Ensign Decommissioning Environmental Appraisal

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Prepared by:	JC (Genesis)	Jude Cooper Digitally signed by: Jude Cooper DN: CN = Jude Cooper email = jude.cooper@genesisoilandgas.com C = GB O = Genesis Oil and Gas Date: 2019.10.02 09:07:53 Z	02 Oct 2019
Reviewed by:	MOS (Genesis)	Martha O'Sullivan Digitally signed by: Martha O'Sullivan DN: CN = Martha O'Sullivan email = martha.osullivan@genesisoilandgas.com C = GB O = Genesis Oil and Gas Date: 2019.10.02 09:08:20 Z	02 Oct 2019
Reviewed by:	S. Mackenzie	Susan Mackenzie Digitally signed by: Susan Mackenzie DN: CN = Susan Mackenzie email = susan.mackenzie@spirit-energy.com C = GB O = Spirit-Energy Date: 2019.10.02 09:08:45 Z	02 Oct 2019
Approved by:	S. Axon	Simon Axon Digitally signed by: Simon Axon DN: CN = Simon Axon email = laptech@btconnect.com C = AD O = Spirit Energy Date: 2019.10.02 09:09:08 Z	02 Oct 2019

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TERMS AND ABBREVIATIONS

ABBREVIATION	EXPLANATION
A-Fields	The collective term for the Audrey, Ann, Alison and Annabel Fields.
ACMI	Alternating-Current Mass Impregnated
BAP	Biodiversity Action Plan
BEIS	Department for Business, Energy and Industrial Strategy
c.	circa (when referring to a distance or length)
CO_2	Carbon dioxide
CPUK	Conoco Phillips UK Limited
cSAC	Candidate Special Area of Conservation
CSV	Construction Support Vessel
dB	Decibel
DD	Drop-down
°	Degree
DP	Decommissioning Programme
DSV	Diving Support Vessel
EA	Environmental Appraisal
EBS	Environmental Baseline Survey
EC	European Commission
ED Well	Ensign undeveloped subsea well
ERRV	Emergency Response and Rescue Vehicle
EIA	Environmental Impact Assessment
EMS	Environmental Management System
Ensign	Installation comprising small topsides and jacket held in location using 4x piles
EPS	European Protected Species
ESDV	Emergency Shutdown Valve
EU	European Union
EUNIS	European Nature Information System
FOC	Features of Conservation
g	Gram
GEL	Gardline Environmental Limited
HD	High Density concrete mattress (6m x 3m x 0.3m, average density 1.9kg/m^3)
HLV	Heavy Lift Vessel
HSE	Health and Safety Executive
HT	Half-thickness concrete mattress (6m x 3m x 0.15m)
Hz	Hertz
ICES	International Council for the Exploration of the Sea
ISO	International Standardisation Organisation
IUCN	International Union for Conservation of Nature
“	Inch; 25.4 millimetres
JNCC	Joint Nature Conservation Committee
k	Kilo
KP	Kilometre Post (Distance along pipeline from point of origin, base of riser at York)
l	Litre
LAT	Lowest Astronomical Tide
LOGGS	Lincolnshire Offshore Gas Gathering System
m	Metre
mm	Millimetre
MAT, SAT	Master Application Template, Supplementary Application Template
MCAA	Marine and Coastal Access Act
MCZ	Marine Conservation Zone
µ	Micro
MD	Mixed Density concrete mattress (6m x 3m x 0.3m average density1.6kg/m^3)
MEG	Mono-ethylene Glycol
MEI	Major Environmental Incident
MPA	Marine Protected Area
MT	Million Tonnes
N,S,E,W	North, South, East, West
n	Nano
n/a	Not Applicable
NB	Nominal Bore

ABBREVIATION	EXPLANATION
NFFO	National Federation of Fishermen's Organisations
NMPI	National Marine Plan Interactive
NORM	Naturally Occurring Radioactive Material
NPAI	Not Permanently Attended Installation
OPEP	Oil Pollution Emergency Plan
OPPC	Oil Pollution Prevention and Control
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSCAR	Oil Spill Contingency and Response (Modelling)
OSPAR	Oslo-Paris Convention
%	Percentage, parts per hundred
/	Per
PAH	Polycyclic Aromatic Hydrocarbons
Piggybacked	Smaller pipeline is adjacent and clamped to a larger pipeline throughout its length
Pipeline	Pipeline or umbilical
PL, PLU	Pipeline and Umbilical Identification numbers
PON	Petroleum Operations Notice
ppb	Parts per Billion
PPC	Pollution Prevention Control
ROV	Remotely Operated Vehicle
RSPB	Royal Society for the Protection of Birds
s	Second
SACs	Special Areas of Conservation
SATs	Subsidiary Application Templates
SCIs	Sites of Community Importance
SD	Standard Density concrete mattress (6m x 3m x 0.3m, average density 1.5kg/m^3)
SEA	Strategic Environmental Assessment
SIMPER	Similarity Percentage Index
SNS	Southern North Sea
SOPEP	Shipboard Oil Pollution Emergency Plan
SOSI	Seabird Oil Sensitivity Index
SPA	Special Protection Area
Spirit Energy	Spirit Energy North Sea Limited
Side Scan Sonar	SSS
Te	Tonnes
THC	Total Hydrocarbon Content
TOC	Total Organic Carbon
TOM	Total Organic Matter
TR	Transect
TUTU	Topsides Umbilical Termination Unit
UCM	Unresolved Complex Mixture
UHB	Upheaval Buckling
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
UKOOA	United Kingdom Offshore Operators Association
VMS	Vessel Monitoring Systems
WGS84	World Geodetic System 1984
WFD	Waste Framework Directive
WMP	Waste Management Plan

1. EXECUTIVE SUMMARY

This summary outlines the findings of the Environmental Assessment (EA) process conducted for the proposed decommissioning of the Ensign Field installation and subsea infrastructure. The assessment concludes that the overall significance of the impacts from the proposed decommissioning activities would be **low**.

The purpose of the report is to record and communicate the findings of the EA process, which assesses the potential for environmental impacts arising from decommissioning activities. The EA report has been prepared to support two Decommissioning Programmes (DPs) [101] & [102] which are combined in one document. The DPs are:

1. The Ensign installation, comprising a steel jacket and topsides;
2. The associated four pipelines, PL2838, PL2839, PLU2840 and PL2841.

Several studies and surveys were undertaken to support the proposed decommissioning and have been considered during the EA, as appropriate.

The EA report and the Comparative Assessment (CA) report are supporting documents to the DPs and will be submitted to the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) for consideration under the regulatory approval process.

1.1 Background to the project

The Ensign installation and pipelines are owned and operated by Spirit Energy North Sea Limited.

The Ensign field lies within the main Southern North Sea (SNS) Gas Province in UK Block 48/14a. The field lies approximately 80km north east of Cromer on the coast of Norfolk in water depths of approximately 25m. The field achieved first production in 2011 and produced until May 2017. The Ensign gas field was developed using a single installation and two installation wells and one subsea well (Ensign ED well). The installation is a Not Permanently Attended Installation (NPAI) supported by four-legged conventional piled steel jacket. The Ensign ED well was tied back to the Ensign installation via a trenched and buried 10” pipeline and piggybacked umbilical (PL2841 and PLU2840), however the well was never developed. Gas from Ensign was exported via a 10” trenched and buried pipeline (PL2838) to the Audrey A (WD) installation and from the Audrey A installation to the LOGGS Production Installation via a 20” gas export pipeline (PL496). A 2” methanol pipeline (PL2839) piggybacked PL2838, whilst methanol pipeline number PL497 piggybacks PL496.

1.2 Decommissioning activities

On the United Kingdom Continental Shelf (UKCS), the decommissioning of offshore oil and gas installations and pipelines is controlled through the Petroleum Act 1998, as amended by the Energy Act 2008. In accordance with the Petroleum Act 1998, Spirit Energy are applying to obtain approval of the two ‘DPs’ from the OPRED before they can proceed with decommissioning the Ensign installation and pipelines.

Spirit Energy plan to completely remove and recover the Ensign installation to onshore. The main length of the buried pipelines and umbilical (PL2838, PL2839, PLU2840 and PL2841) will be decommissioned *in situ.* The exposed pipeline ends where they emerge from existing rock berms and an umbilical section are protected by concrete mattresses on approach to the Ensign ED well. These will be removed and recovered along with all exposed grout bags. The concrete mattresses and concrete plinths that are buried under deposited rock at the pipeline and cable crossings will be decommissioned *in situ.*

A summary of the decommissioning activities at Ensign is presented in Table 1.2.1. Where more than one method could be used to undertake the activity, that which presents the worst case potential environmental impact has been presented and assessed.

