APACHE NORTH SEA LIMITED

Bacchus Production Increase

Environmental Statement

BEIS Project Reference: D/4256/2020

July 2020

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STANDARD INFORMATION SHEET

Project name	Bacchus Production Increase
Project reference number	D/4256/2020
Type of project	Production increase
Undertaker name	Apache North Sea Limited
Undertaker address	Caledonia House Prime Four Business Park Kingswells Causeway, Aberdeen AB15 8PU
Short description	The assessment of the environmental impacts from an increase in production from the Bacchus Field in excess of 500 tonnes of oil per day over the current consent threshold, and the drilling of a new infill well.
<u>Dates</u>	
Anticipated commencement of works	Q4 2020
Date and reference number of any earlier Statement related to this project	D/4066/2009; December 2009
Significant environmental impacts identified	None
Statement prepared by	Apache North Sea Limited Hartley Anderson Limited

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CONTENTS

GLOSSARY AND ABBREVIATIONS

Apache	Apache North Sea Limited
API	American Petroleum Institute
ATK	Helifuel
bbl(s)	Barrel(s) of oil
BECPELAG	Biological Effects Monitoring in Pelagic Ecosystems
BEIS	Department for Business Energy & Industrial Strategy (formerly DECC, the Department of Energy and Climate Change)
BOP	Blow-out Preventer
Cefas	Centre for Environmental, Fisheries, and Aquaculture Science
CH_4	Methane
CIP	Communication and Interface Plan
CNS	Central North Sea
CO_2	Carbon Dioxide
CO_2 eq.	CO_2 equivalent
DP	Dynamic Positioning
DHSV	Down Hole Safety Valve
DSV	Diving Support Vessel
EC	European Commission
ECMWF	European Centre for Medium-Range Weather Forecasts
EEMS	Environmental Emissions Monitoring System
EH&S	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EMS	Environmental Management System
ERRV	Emergency Response and Rescue Vessel
ES	Environmental Statement
EROD	enzymatic induction
EU	European Union
EUOSD	Directive 2013/30/EU on safety of offshore oil and gas operations
FASP	Forties Alpha Satellite Platform
FPS	Forties Pipeline System
GHG	Greenhouse Gas
GOR	Gas:Oil Ratio
GWP	Global Warming Potential. Emissions metric used to indicate the contribution of a certain gas species to radiative forcing, accounting for the atmospheric lifetime of a given gas relative to CO_2, which has a value of 1 (IPCC 2007).

HQ	Hazard Quotient
HP	High Pressure
HYCOM	Hybrid Coordinate Ocean Model
ICES	International Council for the Exploration of the Sea
IPCC	Intergovernmental Panel on Climate Change
JNCC	Joint Nature Conservation Committee
km	kilometre
km^2	square kilometres
µm	micrometre
m	metre
m^3/d	Rate: cubic metres (oil, gas or water) per day
mD	millidarcy
MAH	Major Accident Hazards
MEG	mono-ethylene glycol
mg	milligram
MCZ	Marine Conservation Zone
MEI	Major Environmental Incident
MER	Maximising Economic Recovery
MIV	Manifold Isolation Valve
MoD	Ministry of Defence
MPA	Marine Protected Area – MPAs in Scottish waters made under the *Marine (Scotland) Act 2010* as amended and *Marine and Coastal Access Act 2009* (as amended)
Mt	million tonnes
NAO	North Atlantic Oscillation
NCMPA	Nature Conservation Marine Protected Area
NEC	No Effect Concentration
NGL	Natural Gas Liquids
NO_x	Oxides of nitrogen
NSMB	North Sea Member States
LTOBM	Low Toxicity Oil Based Muds
OCES	Operators Co-operative Emergency Services
OBM	Oil Based (drilling) Mud
OCNS	Offshore Chemical Notification Scheme
OGA	Oil and Gas Authority
OGUK	Oil and Gas UK
OIW	Oil in Water

OPEP	Oil Pollution Emergency Plan
OPPC	The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSCAR	Oil Spill Contingency and Response
OSPAR	The Convention for the Protection of the Marine Environment of the North East Atlantic 1992
OVI	Offshore Vulnerability Index
PAH	Polycyclic Aromatic Hydrocarbons
PEC	Predicted Environmental Concentration
PETS	Portal Environmental Tracking System
PEXA	Practice and Exercise Areas (for military use)
PHB	Prehydrated bentonite
PIMS	Pipeline Integrity Management System
PLONOR	Pose Little Or No Risk
PMF	Priority Marine Feature
PNEC	Predicted no Effect Concentration
POB	Persons on Board
psi	Unit of pressure – pounds per square inch
PTS	Permanent Threshold Shif
PWRI	Produced Water Re-Injection
Ramsar	Wetlands of international importance designated under the Ramsar Convention
ROV	Remotely Operated Vehicle
SAC	Special Areas of Conservation – established under the Habitats Directive
scf	Standard Cubic Feet (Gas). Equal to $0.028m^3$
SEA	Strategic Environmental Assessment
SECEs	Safety and Environmentally Critical Elements
SEMS	Safety and Environmental Management System
SFG	Scope for Growth
SL	Source Level
SNH	Scottish Natural Heritage
SO_2	Sulphur dioxide
SOPEP	Shipboard Oil Pollution Emergency Plan
SOSI	Seabird Oil Sensitivity Index
SOTEAG	Shetland Oil Terminal Environmental Advisory Group
SPA	Special Protection Areas - established under Birds Directive
SPL	Sound Pressure Level

SSIV	Sub-Sea Isolation Valve
SWI	Seawater Injection
TVDSS	True Vertical Depth subsea
TCC	Thermal Cuttings Processing
UK	United Kingdom
UKCS	UK Continental Shelf
UKHO	United Kingdom Hydrographic Office
VMS	Vessel Monitoring System
VOC	Volatile Organic Compound
VSP	Vertical Seismic Profiling
WBM	Water Based Mud

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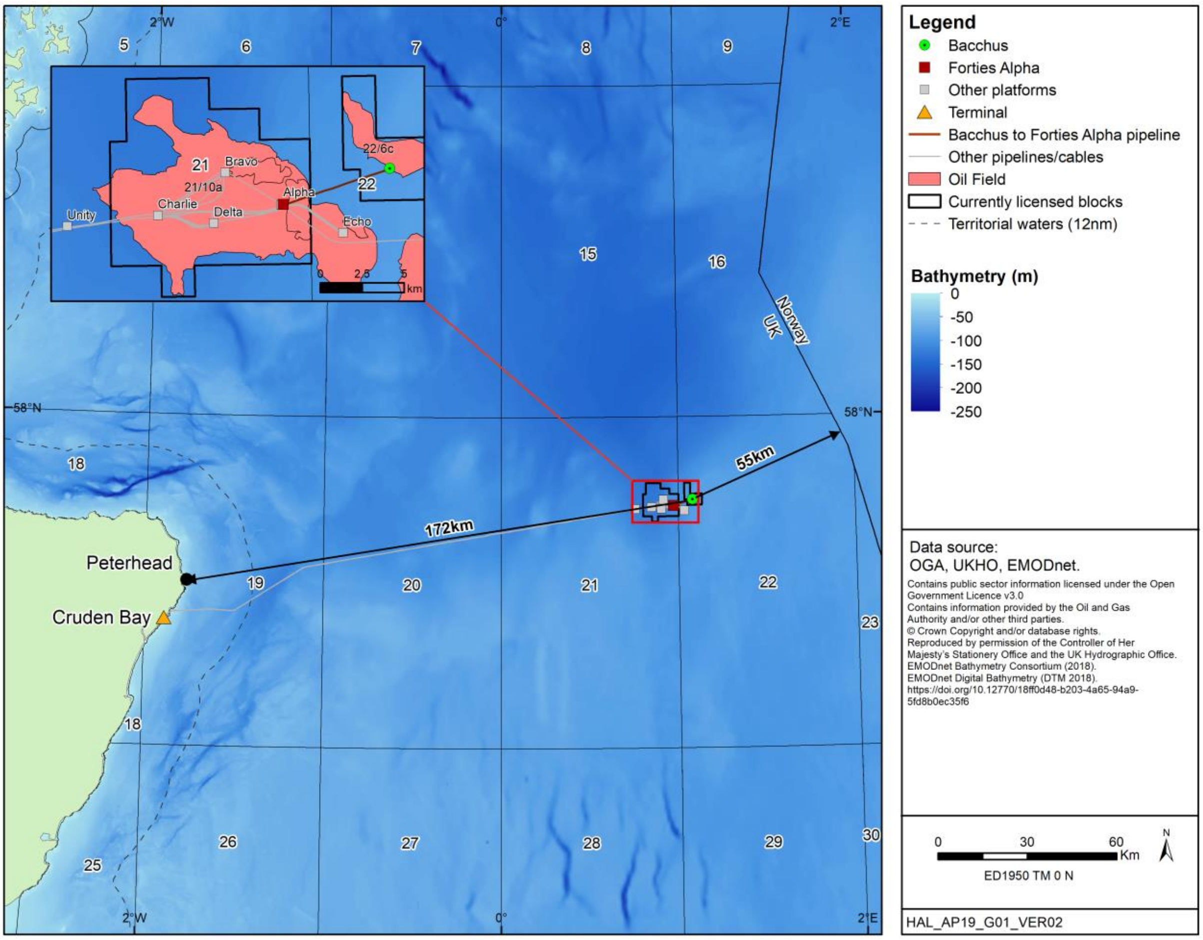
NON-TECHNICAL SUMMARY

This Environmental Statement (ES) presents the findings of the environmental assessment conducted by Apache North Sea Limited (Apache) for a production increase and infill well (Bacchus South) at the Bacchus Field, which lies in United Kingdom Continental Shelf (UKCS) Block 22/6c. The Bacchus South well will be drilled using a semi-submersible drilling rig, and will be connected to the existing Bacchus Field manifold. Hydrocarbons produced from the Bacchus South well will be processed along with existing Bacchus production at the Forties Alpha platform in UKCS Block 21/10 and exported along with Forties Field production through the Forties Pipeline System to Cruden Bay. Bacchus South is located approximately 172km east of Peterhead and 55km from the UK-Norway median line. The Bacchus Field, and Block 22/6c, is covered by licence P.255, acquired by Apache in December 2011.

Location of the Bacchus South well, the Bacchus Field, Forties Field and related pipelines



The ES has been produced in accordance with *The Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999 (as amended)*. The submission of an ES to the Secretary of State for the Department for Business Energy & Industrial Strategy (BEIS) is required when an application for consent for increased production of hydrocarbons from an existing field, exceeds incremental thresholds of 500 tonnes of oil per day, or 500,000m^3 of gas per day. Production forecasts following the drilling of the Bacchus South infill well indicate that production will exceed that already consented beyond the threshold for oil noted above, for the Bacchus Field. Apache has therefore completed an assessment of the potential environmental impacts of the increase in production, and prepared this ES in support of an application for a revised production consent for the Bacchus Field.

Environmental characteristics of the area

The main environmental features of the Bacchus and Forties area are summarised in the following table.

<table>
<tr><th>Aspect</th><th colspan="12">Description</th></tr>
<tr><td>Location</td><td colspan="12">The Bacchus Field is located in Block 22/6c and is located some 172km from the nearest UK landfall (Peterhead) and 55km from the UK/Norwegian median line.</td></tr>
<tr><td>Sediments and topography</td><td colspan="12">Thin surficial seabed sediments are generally homogenous, consisting of a sparse mosaic of small cobbles among a silt and sand matrix overlying coarser material. Boulders are found scattered across the area.</td></tr>
<tr><td>Climate</td><td colspan="12">The area generally has a mild climate for the latitude. Winds in the area are variable and may blow from any direction, through directions between the west and south-west dominate in February and north and south in August. Annual mean wind speed is 10.2m/s. In January, winds of Beaufort force 7 or greater may be experienced at a frequency of approximately 20% in the central-northern North Sea, reducing to between 2 and 4% in July.</td></tr>
<tr><td>Hydrography</td><td colspan="12">The water column stratifies thermally in summer. The depth of the thermocline increases from May to September and by August/September is typically 50m. The thermocline is broken down in autumn with increased wind and convective mixing. Sea surface temperatures range typically from 6.5-7°C in winter and 13.5-14.0°C in summer. Tidal energy is fairly low, and swell direction ranges from southwest to north throughout the year. Annual mean significant wave height is approximately 2.24m.</td></tr>
<tr><td rowspan="4">Plankton</td><td colspan="12">The plankton community present in the Bacchus area is strongly influenced by the region hydrography of the region and is typical of the northern and central North Sea. The phytoplankton community is dominated by the dinoflagellate genus Ceratium, with diatoms such as Skeletonema costatum, Thalassiosira spp. and Chaetoceros spp. also abundant, particularly during the spring bloom.

The zooplankton community is dominated by calanoid copepods (Calanus finmarchicus and C. helgolandicus), although other zooplankton groups such as Paracalanus and Pseudocalanus, Euphausiids and Acartia, are also abundant.</td></tr>
<tr><td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May</td><td>Jun</td><td>Jul</td><td>Aug</td><td>Sep</td><td>Oct</td><td>Nov</td><td>Dec</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="12">Key: Period of increased plankton abundance shown in darker blue</td></tr>
<tr><td>Benthos</td><td colspan="12">Habitat in the area has been characterised by slightly rippled sands with varying proportions of shell fragments and sparse epifauna including hermit crabs, crabs, sponges, sea cucumbers, sea pend and sea stars. Sampling of infauna between Bacchus and Forties Alpha indicated the polychaete Paramphinome jeffreysii was numerically dominant, being found in every sample, with the second and third most abundant taxa also being polychaetes, Galathowenia occulata agg. and Paradoneis lyra.</td></tr>
<tr><td rowspan="4">Commercial fish and shellfish</td><td colspan="12">The area overlaps with spawning grounds of cod, lemon sole, mackerel, Norway pout and sandeel. The area also supports nursery areas several species including for cod, hake, ling, herring, mackerel, Norway pout, Nephrops, plaice, sprat, spotted ray, Spurdog, anglerfish and whiting.</td></tr>
<tr><td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May</td><td>Jun</td><td>Jul</td><td>Aug</td><td>Sep</td><td>Oct</td><td>Nov</td><td>Dec</td></tr>
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<tr><td colspan="12">Key: 1 = 1 species spawning, 2 = 2 species spawning, 4 = 4 species spawning</td></tr>
</table>

<table>
<tr><th>Aspect</th><th>Description</th></tr>
<tr><td>Seabirds and water birds</td><td>Seabird sensitivity in Blocks 21/10 and 22/6 and neighbouring Blocks is low, for those months with data, with the exception of a small number adjacent block-months which are scored as medium. Note that for six months of the year no data are available; where possible sensitivity scores have been interpolated. The area is a considerable distance from important coastal water bird sites and seabird breeding colonies, and beyond the mean foraging range of most seabird species during the breeding season.
<table>
<tr><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th><th>Block</th></tr>
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</table>
<table>
<tr><td>Key:</td><td>Extremely High</td><td>Very high</td><td>High</td><td>Medium</td><td>Low</td><td>No coverage</td></tr>
</table></td></tr>
<tr><td>Marine mammals</td><td>Harbour porpoise are frequently sighted throughout the central North Sea area. White-beaked dolphins, although generally less abundant, are also sighted in the area throughout the year and low numbers of Atlantic white-sided dolphins have been recorded in the area. During summer months, minke whales are widely distributed throughout the central and northern North Sea. The Moray Firth and the coast of eastern Scotland has the only resident population of bottlenose dolphins in the North Sea; however, this is a primarily coastal species and thus unlikely to be present frequently in the Bacchus and Forties area. Harbour and grey seals may occur in the area, but in low numbers.</td></tr>
<tr><td>Conservation sites</td><td>The coasts of north-east Scotland have a variety of important habitats and species protected under international, national and local designations; however, these are at least 160km from the Bacchus Field. These sites have year round importance. The closest Natura 2000 site is the Scanner Pockmark SAC which is located 58km to the north of Bacchus, and the closest MPAs are the East of Gannet and Montrose Fields, located 33km to the south and the Norwegian Boundary Sediment Plain 44km to the east.</td></tr>
<tr><td>Other users</td><td>There is a very low to low shipping density in the Bacchus area throughout the year, although moderate levels occur within the nearby Forties Field. Fishing effort is low throughout the year, with no we-defined seasonal pattern. Other energy infrastructure (~2.7km), cables (~3.5km) and military training areas (~35km) are all some distance from the Bacchus Field.</td></tr>
</table>

Potential sources of effect

The additional production from the Bacchus Field will contribute to security of energy supply and result in a variety of positive commercial and fiscal benefits through the production and sale of the hydrocarbon resource. Through a systematic evaluation of the issues associated with the increased production, and their interactions with the environment, a variety of potential sources of environmental effect were identified. The majority were of limited extent and duration, and deemed negligible. No potential issues of concern were identified through the assessment process, which could not be mitigated to meet regulatory requirements and company policy. The following section provide a summary of the assessment.

Sources of effect relating to the incremental production increase

Effects relating to the operation of the Bacchus Field from the production increase are relatively few, as the hydrocarbons will be similar to that from the existing Bacchus wells and be received, processed and exported at Forties Alpha with no platform modifications. Consequently, the fuel gas/diesel consumption on Forties Alpha, and any associated combustion emissions, should not be significantly increased as a result of the proposed production increment. The only modification to Forties Alpha will be the addition of an asphaltene tank and related pumps, to deliver asphaltene inhibitor to the Bacchus South well to help prevent the deposition of organic solids.

There is no gas export route from Forties Alpha or the wider Forties Field, and any associated gas from Forties is used as fuel gas, to provide gas lift, or is flared. Bacchus South gas will be used as fuel gas (92%), with the remaining gas flared. Fuel gas use will offset that already being imported from the Aviat Field, such that there is expected to be no net change in the atmospheric emissions resulting from fuel gas use. Flaring will result in emissions of carbon dioxide equivalent of up to 0.7% on 2018 UKCS emissions levels or up to 0.012% of the fourth carbon budget for the relevant period (2023-2027), and are considered to be minor.

Water production is expected to rise from Bacchus. It is expected that ~40% of this water will be discharged to sea, with the remainder being re-injected for reservoir support. This will result in a corresponding worst case increase in oil discharged in produced water from of 0.009 tonnes in 2023 (assuming a discharge oil-in-water (OIW) concentration of 20mg/l). The increase in the use of chemicals (methanol, 10% and, scale inhibitor, 15%) and additional use of asphaltene, will be risk assessed via the relevant Bacchus Chemical Permit, as necessary.

Sources of effect relating to the drilling of the Bacchus South well

The production increase will be delivered from the Bacchus South well, to be drilled using a semi-submersible drilling rig which will be on location at Bacchus for a maximum of 112 days (including all contingencies) and supported by a standby, supply vessel and helicopter for crew changes. The drilling of the well will result in a number of emissions (to atmosphere) and discharges (including of treated drill cuttings), as well as generating physical disturbance to the seabed and representing a source of potential interaction with other users of the sea. The well will be subject to further assessment via the Portal Environmental Tracking System (PETS) process.

Atmospheric emissions relating to the drilling of the well are minor in the context of potential air quality-related impacts and their contribution to global atmospheric greenhouse gas loading, representing ~0.02% of wider 2018 UKCS carbon dioxide emissions, or 0.003% of the third carbon budget for the relevant period (2018-2022).

Drilling fluids, cementing and completion chemicals of low toxicity will preferentially be selected for use during the Bacchus South drilling programme. The well will be drilled using a combination of seawater (and some low hazard chemicals added to increase the viscosity to help sweep cuttings out of the wellbore) for the surface hole, and low toxicity oil-based mud for the lower hole sections. Material from the surface hole section of the well will be discharged directly to the seabed, and consist of sediments derived from the seabed and shallow geological formations. This material will form a small pile on the seabed, which will be re-mobilised over time by water currents and burrowing fauna activity. The predicted environmental effects are very localised and of short duration, involving smothering of benthic habitat and animals, with rapid faunal re-colonisation.

Oil-based mud and cuttings from the lower hole sections will be returned to the drilling rig and treated onboard, with the mud being retained for reuse, and the treated cuttings discharged from the rig, just below sea-level. The treatment facilities ensure that the oil content of the cuttings is less than 1% such that their discharge is consistent with obligations under OSPAR 2000/3. In the event that the treatment processing plant is not available, contaminated cuttings will be contained and returned to shore for treatment and disposal.

The physical presence of the drilling rig and vessel used to make the subsea connections for Bacchus South to the Bacchus manifold, have been identified as a potential cause of effect, primarily for fisheries and navigation. Fishing effort in the Bacchus area is low through the year, with no clear seasonal pattern. A 500m exclusion zone is already in place for the Bacchus Field, centred on the Bacchus manifold, and the Bacchus South well and its related pipeline and jumper connection will all be within the existing area. A separate 500m zone centred on the Bacchus South well location will be in place for the duration of drilling. The semi-submersible rig used to drill the wells will use eight anchors deployed radially at a distance of 1,200-1,800m. As the anchors and their related chains/cables will be outside of the rig 500m safety zone, as laid positions will be notified to fishermen and others. All aspects of the subsea infrastructure (wellhead, pipeline, jumper) will be publicised through Notices to Mariners, and marked on navigation and fisheries charts.

Physical disturbance primarily relates to drill rig anchoring and well cuttings. The majority of seabed species recorded from the European continental shelf are known, or believed to have, short lifespans (a few years or less) and relatively high reproductive rates, indicating the potential for rapid population recovery, typically between one to five years. Polychaete species which dominate infaunal assemblages at stations between Bacchus to Forties A platform are characterised by short lifespans and are likely to have high recovery rates. Epifauna is relatively sparse in comparison with infauna and most species are mobile. It would be expected that animals would be able to move away from, and then rapidly recolonise, recently disturbed sediment. It is considered probable that both the physical habitat consequences and benthic community effects of physical disturbance of the seabed from future drilling activities will fully recover within a five to ten year period.

Accidental events

Risk assessment of accidental events involves the identification of credible accident scenarios, evaluation of the probability of incidents, and assessment of their ecological and socio-economic consequences. Evaluating spill risk requires consideration of the probability of an incident occurring and the consequences of the impact.

Historic data for the North Sea shows that the majority of accidental spills are of very small volumes; the probability of a large spill occurring is extremely low.

Spills can impact environmental and socio-economic sensitivities at distance from their source, and risk assessment, therefore, requires the prediction of slick trajectory. For a given scenario, with defined spill volume and weather/metocean conditions, the behaviour of a slick can be modelled. A spill of oil representative of a blowout of Bacchus crude was modelled stochastically, this having been identified as the worst case potential release of hydrocarbons. A diesel spill was not modelled As the diesel inventory would be limited to that on the rig and support vessels, and any resulting spill expected to break up relatively quickly; diesel has very high levels of light ends, evaporating quickly on release and the low asphaltene content prevents emulsification, reducing its persistence. Modelling of a Bacchus well blowout was undertaken seasonally (December-February, March-May, June-August and September to November) for a well blowout scenario, with the shortest time and related probability for oil to cross the median line or reach the coast calculated for the UK and adjacent states.

Stochastic modelling of a Bacchus blowout (58,446 m^3/day on day 1, declining to 3,708 m^3/day at day 120) is estimated to result in a maximum accumulation of oil onshore of 51,225m^3 after 130 days. It is estimated that oil would reach the nearest UK coastline (Shetland) between 6 and >20 days depending on season (December-February and June-August respectively), with a shoreline oiling probability of 40-50% and 30-40% respectively. There is a high probability (90-100%) that surface oil would cross the UK/Norwegian median lines in 18 (December-February and March-May) 24 (June-August) hours and a similarly high probability (up to 100%) that oil would beach in Norway within 7-11 days (September-November and December-February, and June-August, respectively). The probability of surface oiling in the adjacent states of Sweden and Denmark remains relatively high at up to 90% in 7 days and 100% in 10 days respectively. Probabilities for German (up to 30% in 19 days, March-May) and Dutch (up to 20%, March-May) waters are comparatively lower.

The potential impact from a Bacchus well blowout was assessed for its potential to result in a Major Environmental Incident (MEI); an MEI can only occur as a consequence of a major accident. This assessment was done with reference to the key environmental receptors, including the protected sites of the UK and the bordering states; for protected species and natural habitats, the definition of a MEI describes this as an incident which results in *any damage that has significant adverse effects on reaching or maintain the favourable conservation status of such habitats or species*.

Seabirds and marine mammals are generally considered the most vulnerable components of the ecosystem to oil spills in offshore and coastal environments, because of their close association with the sea surface. Benthic habitats and species may also be sensitive to deposition/sedimentation of oil. Effects on sediment communities are typically associated with deoxygenation and organic enrichment.

Mechanisms of impact on seabird populations include oiling of plumage and loss of insulating properties, and ingestion of oil during preening causing liver and kidney damage. Indirect effects associated with bioaccumulation of contaminants from prey, and reduced prey availability, are also possible. The vulnerability of seabirds to surface oiling is related to individual species' behavioural patterns, distribution and ecological characteristics, such as potential rate of population recovery – vulnerability in Blocks 21/10 and 22/6 is low (or with no data) throughout the year (see Section 3.8).

Generally, marine mammals (which rely on blubber for insulation) are less vulnerable than seabirds to fouling by oil, but they are at risk from hydrocarbons and other chemicals that may evaporate from the surface of an oil slick at sea within the first few days. In contrast to seabirds there is relatively little evidence of direct mortality associated with oil spills, although the aggregated distribution of some species (especially dolphins) may expose large numbers of individuals to localised oiling. In the unlikely event of mortality from a spill, population recovery rates are likely to be lower than for most bird species.

Any spilled oil would be expected to float on the sea surface (SG of Bacchus being lower than that of seawater), some low viscosity oils (Bacchus has a viscosity of 13.9) may disperse naturally within the top few metres of the water column. Concentrations of oil in the upper levels of the water column may be sustained close to the release point, in the event the release of oil is continuous. However, spilled oil, with the Bacchus SG, is not expected to penetrate the lower depths of the water column, and as such the impact on species in these lower levels, or on the seabed, is expected to be low.

The sensitivity of planktonic and pelagic communities (e.g. fish and cephalopods) is believed to be lower, both in terms of exposure pathways and the higher recovery potential associated with reproductive capacity. In the unlikely event of oil reaching the seabed, there is potential for localised smothering of habitats used by fish, either as spawning, feeding or nursery grounds, and other benthic fauna. In addition to direct toxicity of oil and dispersants, oil and certain chemicals have the potential to introduce taint (defined as the ability of a substance to impart a foreign flavour or odour to the flesh of fish and shellfish, following prolonged and regular discharges of tainting substances).

Perceived or actual contamination of target species with hydrocarbons or other chemicals may result in economic damage to the fishing industry and associated industries. Following a spill or other incident, in some circumstances exclusion orders may be issued preventing marketing of seafood from areas considered to be contaminated, resulting in economic impacts on both the fishing and processing industries. Loss of public confidence in seafood quality from an affected area may also impact on sales revenues. The landings from Scottish vessels include fish from the Bacchus and wider Forties Area, which lies to the south of a large area of moderate to high level of fishing effort over the Fladen Ground. Monthly fishing effort over the period 2016-2018 was variable, though is low through most of the year, with no well-defined seasonal pattern, with fisheries targeting both demersal and pelagic species, as well as *Nephrops.*

A number of protected sites where the probability of surface oil meeting or exceeding 0.3µm was >30% were identified, these were considered key sites where the impact of an uncontrolled release could potentially be significant; sites where the probability was <30% were also identified, and although these could also be impacted, the impact on these was not considered potentially significant. Of those key protected sites, thirteen were marine sites, and primarily designated for physical features and seabed habitats (e.g. reef, pockmarks, offshore deep sea muds) and biological features including *Arctica islandica* aggregations and sandeels; where sites are fully submerged, it is unlikely that a spill from Bacchus would result in damage to affect the conservation status of these, Bacchus oil being light and expected to remain primarily on the sea surface and not penetrate deep into the water column. The remaining sites include coastal sites and marine area Special Protection Area (SPAs) (e.g. extensions of existing, or marine areas around existing sites, to protect foraging grounds for seabirds) and Special Areas of Conservation (SAC), the qualifying habitats from this latter group not considered particularly sensitive to spills. Of those SPAs identified, in the unlikely event of a major crude oil spill from Bacchus, weathered spilled oil could theoretically affect the qualifying features (e.g. breeding seabirds and wintering waterbirds) when present and when foraging within and outside the boundaries of the SPA.

Fortunately, there is little experience of major oil spills in the vicinity of seabird colonies in the UK. And, where spills have occurred, e.g. the *Braer* (Shetland), long term effects on wildlife have proved to be less than feared with the most notable impact on breeding populations of resident seabirds closest to the spill. For Bacchus, the risk of the potential impact on qualifying features of SPAs is further reduced due to the time of year and abundance (drilling expected during Q3/Q4, outwith the breeding season when the majority of birds are away from breeding colonies and not yet returned in great numbers).

Evaluating spill risk also requires consideration of the probability of an incident occurring. While it is evident from the Deepwater Horizon incident that well blowouts with environmentally significant consequences can and do happen, historically, spills of this magnitude, as a result of well blowouts, have not occurred on the UKCS or in the wider North Sea, and the probability remains remote.

Overall, while the spill modelling scenario for Bacchus does demonstrate the potential for an MEI as described in the EUOSD and SCR (2015) for protected sites and species, this is a worst case scenario that assumes no intervention and response, and the probability of an incident occurring is remote due to preventative measures and response strategies in place.

Cumulative effects

Incremental, cumulative and synergistic effects have been systematically reviewed. Minor incremental or cumulative risks (i.e. effects acting additively or in combination with those of other human activities) were identified in relation to discharges, physical presence and disturbance of the seabed, spills and emissions to atmosphere. None of these were considered to represent more than a small impact in a regional context. No significant synergistic effects – where the joint effect of two or more processes is greater than the sum of individual effects – are predicted.

Transboundary effects

The UK has ratified the *Convention on Environmental Impact Assessment in a Transboundary Context* (Espoo Convention 1991) and thus an assessment is needed of the potential for the proposed activities to result in significant transboundary effects. The production increase and infill well have a limited likelihood of transboundary effects, though the Bacchus Field is located relatively close to the UK/Norwegian median line (55km east). Noise, atmospheric and aqueous emissions from the rig and support vessels are unlikely to be detectable or to significantly affect Norwegian national waters and air quality, nor are any operational discharges including atmospheric emissions from incremental flare and produced water discharges.

Conclusion

The conclusions of the assessment are that the production increase, and the drilling of the Bacchus South well, will not result in significant adverse effects on the environment or other users of the area.

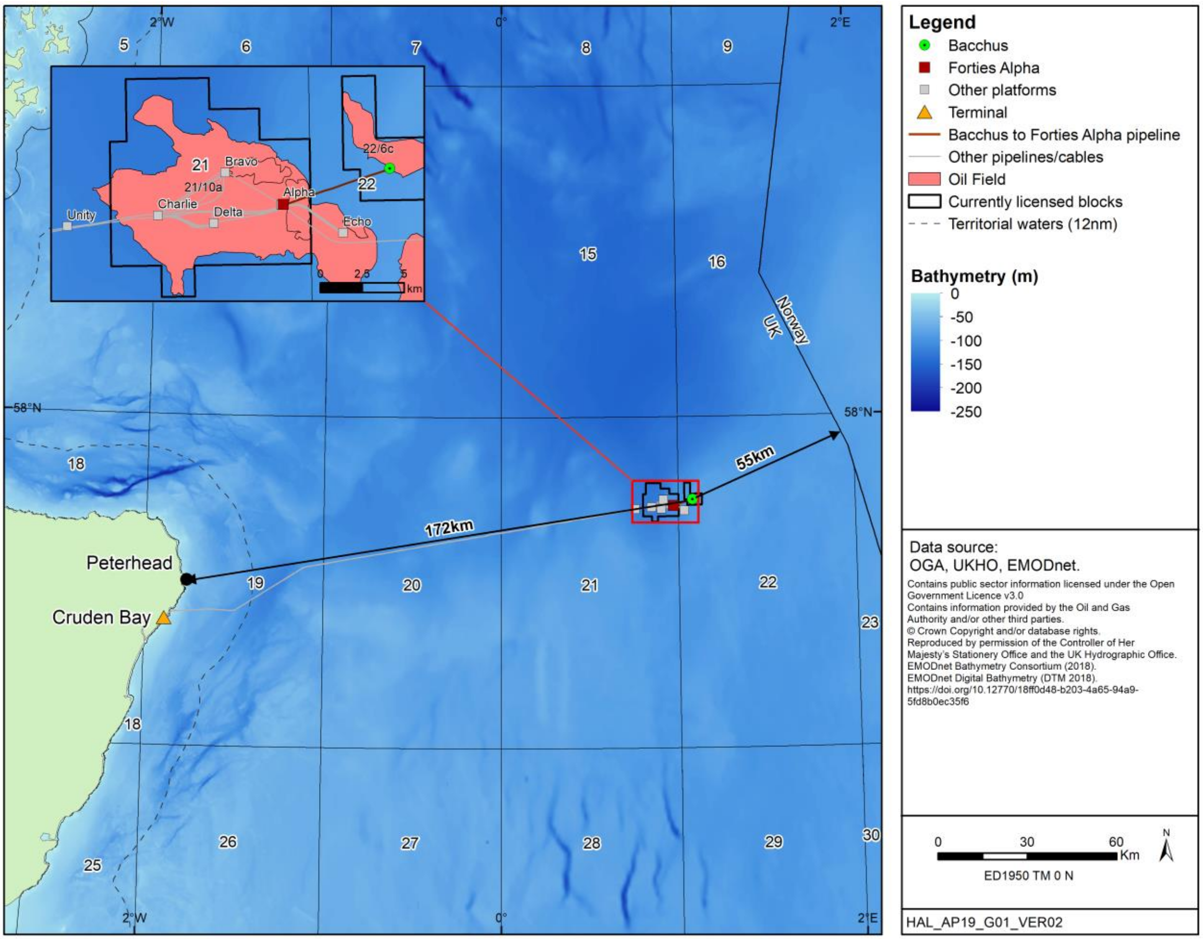
1 INTRODUCTION

This Environmental Statement (ES) presents the findings of an Environmental Impact Assessment (EIA) conducted by Apache North Sea Limited (Apache), in relation to an increase in hydrocarbon production from the Bacchus Field of more than 500 tonnes of oil per day, and the drilling of a new infill well. The objective of the new well and production increase is to extend field life and contribute to maximising the economic recovery of UK oil and gas. Drilling activities are expected to commence in Q3/Q4 2020, and consent for the production increase is currently anticipated to commence from Q2 of 2021.

1.1 Background

The Bacchus Field is located in Block 22/6c which is covered by licence P.255, acquired by Apache in December 2011. Apache has operatorship of the Bacchus and Forties Fields. Bacchus is located some 172km from the nearest UK landfall (Peterhead) and 55km from the UK/Norwegian median line (Figure 1.1).

Figure 1.1: Location of the Bacchus Field, Forties Field and related pipelines



The Bacchus Field was discovered in May 2005 (well 22/6a-14), and was developed as a subsea tie-back to Forties Alpha; production from Bacchus commenced in 2012. The Bacchus manifold is located approximately 6.8km to the north east of the Forties Alpha platform, and is connected via a subsea bundle containing export, water injection and service utility lines. Bacchus, and Forties Alpha, are part of the wider Forties Field complex which includes five fixed platforms (Forties Alpha, Forties Bravo, Forties Charlie, Forties Delta and Forties Echo). Oil from all five Forties platforms, which includes that from Bacchus, is exported via the INEOS operated Forties Unity platform into the Forties Pipeline System (FPS)[1].

A detailed description of the Bacchus Field and the proposed production increase and infill well drilling is provided in Section 2.

1.2 Apache Environmental Management

Apache operates an Environmental Management System (EMS) which is certified as meeting the requirements of the ISO14001:2015 international standard. The EMS is subject to periodic review and assessment by both internal audits and external third-party audits. The most recent certification audit was completed in June 2020.

Apache's Environmental, Health and Safety Policy applies to operations within the remit of the EMS. The policy is shown in Figure 1.2.

The Vice President both endorses and has responsibility for the implementation of the HSSE Policy. The success of its implementation is reviewed annually as part of the Environmental Management review.

As part of Apache's continuing programme of improvements in environmental management, an annual HSSE Management Plan is compiled that details specific projects to be undertaken in relation to improving performance in discharges to sea, management of chemicals, atmospheric emissions, energy efficiency and waste management.

1.3 Environmental Statement

1.3.1 Purpose

Environmental Impact Assessment (EIA) is an integral part of Apache's management processes, which satisfies the company's environmental policy objectives with regard to the assessment of potential risks to the environment from its activities. This Environmental Statement (ES) documents the results of the EIA process, highlighting environmental sensitivities, identifying potential hazards, assessing/predicting risks to the environment and identifying practical mitigation and monitoring measures to be carried forward.

The Environmental Statement has been produced in accordance with the *Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999 (as amended).* Under these Regulations, the submission of an ES to the Secretary of State for the Department for Business, Energy and Industrial Strategy (BEIS) is required when an application for consent for increased production of hydrocarbons from an existing Field exceeds incremental thresholds of 500 tonnes of oil per day, or 500,000m^3 of gas per day.

[1] The Forties Pipeline System, including the Forties Unity riser platform, is operated by INEOS and carries oil from a number of offshore fields. The pipeline has a landfall at Cruden Bay from where it travels underground to Kinneil on the Firth of Forth.

Figure 1.2: Apache Environmental, Health and Safety Policy

Apache North Sea
Environmental, Health and Safety Policy

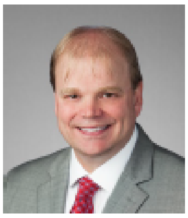
Apache is committed to conducting our business in a manner that protects the health, safety, security and wellbeing of our employees, contractors and the general public while maintaining the quality of the environment in which we operate.

