consider designing the facilities to be fully removable	Statoil can confirm that the design stage has incorporated solutions to fully remove the installations and associated facilities.
	• Consultees raised a concern about the FSU type and the offloading schedule	Statoil confirms that the FSU will be turret moored conventional (ship-shaped) type with relatively low offloading schedule due to the low oil production rates (maximum of 50,000 to 60,000 bbls per day relative to the FSU capacity of 80,000 bbls per day).
	• Consultees required clarification of the seabed cables	Statoil initially clarified that there would be power and control connections from the PDQ to the FSU, with the FSU being powered by the PDQ. Additional fibre optic cable would connect with Statoil's Heimdal platform in the Norwegian Sector of the North Sea. [Note: Since that meeting the FSU has changed to manned status, with its own power systems. The power cable has therefore been deleted.
	• Oil spill emergency planning shall be conducted and addressed within an OPEP document	Statoil can confirm that the design includes measures to eliminate or reduce the risk of potential spill so far as practicable. An OPEP will be developed in accordance with the regulations, centred on an operational base in NE Scotland. Statoil has conducted oil weathering tests for Mariner crudes, and is reviewing the suitability of available oil dispersants and oil collection methods. The results of this work will dictate the approach to oil spill response, to be set out in the OPEP.

Consultee	Consultee's comments / concerns	Statoil's response to comments / concerns
Comments in response to the ES consultation meeting held with Marine Scotland on 24 January 2012		
Marine Scotland (MS)	• Marine Scotland indicated that for oils of the Mariner type, the OSCAR model may be preferable to OSIS for oil spill modelling	OSCAR has been used for oil spill modelling as part of this ES.
	• Marine Scotland noted that fishing quantities quoted in JNCC reports are for UK fleet only and that other countries' fleets fish the area. They noted that trawling is the main fishing method, and that larger trawlers are being built. They recommended that pipelines etc. be suitably protected.	Statoil confirms that the gas import pipeline will be trenched and buried.
Comments in response to the regular consultation meetings held with DECC		
Department of Energy and Climate Change (DECC)	• DECC indicated that the ES should cover the whole development life-cycle, including the decommissioning phase.	Installation, drilling, production and decommissioning phases are covered in this ES.
	• DECC indicated that the ES should discuss alternate development concepts, pipeline route, etc, and give reasons for the selection of the chosen concept.	This is addressed in **Section 3** of the ES.
	• DECC indicated that concrete structures were not preferred under their implementation of OSPAR and because of the difficulty of decommissioning / removal.	All options with concrete structures have been rejected.

Consultee	Consultee's comments / concerns	Statoil's response to comments / concerns
Comments in response to the regular consultation meetings held with DECC		
	• DECC indicated a preference for zero water discharge solutions for new developments.	Statoil confirmed that the preferred water disposal route is reinjection. However, there will be some overboard disposal of produced water during periods when reinjection equipment and wells are not available. All discharged water will be treated to meet the legal quality limits, or better whenever possible. Zero discharge options were considered, but gave no operational advantages but increased operational risks, and hence were not adopted. Dedicated water injection wells will be drilled. An assessment of discharge produced water has been undertaken in **Section 8.2**.
	• DECC indicated that they would expect the ES to address dispersion of drill cuttings, in particular if large volumes would be generated and oil-based mud used	The ES includes analysis of drill cuttings dispersion.
	• DECC indicated that there was no legal requirement for an environmental monitoring (sampling and analysis) plan during operations, but this would be viewed favourably and should be mentioned in the ES if planned to take place.	Statoil practice on the Norwegian Sector is to sample and analyse at 3 year intervals. This practice is likely to be adopted at the Mariner Area Development.
	• DECC asked if any special consideration had been given to the risks of spillage of condensate during transfer operations.	This issue arose before the preferred transfer solution had been determined. The question related to the possibility of "bunkering", and that option was rejected.

Consultee	Consultee's comments / concerns	Statoil's response to comments / concerns
Comments in response to the consultation letters		
Scottish Natural Heritage (SNH)	• SNH confirmed with Statoil that they provide statutory nature conservation advice for Scotland and its territorial seas out to 12 nautical miles, and JNCC provide equivalent advice for offshore waters. • SNH confirmed that due to the offshore location of the proposed Mariner Area Development, JNCC will provide lead advice in this case.	Statoil acknowledge that JNCC is the advisor for the offshore part of the UKCS and will comply with the JNCC guidance relevant to conservation of marine environment and species.
Scottish Fishermen's Federation (SFF)	• SFF indicated that the organisation needs to be kept informed at key stages of the project regarding environmental issues and potential impacts that may arise.	Statoil will forward email updates to the SFF of the key stages to the relevant contact in the SFF.
Marine Coastguard Agency (MCGA)	• MCGA indicated that they would like to be kept informed regarding safety issues that may emerge from the Mariner Area Development installation and operational activities.	Statoil will forward email updates of the key stages and safety issues to the relevant contact in the MCGA.

7 ENVIRONMENTAL RISK ASSESSMENT

7.1 Introduction

This section identifies and ranks the environmental and socioeconomic impacts and risks (potential impacts) that could arise directly or indirectly from routine and emergency situations during the lifetime of the Mariner Area Development. For clarity, the project has been split into four stages: drilling, installation, production and decommissioning. The predicted design field life of the Mariner Area Development is approximately 40 years.

The environmental impacts and risks of decommissioning the facilities are not fully assessed in this ES. As required under The Petroleum Act, 1998, they would be formally assessed towards the end of field life and such an assessment would be undertaken in accordance with the legislation and policy in force at that time. For these reasons, only a high level assessment of the potential impacts from decommissioning has been carried out within the ES.

7.2 Mariner Area Development ENVID Workshop

To support the concept selection review, Statoil undertook an Environmental Impact Identification (ENVID) Workshop to inform decisions on each of the concept options under consideration for the Mariner Area Development (**Section 3**).

The ENVID was carried out with a multi-disciplinary team from Statoil with the aim of systematically:

- identifying the environmental aspects of the project (i.e. the actual or potential causes of environmental impact) and their corresponding impacts (changes caused to sensitive receptors in the physical, chemical, ecological and socioeconomic environments);
- assessing the significance of the potential environmental impacts and risks according to pre-defined criteria which recognise the likely effectiveness of planned mitigating measures that may be taken during the project to minimise or eliminate potential impacts/risks; and
- conducting a screening review to identify and record environmental impact differentiators between each Mariner Area Development option.

The ENVID resulted in the production of a high level Environmental Aspects Register of potential significant impacts / risks for each option, along with the identification of mitigation measures to be taken or considered by Statoil during the project. The output of these results were used to inform a separate risk assessment exercise which was carried out as part of the present ES (see below).

7.3 Risk Assessment Methodology

7.3.1 Purpose and scope of the risk assessment

The purpose of the risk assessment process is to identify those potential impacts and risks that may be significant in terms of the threat that they pose to particular environmental receptors, the need for measures to manage the risk in line with industry best practice and the requirement to address concerns or issues raised by stakeholders during the consultation for this ES.

In this section of the ES, the scope of the risk assessment is confined entirely to the Mariner Area Development. **Tables 7.6** to **7.9** show the outcome of this assessment and **Section 8** provides a more detailed evaluation of those impacts and risks that were assessed to be significant. **Appendix E** provides a justification for those risks that were deemed to present an insignificant or low risk.

7.3.2 Overview of the assessment process

The general definition of risk is:

The probability that a causal event will occur x **A measure of the consequence of the event occurring** = **The overall risk posed by an activity**

In terms of environmental impact assessment this can be defined as:

The likelihood that an event will occur x **The likelihood that the event will have an impact upon a particular environmental receptor** x **The magnitude / severity of the effect on the receptor** = **Significance of the impact / risk**

For the purpose of this EIA, to ensure a transparent, robust, yet fit-for-purpose assessment this method was applied differently for the planned events in the Mariner Area Development and for the unplanned / accidental events which might occur.

The environmental risk assessment applied the criteria presented in **Tables 7.1** and **7.2** while considering the sources of potential impact identified in **Section 3** and the sensitivity of the receptors identified in **Section 4** and **Section 5** to judge the significance of each environmental risk. The risk assessment was undertaken by working through a series of individual tables (**Tables 7.6** to **7.12**), with one table applicable for each stage of the Mariner Area Development (i.e. drilling, installation of pipelines and other subsea installations, production and decommissioning).

7.3.3 Assessment of planned activities

The risk assessment for the planned activities was derived by reducing the definition to:

The likelihood that an event will have an impact upon a particular environmental receptor x **The magnitude of the effect** = **Significance of the impact / risk**

For planned events, it is certain that the event will occur; therefore, the first term can be set as equal to one and effectively be ignored. The primary driver for the risk assessment is then the likelihood that a particular environmental receptor will be affected by the planned activity. This is governed by the receptor's sensitivity to the causes of impact, its location in relation to the source of the impact, the timing of the impact and the ability of the receptor to recover.

The definitions for "the likelihood of occurrence of the impact upon a particular receptor" and the "magnitude / consequence of the environmental impact" for each activity are presented in **Tables 7.1** and **7.2**, respectively.

These factors were combined using a risk assessment matrix (**Table 7.3**) to determine what level of risk the proposed activity could pose to the physical, chemical, biological and socioeconomic receiving environments. The overall significance for a particular activity was determined by taking the highest level of risk associated with the project activity against any one of the components of the receiving environment. The results of the assessment are presented in Tables **7.6 to 7.12**.

Table 7.1: Guidelines for assessing likelihood of occurrence of an impact upon a particular receptor resulting from the planned activities

Decreasing likelihood ↓	Likelihood		Frequency of planned activity impacting receptors during project lifetime
	A	Definite	Impact observed every time; might occur once a year or more on site
	B	Likely	Impact often observed; could happen several times in site life
	C	Possible	Impact occasionally observed; might happen in site life
	D	Unlikely	Impact rarely observed; has occurred only several times in industry
	E	Remote	Impact almost never observed; few if any events in industry

Table 7.2: Guidelines for assessing the magnitude / consequence of the impacts on the environment

Magnitude / consequence		Frequency of an unplanned or accidental event occurring and impacting receptors during project lifetime
1	Catastrophic	Adverse permanent impacts on key ecosystem functions and services in larger natural habitats (e.g. restitution time > 10 years).
2	Severe	Adverse long term impact on ecologically valuable natural habitats (e.g. restitution time 3 to10 years).
3	Major	Adverse medium or long term impacts on a significant part of habitats (e.g. restitution time 1 to 3 years).
4	Moderate	Adverse short term impact on natural habitats
5	Minor	No or very limited impact on natural habitats. No impact on population level, only on individual organism level.

Table 7.3: Environmental risk assessment matrix

		Planned	Accidental	Magnitude/consequence of impact (Table 7.2)				
				5 (Catastrophic)	4 (Severe)	3 (Major)	2 (Moderate)	1 (Minor)
Likelihood of occurrence (Table 7.1 and 7.4)	A	Definite	Likely	High	High	Medium	Medium	Low
	B	Likely	Unlikely	High	High	Medium	Medium	Low
	C	Possible	Very unlikely	High	High	Medium	Low	Low
	D	Unlikely	Extremely unlikely	Medium	Medium	Low	Low	Insignificant
	E	Remote	Almost unheard of	Medium	Low	Low	Insignificant	Insignificant

7.3.4 Assessment of unplanned/accidental events

The risk assessment for unplanned / accidental events was derived by reducing the definition to:

The likelihood that an event will occur x **The magnitude of the effect** = **Significance of the Impact / risk**

In the well regulated and developed UK offshore oil and gas industry the likelihood of an unplanned or accidental event is generally very low. The assessment is focussed on the magnitude of any impact and the probability that the causal event will occur. The magnitude of impact was assessed for each receptor and recorded in the tables.

The definitions for “the likelihood of occurrence of the unplanned or accidental event” and “the magnitude / consequence of the environmental effects” for each activity are defined in **Tables 7.4** and **7.2,** respectively.

Table 7.4: Guidelines for assessing likelihood of occurrence of an impact resulting from unplanned / accidental activities

Decreasing likelihood ↓	**Likelihood**		**Frequency of an unplanned or accidental event occurring and impacting receptors during project lifetime**
	A	Likely	Might happen once a year on site; 1 per year
	B	Unlikely	Could happen several times in site life; 1 per 10 years
	C	Very unlikely	Might happen in site life; 1 per 100 years
	D	Extremely unlikely	Has occurred several times in industry; 1 per 1,000 years
	E	Almost unheard of	Few if any events in industry; 1 per 10,000 years

These factors were combined using a risk assessment matrix (**Table 7.3**) to determine what level of risk the proposed activity could pose to the physical, chemical, biological and socioeconomic receiving environments. The overall significance for a particular activity was determined by taking the highest magnitude of impact associated with the project activity against any one of the components of the receiving environment and compared with the likelihood of the causal event from **Table 7.4**. The results of the assessment are presented in **Tables 7.6** and **7.12**.

7.4 Risk Assessment Findings

The results of the risk assessment are shown in **Tables 7.6** to **7.12**. The left-hand column of the tables identifies the aspects of the project that will definitely cause or have the potential to cause impacts to sensitive receptors. These environmental aspects (BSI, 2004; BSI, 1996) include routine, abnormal and emergency events during the lifetime of the project. The remaining columns of the tables identify the sensitive physical, chemical, biological and socioeconomic receptors. The four right-hand columns of the tables present the transboundary effects, stakeholder concerns, the overall assessment of significance (i.e., the highest assessed risk) and the sections of the report that give a detailed justification of the assessment made.

Taking the effects of planned mitigation into account, no “high” environmental risks have been identified during the assessment. The risk assessment did, however, identify the following activities associated with the Mariner Area Development as having the potential to be of “medium” risk and which are assessed further in **Section 8**:

- localised disturbance to the seabed arising from the drilling and installation activities (**Section 8.1);**
- discharges to sea from the Mariner Area Development wells (**Section 8.2**);
- underwater noise arising from the subsea installation activities (**Section 8.3**);
- the long-term physical presence of the PDQ, FSU, drilling rigs, pipelines and other subsea structures on the seabed (**Section 8.4**); and
- atmospheric emissions arising from the drilling, installation and production activities (**Section 8.5**).

In addition, the potential for accidental hydrocarbon spillage is discussed in relation to the following scenarios, which are also considered as being of significance to the environment:

- accidental hydrocarbon release from a total loss of inventory, a pipeline rupture or major spill from vessel collision (**Section 8.6**)

7.5 Summary of Risk Assessment

The totals for “low” and “moderate” environmental risks associated with each activity are presented in **Table 7.5**.

Incremental impacts or risks classified as “moderate” are discussed further in **Section 8**. No “high” environmental risks have been identified (**Table 7.5**). For the incremental impacts or risks that were considered to be “low”, **Appendix E** provides the justification for the assessment made and for excluding these impacts and risks from further investigation in the EIA.

Table 7.5: Summary of the risk assessment conducted for the proposed Mariner Area Development

Project Stage	Risk							
	Insignificant		Low		Medium		High	
	Planned event	Accidental / unplanned event	Planned event	Accidental / unplanned event	Planned event	Accidental / unplanned event	Planned event	Accidental / unplanned event
Drilling activities at the Mariner field	1	1	19	6	15	0	0	0
Drilling activities at the Mariner East field	0	1	9	5	10	1	0	0
Installation of PDQ	0	1	7	2	3	0	0	0
Installation of FSU	0	1	8	2	4	0	0	0
Installation of pipeline, umbilical and subsea structures	0	1	5	5	6	1	0	0
Production activities	0	0	12	6	8	1	0	0
Decommissioning	0	1	13	1	1	0	0	0

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Table 7.6: Risk assessment of the Mariner field drilling activities

Key

🟥 **High risk**
🟨 **Medium risk**
🟩 **Low risk**
⬜ **Insignificant**

These impacts have been discussed in **Chapter 8, as they represent a cumulative impact on atmospheric emissions from the Mariner Area Development*

Drilling	Physical and Chemical					Biological						Socioeconomic							
	Sediment structure / chemistry	Water quality	Use of resources	Use of disposal facilities	Air quality (local)	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Marine mammals	Integrity of conservation sites	Commercial fishing	Shipping	Military operations	Other users	Transboundary effects	Stakeholder concerns	Overall significance	Justification: section / reference
Installation and drilling from the jack-up drilling rig - Planned events																			
Mobilisation of rig to location												✓	✓					E1	App E
Ballast water discharge from transport vessel(s)		✓					✓	✓								✓		E1	App E
Spud can placement from jack-up rig	✓	✓				✓	✓	✓									✓	E2	8.1
Gaseous emissions from vessels and jack-up rig			✓		✓											✓		E3	8.5
Physical presence of jack-up rig and vessels												✓	✓					E1*	8.4
Power generation from drilling rig (cumulative with PDQ)			✓		✓											✓		E3	8.5
Overboard discharge of non-hazardous drains		✓					✓	✓		✓								E1	App E
Discharge of sewage and macerated galley waste		✓					✓	✓		✓								E1	App E
Discharge of bilge water		✓					✓	✓		✓								E1	App E
Noise from drilling activity								✓		✓								D3	8.3
Permitted discharge of WBM from top sections.	✓	✓				✓	✓	✓									✓	E3	8.2
Processed drill cuttings discharged overboard	✓	✓				✓	✓	✓									✓	E3	8.2
Discharge of thermally treated cuttings	✓	✓				✓	✓	✓									✓	E3	8.2
Emissions from thermal treatment plant			✓		✓											✓		E1	App E
Discharge of cement	✓	✓				✓	✓	✓									✓	E1	8.2
Aqueous discharges from tug / transport vessel(s)		✓					✓	✓		✓								E1	App E
VOCs from mud usage and fuel transfer			✓		✓											✓		E1*	8.5
Spud cans removal	✓	✓				✓	✓	✓										E2	8.1
Demobilisation of the rig (5 years after drilling commences)												✓	✓					E1	App E
Installation and drilling from the jack-up drilling rig - Emergency / Contingency events																			
Onshore disposal of solid waste			✓	✓	✓													C1	App E
Scour and rig stabilisation	✓					✓	✓	✓										C3	8.1
Installation and drilling from the jack-up drilling rig – Accidental events																			
Well blowout (crude oil)	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	A3*	8.6
Hydrocarbon spills of fuel (aviation and diesel)	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	B3*	8.6
Spill of chemicals or mud (loss of on-board containment)	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	C2*	8.6
Objects dropped into the sea	✓					✓	✓	✓										B1	App E

Table 7.6 continued: Risk assessment of the Mariner field drilling activities

Drilling

Key
- 🟥 **High risk**
- 🟨 **Medium risk**
- 🟩 **Low risk**
- ⬜ **Insignificant**

These impacts have been discussed in **Chapter 8, as they represent a cumulative impact on atmospheric emissions from the Mariner Area Development*

Drilling	Physical and Chemical					Biological						Socioeconomic				Transboundary effects	Stakeholder concerns	Overall significance	Justification: section / reference
	Sediment structure / chemistry	Water quality	Use of resources	Use of disposal facilities	Air quality (local)	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Marine mammals	Integrity of conservation sites	Commercial fishing	Shipping	Military operations	Other users				
Drilling from the PDQ - Planned events																			
Overboard discharge from non-hazardous drains		✓					✓	✓		✓								🟩 E1	**App E**
Discharge of bilge water		✓					✓	✓		✓								🟩 E1	**App E**
Discharge of sewage		✓					✓	✓		✓								🟩 E1	**App E**
Onshore disposal of solid waste (operational, OBM)			✓	✓														🟩 C2	**App E**
Noise from drilling activities								✓		✓								🟨 D3	**8.3**
Permitted discharge of WBM from tophole sections.	✓	✓				✓	✓	✓									✓	🟨 E3	**8.2**
VOCs from mud usage and fuel transfer			✓		✓											✓		🟩 E1*	**8.5**
Discharge of thermally treated cuttings		✓					✓	✓										🟨 E2	**8.2**
Discharge of cement	✓	✓				✓	✓	✓									✓	🟨 E3	**8.2**
Drilling from the PDQ - Emergency / Contingency events																			
Onshore disposal of solid waste			✓	✓	✓													🟩 C1	**App E**
Drilling from the PDQ - Accidental events																			
Well blowout (crude oil)			✓	✓	✓													🟩 A3*	**8.6**
Collision with gross fuel loss	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	🟩 B3*	**8.6**
Hydrocarbon spill of fuel (aviation and diesel)	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	🟩 B3*	**8.6**
Spill of chemicals and mud (loss of onboard containment)	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	🟩 C2*	**8.6**
Objects dropped into the sea	✓					✓	✓	✓										⬜ B1	**App E**

Table 7.7: Risk assessment of the Mariner East field drilling activities

Installation of the PDQ

Key

- 🟥 **High risk**
- 🟨 **Medium risk**
- 🟩 **Low risk**
- ⬜ **Insignificant**

These impacts have been discussed in **Chapter 8, as they represent a cumulative impact on atmospheric emissions from the Mariner Area Development*

	Physical and Chemical					Biological						Socioeconomic							
	Sediment structure / chemistry	Water quality	Use of resources	Use of disposal facilities	Air quality (local)	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Marine mammals	Integrity of conservation sites	Commercial fishing	Shipping	Military operations	Other users	Transboundary effects	Stakeholder concerns	Overall significance	Justification: section / reference
Planned events																			
Mobilisation of rig to location												✓	✓					🟩 E1	**App E**
Ballast water discharge from transport vessel(s)		✓					✓	✓								✓		🟩 E1	**App E**
Spud can placement from jack-up rig	✓	✓				✓	✓	✓									✓	🟨 E2	**8.1**
Gaseous emissions from vessels and jack-up rig			✓		✓											✓		🟨 E3	**8.5**
Physical presence of jack-up rig and vessels												✓	✓					🟩 E1*	**8.4**
Power generation from drilling rig (cumulative with PDQ)			✓		✓											✓		🟨 E3	**8.5**
Overboard discharge of non-hazardous drains		✓					✓	✓		✓								🟩 E1	**App E**
Discharge of sewage and macerated galley waste		✓					✓	✓		✓								🟩 E1	**App E**
Discharge of bilge water		✓					✓	✓		✓								🟩 E1	**App E**
Noise from drilling activity								✓		✓								🟨 D3	**8.3**
Permitted discharge of WBM from top sections.	✓	✓				✓	✓	✓									✓	🟨 E3	**8.2**
Processed drill cuttings discharged overboard	✓	✓				✓	✓	✓									✓	🟨 E3	**8.2**
Discharge of thermally treated cuttings	✓	✓				✓	✓	✓									✓	🟨 E3	**8.2**
Emissions from thermal treatment plant			✓		✓											✓		🟩 E1	**App E**
Discharge of cement	✓	✓				✓	✓	✓									✓	🟨 E3	**8.2**
Aqueous discharges from tug/transport vessel(s)		✓					✓	✓		✓								🟩 E1	**App E**
VOCs from mud usage and fuel transfer			✓		✓											✓		🟩 E1*	**8.5**
Spud cans removal	✓	✓				✓	✓	✓										🟨 E2	**8.1**
Demobilisation of the rig (after 5 years of the first production)												✓	✓					🟩 E1	**App E**
Emergency / Contingency events																			
Onshore disposal of solid waste			✓	✓	✓													🟩 C1	**App E**
Scour and rig stabilisation	✓					✓	✓	✓										🟨 C3	**8.1**
Accidental events																			
Well blowout (crude oil)	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	🟩 A3*	**8.6**
Hydrocarbon spills of fuel (aviation and diesel)	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	🟩 B3*	**8.6**
Spill of chemicals or mud (loss of on-board containment)	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	🟩 C2*	**8.6**
Objects dropped into the sea	✓					✓	✓	✓										⬜ B1	**App E**

Table 7.8: Risk assessment of the activities associated with the installation of the PDQ

Installation of the PDQ

Key

🟥 **High risk**
🟨 **Medium risk**
🟩 **Low risk**
⬜ **Insignificant**

These impacts have been discussed in **Chapter 8, as they represent a cumulative impact on atmospheric emissions from the Mariner Area Development*

Installation of the PDQ	Physical and Chemical					Biological						Socioeconomic							
	Sediment structure / chemistry	**Water quality**	**Use of resources**	**Use of disposal facilities**	**Air quality (local)**	**Sediment biology (benthos)**	**Water column (plankton)**	**Finfish and shellfish**	**Seabirds**	**Marine mammals**	**Integrity of conservation sites**	**Commercial fishing**	**Shipping**	**Military operations**	**Other users**	**Transboundary effects**	**Stakeholder concerns**	**Overall significance**	**Justification: section / reference**
Planned events																			
Physical presence of vessels												✓	✓					🟩 E1*	**8.4**
Noise from DP of SSCV lift / crane vessel for PDQ jacket and topsides								✓		✓							✓	🟨 E2	**8.3**
Aqueous discharges from vessels		✓					✓	✓								✓		🟩 E1	**App E**
Discharge of sewage and macerated galley waste from vessels		✓					✓	✓								✓		🟩 E1	**App E**
Discharge of treated bilge water from vessels		✓					✓	✓								✓		🟩 E1	**App E**
Onshore disposal of solid waste from vessels			✓	✓														🟩 E1	**App E**
Power generation from installation vessels			✓		✓													🟩 E1*	**8.5**
Placement of jacket on the seabed	✓	✓				✓	✓	✓									✓	🟨 E2	**8.1**
Noise from piling jacket to seabed and vessels								✓		✓						✓	✓	🟨 E3	**8.2**
Installation of protective structures (e.g. mud mats)	✓	✓				✓	✓	✓										🟩 E1	**App E**
Accidental events																			
Leakage of hydraulic fluid during the piling operations		✓					✓	✓	✓	✓								🟩 C2	**App E**
Hydrocarbon spill of fuel (aviation and diesel)	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	🟩 B3*	**8.6**
Objects dropped into the sea	✓					✓	✓	✓										B1	**App E**

Table 7.9: Risk assessment of the activities associated with the installation of the FSU

Installation of the FSU **Key** 🟥 **High risk** 🟨 **Medium risk** 🟩 **Low risk** ⬜ **Insignificant** ***These impacts have been discussed in **Chapter 8**, as they represent a cumulative impact on atmospheric emissions from the Mariner Area Development*	**Physical and Chemical**					**Biological**						**Socioeconomic**							
	Sediment structure / chemistry	**Water quality**	**Use of resources**	**Use of disposal facilities**	**Air quality (local)**	**Sediment biology (benthos)**	**Water column (plankton)**	**Finfish and shellfish**	**Seabirds**	**Marine mammals**	**Integrity of conservation sites**	**Commercial fishing**	**Shipping**	**Military operations**	**Other users**	**Transboundary effects**	**Stakeholder concerns**	**Overall significance**	**Justification: section / reference**
Planned events																			
Physical presence of vessels												✓	✓					E1*	**8.4**
Placement of the anchors, moorings	✓					✓		✓									✓	E3	**8.1**
Placement of transponders and subsea positioning	✓					✓		✓										E1	**App E**
Attachment of the mooring lines to seabed (suction)	✓					✓		✓										E3	**8.1**
Attachment of the mooring lines to seabed(noise from piling)	✓					✓		✓		✓								E3	**8.3**
Power generation from installation vessels (gaseous emissions)			✓		✓													E1*	**8.5**
Aqueous discharges		✓					✓	✓								✓		E1	**App E**
Discharge of sewage & macerated galley waste		✓					✓	✓								✓		E1	**App E**
Onshore disposal of solid waste			✓	✓														E1	**App E**
Underwater noise from vessels and FSU								✓		✓						✓	✓	E3	**8.3**
Discharge of ballast water		✓					✓	✓		✓								E1	**App E**
VOCs from fuel transfer			✓		✓											✓		E1	**App E**
Emergency / Contingency events																			
Scour stabilisation	✓					✓		✓										C2	**App E**
Accidental events																			
Hydrocarbon spill e.g. collision and loss of fuel	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	B3*	**8.6**
Objects dropped into the sea	✓					✓	✓	✓										B1	**App E**

Table 7.10: Risk assessment of the activities associated with the installation of the pipelines, umbilicals and subsea structures

Key

🟥 **High risk**
🟨 **Medium risk**
🟩 **Low risk**
⬜ **Insignificant**

*These impacts have been discussed in **Chapter 8**, as they represent a cumulative impact on atmospheric emissions from the Mariner Area Development*

Installation of the pipelines, umbilicals and subsea structures	**Physical and Chemical**					**Biological**						**Socioeconomic**							
	Sediment structure / chemistry	**Water quality**	**Use of resources**	**Use of disposal facilities**	**Air quality (local)**	**Sediment biology (benthos)**	**Water column (plankton)**	**Finfish and shellfish**	**Seabirds**	**Marine mammals**	**Integrity of conservation sites**	**Commercial fishing**	**Shipping**	**Military operations**	**Other users**	**Transboundary effects**	**Stakeholder concerns**	**Overall significance**	**Justification: section / reference**
Planned events																			
Physical presence of vessels												✓	✓					E1*	**8.4**
Gaseous emissions from vessels			✓		✓													E1.	**8.5**
Discharge of treated bilge water		✓					✓	✓								✓		E1	**App E**
Discharge of sewage and macerated waste		✓					✓	✓								✓		E1	**App E**
Underwater noise from pipe-laying and trenching vessels								✓		✓						✓	✓	E3	**8.3**
Option: Trench and backfill of pipelines, umbilicals and cables: ploughing	✓	✓				✓	✓	✓				✓					✓	E3	**8.1**
Option: Trench and backfill of pipelines, umbilicals and cables: water jet	✓	✓				✓	✓	✓				✓					✓	E3	**8.1**
Rock-dumping at pipeline ends	✓	✓				✓	✓	✓				✓					✓	E3	**8.1**
Leak testing and commissioning of pipelines		✓					✓	✓		✓								E1*	**8.2**
Rock-dumping at pipeline crossings	✓	✓				✓	✓	✓				✓					✓	E3	**8.4**
Placement of manifold (PLEM) on the seabed	✓	✓				✓	✓	✓				✓					✓	E2	**8.1**
Underwater noise from piling the PLEM								✓		✓						✓	✓	E3	**8.3**
Emergency / Contingency events																			
Additional rockdump	✓	✓				✓	✓	✓				✓					✓	C3	**8.1**
Accidental events																			
Loss of hydraulic fluid during the piling	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	B3	**App E**
Failure during the pipeline testing	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	C2*	**8.6**
Pipeline leak / rupture	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	C2*	**8.6**
Spill of fuel from vessel collision	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	B3*	**8.6**
Spills of chemicals and muds	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	C2*	**8.6**
Objects dropped into the sea	✓					✓	✓	✓										B1	**App E**

Table 7.11: Risk assessment of the activities associated with production activities

Key

- 🟥 **High risk**
- 🟨 **Medium risk**
- 🟩 **Low risk**
- ⬜ **Insignificant**

*These impacts have been discussed in ***Chapter 8***, as they represent a cumulative impact on atmospheric emissions from the Mariner Area Development*