Planned Decommissioning Activities	Description
Removal of topsides and jacket for recovery to onshore.	Using a Heavy Lift Vessel (HLV) and work barge, both anchored at the installation. The HLV and transport barge will both set their anchors, and then the HLV will lift the topsides and place on the anchored transport barge. The HLV and transport barge will then reposition their anchors to allow the HLV to lift the jacket onto the transport barge. Cutting of jacket piles will be done internally using an abrasive water jet cutter. In case internal cutting fails the contingency will be external cutting, which will involve excavation of the seabed around the jacket legs to allow access.
Sever pipelines where they emerge from the deposited rock and disconnect from riser flanges. Removal of pipespools and section of umbilical from where it exits the deposited rock. Leave most of the pipelines *in situ.*	Severing of the pipeline and umbilical will be undertaken using hydraulic shears. Discharge of pipeline and umbilical contents to the marine environment. The pipespools and umbilical section will be recovered using a grappling tool and baskets. Permanent presence of the buried pipelines in the seabed.
Deposit of up to 2 Te of loose rock over pipeline ends, as a contingency measure.	Rock will be placed on existing rock using a fall pipe at four pipeline ends.
Recovery of all exposed concrete mattresses to onshore.	Concrete mattresses will be recovered from the seabed using lifting frames or baskets.
Leave *in situ* concrete mattresses and concrete plinths buried under deposited rock.	Permanent presence of the concrete mattresses and concrete plinths buried under deposited rock on the seabed.
Leave *in situ* existing deposited rock.	Permanent presence of the deposited rock on the seabed.
Removal of any exposed grout bags that are found for recovery to onshore.	Grout bags will be lifted using grappling tools from the seabed and placed in baskets for recovery to onshore.
Seabed over-trawl assessment	The use of fishing gear to trawl the area of the decommissioned facilities to establish the absence of snagging hazards. The use of a non-intrusive assessment to verify a clear seabed will be investigated.
Onshore processing of removed infrastructure	The onshore transport and processing of removed facilities (cleaning, cutting etc.) at a shore-based waste processing facility, in preparation for transport to an appropriately licenced facility for recycling or disposal to landfill.

Table 1.2.1: Planned Decommissioning Activities

1.3 Environmental baseline

An overview of the key environmental features near the Ensign infrastructure that may be affected by the proposed decommissioning works has been presented and is used to assess the level of impact that the aspects have on the environment.

Several environmental baseline surveys have been undertaken at the Ensign field during 2010 and 2013 in preparation for the Ensign development and most recently an environmental survey was undertaken in 2018 in preparation for decommissioning. The survey results have been used to inform the environmental baseline.

The seabed within the vicinity is generally found to undulate gently, with an average seabed gradient of <1° and a maximum natural seabed gradient of 16° associated with megaripples. A minimum water depth of 19.7m LAT was recorded along the 10” gas and 2” methanol pipelines route from Ensign installation to Audrey A (WD) and a maximum water depth of 29.4m LAT was recorded within an area of inferred gravel extraction, 640m west south west of the Ensign installation.

The maximum tidal current speed in the development area during mean spring tides is 0.63m/s. Surge and wind–driven currents, caused by changes in atmospheric conditions, can be much stronger and are generally more severe during winter. The annual mean significant wave height is 1.4m.

The shallow water and active current regime in the SNS produce a high energy environment and as a consequence the seabed at the Ensign field is characterised by sandbanks, sandwaves and megaripples. The Ensign infrastructure is located within the North Norfolk Sandbanks and Saturn

Reef Special Area of Conservation (SAC), designated for the presence of the Annex I habitats: sandbanks which are slightly covered by seawater all the time and reefs. The majority of sandbanks in the North Norfolk area of the SNS are considered to be large-scale mobile seabed forms in dynamic equilibrium with the environment. They can have a wavelength between 1 and 10km, and they can achieve a height of several tens of metres.

Sandwaves are a periodic bottom waviness generated by tidal currents in shallow tidal seas. Typical wavelengths range from 100 to 800m and they can be up to between 1 and 5m high. Megaripples are large, sandwaves or ripple-like features having wavelengths greater than 1m or a ripple height greater than 0.1m.

The seabed sediments were generally interpreted to comprise sand and gravelly sand around the Ensign installation area and predominantly sand and gravel along the Ensign ED well to Ensign installation pipeline corridor. Along the Ensign installation to Audrey A (WD) pipeline corridor the seabed sediments were interpreted to comprise predominantly megarippled sand and gravelly sand with areas of sand and gravel occasionally present.

Along the Ensign ED well to the Ensign installation pipeline corridor and along the Ensign installation to Audrey A (WD) installation pipeline corridor *S. spinulosa* was observed in the form of thin and thick crusts and small and large clumps; clumps of consolidated upright *S. spinulosa* and clumps and larger patches of consolidated *S. spinulosa*, in places embedded with the substrate. None of these aggregations were found to represent an Annex I reef structure. No areas of *Sabellaria spinulosa* were observed along any of the transects within the vicinity of the Ensign installation survey area.

The SNS phytoplankton community is dominated by the dinoflagellates *Ceratium fusus*, *Ceratium furca*, and *Ceratium tripos*. The population of diatoms is also significant and includes *Chaetoceros*. In the SNS, the population of zooplankton is mainly composed of small copepods, predominantly *Parapsuedocalanus* sp, with echinoderm larvae being the second most abundant.

The majority of the dominant benthic infaunal taxa recorded from the Ensign survey area have been identified from other surveys undertaken in similar SNS habitats. Around the Ensign installation the benthos was characterised by a moderate density, moderately diverse macrofaunal community, dominated by the bristleworm polychaete *Ophelia borealis*, the proboscis worm phylum Nemertea and the sand hopper crustacean *Bathyporeia elegans* and the community observed was typical of that expected for coarse sandy sediments, and no effects of contamination on the community were identified. Around the Ensign ED well and along the Ensign installation to Audrey A (WD) pipeline corridor the phylum Annelida was the most abundant, followed by Crustacea and Mollusca. Generally, the faunal community within the Ensign ED well site was found to be of moderate to high diversity, indicating relatively low dominance. *Ophelia borealis* was also the most abundant taxon overall along the pipeline route. Visible benthic fauna included *Asterias rubens*, bryozoans (*Flustra foliacea*, *Alcyonidium diaphanum*), hermit crabs (Paguridae), crabs (Brachyura including *Liocarcinus* sp.), soft coral (*Alcyonium digitatum*) and hydroid/bryozoan turf (Hydrozoa/Bryozoa).

A number of commercially important fish species are known to spawn and have nursery grounds in the area. These include mackerel, herring, plaice, lemon sole, sandeel, sprat, *Nephrops,* whiting and cod. Herring spawning ground potential at Ensign was investigated however only one transect within the survey area was considered as having suitable habitat for herring spawning however the sediment type meant that the area was assigned as being of marginal herring spawning ground potential. Surveys also observed the following fish species: catshark (*Scyliorhinus sp.*), dab (*Limanda limanda*) and dragonet (*Callionymus sp.*).

Harbour porpoise, and white-beaked dolphin have been sighted near the Ensign field. The Ensign field lies within the SNS candidate SAC (cSAC) designated for the presence of the Annex II species, harbour porpoise. The mean density of seals expected near the Ensign field is low for both harbour seals and grey seals (1 - 5 per 25km^2).

In general, seabird sensitivity to oil pollution near the Ensign field is considered low to medium in June, August and September and high/very high and extremely high during October to May and during July.

The Ensign field, including the installation, pipelines and Ensign ED well all lie within the North Norfolk Sandbanks and Saturn Reef SAC and within the SNS candidate SAC (cSAC) for harbour porpoise. The nearest Special Protection Area (SPA) site is the North Norfolk Coast SPA, which is over 90km south-west of the Ensign field. The nearest Marine Conservation Zone (MCZ) to the Ensign field is the Holderness Offshore recommended MCZ which is approximately 55 km west of the Ensign installation.

With regards to fishing, shellfish landings dominate in terms of weight and value although overall commercial fishing effort near the Ensign field is low when compared with the total UK fishing effort.

Shipping in Block 48/14 in which the Ensign installation is situated is considered high whilst shipping in Block 48/15 in which the pipeline between the Ensign installation and Audrey A (WD) is situated is considered moderate. Shipping in Block 49/11 in which the pipeline from Ensign ties into Audrey A (WD) installation is considered high.

The SNS gas basin in which the Ensign field is located is a region well developed by the oil and gas industry. Near the project area several oil and gas developments have commenced decommissioning and have an approved DP whilst others are in the decommissioning planning phase.

The closest operational wind farm to the Ensign infrastructure is Hornsea One (Heron West, Njord and Heron East) located approximately 26km north of Ensign. Although Hornsea One has begun producing power, the construction activities are not yet complete. The consented Hornsea Two project (30km north of Ensign) is also under construction. The Dudgeon operational windfarm is located 40km to the south-west of Ensign. Approximately 5km to the south of Audrey A (WD) is a production aggregate area, Humber 3.