With management commitment and employee personal responsibility, Apache pledges to:

- ✓ Recognise that no business objective is so important that it will be pursued at the expense of the environment or compromise health, safety or security considerations
- ✓ Design and manage our activities to actively prevent environmental and health impacts, optimise energy consumption and provide adequate control of the health, safety and security risks arising from our work activities
- ✓ Comply with all Company operating standards, policies and behaviours which are based on applicable environmental, health, safety and security laws, regulations and best practices for our operations
- ✓ Ensure availability of information and necessary resources to achieve the health, safety, security and environmental objectives and targets
- ✓ Continually measure, audit and assess Apache's health, safety, security and environmental performance and energy consumption against challenging key performance indicators and actively seek to identify improvement opportunities
- ✓ Continuously improve the use of energy resources throughout the operational life cycle, with the purpose of preserving natural resources and reducing atmospheric emissions
- ✓ Manage health, safety, security and environmental risks through appropriate contingency planning, emergency preparedness, response and recovery programs
- ✓ Empower all employees or persons working with us to challenge any activity or condition and to stop the job where, in their opinion it may cause a harmful effect to their own health, safety or security, or to the environment
- ✓ Promote a high standard of health and wellbeing for all employees and encourage open internal and external communications on health, safety, security and environmental matters amongst all stakeholders.

Apache will actively realise the goals of this statement through the commitments and actions of all employees and associated contractors.

We trust you will lead by example.



Ken Neupert

Vice President, Offshore Production Operations

Apache North Sea Limited

Reviewed May 2020

The current production consent for the Bacchus Field extends to 31st of December 2021. The Bacchus South infill well has the purpose of improving recovery of hydrocarbons from the Bacchus Field, which has seen declining performance from existing wells in recent years. The well will extend field life, and is in keeping with the Oil & Gas Authority's (OGA) Maximising Economic Recovery (MER) UK strategy, the central obligation of which is, "*Relevant persons*[2] *must, in the exercise of their relevant functions, take the steps necessary to secure that the maximum value of economically recoverable petroleum is recovered from the strata beneath relevant UK waters*" (also see Section 2.2). The MER-UK Strategy is presently being updated to take account of the UK's commitment to achieving net zero greenhouse gas emissions by 2050[3]. Numerous changes to the strategy are proposed, however, an additional paragraph to the central obligation is that relevant persons must, "*take appropriate steps to assist the Secretary of State in meeting the net zero target, including by reducing as far as reasonable in the circumstances greenhouse gas emissions from sources such as flaring and venting and power generation, and supporting carbon capture and storage projects*." While this consultation is ongoing, the contribution of Bacchus to greenhouse gas emissions from flaring and power generation is considered in this assessment.

1.3.2 Environmental Assessment Process

The EIA process was initiated when the potential to exceed the production threshold was identified. Information on the environment and existing sensitivities was collated and used in the assessment process.

For this ES, the potential impacts of increased production to the environment (in its broad sense) were identified using defined severity criteria (Section 4). Those interactions with the potential to result in significant environmental effects were then assessed in more detail (Section 5). Where appropriate, mitigation measures were identified to avoid or reduce effects (Section 6).

1.3.3 Consultation

Apache consulted a number of organisations as part of the EIA process which included the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED), Marine Scotland and the Joint Nature Conservation Committee (JNCC). Issues raised by those consulted and where they are addressed in the, ES are provided below. Note that JNCC were present at a consultee meeting, and while confirming those issues raised by OPRED and Marine Scotland (below), did not raise any additional concerns.

Consultee	Issue/Concern	Response
OPRED & Marine Scotland	Options selection for the facilities.	Options selection provided in Section 2.4.
OPRED	Inclusion of the Major Environmental Incident (MEI) assessment.	MEI assessment provided in Section 5.3.
Marine Scotland	Option selection for tophole riserless drilling.	The well can only be drilled riserless due to the seabed sediment type at location. Assessment provided in Section 5.2.3.

The ES will be subject to formal statutory public consultation.

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2 Defined under Section 9C of the *Petroleum Act 1998* (as amended), i.e. the holder of a petroleum licence; an operator under a petroleum licence; the owner of (a) a relevant offshore installation, or (b) upstream petroleum infrastructure.

3 https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law and https://www.ogauthority.co.uk/news-publications/consultations/2020/consultation-on-new-oga-strategy/

1.3.4 Areas of Uncertainty

Where definition is lacking, generic information has been used and best estimates of emissions, discharges and other sources of interaction are used in the consideration of possible effects. Any underlying assumptions with regard to these are presented.

1.4 Marine Planning

Bacchus is within an area covered by Scotland’s National Marine Plan (Scottish Government 2015). Apache is aware of Scotland’s National Marine Plan and policies which are relevant to its operations in Scottish waters, including those which are consistent with wider MER-UK strategy (e.g. policy Oil&Gas 1). The increase in production does reflect a long-term activity, but it will be undertaken with consideration to other existing users (e.g. consistent with policy GEN 4 Co-existence and also those interactions with other users notes in policy Oil&Gas 1 and consistent with Oil&Gas 3 and 6), environmental sensitivities of the area (policies GEN 9 Natural Heritage, GEN 12 Water Quality and Resource, GEN 13 Noise and GEN 14 Air Quality) and cumulative effects (policy GEN 21 Cumulative Impacts).

2 BACCHUS PRODUCTION INCREASE

2.1 Introduction

The Bacchus Field was discovered in 2005 following the drilling of a discovery well in Block 22/6a (22/6a-14). The Field was developed as a subsea tie-back to Forties Alpha (Figures 2.1 and 2.2) using a subsea bundle and towhead, such that the manifold, pipeline and umbilical system were manufactured onshore, and transported and installed in a single campaign. The subsea bundle connecting Forties Alpha to Bacchus is surface-laid and consists of two production and water injection lines (6’’ and 4’’ respectively), 4’’ gas lift and 3’’ scale squeeze lines, a 2’’ methanol line along with power, hydraulic and other control lines. Oil and gas are exported from Bacchus to Forties Alpha where it is comingled with Forties crude and exported via the FPS. The Bacchus Field is covered by offshore production licence P.255.

The production increase will be achieved by the drilling of an infill well, Bacchus South, which will necessitate the use of a mobile drilling rig. The exact rig will depend on rig availability which is considered to meet operational, safety and environmental criteria. The rig will have in place all necessary permits and certification for operations on the UKCS. A range of drilling, cementing and completion chemicals will be necessary to drill the well. A proportion of these chemicals will be discharged with the cuttings, dependent on their nature and function, and will be assessed in the application to BEIS for a chemical term permit through the Portal Environmental Tracking System (PETS) process, along with all other relevant permits required for offshore drilling and production increase.

2.2 Bacchus and Bacchus South

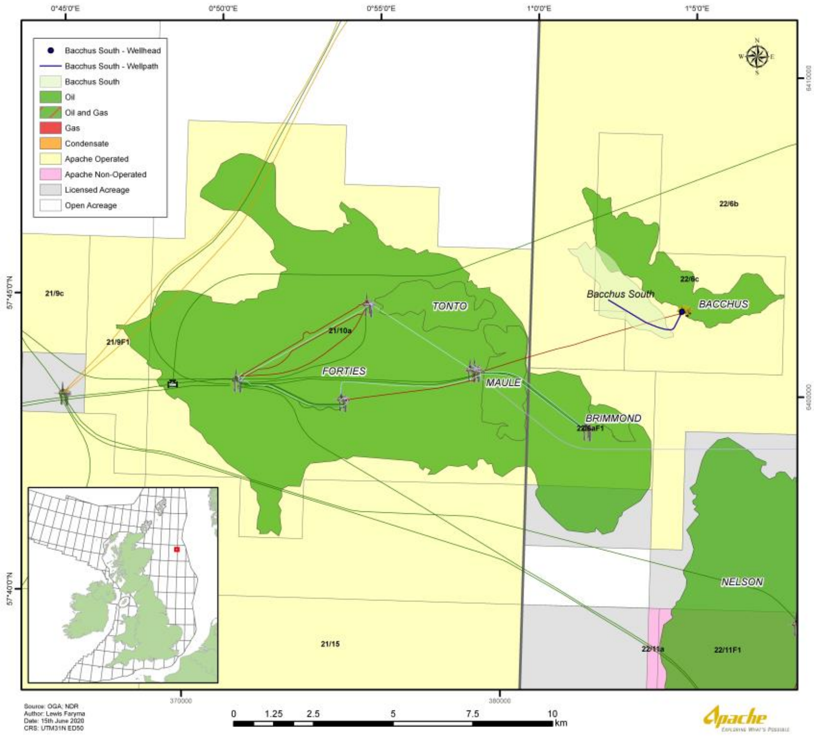
The Bacchus reservoir structure is a tilted fault-block with dip closure to the south-west, fault closure along the south east and north east flanks and stratigraphic closure to the north west. The reservoir is at a depth of 3,670-3,830m TVDSS (true vertical depth subsea) and comprises moderate quality Fulmar shoreface sandstones containing 35º API oil with a GOR (gas:oil ratio) of 320scf/bbl (standard cubic feet/barrel). The reservoir is overpressured and moderately high temperature with initial reservoir conditions of 9,474psi and 143°C. Permeability varies from *ca*. 4mD (millidarcy) in the lower reservoir section to 80mD in the upper section. There are two NNE-SSW conjugate faults with significant offset in the reservoir structure forming three, potentially isolated reservoir compartments. The existing Bacchus wells access the three main Bacchus reservoir compartments, with the wells intersecting major faults between and within the compartments to mitigate potential compartmentalisation risk.

The remaining potential of the Bacchus Field and the immediate surrounding area, was evaluated through a reinterpretation of the structure using broadband processed seismic data acquired in 2016, updated seismic inversions, 4D seismic, reservoir surveillance data and updated reservoir models.

Bacchus South is located immediately to the west of the Bacchus Field (Figure 2.1) and fluids are assumed to be comparable to Bacchus Field fluids as a consequence of their proximity and likely similar charge history. The following reservoir parameters have been estimated for Bacchus South:

- Reservoir Pressure: Virgin pressure of 9,472 psia at 3,755 m TVDSS is expected;
- Temperature: 143°C at 3,755 m TVDSS
- Gas:Oil Ratio (GOR): 321scf/stb

Figure 2.1: Forties Area Fields, including Bacchus South



2.3 Bacchus Facilities

2.3.1 Overview of current Bacchus and Host Facilities

Bacchus facilities include a four slot towhead manifold which is tied back to the Forties Alpha platform via a 6.8km subsea bundle (Figure 2.2). Three subsea wells have been drilled to date (22/06c-B1 (B1), 22/06c-B2 (B2), 22/06c-B3y (B3)) and are connected to the manifold via flexible jumpers; these wells initially flowed naturally (reservoir pressure of ±9,600psi), but as the reservoir pressure declined, one well was converted to providing water injection (22/06c-B3y, converted in 2016) and the remaining production wells require gas lift to produce.

The bundle provides for the routing of fluids and services to the wellhead jumpers as well as providing isolation to the bundle from individual wells by means of Manifold Isolation Valves (MIVs). The bundle terminates at the Forties Alpha Sub-Sea Isolation Valve (SSIV) manifold, which is in turn tied back to a riser caisson at the platform. The bundle and riser caisson incorporate two 6" production lines, a 4" gas lift supply line, and hydraulic, chemical and power/signal supplies. Two 4" heating lines are provided within the bundle which have a dual purpose. The heating lines prevent wax and hydrate formation, making use produced water supplied from Forties Alpha. The two pipelines are designated as supply and return, allowing the heating medium to flow in a loop and return to the Forties Alpha platform using a subsea crossover at the Bacchus subsea manifold. The heating medium is obtained from a tie-in at the Forties Alpha platform produced water reinjection (PWRI) manifold and the return pipeline is tied into the existing Produced Water Degasser Produced water from the Forties Alpha PWRI manifold is also used to provide a motive force for Bacchus pigging operations.

The Bacchus wells require both methanol dosing at the Xmas trees on start-up, to mitigate hydrate risk, and the injection of scale inhibitor at the tree as water cut rises, to protect against scale deposition in the flowline.

Forties Alpha

Bacchus fluids are processed at the Forties Alpha installation (Figure 2.1). Forties Alpha supports equipment packages for, amongst other processes, drilling and workover, oil processing and export, and water treatment and injection.

Forties Alpha processes fluids produced at both Forties Alpha and Forties Echo (and, currently via the Maule Field well and the Bacchus Field wells). Gas and water are initially separated from the produced oil in two, three-phase bulk separators. Oil is subsequently filtered prior to export to Forties Charlie via a 20” pipeline. Separated gas is initially treated to remove water and condensate before being transferred to the Natural Gas Liquids (NGL) plant for further water and condensate removal. Following processing, the gas may be used as fuel or lift gas on Forties Alpha, or be exported to the Forties gas distribution system. In line with the mature production status of Forties, the oil/water interface of the reservoir has risen leading to an increased water cut and a resultant increase in the hydrostatic head and a reduced well flow rate.

Produced water may be discharged following treatment (with a statutory requirement not to exceed an oil in water content of 30mg/l per month) or reinjected, and facilities for both treated seawater (SWI) and PWRI are maintained on Forties Alpha. Water generated from the bulk separators passes through a set of hydrocyclones which separate the denser water from the less dense oil. Any oil is routed to a reclaimed oil vessel from where it is pumped back to the bulk separators. The water is passed to degassing vessels which gather any remaining oil which is passed to the reclaimed oil vessel, which in turn is routed back to bulk separation. Prior to injection of produced water, the water is filtered to remove particles >50µm (primarily sand) which may over time reduce water injection performance. The sand may have a residual oil content which if deemed too great for discharge (>1%) will be subject to a washing process prior to disposal. The filtered water is routed to two electrically driven High Pressure (HP) injection pumps which increase the pressure of the water for discharge via the PWRI manifold.

The Forties Alpha Satellite Platform (FASP) was installed in 2013. The FASP is linked to the west of Forties Alpha by a 90m bridge which carries processed fluids, gas, electrical power and personnel between the two installations. On installation, the platform provided 18 new well slots, additional liquids processing and gas compression capacity for Forties Alpha, and extra power generation for the Forties Field to be exported via the existing power ring main, but relies on Forties Alpha for oil export and flaring facilities.

In 2015, the Aviat shallow gas development was tied-back to Forties Alpha to provide a source of fuel gas so as to offset the use of diesel for fuel generation, as associated gas from the Forties production continues to decline. Due to the lack of a gas export route from Forties, and a fuel gas deficit, all Bacchus associated gas is utilised for energy production either at Forties Alpha, or else exported to other installations in the Forties Field.

Figure 2.2: Forties Alpha and the FASP

2.4 Rationale for Further Development

A number of factors limit the existing and future productivity from the Bacchus development which provide the rationale for the Bacchus South well. These include historical issues with well management, including a decrease in gas lift injection pressure at well B2 and historical wax/asphaltene deposits. Wellbore cleanout and gas lift valve change out intervention was carried out in June 2018, and the wax/asphaltene deposits were removed by jetting with coiled tubing whilst routing fluid back to Forties Alpha. The unloading valves were then changed out, the tubing punched (to deepen the gas lift injection point).

Flow problems were identified with well B1 such that it was shut in during January 2018. The impact of re-instating production at the well has been investigated and found to be detrimental to overall produced volumes when combined with the B2 well. The B2 well appears to be accessing all the decline reserves for the B1 well, in addition to seeing a rate benefit due, in part, to improved reservoir pressures associated with the shut in of well B1. The Field, therefore, is solely produced from well B2 at present.

The B3y water injection well is performing below expectations due to the poorer than expected reservoir properties encountered. However, given the current understanding of the subsurface through a dynamic simulation model, moving the injector location is deemed to be uneconomical. Bacchus has an existing export route and an available well slot to tie a future well into, therefore it is proposed that this available capacity is used rather than separate, dedicated facilities. A new well, Bacchus South (Section 2.5), is proposed in order to enhance the production from Bacchus and extend field life, consistent with OGA's MER-UK Strategy (Section 1.3.1). The new well will account for historical Bacchus well maintenance issues (e.g. by providing for downhole chemical injection of asphaltene inhibitor).

2.5 Bacchus South

Flow from well B2 is routed via both of the 6" Bacchus production lines to optimise production rate, however, it is proposed that production from B2 and Bacchus South would be segregated from each other subsea, by routing each well to one of the production lines, which will be isolated at the manifold (see Figure 2.3 for an overview of connections at the Bacchus manifold). Although likely to impact on

B2 well production rates, if production from the wells were not isolated, due to the anticipated virgin reservoir pressure at Bacchus South the flowing wellhead pressure would back out production from the B2 well, where flowing wellhead pressure is lower due to production related reservoir pressure depletion. Once reservoir pressure at Bacchus South depletes it may be possible to comingle production through both lines to optimise the total Bacchus rate by utilising the full available capacity.

The Bacchus South well will be equipped for downhole chemical injection of asphaltene dispersant to mitigate against the deposition of organic solids in the well, as noted in Section 2.4. The well slot to be used for Bacchus South is not currently tied into the chemical service lines in the manifold. It is proposed to install flexible lines to the chemical interface plate from the unused methanol and scale inhibitor chemical interface plate at the B3y slot, and to tie into one of the unused ¾" chemical injection cores in the bundle for delivery of asphaltene inhibitor.

As the proposed Bacchus South well will utilise the last free slot on the manifold, further expansion at Bacchus would require repurposing the disused B3y (water injection) or B1 production well slots and facilities, with some additional installation or repurposing of gas lift or chemical services possibly required.

A new, ~94m, flexible, 6" production pipeline will be installed between the Bacchus South well and the Bacchus towhead manifold, connected at each end with rigid spoolpieces. Additionally, a jumper providing hydraulic, chemical and control services will be installed between the well and manifold. A 4" gas lift pipeline will also be installed. This will initially be positively isolated at the manifold until gas lift is required.

2.6 Forties Alpha

The Bacchus South fluids will use the existing Bacchus reception facilities at Forties Alpha, and will comingle with the Bacchus production from well B2. Flow from Bacchus can be routed to the inlet separators of either of the two main processing trains on Forties Alpha, or direct to the test separator and recycled back to one of the bulk inlet separators. Reservoir fluid composition and properties from the Bacchus South well are expected to be of a similar nature to the currently produced Bacchus fluids. Flow assurance, production chemistry and process separation management of the fluids are well understood, and it is not anticipated that the Bacchus South well will introduce any additional challenges to process separation and produced water quality. Production from Bacchus South, along with other Forties oil, will be exported to Cruden Bay via the FPS.

Topside modifications are not required for production flowlines, separation and gas processing. The principal modifications are to the chemical supply systems for Bacchus. This includes the addition of an atmospheric chemical storage tank (3,000l, or 3m^3) for asphaltene inhibitor and related duty/standby pumps rated to match existing Bacchus bundle design pressure.

Figure 2.3: Slot connections at the Bacchus manifold

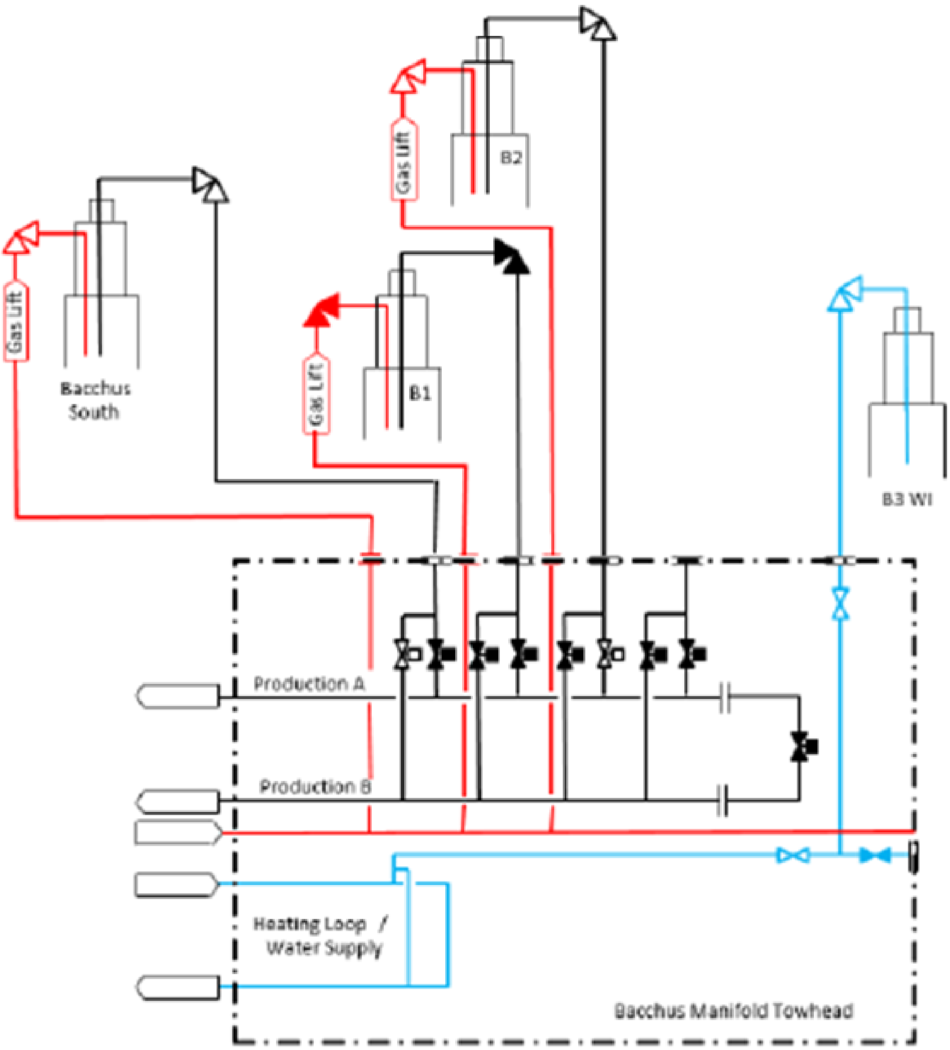
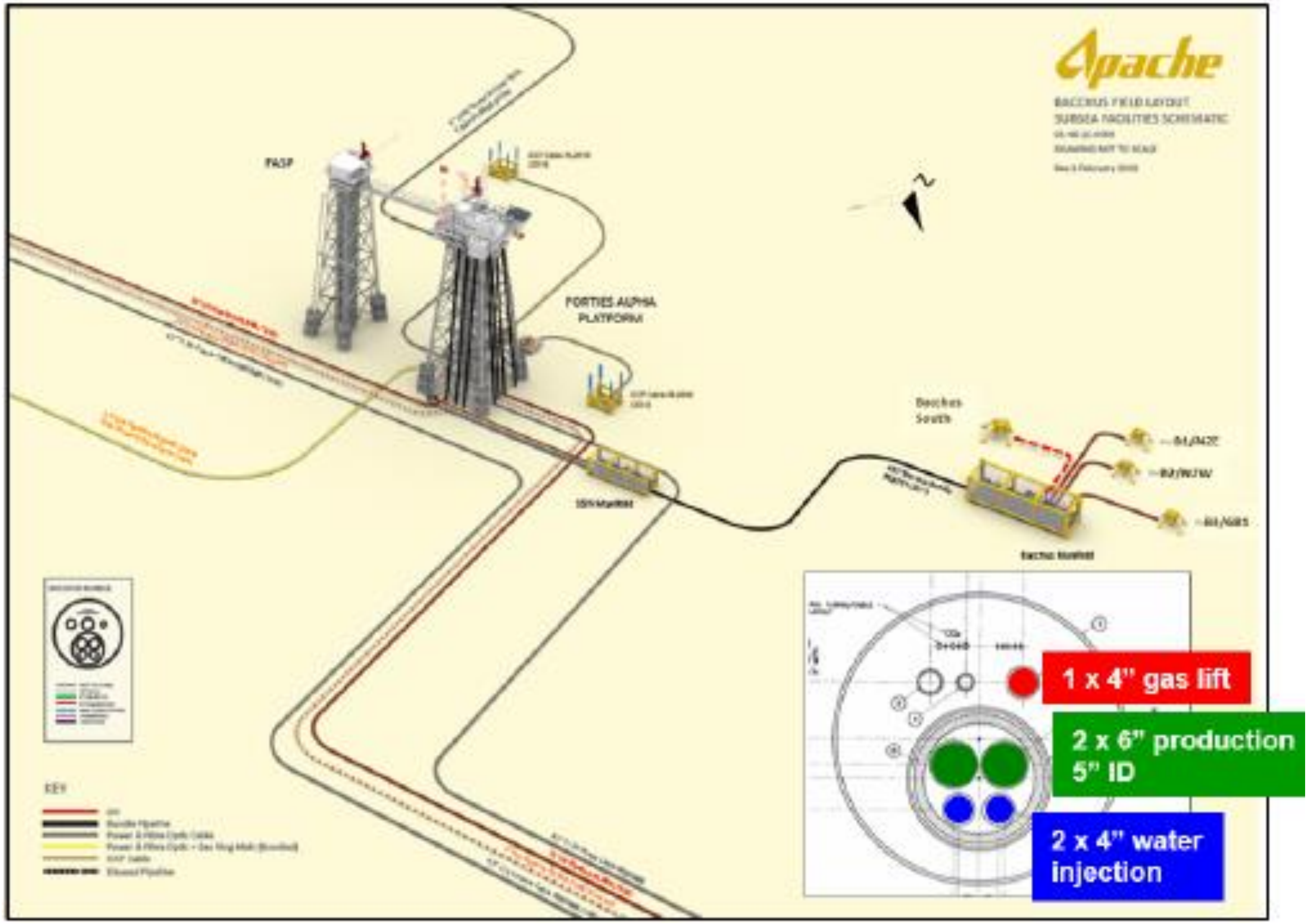


Figure 2.4: Bacchus and Forties Alpha infrastructure, showing Bacchus South



2.7 Bacchus Production Forecasts

2.7.1 Oil and Gas

The Bacchus production consent runs to 2021, with currently consented volumes for up to 600 m^3 (approximately 645 tonnes) per day of oil, and up to 42,850m^3 (approximately 590 tonnes) of gas per day. When accounting for forecast production from the Bacchus B2 well, the addition of Bacchus South is predicted to result in oil and gas exceeding currently consented levels from 2021 and up to 2026, with the incremental rates also exceeding the threshold[4] requiring environmental impact assessment from 2021. Forecast production figures for Bacchus South are provided below (Table 2.1) and are charted in the context of whole Bacchus production (i.e. that expected from the B2 well) over the same period in Figure 2.5.

Table 2.1: Bacchus South oil and gas projections

Year	Oil		Gas	
	t/day	m^3/day	t/day	m^3/day
Bacchus South				
2021	838	780	710	51,638
2022	1,182	1,100	1,001	72,829
2023	1,175	1,094	995	72,385
2024	727	677	616	44,782
2025	351	327	298	21,634
2026	425	396	360	26,209
2027	298	277	252	18,328
2028	213	199	181	13,139
2029	98	91	83	6,020
Wider Bacchus Production				
2021	1,347	1,254	1,141	82,978
2022	1,655	1,541	1,402	101,986
2023	1,608	1,497	1,363	99,092
2024	1,119	1,042	948	68,928
2025	702	654	595	43,279
2026	739	688	626	45,518
2027	577	537	489	35,542
2028	463	431	392	28,505
2029	322	299	273	19,809

[4] Incremental thresholds of 500 tonnes of oil per day or 500,000m^3 of gas per day

Figure 2.5: Bacchus and Bacchus South production rates

2.7.2 Produced Water

There will be a small increment in water production and related processing at Forties Alpha as a result of Bacchus South (Table 2.2). Water rates are expected to be zero initially, but later rise to a maximum of 3.1 m^3/d in 2023. Relative to the wider water rate from Bacchus, the Bacchus South well would represent an increment of up to 1.9% at peak production in 2023, and is therefore extremely minor. It is expected that ~ 60% of this water will be re-injected, with the rest being discharged at Forties Alpha.

Assuming an average oil in water concentration of 20mg/l (note recent Forties Alpha discharges are lower than this; 2018: 17.6 mg/l 2019: 13.3 mg/l and 2020: 11.2 mg/l), and that 60% of produced water is re-injected, it is estimated that oil discharged in produced water would be negligible, at just 0.009 tonnes/year at peak production in 2023 (Table 2.2).

Table 2.2: Bacchus South produced water and oil in water projections

Year	Produced water total volume (m^3/day)	Estimated oil discharged (tonnes/year)
2021	0.5	0.0015
2022	2.0	0.0058
2023	3.1	0.0091
2024	2.7	0.0079
2025	1.5	0.0044
2026	1.9	0.0055
2027	1.3	0.0038
2028	0.9	0.0026
2029	0.4	0.0012

2.8 Drilling Programme

Bacchus South will be drilled using a semi-submersible drilling rig. A range of drilling, cementing and completion chemicals are necessary to drill the well; a proportion of these chemicals may be discharged with the cuttings, dependent on their nature and function, and will be assessed in the application to BEIS for a chemical term permit through the PETS process. The impact of drilling operations to the environment will be assessed in an application to BEIS for a direction via the PETS, and is also considered here (Section 5.2).

2.8.1 Drilling Rig and Support

The rig will have in place all the necessary permits and certification for operation on the UKCS. Apache have experience in the use of such rigs at its assets across the North Sea and a representative example of the type of rig that will drill the Bacchus South well for the purposes of assessment.

A semi-submersible drilling rig is a floating facility, effectively a deck supported on pontoons which contain ballast tanks. The height of the deck can be altered above the sea surface by pumping seawater in or out of the ballast tanks. The main deck supports the drilling derrick and associated equipment and storage facilities, with fuel stored in separate tanks in the pontoons. The rig will have deck measurements of approximately 75x63m, and the draught during drilling is in the region of approximately 23.5m. The drilling derrick, which is located above the drill floor, bears the weight of the "drillstring", a series of long sections of hollow pipe, screwed together and to the bottom of which is attached the rotating drill bit. A series of heavy drill collars is added to the lower drill string to give the drill bit extra weight.

The rig used will already be operating in the wider UKCS and will be towed to site using three anchor handling vessels. Mooring is achieved via eight ~12 tonne anchors connected to the rig by 3.25" chain, a proportion of which will lie on the seabed. Hauling or paying out of anchor chain can subsequently make minor adjustments to the rig position. The precise arrangement of anchors around the rig will be defined by a mooring analysis which will be undertaken prior to bringing the rig into the Field and taking account of the water depth, tidal and other currents, winds and seabed features.

A 500m safety zone will be established around the rig during drilling activities into which unauthorised vessels are not permitted access. This zone will largely overlap the existing subsea safety zone present at Bacchus. The Forties Field standby vessel will be on-station throughout the drilling operations in case of any emergency necessitating evacuation or in the case of man-overboard situation and to warn any non-authorised vessels approaching the exclusion zone. In view of the water depths at Bacchus South (Section 3.2) and experience of previous use of semi-submersibles at such depths, the rig is expected to have an anchor spread of approximately 1,200-1,700m, which extends the anchor locations to beyond the 500m safety zone. As laid positions of the anchors will be notified to fishermen.

Mobile rigs have facilities for drilling, power generation, supporting utilities and accommodation. For cuttings cleaning and mud conditioning, a rig is normally equipped with high efficiency shale shakers together with centrifuges and the drilling area has a sealed drainage system. Spilled mud is returned to the mud tanks.

The rig will require refuelling (bunkering) during the drilling programme; bunkering will take place once every two weeks. Refuelling would be undertaken in favourable sea states and under continual monitoring according to the selected rig operator's procedures. Bunkering procedures are audited by Apache as part of the rig selection and contracting process. Hoses will be subject to formal management and inspection, have colour coded markings according to service and be fitted with dry breakaway fittings. Helifuel (ATK) supplies have a capacity of 8,000 litres across two tanks and are replenished when necessary by replacing an empty with a full tank.

2.8.2 Well Design

The Bacchus South well design is summarised in Table 2.3 and is described below.

The surface hole will be drilled using seawater and sweeps, and conductors (metal pipes) will be installed inside the well bore and cement pumped in the gap (annulus) between it and the hole wall to hold it in place. The surface hole will be drilled riserless, with cuttings associated with this section discharged at the seabed. The seabed sediments and shallow geological formations are not considered to be suitable for alternative methods to create the surface hole, such as jetting or conductor driving (i.e. piling).

Drilling muds are used to cool the drill bit, provide a hydrostatic head to control the well, stabilise the well bore and to circulate rock cuttings out of the hole. Drilling muds are made up of a weighting agent (commonly the dense mineral barite) suspended in a fluid (the base fluid). The base fluid can be Water Based Mud (WBM) or Oil Based Mud (OBM), dependent on the requirements of the well section. The well is relatively long (>5,500m) will be drilled through unstable and reactive shales, and will require a high mud weight to control pressures and wellbore stability. For the relevant well sections (16", 12¼", 8½"), this is best addressed through the use of a Low Toxicity Oil Based Mud (LTOBM). While a relatively large quantity of cuttings will be produced across these three sections (Table 2.3), they will be returned to the rig and treated using a thermal cuttings processing unit (TCC rotomill[5]). The thermal processing unit heats up the cuttings to a temperature at which hydrocarbons are released from the solids, leaving solids with <1% oil in cuttings content, which will reduce LTOBM to a level that the cuttings may be discharged. The cuttings discharge point for these sections is from the rig, at ~11.5m below mean sea level.

Sampling will be undertaken on the cuttings being sent to the rotomill and on the recovered oil three times in each 12 hour shift, with the recovered water being tested once per shift and also in the case of operational issues with the mill, prior discharge.

The recovered cuttings material will have a very fine particle size distribution following processing, with almost all of the material likely measuring <100µm. This material is sampled (50g) once every three hours, with the sampling for each shift amalgamated and mixed to create a composite sample. These representative samples will be collected in a manner consistent with BEIS (2018) sampling guidance. Each sample will be labelled and stored appropriately. Following testing the sample will be sent for further analysis onshore, and further testing of two random composite samples from each well section will be undertaken, both by the rotomill vendor and an independent third party. Samples will be retained for six months.

In the event that the sampling indicates that concentrations of <1% are not met, or the rotomill becomes unavailable, cuttings from the well sections drilled with LTOBM will be retained on the rig in lidded skips and returned to shore for treatment and disposal.

The use of this system eliminates the need to return contaminated cuttings to shore for disposal, as it meets the requirements of OSPAR Recommendation 2000/3, which allows for the discharge of cuttings with oil concentrations below 1%. This oil will include the LTOBMs used to drill the lower hole sections (that cleaned from the cuttings will be recovered and reused), but also a quantity of reservoir hydrocarbons for the well section which coincides with the producing hydrocarbons. While the discharges from the rotomill are not subject to OPPC Regulations (BEIS 2018), the discharge of any reservoir hydrocarbons will require an oil discharge permit (DECC 2014, BEIS 2018); the associated discharge of LTOBM residue will be permitted under the *Offshore Chemical Regulations 2002* (as amended).

[5] http://www.twma.co.uk/solutions/tcc-rotomill

As each hole section is completed, the bore is lined with steel casing which is cemented in place to maintain the integrity of the well. The majority of the cement remains between the casing and the rock. A surface Blowout Preventer (BOP) assembly is fitted as soon as the first string of casing has been run. The BOP assembly comprises a series of rams or packers which can be closed around the drillpipe within 10 to 30 seconds. When activated the BOP assembly seals off the annular space between the casing and the drillpipe. If the drillpipe is out of the hole at the time the pressure develops, the BOP shuts off the hole itself so that the entire wellhead is closed.

Where drilling encounters problems, a mechanical sidetrack may be required. This is not a routine event, and therefore is included here as a contingency. A mechanical sidetrack could be drilled in the 8½" section, having similar characteristics to the 8½" section noted in Table 2.3.

Table 2.3: Bacchus well design, indicative section lengths and cuttings volumes

Hole Section	Section depth (m below seabed)	Section Length (m)	Cuttings Discharge Point	Mud System	Est. Volume of cuttings (m^3)	Est. weight of cuttings (tonnes)	Volume of Mud Discharged (m^3)	Mud density (g/cm^3)
36"	183	82	Seabed	SW & PHB	339	898	445	1.20
26"	418	235	Seabed	SW & PHB	506	1,342	470	1.20
16"	2,752	2,334	TCC Rotomill	LTOBM	1,904	1,120	<1%[1]	1.35
12 ¼"	3,917	1,165	TCC Rotomill	LTOBM	557	328	<1%	1.45
8½" [2]	5,777	1,860	TCC Rotomill	LTOBM	252	1,135	<1%	1.82

Notes: [1]for the purposes of assessment it has been assumed that there is a worst case concentration of 1% on cuttings before discharge, equating to a total discharge of oil of 17 tonnes (or 19.9 tonnes including a contingency sidetrack). Historical lab data indicates an average performance of <0.1% of oil content. [2] the assessment considers the potential for a contingency 8½" sidetrack to also be drilled. SW = Sea Water; PHB = prehydrated bentonite

No wireline, coring, Vertical Seismic Profiling (VSP), checkshots or well testing is planned.

2.8.3 Well Schedule

The indicative schedule shown in Table 2.4 relates to the drilling of one well, including contingency time for issues which could generate downtime (e.g. adverse weather). A mechanical 8½" sidetrack could take up to an additional 20 days to drill, such that the total potential schedule is up to 112 days.

Table 2.4: Indicative schedule for the Bacchus well

Phase	Days
Mobilise & Prep	5.7
Drill 36" Hole	0.9
Run 30" Conductor	2.6
Drill 26" Hole	1.5
Run 20" Casing	2.2

Phase	Days
N/U BOP's & Drill Out 20" Shoe Track	4.5
Drill 16" Hole	7.9
Run 13-3/8" Casing	5.4
Drill 12-1/4" Hole	8.1
Run 9-5/8" Casing	3.8
Suspend Well & Recover BOP's	2.9
Install Subsea Tree	5.7
Drill 8-1/2" Hole	17.2
Drill 8-1/2" mechanical sidetrack (contingency)	20
Run 5.1/2'" Pre-Drilled Liner c/w ICDs	3.5
Run Intermediate Completion	2.5
Wellbore Cleanup	5.0
Run Upper Completion	5.2
Suspend Well	4.6
Demobilise	2.3
Estimated total including weather & contingencies	**112**

2.8.4 Rig and Vessel Fuel Use

Estimates of fuel use have been made for drilling of the Bacchus South well (Table 2.5). These quantities are based on typical consumption rates of vessels which will be used and the estimated duration of activities involving these, and emissions relating to this fuel use are assessed in Section 5.1.

Table 2.5: Estimated fuel use for the drilling campaign

Activity and vessels	Number of vessels	Number of days/trips (including contingency)	Consumption rate tonnes/day (approximate)	Total fuel consumption tonnes	Fuel type
Anchor handlers	3	4 days	20	240	Diesel
Drilling rig on location	1	112 days (including all contingencies)	11.5 (drilling)/7 (on standby)	800	Diesel
Standby vessel[1]	1	112 days (including all contingencies)	3.5	320	Diesel
Support shipping	1	60 days	5	300	Diesel
Personnel transport[2]	-	48 trips (up to 8 additional ad hoc flights may be needed)	-	51	Helifuel

Notes: Total fuel consumption is rounded up to the nearest whole number and assumes:
1. A standby vessel will be in attendance during the drilling and completion operations, note this vessel is on station as part of wider Forties Field activities and therefore emissions from its use during the drilling of Bacchus South have not been estimated.
2. Average of three helicopter round trips per week will be required for drilling activity, with a total of 48 trips for a 112 day campaign, and up to another eight (two per month) possible.