Production activities	**Physical and Chemical**					**Biological**						**Socioeconomic**				**Transboundary effects**	**Stakeholder concerns**	**Overall significance**	**Justification: section / reference**
	Sediment structure / chemistry	**Water quality**	**Use of resources**	**Use of disposal facilities**	**Air quality (local)**	**Sediment biology (benthos)**	**Water column (plankton)**	**Finfish and shellfish**	**Seabirds**	**Marine mammals**	**Integrity of conservation sites**	**Commercial fishing**	**Shipping**	**Military operations**	**Other users**				
PDQ Topsides - Planned events																			
Power generation from turbines, heaters, generators			✓		✓													🟩 E1*	**8.5**
Physical presence of the vessels												✓	✓					🟩 E1*	**8.4**
Produced water discharge when not reinjected		✓					✓	✓									✓	🟨 E2	**8.2**
Drainage discharges		✓					✓	✓									✓	🟩 E1	**App E**
Chemical usage/ discharge		✓					✓	✓		✓								🟩 E1	**App E**
Flaring of excess gas					✓											✓	✓	🟨 E2	**8.5**
Operational flaring					✓											✓	✓	🟨 E2	**8.5**
Cooling water discharge		✓					✓	✓										🟩 E1	**App E**
Overboard disposal of sand		✓					✓	✓										🟩 E1	**App E**
FSU operation - Planned events																			
Physical presence of vessels												✓	✓					🟨 E2	**8.4**
VOC emissions from tandem transfer to shuttle tankers					✓											✓	✓	🟨 E3	**8.5**
Shuttle tanker fuel use, power generation and emissions			✓		✓				✓							✓		🟨 E3	**8.5**
FSU diesel generators emissions			✓		✓													🟩 E1*	**8.5**
Discharge of treated bilge water		✓					✓	✓								✓		🟩 E1	**App E**
Discharge of sewage and macerated waste		✓					✓	✓								✓		🟩 E1	**App E**
Drainage discharge		✓					✓	✓								✓		🟩 E1	**App E**
Ballast water discharges		✓					✓	✓		✓								🟩 E1	**App E**
Pipelines, Umbilical and Cables - Planned events																			
Presence of buried pipelines and umbilicals												✓					✓	🟩 C2*	**8.4**
Presence of rockdump												✓					✓	🟨 D2	**8.4**
Wastage of anodes		✓					✓											🟩 E1	**App E**
Emergency / Contingency events																			
Additional chemical usage			✓	✓	✓													🟩 D1	**App E**

Table 7.11 continued: Risk assessment of the activities associated with production activities

Production activities **Key** 🟥 **High risk** 🟨 **Medium risk** 🟩 **Low risk** ⬜ **Insignificant** **These impacts have been discussed in **Chapter 8**, as they represent a cumulative impact on atmospheric emissions from the Mariner Area Development*	**Physical and Chemical**					**Biological**						**Socioeconomic**							
	Sediment structure / chemistry	**Water quality**	**Use of resources**	**Use of disposal facilities**	**Air quality (local)**	**Sediment biology (benthos)**	**Water column (plankton)**	**Finfish and shellfish**	**Seabirds**	**Marine mammals**	**Integrity of conservation sites**	**Commercial fishing**	**Shipping**	**Military operations**	**Other users**	**Transboundary effects**	**Stakeholder concerns**	**Overall significance**	**Justification: section / reference**
Accidental events																			
Pipeline rupture leading to hydrocarbon spill	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	C2*	**8.6**
Loss of hydraulic fluid during operations		✓	✓		✓		✓	✓	✓	✓								B3*	**8.6**
Spills during transfer to and from shuttle tankers	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	C2*	**8.6**
Anchor chain and riser failure resulting in oil spill	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	C2*	**8.6**
Collision of FSU, PDQ, shuttle tanker or support vessels with gross fuel loss	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	C3	**8.6**
Spills of aviation and diesel fuel	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	B3*	**8.6**

Table 7.12: Risk assessment of the activities associated with decommissioning activities

Production activities **Key** 🟥 **High risk** 🟨 **Medium risk** 🟩 **Low risk** ⬜ **Insignificant** **These impacts have been discussed in **Chapter 8**, as they represent a cumulative impact on atmospheric emissions from the Mariner Area Development*	**Physical and Chemical**					**Biological**						**Socioeconomic**							
	Sediment structure / chemistry	**Water quality**	**Use of resources**	**Use of disposal facilities**	**Air quality (local)**	**Sediment biology (benthos)**	**Water column (plankton)**	**Finfish and shellfish**	**Seabirds**	**Marine mammals**	**Integrity of conservation sites**	**Commercial fishing**	**Shipping**	**Military operations**	**Other users**	**Transboundary effects**	**Stakeholder concerns**	**Overall significance**	**Justification: section / reference**
Vessel operations - Planned events																			
Physical presence												✓	✓					🟩 E1*	**8.4**
Discharge of bilge water		✓					✓	✓								✓		🟩 E1	**App E**
Discharge of sewage		✓					✓	✓								✓		🟩 E1	**App E**
Wells - Planned events																			
Well plugging and abandonment	✓	✓				✓	✓											🟩 E1	**App E**
Mechanical cutting of casing								✓		✓								🟩 E1	**App E**
Retrieve and dispose of wellheads	✓	✓	✓	✓														🟩 E1	**App E**
Presence of cuttings piles	✓	✓				✓	✓	✓										🟨 E2	**8.2**
Removal of the FSU - Planned events																			
FSU removal (including removal of anchors and moorings)	✓	✓				✓	✓	✓				✓	✓					🟩 E1	**App E**
Recycling / disposal onshore			✓	✓														🟩 E1	**App E**
Removal of the PDQ - Planned events																			
Remove platform	✓	✓				✓	✓	✓				✓	✓					🟩 E1	**App E**
Recycling / disposal onshore			✓	✓														🟩 E1	**App E**
Pipelines - Planned events																			
Removal of concrete mattresses, rock-dumping and crossings	✓	✓				✓	✓	✓				✓	✓					🟩 E1	**App E**
Presence of buried pipelines	✓											✓						🟩 E1*	**8.4**
Recycling and/or disposal of materials onshore			✓	✓														🟩 E1	**App E**
Accidental events																			
Hydrocarbon spill e.g. from collision	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	🟩 B3*	**8.6**
Objects dropped into the sea	✓					✓	✓	✓										B1	**App E**

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8 SIGNIFICANT IMPACTS

This section discusses in greater detail the potential impacts (including cumulative, transboundary and global impacts), which were identified in the assessment process (**Section 7**) as being of “medium” risk to the environment. The discussions within each of the following sections take into consideration the mitigation measures that Statoil will have in place when undertaking the proposed operations at the Mariner Area Development:

- localised disturbance to the seabed arising from the drilling and installation activities **(Section 8.1);**
- the discharges to sea from the Mariner Area Development **(Section 8.2);**
- underwater noise arising from subsea installation activities **(Section 8.3);**
- the long-term physical presence of the PDQ, FSU, drilling rigs, pipelines and other subsea structures on the seabed **(Section 8.4);**
- atmospheric emissions arising from the drilling, installation and production activities **(Section 8.5).**

Although the probability of occurrence is very low, the following emergency events are also considered as being of significance to the environment:

- accidental hydrocarbon release **(Section 8.6)**

8.1 Localised physical disturbance to the seabed arising from the drilling and installation activities

This section discusses potential short and longer-term environmental impacts associated with the presence of the development including the placement of the jacket structures for the drilling rig and the PDQ, the mooring system of the FSU, subsea infrastructure, pipeline installation vessels and various support vessels. It also describes the measures taken or planned by Statoil to minimise disturbance to the seabed and the associated environmental receptors.

Any physical disturbance arising as a result of the proposed Mariner Area Development will be managed according to, but not limited to, the following legislation:

- Under the Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001) (as amended) the protection of habitats and species (under the European Directives) in relation to oil and gas activities, such as the Mariner Area Development, are implemented in all UK waters.

- The Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007 (as amended 2010) implement the Birds Directive and Habitats Directive in relation to UK marine areas beyond the territorial sea. These Regulations make provision for the selection, registration and notification of European Offshore Marine Sites in the offshore marine area and for the management of these sites.

- Under the Marine & Coastal Access Act 2009 and the Marine (Scotland) Act 2010 Statoil need to ensure protection for the marine environment and biodiversity in relation to a number of activities associated with the Mariner Area Development, such as the removal of materials from the seabed, and disturbance of the seabed.

- Under the Environmental Liability European Directive (2004/35/EC) 2009 and the Environmental Liability (Scotland) Regulations Directive 2009, Statoil have liability for the prevention and remediation of environmental damage to ‘biodiversity’, water and land from specified activities and remediation of environmental damage for all other activities through fault or negligence.

8.1.1 Methodology

8.1.1.1 Anchor Handling Vessel (AHV) footprint

To quantify the seabed impact from the anchoring activities associated with the AHVs the following assumptions have been made:

- The anchors are repositioned by AHVs and dropped in a corridor between 2 and 3 km wide centred on the pipeline. Each anchor is advanced about 650 m which results in a total of 24 anchor drops being made within the pipe-lay corridor for each 1,300 m advanced (24 drops in an area of 2.8 m^2 (i.e. 0.0028 km^2)) (Hartley Anderson Limited, 2001).

- The anchor type is selected according to sediment and weather/current conditions of the area and is normally either 12 tonne high efficiency seabed penetrating anchors or 25 tonne anchors with dimensions approximately 4 by 4 metres (EnCana, 2006).

- Each anchor is connected with a barge first through a chain and then trough a wire (typically 75 mm diameter) which is in contact with the seafloor with 2 m of chain movement either side (i.e. 4 m lateral movement in total) for each chain (Hartley Anderson Limited, 2001).

- During the tensioning of the anchor wires approximately one third of the anchor chain and cable are in contact with the seabed and anchor chains lying on, and sweeping over the sediments can create gouges, scour marks and mounds of up to 1 m high, depending on the nature of the sediments (Cordah, 2001).

- AHVs support pipeline S-lay or reel-lay barges that usually have an array of 12 to 14 anchors which are redeployed in sequence during pipe-laying.

8.1.1.2 Pipelines Trenching and Backfilling

Large diameter (greater than 16”) pipelines are typically laid directly onto the surface of the seabed while smaller ones are normally trenched into it to a depth of about 1 m (HSE, 1999; Harley Anderson Limited, 2001; Cordah, 2001). Trenching by a plough is usually undertaken in a single pass, where a plough is towed through the seabed by a vessel, creating a ‘V’ shaped trench in the seabed. As the trench is cut, the spoil is pushed away from the edge of the trench by mould boards. The open trench is backfilled using a mechanical backfill plough. The trenching and backfilling processes will result in disturbance to the seabed.

In order to quantify the footprint and the area of impact of a pipeline, the following assumptions have been made:

- The bottom angle of the pipeline trench is approximately 120° **(Figure 8.1)**
- The depth of the pipeline burial is equal to 1 m measured from the top of the pipeline **(Figure 8.1)**
- The area of impact during pipeline burial is considered to be within 10 m on each side of the pipeline trench created by displacement material (OSPAR, 2009a; **Figure 8.1)**

To estimate the footprint area of a trenched pipeline the following equation has been used:

A' (footprint area) = Length of pipeline x W' (width of the trench)

The width of the pipeline trench using:

$$W' = 2 \times ((\tan 60° \times (h' + D'))$$

where h' is the depth of the pipeline burial and D' is the pipeline diameter (**Figure 8.1**).

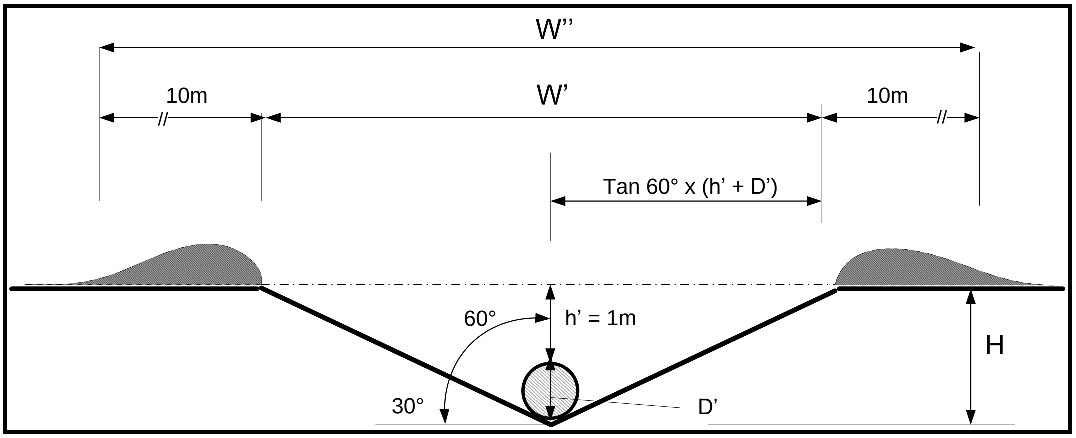


Figure 8.1: Cross section of a trenched pipeline

Pipeline burial results in an impact during the installation phase because of considerable disturbance of the seabed and mobilisation of sediment. The volume and distance that suspended sediments disperse depends on particle size, weight and current velocity. The area of impact during pipeline burial is considered to be within 10 m of the line, but once buried pipelines usually have insignificant impacts (OSPAR, 2009a).

Therefore, it is estimated that ploughing and mechanical backfilling will generate a displacement of material on both sides of the pipeline trench with a maximum width of 20 m (0.02 km) per pipeline and umbilical.

The physical impact to the seabed associated with the proposed Mariner Area Development activities have been addressed in the sections below.

8.1.2 Sources of Potential Impact

Localised physical disturbance to the seabed as a result of the Mariner Area Development will arise as a result of:

Anchoring activities

- Anchoring of AHV and moorings installation for positioning of Mariner drilling rig
- Anchoring of semi-submersible drilling rig at Mariner East
- Anchoring of the mooring system and FSU turret on location
- Potential anchoring of AHV during pipeline installation
- Placement of DMA on the seabed during pipe-lay initiation

Installation of Mariner Drilling Rig and the PDQ jacket

- Placement of PDQ jacket
- Jacking-down the drilling rig legs for both Mariner and Mariner east fields

Pipeline and umbilical installation

- Mechanical trenching and backfilling operations of pipelines, umbilicals and cable
- Spot rock-dumping for protection along the pipelines, cables and pipeline crossings
- Surface laid cable installation

Installation of subsea structures

- Rockdump for levelling one PLEM and six PLETs
- Placement of one PLEM and six PLETs on the seabed
- Installation of the Mariner East subsea template

- installing the Xmas trees, manifolds and riser bases

Physical disturbance of the seabed can cause direct environmental impacts such as smothering of local fauna, mortality of benthic organisms and loss of habitat. Indirect environmental impacts can be caused by sediment re-suspension and subsequent burial of the local fauna coupled with re-mobilisation of historical contaminants from existing sediment sinks.

8.1.2.1 Anchoring activities

Mariner field wells will be drilled from the PDQ platform and a jack-up drilling rig, whist Mariner East wells will be drilled via a semi-submersible drilling rig. Anchor Handling Vessels (AHVs) will be required to position the drilling rig to the PDQ at the targeted locations at Mariner field using a pre-determined anchored pattern. The semi-submersible drilling rig will be held and maintained on station at Mariner East with four to eight anchors. The anchors will be attached to the drilling rig with a chain or chain and cable combination, with approximately 300 m of chain per anchor in contact with the seabed, providing additional holding capacity.

The estimated area of seabed that would be impacted during positioning of the Mariner drilling rig is estimated to be 0.017 km^2 (0.0012 km^2 x 14 anchors) assuming the placement of 14 anchors (with dimensions 4 m by 4 m) and with 300m of chain on the seabed for each anchor (Cordah, 2001) with 2 m of chain movement either side (i.e. 4 m lateral movement in total) for each chain (Hartley Anderson Limited, 2001).

The estimated area of seabed that will be impacted at the Mariner East location as a result of anchoring the semi-submersible rig is 0.0097 km^2 (0.0012 km^2 x 8 anchors) assuming 300 m of chain on the seabed for each anchor and 2 m of chain movement either side (i.e. 4 m lateral movement in total) for each chain (**Table 8.1**).

Statoil has not yet decided whether the anchoring of the mooring system will be based on suction anchors or piles driven into the sediment. In terms of impacts to the seabed, however, the worst case scenario of using suction anchors has been taken into account as suction anchors will create greater footprint on the seabed. The estimated area of seabed that will be impacted as a result of anchoring the FSU on position is 0.0021 km^2 comprising of 16 mooring lines, attached to the seabed suction anchor system, in four separate clusters. The diameter of each suction pile anchor is 6.5 m (**Table 8.1**).

At this stage, it is not known whether the Mariner Area Development pipelines, umbilical and cable will be installed by an AHV, a dynamically positioned (DP) reel-lay vessel or a DP S-lay vessel. To account for the worst-case scenario for the physical impact to the seabed, it is assumed that an anchored S-lay barge will maintain its position by the vessel's anchoring system, supported by AHVs. The entire length of trenched and buried pipelines and umbilical required for the proposed Mariner Area Development is approximately 50 km (**Table 8.3**). Assuming that AHVs use 24 anchor drops per 1300 m, which is equal to a 2.8 m^2 anchor footprint on the seabed (Harley Anderson Limited, 2001), the entire length of the pipe-laying activities would require approximately 98 anchors to be deployed on the seabed. This would generate a total footprint of about 0.000011 km^2.

In addition, for the initiation of the pipe-laying activities during the installation of the gas import pipeline from Vesterled to Mariner PDQ, Statoil intends to use DMA which is assumed to have standard dimensions of 6.5 m by 6.5 m (**Table 8.1**).

Table 8.1: Summary of the footprint disturbance from the anchoring activities at Mariner Area Development.

Vessel requiring anchoring	Dimensions (km)	Number of anchors	Total footprint area (km^2)
Total disturbance from Mariner Area Development anchoring activities			
AHV positioning of Mariner East semi-submersible drilling rig	$(0.004^2)+(0.3x0.004)$	14	0.017
Anchoring of semi-submersible rig	0.91 x 0.004	8	0.0097
FSU positioning on location	$(0.0065)^2$ x 3.14	16	0.0021
AHVs during pipe-laying activities	0.0000028 km^2	98	0.000011
DMA clump anchor for pipe-laying initiation	0.0065 x 0.0065	1	0.00004
Total area of disturbance from proposed anchoring activities			**0.028**

Therefore the total seabed footprint generated as a result of the anchoring activities from the proposed Mariner Area Development is 0.028 km^2.

8.1.2.2 Installation of Jack-up Drilling Rig and the PDQ jacket

PDQ jacket

The steel jacket structure of the PDQ will be piled to the seabed and the Mariner jack-up legs will be jacked-down using ballast water to settle the rig position. During drilling rig installation at the Mariner field, mooring and positioning lines will be required to winch the jack-up drilling rig in position close to the PDQ.

The PDQ jacket structure (88 m in length and 62 m in width, at seabed) will be secured to the seabed via a total of 24 vertical skirt piles, 6 piles in each corner with diameter of 2.438 m (96”). The total footprint area for the PDQ jacket steel structure is 0.005 km^2 with a total footprint for the four jacket legs of 0.00004 km^2 (**Table 8.2**)

Mariner Jack-Up Drilling Rig

It is not known which drilling contractor or specific jack-up drilling rig will be used by Statoil for the drilling at the Mariner field, however, Statoil are intending on using a typical CJ70 jack-up rig at the Mariner field. The total footing area from the rig specification for the jack-up rig is expected to be 0.0004 km^2 (380 m^2) (**Table 8.2**).

Table 8.2: Summary of the footprint disturbance from the jacket placement at the Mariner Area Development.

Equipment/inventory to be installed	Dimensions (km)	Total footprint area (km^2)
Total disturbance from Mariner Area Development jacket placement		
Total footprint of the PDQ jacket	0.088 x 0.062	0.005
PDQ platform jacket (4 legs)	0.0000015 x 24 piles	0.00004
Jack-up placement on the seabed	0.019 x 0.019	0.0004
Total area of disturbance from jacket placement		**0.0054**

Therefore the total footprint area generated as a result of the PDQ jacket placement is 0.0054 km^2.

The Mariner jack-up drilling rig will remain on site for a period of five years, while the Mariner East drilling rig will remain on site for a period of eight months.

8.1.2.3 Pipeline and umbilical installation

Trenching and backfilling operations of pipelines, umbilicals and cable.

The pipelines and umbilical will be trenched by plough, with mechanical backfill. The depth of the trench for the pipelines is to be a minimum of 1 m to the crown of the individual or piggybacked pipelines. The umbilicals will be trenched and backfilled to a depth of approximately 0.6 m to the top of the umbilical.

Trenching the pipelines and umbilicals by plough will disturb the seabed sediments and benthic organisms along the route of the trenches and the organisms in a narrow corridor next to the trench (0.01 km on each side) (OSPAR, 2009a) will be buried by displaced material. It is therefore estimated that the total width of seabed affected by the ploughing and mechanically backfilling operations would result in a maximum width of 0.024 km per pipeline and umbilical. Consequently, the total footprint of the pipe-laying activities will be 0.155 km^2

and the calculated total area affected by the proposed ploughing and trenching operations would be 3.02 km^2 (**Table 8.3**).

Table 8.3: Summary of the footprint disturbance from the pipe-laying activities at Mariner Area Development.

Equipment/inventory to be installed	Length (km)	Total footprint area (km^2)	Total impact area (km^2)
Trenched and buried Mariner Area Development pipelines and umbilical			
6” Gas import pipeline connecting the PDQ to the 32” Vesterled pipeline	~33	0.14	0.84
6” diluent import pipeline connecting the PDQ to the FSU;	~2.4	0.0003	0.06
10” crude export pipeline connecting the PDQ to the FSU	~2.6	0.0006	0.06
12 ¾” crude export pipeline connecting the Mariner East template to the PDQ	~6.4	0.0023	0.156
Umbilical to connect the Mariner East template to the PDQ;	6.5	0.0023	0.156
Communication cable between the PDQ and the Heimdal platform	73	0.009	1.75
Total area of disturbance from pipe-lay activities		**0.155**	**3.02**

The electrical cable for the power supply between Mariner East subsea template and the FSU turret will be surface laid. Statoil are planning to supply the electrical power to the Mariner East via umbilical. However, in case there are configuration difficulties associated with manufacturing of such multi-purpose umbilical, a separate electrical supply cable will be required (**Table 8.4**).

Table 8.4: Summary of the footprint disturbance from the surface laid cable installation at Mariner Area Development.

Equipment/inventory to be installed	Length (km)	Total footprint area (km^2)
Surface laid Mariner Area Development cables		
Electrical cable between Mariner East subsea template and the FSU turret (5”)	5	0.0006
Total area of disturbance from cable lay activities		**0.0006**

The total area of the seabed expected to be disturbed is 0.0006 km^2 (**Table 8.4**).

8.1.2.4 Installation of subsea structures

One PLEM and six PLET manifolds will be installed during the Mariner Area Development as gravity based structures lowered on rockdumped matrixes (**Section 3.6.5**). The footprint of the PLEM and PLETs and the other subsea structures is summarised in **Table 8.5**.

Table 8.5: Summary of the footprint disturbance from the subsea installation at Mariner Area Development

Equipment / inventory to be installed	Dimensions (km)	Total footprint area (km^2)
Total disturbance from Mariner Area Development		
PLEM, to connect the 6” gas import pipeline to the 32” Vesterled pipeline	0.015 x 0.010	0.00015
PLET to connect the 6” diluent import pipeline to the PDQ;	0.003 x 0.004	0.000012
PLET to connect the 6” diluent import pipeline to the FSU	0.003 x 0.004	0.000012
PLET to connect the 10” crude export pipeline to the PDQ	0.003 x 0.004	0.000012
PLET to connect the 10” crude export pipeline to the FSU	0.003 x 0.004	0.000012
PLET to connect the 6” gas import pipeline to the PDQ	0.003 x 0.004	0.000012
PLET for 14” crude export pipeline between the Mariner East and the PDQ	0.003 x 0.004	0.000012
SSIV installation	0.004 x 0.003	0.000012
Installation of the Mariner East subsea template	0.02 x 0.03	0.0006
Total area of disturbance from installation of subsea structures		**0.0008**

Spot Rockdump and concrete mattresses

Spot rock-dumping may be required at various locations along Mariner Area Development pipelines to mitigate against upheaval buckling (UHB). Statoil anticipate a maximum area of footprint of 60,000 m^3 of rock dump would be required to prevent UHB and free span at the pipeline ends (transition zones and at pipeline crossings). In addition, approximately 10,000 m^2 of rockdump will be laid underneath the PLEM and PLETs (**Section 3.6.8** and **3.6.10**). To prevent scour around the jacket legs gravel dumping (maximum 3,000 tonnes) may be required if the soil conditions are determined to be unsuitable for the jack-up foundations. Under a worst case scenario, Statoil anticipate a maximum of 200,000 m^3 of rock dump would be required for the pipelines and 300,000 m^3 of rock dump would be required for the fibre optic cable (**Section 3.6.10**).

Table 8.6: Summary of the footprint disturbance to the seabed from the rock-dumping activities at Mariner Area Development.

Equipment/inventory to be installed	Mass (m^3)	Total footprint area (km^2)
Total disturbance area from rock-dumping		
Rock dumping along the pipelines	200,000	0.1
Rock dump at the foundations of PLEMs and PLETs	10,000	0.05
Rock dumping along the fibre optic cable	300,000	0.015
Contingency rock dump against scout at the jacket legs	3,000	0.0015
Total area of disturbance from rock-dumping		**0.166**

** - estimations based on the assumption of 2 m height of the rock dump*

Concrete mattresses are planned to be used for separation of the gas import pipeline from the pipelines cluster Linnhe to Beryl and also over the communication cable (**Table 8.7**).

Table 8.7: Summary of the footprint disturbance to the seabed from the concrete mattresses protection at Mariner Area Development.

Equipment/inventory to be installed	Amount of mattresses	Dimensions (m)	Total footprint area (km^2)
Total disturbance area from concrete mattresses protection			
Total mattress protection	38	10 m x 3 m	0.0014
Total area of disturbance from concrete mattresses protection			**0.0014**

** Standard mattresses with dimensions 6 m x 3 m 0.15 m.*

8.1.2.5 Summary footprint area of seabed impacted

The total area of localised physical disturbance to the seabed arising from the Mariner Area Development is potentially 3.23 km^2. A summary of the seabed impacts arising from the proposed development activities is presented in **Table 8.8** and by project stage in **Table 8.9.**

Table 8.8: Summary of all equipment to be installed subsea and the potential total footprint.

Equipment / item to be installed subsea	Total area (km^2)
Disturbance from installation of all subsea equipment/items at the Mariner Area Development	
Anchoring activities	0.028
Installation of Mariner Jack-Up Drilling Rig and the PDQ jacket	0.0054
Pipeline and umbilical installation	3.03
Installation of subsea structures	0.0008
Spot rockdump	0.166
Concrete mattresses for pipeline and umbilical protection	0.0014
Total footprint area of disturbance from installation of all subsea equipment / items at the Mariner Area Development	**3.23**

Table 8.9: Summary of the seabed impacts by project stage.

Stage of Mariner Area Development	Total area (km^2)
Disturbance from drilling	
• AHV positioning of Mariner drilling rig	0.017
• Anchoring of semi-submersible rig	0.0097
• Jack-up rig footing area	0.0054
Subtotal	***0.0321***
Installation of FSU	***0.0021***
Disturbance from subsea installations	
• AHVs during pipe-lay activities	0.000011
• DMA clump anchor for pipe-lay initiation	0.00004
• Pipelines trenching and backfilling	3.03
• Rock dump	0.166
• Concrete mattresses	0.0014
• Cables	0.0006
• Manifolds	0.0008
Subtotal	**3.20**
Total	**3.23**

8.1.3 Impact to Receptors

8.1.3.1 Benthic environment

Anchoring, pipe-laying, placement of jackets, installation of subsea infrastructures and spot rock dump along the pipelines will cause direct impacts to invertebrates living on and in the sediments, as a result of physical disturbance to the sediments. The estimated total area of seabed impact is 3.23 km^2 (**Table 8.9**).

The disturbance from anchoring the semi-submersible drilling rig at Mariner East, during positioning of the Mariner drilling rig and the FSU and during AHVs anchoring during pipe-lay activities will be localised and temporary, confined to areas at the anchors and along the part of the chain that touches the seabed. Once the anchors are removed, the natural physical processes of sediment transportation and biological settlement will be expected to restore the seabed to its original condition. The proposed development could result in an estimated area of 0.0325 km^2 impacted due to the placement of anchors and jacket associated with drilling (**Table 8.9**).

In addition, anchors will be used to secure the FSU and the mooring system in position, and will result in loss of habitat over the lifespan of the Mariner Area Development, with consequent impacts on the benthic invertebrate community. However, this disturbance would be localised to an area of approximately 0.0021 km^2 (**Table 8.9**).

The trenching and backfilling of the pipelines and umbilical will disturb the seabed sediments and the benthic organisms living in or on these sediments. Again, this impact will be temporary and once the pipelines and umbilical have been buried, sediment transportation and biological settlement will be expected to restore the seabed to its original condition (OSPAR, 2009a). The mechanical trenching and backfilling of the Mariner Area Development pipelines and umbilical could potentially disturb an area of up to approximately 3.03 km^2 accounting for the suspension of sediments and displacement of sediment material on both sides of the pipeline trench (**Table 8.7**). This area of disturbance will be small in relation to the area of undisturbed similar habitat type and benthic fauna in this region of the northern North Sea and the overall ecological impact would be minor.

Once the subsea operations are completed, both disturbed and resettled sediment will be quickly re-colonised 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).

Published literature has stated that the recovery of the seabed to pristine conditions following chronic disturbance by fishing gears would be in the region of 2.5 to 6 years, depending on the dynamic nature of the area (Hiddink *et al*., 2006). It would be expected, however, that the short term, localised disturbance associated with the Mariner Area Development anchoring activities would result in a shorter recovery time.

Placement of protective spot rock dump and concrete mattresses protection will have an impact on the sediment structure of the seabed. This will result in a localised smothering of animals and an alteration of the local habitat through a change of substrate, although the impact will be limited to approximately 0.167 km^2 (0.166 km^2 for rock dump and 0.0014 km^2 mattresses protection; **Table 8.6** and **Table 8.7**). The areas of rockdump will create a habitat for benthic organisms that live on hard surfaces. Such organisms typically include tubeworms, barnacles, hydroids, tunicates and bryozoans, which are commonly found on submerged rocky outcrops, boulders and offshore structures rather than on sedimentary seabeds. These structures could also provide habitats for crevice-dwelling fish (e.g. ling, conger eel and wolf fish) and crustaceans (e.g. squat lobsters and crabs) (Lissner *et al*., 1991).

Subsea installation operations could also result in indirect impacts through disturbance or re-suspension of any contaminants on the seabed or buried beneath the surface sediments. Sediments that are re-suspended will drift with seabed currents before settling out over adjacent areas of seabed. These re-suspended sediments could have a minor impact on the local community of the area, until they become re-covered by natural sediment. In extreme cases, re-suspended sediments might cause some localised smothering of benthic communities, but otherwise it will be similar in effect to the natural process of sediment transport caused by currents and wave action. The current and wave energy in the Mariner Area Development area is “high” (**Section 4.3.2**). Analysis of sediment samples from the Mariner Area Development survey area indicated no evidence of any significant hydrocarbon or heavy metal contamination across the development area, and therefore no indirect impacts are expected from the re-suspension of sediments as a result of pipe-laying activities (**Section 4.4**).

The benthic community in the area of the Mariner Area Development is relatively uniform and low diversity, with characteristic species normally associated with offshore fine sands with silt /clay substrata in the northern North Sea, comprising predominantly species highly tolerant to sediment re-suspension, burial and indirect effects of contamination such as *Spiophanes bombyx* (ragworm) and *Paramphinome jeffreysii* (**Section 4.5.2**) (Olwen Ager, 2009; Hiscock *et al.,* 2004).

8.1.3.2 Finfish and shellfish

It is possible that there will be localised disturbance to seabed spawning species during the proposed anchoring, subsea installation and pipe-laying activities. A small number of demersal and pelagic fish might be temporarily disturbed by the subsea operations and, if large amounts of seabed sediment were re-suspended into the water column, it is possible that small areas of spawning ground could became degraded for a time. Although there will be localised disturbance to seabed spawning species, fish are likely to return to the area once the anchoring and pipeline installation operations have ceased.