1.4 Impact assessment

An Environmental workshop was held to identify the aspects of the project and assess these considering their potential to have a significant impact on the environment. Impacts that were categorised as of **low** significance and therefore 'scoped out' of requiring detailed assessment were as follows:

1. **Atmospheric emissions –** the principal sources of energy use and atmospheric emissions are associated with vessel use and the onshore transport and processing of materials and waste. This potential impact was considered to be of **low** significance based on the relatively short duration of vessel activities and the relatively small volume of emissions from these vessel activities when put into context with yearly emissions from the UK offshore oil and gas industry;
2. **Underwater sound** - the principal sources of underwater sound are vessel use, excavation of seabed sediments and cutting. This potential impact was considered to be of **low** significance based on: the short duration of vessel activities in an area of relatively high existing vessel traffic; and the relatively small number of cuts required. The associated noise generated is unlikely to be discernible above the background noise;
3. **Discharges and small releases to sea** - Planned discharges to sea will occur from the use of vessels and from the discharge of the contents of the pipelines and umbilical after having been cut. Small unplanned releases of fuel, hydraulic oil, lubricants or chemicals may occur during decommissioning activities. Given the cleaning that has or will be undertaken and Spirit Energy's commitment to conform with the discharge regulations, discharges to sea were considered to be of low significance. Any small unplanned releases of hydrocarbons will be managed under the existing Ensign Field Oil Pollution Emergency Plan (OPEP) and the vessel Shipboard Oil Pollution Emergency Plans (SOPEPs) and therefore this potential impact was considered to be of **low** significance;
4. **Waste production** - Most of the material recovered during the Ensign decommissioning activities will be non-hazardous, including steel (installation) or concrete (mattresses and grout bags). The project aspiration is that all steel and concrete will be recycled, as well as the majority of components of the end sections of pipeline, umbilical, pipespools and pipeline anodes. This potential impact was considered to be of low significance based on the

implementation of a waste management plan, implementation of Spirit Energy's contractor assurance processes for the waste contractor and compliance with relevant waste legislation;

5. **Physical presence –** the physical presence of the pipelines and umbilical was considered to be of **low** significance based on the good depth of burial along the entire length of the pipelines and umbilical (Appendix B), and stability exhibited along their original trenched and buried lengths. The physical presence of project vessels was considered to be of low significance based on a number of mitigation measures that will be in place to minimise the risk of collision including; issuing a notice to mariners prior to operations commencing to give vessels advance warning of the decommissioning operations and kingfisher bulletins issued prior to operations commencing; and,
6. **Transboundary –** Potential impacts such as vessel discharges, underwater noise, and atmospheric emissions were all considered to be localised in nature. Given the Ensign field is located approximately 81 km, to the west of the nearest international boundary; the UK/Netherlands median line, any transboundary impacts were considered to be of **low** significance.

Potential impacts that were categorised as having **medium** significance, were seabed disturbance and large releases to sea; these were selected for further assessment,

1.4.1 Seabed disturbance

The principal sources of seabed disturbance associated with the Ensign field decommissioning, include:

1. The removal of exposed sections of pipelines at the installations and removal of the umbilical section to Ensign ED well protected by mattresses;
2. The removal exposed mattresses and exposed grout bags;
3. Local excavation and cutting operations at the Ensign installation;
4. The use of anchors and anchor chains on the HLV and transport barge; and.
5. The potential over-trawl assessment at the end of decommissioning.

The base case for the over-trawl assessment is that it will be conducted in the 500 m safety zones of the Ensign installation and the Ensign ED well and over a 100 m corridor along the pipeline lengths. These activities will result in the displacement of substrate and the suspension and subsequent settlement of sediment.

Standard measures to control disturbance include operational planning and equipment selection.

The species and habitats observed in the vicinity of the Ensign field are relatively widespread throughout the SNS and the area anticipated to be impacted represents a very small percentage of the available habitat. Furthermore, the environment in the vicinity of the Ensign field is dynamic due to the shallow water depth therefore all disturbed sediments/habitats are expected to recover rapidly though species recruitment from adjacent undisturbed areas.

Decommissioning of pipelines, umbilical and associated stabilisation material *in situ* within the North Norfolk Sandbanks and Saturn Reef SAC equates to an area of approximately 0.0242km2 which is 0.0007% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC. The area is considered small relative to the total area of the SAC and therefore the significance of the impact of seabed disturbance on the North Norfolk Sandbanks and Saturn Reef SAC is considered to be low.

In summary, due to the localised and relatively short duration of the decommissioning activities, and with the identified control and mitigation measures in place, the overall significance of the impact of seabed disturbance as a result of the decommissioning of the Ensign field is considered to be **low**.

1.4.2 Large releases to sea

The worst-case scenario of an accidental hydrocarbon release would result from a complete loss of fuel inventory from on-site vessels. In the unlikely event of such an incident the vessels will have a SOPEP in place and releases will also be managed under the existing OPEP which will be updated if required. Spirit Energy will minimise the likelihood of such an event occurring by awarding the contract only to vessels that meet Spirit Energy's existing marine standard which ensures that relevant regulatory requirements are implemented.

Such a release has the potential to impact plankton, benthos, fish, marine mammals, seabirds and offshore protected areas. The decommissioning activities will take place within the SNS cSAC designated for the protection of the Annex II species harbour porpoise and such a release has the potential to impact cetaceans such as harbour porpoise. The modelled area of surface oiling within the SNS cSAC with a high probability (10% to 20%) is very small with respect to the total cSAC area of 36,958km^2.

The environmental risk of an accidental event is determined by combining an assessment of the consequence of the environmental impact of an event and the likelihood of it occurring.

Given the low likelihood of such a release and the rapid evaporation rate of diesel, low environmental persistence, and with the identified control and mitigation measures in place, the significance of impacts from a large unplanned release of diesel to sea as a result of decommissioning the Ensign field is considered to be moderate. The significance of the risk of this impact, given its very unlikely probability of occurrence, is considered to be **medium** and any impact will be managed to 'as low as reasonably practicable'.

1.4.1 Cumulative

Potential cumulative impacts of the Ensign decommissioning activities, other oil and gas production, development and decommissioning, wind farm development and vessel use on other users of the sea from the physical presence, on the North Norfolk Sandbanks and Saturn Reef SAC from seabed disturbance and on the SNS cSAC from underwater sound were assessed, with the potential cumulative impact assessed as **low** for all three potential impacts.

1.4.2 Summary of control and mitigation measures

Spirit Energy will follow routine environmental management activities for example contractor vessel audits and legal requirements to report discharges and emissions, such that the environmental impact of the decommissioning activities will be minimised. Following the EA process, it can be concluded that activities associated with the decommissioning of Ensign field are unlikely to significantly impact the environment or other sea users, for example shipping traffic and fishing, provided that the proposed mitigation and control measures are put in place.

A summary of proposed control and mitigation measures is shown in Table 1.4.1.

Mitigation and Control Measures
General and Existing
Lessons learnt from previous decommissioning scopes will be reviewed and implemented.
Vessels will be managed in accordance with Spirit Energy's Marine Assurance Standard.
The vessels' work programme will be optimised to minimise vessel use.
The OPEP is one of the controls included in a comprehensive management and operational controls plan developed to minimise the likelihood of large hydrocarbon releases and to mitigate their impacts should they occur.
All vessels undertaking decommissioning activities will have an approved Shipboard Oil Pollution Emergency Plan (SOPEP).
Existing processes will be used for contactor management to assure and manage environmental impacts and risks.
Spirit Energy management of change process will be followed should changes of scope be required.
Atmospheric Emissions
All material taken onshore will be handled by licenced waste management contractors at sites that hold Environmental Permits or Pollution Prevention Control (PPC) permits.
Discharges and Small Releases to Sea
The topsides will be vented and purged prior to their removal.
The use of any chemicals for cleaning and flushing or for any other decommissioning activities will be permitted under the Offshore Chemical Regulations 2002 (as amended) and the discharge of any residual hydrocarbons from pipeline and riser disconnections and cutting activities will be permitted under The Offshore Petroleum Activities (Oil Pollution