2.9 Subsea works

A new, flexible, 6” production pipeline and control jumper providing hydraulic, chemical and power services are to be installed between the Bacchus South well and the Bacchus towhead manifold. The pipeline will be protected by 32 concrete mattresses, and grout bags will be used as a contingency (up to 600).

The pipeline and spools will be pre-filled onshore with 100% MEG, and fitted by divers between the Bacchus South well tree and the manifold. Biocide and dye sticks will be inserted at each flange connection. A proportion of these chemicals will be discharged at Forties Alpha in produced water, with the remainder forming part of the PWRI. A permit for the use and discharge of chemicals associated with the subsea programme will be applied for, with approval sought prior to offshore activities being undertaken. All connections will be within the existing Bacchus manifold 500m safety zone.

Fuel use has been estimated for the subsea connection works (Table 2.6) and related atmospheric emissions are presented and assessed in Section 5.1.

Table 2.6: Estimated fuel use for the subsea programme of works

Activity and vessels	Number of vessels	Number of days[1] (including contingency)	Consumption rate tonnes/day (approximate)	Total fuel consumption tonnes	Fuel type
Subsea Installation					
DSV – pipeline/jumper installation	1	5	16	80	Diesel
DSV – protection material placement and commissioning	1	2	16	32	Diesel
DSV – tie-in	1	5	16	80	Diesel
Inspection survey					
Survey vessel	1	5 per year[2]	16	80	Diesel

Notes: [1]includes mobilisation/demobilisation, transit and working time, therefore, fuel usage will be an over-estimate as this is based on usage while active in the Field. [2]the frequency of inspection and maintenance will be defined as part of the Pipeline Integrity Management System (PIMS) process. However, for the purposes of this impact assessment, it has been assumed that one survey lasting five days will occur shortly after production and every year thereafter (i.e. until predicted end of field life).

2.10 Operation

2.10.1 Chemical use and discharge

An incremental increase in methanol (10%) and scale inhibitor (15%) use is expected, relative to existing usage rates of 50 tonnes and 20 tonnes per year respectively. The dosage of the asphaltene dispersant is not yet calculated. The assessment of the increase and the addition of the asphaltene dispersant will be undertaken as part of the Production Operation Chemical Permit application review.

2.10.2 Gas lift, fuel gas and flare

There is no gas export route from Forties Alpha or the wider Forties Field, and any associated gas from Forties is used as fuel gas, to provide gas lift, or is flared.

Production from Bacchus South will not result in appreciable additional power demands. Following the gas lift system for Bacchus being filled, a proportion of Bacchus South gas will be used as fuel gas (92%), with the remaining gas flared. This amounts to fuel gas use of approximately up to 67,000m^3/day and up to 5,800m^3/day flared at maximum production rates (2022). As there no appreciable additional power requirements for Bacchus South, and Forties area diesel use is already offset through the use of gas as far as is possible from Aviat Field production (Aviat's exclusive function being to provide a source of fuel gas to the Forties area), gas production from Aviat will be reduced to accommodate the Bacchus South gas in the fuel gas system. As a result, there will be no significant net change in atmospheric emissions as a result of Bacchus South.

2.11 Schedule

Drilling is anticipated to commence in Q3/Q4 2020, with subsea work being undertaken in Q1/Q2 2021, with an aim of first oil being achieved by Q2 2021. The minor modifications to Forties Alpha are anticipated to take place in Q4 2020.

2.12 Decommissioning

The Bacchus South well will be decommissioned at a time when production is at a level where it is no longer feasible to economically recover further hydrocarbons. The nature of decommissioning will be consistent with legislative requirements and regulator guidance prevailing at the time, however, at the time of decommissioning the well will be plugged and abandoned, and all surface components of the well and its connection to the Bacchus manifold removed. These works may, or may not, coincide with the decommissioning of the wider Bacchus facilities.

3 ENVIRONMENTAL DESCRIPTION

3.1 Location

The Bacchus Field is located in the central North Sea in UKCS Block 22/6c. The Block is located approximately 172km east of the UK mainland (Peterhead), 55km west of the UK/Norwegian median line, and is immediately adjacent to the Forties Field (Figure 1.1). Forties Alpha is located 7km to the south west of the Bacchus towhead manifold.

3.2 Seabed Topography and Substrates

Generally the seabed topography is uniform with a gentle slope from Bacchus to Forties Alpha (pipeline route surveys, Gardline 2006c, Fugro 2011). The water depth at Bacchus is approximately 89m, deepening only slightly to 90m at the Bacchus South location (Gardline 2019), and is 106m at Forties Alpha.

Surficial seabed sediments are generally homogenous, consisting of a sparse mosaic of small cobbles among a silt and sand matrix. Shell debris is abundant across the area, where the highest concentrations are linked to areas of abundant cobbles. Two sediment types were interpreted at the Bacchus site, slightly silty sand with numerous shells and shell fragments and occasional small cobbles and elongated patches of gravelly silty sand with numerous shells and shell fragments and occasional small cobbles orientated in a north/south direction (Fugro 2011). Boulders are found scattered across the area. Grab samples suggest that the surficial silty sand sediments are a relative thin veneer overlying coarser material beneath (Fugro 2010a, b, 2011). Holocene sands are considered to have a thickness of <0.5m at Bacchus South, which overly the slightly silty sand underlying soft clays of the Witch Ground Formation, which is up to 3m deep at Bacchus South. The Witch Ground Formation deepens to the north, in turn overlying the firm sandy clay with boulders of the Coal Pit Formation (Gardline 2019).

Previous site and pipeline route surveys have not shown the presence of pockmark features in the Bacchus area (Fugro 2011), nor have any been interpreted around Forties Alpha (Fugro 2005), though they have been noted in surveys in the wider Forties Field area (Gardline 2004, 2006a, b).

In addition to natural topographic features, seabed mapping shows evidence of anthropogenic influences. Spudcan depressions and linear debris are located in the vicinity of the Bacchus wells (Gardline 2019), and linear scars are widespread (Fugro 2011, Gardline 2019).

Moderate hydrocarbon concentrations (between 3.0µg.g-1 and 5.7µg.g-1) have been previously recorded in sediments around Bacchus, with highest concentrations in the areas of fine sediment. There was a relatively low level of n-alkanes. All heavy metal concentrations in the study were above concentrations previously recorded in the area and all, with the exception of barium, lead and chromium, were above mean background concentrations (Fugro 2010a).

3.3 Climate and Meteorology

The climate of the area is mild for its latitude, and is strongly influenced by Atlantic Water inflow (see Section 3.4) and westerly weather systems with frequent depressions (OSPAR 2000) and affected by the North Atlantic Oscillation (NAO) (Turrell *et al*. 2003). Air temperatures vary seasonally and are usually in the range 4-13°C except in extended durations of easterly winds which can lead to extreme cold in winter and warm summer conditions (UKHO 2013). Air temperatures below 0°C and above 19°C are rarely recorded (UKHO 2013). Fog (visibility <1km) is not common over the open sea though neither is visibility in excess of 10 miles. Fog is most frequent (~3% of observations) in summer where warm SE-SW winds blow over a relatively cold sea, and is very infrequent (<1% observations) in winter.

Annual rainfall across the North Sea averages 425mm (OSPAR 2000). Seasonal variability is small, with February to April usually the driest period of the year, and October to December being wetter (UKHO 2013).

Fog (visibility <1km) is not common over the open sea. In this part of the North Sea, fog is most frequent (3-4% of observations) in summer where warm SE-SW winds blow over a relatively cold sea, and is very infrequent (<1%) in winter.

Winds in the area are variable and may blow from any direction, through directions between the west and south-west dominate in February and north and south in August (UKHO 2013). Annual mean wind speed at 100m in the Bacchus and Forties area is 10.24m/s, varying seasonally as follows: 9.65m/s (spring), 8.1m/s (summer), 10.91m/s (autumn) and 12.46m/s (winter) (BERR 2008). In January, winds of Beaufort force 7 or greater may be experienced at a frequency of approximately 20% in the central-northern North Sea, reducing to between 2 and 4% in July (UKHO 2013).

3.4 Oceanography and Hydrography

The area is influenced by oceanic waters entering the North Sea from the north by Atlantic inflow along the east of the Shetland Isles, from the northwest through the Fair Isle current (Turrell *et al*. 1992), and a deeper northern inflow over the North Sea Plateau and along the western edge of the Norwegian Trench (Iverson *et al*. 2002). The main circulation flow in the region is cyclonic with the primary outflow of water from the North Sea, the Norwegian Coastal Current flowing northwards along the west coast of Norway in the upper 50-100m of the water column (Ikeda *et al*. 1989). Water movement is dominated by tides running approximately north and south at peak flows, although this pattern may be influenced strongly by short-medium term weather conditions, resulting in considerable seasonal and inter-annual variability. However, tracer studies and modelling have shown a predominantly east to southeast flowing component from residual oceanic circulation in the Bacchus and Forties area, with values $<1m^2/s^{-1}$ (Holt & Proctor 2008). Tidal energy is fairly low, with a mean range of 0.5-1m and peak flow of 0.35m/s and 0.18m/s during spring and neap tides respectively (BERR 2008).

Swell direction ranges from southwest to north throughout the year, with north and northwest swells most common during summer (UKHO 1997). Annual mean significant wave height is approximately 2.24m, varying seasonally as follows: 2.1m (spring), 1.5 (summer), 2.45 (autumn) and 2.95m (winter) (BERR 2008).

The water column stratifies thermally in summer. The depth of the thermocline increases from May to September and by August/September is typically 50m. The thermocline is broken down in autumn with increased wind and convective mixing. Sea surface temperature and salinity values in the Central North Sea are to a large extent influenced by the flow of oceanic Atlantic waters into the North Sea through the Fair Isle Channel (Turrell *et al*. 1992). Sea surface temperatures range typically from 6.5-7°C in winter and 13.5-14.0°C in summer, while bottom temperatures range from 6.5-7.0°C in winter to 7.0-8.0°C in summer. Surface and bottom salinities are approximately 35.0 ppt and 35.1ppt respectively, with very little seasonal variation (BODC 1998).

3.5 Plankton

The plankton community present in the Bacchus area is strongly influenced by the region hydrography of the region and is typical of the northern and central North Sea. The phytoplankton community is dominated by the dinoflagellate genus *Ceratium* (*C. fusus, C. furca, C. lineatum*), with diatoms such as

Skeletonema costatum, *Thalassiosira* spp. and *Chaetoceros* spp. also abundant, particularly during the spring bloom (Johns & Reid 2001).

Zooplankton species richness is greater in the northern North Sea than in the southern North Sea and displays greater seasonal variability (Lindley & Batten 2002). This community is dominated by calanoid copepods (*Calanus finmarchicus* and *C. helgolandicus*), which constitute a major food resource for many commercial fish species (Brander 1992). Other zooplankton groups such as *Paracalanus* and *Pseudocalanus*, Euphausiids and *Acartia*, are also abundant, as are the larval stages of Calanus, with larval stages of fish and most seabed animals also present (Johns & Reid 2001). Common jellyfish in the region include *Aurelia aurita*, *Cyanea capillata* and *Cyanea lamarckii* (Pikesley *et al*. 2014).

The spring bloom begins generally in March, reaching a peak in May, and there is often a smaller peak in production in the autumn. Diatoms are the first to bloom, then as nutrients essential for diatoms become depleted, other groups bloom such as flagellates, followed later by dinoflagellates. Zooplankton abundance increases in response to greater phytoplankton abundance.

In recent decades, a community change in the plankton community as a northwards shift in the warmer-water *C. helgolandicus* has been observed, with a corresponding decline in the colder-water *C. finmarchicus* (Beaugrand 2003). The population of *C. finmarchicus* tends to peak in the cooler, spring months, and observations have indicated that the peak in abundance is arising earlier in the year, with the springtime *Calanus* community between 2009-2014 dominated by *C. finmarchicus* for the first time in almost two decades (Edwards *et al*. 2014, Edwards *et al*. 2016). However, total *Calanus* biomass has declined by 70% since the late 1950s (Edwards *et al*. 2016).

3.6 Benthos

In regional-scale classifications of North Sea benthos, Künitzer *et al*. (1992) indicated that benthic infaunal communities in waters north of the 70m depth contour were typified by finer sediments and the indicator species *Spiophanes kroyeri*, *Prionospio cirrifera* and *Myriochele* spp. (polychaetes). Similarly, Reiss *et al*. (2010) identified a northern and central North Sea infaunal assemblage in water depths averaging ~100m (range 40-185m) characterised by *Myriochele* spp., *Amphiura filiformis* (echinoderm), *Spiophanes* spp. and *Paramphinome jeffreysii* (polychaete). Callaway *et al*. (2002) described the area as a region of transition in the epibenthic community with species typical of water >100m deep such as *Astropecten irregularis* (echinoderm), *Hyalinoecia tubicola* (polychaete), *Echinus* spp. (echinoderm), *Anapagurus laevis* and *Pagurus pubescens* (crustaceans), and the anemone *Hormathia digitata*, as well as species more characteristic of shallower water, including crabs *Hyas coarctatus* and *Pagurus bernhardus*, the whelks *Neptunea antiqua* and *Colus gracilis*, starfish *Asterias rubens* and the hydroid *Hydractinia echinata*. Reiss *et al*. (2010) reported a similar transition between epifaunal communities in the area.

According to EUNIS (Version 2019) habitat classification, predicted seabed habitats in the Bacchus area comprise deep circalittoral sand, transitioning to deep circalittoral mud in the slightly deeper waters of the Forties area (Figure 3.1). According to the Marine Habitat Classification for Britain and Ireland Version 04.05 (Connor *et al.* 2004), one biotope complex was identified from the 2010 Bacchus habitat investigation: circalittoral mixed sediment (SS.SMx.CMx) (Fugro 2011).

The habitat was characterised by slightly rippled sands with varying proportions of shell fragments with sparse epifauna (Figure 3.2) including: polychaete worms (e.g. the sand mason, *Lanice conchilega*), hermit crabs, crabs, sponges, sea cucumbers (Holothuroidea), horseshoe worms (Phoronida), sea pens (*Virgularia mirabilis*) and sea stars (Asteroidea) (Fugro 2011).

Analysis of 12 grabs taken at 4 stations between Bacchus to Forties A platform found 191 discrete macrofaunal taxa, the majority of these were polychaete worms (Fugro 2010b). The polychaete *Paramphinome jeffreysii* was numerically dominant, being found in every sample at mean abundance of 87 individuals. The second and third most abundant taxa (again found in all samples) were also polychaetes, *Galathowenia occulata* agg. and *Paradoneis lyra*. Multivariate analysis indicated 2 weak clusters in the data, distinguished by variation in the abundance of *P. jeffreysii*, the anemone *Cerianthus lloydii* and the polychaete *Minuspio cirrifera* (Fugro 2010b, 2011).

No Annex I habitats or communities of conservation significance (including both methane-derived authigenic carbonates and potential stony reefs) were considered to be present within the survey area. Areas containing relatively high levels of coarse material such as cobbles and shell debris exhibited no topographical relief and thus could not be considered a reef (Fugro 2011).

Figure 3.1: Predicted seabed habitats

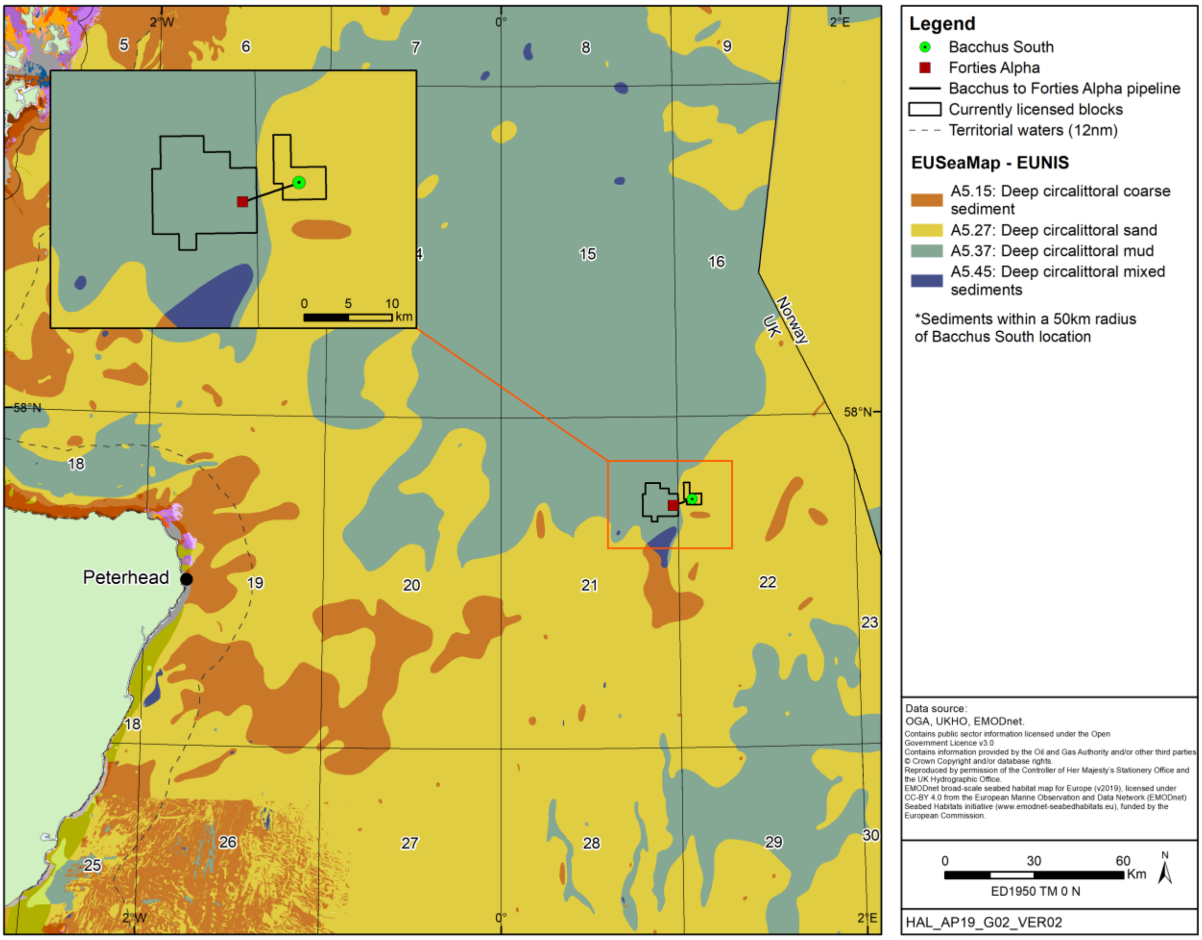
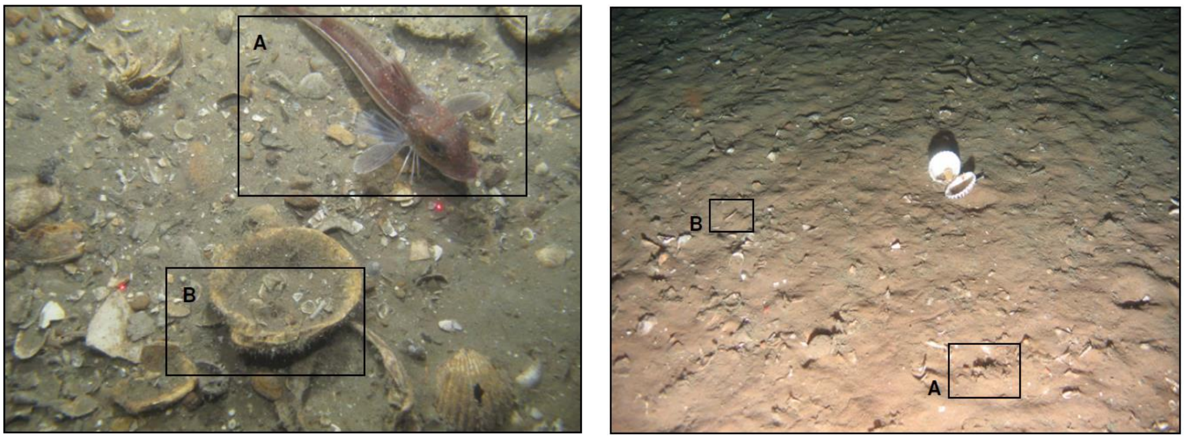


Figure 3.2: Representative seabed photos

a) Station Bacchus01 (Fugro 2011) **b) Station Bac01 (Fugro 2010a)**



Note: both stations located in close proximity to the Bacchus towhead manifold

3.7 Fish, Shellfish and Cephalopods

The demersal fish community of the North Sea was investigated by Callaway *et al*. (2002), including sampling at a site in 100m water, close to the Bacchus location. This was found to be dominated by dab (*Limanda limanda*), long rough dab (*Hippoglossoides platessoides*) and the hagfish (*Myxine glutinosa*), with Norway pout (*Trisopterus esmarkii*), haddock (*Melanogrammus aeglefinus*), whiting (*Merlangius merlangus*), plaice (*Pleuronectes platessa*), grey gurnard (*Eutrigla gurnardus*) and lemon sole (*Microstomus kitt*) also present. Pelagic species found in the area include herring (*Clupea harengus*), mackerel (*Scomber scombrus*) and sprat (*Sprattus sprattus*). Many of these species are abundant in the deeper waters of the central and northern North Sea. Species diversity within the fish community is not as great in the central and northern North Sea as in the southern North Sea (Callaway *et al*. 2002).

Blocks 22/06 and 21/10 are located within ICES rectangles 44F1 and 44F0, respectively, and the spawning grounds for five species of fish (cod, (*Gadus morhua*), lemon sole, mackerel, Norway pout and sandeel) overlap with these rectangles (Table 3.1 and Figure 3.3). Spawning grounds for both sandeel and mackerel are present within 44F1; however, these do not extend over Block 22/6 (Coull *et al*. 1998). In addition, from their work building on that of Coull *et al*. (1998), Ellis *et al*. (2012) also identified spawning (low intensity) for cod throughout the area. Nursery areas for several species overlap with these rectangles, and throughout the year spawning and nursery grounds for *Nephrops* are also present (Table 3.1, Figure 3.4). These features are dynamic and likely to show some degree of spatial and temporal variability (Coull *et al*. 1998).

Less is known about the abundance and distribution in the North Sea of skates and rays. Ellis *et al.* (2004) identified and recorded 26 species throughout the North Sea and surrounding areas, a few of which, including the spurdog (*Squalus acanthias*) (Table 3.1) and starry ray (*Amblyraja radiata*) were recorded from waters in the region.

Figure 3.3: Fish spawning areas, ICES rectangles 44F1 and 44F0

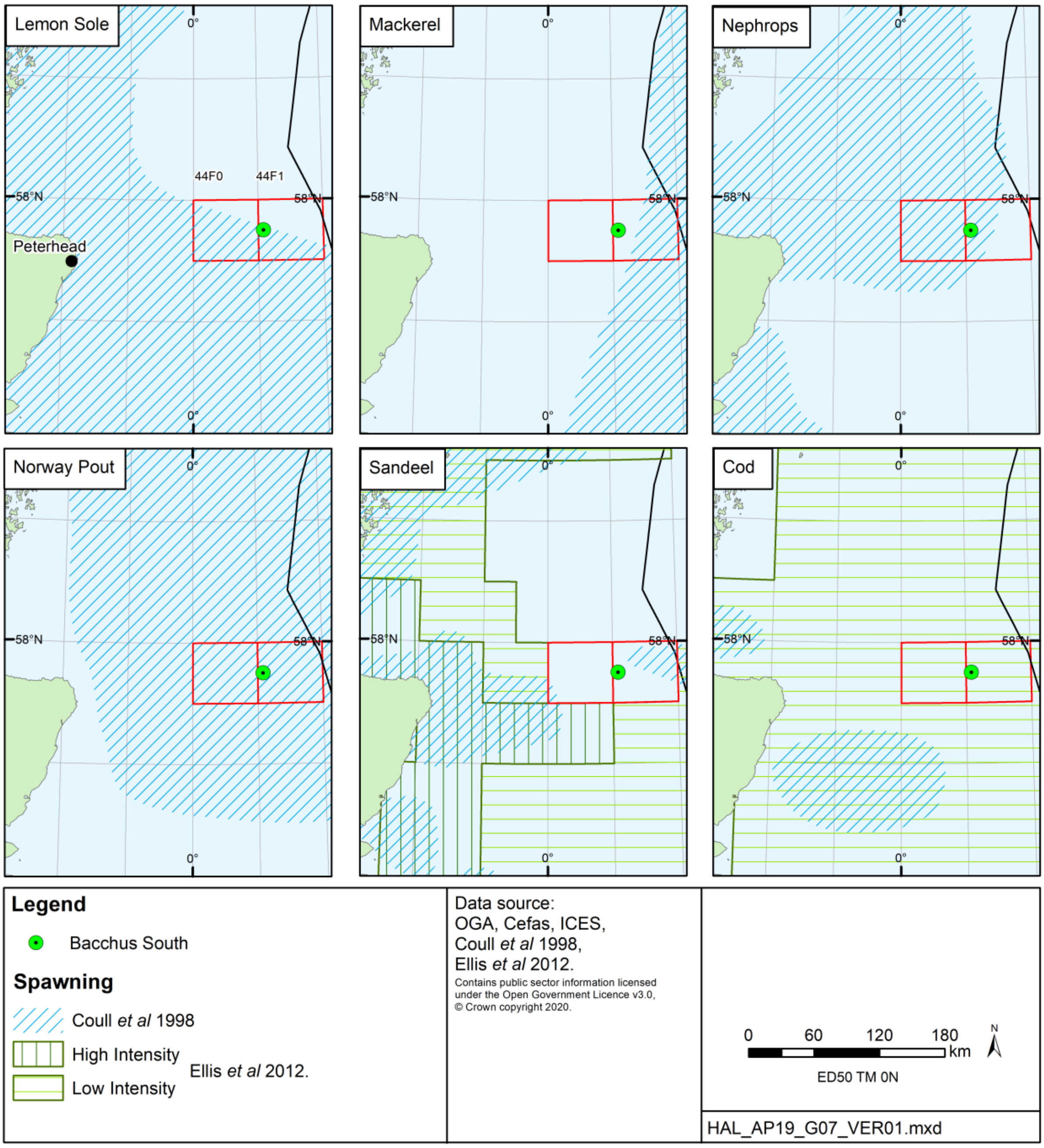


Table 3.1: Spawning and nursery periods for fish and shellfish in the Bacchus Area

Species	Spawning	Spawning period (peak spawning)	Nursery
Anglerfish*	-	-	Low intensity[2]
Blue whiting*	-	-	Low intensity[1,2]
Cod*	✓ (Low)[2]	January-April (February-March)[1]	Low intensity[2] (44F0) High intentisty[2] (44F1)
European hake	-	-	Low intensity[2]
Lemon Sole	✓[1]	April-September[1]	-
Ling*	-	-	Low intensity[2]
Haddock	-	-	✓[1]
Herring*	-	-	Low intensity[2]
Mackerel*	✓[1]	May-August (May-July)[1]	Low intensity[2]
Nephrops	✓[1]	January-December (April-June)[1]	✓[1]
Norway pout*	✓[1]	January-April (February-March)[1]	✓[1]
Plaice	-	-	Low intensity[2]
Sandeel*	✓[1]	November-February[1]	-
Sprat	-	-	✓[1]
Spotted ray	-	-	Low intensity[2]
Spurdog	-	-	Low intensity[2]
Whiting*	-	-	Low intensity[2]

*Notes: * Priority Marine Features in Scottish seas (Nature Scot website)*
Source: [1]Coull et al. (1998), [2]Ellis et al. (2012)

Aires *et al*. (2014) identified areas of significant probability of large aggregations of 0-group fish (fish within the first year of their lives) in Scottish waters. Although no such major aggregations were identified in either 44F1 or 44F0, haddock, hake, Norway pout juveniles, and to a lesser extent whiting and monkfish juveniles, may be present in the Bacchus and Forties area (Figure 3.5).

Figure 3.4: Fish and shellfish nursery areas, ICES rectangles 44F1 and 44F0

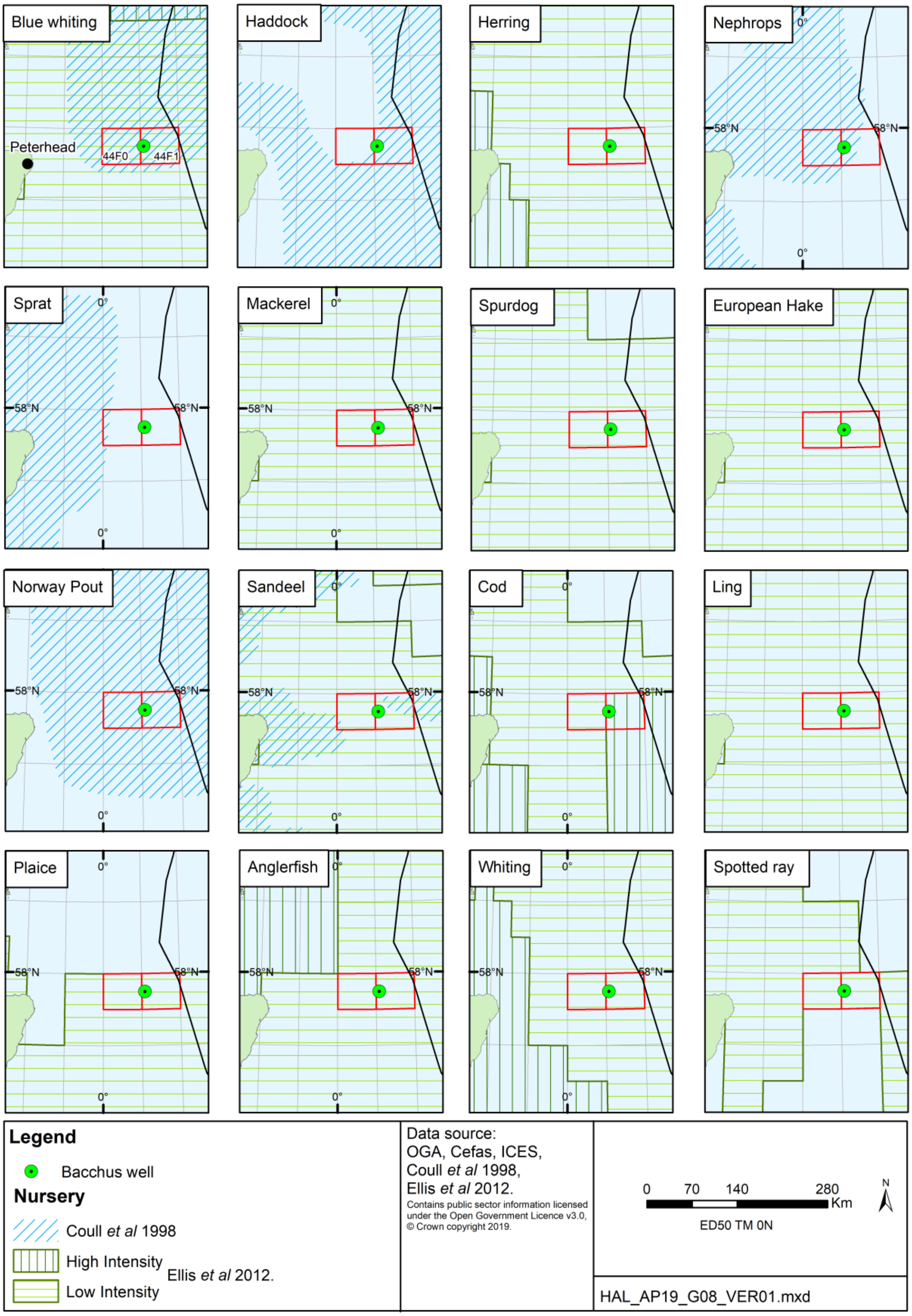
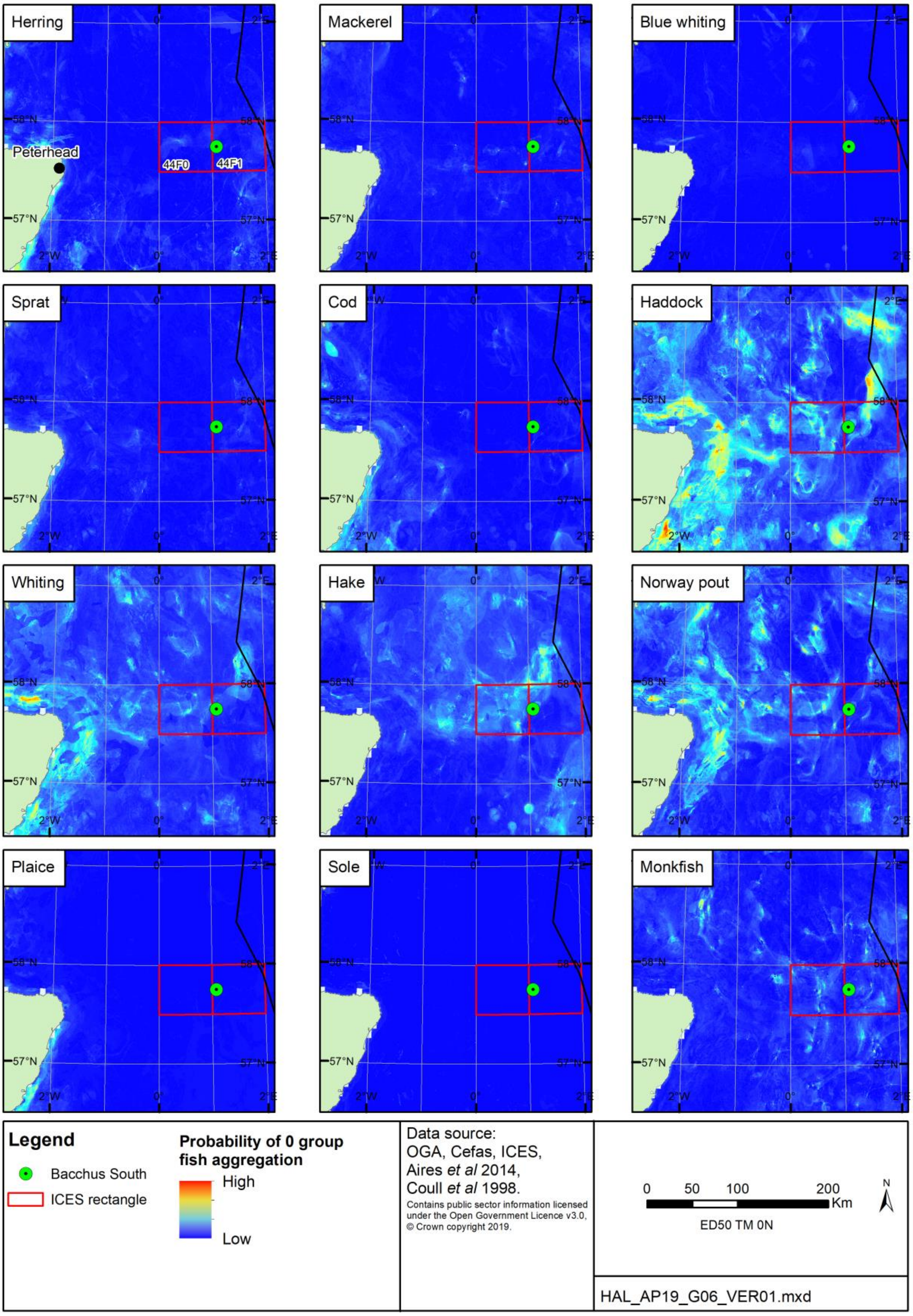


Figure 3.5: Probability of 0-group fish aggregations



3.8 Seabirds

Seabird distribution and abundance in the central North Sea varies throughout the year, with offshore areas, in general, containing peak numbers of birds during late summer/early autumn, following the breeding season, and through winter. The most numerous species will include northern fulmar (*Fulmaris glacialis*), northern gannet (*Morus bassanus*), herring gull (Larus argentatus), black-legged kittiwake (*Rissa tridactyla*), common guillemot (*Uria aalge*), razorbill (*Alca torda*) and Atlantic puffin (*Fratercula arctica*) (Tasker & Pienkowski 1987, Skov *et al*. 1995). Other species also present include Arctic skua (*Stercorarius parasiticus*) and great skua (*Stercorarius skua*), lesser black-backed gull (*Larus fuscus*) and great black-backed gull (*Larus marinus*) (Batty 2008).

From January to March, northern fulmar is present in most offshore waters, with spring migration in January in most years. During February, there are concentrations of common guillemot in the Moray Firth, and puffins are present in large numbers and widely distributed. Herring gull, black-legged kttiwake, common guillemot and razorbill are widespread throughout the area at this time, and are among species starting to return to breeding colonies towards the end of March (Skov *et al*. 1995, Tasker & Pienkowski 1987).

During the breeding season (early spring/summer), the numbers of birds in offshore areas are typically low, as most birds are concentrated around colonies. Information on bird foraging ranges during the breeding season (reviews in Thaxter *et al*. 2012 and Woodward *et al*. 2019) identifies five species with mean maximum foraging ranges of >170km: European storm petrel (336km), northern fulmar (542km), Manx shearwater (1,347km), northern gannet (315km) and great skua (443km). While these distances are large and suggest the potential for birds from many distant colony SPAs to be present in the Bacchus area, seabird density declines with distance from the colony with density-dependent competition, coastal morphology and habitat preferences (Wakefield *et al*. 2017). For example oceanographic features at which seabirds preferentially forage including shelf-edge fronts, upwelling and tidal-mixing fronts, offshore banks and internal waves, regions of stratification, and topographically complex coastal areas subject to strong tidal flow (Cox *et al*. 2018), resulting in highly non-uniform distributions. In the case of the very wide-ranging Manx shearwater and northern fulmar, the results of tagging studies suggest that the longest foraging trips largely correspond to birds ranging far offshore in deep waters west of Britain and Ireland (Edwards *et al*. 2016, Wischnewski *et al*. 2019). Consequently, it is those protected sites on the east coast of Scotland for the aforementioned species which are of greatest relevance to the Bacchus area. Of these, northern fulmar is a feature of the Buchan Ness to Collieston Coast Special Protection Area (SPA), which lies between 143-165km from the Forties-Bacchus area (see Section 3.10). It is noted that the distance offshore of the Bacchus area exceeds the mean foraging range (i.e. the range within which the majority of breeding seabirds will forage from their colonies) of all relevant species reported in Woodward *et al*. (2019) with the exception of Leach's storm petrel, which are largely distributed off the shelf west of Scotland during the breeding season (Kober *et al*. 2010).