The Mariner Area Development has the potential to coincide with the spawning grounds (an area of high intensity of eggs and larvae) for cod, haddock; whiting, saithe, Norway pout, *Nephrops* and sandeels (Coull *et al.,* 1998; Ellis *et al*., 2010) (**Section 4.5.3**). Cod, haddock, whiting, saithe and Norway pout are pelagic spawners and have pelagic eggs that are released into the water column, and are therefore unlikely to be significantly affected by disturbance to the seabed. However, sandeels and *Nephrops* are demersal species confined habitats such as the fine to muddy sands with silt and clay content found in the development area (**Section 4.3.5;** Holland *et al.,* 2008). Therefore these species could potentially be at more risk from activities that disturb the seabed as a result of the proposed subsea activities.

The proposed pipe-laying activities are planned to take place between May and August 2015, the PDQ jacket installation and the FSU installation are planned to occur between July to September and therefore will not coincide with the spawning periods of sandeels (November to February) and *Nephrops* (spawning throughout the year with peak between April to June) (Coull *et al.,* 1998; Ellis *et al*., 2010).

8.1.3.3 Protected habitats and species

Harbour porpoise is the only Annex II species which has been sighted in the Mariner Area Development area (**Section 4.6.3**; UKDMAP, 1998). The localised disturbance to the seabed from the installation of the Mariner Area Development pipelines, umbilical, subsea structures, and spot rockdump are unlikely to have any effect on marine mammals.

8.1.4 Transboundary and Cumulative Impacts

The proposed anchoring activities associated with the Mariner Area Development could result in the creation of anchor mounds at some locations, specifically along the route of the gas import pipeline, if AHVs are utilised during the installation. Surveys in the area have already indicated the presence of residual impacts from past background activities (trawl scars and anthropogenic debris on the seabed). Statoil will work to ensure that no significant anchor mounds are left behind following installation activities. Therefore the proposed anchoring activities are unlikely to have any significant transboundary, cumulative or global impacts

The installation of the pipelines, umbilical and subsea structures would cause localised temporary disturbance and interference of the seabed estimated to cover a total area of up to approximately 3.23 km^2 (**Table 8.8**). Installing the subsea manifolds (PLET and PLEM) would result in a small area of localised physical disturbance of the seabed sediments and associated fauna directly below the subsea structures. Spot rock dumping along the pipelines, umbilical and surface laid cable would alter the character of a small proportion of the seabed. These impacts would all be localised within UK waters, so there will be no transboundary impacts. Cumulative impacts from seabed disturbance arising from the Mariner Area Development would not be significant in relation to similar habitats in the northern North Sea. No global impacts are anticipated.

8.1.5 Consultee Concerns

Statoil has conducted stakeholder consultations in the early stages of the development and has incorporated and addressed the raised issues as much as practically possible in the design basis of the proposed development. The consultations conducted in relation to the Mariner Area Development are summarised in **Section 5.**

During these consultations, DECC advised Statoil to minimise the rock dump during the stabilisation of the jack-up platform and drilling rig. Statoil plan to use up to 3,000 tonnes of gravel to stabilise the drilling rig and platform jacket against scour on the seabed and will endeavour to minimise the amount of rockdump required as low as practically possible.

Marine Scotland expressed concern during the consultation process, regarding the protection of the pipelines and the subsea structures, due to the relatively high fisheries trawling activity in the area. Statoil has incorporated over- trawlable design of the subsea structures located outside of the 500 m safety zone from the PDQ. Statoil will endeavour to eliminate any deposits that can foul or damage trawling nets following trenching activities. Any soil heaps or significant bumps on the seabed will be removed to prevent any damage to fishing gear or interaction with fisheries fleet.

The proposed mitigation measures for reducing the impact on the seabed are summarised in **Section 8.1.6.**

8.1.6 Proposed Mitigation Measures

The planned mitigation measures that Statoil will undertake to minimise the impact of anchoring, pipeline and subsea structure installation activities are detailed in **Table 8.10**.

Table 8.10: Potential sources of impact and planned mitigation measures.

Potential source of impact	Planned mitigation measures
Anchoring the Mariner drilling rig	• Statoil has conducted a debris survey in the Mariner Area Development and is aware of the seabed nature at the proposed anchoring locations • A drill rig anchor plan will be developed that will aim to minimise the effects from anchoring on the seabed. • All anchors will be completely removed from the seabed at the end of the drilling operations.

Installation of pipelines and umbilicals/power cables	• Statoil will eliminate the risk of creating anchor scars and will minimise seabed disturbance during the use of any AHV vessels for the pipe-laying operations. • Pipeline route surveys for the proposed pipeline and umbilical routes have been undertaken to gain detailed information on bathymetry and seabed conditions, so that the optimum routes could be selected. The results of these surveys confirm that the proposed routes will likely result in minimal environmental impact. • Rigorous safeguards to minimise the risk of gear entanglement will be employed, including Kingfisher alerts and guard vessels. • Statoil will notify the Hydrographic Office, which will issue notices to mariners to advise fishing and shipping traffic of the potential hazards to navigation that will be associated with the project. Mariners will be advised of specific periods and locations in which vessel operations should be avoided. Contact information will be provided and details of guard vessels will be given. • Guard vessels will be on station during pipeline installation to alert shipping and fishing vessels of potential navigational hazards. • A post-lay survey will be undertaken to ensure that no significant mounds or debris remain. • If any debris is left or obstructions are caused by pipeline installation operations, every effort will be made to remove them from the seabed.

Table 8.10 continued: Potential sources of impact and planned mitigation measures.

Potential source of impact	Planned mitigation measures
Localised disturbance to the seabed from installation of subsea structures, manifolds and spot rockdump	• The use of a fall pipe on the rock dump vessel, in the case of the requirement for rock dumping, and the use of ROV supervision during rock dump operations, will ensure that the rock dump is placed in the correct position. • Rigorous safeguards to minimise the risk of gear entanglement will be employed, including guard vessels during installation operations, Kingfisher alerts, and fishing-friendly protective structures.

8.2 Discharges to Sea

This section describes the discharges from the Mariner Area Development that were identified in the assessment process (**Section 7**) as being of “medium” risk to the environment. These discharges will occur during the drilling and commissioning phases of the project. The section also describes the management and mitigation measures that will be employed by Statoil to minimise these impacts at source.

Drilling operations at the Mariner Area Development will result in environmental impacts arising from the discharge of water-based mud (WBM) and thermally treated mud and cuttings to the seabed. Installation, commissioning and production operations will result in the discharge of fluids into the marine environment.

Discharges to sea that arise from the Mariner Area Development installation, commissioning and production operations will be managed in accordance with current legislation and standards as summarised below and discussed in **Appendix A**.

- The Offshore Petroleum Activities (Oil Pollution Prevention and Control) (Amendment) Regulations 2011, implements the OSPAR Recommendation 2001/1 (as amended 2006/04) for reduction of discharges of oily water in marine environment. Under these regulations, the concentration of dispersed oil in produced water discharges as averaged over a monthly period must not exceed 30 mg/l and the maximum permitted concentration must not exceed 100 mg/l at any time. The quantity of dispersed oil in produced water discharged must not exceed 1 tonne in any 12 hour period. Statoil must apply for permits under the appropriate schedule of the OPPC Regulations for any oil released in produced water discharges during PWRI shutdown.

- Merchant Shipping (Prevention of Oil Pollution) Regulations 1996 (as amended) implement Annex I of the MARPOL regulations in the UK. Oily discharges from machinery space on vessels and installations must not exceed 15 ppm of oil without dilution from these sources. The PARCOM Recommendation 86/1 sets out a legal limit of 40 mg/l for discharges of displacement water, drainage water and ballast water, which are not covered under MARPOL. The ballast water regulations require Statoil to have a UK Oil Pollution Prevention Certificate (UKOPP) or IOPP Certificate in place for all vessels and to comply with the Ballast Water Management Convention for ballast water exchange at least 200 nm offshore in water at least 200 m deep.

- OSPAR Decision 2000/3 came into effect on 16 January 2001 and effectively eliminated the discharge of cuttings contaminated with oil based fluids (OBF) (includes OBM and SBM) greater than 1% by weight on dry cuttings. The Offshore Chemical Regulations 2002 (as amended) implement this Decision and require a chemical permit for the use and discharge of chemicals including drilling muds. The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 also require a permit for the discharge or re-injection of cuttings containing hydrocarbons from the reservoir. Under these regulations Statoil is required to undertake and demonstrate best available technique/ best environmental practice (BAT/BEP) through OPPC application process for achieving low potential for adverse environmental impacts.

- Under the Offshore Chemicals Regulations 2002 (as amended 2011), which implements the OSPAR Decision (2000/2) and OSPAR Recommendations (2000/4 and 2000/5), Statoil is required to apply for permits and submit relevant Petroleum Operations Notices (PONs) for all planned and potential discharges of chemicals during the associated activities of the Mariner Area Development, i.e. chemicals for drilling: (PON 15B); pipeline testing and commissioning: (PON 15C); during production: (PON 15D); well workovers and interventions: (PON 15F); and decommissioning: (PON 15E). Statoil will submit the relevant PON application to DECC through Offshore Chemical Notification Scheme (OCNS) where the discharged chemicals will be ranked by hazard quotient, using the CHARM model and incorporated in the relevant PON application. Chemicals will only be used in accordance with the corresponding PON permit.

8.2.1 Methodology

The Mariner Area Development will involve drilling two reservoirs (Maureen and Heimdal) through two separate fields (Mariner and Mariner East). Drilling operations at the Mariner field (Maureen and Heimdal reservoirs) are scheduled to commence in Q3 2016 and last for a period of up to 30 years, while drilling operations at Mariner East is scheduled to comment in 2018 and will last for approximately eight months. To access each reservoir, Statoil are to drill short wells, medium wells, long wells, extended reach wells and sidetracks for the production wells and the produced water re-injection (PWRI) wells. In total, the Mariner Area Development drilling programme will utilise up to 12 different well designs.

Section 3.5.10 and **Appendix B** estimate the quantities of drill cuttings to be produced during the drilling programme. The quantity of cuttings generated during drilling is largely determined by the dimensions of the well, as well as by the type of rock formations being drilled.

Drilling the 50 wells slots at the Mariner field and the four tophole (28") sections at the Mariner East production wells will result in a total of 3,819 tonnes of seawater and WBM cuttings discharged directly onto the seabed (**Table 8.10**).

Statoil currently have two options under consideration for the disposal of LTOBM mud and cuttings generated from the 9½" reservoir sections; disposal via containment and disposal of the cuttings onshore, or the use of a thermal cuttings treatment unit offshore.

Under the worst case discharge scenario, the remaining sections (26", 17½", 13½" and 13½" sections) the Mariner and Mariner East wells will result in the overboard discharge of approximately 152,400 tonnes of water-based mud (WBM) and thermally treated LTOBM and cuttings (**Table 8.10**).

Table 8.10: Estimated cuttings volumes for the Mariner wells and Mariner East wells

Mud system	Disposal method	Mariner field	Mariner East field	Mariner Area Development
		Amount of cuttings (tonnes)		
Tophole section drilled with seawater	Discharged directly to seabed to seabed	3,536	283	3,819
WBM drilled sections	Discharged overboard to sea	70,796	4,652	75,448
LTOBM	Thermally treated fine particles discharged to seabed	54,183	1,597	55,780
LTOBM (reservoir sections)	Thermally treated fine particles discharged to seabed or skip and shipped to shore	20,582	595	21,178

The Mariner Area Development includes a number of import and export pipelines (**Section 3.6**). The tie-in and commissioning of these pipelines will result in the discharge of inhibited seawater into the marine environment from flooding, gauging, strength and integrity testing.

These operations are scheduled to commence in Q2 2016 and are expected to last for a period of 2 months (**Section 3.4**).

Prior to discharge, quantities of chemicals to be used and discharged will be detailed in a PON15C application as required under the Offshore Chemicals Regulations 2002 (as amended).

The principal route for disposal of produced water at the Mariner Area Development will be by re-injection into 58 PWRI wells at the Mariner field (**Section 3.5.16; Appendix B**). No produced water re-injection will be required at the Mariner East wells (**Section 3.5.16**).

Produced water volumes are forecast to increase initially peaking in 2021, then following a dip in 2023 and 2024, the volume of produced water will increase again remaining relatively constant as field life increases, (**Table 3.14 and Figure 3.27**). Maximum water production at the Mariner Area Development will be at end of field life in 2056 and is expected to be 43,726 m^3/day (**Section 3.9.3; Table 3.14**).

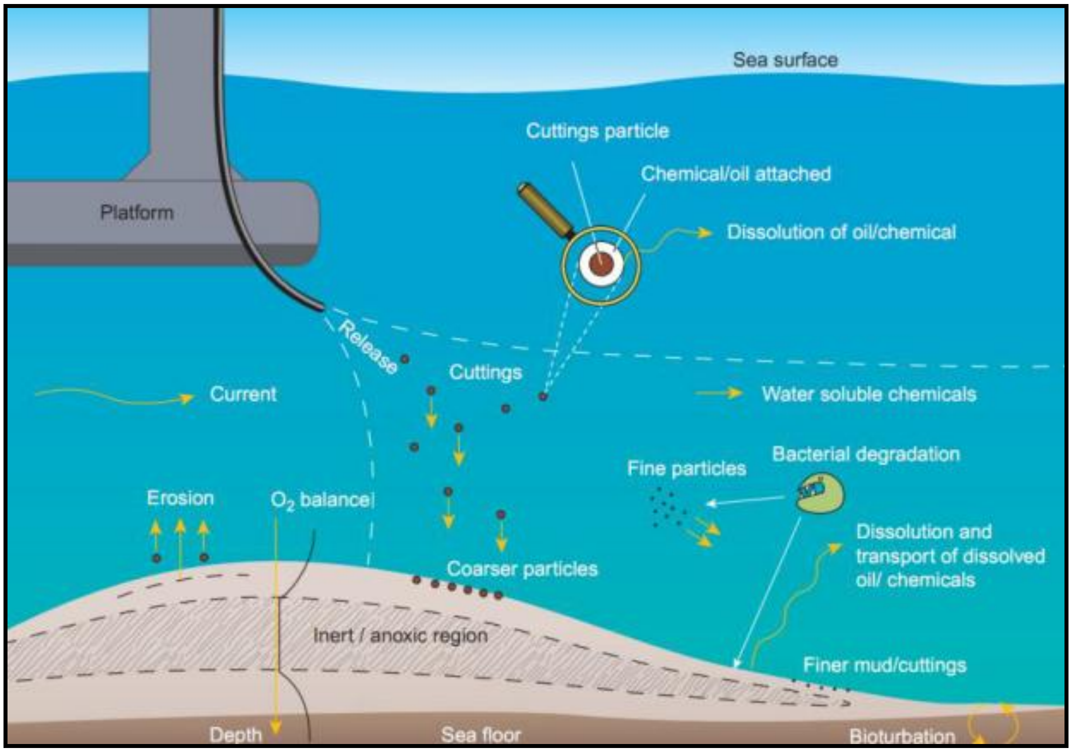
The design specification of the produced water re-injection system is to achieve at least 95% availability, equating to 18 days per year, on average, when water may be discharged overboard. During contingency periods when the PWRI system is unavailable (e.g. equipment downtime) produced water will be disposed of to sea via a dedicated caisson. Before disposal, water will be treated to the required oil-in-water standard.

Drilling cuttings modelling methodology

The discharge of the drilling mud and cuttings at the Mariner Area Development has been modelled using the DREAM (Dose-related Risk and Effect Assessment Model) published by SINTEF (v6.1), which incorporates the ParTrack sub-model used for modelling the dispersion and settlement of solids (Genesis, 2012). The model predicts the fate of materials discharged to the marine environment (their dispersion and physico-chemical composition over time) and it can also calculate an estimate of risk to the environment using a metric known as the Environmental Impact factor (EIF). The EIF is based on taking a threshold of 5% risk to the environment based on well established principles for assessing the acceptability of chemical discharges (Genesis, 2012). An EIF of one in sediments occurs when an area of 100 m x 100 m is judged to exceed a 5% risk on the basis of grain size change or burial thickness.

The DREAM model has been developed to calculate the spreading and deposition of drilling mud and cuttings on the seabed, in addition to the spreading of chemicals in the free water masses. The processes involved in the DREAM/ParTrack model are illustrated in **Figure 8.2.**

The calculations are based on the `particle' approach, combined with a near field plume model and the application of external current fields for the horizontal advection of the particles. The model consists of a plume mode and a far-field mode. The plume mode takes into account effects from water stratification on the near-field mixing, ambient currents and geometrical configuration of the outlet. Once the plume has been trapped in the water masses, particles are free to fall out of the plume and deposit on the bottom. Downwards velocity of the particles is dependent on size and particle density. The far-field model includes the downstream transport and spreading of particles and dissolved matter, once the plume mode is terminated.



Source: Genesis (2012)

Figure 8.2: Processes involved in the DREAM/ParTrack model

The DREAM model was used to produce the following four main outputs for the discharge of the drilling mud and cuttings from the Mariner Area Development:

1. depositional thickness on the seabed;

2. environmental risk on the seabed resulting from burial thickness, particle size change, toxicity and pore water oxygen depletion;
3. environmental risk in the water column resulting from toxicity and particle stresses; and,
4. predicted recovery of the sediments.

The nearest sediment analyses to the Mariner Area Development show the prevailing sediments to be very fine sand and a prevailing reference particle size of 0.063 mm for seabed sediments was taken (Genesis, 2012; **Section 4.2.5**).

Model parameters were chosen with two grid sizes, initially 100 m x 100 m square cells over a large area to gain an overview of environmental risk, followed by a more detailed analysis using a 20 m grid.

To ensure efficient computation of results, the programme has been compressed to 20 years, with the planned 3 year drilling gap shortened to one year. The modelled drilling sequence was designed to broadly reflect the Mariner base case schedule, although such schedules are liable to variation nearer the time to drilling (Genesis, 2012). After the discharges have ceased time development of risk was calculated. The model combines assumptions around biodegradation, bioturbation depths relevant to the depth, oxygen profiles in the sediment, expected recovery times from burial and grain size change and changes in chemical and oil toxicity over time (generally around 10 years after cessation of the drilling programme). This provides a forecast of the reduction in environmental risk to the sediments over time. DREAM/ParTrack predictions have been validated through field measurements at the Trolla field in 26m water depth in the Norwegian Sea, which suggests that the DREAM/ParTrack modelling results are conservative (Genesis, 2012).

8.2.2 Sources of Potential Impact

Discharges to sea will result from the following Mariner Area Development operations and activities:

Drilling discharges

- Discharge of seawater / water based muds and cuttings directly to the seabed.
- Overboard discharge of WBM and thermally treated LTOBM cuttings well slots and sidetracks.
- Cement discharges from the wells.

Commissioning discharges

- Discharge of pipeline contents to the marine environment.

Operational discharges

- Produced water.

8.2.2.1 Drilling discharges

Mud and cuttings

Drilling the Mariner and Mariner East tophole (28”) sections will result in a total of 3,819 tonnes of seawater and WBM cuttings discharged directly onto the seabed. Drilling the 26”, 17½”, 13½” and 9½” sections for the Mariner and Mariner East wells will result in approximately 152,400 tonnes of water-based mud (WBM) and thermally treated LTOBM and cuttings discharged overboard.

All primary and contingency drilling mud chemicals to be used, and potentially discharged, during the drilling phase of each well will be detailed in each PON15B in accordance with the Offshore Chemicals Regulations 2002 (as amended).

Drill Cuttings Modelling

A drill cuttings modelling study has been undertaken to ensure best possible representation of the full Mariner Area Development drilling programme (**Section 3.6**), including a realistic drilling schedule and expected mud fluid use. The mud and cuttings discharges were modelled using the DREAM Model, which incorporates the ParTrack sub-model used for modelling the dispersion and settlement of solids (Genesis, 2012). The model was used to predict the fate of materials discharged to the marine environment, Environmental impact Factor (EIF) for sediment and water column contamination, seabed depositional thickness and distribution of the cuttings piles, the influence of the thermal desorption treatment on the cuttings transport, and the recovery of sediments over an extended period. The preliminary results of the modelling study are presented in **Section 8.2.3**.

Cement

Cement and cementing chemicals will also be used during the drilling operations. The exact chemical constituents required to formulate the cement will be confirmed during the final stages of well design. The majority of the cement will be left downhole but a minimal quantity may be discharged onto the seabed around the top of the casing. The chemicals used will be contained within inert cement. Careful estimates of the final volume of the hole will be made during drilling and the volume of cement used will be adjusted accordingly to minimise the risk of excess cement being squeezed out of the hole onto the seabed. Any excess dry cement not used will be shipped back to shore, rather than being discharged to sea.

8.2.2.2 Commissioning discharges

Marine discharges from testing of pipelines and other lines will be the main source of installation and commissioning discharges (**Section 3.6**).

The Mariner Area Development will involve the installation of oil export pipelines, diluent pipeline, gas import pipeline, flexible risers, spoolpieces and tie-ins. Once this subsea equipment is installed, flooding, gauging (for pipelines), strength-testing and leak-testing will be required. This testing is likely to result in the discharge of inhibited seawater into the marine environment. The exact location of the discharge points will be determined during the final stages of design.

The permitted discharge of chemicals to the marine environment is a routine part of subsea installation operations. Chemicals dissolved in the inhibited seawater would typically comprise an oxygen scavenger such as sodium bisulphite, a biocide, a corrosion inhibitor and fluorescein dye to assist in the detection of leaks. After leak testing, the gas export line will be dewatered using a pig train driven by oil-free nitrogen gas. The pigs will be separated by slugs of potable water dosed with monoethylene glycol.

The quantities of chemicals to be used and discharged will be determined during the detailed design and will be detailed in a PON15C application as required under the Offshore Chemicals Regulations 2002 (as amended).

8.2.2.3 Operational discharges- produced water

Produced water is derived from formation water in oil and gas reservoirs and from seawater that is injected to maintain reservoir pressure (DECC, 2011c; DTI, 2001). It may comprise dispersed oil, metals and organic compounds such as dissolved hydrocarbons, organic acids and phenols. The composition of produced water varies between specific installations and generally differs considerably between oil and gas reservoirs. Produced water discharges are also responsible for discharges of production chemicals used offshore, where these partition into the aqueous phase.

As a result of the implementation of the OSPAR Recommendation 2001/1 for the Management of Produced Water from Offshore Installations as Amended by OSPAR Recommendation 2006/4, oil installations are required to comply with a 30 mg/l monthly average dispersed oil in water discharge. This recommendation also contains a goal for zero harmful discharge by 2020 and, as such, there is a presumption against produced water discharge to sea for new installations (UKOOA, 2011).

The forecasted produced water production will increase as field life increases at the Mariner Area Development, with a maximum of 43,726 m^3/day at end of field life (**Section 3.9.3; Table 3.14**). Produced water will be subject to treatment (i.e. deoiling hydrocyclones) and will be used in combination with dissolved gas floatation to achieve the required oil in water standard. Produced water equipment will be regularly maintained to ensure operational capability.

The principal route for disposal of produced water at the Mariner Area Development will be by re-injection into 58 PWRI wells at the Mariner field (**Section 3.5.16**). No produced water re-injection will be required at the Mariner East wells.

The design specification of the produced water re-injection system is to achieve at least 95% availability, equating to 18 days per year, on average, when water may be discharged overboard. During contingency periods when the PWRI system is unavailable (e.g. equipment downtime) produced water will be disposed of to sea via a dedicated caisson. Before disposal, water will be treated to the required oil-in-water standard.

At peak water production rates, a maximum of 43,726 m^3/day could be discharged for short periods (**Section 3.9.3**). Assuming discharge, at the regulatory limit of 30 mg/l oil in water, for 18 days over that peak year, this would equate to approximately 24 tonnes of oil. The total dispersed oil in produced water discharged to sea by all oil production facilities in the UK sector of the North Sea in 2009 was 2,900 tonnes (DECC, 2011c). The worst case discharge from the Mariner Area Development represents 0.8% of this total. Sampling and monitoring will be carried out in line with OPPC requirements.

8.2.3 Impact to Receptors

8.2.3.1 Drilling discharges

Mud and cuttings

The main environmental impacts that could arise from the discharge of mud and cuttings (WBM and thermally treated LTOBM) to the seabed are:

- the possible creation of a localised cuttings mound, which would result in the smothering of benthic fauna and fish spawning grounds; and
- the release of the drilling and cementing chemicals, which could be hazardous to the organisms within the near field marine environment.

In general, effects of mud and cuttings discharges on the benthic environment are related to the total mass of drilling solids discharged, and the relative energy of the water column and benthic boundary layer at the discharge site (Neff, 2005). In high energy environments, little drilling waste accumulates on the sea floor and adverse effects of the discharges cannot be detected. However, in low to moderate energy environments, such as at the Mariner Area Development location (**Section 4.3.2**), large amounts of mud and cuttings solids may accumulate on the sea floor and adversely affect bottom communities within a few hundred metres of the discharge (Neff, 2005).

Drilling mud comprises a base fluid, viscosifiers, dispersants, flocculants, emulsifiers, surfactants, foaming and weighting agents and contingency chemicals to make it as efficient and safe as possible to drill a well under the given conditions. The effects of WBM that do not contain petroleum-derived base fluids are well documented (Daan and Mulder, 1996; Davies, *et al*., 1983; Ferm, 1996; Kroncke *et al.,* 1992; Olsgard *et al*, 1997; Plante-Cuny, *et al*.,1993) and the impacts of these discharges on the marine environment would be expected to be minimal and of short duration (Neff, 2005).

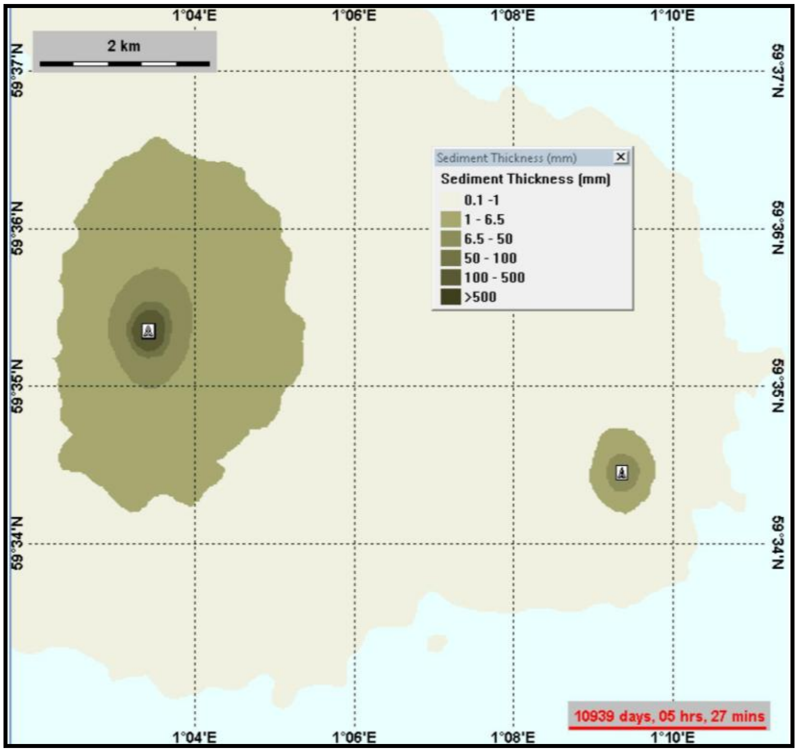
Water column communities are unlikely to be harmed by WBM drilling mud and cuttings discharges because discharges are intermittent and of short duration during drilling and are subject to dispersion. Dilution of dissolved and particulate components in the discharge is also rapid (Neff, 2005). While direct deposition of mud and cuttings may cause chronic ecological damage to a small area of the sea floor, where solids accumulate in a cuttings pile, this would most likely be a result of the burial of benthic fauna or an adverse change in sediment texture.

The exact formulation of the drilling chemicals for the Mariner Area Development has not yet been determined, but all primary and contingency drilling mud chemicals to be used and potentially discharged during the drilling phase of the well would be detailed and subjected to a risk assessment in the required PON 15B chemical permit applications.

Drill Cuttings Modelling

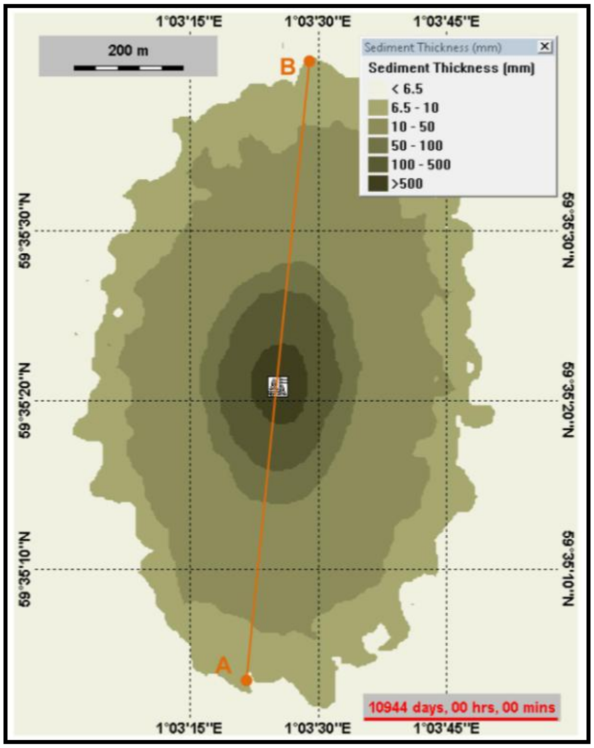
The preliminary DREAM/ParTrack modelling results predict that a high volume but relatively contained area of cuttings would be expected from the proposed drilling programme at the Mariner field. A maximum thickness of around 1,150 mm directly about the drilling centre at the Mariner field was observed, declining to 6.5 mm approximately 750 m from the release site (**Figure 8.3** and **Figure 8.4**).

The preliminary modelling results predicted the distribution of cuttings at both fields to be fairly uniform, spreading away from the release locations in a concentric pattern, but with a North-South trend (Genesis, 2012; **Figure 8.3**). The DREAM/ParTrack modelling results for the Mariner East field predict maximum deposition of around 26 mm directly about the drilling centre, declining to 6.5 mm approximately 220 m from the release site (**Figure 8.3** and **Figure 8.5b**).



Source: Genesis (2012)

Figure 8.3: Preliminary results for the deposition of solids at the Mariner Area Development



Source: Genesis (2012)

Figure 8.4: Preliminary results for the deposition of solids at the Mariner field, close the release point

Modelling was undertaken at a higher resolution closer to each release point to gain a clearer picture of the deposition pattern. **Figures 8.5a** and **8.5b** provide the preliminary illustration of the cuttings deposition close to the release points at Mariner and Mariner East (Genesis, 2012). The preliminary results indicate the peak thickness of deposition (3,500 mm) at the Mariner field would occur within 80 m of the release point, with deposition thickness observed to rapidly diminish with distance (Genesis, 2012). At a distance of 500 m, the maximum depositional thickness observed at the Mariner field was 9.5 mm along the dominant current axis, and 4.5 mm perpendicular to this axis.