Mitigation and Control Measures
Prevention and Control (OPPC)) Regulations 2005 (as amended).
Any ballast water discharges will be in line with the International Maritime Organisation ballast water management convention and guidelines.
Vessel activities such as the release of drainage water and grey water will be subject to separate regulatory requirements.
Waste Production
The selected dismantling site will be able to demonstrate a proven disposal track record and waste stream management throughout the deconstruction process and demonstrate their ability to deliver re-use and recycling options.
A Waste Management Plan for the decommissioning programmes will be prepared and implemented in line with the Waste Framework Directive.
All waste will be managed in compliance with relevant waste legislation by a licenced waste management contractor.
As part of Spirit Energy's standard processes, all sites and waste carriers will have appropriate environmental and operating licences to carry out this work and will be closely managed within Spirit Energy's contractor assurance processes.
Physical Presence
Monitoring will be performed to confirm the pipelines and umbilical decommissioned in situ remain stable and buried at a frequency to be agreed with OPRED.
Pipelines will be marked on admiralty charts and added to the FishSAFE database.
A notice to mariners will be issued prior to operations commencing to give vessels advance warning of the decommissioning operations.
Kingfisher bulletins issued prior to operations commencing.
Transboundary
If waste is shipped internationally, the Ensign Waste Management Plan will present the responsibilities Spirit Energy has under the 'Duty of Care' legislation and identify appropriately licenced international onshore facilities where the waste can be treated.
Seabed Disturbance
All activities which may lead to seabed disturbance will be planned, managed and implemented in such a way that disturbance is minimised.
The presence of anchors and chains will be managed using an anchor management plan and liaison with regional fishing groups.
A debris survey will be undertaken at the completion of the decommissioning activities. Any debris identified as resulting from decommissioning activities will be recovered from the seabed where possible.
Optimise the area that requires an over-trawl assessment through discussion with the NFFO and the regulators. Investigate the use of non-intrusive survey method rather than an over-trawl assessment.
Large Releases to Sea
All vessel activities will be planned, managed and implemented in such a way that vessel durations in the field are minimised.
Spirit Energy's existing marine standard will be followed to minimise risk of hydrocarbon releases.

Table 1.4.1: Summary of proposed control and mitigation measures

1.5 Conclusion

Overall, the EA concludes the significance of the risk of the potential impacts from seabed disturbance is **low** and the significance of the risk of the impacts from a large unplanned release of diesel to sea is **medium**. In addition, the cumulative impact from physical presence and seabed disturbance is determined to be **low** and not significant and no substantive cumulative impacts from underwater sound are anticipated.

2. INTRODUCTION

2.1 Background

This EA report supports the DPs [101] & [102] required by the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) for the proposed decommissioning of the Ensign field facilities and infrastructure.

The purpose of the EA is to assess the significance of the environmental impacts and risks associated with decommissioning, and to identify control and mitigation measures to reduce the level of these impacts and risks to 'as low as reasonably practicable'.

The Ensign gas field lies within the main Southern North Sea (SNS) Gas Province in UK Block 48/14a (Figure 2.1.1), lies ~80km north east of Cromer on the coast of Norfolk in water depths of approximately 25m.

The field was developed using a single installation and achieved first production in 2011. The Ensign installation and pipelines are wholly owned by Spirit North Sea Gas Limited (Spirit Energy). The installation itself is a Not Permanently Attended Installation (NPAI) supported by a four-legged conventional piled steel jacket. Until May 2017, gas from Ensign was exported via a 10" pipeline (PL2838) to Audrey A (WD) and onwards to the LOGGS Production Installation via a 20" gas export pipeline (PL496) (Figure 2.1.2). Please refer to Section 1 of the Decommissioning Programmes [101] & [102] for the date the Cessation of Production justification for Ensign was approved by the Oil and Gas Authority.