June is typically the peak of the breeding season, at which time numbers of birds offshore is low. As the breeding season comes to an end (~July), adult and juvenile birds start to disperse from colonies. In early autumn, rafts of moulting auks (common guillemot and razorbill) can be found widely dispersed in many areas of the North Sea, particularly off the eastern coast of Scotland and northern England. Atlantic puffins, which do not moult until spring, can be found concentrated in the area around the Buchan Front, *ca*. 60-100km off the Aberdeenshire coast during this time. Young gannets start to leave and are flightless for a short period with areas close to colonies containing vulnerable concentrations. Fledglings ringed on sea below a colony on Noss moved on average 60km/day during the first 10-16 days; there is also a gannet colony at Troup Head on the Scottish east coast (Furness 2015).

From autumn and into winter (September-December) seabirds are widely dispersed offshore, with the continuation of the southwards shift in numbers (e.g. common guillemot and razorbill) seen in early

September. Large concentrations of razorbill can be found off the Moray Firth and east of the Forth and Tay, with these areas also important for Atlantic puffins (Skov *et al*. 1995). Great skuas become widespread in the North Sea as they leave their breeding sites in the Northern Isles and move south. At this time, winter visitors become more common, with the arrival of gulls (e.g. herring and great black-backed gulls) in offshore waters from Norway, to areas of the North Sea including the Fladen Ground, while little auk arrive into the (northern) and central North Sea from their Arctic breeding grounds (Furness 2015).

3.8.1 Seabird vulnerability to pollution

The vulnerability of seabird species to oil pollution at sea is dependent on a number of factors and varies considerably throughout the year. The Offshore Vulnerability Index (OVI), developed by JNCC, was used to assess the vulnerability of bird species to surface pollution, taking into consideration four factors: amount of time spent on the water; total biogeographical population; reliance on the marine environment; and potential rate of population recovery (Williams *et al*. 1994, see JNCC 1999).

A revised index was devised and published in 2016 as the Seabird Oil Sensitivity Index (SOSI) (Webb *et al*. 2016). The SOSI is presented as a series of monthly UKCS block gridded maps, with each block containing a score on a scale of low to extremely high; these scores indicate where the highest seabird sensitivities might lie, if there were to be a pollution incident. Seabird sensitivity in Blocks 21/10 and 22/6 and neighbouring Blocks is low, for those months with data, with the exception of a small number adjacent block-months which are scored as medium. However, it should be noted that for six months of the year no data are available (see Table 3.2 and Figure 3.6). Data availability is highlighted by Webb *et al*. (2016) as a wider issue for the index which requires extended data coverage to be improved. JNCC devised guidance to help reduce coverage gaps (JNCC 2017), the first step of which is to utilise data from adjacent months. For Bacchus, this has been sufficient to populate a further four months for both Blocks, which are marked red in Table 3.2 and highlighted yellow. For the remaining months (November and December), gaps in coverage could not be reduced by using the JNCC guidance and have been denoted by N and also highlighted yellow. The Blocks of interest, 21/10 and 22/06, have been shown in bold.

Table 3.2: Monthly seabird oil sensitivity index scores

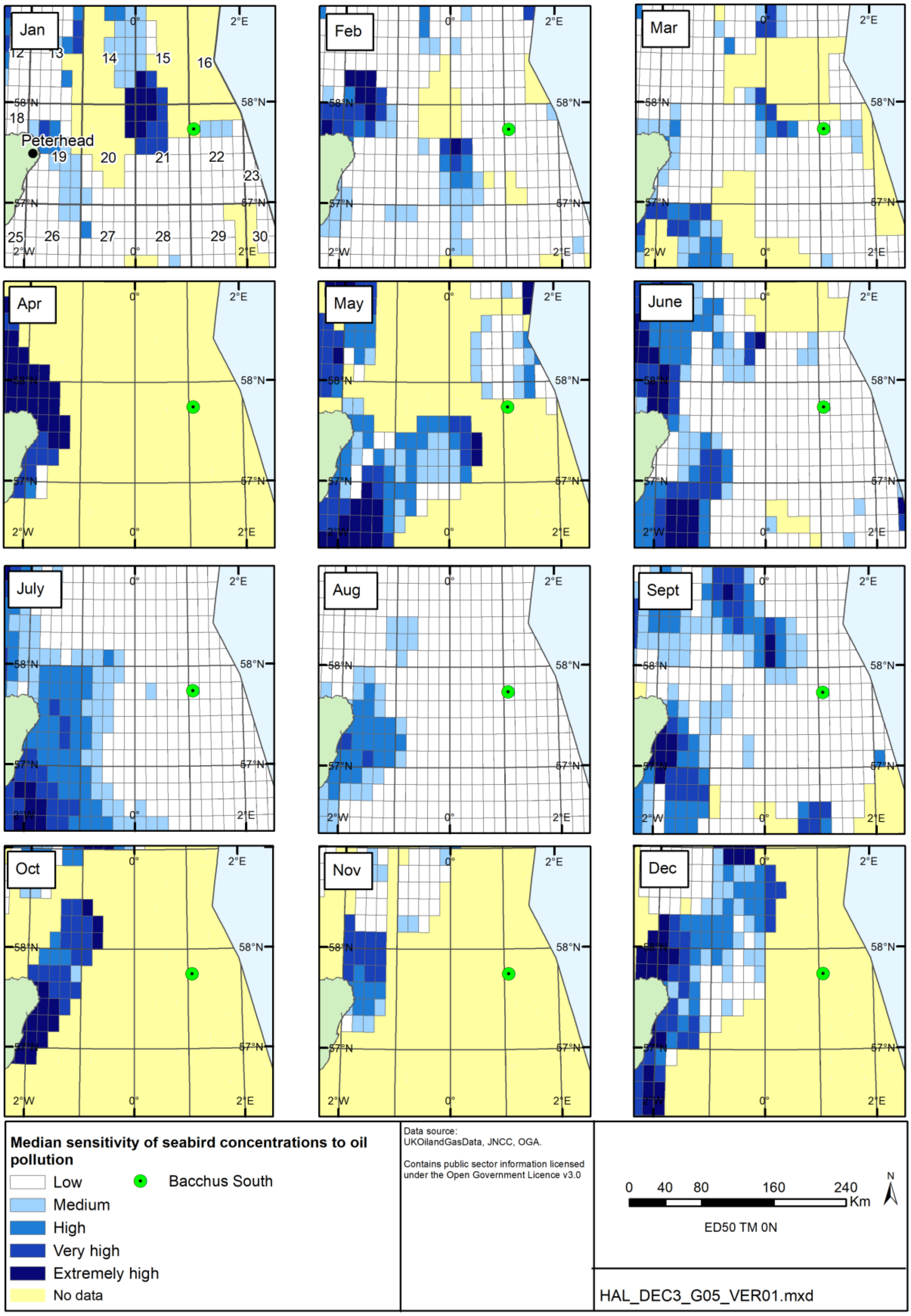
Block	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
21/04	5	5	5	4	4	5	5	5	5	5	N	N
21/05	5	5	5	5	5	5	5	5	5	5	N	N
21/14	5	5	5	5	5	5	5	5	5	5	N	5
21/15	5	5	5	N	N	5	5	5	5	N	N	5
21/09	5	5	5	5	5	5	5	5	5	5	N	N
21/10	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**N**	**N**
22/06	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**N**	**N**
22/07	4	5	5	5	5	5	5	5	5	5	N	4
22/01	5	5	5	5	5	5	5	5	5	5	N	N
22/02	5	5	5	4	4	5	5	5	5	5	N	N
22/11	5	5	5	5	5	5	5	5	5	5	N	5
22/12	5	5	5	5	5	5	5	5	5	5	N	5

Notes:

1 = Extremely high	*2 = Very high*	*3 = High*	*4 = Medium*	*5 = Low*	*N = No coverage*

Source: JNCC (2017)

Figure 3.6: Seabird oil sensitivity in the Bacchus and wider area



3.9 Marine Mammals

The central North Sea has a moderate diversity and density of cetaceans, with a general trend of increasing diversity and abundance of cetaceans with increasing latitude (Reid *et al*. 2003). Harbour porpoise (*Phocoena phocoena*) are frequently sighted throughout the central North Sea area. While present throughout the year, peak numbers are generally recorded in summer months from June to October. White-beaked dolphins (*Lagenorhynchus albirostris*), although generally less abundant, are also sighted in the area and throughout the year, most frequently from July to October. Low numbers of Atlantic white-sided dolphins (*Lagenorhynchus acutus*) have been recorded in the area, with sightings in the northern and central North Sea most frequent from June to September. During summer months, minke whales (*Balaenoptera acutorostrata*) are widely distributed throughout the central and northern North Sea, particularly in the west.

A small, largely resident population of bottlenose dolphins (*Tursiops truncatus*) exists off the east coast of Scotland. They typically range from coastal waters of the Moray Firth to the Firth of Forth; sightings are most frequent within 15km of the coast in the inner Moray Firth (Thompson *et al*. 2011), although areas of persistent high use also occur along the southern coast of the Moray Firth, off the east coast between Aberdeen and Montrose and around the mouth of the Tay (Culloch & Robinson 2008, Cheney *et al*. 2013, Quick *et al*. 2014). Observations of bottlenose dolphins in offshore waters of the central and northern North Sea are rare (Reid *et al*. 2003, Thompson *et al*. 2011).

Hammond *et al*. (2017) provides the latest information on cetacean densities in the North Sea from the SCANS-III survey conducted in summer 2016; the Bacchus area lies within survey stratum 'Q', which covers offshore waters of the central North Sea either side of the UK-Norway median line. Survey stratum 'R' lies within 2km to the west of the Bacchus area, which extends into coastal waters of eastern Scotland and northeast England. Estimated densities (animals per km^2) of surveyed species in strata 'Q' and 'R', respectively, were: 0.333 and 0.599 for harbour porpoise, and 0.007 and 0.039 for minke whales. A small number of white-beaked dolphins were observed in the north of stratum 'Q', but in insufficient numbers to estimate abundance; waters to the west supported higher densities, with an average of 0.243 animals per km^2 across the adjacent stratum 'R' (Hammond *et al*. 2017). No bottlenose, common, Risso's, or white-sided dolphins were observed in stratum 'Q' during the surveys, although a small number of bottlenose dolphin and white-sided dolphin sightings were recorded in the adjacent stratum 'R'. Bottlenose dolphin desnity in stratum 'R' was estimated to be 0.03 animals per km^2. These observed densities in offshore waters of the central North Sea are relatively low for the species concerned, particularly compared to nearshore waters or, for the harbour porpoise, designated sites such as the Southern North Sea SAC.

Model-based assessments of the at-sea distribution of grey and harbour seals around the UK and Ireland have been derived from satellite tagging data and haul-out count data, including several dozen seals tagged at colonies on the east coast of Scotland and Orkney (Jones *et al*. 2015, Russell *et al*. 2017). Results show that grey seals use offshore areas (up to 100km from the coast) connected to their haul-out sites by prominent corridors, while harbour seals primarily stay within 50km of the coastline (Jones *et al*. 2015). Models of marine usage highlight the importance of Scottish territorial waters to both species. Off the northeast coast of Scotland, higher densities of grey seals radiate out from colonies and haul-outs north of Aberdeen, the inner Moray Firth and Orkney; for harbour seals, the majority of animals in water of north east Scotland occur within the inner Moray firth and Orkney inshore waters. Models show both species to be present in low numbers in the Bacchus area, with an estimated <1 harbour and grey seal per 5x5km grid cell (Russell *et al.* 2017).

The JNCC and SNH have developed a list of Priority Marine Features (PMFs) in Scotland to help focus future research, planning and conservation. The list, adopted in 2014, includes grey and harbour seals and most species of cetaceans occurring in UK waters, including all those species mentioned above which may be present in the Bacchus area (Tyler-Walters *et al.* 2016).

3.10 Conservation Sites and Species

The UK coastline has a variety of important habitats and species which are protected under international, national and local conservation designations. The principal international designations are Special Protection Areas (SPAs) established under Birds Directive[6], and Special Areas of Conservation (SACs) under the Habitats Directive[7]. SPAs and SACs collectively form part of the European ecological network of Natura 2000 sites. Ramsar sites are wetlands of international importance designated under the Ramsar Convention[8], and often have the same or similar spatial coverage to certain Natura 2000 sites designated for qualifying wetland features. More recently, offshore conservation sites may be designated at a national level under the *Marine and Coastal Access Act 2009* (as amended) or the *Marine (Scotland) Act 2010* (as amended) in UK offshore and Scottish territorial waters respectively. In Scotland, designations for habitats and species under this legislation are termed, Nature Conservation Marine Protected Areas (NCMPAs), 30 of which have been designated to date. The range of features for which such sites can be designated has been decided at a UK constituent country level, and both these and the approach to their conservation differ from that of Natura 2000 sites.

Many sites designated under the above legislation, and other nationally significant sites (e.g. Sites of Special Scientific Interest), are located along the east coast of Scotland and in territorial waters, the closest of these being some 165km from Forties Alpha and Bacchus. There are no offshore conservation sites in the vicinity of the Forties and Bacchus Fields. The closest Natura 2000 site is the Scanner Pockmark SAC which is located 58km to the north. The site is designated to protect the Annex I habitat, ‘submarine structures made by leaking gases’, containing a total of 67 pockmarks four of which have a considerably larger volume than those others within the site boundaries (Judd & Hovland 2007). The closest NCMPAs are the East of Gannet and Montrose Fields, located 33km to the south of the Bacchus Field, and the Norwegian Boundary Sediment Plain NCMPA 44km to the east (Figure 3.7). Both sites are designated for ocean quahog (*Arctica islandica*) aggregations, with East of Gannet and Montrose Fields also featuring the deep sea muds habitat.

Seabed mapping surveys (Gardline 2006, Fugro 2010, 2011) found no potential Annex 1 habitats or communities of conservation significance in the Bacchus area.

Several marine species occurring in the central and northern North Sea are of conservation concern. These are listed in a variety of international and national documents such as the OSPAR Initial List of Threatened and/or Declining Species and Habitats, the IUCN Red List of Threatened Species, the Wildlife and Countryside Act 1981, UK Biodiversity Action Plans and Annex IV of the Habitats Directive. Of these species, those known or most likely to occur in waters around the Bacchus and Forties area includes: cod, the bivalve *Arctica islandica*, harbour porpoise, minke whale, white-beaked dolphin and black-legged kittiwake. All cetacean species are protected under Annex IV of the Habitats Directive, while the harbour porpoise, bottlenose dolphin, grey seal and harbour seal are listed in Annex II.

Many marine birds, including puffin, guillemot, gannet, lesser black backed gull, fulmar and kittiwake, are also afforded protection in UK waters. All cetacean species are protected under Annex IV of the EC Habitats Directive, while grey and harbour seals are protected under Annex II.

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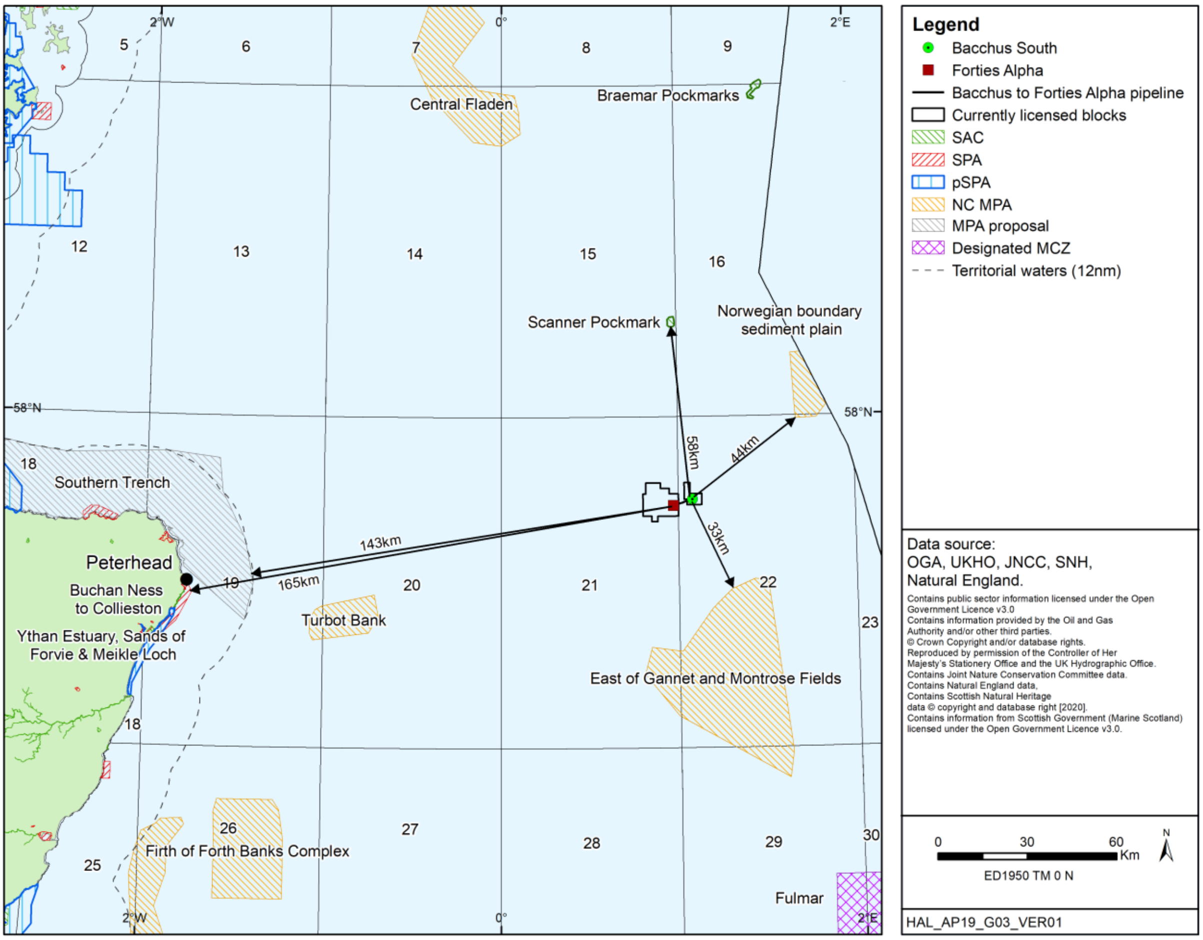
[6] *Council Directive 2009/147/EC on the conservation of wild birds* (the consolidated version of *Council Directive 79/409/EEC as amended*)
[7] Council Directive 92/43/EEC on the conservation of natural habitats of wild flora and fauna
[8] The Convention on Wetlands of International Importance, especially as Waterfowl Habitat

Figure 3.7: Relevant conservation sites



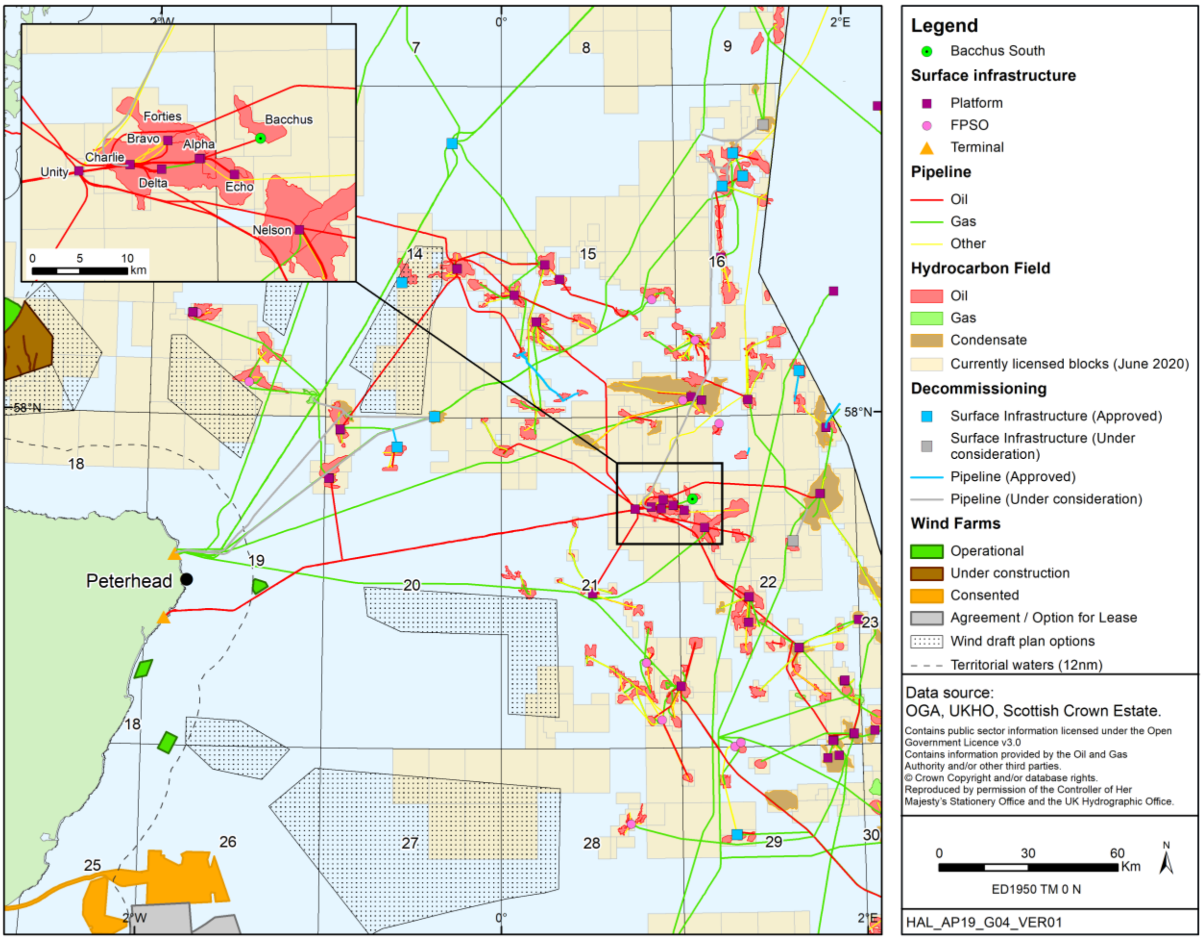
3.11 Users of the Sea and Offshore Environment

3.11.1 Offshore Energy Infrastructure

Bacchus is located ca. 6.5km north-east of the Forties Field which covers an extensive area and is produced by six fixed platforms Forties Alpha, the Forties Alpha Satellite Platform, Forties Bravo Charlie, Delta (Block 21/10) and Echo (Block 22/6a) (Figure 3.8). Other existing oil and gas fields in the vicinity of the Bacchus development include the Nelson (Block 22/6 and 22/11), the Howe (22/12) and the Aviat Fields (Block 22/7a). Aside from the Bacchus to Forties Alpha pipeline, the closest pipeline to the Bacchus development is the Everest to Forties oil pipeline, located 2.7km to the northwest.

There are currently no renewable energy activities in the vicinity of the Forties and Bacchus Fields. The closest area of relevance is the draft Scottish sectoral wind plan area, E2, which is located approximately 50km to the southwest of the Forties and Bacchus Fields.

Figure 3.8: Overview of offshore energy infrastructure



3.11.2 Commercial Fisheries

Bacchus and Forties Alpha are located in ICES rectangles 44F1 and 44F0 respectively. Over the period 2016-2018, demersal species constituted the greatest total live weight of landings followed by pelagic and then shellfish species (Table 3.3, also see Figure 3.9 and Figure 3.10). Landings of demersal species were dominated by haddock, cod, monks/anglers, whiting, hake and saithe, while pelagic species were dominated by herring and mackerel, and shellfish by *Nephrops*. Monthly landings varied, with the peak effort between April and November, though note that data was not disclosed for a number of months across the three years of data.

The vast majority of vessels operating in the area were UK registered with the most common type of gear in operation being demersal trawling. Mackerel and *Nephrops* were the two highest value species landed from the North Sea in 2018, making up 29% and 11% of total value respectively, followed by the demersal species cod, haddock and monks/anglers, which represented 22% of the value landed (Marine Scotland 2019).

Table 3.3: Weight and value of landings taken from ICES rectangles 44F0 & 44F1

Species type	2016		2017		2018	
	Liveweight (tonnes)	Value (£)	Liveweight (tonnes)	Value (£)	Liveweight (tonnes)	Value (£)
44F0						
Demersal	1,494	2,400,712	1,648	2,578,986	905	1,310,096
Pelagic	421	202,050	1,187	670,664	4	3,536
Shellfish	685	3,082,597	860	2,998,443	576	1,766,341
Total	**2,600**	**5,685,359**	**3,694**	**6,248,093**	**1,485**	**3,079,973**
44F1						
Demersal	554	824,202	449	673,359	370	511,381
Pelagic	-	-	662	259,409	1	834
Shellfish	145	678,098	104	372,014	34	112,610
Total	**699**	**1,502,300**	**1,215**	**1,304,782**	**405**	**624,825**

Note: All landings into UK ports. Figures rounded to nearest tonne/£,
Source: Scottish Government website, accessed May 2020

Figure 3.9: Landings weight for 44F0, 44F1 and surrounding rectangles, 2018

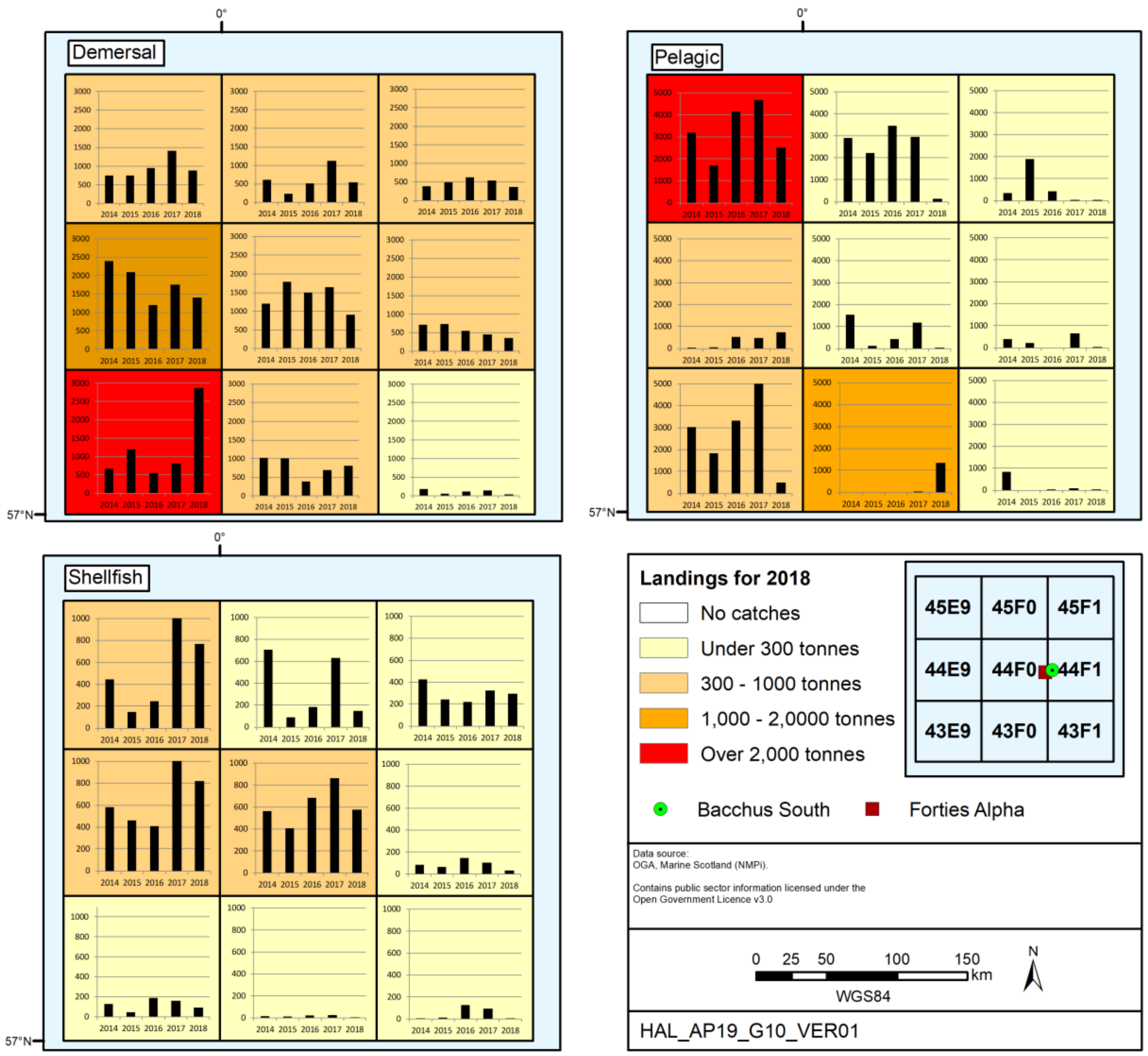
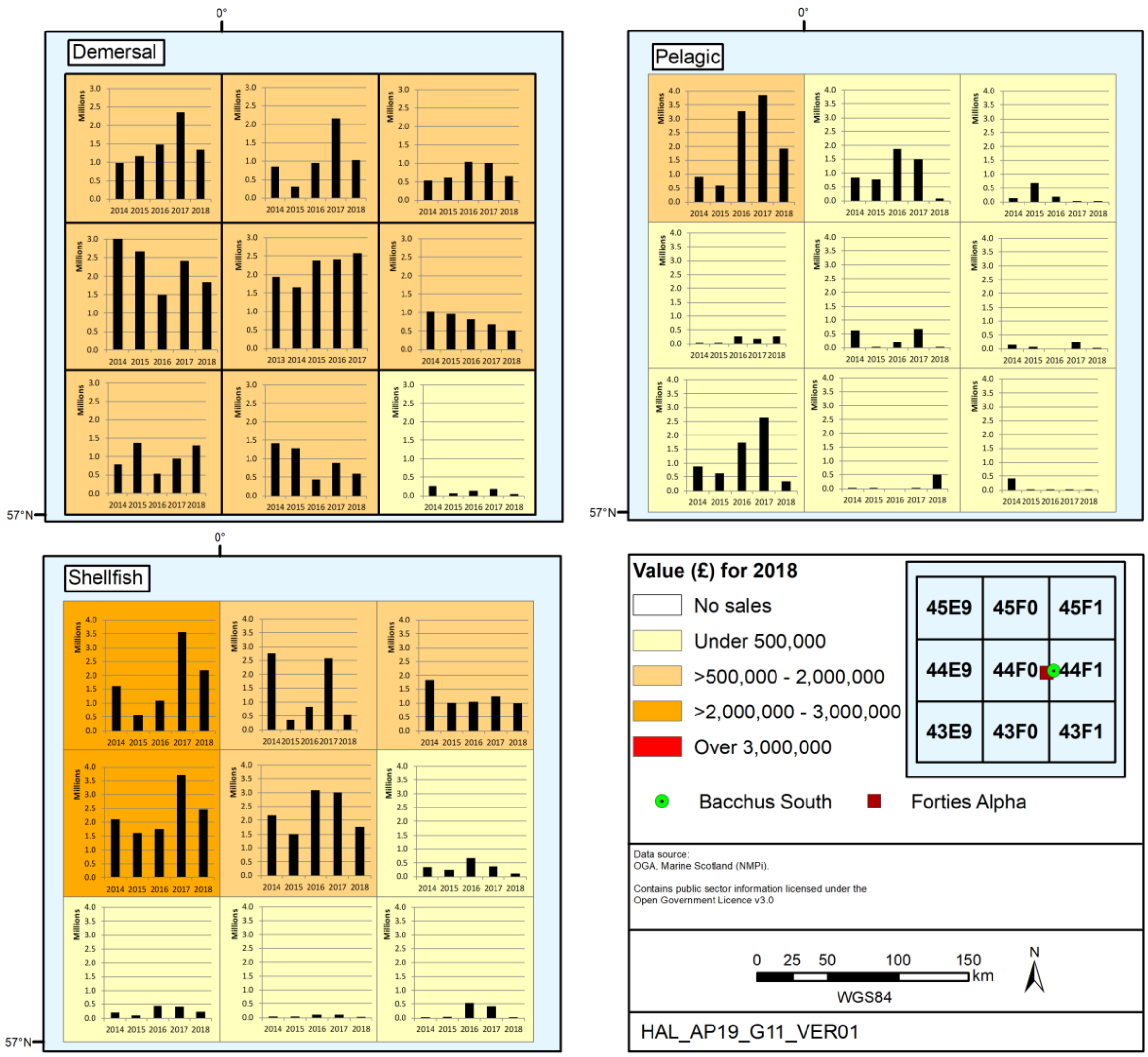


Figure 3.10: Landings value for 44F0, 44F1 and surrounding rectangles, 2018



Effort is relatively low throughout the year and showed a degree of month-month variability. Weather patterns can have a major influence on levels of effort, but no well-defined seasonal patterns were observed.

Table 3.4: Number of days fished per month (all gears) in ICES rectangles 44F1

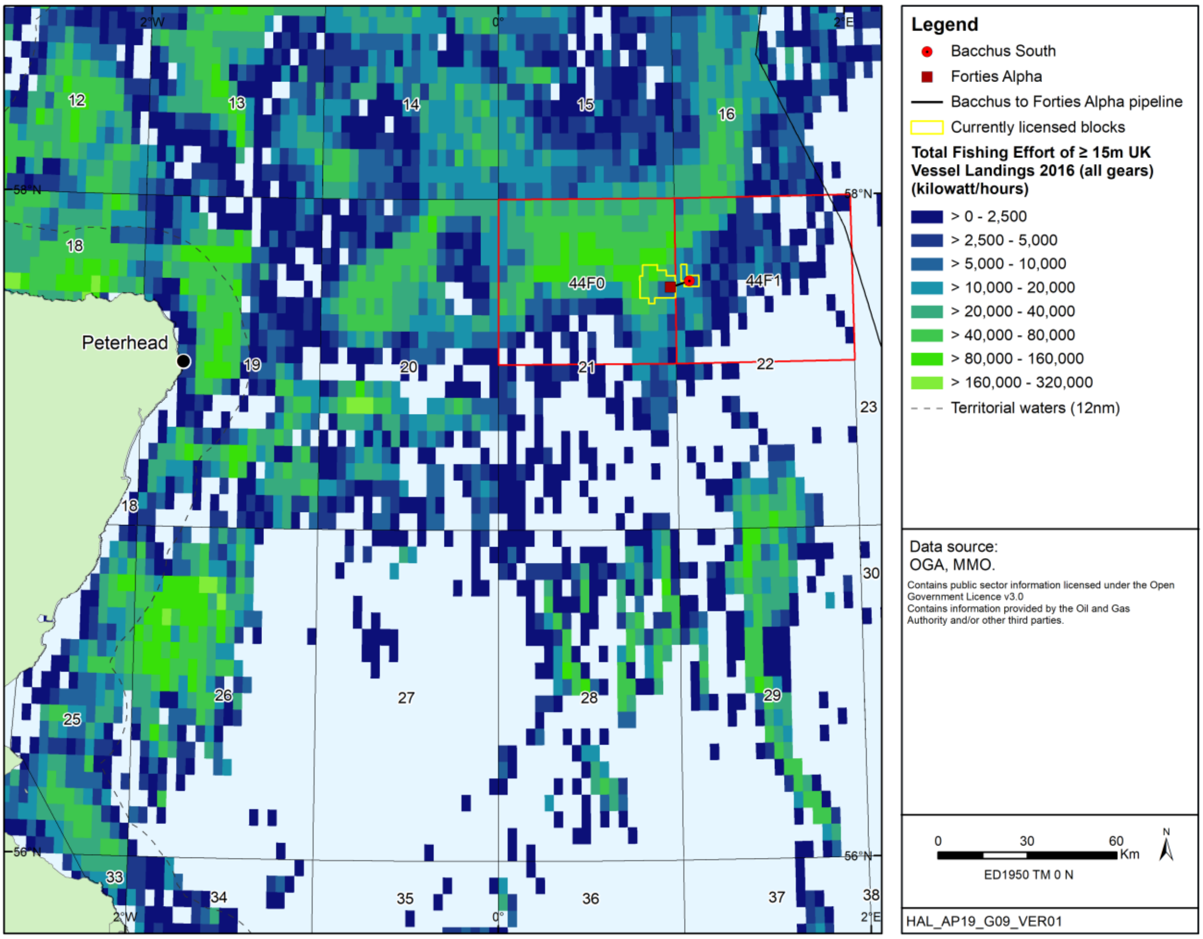
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2016	30	23	D	49	-	D	D	9	10	83	113	36	**352**
2017	5	D	46	5	D	9	11	62	3	35	18	D	**193**
2018	20	-	D	D	D	D	D	24	20	17	24	D	**104**

Note: Monthly fishing effort by UK vessels >10m; 'days fished' includes time travelling within rectangles; green = 0 – 50 days fished, yellow = 51 – 100, orange = 101-150, blue = >151. D= disclosive data
Source: Scottish Government website, accessed May 2020

Vessel Monitoring System (VMS) for 2016 shows fishing activity in the area relative to the wider central and northern North Sea, although is restricted to larger vessels (>15m in length) (Figure 3.11).

This shows the Bacchus area to lie just off the southeastern edge of a large area of moderate to high level of fishing effort over the Fladen Ground.