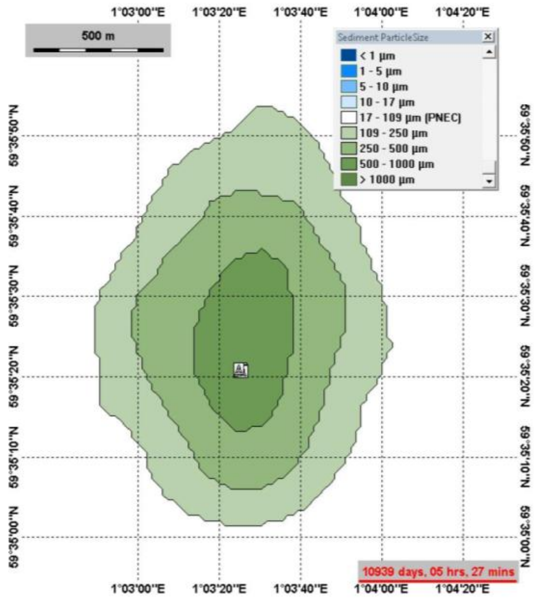


Figure 8.5a: Preliminary results for the median particle size changes at the Mariner field

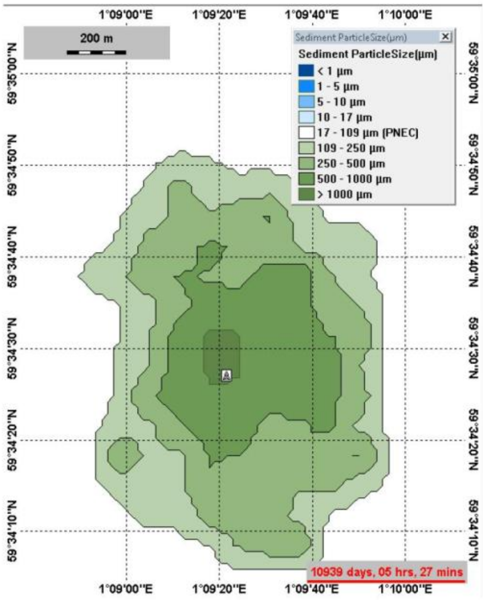


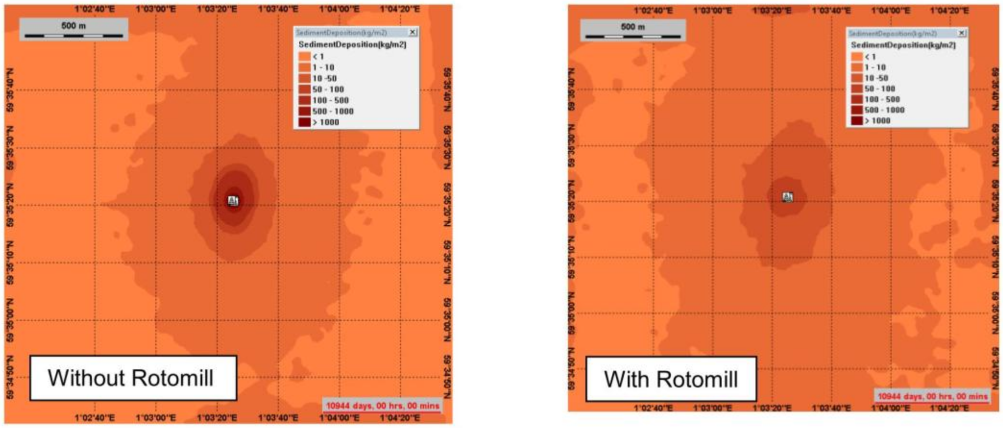
Figure 8.5b: Preliminary results for the median particle size changes at the Mariner East field

Source: Genesis (2012)

The treatment of the LTOBM mud and cuttings by thermal desorption was observed to assist cuttings dispersion (**Figure 8.6**), with areas of very thin deposition reflecting the presence of these very fine solids. The particle size distribution for the LTOBM mud and cuttings treated by thermal desorption was observed to include 60% of particles below 0.028 mm, and 10% below 0.0013 mm. These fine particles travel much further than the majority of rock cuttings which will deposit near to the well, with the vast majority of the deposition occurring within 50 m (Genesis, 2012).

The preliminary results indicate the sediment grain size would change, with a deviation from the median grain size PNEC of ±0.0461mm, expected within 1 km from the Mariner field release site. The maximum median grain size change directly above the Mariner field release site was predicted to be (+)780 µm (Genesis, 2012). Particle size changes were predicted to occur up to 750 m from the Mariner East release site, with maximum median grain size change of (+)1,120 µm. The preliminary results indicate particle stress is likely to be induced from an increase in the grain size rather than decrease (Genesis, 2012).

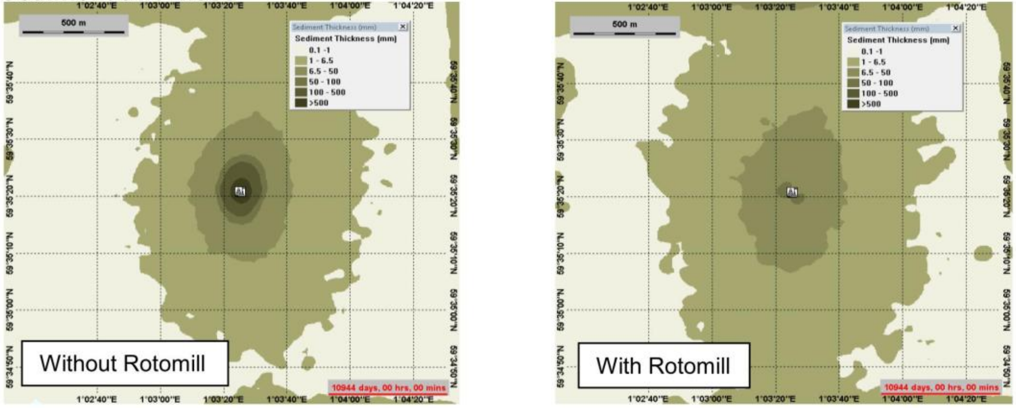
Sediment deposition



Maximum of 6.5 tonnes/ m^2 at release site

Maximum of 0.15 tonnes / m^2 at release site

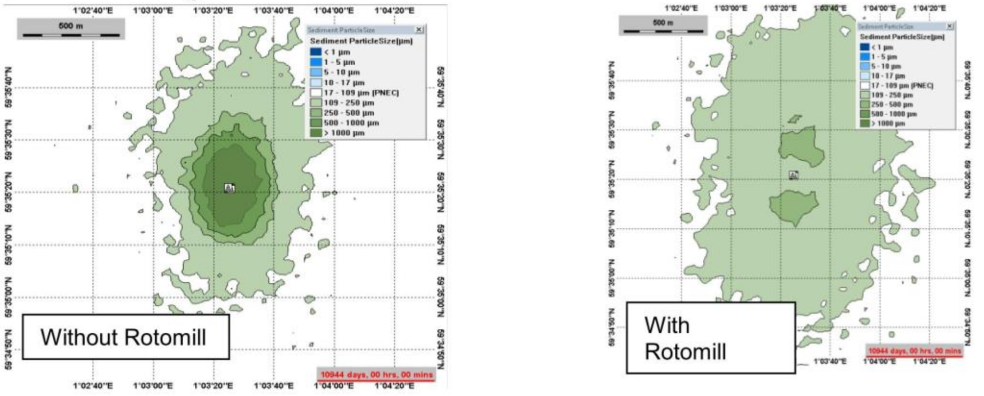
Sediment thickness



Maximum of 6000mm at release site

Maximum of 75mm at release site

Grain size change



Maximum grain size change (+)1970µm

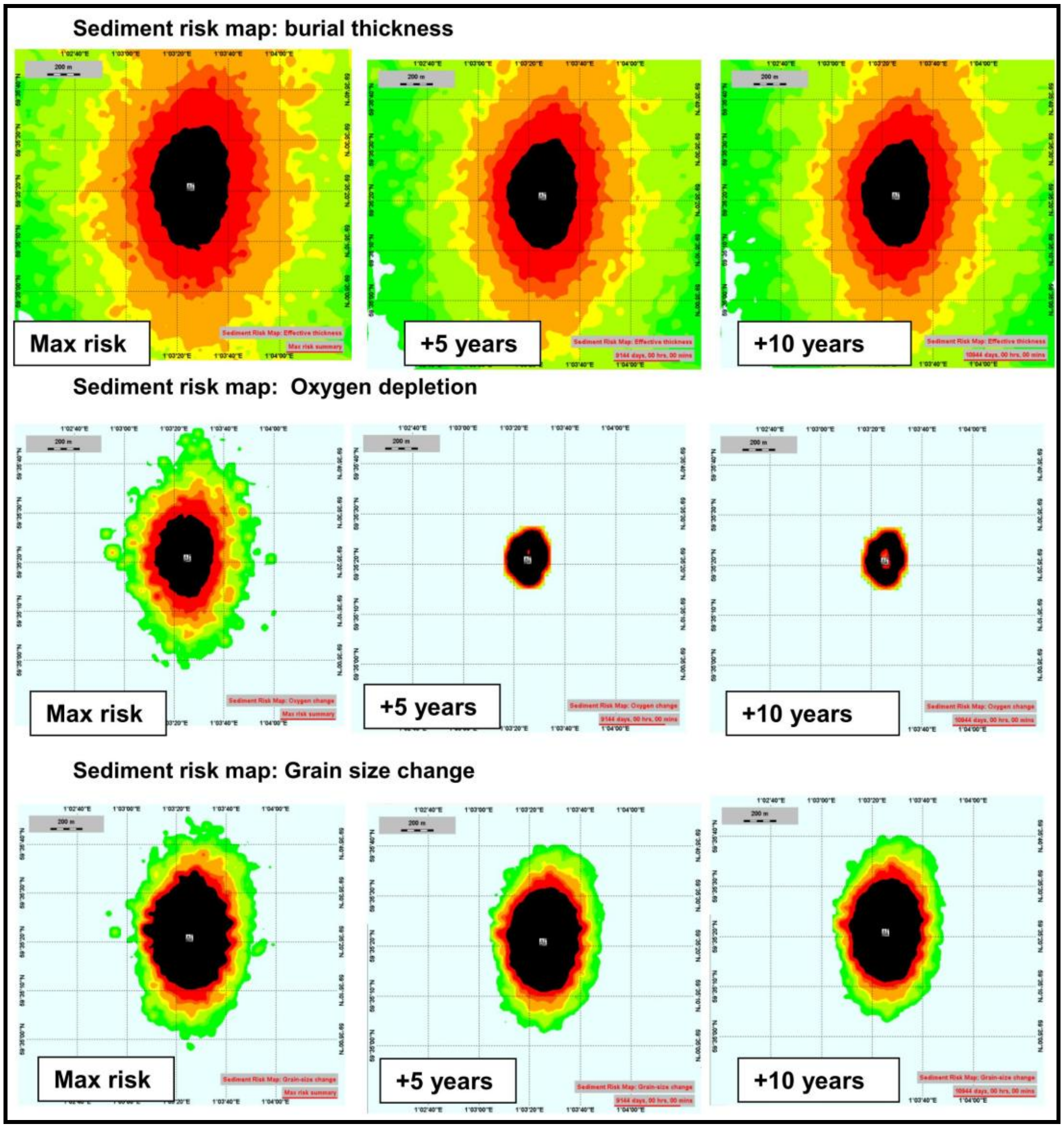
Maximum grain size change (+)306µm

Source: Genesis (2012)

Figure 8.6: Preliminary results illustrating the influence of thermal desorption treatment on the LOTBM mud and cuttings

Modelling results indicate that for much of the drilling period, the environmental risk to the seabed carries a maximum EIF of 4,591 with risk values >5% expected around 400 m from the release point (Genesis, 2012). Risk to the seabed is calculated from the EIF, and is due to grain size change, burial thickness and pore-water oxygen depletion (Genesis, 2012). Contribution to EIF is primarily from heavy metals attached to barite, which may be partially due to the fine cuttings cloud , but also because a fairly high metal-rich grade of drilling barite was selected for the modelling study (Genesis, 2012).

Figure 8.7 presents the risk to the seabed at the Mariner field (the main drilling location and therefore the primary contributor to environmental risk), over a 10 year period following cessation of drilling.



Source: Genesis (2012)

Figure 8.7: Preliminary results illustrating the environmental risk to the seabed from the discharge of the thermally treated LOTBM mud and cuttings

Although the results indicate that the Mariner Area Development will have a moderate long-term physical impact on the local seabed disturbance the results are thought to be overly conservative because the model does not fully account for removal mechanisms such as sediment turnover (Genesis, 2012). The risk from the oil content of the thermally treated LTOBM mud and cuttings discharge is predicted to be negligible (Genesis, 2012).

The environmental risk to the water column was predicted to be locally high, but transient with a maximum EIF of 10,369 (Genesis, 2012). Suspended bentonite and barite accounted for 76% of the cumulative risk. The model predicts that although the discharge of the thermally treated mud and cuttings increase the short-term risk to the water column, the long-term sediment risk are reduced when compared to the corresponding WBM discharge (Genesis, 2012). **Figure 8.8a and 8.8b** illustrate the cross-section of the modelled water column EIF during the drilling programme. **Figure 8.8a** illustrates the initial release of negatively buoyant dense cuttings, while **Figure 8.8b** illustrates the neutral buoyancy and diffusive behaviour of thermally treated cuttings in the water column.

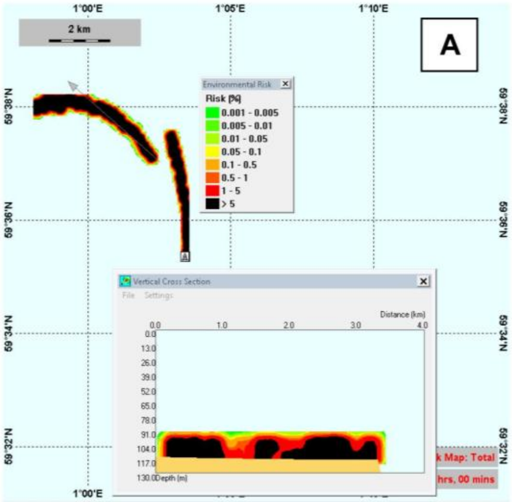


Figure 8.8a: Preliminary results for the cross-section through the tophole discharge plume

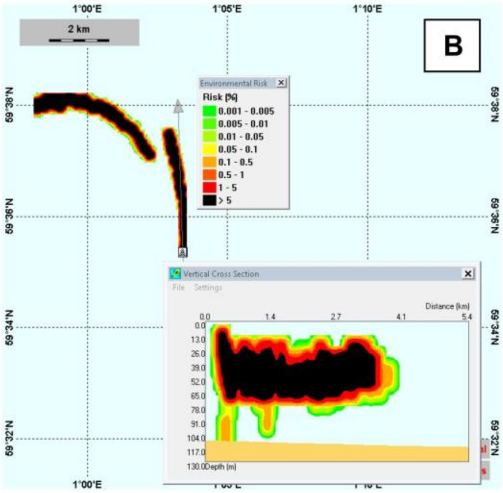


Figure 8.8b: Preliminary results for the cross-section through the caisson discharge plume

Source: Genesis (2012)

Benthic environment

The benthic community in the area of the Mariner Area Development is generally typical of this area of the northern North Sea, characterised by a diverse range of sediment-dwelling polychaetes, amphipods, bivalves and echinoderms (**Section 4.5.2**).

During drilling of the tophole (28”) section of each Mariner well slot and Mariner East wells, the seawater / WBM cuttings generated will be discharged directly to the seabed around the well bore. The effect of this will be to smother a localised area of bottom sediments and associated fauna and to release pollutants, such as organic chemicals, heavy metals or petroleum hydrocarbons into the sediments and the water column. In the short term, this may cause mortality to some benthic organisms, create an area of habitat different to the surroundings and result in the temporary covering of the sediments and loss of habitat required for the benthic fauna (Neff, 2005). In the medium term, however, the local habitat is likely to return to the natural conditions.

Effects of WBM cuttings piles on bottom living biological communities are caused mainly by burial and hypoxia caused by organic enrichment (Neff, 2005). Bacteria and fungi living in marine sediments degrade the organic matter and, in the process, may deplete the oxygen in the pore water of near-surface layers of sediment and generate potentially toxic concentrations of hydrogen sulphide and ammonia (Wang and Chapman, 1999; Gray *et al.,* 2002; Wu, 2002), which can have severe and long lasting effects on the local benthic community in the initial periods during and immediately after the drilling activities (Neff, 2005). However, ecological recovery of benthic communities from burial and organic enrichment occurs by recruitment of new colonists from planktonic larvae and immigration from adjacent undisturbed sediments. Recovery begins as soon as discharge of drilling wastes is completed and often is well advanced within a year; however, it may be delayed until concentrations of biodegradable organic matter decrease through microbial biodegradation to the point where surface layers of sediment become oxygenated (Hartley *et al*., 2003; Neff, 2005).

Fish and shellfish

Fish disturbed by drilling operations are likely to rapidly return to the area once drilling operations have ceased. However, there could be localised disturbance to seabed spawning species. Cod, haddock, whiting, saithe, Norway pout, *Nephrops* and sandeel are known to spawn in the proposed development area (**Section 4.5.3**).

Nephrops and sandeel are benthic spawners and may therefore be at risk from discharges of mud cuttings. The spawning habitat area of *Nephrops and* sandeel may be smothered with cuttings and result in mortality or disturbance to *Nephrops and* sandeel. *Nephrops* are limited in their distribution by the extent of suitable sediment, which is sandy mud to very soft mud

(**Section 4.5.3**), while sediments at the Mariner Area Development comprise medium to dense sand to clay or silty sand (**Section 4.3.5**). Although the sandy sediments at the Mariner Area Development can provide a suitable sandeel habitat, a widespread distribution of sandeels over the North Sea (**Section 4.5.3**) would result in a very small fraction of the population being potentially affected by the development. Consequently, it is unlikely that there would be a significant negative impact on both the *Nephrops* and sandeel populations from the discharge of mud and cuttings at the Mariner Area Development.

Cod, haddock, whiting, saithe and Norway pout are less susceptible to discharges of mud and cuttings as they release their eggs into the water column. These species have a widespread distribution over the central North Sea (**Section 4.5.3**). Therefore, it can be concluded that the spawning populations of fish species are unlikely to be at risk from discharges of mud and cuttings from the Mariner Area Development wells.

Protected habitats and species

There are no areas of potential Annex I habitat were identified in the development area (**Section 4.6.2**). The Braemar Pockmarks cSAC, located to the south of the Mariner Area Development in Block 16/3 is approximately 100 km from the proposed development (**Section 4.6.2**). The results of the modelling study indicate that mud and cuttings from the Mariner Area development could extend to 0.5 km from the discharge point, therefore, the discharge of mud and cuttings at the Mariner Area Development is unlikely to have an impact on any Annex I habitats.

The only Annex II species known to occur in the Mariner Development Area is the harbour porpoise (**Section 4.6.3**). The discharge of mud and cuttings generated from the Mariner Area Development is unlikely to have any effect on marine mammals.

Cement

Discharge of cement slurry into the sea has the potential to cause localised alteration of the sediment structure and smothering of seabed organisms in the immediate area. Any minimal amounts of cement that might be released would set to form an inert hard substratum, which may be colonised naturally by marine organisms, or would be covered by natural re-distribution of sediments. Therefore, it is not expected that there would be deterioration in water quality or any significant impact on benthos or fish from release of cement during drilling.

8.2.3.2 Commissioning discharges

Release of inhibited seawater to the marine environment from pipeline commissioning would result in a short-term and localised impact immediately around the discharge point. The organisms that would be at risk include planktonic organisms (i.e. those drifting in the near-seabed currents), epibenthic organisms (e.g. demersal fish and shellfish), sediment-dwelling filter feeders (e.g. polychaete worms, bivalve molluscs and amphipods) and fish spawning and nursery areas. A quantitative risk assessment of the release of inhibited seawater will be undertaken by Statoil for the required chemical permit, under the Offshore Chemical Regulations 2002 (as amended).

Plankton

Plankton is widely distributed in the water masses that flow over large areas of the North Sea (**Section 4.5.1**). Many plankton populations have the capacity to recover quickly due to the continual exchange of individuals with surrounding waters and any impacts associated with the proposed operations are likely to be small in comparison with the natural variations (NSTF, 1993). Consequently, a short-term discharge of inhibited seawater is unlikely to present a significant risk to the viability of the plankton community at the Mariner Area Development.

Benthic environment

The discharge of inhibited water could result in minor, short-term changes in the seabed chemistry; however this is anticipated to dissipate rapidly with local currents. The benthic community at the Mariner Area Development is therefore unlikely to be impacted by the short-term discharge of inhibited seawater.

Fish and shellfish

Fish are mobile organisms that would be able to move away from the immediate vicinity of the discharge point. Fisheries sensitivity maps show that the proposed development lies within spawning grounds for cod, haddock, whiting, saithe, Norway pout, *Nephrops* and sandeel and within the nursery areas for haddock, whiting, Norway pout, *Nephrops,* blue whiting and mackerel (**Section 4.5.3**). Spawning and nursery grounds are dynamic features of fish life history and are rarely fixed in one location from year to year, and all of these species are mobile and spawn over wide areas of the North Sea. The fish and shellfish in the development area are therefore unlikely to be significantly impacted by the short-term discharge of inhibited seawater.

Protected habitats and species

As discussed above, there are no areas of potential Annex I habitat that were identified in the development area (**Section 4.6.2**). The only Annex II species known to occur in the Mariner Development Area is the harbour porpoise (**Section 4.6.3**). The exact discharge locations are not currently known. However the short-term release of inhibited seawater will disperse rapidly in the water column and is unlikely to have any effect on marine mammals.

8.2.3.3 Operational discharges – produced water

The discharge of produced water into the water column has the potential to cause direct toxicity to planktonic organisms, benthos and fish in the immediate vicinity of the discharge, indirect effects via bioaccumulation in the food chain and a temporary elevation of water temperature (DTI, 2001). Composition and toxicity of produced water varies greatly and although laboratory and enclosure studies have frequently demonstrated the toxicity of produced water from various sources, high dispersion means that significant toxicity in actual receiving waters has rarely been demonstrated (DTI, 2001).

Plankton

Some toxicity to planktonic organisms may result from the occasional (18 days per year; **Section 3.9.3**) discharge of produced water from the Mariner Area Development PDQ. The localised release of produced water is likely to quickly dilute within the water column to levels below those that may cause lethal or sub-lethal effects on the planktonic community (Lee and Neff, 2011; Neff, 2002). In addition, mesocosm experiments designed to simulate conditions in the North Sea found that produced water input caused an increase in bacterial biomass but had no discernible impact on the planktonic community (Gamble *et al*., 1987).

Consequently, a short-term permitted discharge of produced water should not present a significant risk to the viability of the plankton community at the Mariner Area Development.

Benthic environment

Produced water has the potential to cause short-term toxicity or long-term impacts from bioaccumulation to harmful levels within the benthic community (DTI, 2001). The extent of these impacts may depend on the depth of water column, produced water dispersion rates, current speed and dilution (Lee and Neff, 2011).

At the Mariner Area Development the water depth ranges between 95 and 115 m, and it is anticipated that the produced water discharge will dilute to levels too low to cause harm to benthic organisms. Therefore, a significant impact to benthic organisms is not anticipated.

Fish and shellfish

Due to the highly mobile nature of pelagic finfish it is not thought that there will be any significant impact on the finfish community at the Mariner Area Development. In a mesocosm study on the impacts of produced water on finfish undertaken by Gamble *et al.* (1987), no negative impact on the fish community was observed. It is assumed that there is little likelihood of shellfish or other epibenthic organisms suffering impact due to the dispersion rate of the produced water and the depth of water column between the discharge point and the seabed.

Protected habitats and species

There are no areas of potential Annex I habitat were identified in the development area. The short-term release of produced water is unlikely to have any effect on marine mammals or Annex II species. The low number of animals in the area coupled with their high mobility will ensure that no discernable impact should be observed.

8.2.4 Transboundary and Cumulative Impacts

Sediment movement, action of burrowing organisms and the effects of currents would cause the cuttings, particularly the finer fractions, to migrate over time and the chemicals within the cuttings would gradually disperse. It is unlikely that this effect will be distinguishable from the overall movement of sediment at the Mariner Area Development. Coarser material is likely to remain closer to the wells and gradually be buried by natural sediment deposition. The chemicals contained within the mud and cuttings would make a small and temporary addition to the background levels of chemicals in the northern North Sea. The chemicals in the mud and cuttings will disperse and dilute over time.

The discharge of mud and cuttings from the wells would cause a localised smothering of the natural seabed sediments and associated benthic communities. The smothering effects would be confined to a relatively small area, with 0.5 km from the release site.

Cement released to the seabed during the drilling operations will be kept to a minimum by careful planning of the quantities required and shipping to shore of any excess dry cement. It is expected that cement that is released will set to form an inert hard substance, within which any cementing chemicals will be contained and not present a hazard to the marine environment. Therefore, it is not expected that there would be a significant impact to the marine environment from the release of cement to the seabed.

The release of inhibited seawater to the marine environment during pipeline commissioning may result in a short-term, localised impact on marine organisms close to the discharge point. It is not expected that the discharge will significantly impact the water column, plankton, fish or marine mammals and it is highly unlikely that there would be significant cumulative impacts as a result of permitted discharge of inhibited seawater during the installation of the pipelines.

The Mariner Area Development will result in the discharge to sea of produced water during periods of PWRI system downtime, with the potential to impact upon pelagic organisms and benthos.

The Mariner Area Development is located approximately 40 km from the UK/Norway median line and, therefore, no significant transboundary effects are predicted. The identified impacts would all be within UK waters, so there will be no transboundary impacts.

8.2.5 Consultee Concerns

During the consultation process, DECC requested that Statoil's drill cuttings management issues were considered within the EIA process (**Section 6**). Statoil have conducted studies on the use of thermal desorption technology for the treatment of drill cuttings and can confirm that the powdered by-product is suitable for overboard discharge (**Section 6**).

In addition, DECC requested that the ES address the dispersion of the potentially large volumes of drill cuttings. Offshore drill cutting modelling has been undertaken for the Mariner Area Development, with the results summarised in **Section 8.2.3**.

8.2.6 Mitigation Measures

The planned mitigation measures that will be undertaken to minimise the impact of discharges to sea from the Mariner Area Development are given in **Table 8.11**.

Table 8.11: Potential sources of impact and planned mitigation measures relating to discharges to sea

Potential source of impact		Planned Mitigation Measures
Drilling discharges	Mud and cuttings	• The drilling operation will be planned, managed and monitored so as to minimise the volume of residual mud that will have to be disposed of. Detailed records will be kept of the types and volumes of mud chemicals used, lost downhole (i.e. lost into rock strata) and discharged. • All chemicals will be assessed as part of the chemical risk assessment. • Surplus muds and clean-up material will be collected and returned to shore. • Any water will be treated to less than 30 mg/l oil content prior to discharge. Discharge will be monitored and reported.
	Cement	• Excess dry cement will be shipped to shore, rather than discharged to sea. Cement volumes will be carefully calculated and the possibility of excess cement will be minimised by good operating procedures.

Table 8.11 continued: Potential sources of impact and planned mitigation measures relating to discharges to sea

Potential source of impact		Planned Mitigation Measures
Installation and commissioning discharges	Hydrotesting	• During the planning, implementation and monitoring of hydrotesting and other subsea commissioning activities, chemical use and discharge will be minimised as far as practicable. • Flooding, gauging, testing, dewatering and drying operations will be designed and carried out by experienced, specialist contractors, who will be supervised by Statoil personnel. • There will be a strict requirement for contractors to adhere to the conditions of the chemical permit. • Discharges will be made from designated points, will be controlled by means of the appropriate equipment (pumps, valves and instrumentation) and procedures and will be carried out according to specification.
Operational discharges	Produced water	• The primary route of produced water disposal will be via re-injection. Statoil will maximise the availability of the PWRI system, aiming for 95%. • Overboard disposal will be the contingency method during PWRI downtime and during periods of low water cut. • Produced water equipment will be regularly maintained to ensure operational capability.

8.3 Noise

Sound is important for many marine organisms with 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), for example, use sound for navigation, communication and prey detection. Anthropogenic underwater noise therefore has the potential to impact on marine mammals (e.g. Southall *et al.,* 2007, Richardson, *et al.,* 1995). For example, underwater noise may cause animals to become displaced from activities potentially interrupting feeding, mating, socialising, resting or migration. This may effect body condition and reproductive success of individuals or populations (e.g. Southall *et al.*, 2007; Richardson *et al.*, 1995). Feeding may also be affected indirectly if noise disturbs prey species (e.g. Southall *et al.*, 2007; Richardson, *et al.*, 1995; Vella *et al.*, 2001).

Several operations associated with the Mariner Area Development construction/installation will generate underwater noise. This section assesses the potential noise impacts associated with these construction/installation activities on the target species. Although underwater noise will also be generated during the operation of the Mariner Area Development, this is not considered potentially significant and is not included within this assessment.

Underwater noise generated from the Mariner Area Development will be managed in accordance with the current legislation and standards summarised below and discussed in further detail within **Appendix A**.

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 in 2009 and 2010), it is an offence to:

a) deliberately capture, injure or kill any wild animal of a European Protected Species (EPS); and

b) deliberately disturb wild animals of any such species.

Disturbance of animals is defined under the Regulations as including, in particular, any disturbance which is likely to:

a) impair their ability to (i) survive, breed, rear or nurture their young; or (ii) in the case of animals of a hibernating or migratory species, to hibernate or migrate; or

b) to affect significantly the local distribution or abundance of the species to which they belong.

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

8.3.1 Methodology

For each activity associated with the proposed development, the likely sources of noise have been identified. The typical level of sound generated by each source has been obtained from published studies (Reviewed by Genesis, 2011 summarised within **Table 8.12**), sorted by activity and summed accordingly to generate a cumulative sound level. In order to model the worst case scenario, it has been assumed that all sources will operate at all times during each activity. In reality, some vessels may be present only intermittently and some operations may be conducted sequentially rather than simultaneously. The source level may therefore be lower than predicted within this assessment.

Table 8.12: Underwater sound levels produced by different types of vessel and activity

Source	**Source level of underwater sound** (peak to peak dB re 1µPa at 1 m)*	**Predominant frequencies (Hz)**
Mean ambient level	80 to 100	-
Drilling from semi-submersible	154 to 160	100 to 500
Dredging / trenching	178	80 to 200
Piling (1.5 m diameter piles)	234	10 to 12,000
Piling (4.0 m diameter piles)	249	10 to 12,000
Tug vessel	140 to 170	100 to 500
Supply / support / standby vessel	160 to 180	50 to 200
Dynamic positioning vessel	170 to 180	500 to 1,000
Small vessels (55 to 85 m)	170 to 180	< 1,000
Helicopters	109 *	< 500
Anchor handling vessel	164 to 170	50 – 1,000

Key: dB re1 µPa at 1 m – unit of Sound Pressure Level extrapolated to 1m range from source †
* * Received level at 3 to 18 m below the sea surface.
* As measured at the water surface
Source: Genesis (2011), Richardson *et al.* (1995)

8.3.1.1 Prediction of sound levels generated by piling

Nedwell *et al.*, 2005 suggest a correlation between pile diameter and the source sound level, and present the following simplistic formula to predict piling source levels:

$$Ls = 24.3D + 179$$

where *L*s is the peak-to-peak source noise level in dB re 1 µPa-m and *D* is the diameter of the pile in metres.

8.3.1.2 Sound Propagation

Sound propagation from the source was determined using the equation presented by Richardson *et al.* (1995), simplified to exclude absorption:

$$L_r = L_s - 15 \log_{10}(R) - 5 \log_{10}(z) - 60$$

where L_s is the source sound pressure level in dB re 1 µPa-m, L_r is the received sound pressure level in dB re 1 µPa at a distance R in km from the source and z is the depth of the water in metres.

The equation described by Richardson *et al.* (1995) assumes that source and receiver are in the middle of the water column.

8.3.1.3 Evaluation of Potential Impacts

The likely impact of noise generated by the proposed development on cetaceans occurring in the development area has then been assessed by comparing the received noise levels with the Southall *et al.* (2007) criteria for injury and disturbance to marine mammals, according to the recommended method of JNCC (2010b).

8.3.2 Potential Sources of Impact

The main sources of sound associated with the construction/installation stage of the Mariner Area Development, as described within **Section 3**, are summarised in **Table 8.13** and discussed in detail below.