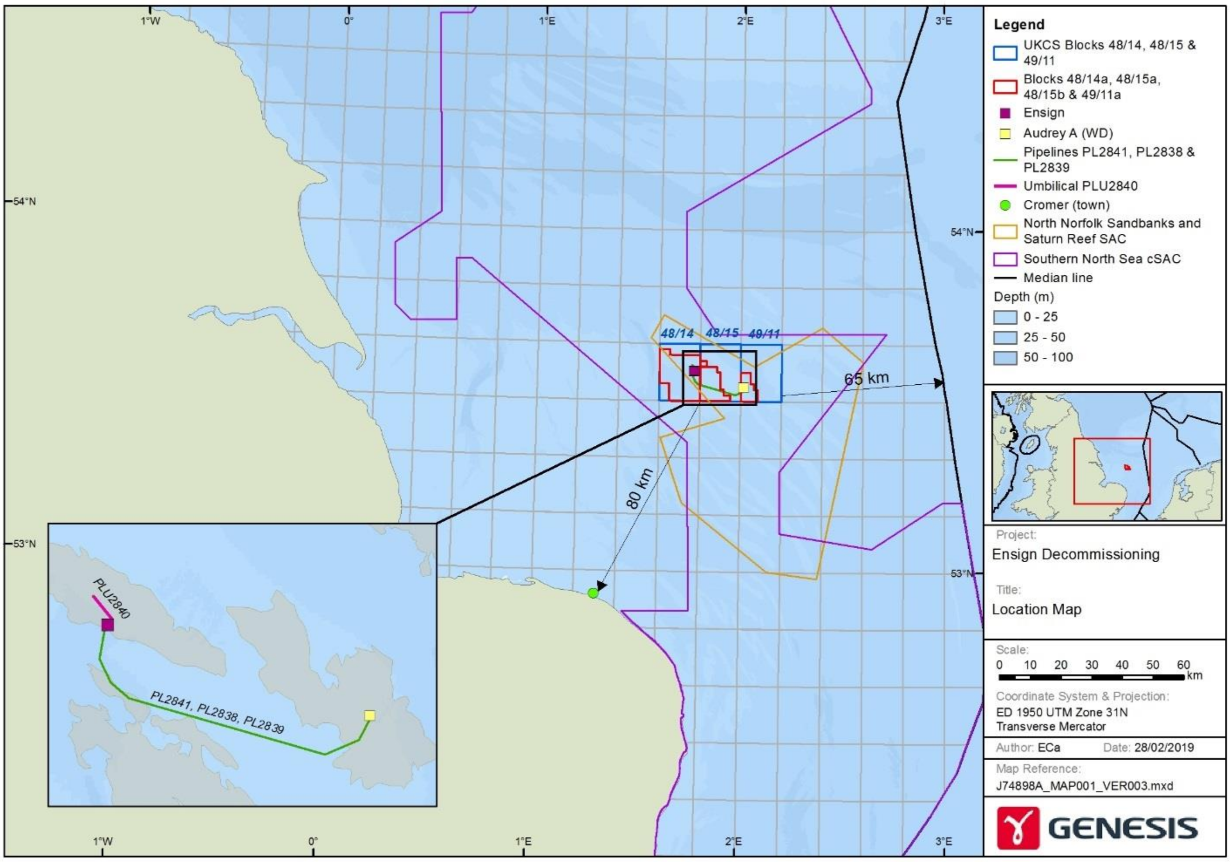


Figure 2.1.1: Location of the Ensign field

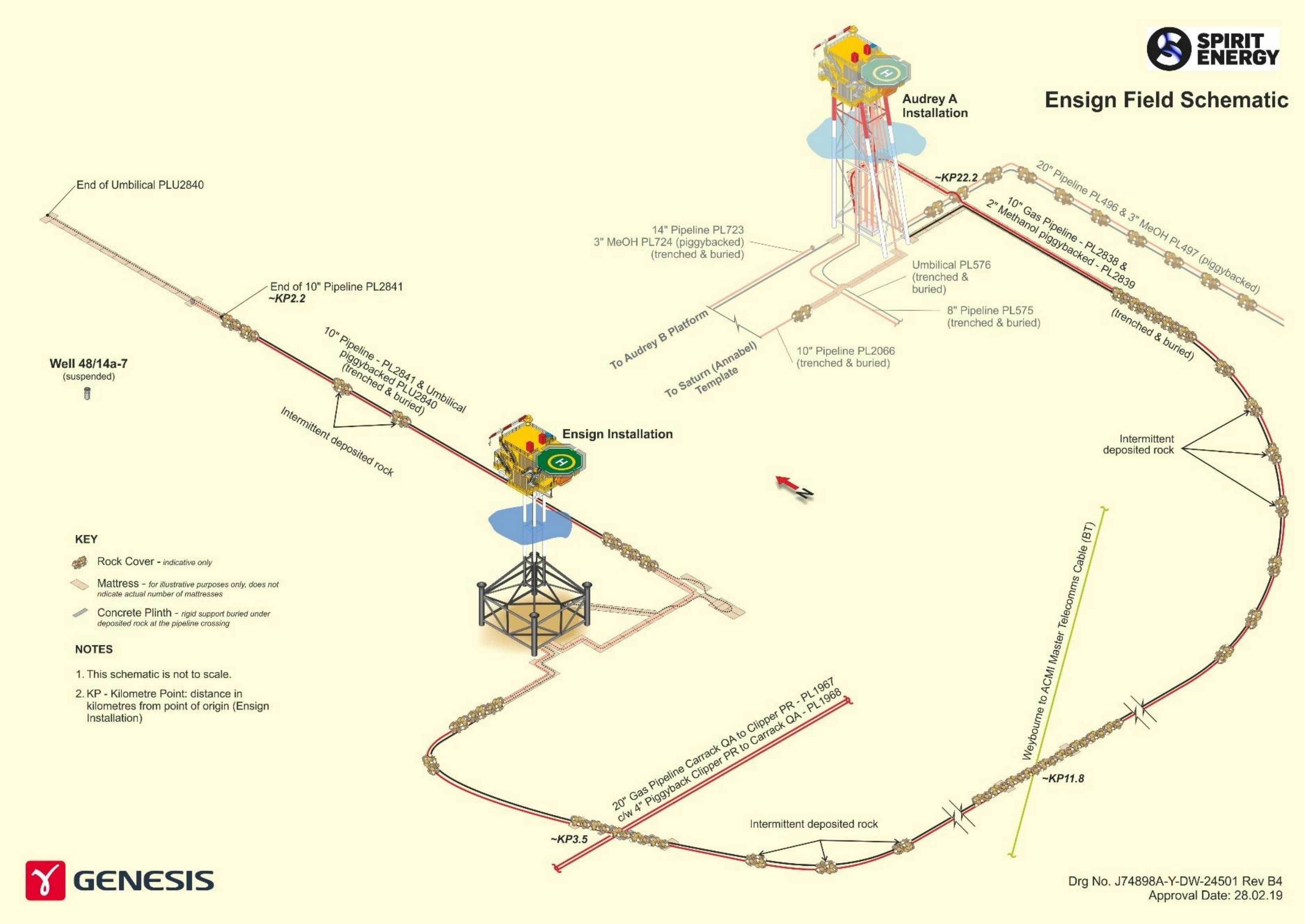


Figure 2.1.2: Ensign field facilities

2.2 Boundaries to the decommissioning project

The scope of this EA is aligned with the scope of the DPs [101] & [102]. The level of detail presented and assessed in the EA is aligned with the level of engineering detail developed at the time of the preparation and submission. The scope covers the following:

1. The Ensign installation;
2. The associated pipelines PL2838 and PL2841 (gas pipelines), PL2839 (methanol pipeline), PLU2840 (umbilical); and,
3. Pipeline stabilisation features (concrete mattresses, plinths, grout bags and deposited rock);
4. The scope excludes well abandonment and preparatory works (Sections 4.1 and 4.2).

The environmental impacts and risks associated with the Ensign facilities during installation and production phases have been assessed and reported in the development Environmental Impact Statement [12], the Ensign Field Oil Pollution Emergency Plan (OPEP) [105] and the Production Operations Master Application Template (MAT) (PRA/114) [104].

2.3 Regulatory context

The UK international obligations on decommissioning are governed principally by the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic Oslo-Paris (OSPAR) Convention [78]. The OSPAR Decision 98/3 [80] sets out the UK's international obligations on the decommissioning of offshore installations. However, pipelines and umbilicals are not included within the Decision and the preference for the decommissioning of pipelines and umbilicals is determined via a Comparative Assessment as set out in the Decommissioning Guidance Notes [107].

On the United Kingdom Continental Shelf (UKCS), the decommissioning of offshore oil and gas installations and pipelines is controlled through the Petroleum Act 1998, as amended by the Energy Act 2008. Under the Petroleum Act 1998, owners of an offshore installation or pipeline must obtain approval of a 'DP' from the OPRED before they can proceed with its decommissioning. Any change to the proposed decommissioning activities will be discussed with OPRED.

There is no statutory requirement to undertake an Environmental Impact Assessment (EIA) that satisfies the EIA Directive (Directive 2011/92/EU as amended by Directive 2014/52/EU) to support a DP. However, OPRED requires that a DP must be supported by an EA report, as set out in the Decommissioning Guidance Notes [107], assessing the potential environmental impacts and risks associated with the preferred decommissioning solution.

Spirit Energy manages environmental impacts via an International Standardisation Organisation (ISO) 14001 certified Environmental Management System (EMS). Decommissioning of Ensign will be managed in accordance with the Spirit Energy EMS through to completion.

2.4 Stakeholder engagement

Stakeholder engagement including consultation is important throughout the decommissioning process. Informal responses received to date from stakeholders have been incorporated into this EA and are described in the DPs [101] & [102], as appropriate.

2.4.1 Future consultation

The formal consultation process will begin with the submission of the draft DPs, supported by this EA report, to OPRED. The process at this stage will include the use of the Spirit Energy's external website to make the documents publicly available.

2.5 Contractor management

Contractor management is one of the primary mechanisms for managing environmental impacts and risks. Spirit Energy will appoint a project management team to select and manage the operations of contractors. The team will ensure the decommissioning is executed safely in accordance with Spirit Energy Health and Safety principles and safeguard the environment in line with the environmental policy [103].

3. ENVIRONMENTAL APPRAISAL PROCESS

3.1 Overview

Activities are first reviewed to identify planned and unplanned (accidental) interactions with the environment (aspects). Using baseline environmental information to identify receptors, the environmental and socio-economic impact of planned aspects are then assessed using the method described in Spirit Energy's Guidance for Environmental Management in Capital Projects. The risk assessment matrix used from the guidance is presented in Appendix A. This evaluates the impacts (on a scale of **low** to **high** significance) as a function of their extent and duration (recovery time) given the application of industry routine control and mitigation measures.

The hierarchy of control and mitigation measures is to preferentially avoid, minimise, restore and finally offset adverse impacts to reduce them to a level that is 'as low as reasonably practicable' in line with Spirit Energy's Environmental Policy [99].

The environmental and socio-economic assessment risk (of impact) from unplanned aspects follows a similar process. Following the assessment of the impact, the risk of impact is determined by factoring in the likelihood of the aspect occurring using the Spirit Energy Risk Assessment Matrix (Appendix A).

Aspects with impacts or risks which have been categorised as of **low** significance are not subject to further assessment (Section 6). Aspects with impacts or risks which have been categorised as of **medium** or **high** significance are assessed in more detail with additional control and mitigation being considered (Section 7).

The process flow chart is presented in Figure 3.1.1.

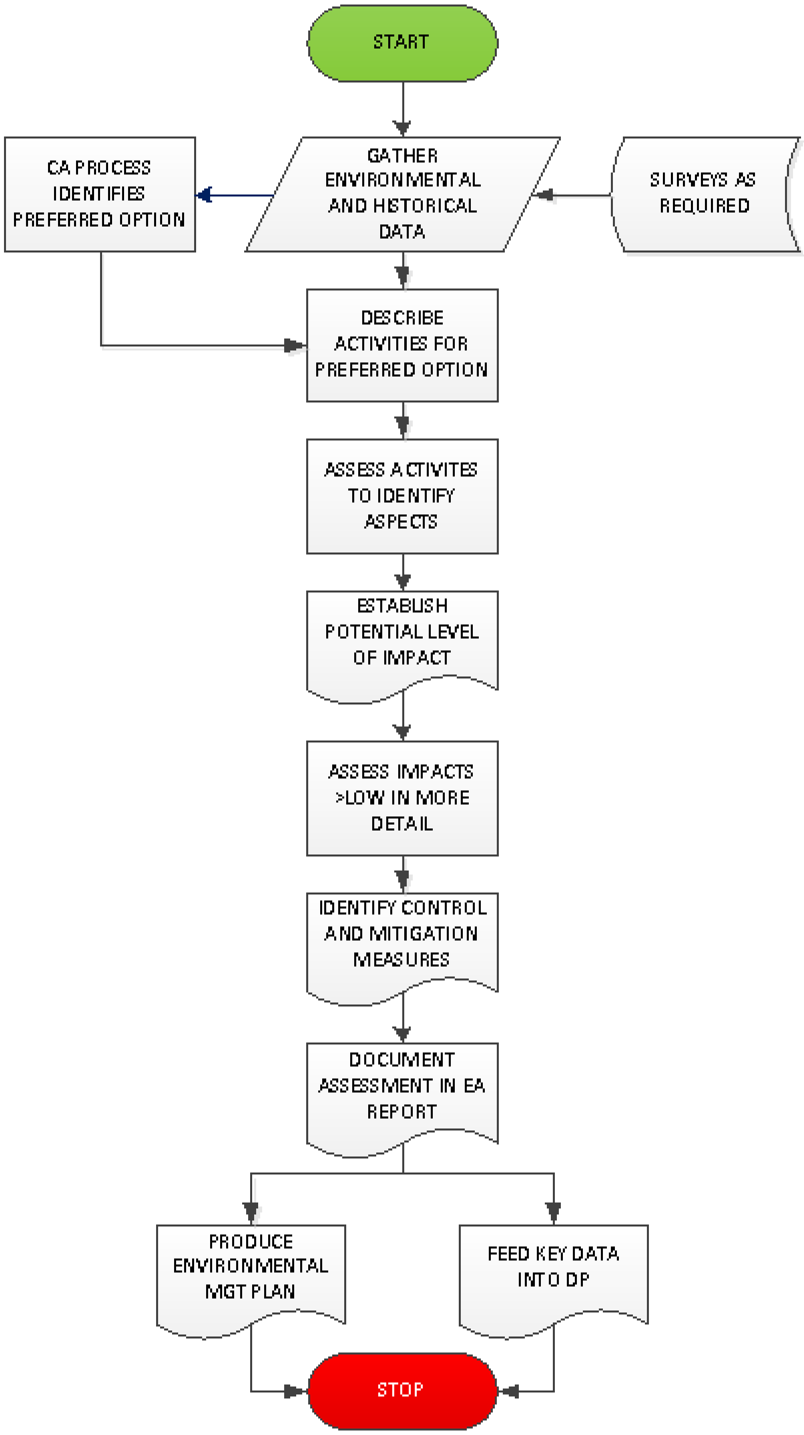


Figure 3.1.1: EA Process Flow Chart

4. PROJECT DESCRIPTION

This section presents the preferred decommissioning solution, hereafter referred to as the 'decommissioning project', as presented in Section 3 of the DPs [101] & [102].