Figure 3.11: Mean annual density of fishing effort by UK vessels (>15m length), 2016



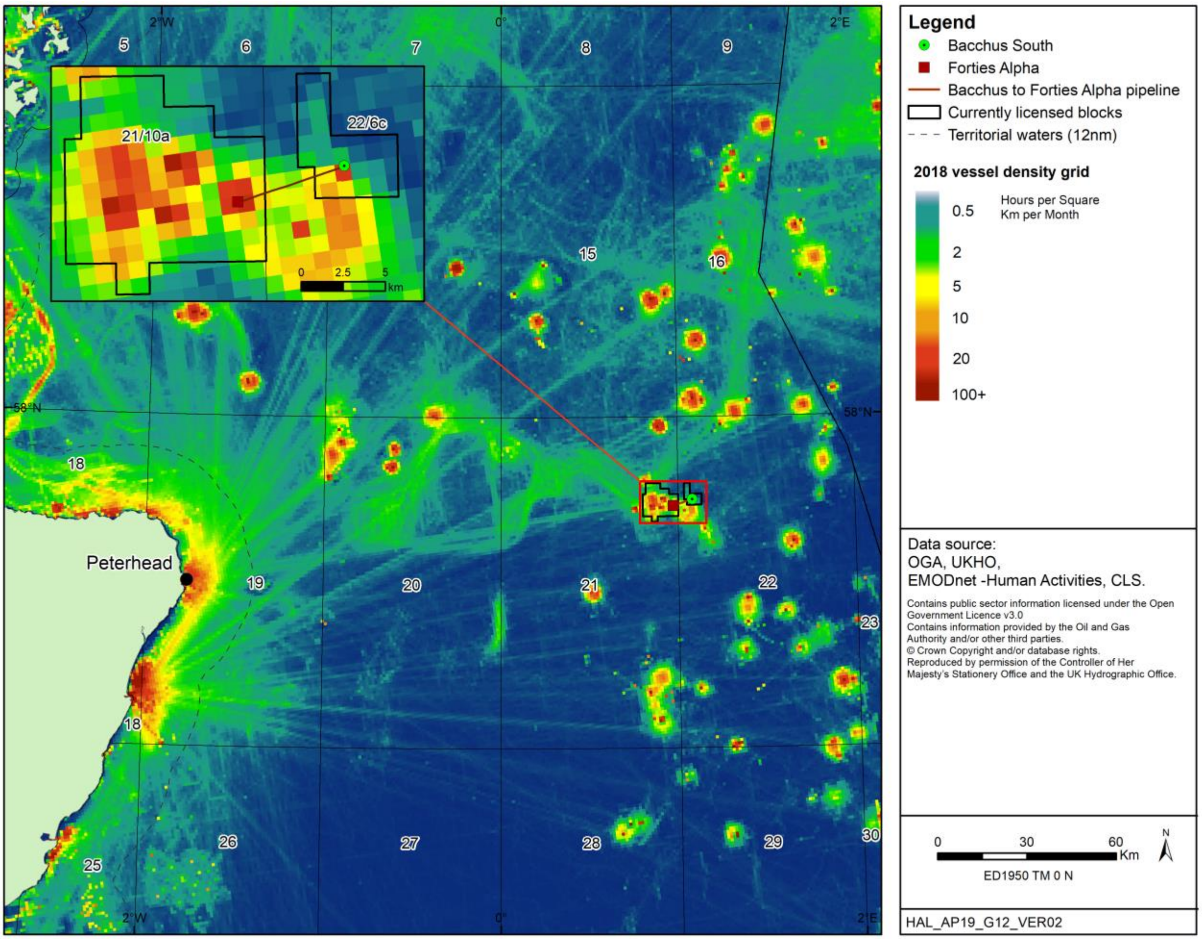
3.11.3 Ports, Shipping and Vessel Traffic

The North Sea contains some of the world's busiest shipping routes, with significant traffic generated by vessels trading between ports at either side of the North Sea and the Baltic. Oil and gas support vessels generate moderate traffic, principally operating from Peterhead, Aberdeen, Montrose and Dundee in the north (UKHO 2013), which in turn results in busy port approaches at these locations (DECC 2016).

Shipping information presented as part of the 29th Seaward licensing round[9] indicates a very low to low level of shipping in the Forties and Bacchus Field areas. Vessel traffic in the area is expected to be as a result of vessels travelling between the UK and Scandinavia and ship movements to/from the many offshore oil and gas installations in the central-northern North Sea. The highest vessel densities in UK wates are generally concentrated along the coast and along major shipping routes (Figure 3.12), which are some distance from the Forties and Bacchus areas. Higher densities of vessel traffic in and around Forties and Bacchus areas (Figure 3.12) are associated with support and supply activities.

[9] https://www.ogauthority.co.uk/media/1419/29r_shipping_density_table.pdf

Figure 3.12: Vessel density, 2018



3.11.4 Military Activity

The closest Ministry of Defence (MoD) practice and exercise area occupies a significant area off the east coast of Scotland (35km to the west). Demarcated as danger areas (D613A), it is used by the airforce for air combat training and high energy manoeuvres, although they do not impinge on the Bacchus area (Figure 3.13).

3.11.5 Cables

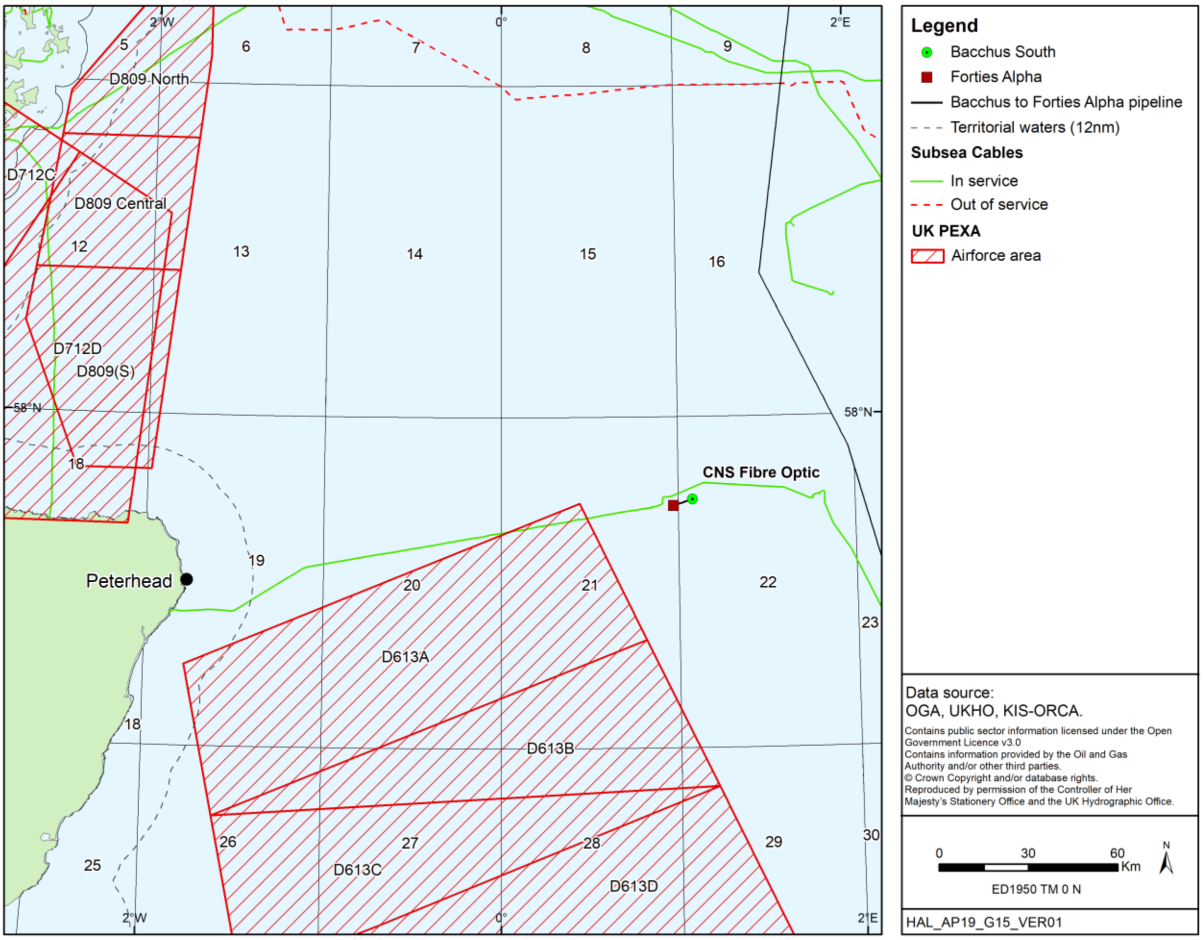
There are no cables in close proximity to the Bacchus Field area (Figure 3.13). The closest (CNS Fibre Optic telecom cable) passes ~3.5km to the north of the proposed Bacchus South well location.

3.11.6 Archaeology and wrecks

No archaeological sites or artefacts have been identified in the Bacchus area to date. Flemming (2004a, b), Wessex Archaeology (2008), Cohen *et al.* (2017) and Dawson *et al.* (2017) summarise the status of marine archaeology in the North Sea to date. These reports indicate that prehistoric submarine archaeological remains dating to *ca*. 12,000 years BP could occur with low probability anywhere between the northern mainland coast out to approximately 1°E. Earlier finds may be precluded by a lack of appropriate site taphonomy, however, the potential for site survival even across marine transgressions should not be dismissed (Flemming *et al.* 2012).

In addition to finds that may be associated with the palaeolandscapes of the North Sea (see Gaffney *et al.* 2007, 2009, 2017), the importance of maritime trade routes and fishing grounds in the region, and past military conflicts, has led to a large number of ship and aircraft wrecks. While many of the locations of these wrecks have been identified and listed by the UK Hydrographic Office (note that none are close to the Bacchus Field), many more remain uncharted. No wrecks designated under the *Protection of Military Remains Act 1986* or the *Marine (Scotland) Act 2010* are close to Bacchus and no wrecks were observed in previous surveys of the area.

Figure 3.13: PEXAs and subsea cables



3.11.7 Tourism and Recreation

The Bacchus area is located at a significant distance from the coast and is not used for recreation, with the possible exception of the occasional yacht on passage.

4 IDENTIFICATION AND SCREENING OF POTENTIALLY SIGNIFICANT ISSUES

4.1 Introduction

The production increase, drilling and subsea activities, have the potential to affect the environment in a number of ways. This section describes the process used to identify and screen the relative significance of the potential environmental effects associated with these. The production increase, drilling and subsea activities will also be subject to assessment as part of their related PETS permits and consents process

4.2 Method

The activity/environment interactions were identified using a range of sources, in particular:

- Regional and site specific environmental data
- Reservoir information
- Engineering descriptions and drawings
- Experience of comparable activities (i.e. activities will increase in frequency rather than representing a new activity or one requiring modifications to installations)
- Reviews and assessments of the environmental effects of oil and gas operations
- Scientific papers describing the effects of specific interactions e.g. Neff *et al.* (1989)
- BEIS Offshore Energy SEA programme environmental reports (DECC 2016), underpinning studies and appropriate assessments

These interactions were then systematically screened against the defined consequence and likelihood criteria in Table 4.1. The results of this screening are given in Section 4.3 (also see Table 4.2).

Table 4.1: Screening criteria for potential environmental effects from the Bacchus production increase

Effect	Consequences
None Foreseen	No detectable effects
Positive	Activity may contribute to recovery of habitats Positive benefits to local, regional or national economy
Negligible	Change is within scope of existing variability but potentially detectable
Moderate	Change in ecosystem leading to short term damage, with likelihood for recovery within 2 years, to an offshore area less than 100 hectares, or less than 2 hectares of a benthic fish spawning ground Possible but unlikely effect on human health Possible transboundary effects Possible contribution to cumulative effects Issue of limited public concern May cause nuisance Possible short term minor loss to private users or public finance
Major	Change in ecosystem leading to medium term (2+ year) damage, with recovery likely within 2-10 years, to an offshore area 100 hectares or more, or 2 hectares of a benthic fish spawning ground or coastal habitat, or to internationally or nationally protected populations, habitats or sites Transboundary effects expected Moderate contribution to cumulative effects Issue of public concern Possible effect on human health Possible medium term loss to private users or public finance
Severe	Change in ecosystem leading to long term (10+ year) damage, with poor potential for recovery, to an offshore area 100 hectares or more or 2 hectares of a benthic fish spawning ground or coastal habitat, or to internationally or nationally protected populations, habitats or sites Major transboundary effects expected Major contribution to cumulative effects Issue of acute public concern Likely effect on human health Long term, substantial loss to private users or public finance

Frequency with which activity or event might occur	Likelihood
Unlikely to occur during the lifetime of operation	**Unlikely**
Once in the life of the rig or facility	**Low**
Once a year	**Medium**
Once a month or regular short term events	**High**
Continuous or regular planned activity	**Very High**

	Likelihood				
Consequences	**Very High**	**High**	**Medium**	**Low**	**Unlikely**
Severe					
Major					
Moderate					
Negligible					
Positive					
None foreseen					

	Issues requiring detailed consideration in the ES	**See Section 5**
	Positive or minor or negligible issues	
	No effects expected	

4.3 Sources of Potential Environmental Effects

From the screening process, a number of environmental interactions were identified as being of potential significance. These are identified in Table 4.2 and discussed in Section 5. Section 5 also considers sources of cumulative and synergistic effects (Section 5.4) and potential transboundary effects (Section 5.5).

Table 4.2: Sources of potential effects, relevant environmental factors and related environmental receptors

Potential for significance	Minor issue

Environmental factor		**Biodiversity, with particular attention to species and habitats protected under Directive 92/43/EEC and Directive 2009/147/EC**						**Land, soil, water, air, climate**			**Material assets, cultural heritage and landscape**							
Activity/Source of Potential Effect	**Population & Human Health[10]**	**Benthic Fauna**	**Plankton**	**Fish & Shellfish**	**Marine Mammals**	**Waterbirds & Seabirds**	**Conservation sites/species**	**Soils & Seabed[A]**	**Water Quality**	**Air & climate**	**Fisheries**	**Other Uses & Resources[B]**	**Shipping**	**Waste Treatment & Landfill resource onshore**	**Cultural Heritage[C]**	**Landscape/seascape**	**Transboundary effects**	**Description**
Incremental Bacchus Production																		
Flaring																		Approximately 8% of Bacchus South gas is expected to be flared, which will make associated minor contributions to local air quality effects and global atmospheric carbon dioxide loading. See Section 5.1.1.
Power generation (operational emissions)																		No significant increase in power demand is expected as a result of the increase in production. Associated gas will contribute to native fuel gas use as part of the wider Forties Field fuel gas distribution and electrical ring main system, avoiding use of diesel for power generation. Aviat Field gas import will be reduced to accommodate Bacchus gas in the fuel gas system, such that there will be appreciable change in the emissions from Forties Alpha. There is no potential for significance.

[10] This topic is largely considered in the context of other environmental factors, for example effects on air quality, climate, other users, landscape/seascape.

Potential for significance | Minor issue

Environmental factor		**Biodiversity, with particular attention to species and habitats protected under Directive 92/43/EEC and Directive 2009/147/EC**						**Land, soil, water, air, climate**			**Material assets, cultural heritage and landscape**							
Activity/Source of Potential Effect	**Population & Human Health[10]**	**Benthic Fauna**	**Plankton**	**Fish & Shellfish**	**Marine Mammals**	**Waterbirds & Seabirds**	**Conservation sites/species**	**Soils & Seabed[A]**	**Water Quality**	**Air & climate**	**Fisheries**	**Other Uses & Resources[B]**	**Shipping**	**Waste Treatment & Landfill resource onshore**	**Cultural Heritage[C]**	**Landscape/seascape**	**Transboundary effects**	**Description**
Fugitive emissions																		No incremental fugitive emissions are expected as a result of the increase in production. There is no potential for significance.
Production chemical use and discharge																		A minor increment to production chemical use and discharge will result from enhanced production from Bacchus. See Section 5.1.2.
Water production management and disposal																		There will be a minor increment to produced water production and processing, 40% of which will be re-injected, with the remainder discharged to sea. See Section 5.1.3.
Bacchus South Well and Subsea Connection Works																		
Rig positioning (anchoring)																		Seabed disturbance will be generated from anchor lay and catenary action of anchor chain, having interactions with seabed sediments and related benthic fauna. See Section 5.2.2.
Physical presence of drilling rig and vessels																		Interactions with other users, particular fisheries, are limited by a 500m subsea exclusion zone established around the rig, and an existing exclusion zone centred on the Bacchus manifold. There will, however, be the temporary presence of rig anchors and anchor chain beyond these exclusion zones. Limited potential for interaction with ecological features sensitive to physical presence. See Section 5.2.3.
Surface noise and light																		Incremental lighting and surface noise from the rig and any additional supply trips will be temporary and not significantly add to existing lighting or noise levels in the area. It is not considered that there is the potential for a significant effect.

Potential for significance

Minor issue

Environmental factor		Biodiversity, with particular attention to species and habitats protected under Directive 92/43/EEC and Directive 2009/147/EC						Land, soil, water, air, climate			Material assets, cultural heritage and landscape							
Activity/Source of Potential Effect	**Population & Human Health[10]**	**Benthic Fauna**	**Plankton**	**Fish & Shellfish**	**Marine Mammals**	**Waterbirds & Seabirds**	**Conservation sites/species**	**Soils & Seabed[A]**	**Water Quality**	**Air & climate**	**Fisheries**	**Other Uses & Resources[B]**	**Shipping**	**Waste Treatment & Landfill resource onshore**	**Cultural Heritage[C]**	**Landscape/seascape**	**Transboundary effects**	**Description**
Potential for introduction of alien species in ballast & on hard structures																		The rig used will be operational in the North Sea and therefore the potential for introduction of alien species will be limited. Any ballasting would be undertaken in keeping with Ballast Management Plans under the Ballast Water Management Convention. It is not considered that there is the potential for a significant effect.
Rig & vessel emissions																		There will be atmospheric emissions associated with the combustion of fuel in rig, support vessel and DSV/survey vessel engines, and in helicopters used for crew changes. These emissions will contribute to local air quality effects and global atmospheric greenhouse gas loading. See Section 5.2.1.
Drill cuttings, cement and chemical discharge																		A quantity of drilling chemicals and cement will be discharged as part of the drilling programme. Surface hole cuttings will be discharged at the seabed, and lower hole section cuttings discharged from the rig following processing. A quantity of drilling and reservoir hydrocarbons will be discharged along with the treated lower hole section cuttings, at concentrations of <1% by dry weight. See Section 5.2.4.
Well completion & clean-up																		Any discharges and emissions will be minor and not significant.

Potential for significance	Minor issue

Environmental factor		Biodiversity, with particular attention to species and habitats protected under Directive 92/43/EEC and Directive 2009/147/EC						Land, soil, water, air, climate			Material assets, cultural heritage and landscape						
Activity/Source of Potential Effect	**Population & Human Health[10]**	**Benthic Fauna**	**Plankton**	**Fish & Shellfish**	**Marine Mammals**	**Waterbirds & Seabirds**	**Conservation sites/species**	**Soils & Seabed[A]**	**Water Quality**	**Air & climate**	**Fisheries**	**Other Uses & Resources[B]**	**Shipping**	**Waste Treatment & Landfill resource onshore**	**Cultural Heritage[C]**	**Landscape/seascape**	**Transboundary effects**	**Description**
Fugitive emissions from fuel and chemical storage																		Emissions include those from cement tanks, mudpits, diesel storage and cooling/refrigeration systems and therefore have the potential to make minor contribution to air quality effects. Such emissions are minor in the context of that from combustion of fuel for power generation and in view of the location and prevailing meteorological conditions, these emissions are not considered to be a significant source of air pollutants. It is not considered that there is the potential for a significant effect.
Drainage, sewage and other discharges																		Rig discharges will contribute to local water quality changes, and associated interactions with water column biota. Rig discharges will include sewage and grey water from accommodation, and deck surface drainage. The rig and vessels will meet MARPOL requirements (e.g. in relation to Annex I and Annex IV on the prevention of pollution by oil and sewage from ships respectively). Vessels and drilling rigs are also required to hold a Shipboard Oil Pollution Emergency Plan (SOPEP). It is not considered that there is the potential for a significant effect.
Other solid and liquid wastes to shore																		Materials returned to shore contribute to onshore activities such as materials processing and landfill. It is not considered that there is the potential for a significant effect.

Potential for significance	Minor issue

Environmental factor		Biodiversity, with particular attention to species and habitats protected under Directive 92/43/EEC and Directive 2009/147/EC						Land, soil, water, air, climate			Material assets, cultural heritage and landscape							
Activity/Source of Potential Effect	**Population & Human Health[10]**	**Benthic Fauna**	**Plankton**	**Fish & Shellfish**	**Marine Mammals**	**Waterbirds & Seabirds**	**Conservation sites/species**	**Soils & Seabed[A]**	**Water Quality**	**Air & climate**	**Fisheries**	**Other Uses & Resources[B]**	**Shipping**	**Waste Treatment & Landfill resource onshore**	**Cultural Heritage[C]**	**Landscape/seascape**	**Transboundary effects**	**Description**
Underwater noise from drilling and vessels, including DP																		Vessels will contribute to underwater noise, which has the potential to have a minor impact on noise sensitive species. Activities generating significant, impulsive noise, are not proposed, and Bacchus is not located in or close to an area of significance for noise sensitive species, including marine mammals. It is not considered that there is the potential for a significant effect.
Physical disturbance from subsea connection works																		Subsea works will include the placement of concrete mattresses and contingency grout bags at strategic locations on the pipeline route. Placement is localised and within the existing Bacchus 500m subsea safety zone. See Section 5.2.2.
Accidental Events																		
Spills of oil																		There will an incremental risk of an oil spill relating to the Bacchus South well. See Section 5.3.
Spills of diesel fuel																		There is the risk of spills of diesel from bunkering operations or in the worst case, from vessel collision/complete loss of rig diesel inventory. See Section 5.3.
Chemical spills																		Appropriate chemical handling and storage procedures will be in place. No significant increment in risk of chemical spills is predicted. There is no potential for significance.
Dropped objects																		No significant increment in risk of dropped objects is predicted. There is no potential for significance.

Potential for significance

Minor issue

Environmental factor		**Biodiversity, with particular attention to species and habitats protected under Directive 92/43/EEC and Directive 2009/147/EC**						**Land, soil, water, air, climate**			**Material assets, cultural heritage and landscape**							
Activity/Source of Potential Effect	**Population & Human Health[10]**	**Benthic Fauna**	**Plankton**	**Fish & Shellfish**	**Marine Mammals**	**Waterbirds & Seabirds**	**Conservation sites/species**	**Soils & Seabed[A]**	**Water Quality**	**Air & climate**	**Fisheries**	**Other Uses & Resources[B]**	**Shipping**	**Waste Treatment & Landfill resource onshore**	**Cultural Heritage[C]**	**Landscape/seascape**	**Transboundary effects**	**Description**
Vessel collision																		The production increase is delivered by a subsea infill well. No significant operational increment in collision risk as a result of the increase in production is predicted. A minor increment in risk would be associated with the physical presence of the rig and vessels associated with the subsea connection works, however, this is not considered to be a potential source of significant effect (also see Physical presence of drilling rig and vessels, and Section 5.2.3).

Notes:
A. Includes natural seabed features.
B. Includes cables, oil and gas, aggregate and other dredging, military, yachting etc.
C. Includes underwater archaeology and wrecks

4.3.1 Potential Effects to be Considered Further

The potential for significant effects were identified in relation to environmental factors for relatively few activities related to the Bacchus production increase (Table 4.2). The major sources of potentially significant effect have been grouped against those activities identified as likely to, directly or indirectly, affect one or more relevant environmental factors (and interactions between these). These have been listed below and are described and assessed in detail in Section 5.

Issues related to incremental production:

- Atmospheric emissions relating to the flaring of a proportion of Bacchus South associated gas
- Production chemical use and discharge
- Produced water management and disposal
- Incremental risk of spills of oil and chemicals

Issues Related to the drilling of the Bacchus South well and subsea tie-in:

- Rig and vessel atmospheric emissions
- Physical disturbance from rig positioning (anchoring) and subsea works
- Physical presence of drilling rig and vessels (supply, support and subsea works)
- Drill cuttings, cement and chemical discharge
- Effects of underwater noise
- Accidental events: spills of oil and rig diesel inventory

The potential for cumulative or transboundary effects associated with the Bacchus production increase are considered in Sections 5.4 and 5.5, taking into account the assessment made in Sections 5.1-5.3.

5 EVALUATION OF POTENTIALLY SIGNIFICANT ISSUES

5.1 Issues Related to Incremental Production

The following sections assess sources of potentially significant effect associated with the incremental increase in production from Bacchus. These include:

- Atmospheric emissions relating to the flaring of a proportion of Bacchus South associated gas
- Production chemical use and discharge
- Produced water management and disposal
- Incremental risk of spills of oil and chemicals (covered in Section 5.3)

5.1.1 Atmospheric Emissions

Anthropogenically enhanced levels of greenhouse gases (GHGs, principally CO_2) have been linked to global climate change (IPCC 2013). Predicted effects include *inter alia* an increase in global temperate (Kirtman *et al.* 2013, Collins *et al.* 2013), rising sea-levels (Lowe *et al.* 2009, Church *et al.* 2013, Horsburgh *et al.* 2020), changes in ocean circulation (Collins *et al.* 2013) and potentially more frequent extreme weather events (Wolf *et al.* 2020), and other effects including ocean acidification generated by enhanced atmospheric acid gas loading, deposition and exchange (see Humphreys *et al.* 2020). These effects, most recently summarised in the Intergovernmental Panel on Climate Change (IPCC) 5th assessment report (IPCC 2013, also see Dolan 2015), are the rationale on which global carbon dioxide reduction measures such as the Paris Accord and the UK Government commitment to achieving net zero GHG emissions on 1990 levels, by 2050, are based.

In addition to effects associated with atmospheric greenhouse gases, emissions also have the potential to have negative effects on air quality. Poor air quality can result in effects on human health, the wider environment and infrastructure. Reduction in local air quality through inputs of contaminants such as oxides of nitrogen (NO_X), volatile organic compounds (VOCs) and particulates (e.g. PM_{10}, $PM_{2.5}$), may contribute to the formation of local tropospheric ozone and photochemical smog, which in turn can result in human health effects (see WHO 2013, EPA 2017).

Present climate change projections (see Lowe *et al.* 2009, Palmer *et al.* 2018, Pörtner *et al.* 2019) are unlikely to significantly alter prevailing conditions during the time horizon of the development activities or operational life of the field.

The principal GHG of concern is CO_2 as it constitutes both the largest component of global combustion emissions (generally ~80% of total GHG emissions), and has a long atmospheric residence time such that emissions made today continue to contribute to radiative forcing for some time[11]. Emissions of relevant gas species and their associated Global Warming Potential (GWP) have been estimated for the incremental gas flaring for Bacchus (see Section 2.10). This has involved the use of standard Environmental and Emissions Monitoring System (EEMS) conversion factors (DECC 2008) to estimate the relative quantity of each gas species from flaring, and the most recent GWP metrics (Myhre *et al.* 2013, Table 5.1). The result is a value in tonnes of CO_2 equivalent (CO_2 eq.) based on the radiative forcing effect of each GHG species relative to CO_2 and the atmospheric residence time of each gas. The GWP factor therefore changes depending on the "time horizon" considered (see IPCC 2001, 2007, Myhre *et al.* 2013, and Shine 2009 for a synthesis and critical review). GWP factors for CO have previously been calculated as 1.9 at 100 years, and that for NO_x is considered highly uncertain (Forster *et al.* 2007), and these are therefore not calculated.

[11] Figures vary widely from between 5-200 years (Houghton *et al.* 2001) to *ca.*1,000 years (Archer 2005); Ciais *et al.* (2013) indicate that, based on emissions projections, 15-40% of CO_2 emitted until 2100 will remain in the atmosphere longer than 1,000 years.

Table 5.1: Emissions Factors

Gas	CO_2	N_2O	CH_4	CO	NOx	SO_2	NMVOC
Gas flaring (associated gas)	2.8	0.000081	0.01	0.0067	0.0012	0.0000128	0.01
GWP at 100 years	1	265	28	-	-	-	-

Source: IPCC (1996), DECC (2008), Myhre et al. (2013), AEA-Ricardo (2015)

As noted in Section 2.7, rates for oil and gas production exceed those currently consented in 2021-2024, and exceed the threshold requiring EIA only in 2022-2023. The only source of incremental emissions identified was from the flaring of a proportion of the associated gas from Bacchus (equivalent to 8% of produced gas). Emissions associated with this incremental flaring are presented below in Table 5.2 – note that only emissions from the incremental production above that level presently consented has been calculated.

Table 5.2: Emissions from Bacchus South Flaring (tonnes/year)

Year	CO_2	N_2O	CH_4	SO_2	CO	NO_x	VOC	GWP (CO_2 eq.)	%carbon budget[1]
2021	58,050	1.68	207	139	25	0.27	207	64,291	0.006
2022	81,874	2.37	292	196	35	0.37	292	90,678	
2023	81,376	2.35	291	195	35	0.37	291	90,148	0.012
2024	50,348	1.46	180	120	22	0.23	180	55,774	
2025	24,324	0.70	87	58	10	0.11	87	26,946	
2026	29,466	0.85	105	71	13	0.13	105	32,632	
2027	20,604	0.60	74	49	9	0.09	74	22,834	
2028	14,774	0.43	53	35	6	0.07	53	16,371	0.001
2029	6,770	0.20	24	16	3	0.03	24	7,494	

Notes: the percentage of the carbon budgets for the periods 2018-2022 (3rd carbon budget), 2023-2027 (4th carbon budget) and 2028-2032 (5th carbon budget), set at 2,544, 1,950 and 1,765MtCO_2eq. respectively.

As noted in Section 2.10, gas which is not flared (approximately 92% of the associated gas) will be used as fuel gas for the Forties Field which will be accommodated in the Forties fuel gas system by reducing production from the Aviat Field, which has the exclusive purpose of providing fuel gas to the Forties area. There will, therefore, be no significant net change in emissions from Forties as there is no appreciable increase in power demand as a result of the increase in production. The use of associated gas as fuel gas, as opposed to using diesel for power generation, reduces the need to transport large quantities of diesel to the field, and has comparably lower GHGs when consumed in turbines.

To place the CO_2eq. emissions from activities associated with Bacchus in context, in 2019 UK emissions of the basket of seven greenhouse gases covered by the Kyoto Protocol are provisionally estimated to be 435.2 million tonnes (Mt) CO_2 eq.; CO_2 being the most dominant of these, accounting for *ca*. 81% of the emissions (361.5 Mt). The total emissions were 3.6% lower than the 2018 figure of 451.5 million tonnes CO_2 eq., and net CO_2 emissions were 3.9% lower than the 2018 figure (365.7 Mt); primarily related to a decrease in the use of coal in electricity generation (BEIS 2020). Approximately 13.2 MtCO_2 was attributable to installations in the UKCS in 2018 (OGUK 2019). The flaring would contribute a maximum annual increment of 0.02% and 0.7% respectively on these values at peak production (2022). To consider the implications of the production increase at Bacchus on the UK's carbon budget[12], the above flaring emissions have been considered in relation to the targets set for each carbon accounting period, which can be seen to be minor.

Conclusion

The consideration of effects from the emission of GHGs has been limited to the operation of the Bacchus Field, and specifically those emissions which are relevant to the production increase which is the subject of this EIA. As hydrocarbons are traded commodities, their end use (the carbon intensity of which would be highly varied) is outside of the control of the project and cannot be meaningfully quantified and assessed here, but will likely include both use in fuel generation and in finished goods. Apache are cognisant of the UK Government's commitment to achieving net zero GHG emissions by 2050 which has also been legislated for under *The Climate Change Act 2008 (2050 Target Amendment) Order 2019*, and is also aware of its own obligations under the MER-UK strategy to maximise economic recovery of hydrocarbons, and the proposed changes to this strategy to account for the net zero commitment. While the updated strategy is yet to be formally published, in keeping with its proposals, Apache will maximise the use of associated Bacchus gas as fuel gas to avoid the use of diesel in power generation – as there is no feasible gas export route from Forties, the use of such gas as fuel gas is considered to presently be the most feasible option to limit upstream production emissions from Bacchus. Additionally, Apache will minimise, as far as possible, any flaring relating to the production increase (noting those quantities estimated above).

See environmental management issue 5 and 8, and associated actions in Table 6.1.

5.1.2 Production Chemical Use and Discharge

Chemicals/substances for use on the UKCS have to be notified and tested under the Offshore Chemical Notification Scheme (OCNS); the OCNS list includes a ranking for each chemical (Hazard Quotient (HQ) values or OCNS group). Final chemical selection for drilling and completion activities, flowline testing and operational use will be based on least harmfulness consistent with technical function. Permit applications for the use and discharge of chemicals are required by *The Offshore Chemicals Regulations 2002* (as amended) and will be submitted to BEIS via the PETS process in advance of the commencement of the various development and production operations.

Additional production chemical use is expected to be limited. The chemicals presently used for Bacchus production are methanol and scale inhibitor, with the latter categorised as OCNS E/Gold and with no substitution warning. There will be a minor increase in use for these production chemicals, in proportion to the increase in production. It is anticipated that there would be an increase in methanol use by ~10% (5 tonnes/year), and of scale inhibitor by ~15% (3 tonnes/year). Asphaltene dispersant will also be used to mitigate against the deposition of organic solids in the well. This was not previously used at Bacchus and minor modifications to Forties Alpha (in the form of a storage tank and pumps) will be made to accommodate this. The assessment of the incremental operational chemical use, and the addition of the asphaltene dispersant, will be made as part of the relevant permit application, however, chemicals which are marked for substitution, with heavy metal or other warnings, will be avoided unless there is no technical alternative. Significant effects from operational chemical use are not predicted.

See environmental management issue 4 and associated actions in Table 6.1.

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[12] The mechanism under the *Climate Change Act 2008* (as amended) which sets targets to progressively reduce the level of GHGs which the UK should be emitting, set by UK Government on advice from the Climate Change Committee, with a view to reducing net emissions by 57% in 2030, and 100% by 2050 (on 1990 levels).

5.1.3 Produced Water

Treated produced water may contain low concentrations of dispersed and dissolved reservoir hydrocarbons, dissolved other organic and inorganic compounds that were present in the geological formation, along with some of the chemicals added during the production process.

The impact of produced water on water quality is dependent on a number of physical, chemical and biological processes, including the volume and density of the discharge, dilution, volatilisation or low molecular weight hydrocarbons and biodegradation of organic compounds. Most studies of produced water toxicity and dispersion have concluded that the necessary dilution to achieve a No Effect Concentration (NEC) would be reached at <10 to 100m, and usually less than 500m from the discharge point (E&P Forum 1994, OLF 1998, Riddle *et al.* 2001, Berry & Wells 2004). Kenny *et al.* (2005) reviewed studies and data (including analyses of produced water composition from Irish Sea facilities), and reached a similar conclusion. However, under some circumstances (e.g. strong stratification: Washburn *et al.* 1999), a plume concentration sufficient to result in sub-lethal effects may persist for >1,000m (Burns *et al.* 1999).

Plankton abundance is influenced strongly by the physical environment and variables such as water temperature, current velocity, stratification in the water column and nutrient concentration. As a result, they are particularly vulnerable to discharges and spills of chemicals and hydrocarbons. Plankton may be exposed to these contaminants through passive diffusion, active uptake or through eating contaminated prey. As plankton spend most of their lives in the water column, they will be exposed to those contaminants that remain in solution (Sheahan *et al.* 2001). Produced water can affect recruitment in calanoid copepods (Hay *et al.* 1988), with lowered fecundity and increased offspring mortality reported for some plankton, as outcomes of hydrocarbon contamination (van Beusekom & Diel-Christiansen 1993). Strømgren *et al.* (1995) found that acute toxicity in the diatom *Skeletonema* spp. was only likely in individuals in the immediate vicinity of the source of produced water, where concentrations of contaminants are highest.

The ICES Biological Effects Monitoring in Pelagic Ecosystems workshop (BECPELAG), analysed samples from caged organisms and passive samplers using a wide range of biomarkers and bioassays for chemical, molecular, cellular and physiological changes (e.g. toxicity bioassays, enzymatic induction (EROD), lysosomal damage, Scope for Growth (SFG), genotoxicity, endocrine disruption effects, metallothionein induction, polycyclic aromatic hydrocarbon (PAH) metabolites, acetylcholinesterase inhibition and bacterial diversity). Although a variety of detectable responses (in caged organisms) around an oil platform were observed and attributed to produced water effects, there was not a gradient of effect and the ecological significance of these responses is unclear.

The QSR 2010 noted that water column monitoring to determine possible effects from PAHs and other chemicals such as alkyl phenols discharged with produced water has been carried out to a limited extent in the OSPAR area. Monitoring with caged mussels in the Netherlands and Norwegian sectors of the North Sea has shown that mussels exposed to produced water discharges may accumulate PAH and show biological responses up to 1000m from the discharge. Concentrations of PAHs and alkyl phenols and measured biological responses in wild fish such as cod and haddock caught in the vicinity of offshore installations from Norwegian waters in 2002 and 2005 showed a mixed pattern mostly with no increased concentrations, but some elevated biological responses suggesting past exposure. Exposure of cod sperm cells to environmentally relevant concentrations (100, 200, 500 ppm) of produced water from the Hibernia platform, Newfoundland, did not result in a strong toxicity to the cells (only subtle changes were observed) or a significant change in fertilisation rate (Hamoutene *et al.* 2010).

Bakke *et al*. (2013) reviewed research on the biological effects of offshore produced water (and drill cuttings, see Section 5.2.3) discharges, with focus on the Norwegian waters. Produced water discharges are a continuous source of contaminants to continental shelf ecosystems, and alkylphenols and PAHs were found to accumulate in cod and mussels caged near the discharge points, but these compounds are rapidly metabolized in cod. Such compounds may affect reproductive functions, and various chemical, biochemical and genetic biomarkers but Bakke *et al*. (2013) concluded that the risk of widespread impact from such operational discharges is low.

Produced water at Forties Alpha may be discharged following treatment or re-injected, and facilities for both SWI and PWRI are maintained on Forties Alpha. Produced water at Forties Alpha which is not re-injected is discharged to sea with oil-in-water (OIW) concentrations typically in the range 11-17mg/l (based on yearly average concentrations 2018-2020). Water production from Bacchus is predicted to increase from $0.5m^3/d$ in the first year of production, peaking at $3.1m^3/d$ in 2023, and declining thereafter through field life (see Table 2.2). It is expected that 40% of this water will be discharged to sea, with the remainder being re-injected for reservoir support. This will result in a corresponding discharge of oil in produced water of just 0.009 tonnes/year at the peak water production rate in 2023 (for the purposes of assessment, an OIW concentration of 20mg/l has been assumed).

Conclusion

Any effects from the increment in produced water discharges from Bacchus are considered to be negligible; significant effects are not considered to be likely. No further management measures or mitigation is considered to be required.