Table 8.13: Main activities and associated vessels associated with the installation phase of the Mariner Area Development

Activities	Associated Vessels

• drilling from a jack-up drilling and semi-submersible rigs
• installation of the PDQ
• installation of subsea facilities including:
  • a 6", ~33 km gas import pipeline connecting the PDQ to the 32" Vesterled pipeline (Vesterled Tee);
  • a 6" ~2.4 km diluent import pipeline connecting the PDQ to the FSU;
  • a 10" ~2.6 km crude export pipeline connecting the PDQ to the FSU;
  • a PLET and spool to connect the 6" diluent import pipeline to the PDQ;
  • a PLET (to connect the 6" diluent import pipeline to the flexible risers at the FSU;
  • a PLET and spool to connect the 10" crude export pipeline to the PDQ;
	• installation /construction vessels
	• pipe-laying vessel
	• support vessel
	• anchor handling vessels (AHVs) and tugs
	• rockdump vessel
	• cable lay vessel
	• heavy lift vessels
	• heavy transport vessels
	• trenching and backfill vessel
	• survey vessels
	• intermittent supply vessels
	• intermittent helicopters

Table 8.13 continued: Main activities and associated vessels associated with the installation phase of the Mariner Area Development

Activities	Associated Vessels
• a PLET (to connect the 10" crude export pipeline to the flexible risers at the FSU; a PLET and spool to connect the 6" gas import pipeline to the PDQ; • a PLET to connect the 6" gas import pipeline to the PLEM at the Versterled tie-in location; • a PLEM, to connect the 6" gas import pipeline to the 32" Vesterled pipeline (Vesterled Tee); • a 12¾" 6.5 km crude export pipeline connecting the Mariner East template to the PDQ; • a 6.5 km umbilical to connect the Mariner East template to the PDQ; • a SSIV close to the PDQ, remotely controlled from the PDQ; and • a 73 km fibre optic communication cable is to be installed between the PDQ and the Heimdal platform. rockdump and mattresses	•

8.3.2.1 Sound generated during PDQ Installation

The PDQ topside will be supported upon an eight legged jacket (**Figure 3.14**), secured to the seabed by 6 piles at each of the four corners (**Figure 3.15**). Each pile will be 2.438 m (96") in diameter, and will be piled to a penetration depth of 60 m.

Piling involves repeated impact of the pile using a hydraulic hammer in order to drive the pile to the desired depth. Piling noise varies with factors such as the diameter and length of the pile, piling technique and seabed condition (Genesis, 2011; OSPAR, 2009b). Piling generates high levels of underwater sound that is characterised as a multiple impulsive sound with long duration (Nedwell *et al*., 2005). The frequency spectrum is dominated by low frequency noise at approximately 100 to 400 Hz, with tones at higher frequencies (OSPAR, 2009b; Thomsen *et al*., 2006). Noise from piling can enter the marine environment by at least three routes: through the air, as transmission of vibrations from the pile into the water column and through the seabed. Transmission directly from the pile into the water column is typically the route by which the greatest energy is transmitted (Nedwell *et al*., 2005).

The predicted source sound level generated during the PDQ installation is 181 dB re 1 µPa-m (excluding piling) and 237 dB re 1 µPa-m (including piling) (**Table 8.14**).

Table 8.14: Predicted sound levels generated during PDQ installation

Source	dB re 1 µPa-m	Quantity	Combined Source Level dB re1µPa-m	
Tug pulling barge	170	2		
Heavy lift vessel	180	1		
Piling	237	-	**Excluding piling** **181**	**Including piling** **237**

8.3.2.2 Sound produced during pipeline installation, including trenching, burial and rock dumping

As described within **Section 3.6**, the Mariner Area Development will require the installation of diluents, gas import and crude export lines. At this stage, the method of pipeline installation is unknown, although may require an anchored lay vessel, a dynamically positioned (DP) reel-lay vessel or a DP S-lay vessel.

Measurements of noise generated by pipe-laying vessels suggest that the spectrum is dominated by sound at low frequencies of between 10 and 1,000 Hz, with peak source levels at less than 500 Hz (Genesis, 2011). Trenching vessels produce continuous sound with strongest levels at low frequencies but with high frequency tones also present. Few measurements are available but peak sound levels may be around 177 dB re 1 µPa at 1 m and levels are likely to fluctuate with operating status of the vessel (Genesis, 2011; Nedwell and Edwards, 2004; Richardson *et al*., 1995). In general, sound levels from the vessels required for trenching are likely to be greater than the trenching activity itself (Genesis, 2011).

Rock dumping is also likely to produce noise. However, measurements of rock placement from a fall pipe rock dumping vessel found no evidence that the rock placement itself contributed to the noise level from the vessel (Nedwell and Edwards, 2004).

The predicted source sound level generated during pipeline installation is 186 dB re 1 µPa-m (**Table 8.15**).

Table 8.15: Predicted sound levels generated by pipeline installation activities

Source	dB re 1 µPa-m	Quantity	Combined Source Level dB re1µPa-m
Anchor handling vessel	170	1	**186**
DP pipe-lay vessel	180	1	
Support vessel	180	1	
Rock dump vessel	180	1	
Construction vessel	180	1	

8.3.2.3 Sound generated during FSU installation

Following the installation of the mooring system in 2015, the FSU will be installed in Q2/Q3 2016. Installation and hook-up operations are expected to take two weeks. The FSU will be towed to location by two tugs. The mooring lines will be attached to the seabed either by anchors or by suction pile anchor system. Noise from the suction pile installation is expected to be very low since the only noise source is a suction pump located above water (Spence *et al.* 2007).

The predicted combined source level of sound produced during FSU installation is 185 dB re 1 µPa-m as detailed within **Table 8.16**.

Table 8.16: Predicted sound levels generated during FSU installation

Source	dB re 1 µPa-m	Quantity	Combined Source Level dB re1µPa-m
Anchor handling vessel	170	1	185
Tug	170	2	
Support vessel	180	1	
Construction vessel	180	2	

8.3.2.4 Sound generated during jack-up installation

The jack-up drilling rig for the Mariner field will either be towed to location by several tugs or will be shipped on the back of a large barge. Installation will occur in Q3 2016.

The predicted combined source level of sound produced during jack-up installation is 175 dB re 1 µPa-m as detailed within **Table 8.17**.

Table 8.17: Predicted sound levels generated during FSU installation

Source	dB re 1 µPa-m	Quantity	Combined Source Level dB re1µPa-m
Anchor handling vessel	170	3	**175**

8.3.2.5 Sound produced during drilling operations

As described within **Section 3.5**, the development of the Mariner field will involve 60 well slots, a maximum of 50 simultaneously active wells and 92 sidetrack wells, drilled via the PDQ platform and the jack-up drilling rig. The jack-up drilling rig will leave the Mariner field in 2021, after a five year drilling campaign after which, the 92 sidetracks will be drilled through the well slots from the PDQ after 2021. The Mariner East field will be developed by drilling four production wells from a separate semi-submersible drilling rig located 6.5 km from the Mariner drilling rigs.

The PDQ topside will be supported upon an eight legged jacket. Underwater noise produced from such platforms is expected to be relatively low given the small surface area for sound transmission and given all the machinery is located above the waterline (Genesis, 2011). No data is currently available describing sound levels generated from jack-up drilling rigs, it is expected levels would be similar to those arising from steel production platforms (**Table 8.18**, Genesis, 2011).

There are few published measurements of noise generated by drilling facilities (Genesis, 2011; Richardson *et al.*, 1995). Sound levels from semi-submersible drilling rigs is typically low frequency and continuous in character, with a measured bandwidth between 10 - 1,000 Hz (Genesis, 2011). Richardson *et al.*, (1995) suggests sound levels from drilling by drill rigs (‘drillships’) are higher than semi-submersibles, as semi-submersibles lack a large hull area and are therefore decoupled from the water. Additionally, with semi-submersibles, machinery is raised above the sea on risers supported by submerged flotation chambers, with sound consequently transmitted to water via air or risers rather than directly from a hull. McCauley (1998) estimated a source level of 157 to 160 dB re 1 µPa at 1 m from a semi-submersible during drilling periods, with a reduction of 4 dB outside drilling periods.

The predicted combined source sound level produced during drilling at the Mariner and Mariner East fields is summarised in **Table 8.18.**

Table 8.18: Predicted combined source sound levels during drilling operations

Source	dB re 1 µPa-m	Quantity	Combined Source Level dB re1µPa-m
Mariner			
Jack-up drilling rig	162	1	**183**
PDQ	162	1	
Helicopter	109	1	
Standby vessel	180	1	
Supply vessel	180	1	
Mariner East			
Semi submersible	160	1	**170**
AHV	170	1	

8.3.2.6 Cumulative sound levels

The estimated source and received noise levels at various distances from the Mariner Area Development installation activities are detailed within **Table 8.19**. As piling can generate high sound levels but is likely to be of short duration, noise levels have been estimated for the periods of installation during and outside piling operations.

Table 8.19: Predicted sound level at distance from source during Mariner Area Development installation

Development activity	Source SPL (dB re 1 µPa-m)	Received SPL (dB re 1 µPa) at distance (km) from source								
		0.01	0.5	1	2	5	10	25	50	100
Drilling operations (Mariner)	183	143	117	113	108	102	98	92	87	83
Drilling operations (Mariner East)	170	130	105	100	96	90	85	79	75	70
Installation of PDQ with piling	237	197	172	182	178	157	152	146	142	137
Installation of PDQ without piling	180	141	115	126	121	100	96	90	85	81
Installation of pipeline	186	146	120	131	126	105	101	95	90	86
FSU installation	185	145	119	115	110	104	100	94	89	85
Jack-up installation	175	135	109	105	100	94	90	84	79	75

The project schedule (**Section 3.4**) indicates that all operations will occur sequentially, with the exception of the following activities proposed to commence Q3 2016:

- Drilling (Mariner)
- Jack-up installation (Mariner)
- FSU installation and hook up (Mariner)

Tables 8.20 and **8.21** detail the predicted source and distance based cumulative sound levels likely to be generated during this period.

Table 8.20 Predicted sound levels generated during Q3 2016.

Activity	dB re 1 µPa-m	Combined Source Level dB re1µPa-m
Drilling operations (Mariner)	183	**187**
Jack-up installation	175	
FSU installation and hook up	185	

Table 8.21: Predicted sound level at distance from source during activities scheduled during Q3 2016

Development activity	Source SPL (dB re 1 µPa-m)	Received SPL (dB re 1 µPa) at distance (km) from source								
		0.01	0.5	1	2	5	10	25	50	100
Q3 activities	187	147	121	117	112	106	102	96	91	87

8.3.3 Assessment of Impact

8.3.3.1 Thresholds 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 sound level source, noise can have a severe effect. However, at greater distance from a source the noise decreases and the potential effects are diminished (Nedwell *et al*., 2005; Nedwell and Edwards, 2004). Hearing sensitivity, in terms of the range of frequencies and sound levels that can be perceived, varies with species and the minimum level of sound that a species is able to detect (the “hearing threshold”) varies with frequency (e.g. 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 (high-, mid- and low-frequency hearing types) subjected to different types of noise (single pulse, multiple pulse and non-pulse). These criteria are now widely recognised within the scientific community as the appropriate precautionary noise criteria for assessing the impact of underwater noise on marine mammals (JNCC, 2010b).

There are major differences in the hearing capabilities of different marine mammal species and, consequently, vulnerability to impact from underwater noise differs between species. **Table 8.22** lists the cetacean functional hearing groups used by Southall *et al*. (2007) and the species in each group that may occur in the vicinity of the Mariner Area Development (**Section 4.5.5**).

Table 8.22 Functional cetacean hearing groups

Cetacean functional hearing group	Estimated auditory bandwidth	Species sighted in the Mariner Area Development area (Quadrant 9)
Low-frequency	7 Hz – 22 kHz	Minke whale
Mid-frequency	150 Hz – 160 kHz	White-beaked dolphin White-sided dolphin Killer whale
High-frequency	200 Hz – 180 kHz	Harbour porpoise

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

Table 8.23 lists the different noise types described by Southall *et al.* (2007) and categorises the sound generating activities associated with the Mariner Area Development. 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.

Table 8.23: Noise types and activities associated with the Mariner Area Development

Noise type	Definition *	Installation activities
Single pulse	Brief, broadband, atonal, transient, single discrete noise events, characterised by rapid rise to peak pressure.	Single pile strike
Multiple pulse	Multiple pulse events within 24 hours.	Multiple pile strikes
Non-pulse	Intermittent or continuous, single or multiple discrete acoustic events within 24 hours; tonal or atonal and without rapid rise to peak pressure	Vessel activity, drilling, pipe-laying, trenching, rock dumping

The proposed precautionary thresholds for peak sound pressure levels and sound exposure levels that are likely to lead to injury (permanent threshold shift (PTS)) and disturbance to marine mammals for different noise types are described within **Table 8.24** (Southall *et al.* 2007).

Table 8.24: Precautionary thresholds 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	Single pulse	Multiple pulse	Non-pulse
Low-frequency	SPL	230	230	230	224	-	-
	SEL	198	198	215	183	-	-
Mid-frequency	SPL	230	230	230	224	-	-
	SEL	198	198	215	183	-	-
High-frequency	SPL	230	230	230	224	-	-
	SEL	198	198	215	183	-	-

Notes:

1. SPL – peak Sound Pressure Level in dB re 1 µPa; SEL – Sound Exposure Level in dB re 1 µPa2s.

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

For pulse and non-pulse sounds, Southall *et al.* (2007) concluded that the available data on marine mammal behavioural response were too variable and context-specific to justify proposing single disturbance criteria for broad categories of taxa and sounds. Instead, Southall *et al.* (2007) reviewed available observations on behavioural responses of each marine mammal functional hearing group to different types of sound and ranked the reported responses according to a “behavioural response severity” scale which is shown in **Table 8.25**

Table 8.25: Behavioural response severity to noise from Southall *et al.* (2007)

Score	Definition
0-3	Behaviour that is relatively minor or brief
4-6	Behaviour with a higher potential to affect foraging, reproduction of survival rates
7-9	Behaviour considered likely to affect foraging, reproduction or survival rates

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 (2010b), 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, suggest that disturbance to a marine mammal is likely to occur from sustained or chronic behavioural response with a severity scoring of 5 or above according to the scale of Southall *et al.* (2007).

8.3.4 Injury to Marine Mammals

For each project activity, **Table 8.26** indicates the distance from the operations beyond which the predicted noise level would be too low for injury under these criteria. The threshold for injury is predicted to be exceeded only during the installation of the PDQ jacket during piling. The peak sound pressure level, rather than sound exposure level, criteria are used because the former is more readily available in the literature (Southall *et al.*, 2007). Piling, which is the most significant noise source associated with the Mariner Area Development, is a “pulse” or “multiple pulse” type noise and so peak pressure level is likely to be the most appropriate indicator of potential impact on marine mammals (Southall *et al.,* 2007) (**Table 8.26**).

Table 8.26: Predicted zones of injury and disturbance (single pulse sounds)

Activity	Source SPL (dB re 1 µPa-m)	Distance to Southall et al. (2007) threshold for injury (metres)	Distance to Southall et al. (2007) threshold for disturbance (single pulse sounds) (meters)
Drilling operations (Mariner)	183	never exceeded	never exceeded
Drilling operations (Mariner East)	170	never exceeded	never exceeded
Installation of PDQ jacket with piling	237	0.1	0.2
Installation of PDQ jacket without piling	181	never exceeded	never exceeded
Installation of pipelines	186	never exceeded	never exceeded
FSU installation	185	never exceeded	never exceeded
Jack-up installation	175	never exceeded	never exceeded

8.3.5 Disturbance to Marine Mammals

Following the recommended method, the noise studies reviewed by Southall *et al.* (2007) have, where possible, been used to determine received noise levels from the Mariner Area Development that may cause a severe behavioural response. This has been undertaken by considering studies that:

- are relevant to the Mariner Area Development because they report on similar noise sources and similar species; and
- report a behavioural response of severity 5 or above.

These thresholds have been compared with the sound levels and noise types generated by the activities associated with the proposed development to estimate a distance from the activities within which a severe behavioural response may occur for each marine mammal hearing type (**Table 8.27**). An estimate of the density of animals in the area, based on the Small Cetaceans in the European Atlantic and North Sea (SCANS) II July 2005 survey (SCANS II, 2010), has then been used to estimate the number of animals of each species potentially experiencing severe disturbance (**Table 8.28)**

It should be noted that the estimated number of animals disturbed is likely to be an overestimate because there is no clear relationship between received sound pressure level (SPL) and severe behavioural response; this analysis conservatively uses the lowest reported SPL causing severe behavioural response. Additionally, in practice marine mammals are likely to be patchily located and move over large areas; there may be no individuals within the estimated zone of disturbance at the time of the installation.

8.3.5.1 Potential effects of noise from piling operations

The greatest noise source associated with the Mariner Area Development construction/installation will be associated with piling. Cetacean species anticipated to be present in the project area during the scheduled period for these operations are harbour porpoise, white-beaked dolphin, white-sided dolphin and minke whale.

There is little empirical information on the impact of pile driving on cetacean individuals or population and currently no direct evidence for a causal link between pile driving sound and physical injury exists (JNCC, 2010b). However, auditory sensitivity data does suggest that, without mitigation, pile driving is likely to produce sound levels capable of causing injury or disturbance to cetaceans (JNCC, 2010b; OSPAR, 2009b). Several studies have addressed the impact of pile driving during wind farm construction on harbour porpoises (Brandt *et al.* 2011*;* Carstensen *et al.*, 2006; Tougaard *et al.*, 2006, 2003). Tougaard *et al.* (2003) found that acoustic activity from harbour porpoises decreased at the onset of piling but returned to normal several hours after cessation of piling. Changes in swimming behaviour were also noted. The area of impact extended to 15 km from the piling site. Tougaard *et al.* (2006) and Carstensen *et al.* (2006) reported similar impacts. Brandt *et al.* (2011) found that the time taken for harbour porpoise acoustic activity to return to baseline decreased with increasing distance from the construction site; at 2.6 km, recovery took one to three days. These results suggest that piling has the potential to temporarily disturb cetaceans (David, 2006).

Table 8.27: Estimated zones of disturbance (multiple pulse and non-pulse sounds)

Cetacean functional hearing	Noise type	Received SPL (dB re 1 µPa) potentially causing behavioural response of severity ≥5 (Southall et al. 2007)	Distance (km) from Mariner Area Development activity beyond which SPL is lower than SPL potentially causing severe behavioural response						
			Drilling operations (Mariner)	Drilling operations (Mariner East)	Installation of PDQ jacket with piling	Installation of PDQ jacket without piling	Installation of pipelines	FSU installation	Jack-up installation
Low-frequency	Multiple pulse	~ 140 – 160 dB	0.016	0.002	64.200	0.011	0.025	0.021	0.004
	Non-pulse	~ 120 – 160 dB	0.335	0.048	1383.151	0.236	0.535	0.463	0.094
Mid-frequency	Multiple pulse	No clear relationship between received SPL and response severity. Response of severity 7 at SPL ~ 170 – 180 dB by some species to various sounds.	0.000	0.000	0.642	0.000	0.000	0.000	0.000
	Non-pulse	No clear relationship between received SPL and response severity. > ~ 120 dB	0.335	0.048	1383.151	0.236	0.535	0.463	0.094
High-frequency	Multiple pulse	ND	NA	NA	NA	NA	NA	NA	NA
	Non-pulse	Strong response at >~140 dB	0.016	0.002	64.200	0.011	0.025	0.021	0.004

Notes: NA (Not Applicable) – noise type is not applicable to this activity;

ND (No Data) – lack of data in the scientific literature;

Received SPL thresholds have been estimated from studies reviewed by Southall et al. (2007) considered relevant to the project (similar species and noise sources).

Table 8.28: Estimated number of animals potentially experiencing behavioural disturbance

Species	Estimated density in area (animals/km^2) [1]	Estimated number of animals that may experience severe behavioural disturbance [2]						
		Drilling operations (Mariner)	Drilling operations (Mariner East)	Installation of PDQ jacket with piling	Installation of PDQ jacket without piling	Installation of pipelines	FSU installation	Jack-up installation
Minke whale	0.013	0.000	0.000	168.246	0.000	0.000	0.000	0.000
Killer whale	ND	ND	ND	ND	ND	ND	ND	ND
White-beaked dolphin	0.011	0.004	0.000	0.0142	0.002	0.010	0.007	0.000
White-sided dolphin	0.094	0.033	0.001	0.1217	0.016	0.084	0.063	0.003
Harbour porpoise	0.177	0.000	0.000	ND	0.000	0.000	0.000	0.000

[1] *Source: SCANS II (2010)*

[2] *Calculation method based on Southall et al. (2007) as recommended by JNCC (2010b)*

Note: ND indicates lack of data on density or threshold for disturbance.

8.3.6 Transboundary and Cumulative Impacts

The proposed development is located approximately 40 km from the UK/Norway median line. At this distance, noise levels from piling, the greatest source of sound associated with the development, would attenuate to approximately 188 dB re 1 µPa. This is higher than the level expected for ambient noise in the open ocean (**Table 8.12**; Wenz, 1962) but is lower than levels likely to cause injury or disturbance to any cetacean species (**Table 8.22**). Therefore, there is unlikely to be a transboundary or global impact from the noise generated by the proposed development.

8.3.7 Consultee Concerns

No concerns were raised through the informal consultation process (**Section 6**).

8.3.8 Mitigation Measures

The proposed mitigation measures to minimise the impact of underwater noise generated by Mariner Area Development construction activities are detailed in **Table 8.29**. These include measures described by JNCC (2010b), and outline a protocol for mitigating the potential impacts of underwater noise from pile driving.

Table 8.29: Mitigation measures

Potential source of impact	Planned mitigation measures
Underwater noise from piling	• Presence of trained marine mammal observers to conduct a pre-operational search for marine mammals within a mitigation zone of at least 500 m radius around the operations, leading to a delay in piling operations if marine mammals are detected. • Soft-start of pile driving, whereby the piling power is increased slowly over a set time period. This is believed to allow any marine mammals to move away from the noise source, reducing the likelihood of exposing animals to sounds which may cause injury or disturbance. • Where possible, conducting operations during daylight hours.
Underwater noise from construction activities	• Machinery and equipment will be in good working order and well-maintained. Helicopter maintenance will be undertaken by contractors in line with manufacturers and regulatory requirements. • The number of vessels utilising DP will be minimised and restricted to supply and anchor handling vessels. • Drilling, rockdumping, vessel activity and trenching are in general not considered likely by JNCC (2010b) to pose a high risk of injury or non-trivial disturbance. The noise impact assessment undertaken supports this view, showing that there is unlikely to be any significant impact on any marine species. It is therefore considered unlikely that further mitigation measures will be required.

8.4 The Long-term Physical Presence of the PDQ, FSU, Drilling Rigs, Pipelines and other Subsea Structures on the Seabed

This section discusses potential long-term environmental and socioeconomic impacts associated with the presence of the Mariner Area Development including: PDQ, FSU, drilling rigs, pipelines, subsea infrastructure, and various support vessels.

Installation of the PDQ and subsea drilling template, drilling rigs, pipeline trenching, rock-dumping and mooring of the FSU will result in the long-term physical presence of structures on the seabed. This long-term presence can cause direct environmental impacts such as benthic habitat degradation and the mortality of benthic organisms, while pipelines and subsea structures also have the potential to limit access for fishing and impede fishing gear.

Physical presence and disturbance as a result of the Mariner Area Development will be managed in accordance with current legislation and standards as summarised below and discussed in **Appendix A**.

- Under the OSPAR Recommendation 2010/5 on the assessment of environmental impacts on threatened and/or declining species, Statoil need to ensure all relevant species and habitats on the OSPAR List of threatened and/or declining species and habitats are included within the Mariner Area Development environmental assessment.

- Under the Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001) (as amended), the protection of habitats and species (under the European Directives) in relation to oil and gas activities, such as the Mariner Area Development, are implemented in all UK waters.

- The Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007 (as amended 2010) implement the Birds Directive and Habitats Directive in relation to UK marine areas beyond the territorial sea, such as the Mariner Area Development. These Regulations make provision for the selection, registration and notification of European Offshore Marine Sites in the offshore marine area and for the management of these sites. Statoil need to demonstrate within the ES that all steps will be taken to avoid the disturbance of species and deterioration of habitat in respect of the offshore marine sites before the Mariner Area Development will be authorised by DECC.

- Under the Marine & Coastal Access Act 2009 and the Marine (Scotland) Act 2010 Statoil need to ensure protection for the marine environment and biodiversity in relation to a number of activities associated with the Mariner Area Development such as the removal of materials from the seabed, and disturbance of the seabed.

- Under the Environmental Liability European Directive (2004/35/EC) 2009 and the Environmental Liability (Scotland) Regulations Directive 2009, Statoil have liability for the prevention and remediation of environmental damage to ‘biodiversity’, water and land from specified activities and remediation of environmental damage for all other activities through fault or negligence.

- Under the EIA Directive 97/11/EC implemented through the Environmental Impact Assessment (Scotland) Regulations 1999 as amended, the Mariner Area Development falls within Annex I list for which the EIA process is mandatory and requires the assessment of the effects of certain public and private projects on the environment.

- Statoil will require navigational provision to locate the planned drilling activities. The provisions under The Coast Protection Act (CPA) 1949 (as extended by the Continental Shelf Act 1964) have been transferred to Energy Act 2008 Part 4A by the MCAA and MSA to cover navigation considerations related to the proposed activities.

8.4.1 Methodology

This section assesses the long-term physical presence of the structures (PDQ, FSU, drilling rigs pipelines and other subsea structures) which are installed at project initiation and remain on the seabed throughout the 30 year lifetime of the Mariner Area Development project (**Section 3**). The presence of the jack-up and semi-submersible drilling rigs, will remain on-site at each location for a period of five years following commencement of drilling activities, and have been included within this assessment.

This assessment takes into account the socioeconomic environment that surrounds the Mariner Area Development and is summarised in **Section 5**. From the socio-economic description in **Section 5**, other users of the sea include those involved in or responsible for commercial fisheries, shipping, submarine cables, oil and gas activities, military activities, designated wrecks, renewable activities, gas storage and CO_2 storage, and aggregate extraction. Of these, commercial shipping and fishing are examined in this assessment due to their proximity to the Mariner Area Development location.

The area of seabed likely to be impacted by the long-term physical presence of the Mariner Area Development has been estimated in **Section 8.1**, **Table 8.8,** to be at most 3.23 km^2. In addition, there would be the long-term exclusion/safety zone around the

FSU, PDQ, flotel and the subsea drilling template have estimated to be 3.14 km^2 assuming four separate zones, with a 500 m radius.

8.4.2 Sources of Potential Impact

The following structures will be installed and remain on the seabed during the proposed lifetime of the Mariner Area Development project:

- One PDQ platform (jacket and topside modules);
- One jack-up drilling rig;
- One flotel (if anchored);
- FSU anchors and mooring lines;
- One semi-submersible drilling rig;
- One subsea template;
- one PLEM;
- six PLETs;
- a 6", ~33 km gas import pipeline connecting the PDQ to the 32" Vesterled pipeline;
- a 6" ~2.4 km diluent import pipeline connecting the PDQ to the FSU;
- a 10" ~2.6 km crude export pipeline connecting the PDQ to the FSU;
- a 12¾" 6.5 km crude export pipeline connecting the Mariner East template to the PDQ;
- a 6.5 km umbilical connecting the Mariner East template to the PDQ;
- a 73 km fibre opticcommunication cable is to be installed between the PDQ and the Heimdal platform;
- a subsea isolation valve (SSIV) close to the PDQ, remotely controlled from the PDQ.; and
- rockdump and concrete mattresses protection.

The pipelines will be trenched and buried using a water-jet or a mechanical plough. Spot rock-dumping may be required along the pipelines, to provide stability and protection against fishing gears. The pipelines and umbilicals will be trenched separately, approximately 50 m apart.

During the pipe-laying activities, there is an interim period where the pipeline would be left uncovered or laid on the seabed for a period of two to three days. Guard vessels would be employed during this period to alert fishing vessels to the presence of the pipelines and umbilical.

Rockdump will be used to protect spool pieces and jumpers at the ends of the pipelines and umbilical, and at the pipeline crossings. Rock sleepers will be used at pipeline crossings as supports, separating and protecting the pipelines from an existing third-party pipeline.

The Mariner Area Development will require the installation of a PDQ platform, supported by steel piled jacket structures installed on the seabed (**Section 3**), which will be surrounded by a 500 m exclusion zone.

The field life of the Mariner Area Development is expected to be approximately 30 years. The pipelines, subsea structures, the FSU and PDQ will remain in place for the duration of the field life before being decommissioned (**Section 3**).

The area of seabed likely to be impacted by the long-term physical presence of the Mariner Area Development has been estimated to be at most 3.09 km^2 (**Section 8.1**; **Table 8.8**).

8.4.3 Impact to Receptors

The long-term physical presence of the PDQ, FSU, flotel, pipelines, rockdump and subsea structures have the potential to interfere with fishing gear, leading to a loss of catch/revenue for fishermen and may also disrupt previously established shipping operations in the area.

Exclusion zones of 500 m will be in place at the PDQ, FSU, flotel and Mariner East subsea drilling template locations, with fishing and other vessels being excluded from these areas during the field life (30 years). The drilling rigs will also have a temporary safety exclusion zone in place during the five years they are both on location.

8.4.3.1 Commercial shipping

The Mariner Area Development is located in an area of low shipping activity (**Section 5**), with offshore vessels dominating the shipping traffic using the area.

With regard to commercial shipping, 13 designated shipping routes pass within 18.5 km (10 nm) of the Mariner Area Development location, and are trafficked by an estimated 500 ships per year, averaging 1 to 2 vessels per day (**Section 5.1.3**). Cargo and offshore support vessels (1,500 to 5,000 DWT vessels) dominate the shipping traffic within the Mariner Area Development area (**Section 5.1.3**).

The capacity of the Mariner Area Development to interact with commercial shipping would be relatively limited and be mitigated through statutory notifications (Notices to Mariners) and charting (on Kingfisher Charts), maintenance of a temporary 500 m radius exclusion/safety zone around the drilling rigs and pipe-lay vessel, the presence of guard vessels during these operations, maintenance of the safety/exclusion zone around the PDQ, FSU, flotel and subsea drilling template, marine communications, and navigational systems. All of these measures would enable commercial vessels to navigate around the Mariner Area Development.

8.4.3.2 Commercial fishing

With respect to commercial fishing, the potential impacts are loss of access to areas fished and the impedance to fishing by subsea structures. The relative UK fishing value and effort in the 3,390 km^2 seas area defined by ICES rectangle 48F1 (which includes the Mariner Area Development) were assessed to be of medium value (£1,500,000 to £3,000,000) (**Section 5.1.1**). Exclusion of fishing vessels will occur within the temporary exclusion/safety zones during pipeline installation and in the vicinity of other operations not governed by exclusion zones (e.g. rockdump placement). Long-term vessel exclusion will occur within the exclusion/safety zone around the FSU, PDQ, flotel and the subsea drilling template (seabed area 3.14 km^2; **Section 8.4.1**). These areas are small in comparison to the extensive adjacent areas of grounds which will be available for fishing.

Navigational issues relating to commercial fishing are governed by the same mitigation measures that apply to commercial shipping (with the addition of a fisheries liaison officer, as appropriate). They are also governed by the design controls to minimise the risk of impedance to fishing, which are discussed below.

The physical presence of the Mariner Area Development pipelines and subsea structures on the seabed could interfere with demersal (bottom-towed) fishing gear and also indirectly lead to a loss of catch/revenue for fishermen in the project area. The Mariner Area Development is located in an area of medium commercial value for fish species landed and the main fishing gears used in the area are demersal methods (**Section 5**), which have the greatest potential to interact with subsea pipelines. Passive gears, such as nets and lines, can also be impacted during pipeline installation (Hansen, 1999), but after a pipeline has been laid, it is unlikely to represent any hazard to passive fishing gears.