The preferred decommissioning solution involves:

1. Complete removal and onshore disposal of the Ensign topsides and jacket in line with the requirements of OSPAR Decision 98/3 [80];
2. *In situ* decommissioning of the buried pipelines and umbilical (PL2838, PL2839, PLU2840 and PL2841)[1];
3. Removal and onshore disposal of exposed pipeline sections including those buried under concrete mattresses, but excluding sections buried under deposited rock;
4. Removal of all exposed pipeline stabilisation features such as concrete mattresses and grout bags; and,
5. *In situ* decommissioning of all stabilisation features such as concrete mattresses and concrete plinths that are buried at the pipeline and cable crossings. That is, the pipeline and cable crossings will be left undisturbed.

An overview of the preferred decommissioning solution is presented in Figure 4.6.1 and the Ensign field following completion of the preferred decommissioning solution is presented in Figure 4.9.1.

4.1 Well abandonment

The Ensign wells (48/14a-7y, 48/14a-5 and 48/14a-6) will be decommissioned in compliance with Health and Safety Executive Regulations [35] and with Oil and Gas UK (OGUK) Guidelines [75]. A MAT and the supporting Subsidiary Application Templates (SAT) will be submitted to OPRED in support of works carried out. A Petroleum Operations Notice (PON5) will also be submitted to OPRED for application to decommission the wells.

4.2 Facilities preparatory works

The topsides will be vented and purged prior to their removal. The waste types and proposed disposal routes from the topsides flush, purge and cleaning are presented in Table 4.4.1. Pipelines currently contain inhibited seawater or filtered seawater and will not require any further cleaning to be undertaken. The hydraulic fluid cores of the umbilical PLU2840 will not be flushed (See Section 4.4.3).

[1] The preference for the pipelines and umbilicals was determined via a Comparative Assessment [100]

4.3 Ensign facilities

The installation and pipelines, including pipeline stabilisation features, covered under the DPs are presented in Figure 2.1.2, Table 4.3.1 to Table 4.3.3 and Figure 4.3.1 to Figure 4.3.5.

4.3.1 Surface installation

Name	Facility Type	Location		Topsides/ Facilities		Jacket		
				Weight (Te)	No. of Modules	Weight (Te)	Number of Legs and Piles	Weight of Piles (Te)
Ensign installation	Small fixed steel	WGS84 Decimal	53.59054°N 1.773314°E	465	1	599	4 piles	433
		WGS84 Decimal Minute	53°35.4322"N 1°46.3988"E					

Table 4.3.1: Surface installation information

4.3.2 Pipelines including stabilisation features

Item	Diameter (NB) (inches)	Length (km)	Original Product Conveyed	From – To End Points
Gas pipeline PL2838	10"	22.315	Natural gas, condensate, water	Emergency shut down valve (ESDV) flange at Ensign installation to ESDV flange at Audrey A (WD)
Methanol pipeline PL2839	2"	22.240	Methanol and corrosion inhibitor	Audrey-LOGGS Methanol Pipeline tie-in at Audrey A (WD) to Ensign installation 3" Methanol riser ESDV flange
Umbilical PLU2840	4.8"	2.190	Not used	Ensign umbilical Topsides Umbilical Termination Unit (TUTU) to end of concrete mattresses on approach to Ensign ED well
Gas pipeline PL2841	10"	2.050	Not used	End of deposited rock on approach to Ensign ED well to ESDV flange at Ensign installation
NOTE: PL2838 and PL2839 and PLU2840 and PL2841 are piggybacked. PL2840 and PL2841 were not brought into operation.				

Table 4.3.2: Pipeline information

Stabilisation Feature	Total Number	Total Weight (Te)	Location(s)	Exposed/Buried/Condition
Concrete mattresses and plinths	20	168.5	5 x mixed density (MD) in vicinity of Ensign ED well; 15 x standard density (SD) in vicinity of Ensign ED well; Refer Figure 4.3.2	Survey data suggests that most of the concrete mattresses in vicinity of Ensign ED well approach are exposed.
	42	348.6	12 x SD in vicinity of Ensign installation (PL2838/PL2839); 30 x SD in vicinity of Ensign installation (PLU2840/PL2841); Refer Figure 4.3.1	Survey data suggests that most of the concrete mattresses in vicinity of Ensign are exposed.
	4	27.2	2 x half-thickness (HT) at Weybourne to the ACMI cable crossing; 2 x SD at Weybourne to the ACMI cable crossing; Refer Figure 4.3.4	These mattresses are buried under rock at the crossing.
	7	56	2 x HT at Carrack QA to Clipper PR pipeline crossing; 2 x SD at Carrack QA to Clipper PR pipeline crossing; 1 x concrete plinth type 1 (1m x 2.4m x 6m); 1 x concrete plinth type 2 (1m x 2.4m x 6m); 1 x concrete plinth type 3 (0.6m x 2.4m x 6m); Refer Figure 4.3.3	These mattresses and plinths are buried under deposited rock at the crossing.
	33	261.9	5 x MD in vicinity of Audrey A (WD) installation; 25 x SD in vicinity of Audrey A (WD) installation; 3 x HT in vicinity of Audrey A (WD) installation; Refer Figure 4.3.5	Survey data suggests that most of the concrete mattresses in vicinity of Audrey A (WD) are exposed.
Grout bags	358	9.0	Notional number of grout bags. As-built data not explicit.	Survey data suggests that most of the grout bags in vicinity of Ensign are exposed.
Deposited rock	n/a	1,084	Approaches to Ensign ED well, 121m long; Refer Figure 4.3.2	Largely exposed.
	n/a	2,306	Approaches to Ensign installation, 244m long; Refer Figure 4.3.1	Largely exposed
	n/a	782	Approaches to Audrey A (WD), 124m long; Refer Figure 4.3.5	Largely exposed
	n/a	6,925	PL2838 and PL2839 Upheaval Buckling (UHB) mitigation, intermittent between KP0.02 and KP21.1; Total 1,7km long	Largely exposed
	n/a	76	PLU2840 and PL2841 UHB mitigation, between KP0.18 and KP.19 and between KP0.28 and KP0.29; Total 18m long	Largely exposed
	n/a	7,179	Carrack QA to Clipper PR pipeline crossing; 346m long; Refer Figure 4.3.3	Largely exposed
	n/a	3,598	Weybourne to ACMI master cable crossing; 249m long; Refer Figure 4.3.4	Largely exposed