5.2 Bacchus South Well and Subsea Connection

The following sections assess those sources of potentially significant effect for the drilling and completion of the Bacchus South well, and the short subsea programme to connect the well to the Bacchus manifold and associated works. These include:

- Rig and vessel atmospheric emissions
- Physical disturbance from rig positioning (anchoring) and subsea works
- Physical presence of drilling rig and vessels (supply, support and subsea works)
- Drill cuttings, cement and chemical discharge
- Effects of underwater noise
- Accidental events: spills of oil and rig diesel inventory (covered in Section 5.3)

5.2.1 Atmospheric Emissions

The basis for considering atmospheric emissions (i.e. in terms of their contribution to local air quality and climate change related effects) has already been outlined in Section 5.1.1. The emissions factors relevant to the drilling of the Bacchus South well and completing the subsea tie-in works are provided in Table 5.3, and tabulations of emissions associated with the drilling and subsea works is provided in Table 5.4 and Table 5.5 respectively.

Table 5.3: Emissions Factors

Gas	CO_2	N_2O	CH_4	CO	NOx	SO_2	NMVOC
Diesel (engine)	3.22	0.00022	0.00018	0.0157	0.0594	0.004	0.002
Aviation fuel (helicopter)	3.15	0.00012	0.00035	0.00953	0.012	0.0009	0.00306
Diesel (turbines)	3.2	0.00022	0.0000328	0.00092	0.0135	0.004	0.000295
GWP at 100 years	1	265	28	-	-	-	-

Notes: [1]sulphur content of marine diesel fuel assumed to be 0.1% based on requirements for Emissions Control Areas: IMO website (accessed June 2020).
Source: IPCC (1996), DECC (2008), Myhre et al. (2013), AEA-Ricardo (2015)

Table 5.4: Estimated Drilling Emissions

	Helicopter traffic	Supply vessel	Anchor handling	Rig on location	Total mass	GWP	Total GWP
CO_2	133	960	768	2,562	4,423	1	4,423
N_2O	0.00	0.07	0.05	0.18	0.3	265	79
CH_4	0.01	0.05	0.04	0.14	0.26	28	7
NO_X	0.50	17.82	14.26	47.56	80.14	-	-
SO_2	0.04	1.20	0.96	3.20	5.40	-	-
CO	0.40	4.71	3.77	12.57	21.45	-	-
VOC	0.13	0.60	0.48	1.60	2.81	-	-
						Total GWP (tCO_2 eq.) at 100-years	4,510

Note: if required, the contingent 8 ½” mechanical sidetrack is estimated to result in an additional ~780tCO_2 eq.

Table 5.5: Estimated Emissions from Subsea Works

	DSV (tie-in)	DSV (protection material and commissioning)	Inspection survey[1]	Total mass	GWP	Total GWP
CO_2	512	102	2,304	2,918	1	2,918
N_2O	0.04	0.01	0.16	0.2	265	53.17
CH_4	0.03	0.01	0.13	0.16	28	4.60
NO_X	9.5	1.9	42.77	54.17	-	-
SO_2	0.64	0.13	2.88	3.65	-	-
CO	2.51	0.5	11.30	14.32	-	-
VOC	0.32	0.06	1.44	1.82	-	-
					Total GWP (tCO_2 eq.) at 100-years	2,976

Note: [1] incorporates an annual inspection survey of the Bacchus facilities, through field life.

To place the CO_2 eq. emissions from activities associated with the drilling of the Bacchus South well (including sidetrack) in context, they represent 0.01% of 2019 UK CO_2eq. emissions (BEIS 2020), or 0.04% of CO_2 emission relating to UKCS operations in 2018 (OGUK 2019). The subsea works and inspection surveys represent just 0.0007% of 2019 UK emissions, or just 0.02% of 2018 UKCS emissions, and are therefore very minor in a regional context. Though minor, the implications of the emissions from the drilling and subsea programme taken together are recognised, including their contribution to the current UK carbon budget (2018-2022), which is equivalent to 0.003% of the 2,544MtCO_2 eq. level.

Conclusion

Emissions associated with the drilling of the Bacchus South well, subsequent subsea connection works and annual survey, are temporary and minor in significance. Apache will make use of the existing Forties standby vessel such that there will be no additional emissions from providing this function.

See environmental management commitments 1, 5, 8 and 9, and associated actions in Table 6.1.

5.2.2 Physical Disturbance

Drilling rig

The main source of physical disturbance from drilling the Bacchus South well is the use of anchors to maintain the station of the semi-submersible drilling rig. Each anchor will produce a linear scar on installation in the order of 50m length, with additional disturbance generated by surface scrape as a result of catenary contact of the anchor chain with the seabed. The total seabed area affected by semi-submersible anchoring is partly a function of water depth, for example an area of seabed 0.032km^2 was affected by anchoring a rig in ~140m of water (see BP 2010). The area to be affected by rig positioning would be less than the above given the depth over the Bacchus South well location (90m).

Physical effects of seabed disturbance may include mortality to benthic fauna as a result of physical trauma, smothering by re-suspended sediment, and habitat modification due to changed physico-chemical characteristics, including from the introduction and removal of hard substrates.

Anchor scars will be formed by the placement of the rig, but these will be localised features and are not expected to be permanent. Given the water depths and low tidal energy over the area, physical recovery of the seabed will be over the medium to long term. For example, the recent Gardline (2019) survey identified four depressions interpreted as spud-can depressions associated with Well 22/6a-14z drilled in 2006.

The surface hole section of the well will be drilled riserless, producing a localised (and transient) pile of surface-hole cuttings around the surface conductor (also see Section 5.2.4). These cuttings are derived from shallow geological formations and a proportion will be similar to surficial sediments in composition and characteristics. The persistence of cuttings discharged at the seabed is largely determined by the potential for it to be redistributed by tidal and other currents. After installation of the surface casing (which will result in a small quantity of excess cement returns being deposited on the seabed), the blowout preventer (BOP) is positioned on the wellhead housing. These operations (and associated activities such as Remotely Operated Vehicle (ROV) operations) may result in physical disturbance of the immediate vicinity (a few metres) of the wellhead. At the time of decommissioning, and on well abandonment, the conductor and casing are plugged with cement and cut below the mudline (seabed sediment surface) using a mechanical cutting tool usually deployed from a rig and the wellhead assembly is removed. The seabed "footprint" of the well is therefore removed on decommissioning, although post-well sediments may vary in the immediate vicinity of the well compared to the surrounding seabed (see for example, Jones *et al*. (2012)).

The duration of effects on benthic community structure are related to individual species biology and to successional development of community structure. The majority of seabed species recorded from the European continental shelf are known, or believed to have, short lifespans (a few years or less) and relatively high reproductive rates, indicating the potential for rapid population recovery, typically between one to five years (Jennings & Kaiser 1998). In general, macrofaunal population levels are limited by post-settlement factors rather than larval availability. Polychaete species which dominate at stations between Bacchus to Forties Alpha (Fugro 2010b) are characterised by short lifespans and are likely to have high recovery rates. Given the localised nature of the seabed disturbance, recruitment by adult mobility from neighbouring areas will be possible and therefore the resilience of the benthic community to the physical disturbance is likely to be high. It is therefore considered probable that both the physical habitat consequences and benthic community effects of physical disturbance of the seabed from future drilling activities will fully recover within a five to ten year period.

Subsea connection works

The installation of a flexible 6" production pipeline, jumper and 4" gas lift pipeline between the Bacchus South well and the Bacchus towhead manifold will have a limited seabed footprint. The pipelines and jumper will each be less than 100m long and protected by concrete mattresses along their length. Based on a mattress size (6x3m, 32 mats covering each 100m length) and a contingency buffer of 2m around each mat to account for potential disturbance during their installation, the maximum extent of physical disturbance associated with the subsea works is estimated at 0.001km^2. Additionally, up to 600 grout bags with dimensions 0.45x0.3m could be used as a contingency. In the worst case that all of the bags were used, their footprint would be ~0.00008km^2. Given the localised nature of the seabed disturbance, recruitment by adult mobility from neighbouring areas will be possible and therefore the resilience of the benthic community to the physical disturbance is likely to be high. It is therefore considered probable that both the physical habitat consequences and benthic community effects of physical disturbance of the seabed from subsea works will fully recover within a five to ten year period.

Conclusion

Incremental disturbance from the positioning of a mobile rig and installation of the pipelines, jumpers, spools and related protection materials, would result in some temporary physical disturbance to the seabed. The nature and inferred general resilience of the seabed, habitat and species, leads to the conclusion that effects at the seabed would not be significant. See environmental management commitments 6, 7 and 8, and associated actions in Table 6.1.

5.2.3 Physical Presence

Potential effects on other users

The physical presence of the rig, associated support and supply vessels, the vessel used to complete the subsea connection of the well to the Bacchus manifold, and the subsea well and its connections, have the potential to affect other users of the sea through disruption of their activities. This includes for shipping and fishing.

The potential scale of the effect on shipping is limited as vessel density in the area is low to very low (see Section 3.11.3), and offshore activities will be temporary and small in scale. Data for the wider ICES rectangles which contain Bacchus, which include Bacchus South, and Forties Alpha (44F1 and 44F0) indicate a moderate level of fishing, with trawls generally targeting demersal species and *Nephrops*, but with variable levels of fishing for pelagic species in recent years (see Section 3.11.2). Vessel Monitoring System (VMS) data for the area (whilst limited to vessels of >15m in length) indicates that the majority of effort is to the north and west over the Fladen Ground, with a relatively low level of fishing taking place at and around Bacchus. Considering the years 2016-2018, fishing is undertaken throughout the year in the area, with no well-defined seasonal pattern.

The rig will have a temporary 500m safety exclusion zone in place for the duration of the drilling and completion activities, and vessels in the area will be monitored by the Emergency Response and Rescue Vessel (ERRV) which will communicate with them as appropriate. The drilling rig will use eight anchors to maintain station, and the anchor spread is expected to be approximately 1,200-1,700m, which extends the physical footprint of the rig to outside of the 500m safety zone. The as laid positions of anchors will be notified to fishermen and others through the normal routes, including publication in Notice to Mariners and in Kingfisher bulletins, detailing rig position, activities and timing. In addition, other measures to minimise the risk of interactions between shipping, fishing and the rig include full navigation lighting on the rig and associated vessels.

The Bacchus manifold and existing wells are covered by an established 500m safety zone[13], and the Bacchus South well, its connection to the Bacchus manifold and related protection materials will also be within this area. A Deposit Consent Application will be included for an estimated use of up to 32 mattresses and 600 grout bags. In view of the proximity of Bacchus South to the manifold, and the presence of an existing, established safety zone, there will be no incremental exclusion to fisheries from Bacchus South during its operation.

Potential effects on sensitive species

The physical presence of vessels and rig associated with Bacchus South activities may potentially cause low level displacement and/or other behavioural responses in birds. Seabird distribution and abundance in the central North Sea varies throughout the year, but the area as a whole is of low importance, due to the distance from shore, and availability of prey; the offshore area in general, containing peak numbers of birds following the breeding season and through winter (see Section 3.8), with birds present likely to be on transit through the area. From the mean and mean maximum (km) foraging distances for seabird species during the breeding season, (as described in Woodward *et al.* 2019), Bacchus South is considered too far offshore (>172km) for the majority of these to forage during this period, although non-breeding adults may be present. Of those species that could be present, such as northern fulmar, northern gannet, European storm petrel and great skua, these are not judged to be highly sensitive to ship traffic (Garthe & Hüppop 2004, Furness *et al.* 2015, Fliessbach *et al.* 2019). The location of Bacchus South precludes interaction with the most sensitive species to vessel movement such as divers and scoters, which generally forage in coastal waters of ≤20m depth (Fox *et al.* 2003). While rafting

[13] *The Offshore Installations (Safety Zones) (No. 4) Order 2012*

birds may move in response to vessels in transit, such effects are of low magnitude and short duration, and will represent negligible additional disturbance over routine vessel movements. Significant effects on bird species are therefore not considered to be likely.

In addition to potential disturbance to birds, the physical presence of the vessels may influence the distribution and movements of sensitive species in the water column, namely migratory fish and marine mammals. As hearing specialists, any displacement of marine mammals is most likely associated with acoustic disturbance, which is discussed in 5.2.5. There may also be responses from marine mammals and fish to the general physical presence of infrastructure and vessels (Sparling *et al.* 2015), along with the risk of collisions from vessels in transit.

A moderate density and diversity of marine mammals is present in the Bacchus area, and wider central North Sea (Section 3.9), which include harbour porpoise, white-beaked dolphin, Atlantic white-sided dolphin and minke whale, while observed densities of marine mammals for relevant strata of the SCANS-III survey conducted in summer 2016 (Hammond *et al.* 2017) were relatively low. Activities associated with the drilling of the Bacchus South well and the subsea connection works will result in the temporary presence of the rig (up to 112 days) and associated support and standby vessels, and that of a Diving Support Vessel (DSV) (up to 12 days in total) and survey vessel (5 days/year), and not significantly add to existing levels of shipping in the wider Bacchus and Forties area (Section 3.11.3). These activities are anticipated to cause no more than temporary and localised low-level behavioural responses similar to those from normal operations, such that significant effects are not predicted.

Conclusion

It is not considered that the rig is at significant risk from collision given both statutory notification and lighting, and protection afforded by a standby vessel. Interactions with other users of the area, specifically fishing and navigation, are considered to be short lived (days or weeks) for the drilling and subsea connection programme, and negligible throughout the expected life of the Field as there is no incremental exclusion to other users from Bacchus South. The subsea well will be within an existing 500m safety zone, be publicised through Notices to Mariners, and marked on navigation and fisheries charts.

Species sensitive to the physical presence of the rig and vessels are either not present, or are in low abundance; any effect would be temporary, minor and not significant.

See environmental management commitments 7 and associated actions in Table 6.1.

5.2.4 Discharges: Bacchus South and Subsea Connections

Drill cuttings, Cement and Chemical Discharge

The UK is a contracting party to the 1992 OSPAR Convention under which it has a requirement to, amongst other things, register and assess chemicals used and discharged by the oil and gas industry. In the UK this is done under the Offshore Chemical Notification Scheme (ONCS) administered by BEIS, using scientific and environmental advice from the CEFAS (the Centre for Environmental, Fisheries, and Aquaculture Science). Information required on the OCNS includes a ranking for each chemical, either their HQ (Hazard Quotient) value (categories being Gold, Silver, White, Blue, Orange, Purple) or OCNS Group (A, B, C, D and E), which gives an indication of whether they would have a significant environmental effect; HQ Gold and OCNS E representing the least potential hazard (see CEFAS website: https://www.cefas.co.uk/data-and-publications/ocns/). Using expert judgement and after assessment, the OSPAR Commission also regularly publish a list of PLONOR substances, which are considered to Pose Little or No Risk to the environment, and as such the use and discharges of which do not require strong regulation.

The well design and mud systems proposed for the Bacchus South well are described in Section 2.8. The well will utilise a combination of seawater and high viscosity (bentonite) sweeps for the drilling of the surface holes and Low Toxicity Oil Based Muds (LTOBMs) for the lower and bottom hole sections. Some 845m^3 of cuttings will be discharged direct to the seabed around the wellbore from the riserless drilling of the 36" and 26" hole sections. Surface hole cuttings are derived from shallow geological formations and a proportion will be similar to surficial sediments in composition and characteristics. This material will smother an oval area of seabed extending ca. 30m by 25m to a depth of around 1m, with thicker deposits immediately around the wellhead and rapidly thinning depths at the periphery. The predicted effects are localised and of short duration, involving smothering of benthic habitats and fauna with relatively rapid recovery through faunal re-colonisation. Relevant information on the recovery of benthic habitats to smothering mainly comes from studies of dredge disposal areas (see Newell *at al.* 1998). Recovery following disposal occurs through a mixture of vertical migration of buried fauna, together with sideways migration into the area from the edges, and settlement of new larvae from the plankton. Defaunated sediments will be rapidly recolonised, likely by a combination of opportunistic species and the species more typical of the Bacchus area (Eagle & Rees, 1973). Harvey *et al.* (1998) suggest that it may take more than two years for a community to return to a closer resemblance of its original state (although if long lived species were present this could be much longer). In contrast to habitats in energetic shallow waters, a stable sand and gravel habitat in deeper water is believed to take years to recover (see Newell *et al.* 1998, Foden *et al*. 2009).

In addition to surface hole cuttings, a small quantity of excess cement used to locate the conductor will be returned to the seabed. Cement returns to seabed surface will be monitored by ROV so pumping of cement can be stopped when returns appear at the seabed. The cement and cement chemicals will be subject to individual chemical risk assessment as part of the permit application process for the Bacchus South well. After installation of the surface casing, the BOP is positioned on the wellhead housing. These operations (and associated activities such as ROV operations) may result in physical disturbance of the immediate vicinity (a few metres) of the wellhead.

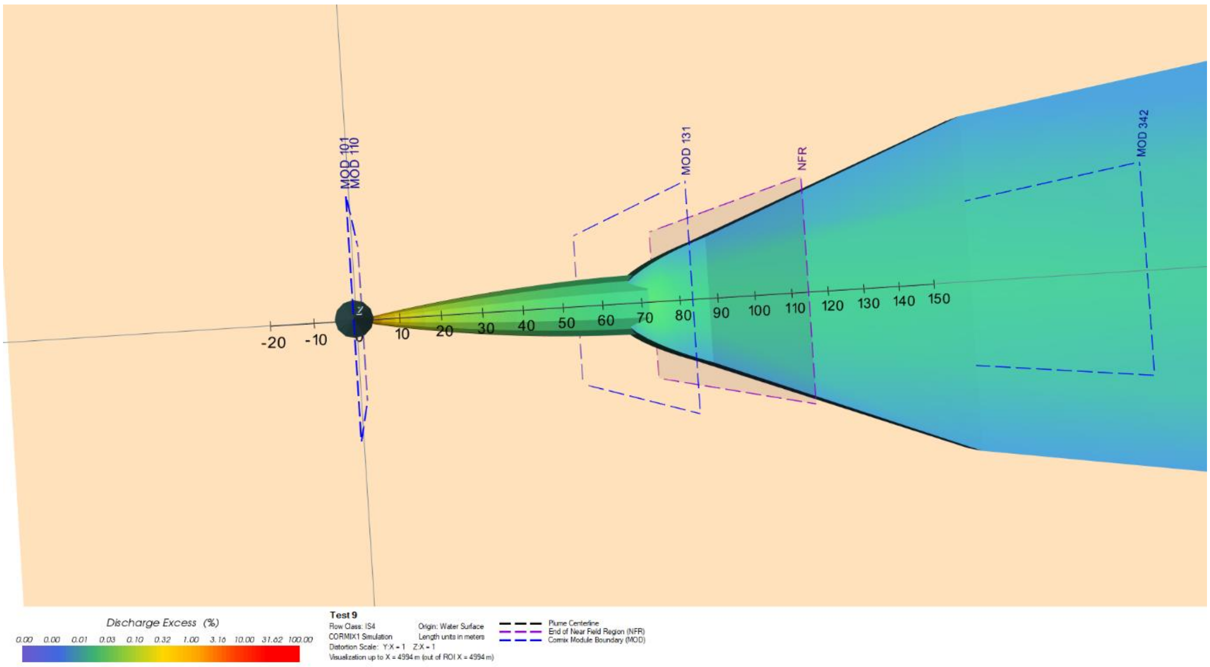
All other well sections are to be drilled using LTOBMs, which will be returned to the rig for treatment in a Rotomill (as described in Section 2.8). Such treatment pulverises the cuttings and removes the majority of the base oil (to meet or exceed the OSPAR standard for discharge of <1% oil by weight of dry cuttings). The cleaned solids will be subject to a sampling programme to ensure these standards are met. The processed cuttings will be discharged from the rig, at approximately 11.5m below mean sea level.

Trannum *et al.* (2016) provide a representative particle size distribution of treated cuttings from the Martin Linge field (Norwegian sector) which have been used here as a basis for cuttings dispersion modelling using the Cornell Mixing Zone Expert System (CORMIX) Version 11 (www.cormix.info). CORMIX is a steady state model which assumes a continuous discharge release.

The model examines the composite sediment accumulation over a range of particle size distributions, each having calculated constant settling velocities. Particle separation and settling from the discharge plume in the near-field is limited by the turbulent jet behaviour of the plume. CORMIX uses a number of simulation modules executed sequentially, corresponding to different flow processes and associated spatial regions. Particle size distributions of representative drill cuttings and fluids were used to estimate the settling velocities for ten particle size classes derived from the Martin Linge thermally treated cuttings (TCC) cuttings data. Finer particle sizes are typically transported over greater distances than larger or more dense particles.

All particles are carried horizontally at the same velocity as the tidal and other currents. The model permits a single horizontal current speed applied throughout the water column and an average current speed was used from regional hydrographic data (Figure 5.1). The dominant surface tidal current direction (flowing towards the south) was applied. Plume excess over background levels attenuates over distance.

Figure 5.1: Modelled cuttings dispersion plume of excess over background



The bulk (77%) of the Martin Linge cuttings were fine particles ranging in diameter from <2µm (clay) and 250µm (fine sand), with 26% being between 125-250µm in diameter. The modelling for Bacchus South TCC cuttings discharges indicated that the bulk of the material would settle within 500m of the well location with a proportion of the finer particulates likely to spread several tens of kilometres from the discharge point and eventually settle to the seabed over a wide area at imperceptible thicknesses.

Aquateam COWI (2014) summarise SINTEF dispersion modelling of discharged TCC OBM cuttings from the three lower hole sections of a representative well on Ivar Aasen (water depth 113m and discharge one metre below the sea surface) for summer and winter scenarios. The modelling indicated that a maximum concentration of TCC cuttings in the water column of 1-5mg/l, and that the maximum thickness of the cuttings on the seabed occurred 250-300m from the discharging rig. In an area equivalent to 50 x 50 metres, the thickness of cuttings deposition was up to 1.8mm.

Trannum *et al.* (2016) undertook mesocosm and bottle slurry experiments to assess the effects of a 6.3mm layer of (Rotomill) TCC and to contrast them with those of WBM cuttings. The effects on benthic community structure, oxygen microprofiles and biogeochemical fluxes were investigated. Results from both experimental approaches showed significantly increased biodegradation indicated by consumption of oxygen and nitrate & nitrite in both the WBM and the TCC treatments compared to controls. Based on the mesocosm experiments results WBM cuttings were characterized as non-detrimental to macrofauna but the TCC cuttings caused mass mortality and reduction in macrofaunal biomass. The adverse effect of TCC cuttings was considered possibly due to the calcium oxide content of the cuttings resulting in strongly alkaline conditions. It was also noted that such effects may not be evident in the field as a result of buffering and dissolution by the seawater during the passage of the cuttings through the water column. It should also be noted that the high calcium oxide concentrations are a feature of the particular mud formulation used at Martin Linge, not as a consequence of thermal treatment of the cuttings.

From the predicted maximum depth of deposited TCC cuttings, significant effects on the benthic fauna around the Bacchus South well are not predicted, i.e. the maximum depth of deposited material is within the burial movement or particulate clearance abilities of the benthic faunal species known from the area.

Subsea works

The pipeline and spools will be pre-filled onshore with 100% MEG, and fitted by divers between the Bacchus South well tree and the manifold. Biocide and dye sticks will be inserted at each flange connection with no discharges expected upon insertion. A proportion of these chemicals will be discharged at Forties Alpha in produced water, with the remainder forming part of the PWRI. A permit for the use and discharge of chemicals associated with the subsea programme, will be applied for, with approval sought prior to offshore activities being undertaken.

Conclusion

Drilling (including well clean-up) and rig discharges from the proposed Bacchus South well are not predicted to result in significant effects on the marine environment, such effects as are predicted will be localised and of relatively short duration. This conclusion is based on the nature of the proposed operations, mitigation measures undertaken or planned and the physical and biological conditions in the vicinity of the well. It is also supported by a number of studies of the effects of similar drilling in the North Sea and elsewhere.

Final chemical selection for the drilling fluids to be used has not yet been made although chemicals will be selected for least harmfulness consistent with technical function. Chemicals with substitution or other warnings will be avoided, where possible and preference will be given to those chemicals which have the lowest Hazard Quotient (Gold or OCNS Group E), where it is technically feasible to do so. All chemicals will be further assessed during the relevant permit applications for the use and discharge of chemicals.

See environmental management commitments 1, 4, 6, 7 and 8 and related actions in Section 6.

5.2.5 Effects of Noise

Underwater Noise Sources and Propagation

No high intensity impulsive noise generating activities are proposed as part of the Bacchus production increase; all noise sources will be of a non-impulsive nature, the characteristics of which result in a far lower potential to cause injury to marine fauna. Non-impulsive sound occurs when the acoustic energy is spread over a significant time (several seconds to hours); it may contain broadband noise and/or tonal (narrowband) noise at specific frequencies and its amplitude may vary. Mechanisms for non-impulsive noise generation from offshore activities include propeller cavitation and rotating machinery from vessels, rigs and ROVs, and the use of underwater cutting tools.

The key noise sources associated with the proposed activities include:

- positioning of the rig including running anchors and associated vessels;
- operation of the rig, including drilling, power generation and other machinery involved in rig operations such as such as hydraulic systems and compressors;
- standby, supply, survey and dive vessel operations; and,
- helicopter movements.

Drilling and rig operations

Drilling and completion will be undertaken from a semi-submersible rig. The rig will be towed to the location by three tugs, with anchoring taking place while on site with the assistance of anchor-handling vessel(s), assisted by dynamic positioning (DP) thrusters. At the end of operations, the rig's anchors will be retrieved before being towed off location by tugs. The rig is anticipated to be on-site for up to

112 days (excluding mob/de-mob and contingencies), within which up to 56 days is allocated to active drilling (including up to 20 days to drill a contingency mechanical sidetrack).

Underwater noise associated with a jack-up rig is of a very similar dominant frequency range as that from large merchant vessels, albeit of lower average intensity. Measurements alongside a three-legged jack-up rig drilling in shallow water on the Dogger Bank showed that sound levels were in the order of $L_{p,rms}$ 120dB re 1µPa broadband with most energy between 2-1,200Hz; sound levels dropped off rapidly above 8kHz and were in the region of 15-20dB quieter during operations other than drilling (Todd & White 2012). It was noted that, at lower frequencies, the rig was considerably quieter than its associated support vessels (Todd & White 2012). Slightly higher source levels are likely from semi-submersible rigs due to greater rig surface area contact with the water column.

Vessel noise

In addition to the use of tugs to mobilise/de-mobilise and position the rig, supply and standby vessels will support the rig while on-site. A supply vessels will support the rig for 60 days of the drilling programme, and a single standby vessel will be on-station throughout the well operations in case of emergency necessitating evacuation, or in case of person-overboard situations. In addition to noise generated by vessels in transit, cavitational noise is important when vessels are operating under high load conditions (high thrust) and when DP systems are in use (Spence *et al*. 2007, Abrahamsen 2012). For example, the use of thrusters for DP has been reported to result in increased sound generation of *ca.*10dB compared to the same vessel in transit: measurements at 600m range to an offshore supply vessel of 79m length recorded broadband $L_{p,rms}$ (18-3,000Hz) of 148.0dB re 1µPa when in DP mode, compared to 135.5dB re 1µPa when in transit at a speed of 10 knots (Rutenko & Ushchipovskii 2015).

Acoustic modelling in support of oil & gas operations have shown that across a variety of vessels, activities and localities, exposure to $L_{p,rms}$ >180dB re 1 µPa is highly unlikely; levels >160dB re 1 µPa are encountered only within the immediate vicinity of the activity (<50m), while levels > 120dB re 1 µPa are encountered up to a few kilometres (Neptune LNG 2016, Fairweather 2016, Owl Ridge Natural Resource Consultants 2016).

Helicopter operations

Helicopters will be used to transfer personnel to and from the rig, with approximately three helicopter flights per week and an additional two *ad hoc* flights possibly required. Measurements of an air-sea rescue helicopter over the Shannon estuary (Berrow *et al*. 2002) indicated that due to the large impedance mismatch when sound travels from air to water, the penetration of airborne sound energy from the rotor blades was largely reflected from the surface of the water with only a small fraction of the sound energy coupled into the water. The limited number of helicopter flights will occur within established routes.

Potential impacts

Anthropogenic noise in the marine environment is widely recognised as a potentially significant concern, especially in relation to marine mammals. Potential (and postulated) effects of anthropogenic noise on receptor organisms range from acute trauma to subtle behavioural and indirect ecological effects, complicating the assessment of significant effect. The sources, measurement, propagation, ecological effects and potential mitigation of underwater noise have been extensively reviewed and assessed (e.g. Richardson *et al*. 1995, McCauley *et al*. 2000, MMS 2004, Southall *et al*. 2007), while the Offshore Energy SEAs (DECC 2009, 2011, 2016) provided a detailed strategic assessment of the effects of underwater noise associated with offshore energy activities at a regional scale for the UK marine environment.

Marine mammals, for which sound is fundamental across a wide range of critical natural functions, show high sensitivity to underwater sound. Generally, the severity of effects tends to increase with increasing exposure to noise with both sound intensity and duration of exposure being important. A distinction can be drawn between effects associated with physical (including auditory) injury and effects associated with behavioural disturbance. With respect to injury, risk from an activity can be assessed using threshold criteria of sound levels (Southall *et al*. 2007, 2019). In addition, auditory capabilities are frequency-dependent and vary between species. Table 5.6 provides details of the relevant marine mammals listed by functional hearing group, their relevant auditory bandwidth and proposed injury criteria, defined as the sound level at which a permanent threshold shift (PTS; permanent hearing damage) is estimated to occur (Southall *et al*. 2019). Thresholds have been suggested for both impulsive (e.g. seismic airgun pulses, pile-driving, explosions) and non-impulsive (e.g. vessel noise, drilling) sounds, due to the characteristics of impulsive sounds (e.g. steep rise time) having a greater potential for injury than non-impulsive sounds.

It is noted that two metrics are provided for proposed injury threshold criteria (Table 5.6). Broadband SPL, annotated as $L_{p,\mathrm{pk}}$, is a more straightforward calculation best suited to single pulses and for all sounds which include intense peak pressure components. The second metric, sound exposure level (L_E) refers to the total sound energy received over time relative to a reference value in water of 1µPa^2·s; this allows sounds of different durations to be compared in terms of total energy and is better suited to assessing cumulative exposure. The L_E thresholds presented in Table 5.6 correspond to a cumulative exposure over a 24h period with a frequency weighting to compensate quantitatively for the differential frequency response between functional hearing groups.

Table 5.6: Marine mammal auditory injury criteria to impulsive and non-impulsive sounds by functional hearing group

Functional hearing group (species relevant to the Bacchus/Forties area)	**Estimated hearing range (region of greatest sensitivity) [frequency of peak sensitivity]**	**Proposed injury (PTS onset) threshold criteria**	
		Impulsive sounds *Lp,pk* (dB re re 1 µPa)	**Non-impulsive sounds $L_{E,24h}$** (dB re 1 µPa^2·s)
Low-frequency cetaceans Minke whale (*Balaenoptera acutorostrata*)	7Hz to 35kHz (200Hz to 19kHz) [5.6kHz]	219	199
High-frequency cetaceans White-beaked dolphin (*Lagenorhynchus albirostris*) Atlantic white-sided dolphin (*L. acutus*)	150 Hz to 160 kHz (8.8 kHz to 110 kHz) [58 kHz]	230	198
Very High-frequency cetaceans Harbour porpoise (*Phocoena phocoena)*	275 Hz to 160 kHz (12 kHz to 140 kHz) [105 kHz]	202	173
Phocid seals in water Grey seal (*Halichoerus grypus*) Harbour seal (*Phoca vitulina*)	50 Hz to 86 kHz (1.9 kHz to 30 kHz) [13 kHz]	218	201

Notes: $L_{p,pk}$ = unweighted peak sound pressure level (SPL); $L_{E,24h}$ = cumulative sound exposure level over 24 hours, weighted according to functional hearing group.
Source: Southall et al. (2019)

Of the species likely to occur in the Bacchus area, the harbour porpoise (very high-frequency hearing group) has the lowest threshold criteria for the onset of PTS from both impulsive and non-impulsive sounds, at $L_{\mathrm{p,pk}}$ 202dB re 1µPa and $L_{E,24h}$ 173dB re 1µPa^2·s; thresholds for all other functional hearing groups are $L_{p,pk}$ ≥218dB re 1µPa and $L_{E,24h}$ ≥198dB re 1µPa^2·s.

Source levels from sources of non-impulsive noise including rig operations and vessel movements may achieve source sound pressure levels of *ca*.180dB re 1µPa; however, received levels within the general vicinity of operations (i.e. hundreds of metres to a few kilometres) are likely to be of the order of 120-160dB re 1µPa. Consequently, it can be concluded that the proposed activities will not result in auditory injury to any species of marine mammal.

Underwater noise from rig and vessel operations could potentially cause behavioural disturbance of marine mammals present in the area. It has proved difficult to establish broadly applicable threshold criteria for disturbance of marine mammals based on exposure alone. This is due, in part, to the challenges encountered in studies of wide-ranging species with complex behaviour, but also because many behavioural responses are context-specific.

Reported responses of marine mammals to vessels include avoidance, changes in swimming speed, direction and surfacing patterns, and alteration of the intensity and frequency of calls and increases in stress-related hormones (review in Erbe *et al*. 2019). Harbour porpoises, white-sided dolphins and minke whales have been shown to respond to survey vessels by moving away from them, while white-beaked dolphins have shown attraction (Palka & Hammond 2001).

While some behavioural disturbance of harbour porpoise and other cetaceans may occur, the increase in underwater noise from vessel traffic associated with the proposed activities, relative to existing levels in the wider area, is expected to be small. In UK waters, a modelling study indicated a negative relationship between the number of ships and the presence and abundance of harbour porpoises within relevant management units when shipping intensity exceeded a suggested threshold of approximately 80 ships per day (within any of the model's 5km grid cells) in the North Sea (Heinänen & Skov 2015). AIS data (see Section 3.11.3) for 2018 suggests that the majority of 1km^2 grid cells in the Bacchus area experience <10 vessel hours *per month*; although moderate levels of activity (~75 vessel hours per month) occurs around the Forties Field platforms reflecting ongoing operations at these facilities.

It is noted that the Bacchus does not overlap and is not close to any designated or proposed marine protected areas for marine mammals, and is not an area identified as of particular importance to marine mammals. The density of grey and harbour seals in the area is expected to be very low.

Considering the characteristics of the relevant noise sources, the evidence for limited potential of short-term behavioural disturbance, the open nature of the habitat, the generally low densities of marine mammals likely to be present in the area and its apparent low importance relative to other areas within the North Sea (for example: the southern North Sea for harbour porpoise; waters further west for white-beaked dolphin), it is concluded that the proposed activities involving a drilling rig and vessels will not result in significant behavioural disturbance to any species of marine mammal.

Fish and fisheries

There is no evidence of mortality or potential mortal injury to fish from ship noise (Popper *et al*. 2014). While it is recognised that impulsive noise, vessel and other continuous noise may influence several aspects of fish behaviour, including inducing avoidance and altering swimming speed, direction and schooling behaviour, (e.g. De Robertis & Handegard 2013, Popper *et al*. 2014), any such effects will be localised and short-term.

Given the source level characteristics and the context of similar contributions to the ambient anthropogenic noise spectrum of the area over several decades (i.e. the oil and gas associated installations, vessels and rigs movements in and around the Forties and wider central North Sea area), no injury or significant behavioural disturbance to fish populations is anticipated.

Diving birds

Evidence for underwater noise impacts on diving seabirds is very limited. While exposure to very high amplitude low frequency underwater noise (i.e. with tens of metres of underwater explosions) has been shown to cause acute trauma to diving seabirds (Danil & St Leger 2011), no activities which could generate such high intensity impulsive noise will occur during the proposed activities.

Hearing sensitivity for species measured so far peaks between 1 and 3kHz, with a steep roll-off after 4kHz (Crowell *et al*. 2015). The observed region of greatest hearing sensitivity suggests limited overlap with peak energy from rig and vessel operations. As such, and given the short-term duration of vessel presence, in the context of many decades of shipping and fishing activity in the region, and the relatively low importance of the Bacchus area to diving seabirds, significant disturbance to diving seabirds is assessed as highly unlikely.

Conclusion

Considering the characteristics of all the relevant noise sources, the evidence for limited potential of short-term behavioural disturbance among the most sensitive receptors (harbour porpoise), the open nature of the habitat, the generally low densities of marine mammals, diving birds and fishing activity likely to be present in the area and its apparent low importance relative to other areas within the North Sea, it is concluded that the proposed activities will not result in significant behavioural disturbance to relevant species.

5.3 Accidental Events and Major Environmental Incidents

Risk assessment of accidental events involves the identification of credible accident scenarios, evaluation of the probability of incidents, and assessment of their ecological and socio-economic consequences. The principle source of significant effect which could occur as a result of an accident is a large spill of liquid hydrocarbons (blowout). Evaluating spill risk requires consideration of the probability of an incident occurring and the consequences of the impact. The following section considers:

- Historical data, including frequency of relevant incidents
- Possible spill mechanisms, including blowouts and other accidental events
- Fate and behaviour of spilled oil and chemicals
- Oil spill modelling
- Environmental and socio-economic sensitivities and the impacts of an oil spill incident on these sensitivities
- Mitigation measures and response strategy

5.3.1 Historical Frequency of Spill Events on the UKCS

Oil spills on the UKCS have been subject to statutory reporting since 1974 under PON1 (formerly under CSON7); annual summaries of which were initially published in the "Brown Book" series, now superseded by on-line data available from the BEIS website[14]. Discharges, spills and emissions data from offshore installations are also reported by OSPAR (e.g. OSPAR 2019). BEIS data indicates that the most frequent types of spill from mobile drilling rigs have been of chemicals, with fewer numbers of spills of oils which mainly relate to hydraulic fluid, diesel, and a small number of drilling mud losses.

[14] https://www.gov.uk/guidance/oil-and-gas-environmental-alerts-and-incident-reporting#pon-1

Topsides couplings, valves and tank overflows are the most frequent sources of spills from production operations, with most spills being <1 tonne.

Since the mid-1990s, the reported number of spills has increased consistent with more rigorous reporting of very minor incidents (e.g. the smallest reported crude spill in 2019 was 2×10^{-9} tonnes). However, the underlying trend in oil spill quantity (excluding specifically-identified large spills) suggests a consistent annual average of 30 tonnes or less (2014-2019 PON1 data). In comparison, oil discharged with produced water from the UKCS in 2017 totalled 2,139 tonnes (OSPAR 2019).