The Mariner Area Development is located in an area where the main fishing gears used are demersal trawls (otter and pair) (**Section 5.1.1**), which have the potential to interact with subsea pipelines. Trawling is the operation of towing a net to catch fish. The net may be towed over the seabed or at any depth in mid-water according to the species sought, by one or two vessels. Demersal trawling is where the net is towed directly over the seabed. The weight and width of fishing gear and the nature of the benthic substrate to a large extent determines the degree of impact.

The fishing techniques with the greatest level of seabed interaction are beam trawling, rock hopper otter trawls and shellfish dredging. Otter and pair trawling are the main method of demersal trawling that occurs in the Mariner Area Development area. Otter and pair trawling targets both finfish and shellfish species found on or near the seabed bottom.

To minimise impacts to fisheries, the PLEM and PLETs will be encased in a protective structure which will have a smooth frame that will allow nets to ride up and over the top, thus reducing the risk of snagging. Furthermore, the pipelines and umbilicals will be trenched and buried and, where necessary, spot rock dumping will be undertaken to prevent any upheaval buckling and consequent exposure of the pipelines or umbilicals.

8.4.3.3 Fishing gear interaction with PDQ and FSU

Exclusion zones of 500 m will be in place at the PDQ, FSU and subsea drilling template locations, with fishing and other vessels being excluded from these areas during the 40 year Mariner Area Development field life. The drilling rigs will also each have a temporary safety exclusion zone in place. The PDQ, the FSU, the subsea drilling template and the drilling rigs will therefore not represent a risk to fishing or other users of the sea.

8.4.3.4 Fishing gear interaction with areas of long-term rockdump

When trawling over rockdumped sections of a pipeline, graded rock can be dragged off by bottom-towed fishing gear and spread over the seabed. In addition, the rock can cause wear and tear on the net, damage fish when caught and damage or crush the fish when unloaded.

During 1997, the Norwegian Institute of Marine Research conducted an over-trawling experiment to assess the risk of rockdumped pipelines to bottom trawling fishing gears (Soldal, 1997). The trial concluded that the lighter types of fishing gear with a weighted ground line were not suitable for crossing rock dumped pipelines. However, fishermen trawling this trial area for whitefish have towed their gear without reported difficulty (Soldal, 1997). In addition, over-trawling tests were conducted over areas of rockdump along Statoil’s 20” Sleipner condensate flowline, an area extensively fished by prawn trawlers. During 2002, meetings were held with fishermen regarding Norsk Hydro’s Ormen Lange flowline in the Norwegian sector of the northern North Sea. The fishermen confirmed that they trawled over flowline rockdumps without operational problems or fishing gear damage, due mainly to the fact that they used heavy net trawl gear.

Spot rock-dumping will be carried out over areas where there is a risk of upheaval buckling or where backfilling operations leave areas of the pipelines exposed. The rock dump will be graded and the pipelines and umbilical will not be blanket rockdumped. There may be a slightly increased risk of fishing gear interaction with areas of spot rock dump but the risk will be minimised by careful planning of trenching and backfilling operations to minimise the quantity of rock required.

8.4.3.5 Fishing gear interaction with subsea infrastructure

The protective structures over the PLEM and PLETs have been designed to have a fishing-friendly profile with sloping sides designed to deflect trawls, and have also been designed to protect the structures from:

- dropped object impacts (up to 75 kJ);
- fishing equipment impacts (up to 13 kJ); and
- trawl gear snag loads (up to 60 tonnes).

The structures will also be designed to mitigate the potential for fishing gear interaction.

The characteristics and profiling of any areas of rock dumping will be designed to minimise the risk of snagging to fishing gear. In addition, mariners will be notified of the location of all seabed structures which will be recorded on admiralty charts and notified via ‘Kingfisher’ reports.

8.4.3.6 Impact to benthic habitats

Rockdump on the pipelines is likely to provide an ideal substrate for colonisation by soft corals. Colonisation of the rockdump is likely to take several years, as settlement may be sporadic and not begin for several years (MarLIN, 2009). Some of the soft corals such as Paragorgia and Primnoa are known to be slow-growing and may live for more than 100 years (Freiwald et al., 2004).

Anemones have a high recovery rate and re-colonisation is likely to be rapid and occur within 2 - 3 years, with full dominance restored within ~5 years (MarLIN, 2009). Sponges tend to be slow growing and long-lived and may therefore take more time to recolonise and recover. The covering of rockdump along the pipeline routes will provide an ideal substrate for the recolonisation of anemones and sponges.

The recovery and colonisation of the mobile benthic invertebrates such as echinoderms and crustacean are likely to be fairly rapid. The disturbance band will be relatively narrow

(~3 m), and it is likely that other adult organisms may migrate into the new substrate. In addition, echinoderms are relatively fecund organisms that reproduce annually, and their long-lived pelagic larvae have a relatively high dispersal potential.

Other fauna that are known to colonise the deeper parts of man-made offshore structures (i.e. within a few metres of the seabed) and are thus likely to colonise the rock dump, include hydroids, soft corals, anemones, tubeworms, barnacles, tunicates and mobile organisms such as crustacean, polychaetes and echinoderms.

8.4.4 Transboundary and Cumulative Impacts

The PDQ, FSU, drilling rigs, rockdump, pipelines, umbilicals and subsea structures are all localised and within UK waters, so there will be no transboundary or cumulative impacts.

Cumulative effects arising from the proposed development that have a potential to act additively with both existing and new developments or other human activities cannot be quantified as the Mariner Area Development will be located in a well developed area of the northern North Sea (**Section 5**) and there is no comparative data that can be used to quantify these effects. Overall, the Mariner Area Development will represent an additional 6.37 km^2 (3.23 km^2 and 3.14 km^2) long-term cumulative impact on the seabed in the area, caused by the equipment and infrastructure that will remain on the seabed for the 30 year life of the development.

8.4.5 Consultee Concerns

During the consultation process, Marine Scotland informed Statoil that trawling is the main fishing method in the development area and recommended that Statoil suitably protect pipelines (**Section 6**). Statoil have undertaken an assessment of commercial fisheries in the development area in **Section 5**, and included the results within this section.

8.4.6 Mitigation Measures

The planned mitigation measures that will be undertaken to minimise the impact of the long-term presence of structure arising from the Mariner Area Development are given in **Table 8.30**.

Table 8.30: Potential sources of impact and planned mitigation measures relating to atmospheric emissions

Potential source of emissions	Planned Mitigation Measures
Long-term physical presence of the PDQ, FSU, drilling rigs, pipeline s and other subsea structures	• A 500 m exclusion zone will surround the PDQ, flotel, FSU, subsea drilling template and drilling rigs • Pipelines and umbilicals will be trenched and buried to prevent impediment to fishing gear. • The subsea structures have been designed to mitigate the potential for fishing gear interaction. • Safeguards to minimise the risk of gear entanglement will be employed, including Kingfisher alerts and guard vessels. • The use of a fall pipe on the rockdump vessel, in the case of the requirement for rock-dumping, and the use of ROV supervision during spot rockdump operations would ensure that the rockdump was placed in the correct position. • Statoil would obtain all necessary licences before any spot rock-dumping was carried out and avoid the need for rock-dumping where possible through good project design and planning. • Mariners will be notified of the location of all seabed structures and the locations of any subsea structures, including pipelines, will be recorded on admiralty charts and via ‘Kingfisher’ reports. • Statoil will notify the Hydrographic Office, which will issue notices to mariners to advise fishing and shipping traffic of the potential hazards to navigation that will be associated with the project. Mariners will be advised of specific periods and locations in which vessel operations should be avoided. Contact information will be provided and details of guard vessels will be given. Guard vessels will be on station during pipeline installation to alert shipping and fishing vessels of potential navigational hazards. • Guard vessels will be on-site during the interim period where the pipelines are uncovered on the seabed for a year, before trenching operations are completed.

8.5 Atmospheric Emissions arising from the Drilling, Installation and Production Activities

This section quantifies the likely sources of atmospheric emissions that will arise from the Mariner Area Development and provides an estimate of emissions during drilling, installation and production activities. It also describes the measures that will be put in place to both minimise emissions and optimise energy use.

The main exhaust gases emitted by diesel-powered engines are CO_2 together with small quantities of NO_X, CO, SO_X and trace quantities of VOCs, N_2O and CH_4. The main gases emitted during tanker loading operations are VOCs.

Gaseous emissions generated from the Mariner Area Development will be managed in accordance with current legislation and standards as summarised below.

- Under the Merchant Shipping (Prevent of Air Pollution from Ships) Regulations 2008 (as amended 2010), all vessels, including the drilling rigs and FSU, associated with the Mariner Area Development will require an International Air Pollution Certificate. In addition, the 2010 amendments to these regulations specify the maximum sulphur content for marine fuel.

- Under the Petroleum Act 1998, Statoil will require written consent for flaring of gas as a result of the Mariner Area Development. In addition, venting and flaring permits will be required under the Energy Act 1976.

- The European Union Emissions Trading Scheme requires that the Mariner Area Development FSU must be issued with a permit under The Greenhouse Gas Emissions Trading Scheme Regulations 2005 (as amended) for power generation and flaring.

- The reporting and maintenance requirements, including leak detection, specified by the Environmental Protection (Controls on Ozone Depleting Substances) Regulations 2002 (as amended 2008) and the Fluorinated Greenhouse Gases Regulations 2009 must be adhered to for all refrigeration, heat pumps, air conditioning and fire protection systems.

- The UK has several pieces of legislation that provide a framework for the UK to achieve long-term goals of reducing greenhouse gas emissions, including The Climate Change Act 2008 and The National Emissions Ceilings Regulations 2002.

- In addition, the Environmental Emissions Monitoring System (EEMS) database was established by UKOOA in 1992 to provide a more efficient way of collecting data on behalf of the UK oil and gas industry. Atmospheric data from the EEMS system is reported on an annual basis and can be used to show trends in UK offshore oil and gas activity greenhouse gas emissions.

Appendix A summarises the legislation listed above and the legislative requirements Statoil must comply with.

8.5.1 Methodology

The atmospheric emissions from vessel operations can be estimated on the basis of the numbers and types of vessels, the duration and type of operations, the average daily consumption of fuel based on vessel type and published conversion factors for the unit amounts of various gases emitted when fuel is burnt (EEMS, 2008; UKOOA, 2002; Institute of Petroleum (IoP), 2000). Similarly, the emissions from the flaring of production fluids can be estimated on the basis of the total masses of gas and oil burnt and published factors for the combustion of those fluids.

This section presents a worst-case quantification of the emissions potentially arising as a result of the Mariner Area Development, evaluates their contribution to the corresponding quantities of atmospheric emissions from all oil and gas activities on UKCS using reference industry data from 2009 (UKOOA, 2011) and assesses the environmental impact of these emissions.

At the local, regional and transboundary levels, gaseous emissions may impact air quality. Key issues include the formation of acid rain from oxides of sulphur (SO_x) and nitrogen (NO_x), direct impacts on human health from NO_x, volatile organic compounds (VOCs) and particulates and the contribution to photochemical pollutant formation from NO_x, SO_x, VOCs (DECC, 2011a). The Mariner Area Development is located offshore, where the prevailing conditions would be expected to result in rapid dispersion of emissions.

At the global level, there is increasing evidence that anthropogenic gaseous emissions are amplifying the natural atmospheric greenhouse effect, leading to global warming and climate change (DECC, 2011a; IPCC, 2007). Some gases, including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), have a direct effect on radiative warming. These gases differ in the “strength” of their impact; for example, CH_4 has 21 times the global climate change potential of the main greenhouse gas, CO_2 (IPCC, 2007). Other gases, including carbon monoxide, VOCs, nitric oxide (NO), NO_2 and SO_2 have an indirect impact on the abundance of greenhouse gases through chemical reactions in the atmosphere (DECC, 2011a). In addition, research suggests that the absorption of anthropogenic CO_2 is causing acidification of sea water, with potential impact on the shells and skeletons of marine organisms (DECC, 2011a).

8.5.2 Sources of Potential Impact

Several operations associated with the installation and operation of the Mariner Area Development will release gases to the atmosphere which have the potential to affect air quality at a local level and contribute to global greenhouse gas emissions. Atmospheric emissions will arise as a result of the following operations and activities associated with the proposed Mariner Area Development:

Installation activities

- The consumption of diesel fuel by vessels, the drilling rig, flotel and helicopters during drilling operations and installation operations (pipelines, umbilicals, subsea structures and the PDQ).

Production activities

- Power generation of the PDQ and FSU;
- Flaring of excess produced gas; and
- Tanker loading operations from the FSU.

8.5.2.1 Installation activities

During the installation stage, the Mariner Area Development will involve the use of two drilling rigs, various support and construction vessels and helicopters. These vessels will be present at the Mariner Area Development location for varying amounts of time and will burn diesel fuel, which will result in gaseous emissions.

Tables 3.8a to **3.8h** in **Section 3.9.2** present the estimated gaseous emissions for vessel operations during drilling operations at the Mariner field, drilling operations at the Mariner East field, installation of the PDQ, installation of the FSU, installation of subsea infrastructure and helicopter use, respectively. **Table 8.31** summarises the estimated vessel gaseous emissions resulting from the Mariner Area Development drilling and installation operations.

Table 8.31: Summary of estimated gaseous emissions from vessels, drilling rigs and helicopters during installation operations of the Mariner Area Development

Mariner Area Development activity	Emissions (tonnes)						
	CO_2	CO	NO_x	N_2O	SO_x	CH_4	VOC
Total vessel gaseous emissions from PDQ transportation and installation operations	67,552	168.88	1,245.50	4.64	84.44	5.70	50.67
Total vessel gaseous emissions from Mariner field drilling operations	120,432	301	2,220	8	151	10	90
Total vessel gaseous emissions from Mariner East field drilling operations	24,960	62.4	460.2	1.71	31.2	2.10	18.72
Total vessel gaseous emissions from FSU transportation and installation operations	40,838	102.1	752.96	2.81	51.05	3.45	30.63
Total vessel atmospheric emissions from flotel installation and operation	106	0.26	1.95	0.01	0.13	0.01	0.08
Total vessel gaseous emissions from subsea operations	16,035	40.09	295.65	1.37	20.04	1.36	13.07
Total gaseous emissions from helicopter operations	65,229	106	254.8	4.48	81.53	1.77	16.31
Total gaseous emissions from vessels, drilling rigs and helicopter operations during installation operations at the Mariner Area Development	**335,152**	**780.81**	**5,231.52**	**23.30**	**418.93**	**24.56**	**219.81**
Emissions from UKCS Offshore Exploration and Production Activities							
Total emissions from UKCS offshore exploration and production during 2010[1]	16,393,119	24,649	55,837	1,006	2,628	50,476	54,050
Emissions from vessels, drilling rigs and helicopter operations during installation operations at the Mariner Area Development as a percentage of 2010 UKCS emissions from offshore oil and gas activities	2.04	3.17	9.37	2.32	15.94	0.05	0.41

Notes:
(1) Total emissions for offshore activities includes emissions arising from: diesel, gas and fuel oil consumption, flaring, venting, direct process emissions, oil loading and fugitive emissions. This includes emissions from production and mobile drilling rigs. The SCOPEC data does not include emissions produced by support vessels or helicopters.
(2) Results given to 2 significant figures.

Source: Oil and Gas UK (2012)

Table 8.31 also shows the total emissions during 2010 on the UKCS from offshore oil and production (Oil and Gas, 2012). These values represent total estimated emissions for offshore activities, and include emissions arising from diesel, gas and fuel oil consumption, flaring, venting, direct process emissions, oil loading and fugitive emissions. The data include emissions from production and mobile drilling rigs but do not include emissions produced by support vessels or helicopters. Therefore, a comparison between these emissions and those predicted to be generated during the Mariner Area Development installation operations is not a direct comparison but it does provide a useful indication of the relative scale of the emissions.

Results are given to two significant figures. Each table presents:

- Statoil's estimates of the duration of use and operating status of each vessel;
- the estimated fuel use per day as provided by IoP (2000);
- the total fuel use for each vessel for each operating status; and
- the associated gaseous emissions calculated using factors provided by UKOOA (2002).

The Mariner Area Development installation operations are predicted to generate approximately 335,000 tonnes of CO_2. This represents 2.04% of the total CO_2 emissions during 2010 from UKCS oil and gas installations (**Table 8.31**).

8.5.2.2 Production operations

Power generation aboard the PDQ and FSU will result in fuel use and gaseous emissions.

The resulting atmospheric emissions from power generation can be estimated based on the quantity of fuel that will be consumed and factors relating fuel consumption to quantities of gases emitted. Emission factors, which provide an estimate of the typical amount of each gas produced per unit of a particular fuel, were taken from EEMS (2008).

The main power generators aboard the PDQ will be (**Section 3.9.3**):

- ***Gas turbine generators.*** Both turbines will be able to use produced gas and imported gas for fuel. One will be a dual-fuel fired turbine generator, and will be able to use diesel during periods when fuel gas is unavailable. Statoil predict that the two gas turbines will be unavailable for 16 days a year due to scheduled and unscheduled maintenance.
- ***Diesel generators***. Diesel will be used for the auxiliary generators and the dual fuel power generator. Statoil estimate that 100 tonnes of diesel per year will be required at the Mariner Area Development over its field life to fuel the auxiliary and dual-fuel generators for testing and additional operations.

Tables 3.9 and **3.10** in **Section 3.9.3** provide a summary of the estimated annual power generation emissions (diesel and gas) at the Mariner Area Development PDQ over the field life. Fuel use and associated gaseous emissions are expected to reach a peak of approximately 113 million m^3 of gas per year in 2022.

The FSU will be powered independently from the PDQ. Power generation on the FSU will be generated by diesel generators (**Section 3.9.3**). Statoil estimate the diesel generators on the FSU will utilise an average of 7,332 tonnes of diesel per year over field life. **Table 3.11** in **Section 3.9.3** provides a summary of the estimated annual power generation emissions at the Mariner Area Development FSU.

Table 8.32 summarises the highest case annual emissions from power generation aboard the PDQ and FSU. It should be noted that these numbers represent the worst case because they have been calculated assuming the highest production profile, highest production year and worst design selected with respect to emissions. The power generation from the Mariner Area Development PDQ and FSU contributes approximately 347,000 tonnes of CO_2 emissions each year, representing 2.12 % of the total CO_2 emissions during 2010 from UKCS oil and gas installations.

Table 8.32: Estimated annual gaseous emissions from power generation aboard the Mariner Area Development PDQ and FSU

Mariner Area Development activity	**Emissions (tonnes)**						
	CO_2	**CO**	**NO_x**	**N_2O**	**SO_x**	**CH_4**	**VOC**
Diesel turbine factor (te/te)[1]	*3.2*	*0.00092*	*0.0135*	*0.00022*	*0.004*	*0.0000328*	*0.000295*
Gas turbine factors(te/te)[1]	*2.86*	*0.003*	*0.0061*	*0.00022*	*0.0000128*	*0.00092*	*0.000036*
Annual gas power generation on the PDQ (2022)	322,877	338.68	688.66	24.84	1.45	103.86	4.06
Annual diesel power generation on the PDQ	320	0.09	1.35	0.02	0.40	0.00	0.03
Annual diesel power generation on the FSU	23,462	6.75	98.98	1.61	29.33	0.24	2.16
Total annual power generation on the PDQ and FSU	**346,659**	**345.52**	**788.99**	**26.47**	**31.18**	**104.10**	**6.25**
Emissions from UKCS Offshore Exploration and Production Activities							
Total emissions from UKCS offshore exploration and production during 2010[2]	16,393,119	24,649	55,837	1,006	2,628	50,476	54,050
Annual power generation gaseous emissions from the Mariner Area Development PDQ and FSU as a percentage of 2010 UKCS emissions from offshore oil and gas activities	2.12	1.40	1.41	2.63	1.19	0.21	0.01
Notes: Results given to 2 significant figures.							

Source: [1]EEMS (2008); [2]Oil and Gas UK (2012)

Operational Flaring on the PDQ

Routine flaring and venting of gas during normal operational conditions are not expected at the Mariner Area Development, with excess gas only expected to be flared at the PDQ during 2017 and 2018, the first two years of production. However, for calculating a worst case flaring scenario at the Mariner Area Development, Statoil assume 2% of produced gas will be flared over field life due to process upset conditions, and flaring of the excess gas (**Table 3.13** in **Section 3.8.3).** The worst case quantity of gas flaring at the PDQ has been estimated as 51.3 million m^3 of gas per year.

The quantity of gaseous emissions resulting from the flaring can be estimated using emission factors specific to the flaring of gas, as described above. **Table 8.33** shows the estimated worst case gaseous emission as a result of excess gas flaring from the PDQ. The contribution of approximately 120,000 tonnes of CO_2 represents approximately 0.73% of the total UKCS offshore CO_2 emitted.

Table 8.33: Estimated annual gaseous emissions from excess gas flaring aboard the Mariner Area Development PDQ

Mariner Area Development activity	Emissions (tonnes)						
	CO_2	CO	NO_x	N_2O	SO_x	CH_4	VOC
Gas emission factors(te/te)[1]	*2.8*	*0.0067*	*0.0012*	*0.000081*	*0.0000128*	*0.045*	*0.005*
Annual gas flared (51.3 million m^3 of gas)	119,652.12	286.31	51.28	3.46	0.55	1,922.98	213.66
Emissions from UKCS Offshore Exploration and Production Activities							
Total emissions from UKCS offshore exploration and production during 2010[2]	16,393,119	24,649	55,837	1,006	2,628	50,476	54,050
Annual flaring gaseous emissions from the Mariner Area Development PDQ as a percentage of 2010 UKCS emissions from offshore oil and gas activities	0.73	1.16	0.09	0.34	0.02	3.81	0.40
Notes: *Results given to 2 significant figures.*							

Source: [1]UKOOA (2002); [2]Oil and Gas UK (2012)

Venting from crude offloading

Vented hydrocarbons from offloading of crude oil from the Mariner Area Development FSU storage tank to the shuttle tankers will result in VOC emissions. These can be estimated using emission factors provided by EEMS (2002) that relate the quantity of oil offloaded to the quantity of VOCs typically produced. The results are presented in **Table 3.15** in Section **3.9.4**, for each year of the Mariner Area Development field life. These estimates are based on the high case oil production profile (**Table 3.16**) and represent the worst case in terms of venting related VOC emissions.

Emissions are predicted to peak in 2019 at approximately 10,109 tonnes of VOCs, which represent approximately 19% of the total UKCS VOC in 2010 (**Table 8.34**; Oil and Gas, 2012). Thereafter, emissions are expected to decline in line with declining production.

Table 8.34: Estimated annual gaseous emissions from venting during crude offloading

Production year	Daily production	Annual oil production	Annual oil production	Annual VOC emissions
	m^3/day	m^3	Tonnes*	Tonnes**
2019	12,009	4,383,266	5,054,710	10,109
Emissions from UKCS Offshore Exploration and Production Activities				
Total emissions from UKCS offshore exploration and production during 2010[1]				54,050
Annual VOC emissions from the Mariner Area Development as a percentage of 2010 UKCS emissions from offshore oil and gas activities				18.70
Notes: **Based on Mariner / diluent blend API 18 / Density 0.946488294* ***Based on VOC emission factor 0.002 (te/te)*				

Source: [1]Oil and Gas UK (2012)

8.5.3 Impact to Receptors

Emissions from the Mariner Area Development will contribute to greenhouse gas emissions, which are implicated in climate change. The main environmental effects of the emission of gases to atmosphere are:

- contribution to global warming (CO_2, CH_4); and
- contribution to photochemical pollutant formation (NO_x, SO_x, VOCs).

The direct effect of the emission of CO_2, CH_4 and VOCs is their implication in global climate change (CH_4 has 21 times the global climate change potential of the main greenhouse gas CO_2) and contribution to regional level air quality deterioration through low-level ozone production. The indirect effects of low level ozone include deleterious health effects, as well as damage to vegetation, crops and ecosystems.

The direct effect of NO_x, SO_x and VOC emissions is the formation of photochemical pollution in the presence of sunlight. Low-level ozone is the main chemical pollutant formed, with by-products that include nitric and sulphuric acid and nitrate particulates. The effects of acid formation include contribution to acid rain formation and dry deposition of particulates.

The main environmental effect resulting from the emission of SO_2, as a consequence of acid gas flaring is the potential to contribute to the occurrence of acid rain; however the fate of SO_2 is difficult to predict due to its dependence on weather.

The total emissions during installation operations are estimated to represent approximately 2.04% of typical annual UKCS CO_2 emissions from oil and gas production. The largest component of these emissions is expected to be from installation vessels. In reality, the Mariner Area Development installation gaseous emissions will be intermittent over a two year period so the annual contribution will be lower than that estimated here.

The total worst-case annual gaseous emissions during the Mariner Area Development operation are estimated to represent approximately 3% of typical annual UKCS emissions from oil and gas production. This contribution is estimated based on the highest year of production and highly conservative assumptions in terms of the PDQ and FSU design and excess gas flaring rate. Therefore, the actual emissions will be lower than those estimated here.

Based on this emissions quantification, emissions associated with the Mariner Area Development are expected to represent only a small proportion of emissions typically arising from oil and gas production on the UKCS.

The exposed offshore conditions will promote the rapid dispersion and dilution of these emissions. The Mariner Area Development is located approximately 130 km east of the nearest UK coastline (Shetland Islands) and approximately 230 km west of the nearest Norwegian coastline. There are no proposed or designated sites located in close proximity that would be impacted by these atmospheric emissions.

Harbour porpoise are the only Annex II species which has been recorded with frequent sightings in the Mariner Area Development area (**Section 4.6.3**). In the open conditions that prevail offshore, the atmospheric emissions generated from the Mariner Area Development would be readily dispersed. This would ensure that, outside the immediate vicinity of the Mariner Area Development, all released gases would only be present in low concentrations. The atmospheric emissions from the Mariner Area Development are therefore unlikely to have any effect on marine mammals.

8.5.4 Transboundary and Cumulative Impacts

As the Mariner Area Development is located approximately 40 km from the UK/Norwegian median line, there is a potential for transboundary transport of atmospheric contaminants. However, under these offshore conditions, the amount of additional air emissions that will be produced are unlikely to be sufficient to have any measurable transboundary effect.

The short-term, transient nature of the drilling and installation operations will limit the emissions to air. The small volumes of resulting exhaust gases from vessels are expected to disperse rapidly in the offshore environment.

The potential cumulative effects associated with atmospheric emissions produced by the drilling operations, the installation operations, and operational emissions from continued power generation, gas flaring and tanker offloading at the FSU include global climate change (greenhouse gases), acidification (acid rain) and local air pollution. The temporary increase in emissions from the proposed operations in relation to existing operations in the area does not represent a significant additive effect when considering the total annual offshore emissions from the UKCS (**Tables 8.31** to **8.34**).

8.5.5 Consultee Concerns

No concerns were raised through the informal consultation process (**Section 6**).

8.5.6 Mitigation Measures

The planned mitigation measures that will be undertaken to minimise the impact of atmospheric emissions arising from the Mariner Area Development are given in **Table 8.35**.

Table 8.35: Potential sources of impact and planned mitigation measures relating to atmospheric emissions

Potential source of impacts		Planned Mitigation Measures
Operations during the installation and start up stage	Consumption of diesel fuel by vessels, the drilling rig and helicopters	• Vessels will be audited as part of selection and pre-mobilisation and management system requirements. • Fuel consumption will be minimised by operational practices and power management systems for engines, generators and other combustion plant and maintenance systems. • Vessels will use ultra low sulphur fuel in line with MARPOL requirements. • Work programmes will be planned to optimise rig and vessel time in the field.
Operations during the production stage	Power generation aboard the PDQ	• Turbine design and operation will be optimised to minimise fuel consumption and maximise efficiency. This will be achieved through contractor management and BAT assessment. • Dual fuel turbine to be used on the PDQ. All start-up operating cases will be reviewed and diesel use will be minimised where possible. • Waste heat recovery units on main generators • Fuel consumption will be minimised by operational practices, power management systems (where applicable) for engines, generators and other combustion plant and maintenance systems.

Table 8.35 continued: Potential sources of impact and planned mitigation measures relating to atmospheric emissions

Potential source of impacts		Planned Mitigation Measures
Operations during the production stage	Power generation aboard the FSU	• Diesel generator design and operation will be optimised to minimise fuel consumption and maximise efficiency. This will be achieved through contractor management and BAT assessment. • All start-up operating cases will be reviewed. • Waste heat recovery units on main generators. • Fuel consumption will be minimised by operational practices, power management systems (where applicable) for engines, generators and other combustion plant and maintenance systems.
	Venting from tanker loading and crude storage tanks	• BAT assessment will be conducted during the final design stage to optimise blanketing strategy. • Shuttle tankers will be moored to the FSU and will be kept in position with DP thrusters as necessary. • A vapour recovery system will be designed and installed on the FSU to recover VOC vapour from the cargo tanks. The system shall be designed to limit/contain any hydrocarbon release through the vent system.
	Operational flaring from the PDQ	• Routine flaring and venting of gas is not expected during normal operations. Unplanned flaring minimised through good design and operational practices. • Final selection of the flaring system will be subject to BAT assessment • Compressors operation will be optimised at all flow rates over field life.

8.6 Accidental Hydrocarbon Release

The Mariner Area Development is committed to minimising the likelihood of accidental spills through sound design and operational practice. This section evaluates the impact of accidental spills and describes planned prevention measures to reduce their probability. It also discusses proposed contingency measures and mitigation strategies in the event of a significant hydrocarbon release.

An accidental release of hydrocarbons or other chemicals can result in a complex and dynamic pattern of pollution distribution and impact in the marine environment. Due to the number of factors, both natural and anthropogenic, that could influence an accidental spill, each one is unique. As part of the ES process it is necessary therefore to estimate the extent and impact of an unplanned release of hydrocarbons; critically assess the effects of such an unplanned event on key receptors; and identify prevention and effective response measures.

The key regulatory drivers that assist in reducing the consequences of potential oil or chemical releases are summarised below:

- International Convention on Oil Pollution Preparedness, Response and Cooperation 1990 requires that Operators of offshore installations under UK jurisdiction have oil pollution emergency plans which are coordinated with UK National Contingency Plan.

- Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998 (as amended 2001) require that every offshore installation and oil handling facility must have an approved Oil Pollution Emergency Plan (OPEP) setting out arrangements for responding to incidents which cause or may cause marine pollution by oil, with a view to preventing such pollution or reducing or minimising its effect. The regulations also require that personnel with responsibility for the oil pollution incident response must be competent, both in oil pollution incident response and in the use of their OPEP.

- Offshore Installations (Emergency Pollution Control) Regulations 2002 require OPEPs to contain arrangements for the potential involvement of the Secretary of State's Representative for Maritime Salvage and Intervention in an incident.

- EC Directive 2004/35 on Environmental Liability with Regard to the Prevention and Remedying of Environmental Damage enforces strict liability for prevention and remediation of environmental damage to "biodiversity", water and land from specified activities.

8.6.1 Sources of Potential Impact

All offshore activities carry a potential risk of a hydrocarbon or chemical spillage to sea. During the period 1975 to 2007, a total of 17,012 tonnes of oil were discharged from 5,826 individual spill events on the UKCS (UKOOA, 2006). Analysis of spill data between 1975-2005 shows that 46 % of spill records related to crude oil, 18 % to diesel and the other 36 % to condensates, hydraulic oils, oily waters and other materials (UKOOA, 2006). The likelihood of an oil spill occurring in the UKCS rose from 1975 to 2005 with increased oil and gas activity. However, when normalised against the number of fields, spill frequency can be seen to level off to just under 1.5 spills per field (refer to **Figure 8.9**) with average volumes spilt dramatically reducing from 1990.