Table 4.3.3: Subsea pipeline stabilisation information

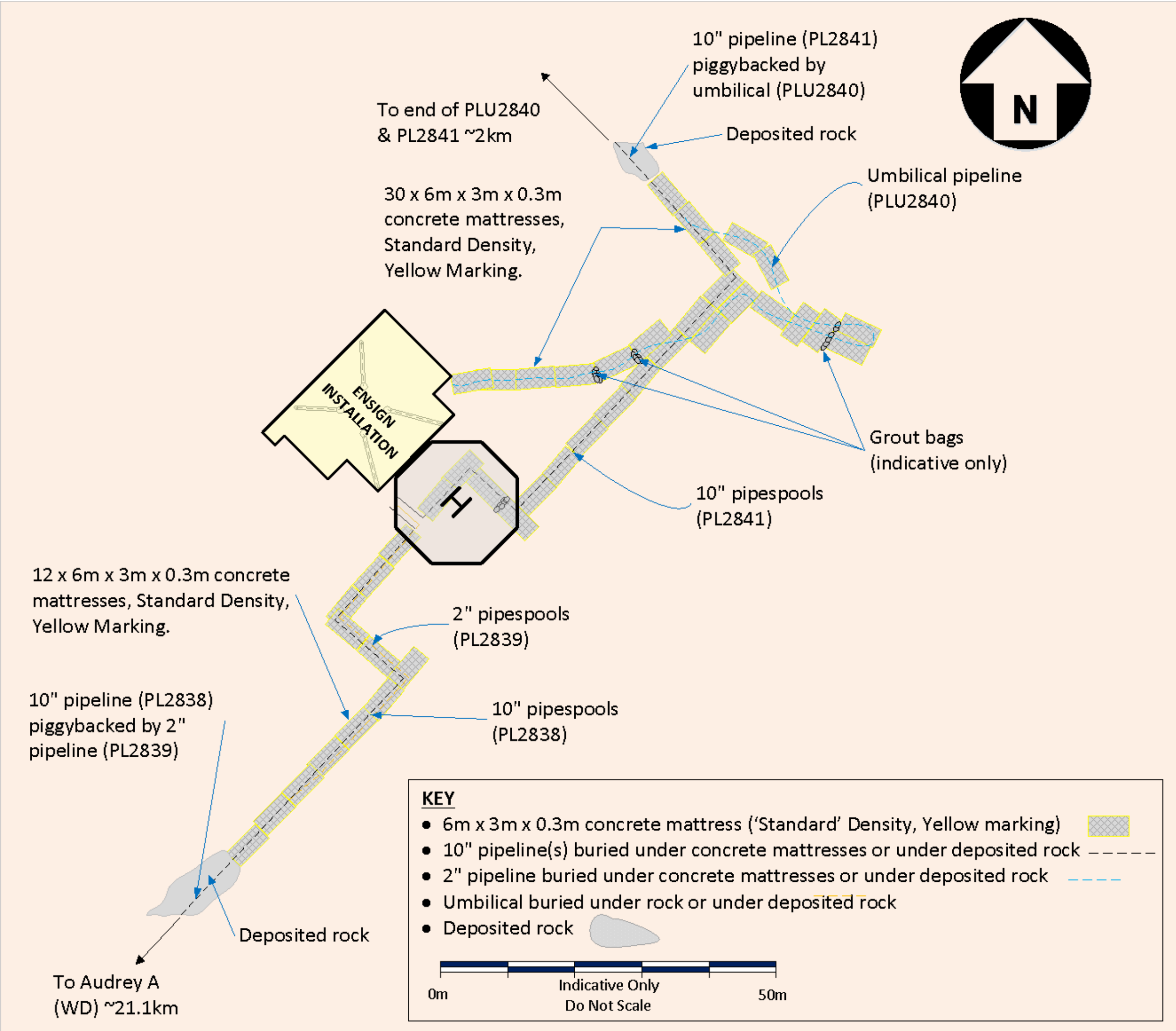


Figure 4.3.1: Overview of Ensign approaches

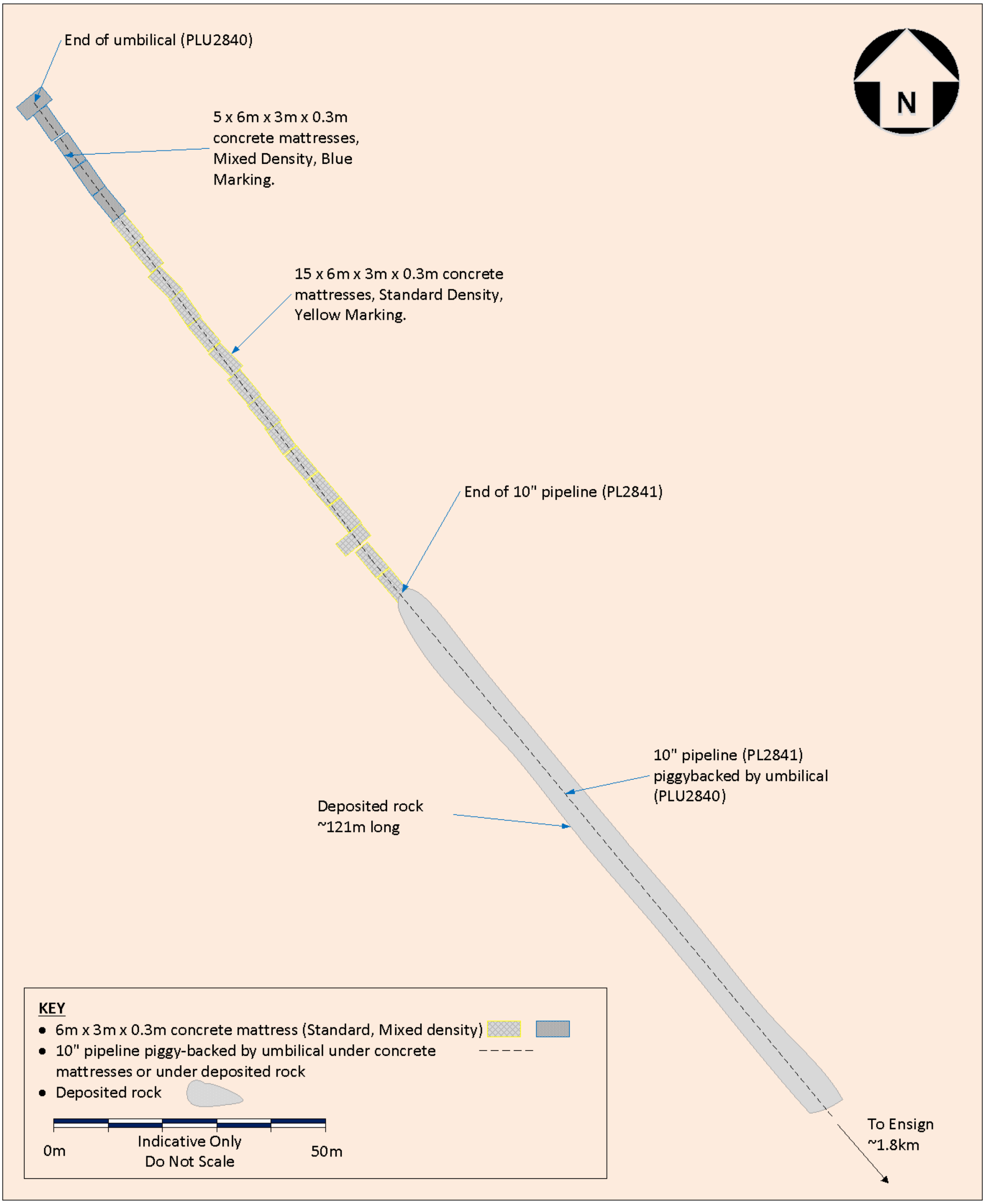


Figure 4.3.2: Ensign suspended well approaches (~KP1.9)