In 2019 there were a total of 205 oil spills, two of which were greater than one tonne. The 2019 annual total of number recorded spills was the lowest recorded since 1995 and 72 less than the mean annual total of 277 releases reported between 2013 and 2018. Analysis of oil types showed that 40% of reported releases were lubrication and hydraulic oils, followed by fuel oils at 19% and crude oils at 12%, with the remaining spills being releases, largely from drainage systems. The majority of spills were small, with some 80% of releases being less than 10kg, and 51% less than 1kg.

5.3.2 Well Related Scenarios

A number of incidents – loss of well control (blowout), loss of containment, oil and/or chemical spills due to handling and transfers, dropped objects, drilling contingencies (e.g. kicks, downhole mud loss, stuck pipe, etc.), fire/explosion, collision with other vessels – may lead to the loss of hydrocarbons or other chemicals to the sea.

Well control incidents (i.e. “blowouts” involving uncontrolled flow of fluids from a wellbore or wellhead) have been too infrequent on the UKCS for a meaningful analysis of frequency based on UK data. A review of blowout frequencies cited in UKCS Environmental Statements as part of the OESEA2 gave occurrence values in the range 1/1,000-10,000 well-years. Analysis of the SINTEF Offshore Blowout Database which is based on blowout data from the US Gulf of Mexico, UKCS and Norwegian waters for period 1980 to 2014, provided blowout frequencies (per drilled well) for North Sea standard operations, for exploration drilling of normal oil (1.3×10^{-4}) and gas wells (1.6×10^{-4}), as well as deep high pressure high temperature oil (8.0×10^{-4}) and gas (9.8×10^{-4}) wells (IOGP 2019). Accident statistics for offshore units on the UKCS estimated an annual average frequency of blowouts[15] for mobile drilling units of 6.6×10^{-3} per unit year for the period between 2000 and 2007 (based on analysis of a total of 455 unit years, OGUK 2009).

Possible release locations of reservoir fluids from a blowout may be subsurface (with possible escape to seabed outside the well conductor), subsea through loss of containment at the riser, or from the rig (e.g. at the drill floor). Blowout rates and duration may vary significantly according to the reservoir and the formation conditions and to the intervention. Under most conditions, initial flow rates reduce quickly due to natural bridging (reduction in permeability of the rock formations and well bore).

5.3.3 Fate and Behaviour of Spilled Oil

The primary processes of spilled oil on the water are drifting, spreading, and weathering. Drifting is the process of lateral transport of the oil due to the driving force of winds and currents, and is the primary driving mechanism for oil spills. Oil typically moves at 3% of the wind speed and 100% of the current speed. Expected hydrocarbons from Bacchus South are mainly oil, and are expected to be comparable to Bacchus Field fluids, which are a relatively light (35º API) oil.

Diesel is a low viscosity distillate fuel and contains a significant proportion of light-ends, which means that evaporation will be an important process contributing to the reduction in mass balance. Diesel will

[15] An uncontrolled flow of gas, oil or other fluids from the reservoir, i.e. loss of 1.barrier (i.e. hydrostatic head) or leak and loss of 2. barrier, i.e. BOP/ Down Hole Safety Valve (DHSV).

spread rapidly on water and should evaporate within a few days, upon release onto the sea surface, and a small percentage may also dissolve. Evaporation can be enhanced by higher wind speeds, warmer water and air temperatures.

In the event of an OBM mud spill, the spilled material will sink rapidly due to the density of the mud weighting agents, and degradation will take place through the water column and at the seabed (Daan and Mulder, 1996). Sheen may appear at the sea surface due to the base fluids however evaporation and dispersion process will accelerate the natural attenuation.

5.3.4 Fate and Behaviour of Chemicals

The fate of a spilled substance is determined by its volatility, solubility and density. In general terms, a substance spilled at sea will behave in one or more of the following ways: dissolve, evaporate, float, or sink. In addition, some substances may biodegrade or photo-oxidise. The hazard presented by a chemical spill would also reflect the toxicity, flammability, reactivity, explosivity, corrosiveness, etc. of the substance.

5.3.5 Oil Spill Modelling

Spills can impact environmental and socio-economic sensitivities at distance from their source, and risk assessment, therefore, requires the prediction of slick trajectory. For a given scenario, with defined spill volume and weather/metocean conditions, the behaviour of a slick can be modelled.

A spill of oil representative of a blowout of Bacchus crude was modelled stochastically using the Oil Spill Contingency and Response (OSCAR) model v11.0.1. Modelling was undertaken seasonally (December-February, March-May, June-August and September to November) for a well blowout scenario, with the shortest time and related probability for oil to cross the median line or reach the coast calculated for the UK and adjacent states. The results are summarised in Table 5.9 and in Figure 5.2 and Figure 5.3. Metocean parameters used in the model are summarised in Table 5.7.

Table 5.7: Metocean and hydrocarbon parameters used in oil spill scenarios

<table>
<tr><th colspan="2">Release parameter</th><th colspan="2">Crude blowout</th></tr>
<tr><td colspan="2">Release rate/quantity</td><td colspan="2">58,446 m³/day on day 1, declining to 3,708 m³/day at day 120</td></tr>
<tr><td colspan="2">Total simulation time</td><td colspan="2">130 days[1]</td></tr>
<tr><td colspan="2">Release period</td><td colspan="2">Multi-year statistic (seasonal)</td></tr>
<tr><td colspan="2">Number of simulations</td><td colspan="2">25 per year</td></tr>
<tr><td colspan="2">Total number of simulations</td><td colspan="2">Total number of simulations per season in excess of 100</td></tr>
<tr><td colspan="2">Diameter of release pipe</td><td colspan="2">9-5/8”</td></tr>
<tr><td colspan="2">Density of released gas</td><td colspan="2">1.6 kg/m³</td></tr>
<tr><th colspan="4">Metocean parameters</th></tr>
<tr><td>Air temperature</td><td>Variable</td><td>Sea temperature</td><td>Variable</td></tr>
<tr><td>Wind data
(years covered)</td><td>2008 – 2014</td><td>Wind data reference</td><td>European Centre for Medium-Range Weather Forecasts (ECMWF)</td></tr>
<tr><td>Current data
(years covered)</td><td>2008 – 2014</td><td>Current data reference</td><td>Hybrid Coordinate Ocean Model (HYCOM)</td></tr>
</table>

Notes: [1]release duration assumed to be arrested after 120 days, as indicted by worst case relief well drilling estimated timings.

Table 5.8: Probability (≥1%) and shortest time of surface oil crossing median line

Member States	Dec – Feb	Mar – May	Jun – Aug	Sep – Nov
Norwegian Waters	**90 – 100%**	**90 – 100%**	90 – 100%	90 – 100%
	18 hours	**18 hours**	24 hours	21 hours
Danish Waters	**90 – 100%**	**90 – 100%**	90 – 100%	70 – 80%
	7 days	**7 days**	8 days	8 days
Swedish Waters	**80 – 90%**	90 – 100%	90 – 100%	70 – 80%
	13 days	16 days	15 days	13 days
German Waters	60 – 70%	**90 – 100%**	60 – 70%	50 – 60%
	14 days	13 days	15 days	**7 days**
Dutch Waters	50 – 60%	**80 – 90%**	40 – 50%	40 – 50%
	12 days	13 days	18 days	**11 days**
Faroese Waters	1 – 5%	**10 – 20%**	-	1 – 5%
	>20 days	**>20 days**	-	>20 days

Table 5.9: Shoreline oiling probability: shortest time (days) to beach and % probability for shoreline oiling

Shoreline	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov
United Kingdom				
Scotland				
Shetland	40 – 50%	30 – 40%	30 – 40%	**50 – 60%**
	6 days	11 days	>20 days	7 days
Orkney	30 – 40%	5 – 10%	1 – 5%	10 – 20%
	5 days	**5 days**	>20 days	16 days
Highlands	20 – 30%	5 – 10%	-	10 – 20%
	14 days	14 days	-	>20 days
Grampian	**50 – 60%**	20 – 30%	10 – 20%	**50 – 60%**
	10 days	7 days	>20 days	7 days
Tayside	20 – 30%	10 – 20%	5 – 10%	30 – 40%
	15 days	11 days	>20 days	8 days
Fife	30 – 40%	10 – 20%	5 – 10%	30 – 40%
	15 days	13 days	>20 days	11 days
Lothian	20 – 30%	10 – 20%	1 – 5%	20 – 30%
	14 days	15 days	>20 days	13 days
Borders	30 – 40%	10 – 20%	1 – 5%	20 – 30%
	14 days	16 days	>20 days	19 days
England				
North East	20 – 30%	10 – 20%	1 – 5%	**30 – 40%**
	17 days	**17 days**	>20 days	>20 days
Yorkshire and The Humber	10 – 20%	10 – 20%	1 – 5%	10 – 20%
	>20 days	>20 days	>20 days	>20 days

Shoreline	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov
East Midlands	-	-	-	5 -10%
	-	-	-	>20 days
North Sea Member States				
Norway	**90 – 100%**	**90 – 100%**	**90 – 100%**	**90 – 100%**
	7 days	8 days	11 days	**7 days**
Denmark	80 – 90%	**90 – 100%**	90 – 100%	40 – 50%
	11 days	**10 days**	12 days	10 days
Sweden	60 – 70%	**80 – 90%**	**80 – 90%**	60 – 70%
	17 days	**17 days**	**17 days**	15 days
Germany	20 – 30%	**20 – 30%**	5 – 10%	10 – 20%
	>20 days	**19 days**	>20 days	19 days
Netherlands	5 – 10%	**10 – 20%**	-	-
	>20 days	**>20 days**	-	-
Maximum accumulations onshore				
After 130 days[16]	**51,225 m^3**	**48,659 m^3**	**46,414 m^3**	**40,477 m^3**

[16] [1]This is the maximum mass accumulated onshore across all beaching locations from one of the 100+ simulations. Highlighted/bold figures indicate the greatest shoreline oiling likelihood and shortest time to beaching for each area

Figure 5.2: Probability (≥10%) of Surface Oiling Meeting or Exceeding 0.3 µm

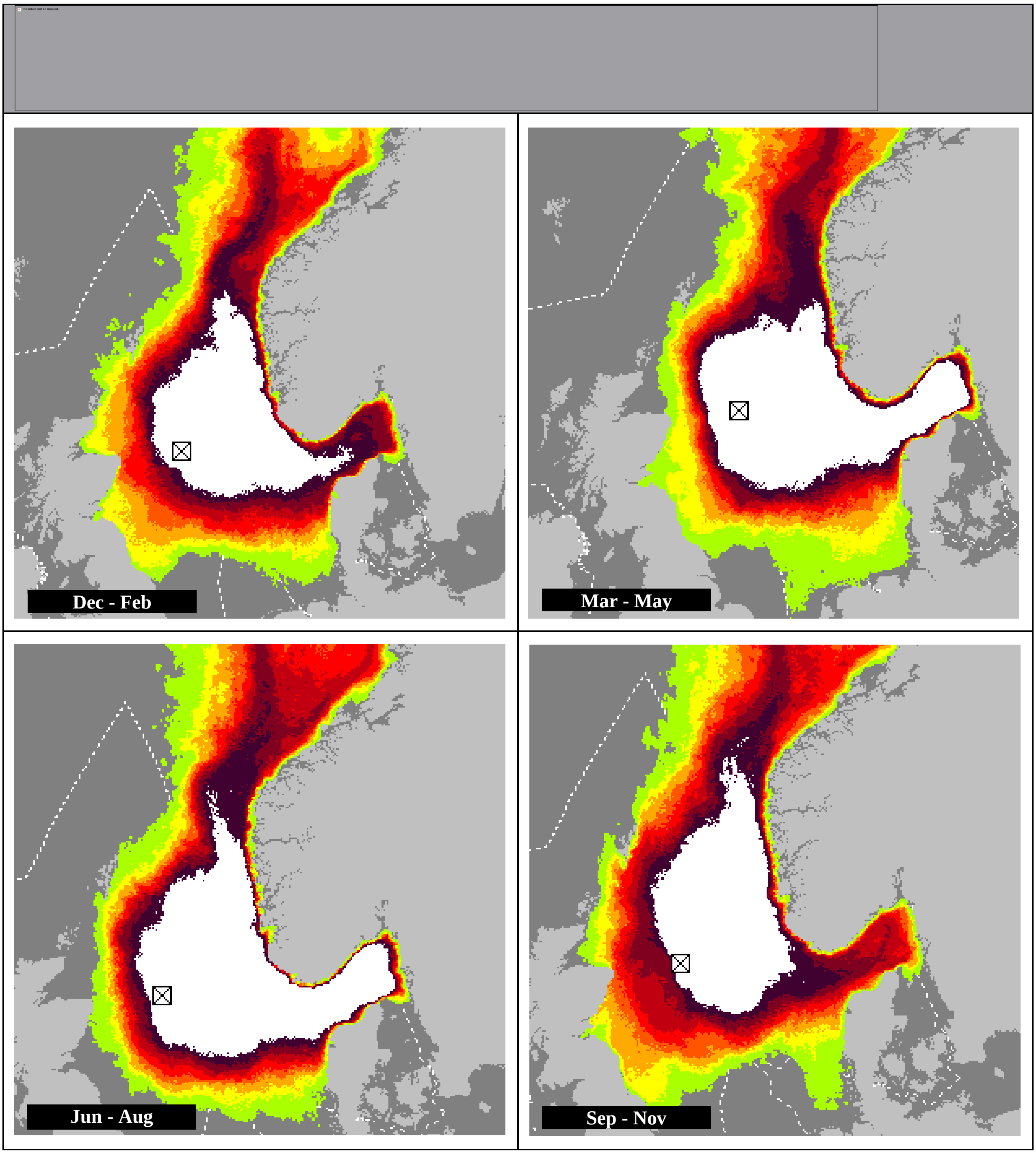


Figure 5.3: Probability (≥1%) of Surface Oil (≥0.3 µm) Crossing Median Line

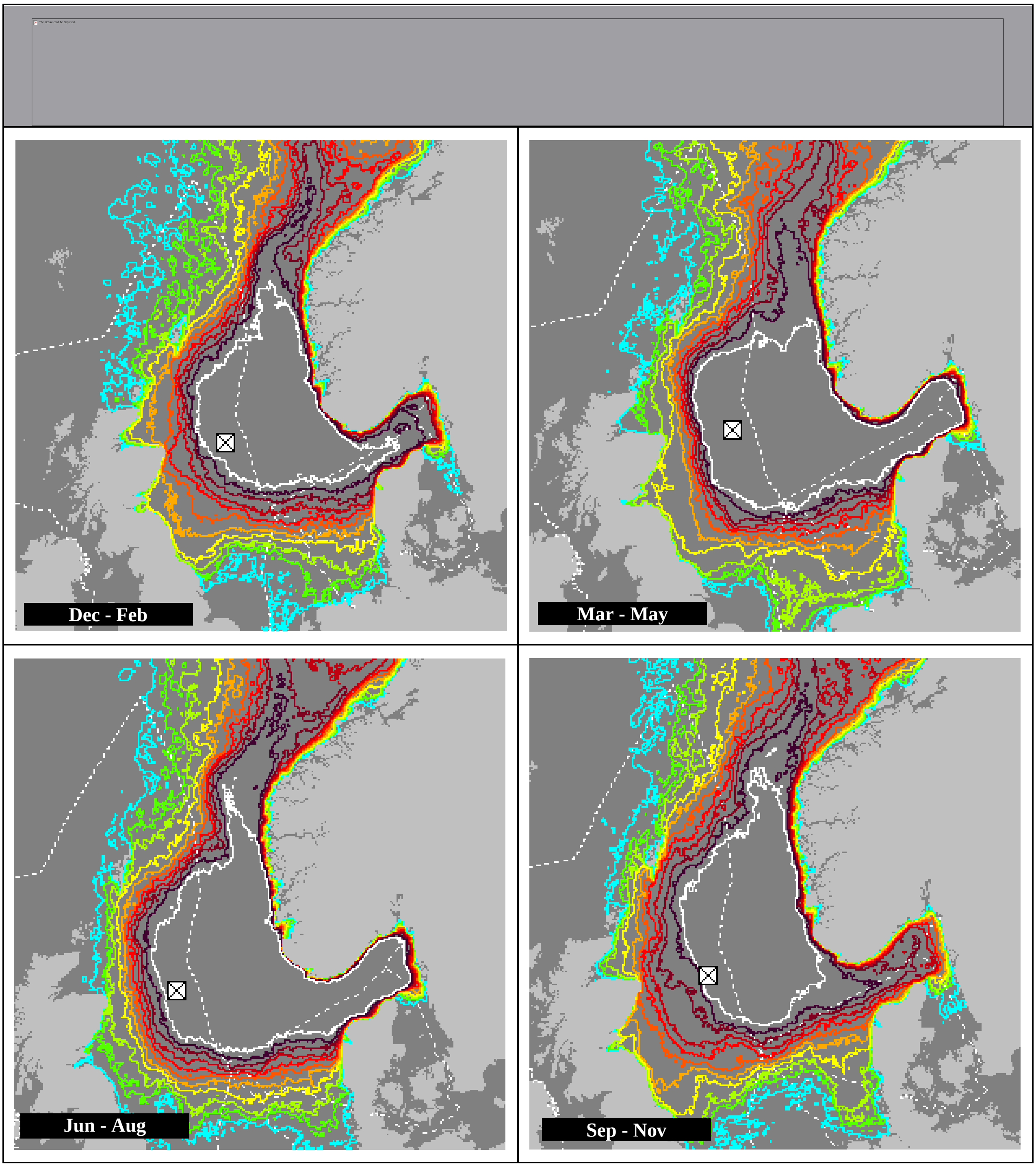
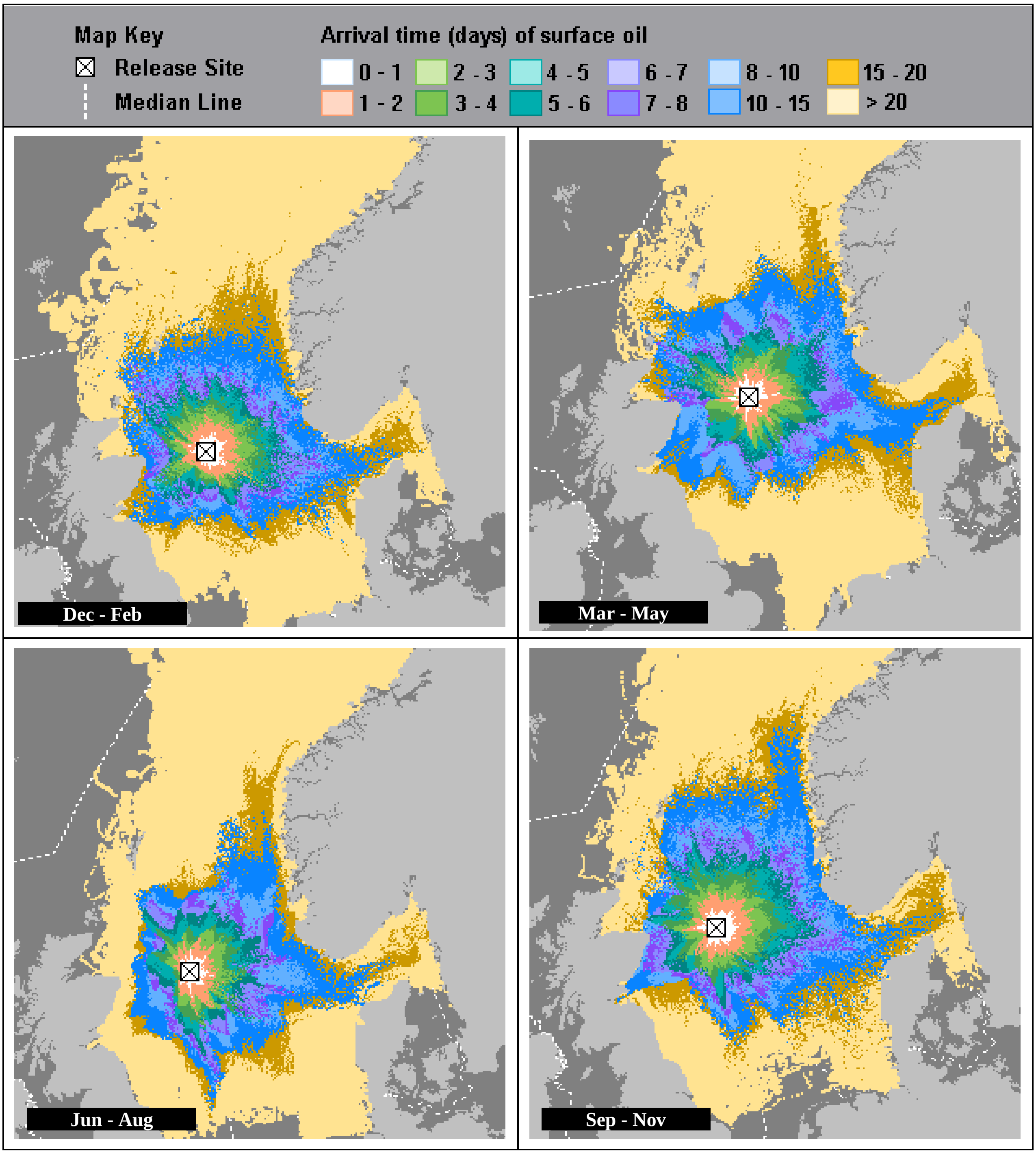


Figure 5.4: Arrival Time of Surface Oil



5.3.6 Spill Risk and Major Environmental Incident Assessment

There is a requirement under the EIA Regulations to assess the worst case oil spill scenarios, summarising the likely fate and impact of the potential release. – see Sections 5.3.1-5.3.6 above.

The publication of Directive 2013/30/EU on safety of offshore oil and gas operations (EUOSD) and *The Offshore Installations (Offshore Safety Directive) (Safety Case etc) Regulations 2015* (SCR 2015) that transpose the requirements of the Directive into UK law, acknowledged the environmental element associated with major accident hazards (MAH), with the regulations now including a further definition of Major Accident, a Major Environmental Incident (MEI). A MEI is an incident which results, or is likely to result in, significant adverse effects on the environment and for an incident to be a MEI, it must have as a precursor, a safety related major accident; an MEI can only occur as a consequence of a major accident. There is now significant overlap with the SCR 2015 and EIA requirements and as such, it should be determined if the uncontrolled release of hydrocarbons will result in a significant impact that would constitute an MEI.

In its definition of MEI, the EUOSD describes this as an incident which *results, or is likely to result, in a significant adverse effects on the environment in accordance with Directive 2004/35/EC*. From this Directive, and in respect to significant adverse effects, environmental damage is defined as:

- *damage to protected species and natural habitats which is any damage that has significant adverse effects on reaching or maintaining the favourable conservation status of such habitats or species. The significance of such effects is to be assessed with reference to the baseline conditions, taking account of the criteria set out in Annex I (of the Directive)*
- *water damage which is any damage that significantly adversely affects the ecological, chemical and/or quantitative status and/or ecological potential as defined in Directive 2000/60/EC or the waters concerned*
- *land damage, which is any land contamination that creates a significant risk of human health being adversely affected as a result of the direct or indirect introduction in, on or under land, of substances, preparations, organisms or micro-organisms*

Here, “damage” is defined as a measurable adverse change in natural resource or measurable impairment of a natural resource service which may occur directly or indirectly.

The impact that may be caused by a spill is dependent on the location of the spill, spill size, the hydrocarbon properties, the prevailing weather and metocean conditions at the time of the spill, the sensitivities of environmental receptors that could be impacted by the spill, and the success of the spill response process.

The loss of diesel inventory and inventories of chemicals are expected to rapidly disperse to levels where their impact would not be considered significant. Therefore, the impact from these accident hazards would not constitute an MEI, in terms of the above, and have not been considered further.

The remaining uncontrolled release of a liquid hydrocarbon related to a major accident from Bacchus South is a well blowout during drilling of the infill well (based on a loss of 58,445.9m^3/day, declining to 3,708.3m^3/day at day 120). The results of this modelling and the impact of oil on relevant sensitivities are shown in section 5.3.5 above.

The impact from the well blowout has been identified as a MEI, due to the potential environmental impacts on protected sites and species (if the release were to occur in the absence of mitigation and response). An uncontrolled spill of Bacchus oil is not expected to result in water or land damage as described above, and are not considered further, with the focus of this assessment therefore the potential damage to protected species and natural habitats. The impact that may be caused by a spill is dependent on the location of the spill, spill size, the hydrocarbon properties, the prevailing weather and metocean conditions at the time of the spill, the sensitivities of environmental receptors that could be impacted by the spill, and the success of the spill response process.

Protected Sites and Species

Coastal sensitivities to oil spills are well-recognised, and despite the controls and mitigation measures in place, the possibility of a crude oil spill resulting in oiling of the coast (assuming a worst-case scenario) cannot be ruled out, though the probability of such a spill occurring and affecting the coast is considered extremely remote.

Special Protection Areas (SPA) are classified for rare and vulnerable birds, listed in Annex I of the Birds Directive (2009/147/EC), and for regularly occurring migratory species, and Special Areas for Conservation (SAC) are classified for habitats and species most in need of conservation at a European level, as listed in Annex I and Annex II of the Habitats Directive (92/43/EEC) respectively. These sites are collectively referred to as Natura 2000. Several offshore SACs have been classified in UK waters, and those of adjacent EU Member States, however there are comparatively fewer offshore SPAs, and none in the UK North Sea. At a national level, the other principal offshore designated areas established for the protection of species and habitats are Nature Conservation Marine Protected Areas (NCMPA) and Marine Conservation Zones (MCZ) (see Section 3.10). Both Natura 2000 and national designations are also present along the coastlines of Europe.

The offshore and coastal sites potentially affected by oiling as a result of an uncontrolled release (well blowout) from the proposed activities are shown in Figure 5.5 to Figure 5.9. These sites were selected for inclusion/exclusion with respect to whether there was the potential for an interaction with the marine features for which they are designated, and an oil spill. Sites relevant to UK coasts and waters are also listed in

Table 5.10: Selected UK protected sites and species potentially impacted by uncontrolled release of hydrocarbons

Site name	Feature present[1]	Designated features
Special Protection Areas (SPA)		
Hermaness, Saxa Vord and Valla Field	B	**Qualifying feature:** red-throated diver, gannet, great skua, breeding seabird assemblage
Fetlar	B	**Qualifying feature:** Arctic tern, red-necked phalarope, dunlin, great skua, whimbrel, breeding seabird assemblage
Otterswick and Graveland	B	**Qualifying feature:** Red-throated diver
Ronas Hill-North Roe and Tingon	B	**Qualifying feature:** Red-throated diver, skua
Papa Stour	B	**Qualifying feature:** Arctic tern
East Mainland Coast, Shetland pSPA	B	**Qualifying feature:** red-throated diver, great northern diver, Slavonian grebe, eider, long-tailed duck, red-breasted merganser
Bluemull and Colgrave Sounds pSPA	B	**Qualifying feature:** Red-throated diver
Noss	B	**Qualifying feature:** gannet, great skua, guillemot, breeding seabird assemblage
Sumburgh Head	B	**Qualifying feature:** Arctic tern, breeding seabird assemblage
Papa Westray (North Hill and Holm)	B	**Qualifying feature:** Arctic tern
East Sanday Coast	W	**Qualifying feature:** purple sandpiper, turnstone

Site name	Feature present[1]	Designated features
North Orkney pSPA	B, W	**Qualifying feature:** red-throated diver, great northern diver, Slavonian grebe, eider, long-tailed duck, velvet scoter, red-breasted merganser, shag
Orkney Mainland Moors	B	**Qualifying feature:** hen harrier, red-throated diver, short-eared owl, hen harrier
Auskerry	B	**Qualifying feature:** arctic tern, storm petrel
Copinsay	B	**Qualifying feature:** Breeding seabird assemblage
Hoy	B	**Qualifying feature:** peregrine, red-throated diver, **b**reeding seabird assemblage
Scapa Flow pSPA	B, W	**Qualifying feature:** red-throated diver, great northern diver, black-throated diver, Slavonian grebe, shag, eider, long-tailed duck, goldeneye, red-breasted merganser
Foula	B	**Qualifying feature:** Arctic tern, Leach's storm petrel, red-throated diver, great skua, common guillemot, Atlantic puffin, European shag, breeding seabird assemblage
Seas off Foula	-	**Qualifying feature:** Proposed marine area encompassing Foula, covering the marine foraging habitat and prey supporting the currently protected seabird colony and waters immediately surrounding it
Mousa	B	**Qualifying feature:** Storm petrel, Arctic tern, common guillemot
Fair Isle	R, B	**Qualifying feature:** Fair Isle wren, Arctic tern, breeding seabird assemblage
Sumburgh Head	B	**Qualifying feature:** Breeding seabird assemblage
Pentland Firth Islands	B	**Qualifying feature:** Arctic tern, and breeding seabird assemblage
Pentland Firth[17]	-	**Qualifying feature:** Proposed waters within the Pentland Firth between the north coast of Caithness and the south of Orkney mainland. Breeding Arctic ten and seabird assemblage.
East Caithness Cliffs	B	**Qualifying feature:** peregrine, razorbill, herring gull, shag, kittiwake, guillemot, seabird assemblage
Moray Firth pSPA	W, B	**Qualifying feature:** great northern diver, , red-throated diver, Slavonian grebe, shag, scaup, eider, long-tailed duck, common scoter, velvet scoter, common goldeneye, red-breasted merganser, shag
Troup, Pennan and Lion's Heads	B	**Qualifying feature:** guillemot, breeding seabird assemblage
Loch of Strathbeg	B, W	**Qualifying feature:** sandwich tern, whooper swan, teal, greylag goose, pink-footed goose, goldeneye, waterfowl assemblage
Buchan Ness to Collieston Coast	B	**Qualifying feature:** Breeding seabird assemblage
Ythan Estuary, Sands of Forvie and Meikle Loch	B	**Qualifying feature:** common tern, little tern, Sandwich tern, pink-footed goose, waterfowl assemblage
Ythan Estuary, Sands of Forvie and Meikle Loch pSPA (extension)	B	**Qualifying feature:** Sandwich tern, little tern
Fowlsheugh	B	**Qualifying feature**: guillemot, kittiwake, breeding seabird assemblage
Montrose Basin	W	**Qualifying feature:** greylag goose, knot, pink-footed goose, oystercatcher, redshank, waterfowl assemblage

[17] Further consultation on proposed Special Protection Areas in Scotland is underway: https://consult.gov.scot/marine-scotland/sea-and-site-classification/. It has been recommended that the Pentland Firth pSPA be removed from the network. This site is still listed here as a decision on whether to take the site forward for classification has not yet been made by Scottish Ministers.

Site name	Feature present[1]	Designated features
Firth of Tay and Eden Estuary	B, W	**Qualifying feature**: little tern, marsh harrier, bar-tailed godwit, greylag goose, pink-footed goose, redshank, waterfowl assemblage
Outer Firth of Forth and St Andrews Bay Complex	B, W, P	**Qualifying feature:** Proposed (pSPA) area stretching from Arbroath to St Abb's Head, encompassing the Firth of Forth, the outer Firth of Tay and St Andrews Bay, supports important populations of 21 species of marine birds. Includes breeding common tern, Arctic tern, shag, gannet; over-wintering red-throated diver, little gull, Slavonian grebe, eider; seabird and waterfowl assemblages.
St Abb's Head to Fast Castle SPA	B	**Qualifying feature:** Breeding seabird assemblage
Northumberland Marine	B	**Qualifying feature:** Arctic tern, common tern, common guillemot, little tern Atlantic puffin, roseate tern, sandwich tern, breeding seabird assemblage
Northumbria Coast	B, W	**Qualifying feature:** little tern, arctic tern, purple sandpiper, turnstone
Coquet Island	B	**Qualifying feature:** Arctic tern, common tern, roseate tern, Sandwich tern, breeding seabird assemblage
Farne Islands	B	**Qualifying feature:** Arctic tern, Common tern, Sandwich tern, guillemot, breeding seabird assemblage
Teesmouth and Cleveland Coast	B, W, P	Qualifying feature: avocet, sandwich tern, common tern, ruff, knot, redshank, waterfowl assemblage
Lindisfarne	B, W, P	Qualifying feature: little tern, roseate tern, bar-tailed godwit, golden plover, whooper swan, ringed plover, grey plover, greylag goose, light-bellied brent goose, sanderling, wigeon, dunlin, ringed plover, long-tailed duck, red-breasted merganser, eider, shelduck
Flamborough and Filey Coast	B	**Qualifying feature: k**ittiwake, gannet, guillemot, razorbill, breeding seabird assemblage
Special Areas of Conservation (SAC)		
Mousa	YR	**Qualifying feature:** Harbour sea, Reefs, Submerged or partially submerged sea caves
Fair Isle	YR	**Qualifying feature:** Vegetated sea cliffs of the Atlantic and Baltic Coasts, European dry heaths.
Yell Sound Coast	YR	**Qualifying feature:** otter, harbour seal
Buchan Ness to Collieston Coast	YR	**Qualifying feature:** Vegetated sea cliffs of the Atlantic and Baltic Coasts
Scanner Pockmark	YR	**Qualifying feature:** Submarine structures made by leaking gas
Pobie Bank Reef	YR	**Qualifying feature:** Reefs
Braemar Pockmarks	YR	**Qualifying feature:** Submarine structures made by leaking gases
Sanday	YR	**Qualifying feature:** Sandbanks, Mudflats and sandflats, harbour seal
East Caithness Cliffs	YR	**Qualifying feature:** Sea cliffs
River Naver	YR	**Qualifying feature:** freshwater pearl mussel, Atlantic salmon
River Thurso	YR	**Qualifying feature:** Atlantic salmon
Berriedale and Langwell Waters	YR	**Qualifying feature:** Atlantic salmon
Moray Firth	YR	**Qualifying feature:** Bottlenose dolphin
River Spey	YR	**Qualifying feature:** freshwater pearl mussel, sea lamprey, Atlantic salmon, otter
Sands of Forvie	YR	**Qualifying feature: c**oastal dunes
River Dee	YR	**Qualifying feature:** freshwater pearl mussel, Atlantic salmon, otter
River South Esk	YR	**Qualifying feature:** freshwater pearl mussel, Atlantic salmon
River Tay	YR	**Qualifying feature**: Atlantic salmon, sea lamprey, brook lamprey, river lamprey, otter

Site name	Feature present[1]	Designated features
Firth of Tay and Eden Estuary	YR	**Qualifying feature:** sandbanks, mudflats and sandflats, harbour seal
Isle of May	YR	**Qualifying feature:** reefs, grey seal
St Abb's Head to Fast Castle	YR	**Qualifying feature:** Sea cliffs
River Tweed	YR	**Qualifying feature:** Atlantic salmon, sea lamprey, brook lamprey, river lamprey, otter
Tweed Estuary	YR	**Qualifying feature**: estuaries, mudflats and sandflats, sea lamprey, river lamprey
Dogger Bank	YR	**Qualifying feature:** Sandbanks which are slightly covered by seawater all the time
Berwickshire and North Northumberland Coast	YR	**Qualifying feature:** Mudflats and sandflats not covered by seawater at low tide, Large shallow inlets and bays, Reefs, Submerged or partially submerged sea caves, Grey seal
Southern North Sea	YR	**Qualifying feature:** Harbour porpoise
Nature Conservation Marine Protected Areas (NCMPA)		
Mousa to Boddam	YR	**Qualifying feature:** Sandeels, Marine geomorphology of the Scottish Shelf Seabed.
Southern Trench	YR, M	**Qualifying feature:** Proposed area for Burrowed mud, fronts, minke whale and shelf deeps, Quaternary of Scotland – sub-glacial tunnel valleys and moraines, submarine mass movement – slide scars
Central Fladen	YR	**Qualifying feature:** Burrowed mud (seapens and burrowing megafauna and tall seapen components), Sub-glacial tunnel valley representative of the Fladen Deeps
Norwegian Boundary Sediment Plain	YR	**Qualifying feature:** *Arctica islandica* aggregations
East of Gannet and Montrose Fields	YR	**Qualifying feature:** Offshore deep sea muds, *Arctica islandica* aggregations
Turbot Bank	YR	**Qualifying feature:** Sandeels
Firth of Forth Banks Complex	YR	**Qualifying feature:** *Arctica islandica* aggregations, offshore subtidal sands and gravels, shelf banks and mounds, moraines representative of Wee Bankie Kay Geodiversity Area
Marine Conservation Zones (MCZ)		
North East of Farnes Deep	YR	**Qualifying feature:** Subtidal coarse sediment, subtidal sand, subtidal mixed sediments, subtidal mud, *Arctica islandica* aggregations
Farnes East	YR	**Qualifying feature:** Moderate energy circalittoral rock, subtidal coarse sediment, subtidal sand, subtidal mud, subtidal mixed sediments, sea-pen and burrowing megafauna communities, *Arctica islandica* aggregations
Swallow Sand	YR	**Qualifying feature:** Subtidal coarse sediment, Subtidal sand, North Sea glacial tunnel valley
Fulmar	YR	**Qualifying feature:** Subtidal sand, Subtidal mud, Subtidal mixed, sediments, *Arctica islandica* aggregations
Berwick to St Mary's	YR	**Qualifying feature:** Common eider
Runswick Bay	YR	**Qualifying feature:** High and moderate and low energy intertidal rock, and circalittoral/infralittoral rock; subtidal sand, mud, and coarse and mixed sediments, *Arctica islandica* aggregations

Any weathered oil as a result of a well blowout from Bacchus, is not expected to have, or likely to have, a significant effect on certain habitat features of those sites identified, for example sandbanks covered by seawater all of the time, submarine structures made by leaking gases, or reefs (e.g. features of Dogger Bank, Scanner pockmark, Pobie Bank); and geological features of NCMPAs (e.g. those of Mousa to

Boddam, Southern Trench and Central Fladen), as these features are not generally considered sensitive to oil spills.

Seabirds and marine mammals are generally considered the most vulnerable components of the ecosystem to oil spills in offshore and coastal environments, because of their close association with the sea surface. Benthic habitats and species may also be sensitive to deposition/sedimentation of oil. Effects on sediment communities are typically associated with deoxygenation and organic enrichment.