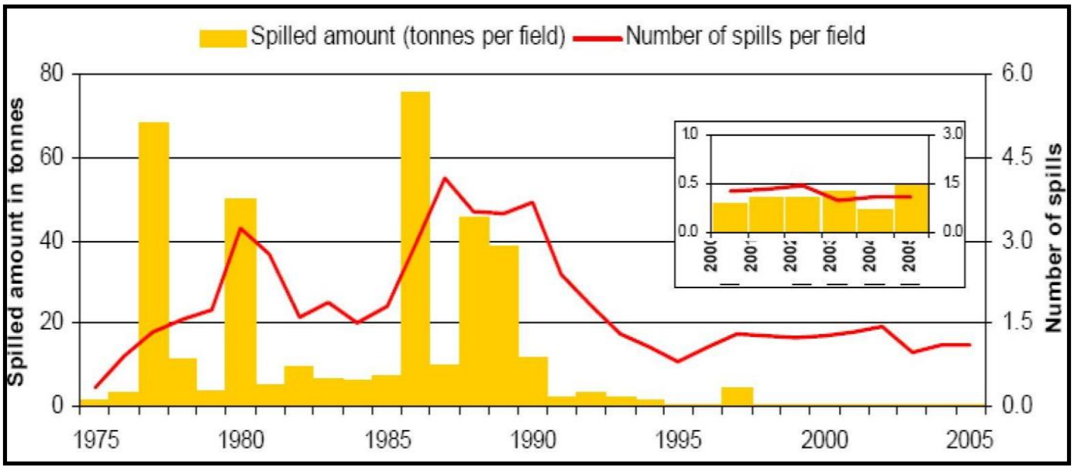


Figure 8.9: Number of spills and spill amounts normalised by the number of fields in production (UKOOA, 2006)

The potential sources of hydrocarbon spillages for the Mariner Area Development have been identified through ENVIDs, HAZIDs and the knowledge and experience developed from Statoil's and Oil and Gas Industry operations in the North Sea. Examples are given in **Table 8.36**. The spill modelling undertaken for accidental releases from the FSU were considered to be the worst case scenarios and discussed in **Section 8.6.2.3**.

Table 8.36: Potential sources of hydrocarbon spillage

Project Activity	Potential sources of accidental spills (examples)
Drilling	• Well blow out • Loss of inventory from MODU • Operational spills (e.g. diesel during transfer, lubricants and other chemicals, low toxicity oil-based mud, drilling fluids, etc)
Subsea infrastructure	• Loss of pipeline or umbilical inventory • Spills from installation vessels • Hydraulic valves
PDQ	• Loss of diesel tank inventory • Diesel bunkering operations • Chemical storage and bunkering operations
FSU	• Major loss of crude storage tanks inventory • Major loss of diluent storage tanks inventory • Loss of diesel tank inventory • Crude oil off-loading • Diesel bunkering operations • Chemical storage and bunkering operations

8.6.2 Assessment of Impact

The environmental impact of a spill depends on numerous factors including:

- location and time of the spill;
- spill volume;
- hydrocarbon or chemical properties;
- prevailing weather / metocean conditions;
- environmental sensitivities; and
- efficacy of the contingency plans.

8.6.2.1 Behaviour of oil at sea

When oil is released in the sea it is subjected to a number of processes including: spreading, evaporation, dissolution, emulsification, natural dispersion, photo-oxidation, sedimentation and biodegradation (**Table 8.37**).

Table 8.37: Overview of the main weathering fates of oil at sea

Weathering process	Description
Evaporation	Lighter components of oil evaporate to the atmosphere.
Dispersion	Waves and turbulence at the sea surface can cause a slick to break up into fragments and droplets of varying sizes which become mixed into the upper levels of the water column.
Emulsification	Emulsification occurs as a result of physical mixing promoted by wave action. The emulsion formed is usually very viscous and more persistent than the original oil and formation of emulsions causes the volume of the slick to increase between three and four times and slows and delays the other processes which cause the oil to dissipate.
Dissolution	Some compounds in oil are water soluble and will dissolve into the surrounding water.
Oxidation	Oils react chemically with oxygen either breaking down into soluble products or forming persistent tars. This process is promoted by sunlight.
Sedimentation	Sinking is usually caused by the adhesion of sediment particles or organic matter to the oil. In contrast to offshore, shallow waters are often laden with suspended solids providing favourable conditions for sedimentation.
Biodegradation	Sea water contains a range of micro-organisms that can partially or completely breakdown the oil to water soluble compounds (and eventually to carbon dioxide and water).

Source: (DTI, 2001).

The processes of spreading, evaporation, dispersion, emulsification and dissolution are most important early on in a spill whilst oxidation, sedimentation and biodegradation are more important later. The behaviour of crude oil releases at depth will depend on the immediate physical characteristics of the release and on subsequent plume dispersion processes (DTI, 2001).

8.6.2.2 Hydrocarbon properties

The fate and effect of a spill is dependent on the chemical and physical properties of the hydrocarbons. Hydrocarbons used in, or produced by the Mariner Area Development include diesel, crude, and diluent.

8.6.2.3 Overview of modelling undertaken

Spill modelling was undertaken for a number of potential spill scenarios to identify a worst-case release, its fate and behaviour, the areas that could be impacted, including potential beaching locations and the waters of adjacent states, and the likely time for hydrocarbons to beach or cross a median line.

The assessment was conducted using the SINTEF OSCAR model. OSCAR is an oil fate model which computes the fate and weathering of oil and potential biological effects. The software allows for subsea and surface oil release modelling for stochastic and deterministic cases and calculates and records the distribution of contaminants on the water surface, on shorelines, in the water column, and in sediments. For subsurface releases (e.g. blow-outs or pipeline leaks), the near field part of the simulation is conducted with a multi-component integral plume model that is embedded in the OSCAR model. The near field model accounts for buoyancy effects of oil and gas, as well as effects of ambient stratification and cross flow on the dilution and rise time of the plume.

A number of spill scenarios were identified for modelling based on the outcomes of ENVID workshops and operational experience; a well blow-out and the total loss of containment from the FSU. A blow-out of a well (an uncontrolled flow of formation fluids from a reservoir to the surface, occurring through the loss of primary and secondary well control) can lead to the loss of hydrocarbons to the environment. Statoil have undertaken studies on the likelihood of a blow-out occurring at the Mariner Area Development, due to the heavy weight of the oil in the reservoir. Although the studies have indicated that a blow-out from a Mariner well could occur, the likelihood of a blow-out occurring remains low. The worse case scenarios modelled for the purpose of this ES include a vessel collision with the FSU and a catastrophic event with the FSU leading to a loss of a majority of the inventory.

The two model scenarios were run for both winter and summer periods, to account for seasonal variation in metocean conditions. As an analogue to the Maureen blends likely to be stored on the FSU the oil IF-180 STATOIL was chosen from the OSCAR database as it had the closest predicted properties to the Maureen blend (API 16.5; Specific Gravity 0.956; Pour Point 12^{o}C).

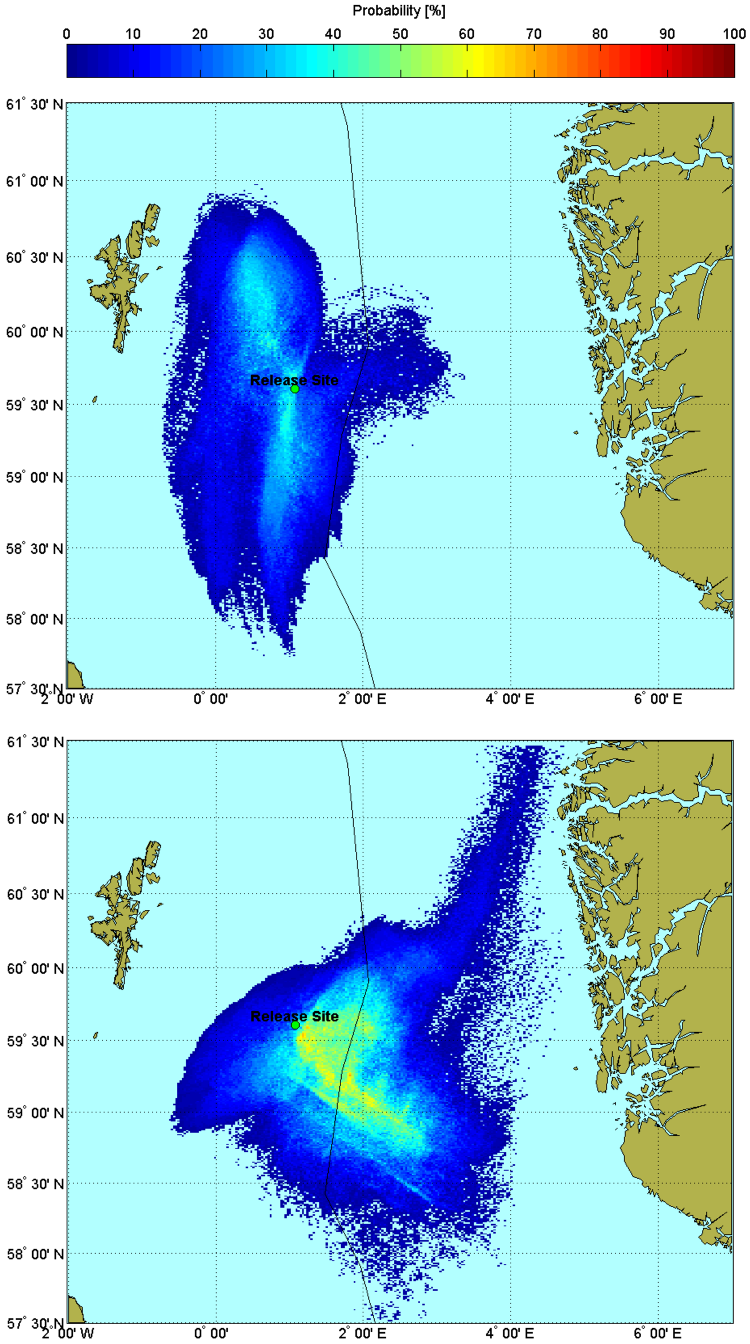
- The vessel collision scenario is based on the potential loss of inventory from two 7,000 m^3 tanks: 14,000 m^3 (12,808 tonnes), instantaneous release for 336 hours.
- The catastrophic event involving the FSU scenario is based on the potential loss of inventory from ten, 7,000 m^3 tanks: 70,000 m^3 (64,039 tonnes), instantaneous release for 336 hours.

8.6.2.4 Modelling results

For both scenarios, the stochastic model predicts a greater visible surface sheen in the winter months. For the ship collision scenario (**Figure 8.10**), the highest probability of beaching occurs during the winter period at 4%, for summer the probability drops to less than 2%. For the FSU catastrophic event (**Figure 8.11**), the highest probability of beaching occurs during the winter period at 8%, for summer the probability drops to less than 2%. Overall the stochastic model predicts that there is a low probability of beaching along the Norwegian coastline (**Figure 8.12**).

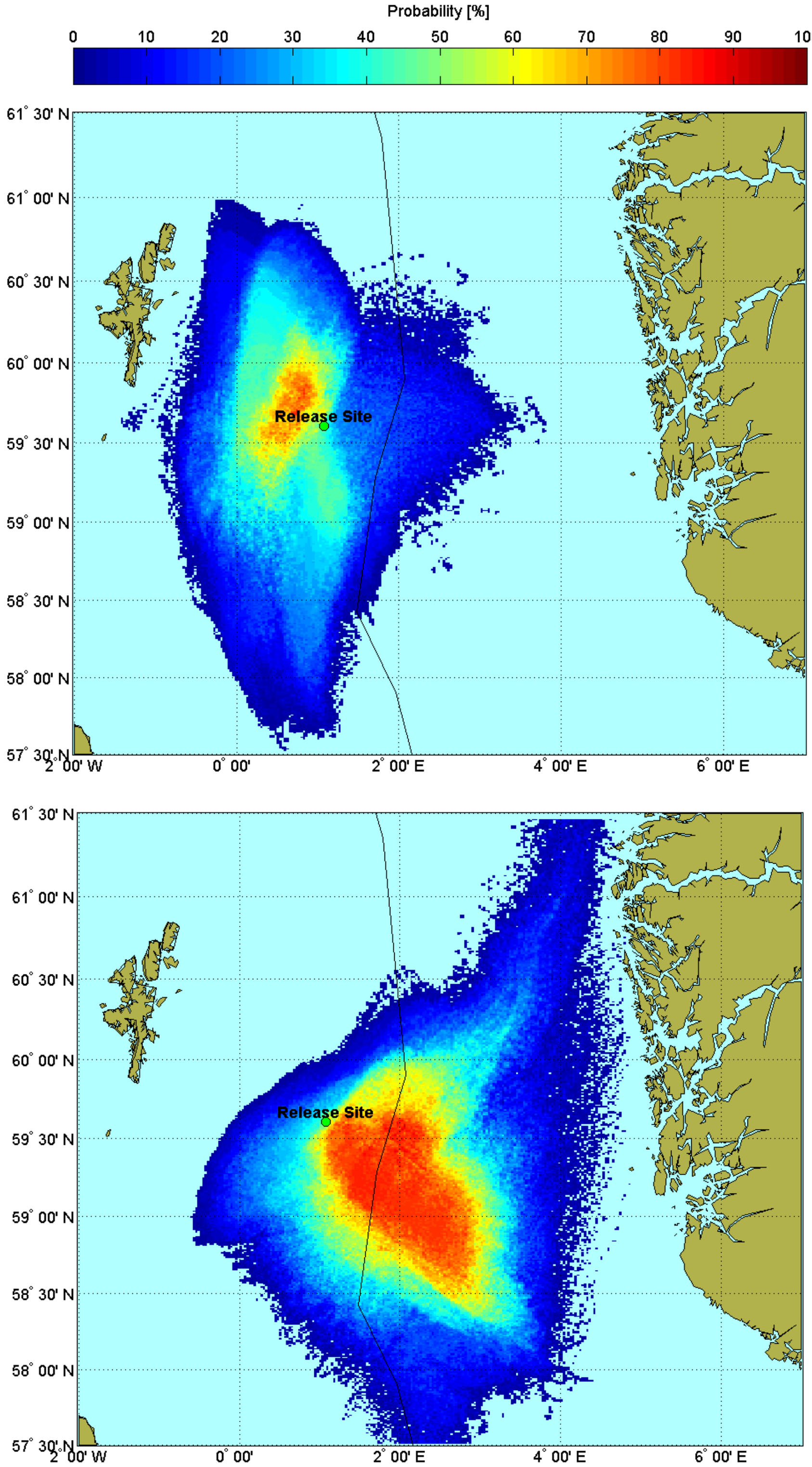
Based on the simulated conditions, trajectory models provide guidance as to the worst case impact on UK and Norwegian coastlines. Although not a true reflection of the likely fate of oil, they assist in decision making and leading the management and mitigation of oil spill strategies. Statoil will ensure that the results of this modelling play an integral part in the development of strategy for the Mariner Area Developments.

For the trajectory models, **Table 8.38** provides a summary of the key results for a 30 knot wind towards the UK and Norwegian coastlines. The largest volume of oil beaching occurs on the Norwegian coastline during the summer period. The maximum length of coastline impacted is predicted to be 1991 km during the summer period on the Norwegian coastline. Shortest landfall would occur within 3 days hitting the Shetland Islands coastline



Note: A value of 0.004mm is the approximate thickness required to see an oil sheen on the water. Above – summer; below – winter.

Figure 8.10: Probability of visible sheen on surface from the ship collision scenario (14,000 m^3)



Note: A value of 0.004 mm is the approximate thickness required to see an oil sheen on the water. Above – summer; below – winter.

Figure 8.11: Probability of visible sheen on surface from the FSU catastrophic event (70,000 m^3)

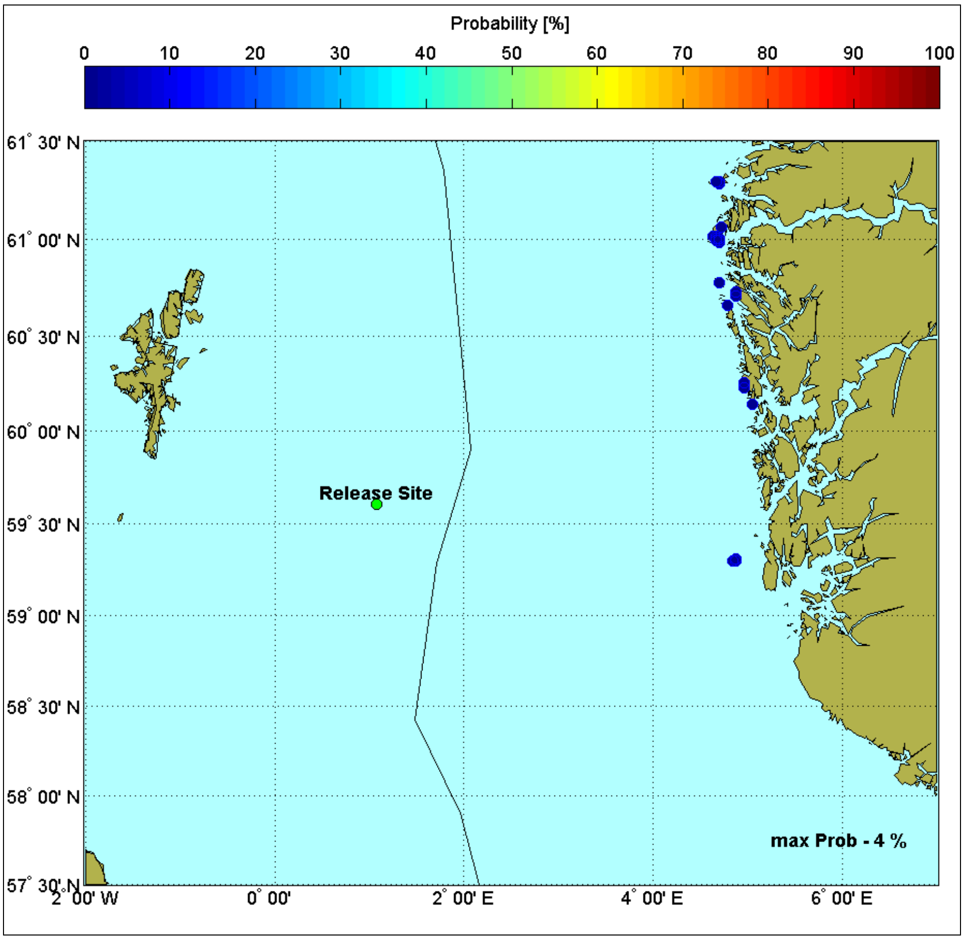


Figure 8.12: Probability of landfall on the Norwegian coast based on stochastic modelling results

Table 8.38: Modelling Scenarios for the Mariner Area Development

	Beached (tonnes)		Length of beaching (km)		Time until beaching	
	summer	winter	summer	winter	summer	winter
Shetland						
Vessel collision scenario (14,000 m^3)	2,293	1084	774.2	635.2	3 d	4 d 21 h
FSU catastrophic event (70,000 m^3)	6,485	6,306	1,886	1,806	3 d	4 d 15 h
Norway						
Vessel collision scenario (14,000 m^3)	974.7	865.3	516.1	397	4 d 21 h	5 d
FSU catastrophic event (70,000 m^3)	6,921	6,273	1,991	1,608	4 d 21 h	5 d

Figures 8.13 and **8.14** present the results of modelling predictions for oil spill trajectory landfall sites, and the distribution and volume of beached oil. All maps depict spills occurring during the summer period as worse case. Based on the model predictions, for the impacted stretches of coastline, key sensitivities including international and national conservation designations and species of concern are discussed in detail in **Appendix D**.

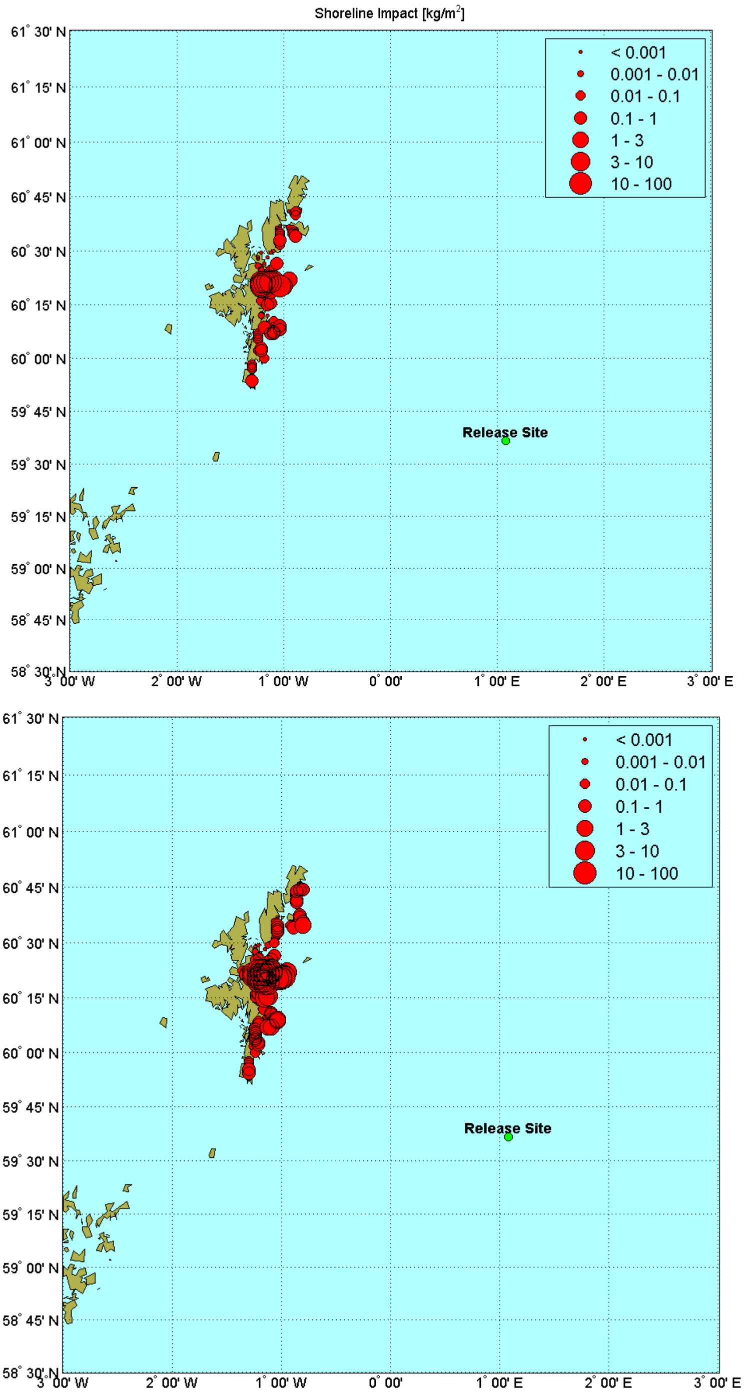


Figure 8.13: Predicted location of beaching (independent of time) on the Shetland Islands (*Ship collision scenario (14,000 m^3) – above; FSU catastrophic event (70,000 m^3) – below)*

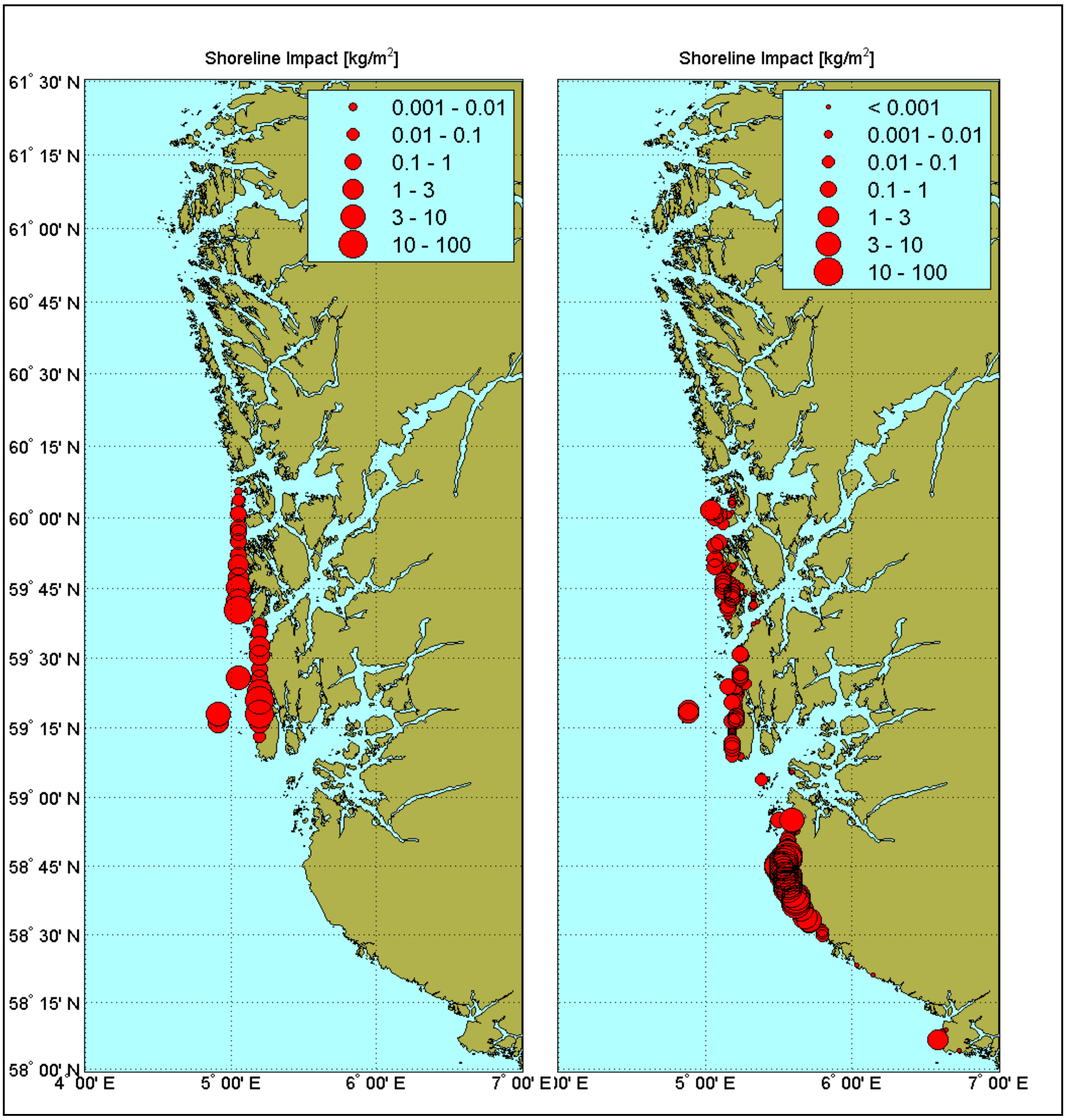


Figure 8.14: Predicted location of beaching (independent of time) in Norway. *(Ship collision scenario (14,000 m^3) – on left; FSU catastrophic event (70,000 m^3) – to right.)*

8.6.3 Impact to Receptors

Although the likelihood of a hydrocarbon spill from the Mariner Area Development is remote, there is a potential risk to organisms in the immediate marine environment if a spill were to occur. The following sections highlight biological receptors that may be impacted from a potential oil spill incident. **Table 8.39** summarises the potential effects of oil spills to marine life from the Mariner Area Development. As the majority of potential spills are likely to be on the surface and any subsea release will result in localised oil rising through the water column to the surface; both planktonic and benthic communities are less likely to be influenced by an accidental spill from the proposed Mariner Area Development. Other communities however, may be impacted, including; fish, birds and marine mammals. These will be discussed in greater detail.

Table 8.39: Summary of main biological receptors

Biological Receptor	Potential effect
Plankton	Localised effects due to toxicity.
Benthos	Usually only localised effects from toxicity and smothering, and only if oil reaches the seabed. Benthic communities may be affected by gross contamination, with recovery taking several years.
Fish and nursery grounds	Adult fish are expected to avoid the affected area, but if they are affected, the hydrocarbons may result in tainting of fish, and a reduction of its commercial value. Eggs and larvae may be affected, but such effects are generally not considered to be ecologically important because eggs and larvae are distributed over large sea areas.
Seabirds	Physical fouling of feathers and toxic effects of ingesting hydrocarbons can result in fatalities. Effects will depend on species present, their abundance and time of year.
Marine mammals	Inhalation of toxic vapours, eye / skin irritation, bioaccumulation. Fouling of the fur of young seals reduces their resistance to cold.

Source: JNCC (1999), DTI (2001), SMRU, (2001).

8.6.3.1 Fish and shellfish

The egg and juvenile stages in fish lifecycles are particularly vulnerable to hydrocarbon spills; adult fish are highly mobile and are generally able to avoid polluted areas. The Mariner Area Development area coincides with nursery areas for Norway pout, mackerel, haddock, whiting, blue whiting, herring, sandeel, ling, anglerfish, European hake and *Nephrops*. It lies within spawning grounds for Norway pout, haddock, whiting, saithe, cod, sandeel and *Nephrops* (**Section 4.5.3**). These species spawn over wide areas of the North Sea and spawning areas are not rigidly fixed, changing from year to year depending on the response to changes in the environment.

8.6.3.2 Seabirds

The potential risk to seabirds from oil and diesel pollution is through damage to feathers resulting in loss of mobility, buoyancy, insulation and waterproofing. Birds may also be at risk from toxicity through ingestion of hydrocarbons and may face starvation through depletion of food sources. The birds most affected are those such as Guillemots, Razorbills and Puffins that spend large periods of time on the water, particularly during the moulting season when they become flightless (DTI, 2001).

Seabird vulnerability to oil pollution in the Mariner Area Development area has been derived from JNCC block-specific data (**Section 5.4**). Seabird vulnerability ranges from low to very high throughout the year, with a peak in vulnerability in October and November. Overall, the seabird vulnerability to oil pollution within the Mariner Area Development area is 'high to moderate'.

8.6.3.3 Marine Mammals

Marine mammals that come into contact with oil may be impacted in a number of ways. For some species, such as otters, the insulation properties of fur are greatly reduced when covered in oil increasing the risk of hypothermia. Insulation is considered less of an issue for other marine mammals, for example seals and cetaceans, which have relatively little fur. However, there is the potential for it to cause irritation to the eyes or burns to mucous membranes.

As marine mammals feed on fish and/or plankton, oil contamination affecting this food source could have a negative impact on marine mammals, either directly as a result of lack of prey or indirectly as a result of bioaccumulation of contaminants. Ingestion of oil by marine mammals (either directly or through the contaminant content of their prey) can damage the digestive system or affect the functioning of livers and kidneys. If inhaled, hydrocarbons can impact the respiration.

Seals

Two species of seal regularly occur in the North Sea: harbour seal and grey seal. In Norway the harbour seal is a relatively stationary species that lives in breeding colonies along the entire coast and in some fjords. Harbour seals pup in June and July in sheltered waters, often sandbanks and estuaries and forage primarily in near-shore waters (Sharples & Hammond, 2004).

Grey seals are widely distributed in UK offshore waters and along the coast of Norway. Grey seals tend to be present all year round in low densities and generally in water depths of less than 200 m, with lowest numbers between October and December when animals go ashore to pup and mate. In Norway, with the exception of a small breeding colony on the southwest coast, grey seals breed in several colonies from central Norway to the Russian border, however outside the breeding season grey seals disperse over wider areas in order to find food.

Seals are particularly sensitive to oil at their haul out sites during breeding season and periods of moult. At other times they are likely to be less sensitive but may still be affected through impacts to their food sources.

Cetaceans

The cetaceans inhabiting the North East Atlantic include a diverse range of species including deep diving species and predominantly coastal small cetaceans and porpoises. Several cetacean species occur regularly in the Mariner Area Development area. These include harbour porpoise, minke whale, killer whale, white-beaked dolphin and white-sided dolphin. It is noted that very few individuals are ever present at any one time (**Section 5**). Therefore, in the unlikely event of a hydrocarbon spill, it is not considered that any significant impact is likely to occur to any particular species.

Otters

Otters occur widely in coastal Norway and along the Scottish coast. These animals may be impacted by oil if in contact with it or if the habitat is contaminated. Oil can cause loss of the insulation properties, cause skin and eye irritations, and if inhaled or ingested can affect internal organs.

8.6.3.4 Protected habitats and species

There are no Annex I habitats found in the area. This includes Annex I Submarine structures made by leaking gases, pockmarks, MDAC derived outcrops, bubbling reefs and Annex I Reefs such as stony, bedrock or biogenic reefs.

The only Annex II species frequently sighted in the surroundings of the proposed development area is harbour porpoise with very high abundance in February, and high abundance in July.

8.6.3.5 Shoreline impact

Stochastic oil spill modelling for the Mariner Area Development predict that only a single stretch of the Norwegian coastline may incur beaching. However, trajectory models predict beaching may occur on the coastline of Shetland, potentially impacting an internationally and nationally important area for wildlife. Numerous conservation designations are assigned to stretches of the Shetland and Norwegian coastline, for a summary of coastal sensitivities that may be impacted by such an event (**Appendix D)**.

8.6.3.6 Socio-economic Impacts

A number of sectors may be influenced by a potential spill from the Mariner Area Development. These could include:

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 relative UK fishing effort in the Mariner Area Development area (ICES rectangles 48F1) in 2010 was "very low" in comparison to other areas of the North Sea. The "relative effort" in ICES rectangle 48F1 was "medium" for demersal fisheries, and "very low" for pelagic and *Nephrops*; there was no recorded fishing effort for shellfish and industrial fisheries (Marine Scotland, 2011b). The impacts on fishing offshore are limited for the duration that oil remains on the surface when access to fishing grounds would be limited. There is the potential for fish in contact with hydrocarbons to become tainted precluding sale. However, there is no evidence of any long-term effects of oil spills on offshore fisheries.

Tourism

Coastal tourism can be adversely affected by oil pollution events, e.g. reduced amenity value. Impact can be further influenced by public perception and media coverage. Due to the location of the development and the low probability of beaching, no impacts to tourism are anticipated.

Oil and Gas

The oil and gas industry is well established in the North Sea, supporting in particular the UK and Norwegian economies. The Netherlands, Germany and Denmark have smaller economic interests within the oil and gas industry. Although all the above may potentially be impacted by an oil spill, the impacts will likely last whilst there is oil on the sea surface, which may restrict access. However, it is unlikely that there will be any long-term socio-economic impacts on these industries.

8.6.4 Transboundary and Cumulative Impacts

As the Mariner Area Development is located approximately 40 km from the UK/Norwegian median line, there is a potential for transboundary transport of contaminants. The residual risk of environmental impact from accidental oil or chemical spills during the Mariner Area Development will be reduced to levels that are as low as reasonably practicable. This will be achieved by the preventive measures incorporated during design, operational control procedures and training. Even with these in place, there will still be a residual, albeit very low, risk of marine and coastal environmental and socio-economic impact. Statoil will further refine its response strategy in the Mariner Field OPEP.

Cumulative impacts occur as a result of a number of activities, discharges and emissions combining, potentially to create a significant impact. Cumulative effects arising from the

Mariner Area Development have the potential to act additively with those from other oil and gas activity, including both existing activities and new activities, or to act additively with those of other human activities (e.g. fishing and marine transport of crude oil and refined products etc) (DTI, 2004). Cumulative impacts would most likely occur from the nearby Beryl Field installations outlined in **Table 8.40.** (Anatec, 2010).

Table 8.40: Nearby Oil and Gas Surface facilities

Installation	Facility operator	Distance (nm)	Bearing (°)
Beryl B Platform	Apache	13.9	85
Beryl Flare Platform		14.7	100
Beryl A Platform		14.8	100
Beryl A Riser Platform		14.8	100

Any hydrocarbon discharge as a result of the Mariner Area Development would be expected to disperse rapidly in the immediate environment without the potential to combine with other discharges from concurrent incidents. It is difficult to predict whether or not the impacts from an oil spill to the marine ecology of the affected area would be cumulative. This would depend on previous disturbances or releases at specific locations. Cumulative effects of overlapping "footprints" for detectable contamination or biological effect are considered to be unlikely. No significant synergistic effects are currently identified (DTI, 2004).

Modelling predicts that the most likely trajectory for an accidental spill will cross the median line. Depending on the size of the spill, in the event of an oil spill entering Norwegian waters it may be necessary to implement the NORBRIT Agreement (the Norway-UK Joint Contingency Plan). 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 MCA Counter Pollution and Response Branch also has agreements with equivalent organisations in other North Sea coastal states, under the Bonn Agreement 1983. Applicable international arrangements are further described in **Appendix A.**

8.6.5 Consultee Concerns

During the consultation process, DECC requested that Statoil undertake oil spill emergency planning which should be addressed within an OPEP document (**Section 6**). Statoil confirmed that the development design will include measures to eliminate or reduce the risk of potential spill so far as practicable. Statoil will develop an OPEP in accordance with the regulations, centred on an operational base in northeast Scotland.

In addition, Statoil have undertaken oil weathering tests for the Mariner crudes, and are reviewing the suitability of available oil dispersants and oil collection methods. The results of this work will dictate Statoil's approach to oil spill response, which will be set out in the OPEP.

Marine Scotland indicated that for oils of the Mariner type, the OSCAR model may be preferable to OSIS for oil spill modelling. Statoil can confirm that OSCAR has been used for oil spill modelling **Section 8.6.2.**

8.6.6 Mitigation Measures

Mitigation and management will focus primarily on prevention or minimising the probability of an accidental spill and then reducing the consequences of the event through optimum and efficient containment and response.

8.6.6.1 Competency and training

To ensure implementation of control and mitigation measures the following aspects of competency, training and documentation will be in place:

- Trained and competent offshore crews and supervisory teams.
- Approved OPEP in place prior to any activities being undertaken.
- OPEP commitments (i.e. training, exercises) captured by environmental audit.
- Co-ordinated industry oil spill response capability.
- Enhanced sharing of industry best practice via the OGUK (ex-OSPRAG) Working Groups.

8.6.6.2 Spill Prevention

Table 8.41 lists the planned measures to prevent or reduce the likelihood of a spill occurring during drilling, installation or operation of the Mariner field facilities.

Table 8.41: Spill Preventative measures

Activity	Preventative Measures
Blowout and MODU spills	
Well Design	• The Mariner and Mariner East will be designed as per the requirements laid out in Statoil Well Design Standards. None of the wells will be high pressure high temperature. • Double barrier principle. • While drilling, the primary well control barrier will be weighted mud and the secondary barrier will be the BOP equipment. • Statoil will source a “cap and contain” system from a suitable North Sea coastline location. • The reservoir will at all times be overbalanced during completion. • The production casing will be designed to withstand gas pressure to surface. • Seal assemblies will be locked to the wellhead and tested.
Well Control	• Statoil Well Control Procedures will be in place during execution of the well operations. • Training and competency of relevant staff will be assured via Statoil training systems, which will enable personnel critical for monitoring well parameters and for responding to any unplanned influxes to be ready to safely respond to a well control situation. • The drilling contractor key personnel will be audited for their well control qualification and monitored during operation by the Statoil supervision and tested with drills. • Specific Drilling Contractor’s procedures will be reviewed and aligned with Statoil standards.
BOP Equipment	• The high pressure components of the BOP system, comprising the topside BOP stack, control system, choke and kill lines and surface lines through to the choke manifold will be rated in excess of the maximum, worst case possible surface pressure. The BOP stack will have all of the functionality expected for this duty and this functionality and condition will be verified by Statoil prior to running the BOP stack. • The BOP stack will be compliant with current UK requirements.
Rig Selection	• The rigs will have a UK Safety Case and will be Class certified. • Statoil will perform assurance audits prior to rig acceptance to confirm all critical systems are fully certified and working as designed. Critical systems for well containment are the BOP equipment, surface blow out prevention equipment, drilling fluid circulating and processing systems. • Fuel handling, transfer and monitoring procedures will be put in place. • Procedures will be in place for bunker and other bulk storage transfer, and mud handling to minimize risk of spillage. • Drums and storage tanks will be secured with secondary containment.
Subsea Pipelines and Facilities	
Design and installation	• Design of the pipeline to appropriate integrity standards taking account of the fluids being carried and the environmental conditions. • Production pipeline materials - corrosion resistant alloy. • Pipelines strength tested and pipeline system will be fully leak tested prior to hydrocarbon introduction. • Subsea structures are over-trawlable fishing friendly design to meet possible fishing impact or dropped object loads. • Protection of the pipelines and umbilical from impact by burying or rock dumping. • Quality management during construction.

Table 8.41 continued: Spill Preventative measures

Activity	Preventative Measures
Subsea Pipelines and Facilities	
Operation and maintenance	• Pig launcher/receiver will be provided at each pipeline end to allow for internal monitoring inspection as required. • Proactive monitoring – risk base pipeline integrity management system for inspection and maintenance. • Pressure and temperature sensors in system for monitoring conditions. • Control system will be a closed loop hydraulic design • Pipeline leak detection systems will be reviewed for the pipelines as part of FEED. Suitable systems will be considered in detailed design, commensurate with risk.
FSU	
Crude and diesel storage tanks	• Experienced contractors will be employed to design and construct the FSU. • The FSU will have a double bottom. • The scuppers on board the FSU will allow plugging in the event of a large spill to stop hydrocarbon release to the sea. • Anticorrosion coating and corrosion protection anodes for cargo tanks. • The 500 m safety zone and the standby vessel will provide a security cordon around the FSU which excludes unauthorised vessels.
Operational spills	• Operational control procedures will govern loading/offloading. • Areas for diesel transfer will be minimised. Use of permanent piping for transfer to day tanks from the bunkering station will be put in place. • The export hose will be stored on a hose reel with adequate bunding and spills containment connected to drains. The FSU will have hard piped hose connections, with control procedures for exporting operations. • Utility stations for temporary equipment will be set up with diesel points to avoid using temporary hoses. • Leaked metering for crude blend / diluent FSU/PDQ pipelines will be installed. • Plated decks will be in place on process decks as a safety feature, will have process and hazardous open drains, and will have bunded areas to contain any small oil spill.
Chemical spills	
Storage and transfer	• Chemical storage areas will be bunded, and have isolation valves. • Tote tanks will be used for bulk transfer of most chemicals. • Hose management system will be developed as appropriate.

8.6.6.3 Contingency Planning

Statoil will have resources in place to provide the necessary level of response to the size of a spill encountered. Statoil recognises three tiers of oil spill incident. Tier 1 spill response will be undertaken utilising infield resources under the command of the Offshore Installation Manager (OIM). When these resources are insufficient, Tier 2 and/or Tier 3 resources will made available via an onshore Emergency Response Team (ERT).

- Tier 1 Spill - Oil is expected to disperse naturally at sea due to its characteristics and the limited volume. Monitoring and evaluating is the primary response option.

- Tier 2 Spill - Monitoring and evaluation will be provided by aerial observation. Natural dispersion of the oil will occur but will be affected by sea state and wind speed. If the oil does not disperse rapidly, and there is a risk of impact to environmental and/or socioeconomic resources, spraying of chemical dispersants will be necessary in consultation with Marine Scotland.

- Tier 3 Spill - In the event that an oil spill incident escalates to Tier 3, the UK National Contingency Plan may be activated and national and international resources deployed.

8.6.6.4 Response Arrangements

Response arrangements will be determined at a later date and will form the basis for developing a Mariner Field OPEP.

Oil Pollution Emergency Plan (OPEP)

The OPEP will be prepared in accordance with current DECC guidelines (DECC, 2011b), will align with Statoil's current onshore emergency strategy, and will detail response strategies and resources available. Mariner Field OPEPs will be developed to cover both the drilling programme and drilling operations within the Mariner field area. The plan will also define roles and responsibilities between Statoil as well as contracted operators for tiered response and external communications.

To support OPEP, spill modelling will be updated in line with DECC guidelines (DECC, 2011b) and will reflect the selected PDQ and FSU design. In addition, Statoil will carry out oil weathering and dispersability analysis to evaluate the effectiveness of dispersants.

Response resources

Statoil will have arrangements in place to mobilise resources of a suitable oil spill response organisation. The provision of resources will incorporate: aerial surveillance capability, availability of dispersants and containment equipment, etc. These will be detailed in the OPEP.

Well control and relief well planning

Statoil will have a capping device tested and available for deployment. The capping device will be stored at a suitable North Sea coastline location.

Contracts will be in place with providers of specialist response to a blow-out situations. Emergency equipment stock for drilling a relief well will be available within the Statoil inventory.

9 ENVIRONMENTAL MANAGEMENT

As a company, Statoil has a clear goal to ensure sustainable development and is committed to minimising environmental impacts. This section introduces Statoil's HSE policy, their Management System and how this will be implemented within the Mariner Area Development.

9.1 Health, Safety and the Environment Policy

We will ensure safe operations which protect people, the environment, communities and material assets. We will use natural resources efficiently, and will provide energy which supports sustainable development. We believe that accidents can be prevented.

<u>We are committed to</u>:

- Integrating HSE in how we do business
- Improving HSE performance in all our activities
- Contributing to the development of sustainable energy systems and technology
- Demonstrating the importance of HSE through hands-on leadership and behaviour
- Openness in all HSE issues and active engagement with stakeholders

<u>How we work</u>:

- We take responsibility for our own and others' safety and security
- We work systematically to understand and manage risk
- We provide employees with necessary resources, equipment and training to deliver according to designated responsibilities
- We cooperate with our contractors and suppliers based on mutual respect
- We stop unsafe acts and operations
- We apply clean and efficient technologies to reduce the negative environmental impact of existing operations
- We work to limit greenhouse gas emissions

- We aim for a safe and attractive working environment characterised by respect, trust and cooperation
- We monitor our people's health in job-related risks
- We establish work processes, goals and performance indicators to control, measure and improve them
- We run HSE improvement processes based on surveys and risk assessments, and we involve our people
- We build robust installations/plants and maintain them to prevent accidents
- If accidents occur, our emergency preparedness shall do the utmost to reduce injury and loss. Saving lives is our highest priority

9.2 The Statoil Management System

The Statoil management system defines how we work and describes how we lead and perform our activities. Our management system has three main objectives:

1. Contribute to safe, reliable and efficient operations and enable us to comply with external and internal requirements;
2. Help us to incorporate our values, our people and our leadership principles in everything we do; and
3. Support our business performance through high-quality decision making, fast and precise execution, and continuous learning.

Commitment to and compliance with our management system are a requirement.

As illustrated within **Figure 9.1**, the Statoil management system has a hierarchical form, in which the corporate values are supported by our people and leadership processes, and in turn by an operating model comprising our organisational principles, our business improvement model "ambition to action", our capital value process, our business review processes ("arenas") and our monitoring systems. These are then supported by corporate policies in nine key areas, the first of which is for health, safety and environment.

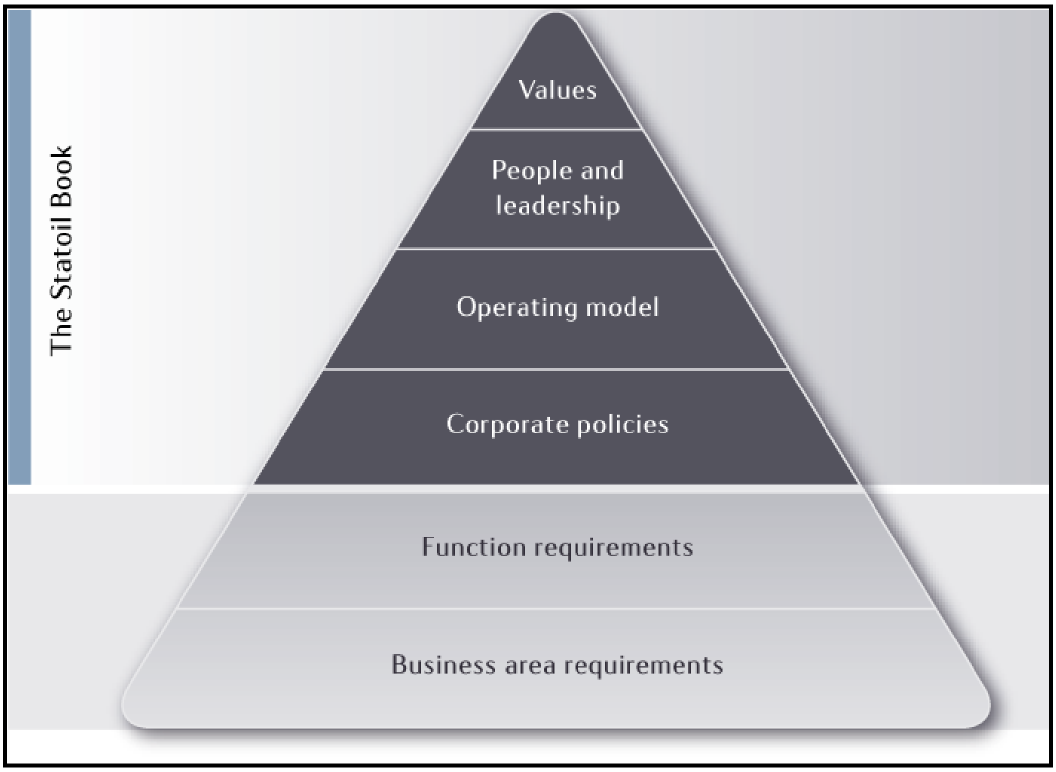


Figure 9.1: The Statoil Management System

Corporate functional requirements dictate how businesses are to be managed, through setting of standards and by defining the management activities that must take place. These are then supplemented at the level of individual business areas or geographical units by more detailed documents that are compliant with the corporate requirements, whilst being adapted for individual business area needs and to comply with local legislation.

Requirements for managing activities and processes in Statoil within the HSE area are specified in the document ‘HSE Management in Statoil (FR10)’. HSE activities and processes form an integral part of the business, of commercial planning and of decision-making processes. Responsibility for ensuring this and for documenting it to the necessary extent rests with the line organisation. Statoil require that all entities must have established and documented appropriate systems, which determine that HSE requirements are met. The above objectives will ensure that all mitigation commitments within this statement are effectively implemented, measured and controlled, and that any evidence of non-conformance will be addressed through appropriate corrective action.

The Statoil environmental management system (EMS) is fully compatible with recognised environmental management standards including ISO 14001.

9.3 Technical Standards

Statoil's governing documents stipulate technical and professional requirements to apply to all projects. These include, for example TR1011 – Technical Environment Standard for Design, Modifications and Operation for Offshore Plants, which defines the group's technical environmental requirements for offshore developments and operations, including Mariner. The guiding principles of this document include:

- Alternative concepts and technologies shall be identified and evaluated. Technology selection shall be prioritized in the following order: prevent, minimize, mitigate and compensate.

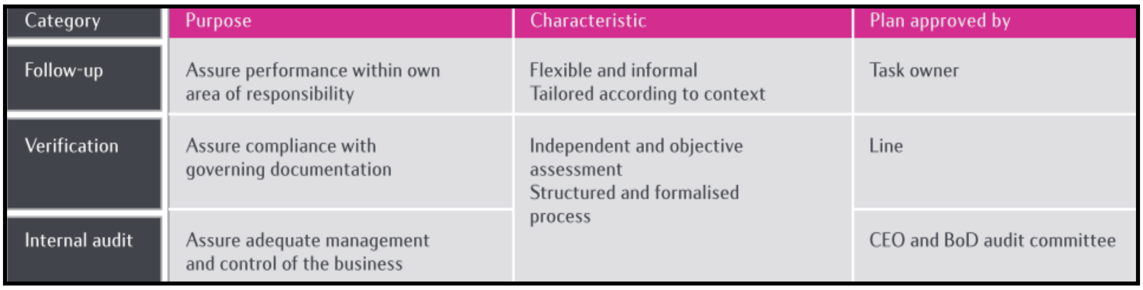
- Best Available Techniques (BAT) is the overriding principle. BAT assessments shall be performed and documented for the design and operation of each facility. BAT assessments shall include cost/benefit calculations. National laws and requirements and corporate goals and requirements shall be met.

- All selections of concepts and technical solutions shall be documented by an environmental budget for the expected lifetime, including as a minimum:
    - Energy demand
    - Energy utilisation (efficiency)
    - Air emissions
    - Discharge to sea
    - Chemical usage and discharge
    - Waste handling
    - Decommissioning

9.4 Performance Monitoring

Monitoring is conducted to manage risk, and drive performance and learning. This process ensures quality, effectiveness and assures compliance with the management system and provides a basis for improvement.

Monitoring will be performed by internal and external parties. The scope and frequency of internal monitoring depends on an assessment of risks performed by line managers, process owners and corporate staff functions. Internal monitoring consists of three main categories: follow-up, verification, and internal audit (**Figure 9.2**).



Category	Purpose	Characteristic	Plan approved by
Follow-up	Assure performance within own area of responsibility	Flexible and informal Tailored according to context	Task owner
Verification	Assure compliance with governing documentation	Independent and objective assessment Structured and formalised process	Line
Internal audit	Assure adequate management and control of the business		CEO and BoD audit committee

Figure 9.2: Performance Monitoring

9.5 Environmental Commitments

A commitments register has been developed to address each aspect of the Mariner Area Development (**Table 9.1**). This register will form part of an Environmental Management Plan and will be integrated into the relevant project execution and operational phases. The commitments register provides a summary of key management and mitigation measures identified during the EIA process. The commitments register will be updated as each element of the project continues into detailed design, execution and subsequent operational phases. Mitigation measures identified and commitments made will also be embedded into the following documents to ensure appropriate execution and management:

- detailed engineering specifications;
- contracts; and
- execution and operation plans.

Each commitment will be assigned an owner within the Mariner Area Development team and will be reviewed periodically to ensure that the commitment is being met.

During implementation of the project, objectives and targets will be co-jointly developed and used by Statoil and the contractors, to set goals for continuous improvement in performance. In this way, environmental management is an ongoing interative process, continuing beyond the identification of mitigation measures during this EIA process. It also ensures that the development will remain responsive to continual improvement and changing regulatory requirements.

Table 9.1: Statoil's Environmental Commitments

Issue	Commitment	Project Phase		
		Design	Construct	Operate
Environmental Management				
Environmental Responsibilities	Key environmental responsibilities, duties, communication, reporting and interface management arrangements of Statoil and the main contractors involved in the design and installation of the facilities, wells, pipelines and subsea infrastructure will be agreed, documented and communicated at the appropriate stages of the project.	✓	✓	✓
Environmental Management System	The contractors will have in place environmental management systems that align with Statoil's EMS and meet Statoil's requirement.	✓	✓	✓
	Vessels will be subject to audits as part of Statoil's selection and pre-mobilisation and management system requirements.	✓	✓	
Delivery of Commitments	The commitments made within this ES will be incorporated into operational work programmes, plans and procedures. Programmes will be tracked to ensure that commitments and mitigation measures are implemented throughout the Mariner Area Development	✓	✓	✓
Atmospheric Emissions				
Atmospheric emissions arising from the Mariner Area Development Project	All engines, generators and other combustion plant will be operated to maximise efficiently thereby minimising emissions. Low sulphur diesel will be utilised.	✓	✓	✓
Power generation	Main electrical power at the Mariner Area Development will be generated using gas turbine generators on the PDQ and diesel powered generators on the FSU. Statoil propose to use high-efficiency, low NOx and low CO_2 emission type turbines employing Dry Low Emission (DLE), which is regarded as BAT. Management systems will be provided which will ensure that the overall system operation is optimised such that the use of fuel will be minimised for best energy efficiency and lowest environmental emissions.	✓	✓	✓
Flaring	No continuous flaring or venting of hydrocarbons will occur.	✓		✓
	There will be some flaring of excess gas, which is not generally regarded as BAT. A range of alternatives was considered by Statoil, including export of the excess, but given the relatively low excess gas volumes and short duration of the excess, these alternatives could not be justified	✓		✓

Table 9.1 (continued): Statoil's Environmental Commitments

Issue	Commitment	Project Phase		
		Design	Construct	Operate
Atmospheric Emissions				
VOCs	A vapour recovery system will be installed on the FSU to recover VOC (volatile organic compounds) vapour from the cargo tanks. The system shall be designed to limit/contain any hydrocarbon release through the vent system.	✓	✓	✓
Disturbance to the Seabed and Interactions with Other Users of the Sea				
Project footprint	Subsea infrastructure will be designed, so far as practicable, to minimise the seabed footprint.	✓	✓	✓
Installation of jacket, the bundle, manifolds, pipelines, wellheads and other subsea structures.	Other sea users will be alerted to the installation operations by consultation, Kingfisher alerts, notices to mariners, use of guard vessels, and fisheries liaison officers, where appropriate.		✓	
	Subsea structures will be designed to be fishing friendly and withstand fishing interaction loads and dropped object loads.	✓		
	Post-installation surveys of the seabed will be carried out to identify significant anomalies and dropped objects. Appropriate remedial action will be taken if these are found.		✓	
Underwater Noise				
Underwater noise from piling the platform foundations, the PLEM, FSU moorings and bundle initiation pin-pile	Mitigating measures will be discussed in consultation with JNCC prior to piling operations.		✓	
Waste				
Management	Garbage management plan(s) and waste management and minimisation plan(s) will be developed		✓	✓
Management	Regular internal and third party audits will be carried out to assess the effectiveness of, and conformity to, waste management procedures.		✓	✓
Staff awareness	Staff will undergo appropriate training and be notified of the separation and disposal requirements for each category of waste.		✓	✓

Table 9.1 (continued): Statoil's Environmental Commitments

Issue	Commitment	Project Phase		
		Design	Construct	Operate
Discharges to Sea				
Produced water	Produced water reinjection will be the primarily disposal route for produced water. In periods where injection is not possible, the produced water will be treated to the required oil in water level and disposed to sea.	✓	✓	✓
Chemical use and discharge	Chemical selection will be governed by Statoil's chemical selection philosophy and in accordance with Offshore Chemicals Regulations 2002 (as amended).	✓	✓	✓
	Where required, chemicals, fuel and lubrication oil storage areas will be bunded in order to contain drips and spills, and minimise the risk of overboard discharge.	✓	✓	✓
Cuttings management	A thermal cuttings treatment unit is planned to be utilised offshore for treatment of cuttings. Cuttings will be treated and cleaned to the required oil content and discharged to sea.	✓	✓	✓
FSU ballasting prior to entry into the North Sea	The management of ballast water will meet the IMO guidelines.	✓	✓	✓
		Design	Construct	Operate
Accidental Spills				
Integrity assurance	Integrity inspection and management systems for the FSU and subsea infrastructure will be developed.	✓	✓	✓
	Bundle production and test lines will be lined with corrosion resistant alloy.	✓	✓	
	Selection of pipeline leak detection systems, based on strategic deployment of temperature ssensors on pipeline walls, will be included in design.	✓		
	Collision risk and dropped object studies will be undertaken	✓		
Offloading, bunkering and other transfer operations	All offloading and transfer operating involving hazardous fluids will be governed by operational control procedures and in accordance with the Statoil Procedures. Training of all personnel involved in transfer activities will take place to raise awareness of the relevant procedures and the sensitivity of the environment. Controls and mitigation will be in place to ensure that risks are ALARP.	✓	✓	✓
	Hose management system will be developed.			✓
	Shuttle tankers and supply vessels will be dynamically positioned.		✓	✓

Table 9.1 (continued): Statoil’s Environmental Commitments

Issue	Commitment	Project Phase		
Accidental Spills				
Accidental Spills	An OPEP will be prepared for the development. As required by the legislation, this will be consistent with the National Contingency Plan. It will also be consistent with Statoil’s oil spill response processes developed for the NCS. The plan will cover actions to be taken in the event of any spill during the Mariner Area Development. It will also cover scheduled spill exercises and training.		✓	✓
	Tier 1, 2 and 3 spill management arrangements will be in place and will include contingencies for drilling emergency relief wells and fitting a well capping device as applicable.		✓	✓
	Statoil will perform assurance audits prior to rig acceptance to confirm all critical systems are fully certified and working as designed. Critical systems for ensuring well containment are the BOP equipment, surface blow-out prevention equipment, drilling fluid circulating and processing systems.		✓	
	A relief well planning study will be undertaken prior to drilling.	✓		
	Oil weathering and dispersion analysis will be carried out to evaluate the effectiveness of dispersants.	✓		✓
Decommissioning				
Decommissioning	A full decommissioning plan will be developed at the time of CoP and will be designed to ensure that potential effects on the environment resulting from the decommissioning of the facilities will be minimised.	✓		✓

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10 CONCLUSIONS

An EIA is an important management tool used by Statoil to ensure that environmental considerations are incorporated into project planning and decision making. This ES presents the findings of an EIA for the proposed development of the Mariner and Mariner East fields in the UKCS northern North Sea and provides sufficient information to enable an evaluation to be made of the environmental consequences of the proposed activities.

The marine environment where the Mariner Area Development is located is typical of the northern North Sea. While recognising that there are certain times of the year when populations of seabirds, fish spawning and commercial fisheries are vulnerable to oil pollution, the conclusion is that the area is not particularly sensitive to a development of the type proposed, irrespective of the scheduling of this development.

Of the Annex I habitats identified in the EU Habitats Directive only ‘submarine structures made by leaking gases’ and ‘reefs’ are present in the northern North Sea. No evidence of MDAC, reef-like structures, or any other defining features of habitats protected under the Annex I of the EU Habitats Directive were identified in the Mariner Area Development during the seabed surveys commissioned by Statoil (FSL, 2008; Gardline, 2009; Subsea 7, 2011, DNV, 2011).

Harbour porpoise were the only Annex II species of the Habitats Directive recorded within and around the proposed development area. Harbour porpoise are present in most of the North Sea throughout the year, with higher numbers occurring in the waters surrounding the Mariner Area Development in February and July.

Following the identification of the interactions between the Mariner Area Development associated activities and the local environment, the assessment of all potentially significant environmental impacts and the stakeholder consultation, the key environmental concerns identified as requiring consideration for impact assessment were:

- localised disturbance to the seabed;
- discharges to sea;
- underwater noise;
- long-term physical presence; and
- atmospheric emissions

Mitigation to avoid and reduce the above environmental concerns is in line with industry best practice. Statoil has an established EMS, which will ensure that proposed mitigation measures are implemented (**Section 9**).

Although their probability of occurrence is very low, the following emergency events could potentially result in significant impacts:

- accidental hydrocarbon release from a blow-out, pipeline rupture, blow-out or major spill from vessel collision.

The preventative measures proposed by Statoil would be sufficient to minimise the risk of these unplanned events to a level that is as low as reasonably practicable (i.e. in line with industry best practice) and to control and mitigate the effects in the event of their occurrence. Preventative measures for emergency events are focused on the development and implementation of suitable procedures for well control and fuel handling and transfer (to prevent a diesel / product spill).

The overall risk to the environment, from both routine and the unplanned / emergency events is therefore considered to be low. The integrity of statutory conservation sites designated or likely to be designated under the Habitats Directive is not considered to be at risk.

The project will comply with the Offshore Chemical Regulations 2002 (as amended). A detailed chemical risk assessment will be undertaken in line with the statutory consents required for drilling, pipe-laying and production operations.

Statoil has made, or intends to make, the necessary provisions to comply with all appropriate legislative and company policy requirements during the implementation of the Mariner Area Development.

Overall, the ES has evaluated the environmental risk reduction measures to be taken by Statoil and it concludes that Statoil have, or intend to, put in place sufficient safeguards to mitigate environmental risk and to monitor the implementation of these safeguards.

Therefore, it is the conclusion of this Environmental Statement that the current proposal to develop the Mariner Area Development can be completed without causing significant impact to the environment.

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