Mechanisms of impact on seabird populations include oiling of plumage and loss of insulating properties, and ingestion of oil during preening causing liver and kidney damage (Furness & Monaghan 1987). Indirect effects associated with bioaccumulation of contaminants from prey, and reduced prey availability, are also possible. The impact of the Macondo (Deepwater Horizon) well blowout on birds offshore is difficult to quantify due to the low resolution of antecedent seabird surveys and the paucity of observed carcasses during the oil spill response, potentially due to the rapid decomposition rates of bird carcasses in the relatively warm seas, opportunistic scavenging (e.g. by tiger sharks), and due to in situ burning of surface oil slick (Haney *et al.* 2014a). Modelling (Haney *et al*. 2014a, b) estimated mortality of 200,000 in coastal and open waters immediately after the blowout, when considered across the range of species known to be affected by the spill, would represent <10% of their breeding population. When considering those birds exposed in coastal and estuarine environments, Haney *et al*. (2014b) estimated that bird mortality was approximately 700,000. Within coastal waters, mortality was estimated to have mainly affected four species: northern gannet *Morus bassanus* (8%), brown pelican *Pelecanus occidentalis* (12%), royal tern *Thalasseus maximus* (13%) and laughing gull *Leucophaeus atricilla* (32%). Both studies suggested future work is required to understand the demographic consequences to the Gulf's coastal birds from this large marine spill. Sackmann and Becker (2015) criticised the study by Haney *et al,* who suggested there was an overestimation of bird deaths, from the underestimation of carcass transport probability to shoreline, this subsequently refuted by Haney *et al*. (2015) (Beyer *et al*. 2016).

The vulnerability of seabirds to surface oiling is related to individual species' behavioural patterns, distribution and ecological characteristics, such as potential rate of population recovery. Seabirds are considered one of the groups most vulnerable to oil spills in offshore and coastal environments. There are a number of SPAs along the north east coast of the UK, such as the East Caithness Cliffs and Troup, Pennan and Lion's Head, as well as the SPAs located within the various Firths of the region (Cromarty Firth and Inner Moray Firth), and some in adjacent states including Germany (Seevogelschutzgebiet Helgoland SPA) which have breeding seabird features. There is the potential for these mobile qualifying species of relevant sites to interact with waters where surface oil has the potential to meet or exceed 0.3µm in thickness. There is, therefore, the potential that if a major spill from Bacchus were to occur, weathered oil could theoretically affect these mobile species; seabird sensitivity in Blocks 21/10 and 22/6 and neighbouring Blocks is low, for those months with data, with the exception of a small number adjacent blocks scored as medium (see Table 3.2). However, for six months of the year no data are available.

Fortunately, there is little experience of major oil spills in the vicinity of seabird colonies in the UK. In January 1993 the Braer ran aground at Garth's Ness in Shetland and began leaking Norwegian Gulfaks crude oil, spilling a total 85,000 tonnes of oil. 207 birds were received at the cleaning centre set up to deal with oiled birds, of these 23 were successfully rehabilitated, while an estimated 31 out of 34 seals were successfully rehabilitated. There was difficulty in determining the number of birds that died as a result of the oil as some would never have been found and stormy weather at the time of the spill caused a high mortality of storm victims that became oiled after death. 1,538 dead birds were found on the beaches including shag (857), black guillemot (203), kittiwake (133), and long-tailed duck (96), as well as great northern diver (13), eider (70) and great black-backed gull (45). There was a clear excess of females over males found. The main groups of breeding seabirds affected by the spill were locally resident species, as summer visitors were not in Shetland waters at the time of the spill. In general the 1993 breeding season was successful for most species that may have been affected by the oil spill, with the exception of shag and black guillemot (Heubeck and Mellor 1993, DTI 2003). The stormy weather during the Braer spill resulted in the rapid dispersion of the oil in the water column. Long term effects on wildlife have proved to be less than first feared with the most notable impact on breeding populations of resident seabirds closest to the spill (Heubeck and Mellor 1993).

Generally, marine mammals (which rely on blubber for insulation) are less vulnerable than seabirds to fouling by oil, but they are at risk from hydrocarbons and other chemicals that may evaporate from the surface of an oil slick at sea within the first few days. In contrast to seabirds there is relatively little evidence of direct mortality associated with oil spills (Geraci & St. Aubin 1990, Hammond *et al.* 2003), although the aggregated distribution of some species (especially dolphins) may expose large numbers of individuals to localised oiling. In the unlikely event of mortality from a spill, population recovery rates are likely to be lower than for most bird species.

Grey seals (e.g. Berwickshire and North Northumberland Coast SAC) and harbour seals (e.g. Mousa SAC, Firth of Tay and Eden Estuary SAC) come ashore regularly throughout the year between foraging trips and additionally spend significantly more time ashore during the moulting period (February-April in grey seals and August-September in harbour seals) and particularly the pupping season (October-December in grey seals and June-July in harbour seals). Animals most at risk from oil coming ashore on seal haulout sites and breeding colonies are neonatal pups, which rely on their prenatal fur and metabolic activity to achieve thermal balance during their first few weeks of life, and are therefore more susceptible than adults to external oil contamination. Direct mortality of seals as a result of contaminant exposure associated with major oil spills has been reported, e.g. following the Exxon Valdez oil spill in Alaska in 1989. Animals exposed to oil over a period of time developed pathological conditions including brain lesions. Additional pup mortality was reported in areas of heavy oil contamination compared to un-oiled areas.

Any spilled oil would be expected to float on the sea surface (SG of Bacchus being lower than that of seawater), some low viscosity oils (Bacchus has a viscosity of 13.9) may disperse naturally within the top few metres of the water column. Concentrations of oil in the upper levels of the water column may be sustained close to the release point, in the event the release of oil is continuous. However, spilled oil, with the Bacchus SG, is not expected to penetrate the lower depths of the water column, and as such the impact on species in these lower levels, or on the seabed, is expected to be low (ITOPF 2014).

The sensitivity of planktonic and pelagic communities (e.g. fish and cephalopods) is believed to be lower, both in terms of exposure pathways and the higher recovery potential associated with reproductive capacity. In the unlikely event of oil reaching the seabed, there is potential for localised smothering of habitats used by fish, either as spawning, feeding or nursery grounds, and other benthic fauna. In addition to direct toxicity of oil and dispersants, oil and certain chemicals have the potential to introduce taint (defined as the ability of a substance to impart a foreign flavour or odour to the flesh of fish and shellfish, following prolonged and regular discharges of tainting substances). A number of coastal SACs in the UK (Berriedale and Langwell Waters SAC), and adjacent states (e.g. Nissum Fjord SAC, Nordre älvs estuarium SAC), are designated for migratory and diadromous fish which have the potential for an interaction with any spill, however, fish are at greatest risk from contamination by oil spills when the water depth is very shallow

Perceived or actual contamination of target species with hydrocarbons or other chemicals may result in economic damage to the fishing industry and associated industries. Following a spill or other incident, in some circumstances exclusion orders may be issued preventing marketing of seafood from areas considered to be contaminated, resulting in economic impacts on both the fishing and processing industries. Loss of public confidence in seafood quality from an affected area may also impact on sales revenues. The landings from Scottish vessels include fish from the Bacchus and wider Forties Area, which lies to the south of a large area of moderate to high level of fishing effort over the Fladen Ground. Monthly fishing effort over the period 2016-2018 was variable, though is low through most of the year, with no well-defined seasonal pattern, with fisheries targeting both demersal and pelagic species, as well as *Nephrops* from ICES rectangles coinciding with the Bacchus area (44F0 and 44F1) – see Section 3.11.2.

The modelling scenario indicates the oil from an unconstrained release, without emergency response, has the potential to beach on the UK coastline (Scotland and England) and the coastline of a number of other North Sea Member States (NSMB) (Norway, Denmark, Sweden, Germany and the Netherlands), with Shetland and Grampian in the UK (50-60% each) and Norway and Denmark from the NSMBs (90-100%) having the highest probability for oil beaching. Orkney in the UK has the shortest estimated time for oil reaching the shoreline, at 5 days, with the probability of this being 30-40% (Dec-Feb). The worst case beaching accumulation (total across all beaching locations) is estimated at 51,225m^3 (Dec-Feb).

The extent to which beached oil can have an impact will depend on a number of factors, including the oil characteristics, (Bacchus oil is a light crude), the volume of oil beaching, the levels of energy to which the shoreline is exposed, as well as the sensitivities present and their tolerance/recovery rates. High energy rocky shores, exposed to the scouring effects of wave action and tidal currents, which elicits the natural break up of oil, with any beached oil on rock surface exposed to weathering, are generally more resilient to the effects of an oil spill. More sheltered, low energy areas, not exposed to the same rigorous wave and tidal regimes, are less resilient and more sensitive to spill.

While the modelling scenario indicates there is a 50-60% probability of beaching in some areas along the UK coast, or up to 100% in Norway and Denmark, the corresponding probability that this surface oil will reach, or exceed 0.3µm can be much lower; and, while it is difficult to determine the quantity of oil that will give rise to damage to a protected site or species to significantly affect it from reaching or maintaining its conservation status, it can be assumed the greater the volume of oil beaching, the greater the potential for a significant environmental impact.

Evaluating spill risk also requires consideration of the probability of an incident occurring. While it is evident from the Deepwater Horizon incident that well blowouts with environmentally significant consequences can and do happen, historically, spills of this magnitude, as a result of well blowouts, have not occurred on the UKCS or in the wider North Sea, and the probability remains remote.

Overall, while the spill modelling scenario for Bacchus does demonstrate the potential for an MEI as described in the EUOSD and SCR (2015) for protected sites and species, this is a worst case scenario that assumes no intervention and response, and the probability of an incident occurring is remote due to preventative measures and response strategies in place.

Figure 5.5 Protected areas potentially impacted by uncontrolled release of hydrocarbons

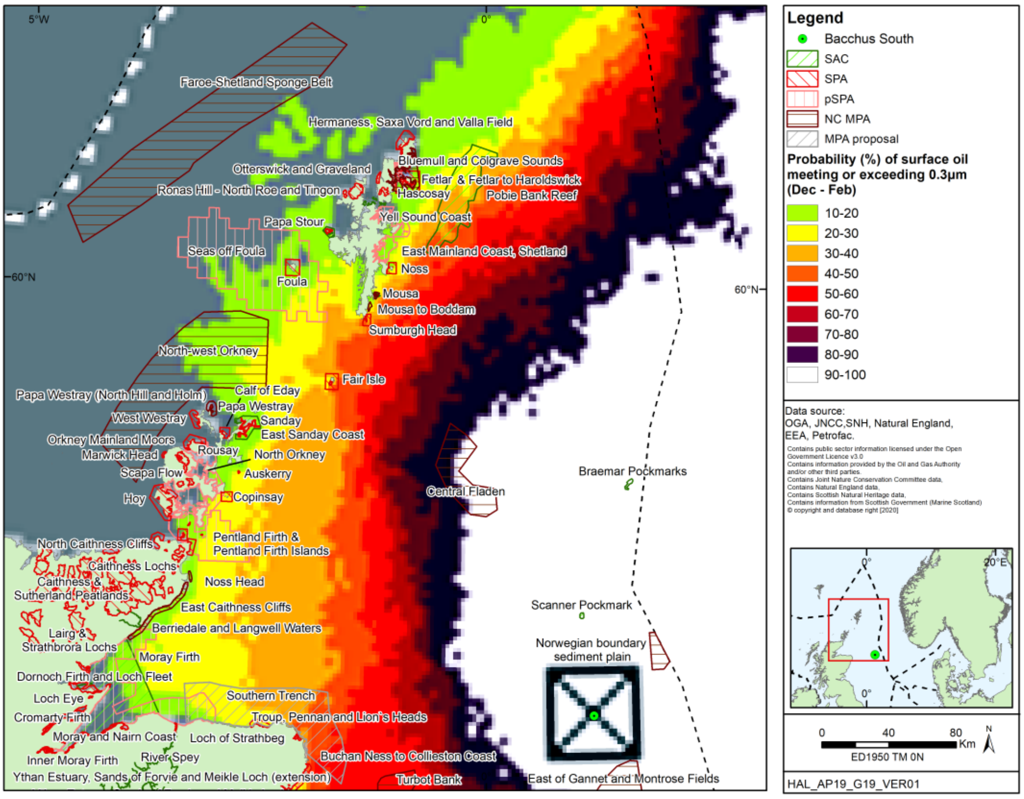


Figure 5.6: Protected areas potentially impacted by uncontrolled release of hydrocarbons (continued)

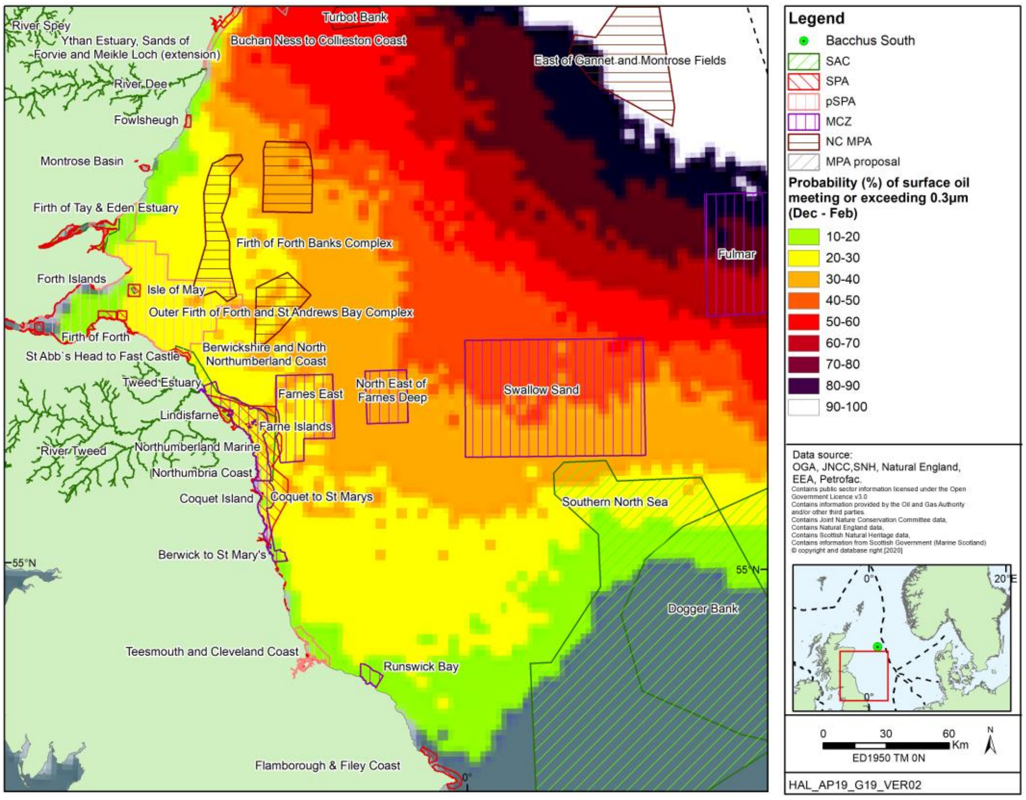


Figure 5.7: Protected areas potentially impacted by uncontrolled release of hydrocarbons (continued)

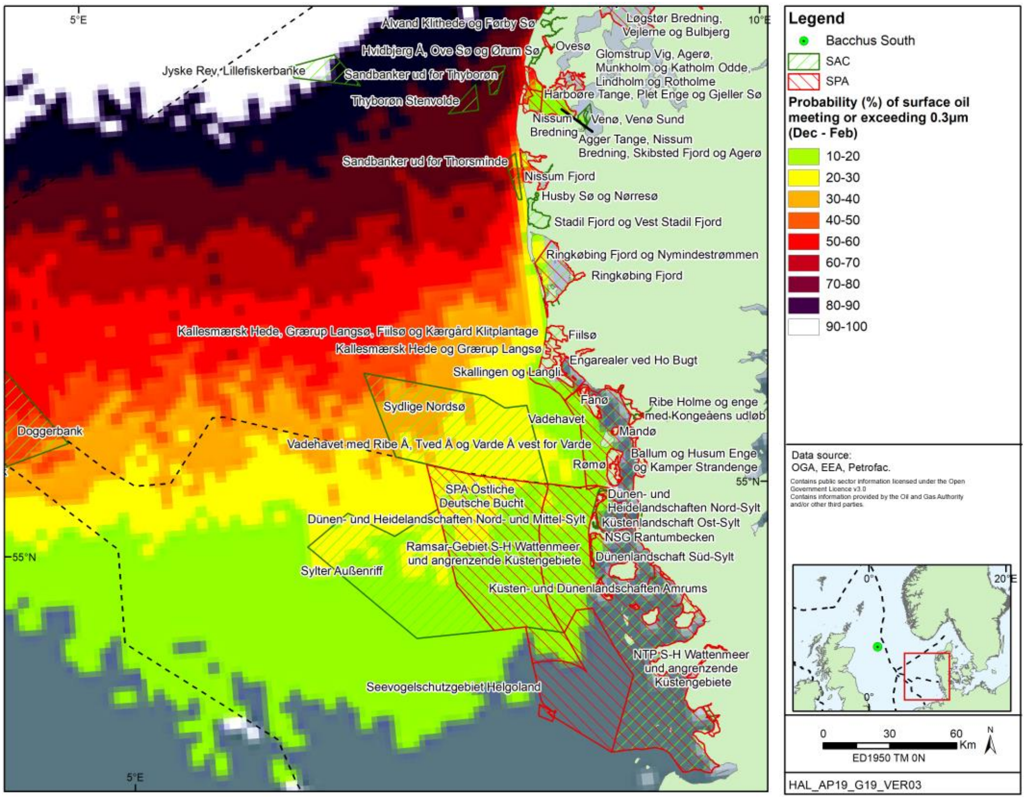


Figure 5.8: Protected areas potentially impacted by uncontrolled release of hydrocarbons (continued)

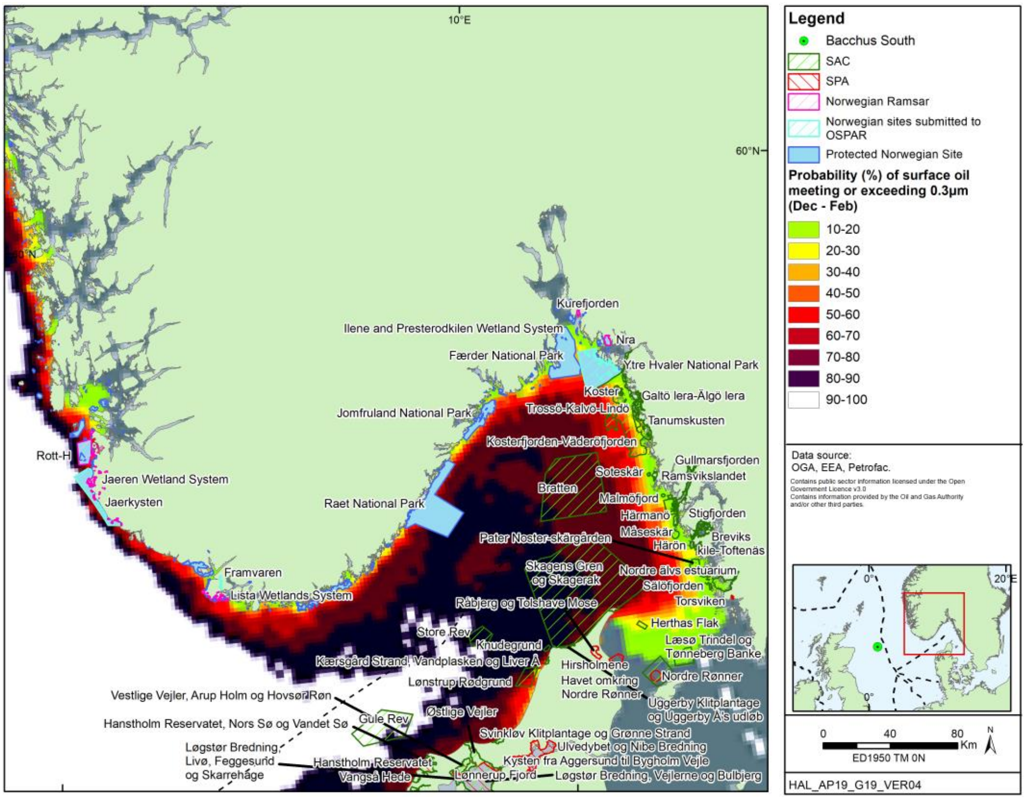
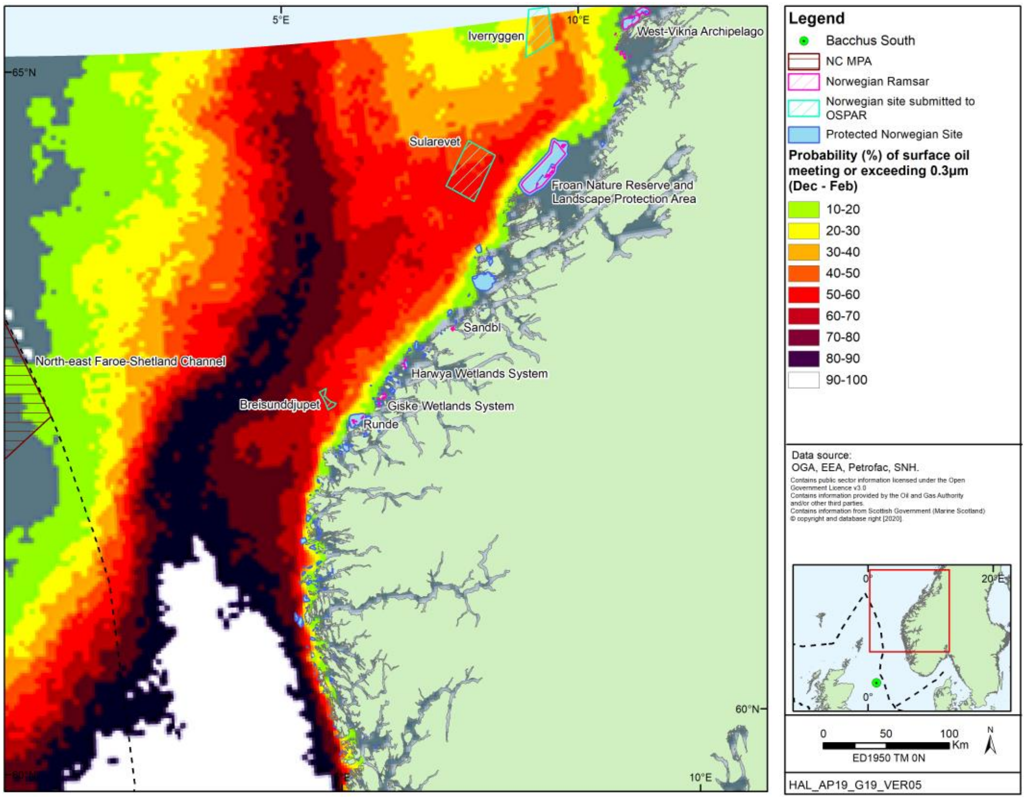


Figure 5.9: Protected areas potentially impacted by uncontrolled release of hydrocarbons (continued)[1]



Note: [1]Protected Norwegian Sites include Nature Reserves, Protected Landscapes, Natural Monuments, Wildlife Conservation Areas, sites for Zoological Protection of Species, Botanical Conservation Areas, Wildlife/Botanical Conservation Areas, National Parks, Protected Geotopes and, Habitat management areas only where these have significant marine components, and also Marine Protected Areas.

5.3.7 Prevention, Mitigation and Response

Spills from production facilities, drilling rigs and support vessels, are largely preventable through provision of appropriate equipment (e.g. the primary and secondary well control features of the chosen rig), maintenance, procedures and training. Awareness of environmental sensitivities and practical measures to reduce risks will be integral to the contractual and management arrangements for the proposed well and specific measures which will be implemented for the well are described below.

Preventative Measures

Apache have a well examination scheme operated by independent well examiners to ensure there is an independent check on well design, construction, maintenance and operation. These barriers (including well barriers) and preventative controls are in place to minimise the occurrence of a Bacchus well blowout, including those at design stage, such as analysis of analogues wells, drill fluid design, and during operation through the deployment of a tested and maintained Blowout Preventor (BOP).

Safety and environmentally critical elements (SECEs) are identified and are part of a maintenance programme and these include, for example, emergency shut down vales, non-return valves, and isolation valves, all of which are in place to control design failure. Systems are also in place to mitigate against over pressurisation of equipment, such as pressure alarms, and velocity checks.

Safety and Environmental Management system (SEMS) is in place, along with documented interfaces between contracted parties and Apache have well established practices and procedures in place to also ensure effective training and competence.

For the drilling of the well, Apache will develop a Communication and Interface Plan (CIP) which will include the actions and notifications, and the roles and responsibilities of the offshore personnel in the event of an oil spill incident.

Smaller spills of for e.g. diesel can also occur through bunkering and supply operations, storage of fuel/chemicals and rig operations. These are prevented and controlled through measures including adequate storage and maintenance of hoses, with couplings subject to inspection, critical valves being locked and controlled by permits to work, storage in bunded areas, presence of drip trays and provision of deck spill containment and clean up kits on the rig.

Measures to stem the well flow

Well procedures and equipment are in place to control the well, including killing the well and the deployment of a BOP. Well kill typically involves the pumping of a higher density mud into the wellbore, while the BOP is, typically, a large specialised valve, when closed stops the flow of hydrocarbons in the event of an emergency.

Another measure is a capping device, this designed to seal off the well and regain control in the event of a blowout.
If primary and secondary well control is lost and oil flows uncontrollably from the well to the environment (blowout), then a relief well may be required to stop the flow and bring the well back under control. Apache estimate that approximately 120 days would be required to both source a suitable replacement rig, and to drill a relief well and regain well control (including time to rent in a surface wellhead system, use a combination of conductor from stock/purchase and gather any other equipment requirements, through the existing call-off contracts Apache have with suppliers). Apache’s strategy for obtaining a suitable relief well drilling rig, is as follows:

- Review rigs involved in Apache operations to assess the suitability of each available unit for drilling a relief well.
- Contact partners involved in the well operation, to establish which rigs they have on contract and assess the suitability of each unit for drilling a relief well.
- Contact the drilling contractor involved in the well operation, to establish which rigs it has operating on the UKCS and assess the suitability of each unit for drilling a relief well.
- Contact other operators and drilling contractors to establish which rigs they have operating in the UKCS and assess the suitability of each unit for drilling a relief well.

Oil Spill Response Measures

During the drilling of the Bacchus well, the Forties standby vessel will be available, this is equipment with dispersant and spraying equipment.

Apache is a member of the Operators Co-operative Emergency Services (OCES), an organisational framework under which oil and gas companies operating in the North Sea and adjacent waters of the North West European Continental Shelf co-operate and share resources in the event of an emergency situation. Apache will cover the costs associated with suspending well operations and operations associated with getting the well operation back to where it was, prior to suspension, to allow release of a suitable drilling unit.

Apache follows the international and UK best practice regarding oil spill response, and adheres to the three tiered approach defined in the UK National Contingency Plan. Apache has the capability to employ a number of oil spill response strategies for an oil spill incident of any severity. Apache maintain oil spill response equipment on the field standby vessel, which includes 5 tonnes of dispersant, that can be used if deemed part of the response strategy. The procedures to mobilise equipment and respond to an oil spill are detailed in the Forties Field Offshore OPEP. Apache will update the Forties Field Offshore OPEP to include the Bacchus South well once drilled and operational. Any rig to be used will have its own Non Production Installation OPEP.

The CIP developed by Apache for the Bacchus well will include an outline of field specific data on the fate of hydrocarbons and environmental sensitivities, and a relevant spill response strategy, including response effectiveness (referencing the OGUK Oil Spill Response Effectiveness Register). Both the Forties Field Offshore OPEP and CIP will be submitted to the relevant statutory agencies for consultation and approval before work commences. Apache will be the well operator during the drilling and subsequent operational phases.

Overall, it may be concluded that risks of significant environmental or socio-economic impacts resulting from an accidental spill from Bacchus South are extremely low. Principal considerations are:

- Low historical frequency of significant incidents associated with well completion and production operations
- Technical, operational and management measures in place to prevent spills
- Spill response strategies to effectively respond to a spill

Protected sites are largely located on the east coast of Scotland, Orkney and Shetland, located 165km west, and along the coast of Germany, Denmark, Sweden and Norway. The closest offshore conservation sites are the East of Gannet and Montrose MPA, Norwegian Sediment Boundary Plain MPA and Scanner Pockmark SAC, located 33km, 44km and 58km from the Bacchus South well respectively (Figure 3.7).

See environmental management commitments 1, 3 and 7, and associated actions in Table 6.1.

5.4 Cumulative Effects

Consistent with *The Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999* (as amended), current BEIS (2020) guidance requires the assessment to consider, where relevant to do so, *the impacts of other existing, consented or planned activities in the development area, and determine whether there are likely to be any significant in-combination or cumulative impacts.* As such, consideration has been given to the potential for cumulative effects to arise from the Bacchus production increase in the context of all other activities taking place in the area.

DTI (2003) defined three categories of “additive” effects in the context of Strategic Environmental Assessment:

Incremental effects are considered within the EIA process as effects from licensing exploration and production (E&P) activities, which have the potential to act additively with those from other oil and gas activity, including:

- forecast activity in newly licensed areas
- new exploration and production activities in existing licensed areas
- existing production activities
- forecast decommissioning activities

- “legacy” effects of previous E&P activities, post-decommissioning (e.g. unrecovered debris and cuttings material)

Cumulative effects are considered in a broader context, to be potential effects of E&P activities which act additively or in combination with those of other human activities (past, present and future), notably:

- fishing
- shipping
- other Oil and gas and other industrial related activity (e.g. exploration, appraisal, development)
- oil and gas decommissioning

Synergistic effects – synergy occurs where the joint effect of two or more processes is greater than the sum of individual effects – in this context, synergistic effects may result from physiological interactions (for example, through inhibition of immune response systems) or through the interaction of different physiological and ecological processes (for example through a combination of contaminant toxicity and habitat disturbance).

The proposed increase in production from the Bacchus Field is not anticipated to result in any adverse incremental or cumulative effects. There will be a minor positive incremental effect in terms of UK energy supplies and balance of payments, with only minor increment to emissions and discharges.

The principal incremental effects are those from additional chemical use and discharge, and flaring, during the operational phase, and mobile drilling rig physical disturbance and presence, however these are expected to be extremely minor (Section 5.2) or spatially and temporally limited in extent. No synergistic effects are anticipated.

Physical presence	**Incremental**: the presence of the drilling rig, associated vessels and vessels for the subsea installation will be of a temporary nature, and signify a small and transient incremental increase in surface infrastructure (rig) and vessels in the area. The temporary 500m safety exclusion zone around the rig during drilling activities is largely covered by the existing Bacchus safety zone, such that incremental exclusion is negligible (~0.11km^2), This area is not regarded as commercially significant in terms of loss of access for fishing; the area records low overall fishing effort. Similarly, the physical presence of the pipeline system will not result in loss of fishing area as it is within the established Bacchus subsea safety zone. **Cumulative**: No other significant access restrictions to navigation in the area; there are existing Duration of the drilling/subsea activities is such that cumulative effect with shipping of the wider North Sea is not considered significant. **Synergistic**: none
Physical disturbance	**Incremental**: There will be minor incremental disturbance to the seabed as a result of rig placement and subsea works associated with the Bacchus South well, however, the total area affected is small. Disturbance from semi-submersible rig anchor placement will be incremental to that which was the result of the previous drilling of the Bacchus production wells, and subsequent well intervention. **Cumulative**: fishing effort is low in comparison to other areas, with both demersal and pelagic fishing gear types used. Demersal trawls probably represent the principal source of seabed disturbance in this and the wider area. In view of the subsea safety zone in place around Bacchus which should minimise interaction between Bacchus and fisheries, significant cumulative effects from the scale of activities proposed for Bacchus South are not predicted. **Synergistic**: none
Discharges (drilling, operational)	**Incremental**: Discharges associated with drilling and subsea activities will be incremental to that resulting from previous exploration, appraisal and development wells and pipeline installations in the area. The vast majority of chemicals are expected to be E, PLONOR or Gold, with the lowest hazard potential. Discharges of chemicals associated with the production increase are not expected to be significant. Operational discharge of produced water will be very minor (maximum of 3.1m^3/day in 2023) with a related maximum annual oil in water content

	of 0.009 tonnes. These will be incremental to wider Bacchus Field production, and also wider Forties Field production **Cumulative**: Discharges from drilling will be of short duration, and operational discharges will be minor; significant cumulative effects with other discharge sources, including the wider Forties Field, are not predicted. **Synergistic**: none
Emissions	**Incremental**: Emissions associated with power generation on the drilling rig, support and subsea construction vessels, and additional gas flaring, will represent an increment to North Sea oil and gas emissions during the period in which these activities are undertaken, though in the context of annual UK and UKCS emissions, represent a very small increment (see Sections 5.1.1 and 5.2.1). In terms of air quality, there is very high available dispersion, and the emissions sources (rig and Forties Alpha) are some distance from and landfall (at least 172km). There will be no appreciable power load requirement to support the production increase, and the majority (92%) of Bacchus gas will be used as fuel gas. **Cumulative**: The drilling of the well and subsequent operations will result in greenhouse gas emissions that will be cumulative in global context, though they are relatively small in scale, and will be minimised as far as practically possible. **Synergistic**: none
Noise	**Incremental**: The rig and vessels will be the primary source of underwater noise during activities, and will be incremental to other similar activities in the Bacchus and adjacent areas. However, the increment will be small and short-term, and is not considered to have significant synchronous effects (i.e. additive to other acoustic disturbance at the time) or significant temporal effects (i.e. additive to previous and subsequent disturbance by seismic and other activities). **Cumulative**: Other sources of anthropogenic noise include shipping – the cumulative increment from the development of Bacchus will be minor in the context of existing noise levels from shipping transiting the area. Noise sources associated with Bacchus will be spatially and temporally minimal. **Synergistic**: In addition to those noise sources identified above, high contaminant burdens and their effects on reproductive success are a concern for many species of marine mammal in the north-east Atlantic (e.g. Murphy *et al*. 2015, Jepson *et al*. 2016), while other stressors may include changes in oceanographic conditions, prey availability, predator distribution and outbreaks of pathogens. No synergistic effects between noise and other stressors have been conclusively demonstrated to date, with the identification of interactions between multiple stressors being notoriously difficult to study, particularly among marine mammals (The National Academies of Sciences 2017). Nonetheless, given the limited potential for the effects of noise associated with the drilling of Bacchus South, the low potential for incremental or cumulative effects identified above, alongside many decades of human activity in the wider area, synergistic effects arising from the development of Bacchus are considered to be highly unlikely.
Accidental events	**Incremental**: The combined probability of ecologically significant oil spills from drilling and production activity in the Bacchus, Forties, and surrounding area is extremely low. **Cumulative**: The adjacent coasts (the closest coastal conservation site is ~165km away) are exposed to risks associated with oil/product tanker and other vessel traffic through the region and adjacent ports (Peterhead/Aberdeen/Dundee). The contribution to overall risk of the proposed Bacchus South drilling, subsea works and subsequent production increase is small. **Synergistic**: none

5.5 Transboundary Effects

The activities associated with the proposed increase in production are not considered likely to alter the existing risk of transboundary effects occurring, although the site is located relatively close to the UK/Norwegian median line (~55km east). Routine noise, atmospheric and aqueous emissions from the production of Bacchus South are unlikely to be detectable or to significantly affect Norwegian waters and air quality.

In the event of a large oil spill, it is noted in Section 5.3 that there is a risk that the slick could cross the median line into Norwegian, Danish, Swedish, German or Dutch waters. In the case of Norway, should a slick cross into Norwegian waters the NORBRIT Agreement would be implemented. For all adjacent states, the UK would notify relevant parties under the terms of the Bonn Agreement.

6 ISSUE MANAGEMENT AND CONCLUSION

The activities associated with the production increase will be conducted in accordance with Apache's HSSE Policy. The Apache EMS is consistent with the ISO 14001:2015 International Standard for Environmental Management Systems. A number of contractors will be involved in the detailed planning and execution of the well and subsea works, and Apache has established contractor selection and management procedures which include evaluations of HS&E aspects and environmental management and compliance. The Bacchus South well will be subject to further assessment via the PETS process.

The increase in use and discharge of production chemicals will be risk assessed and a variation to the relevant Chemical Permit sought, as necessary. Similarly, the flaring of Bacchus gas will be considered in relation to currently consented levels. Chemical use and discharge associated with drilling of the wells and subsea connection works will be risk assessed as part of permit applications related to these activities.

The additional production from Bacchus will contribute to security of energy supply and result in a variety of positive commercial and fiscal benefits through the production and sale of this UK hydrocarbon resource. Through a systematic evaluation of the issues associated with the increased production and their interactions with the environment, a variety of potential sources of environmental effect were identified. The majority were of limited extent and duration and deemed negligible. Those activities which were identified as being of potentially greater concern were assessed further in Section 5. No potential issues of concern were identified through the assessment process which could not be mitigated to reduce them to meet regulatory and company policy requirements. The incremental risk of spill has been considered and there are preventative measures and procedures already in place to minimise the likelihood of their occurrence and potential environmental damage.

Table 6.1 presents a summary of environmental management commitments identified through the assessment process and actions for the activities, matched with their responsible team; the table below does not include legal requirements, e.g. obtaining and complying with approved permits, and the required oil spill response documents (i.e. OPEPs). These are to be taken forward into project execution and operations.

Table 6.1: Summary of commitments and actions

Issue		Action	Responsibility
1	Environmental objectives	Monitor and review performance against indicators, targets and environmental policy, ensuring remedial action is instigated where necessary.	Environmental Team
3	SECEs	Maintain the register of SECEs, ensuring that scheduled maintenance checks are undertaken and that items are appropriately prioritised.	Maintenance Team
4	Chemical use and discharge (operation and well related)	Replace chemicals with substitution or other warnings when technically feasible.	Operations & Environmental Teams
5	Atmospheric emissions	Minimise atmospheric emissions as far as practically possible by minimising flaring, and maximising associated gas use for fuel gas.	Operations Team
6	Seabed disturbance	Minimise protection material, and related seabed disturbance, as far as possible.	Wells Team

Issue		Action	Responsibility
7	Contractor management – field operations	Ensure contractor management assurance processes are applied.	Supply Chain Team
8	Review	Monitor accuracy of ES predictions in the context of actual emissions, discharges, durations etc.	Environmental Team

The overall conclusion of the EIA is that the production increase as outlined in Section 2 will not result in significant adverse effects on the environment or other users of the area.

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