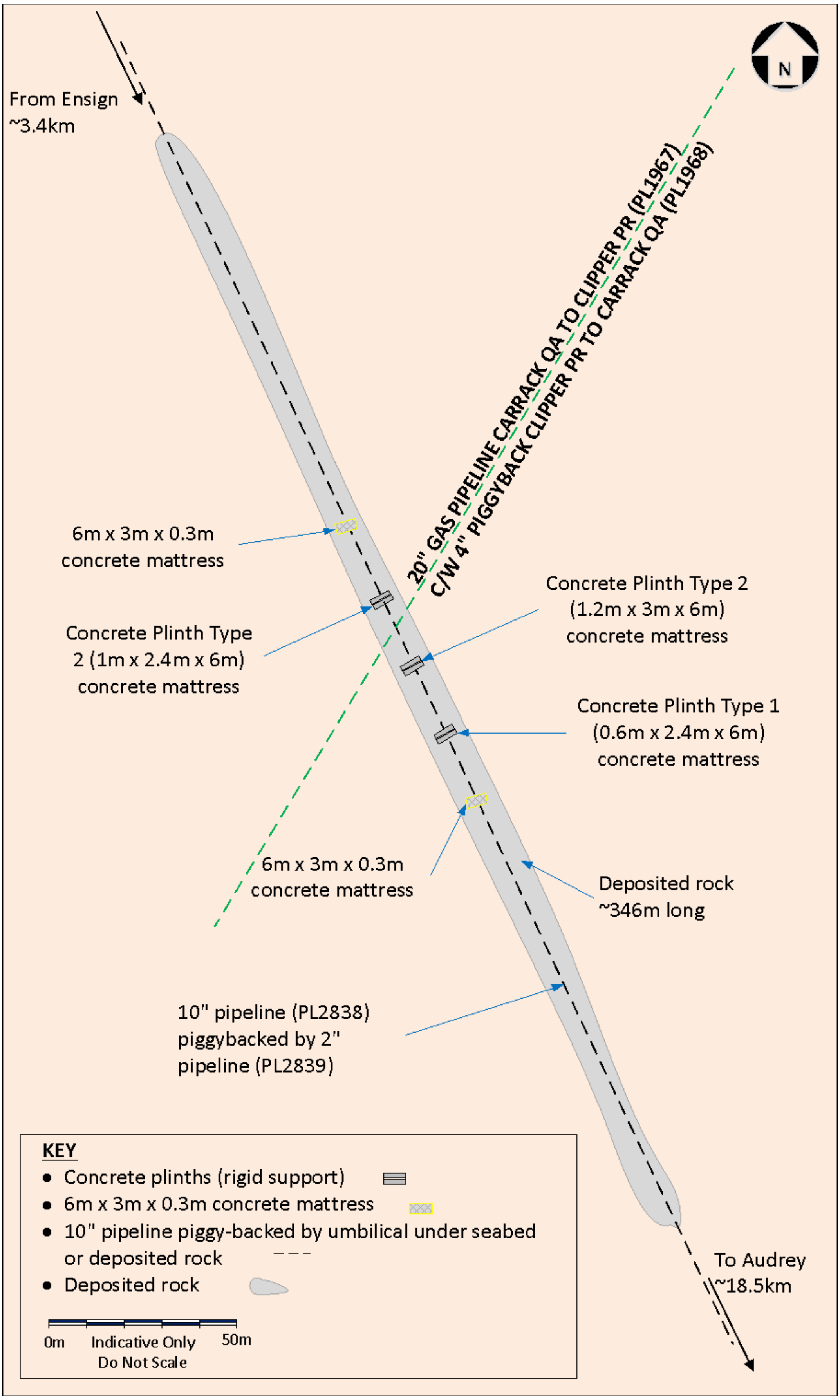


Figure 4.3.3: Carrack QA to Clipper PR pipeline crossing (~KP3.5)

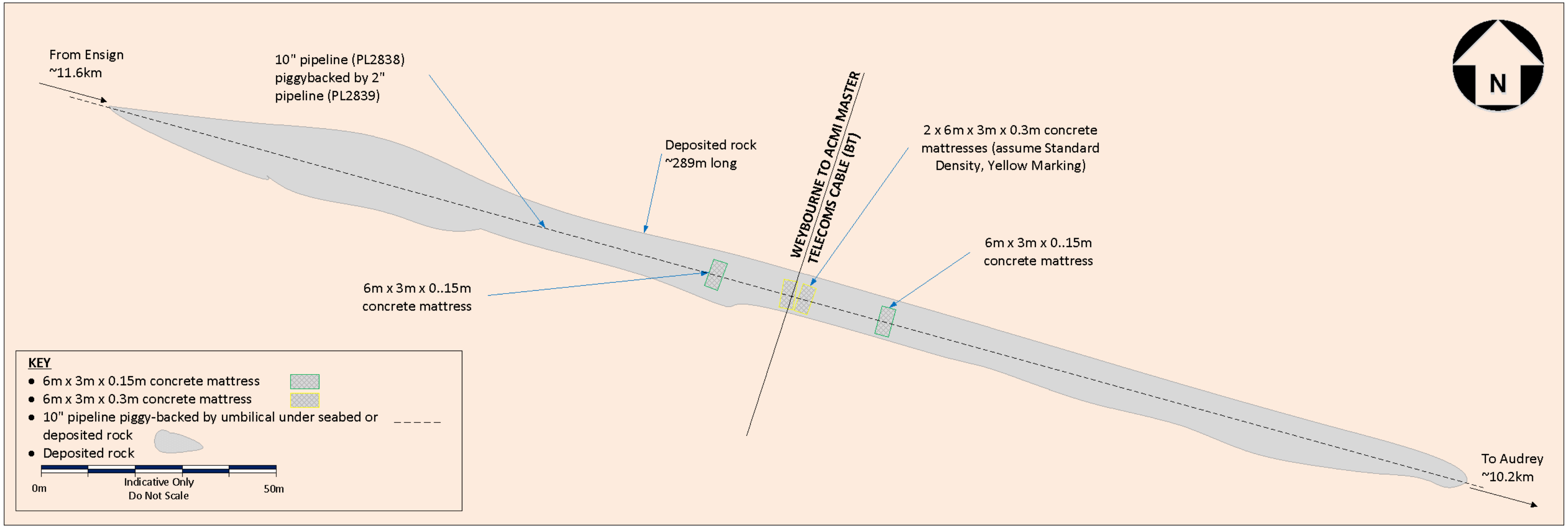


Figure 4.3.4: Overview of Weybourne to ACMI cable crossing (~KP11.8)

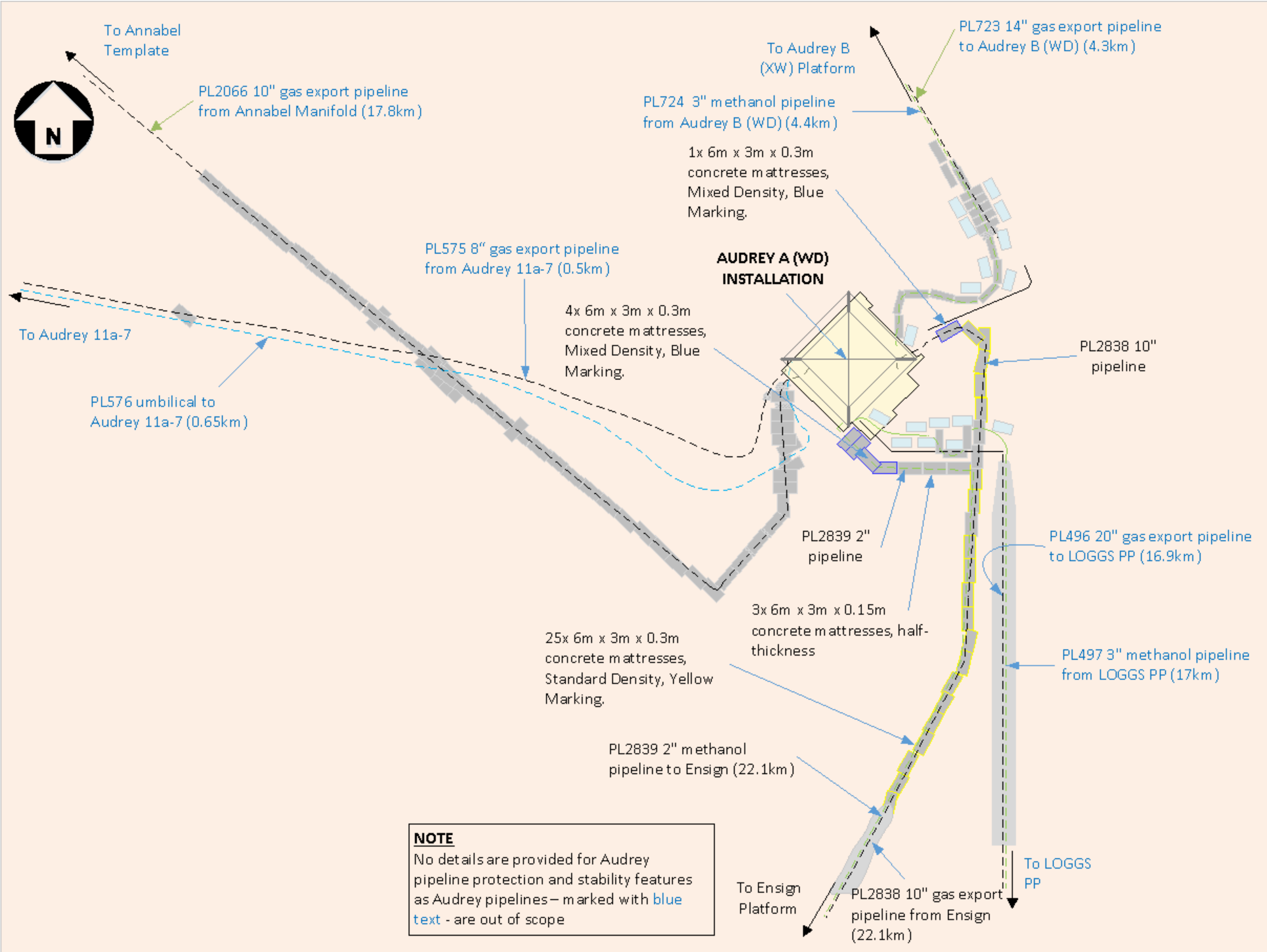


Figure 4.3.5: Overview of approaches to Audrey A (WD)

4.4 Decommissioning activities

The preferred decommissioning solution is described below and is summarised in Table 4.4.2. It is shown graphically in Figure 4.6.1.

4.4.1 Ensign installation topsides

The Ensign topside structure comprises a cellar deck, mezzanine deck and weather deck with overall plan dimensions 35m x 24m. The Ensign topside structure will be completely removed and recovered to shore. Possible methods of removal are presented in Table 4.4.2. A final decision on removal methods will be made following a commercial tendering process.

Prior to removal the topsides will be vented and purged using the methods presented in Table 4.4.1.

Waste Type	Composition of Waste	Disposal Route
On-board hydrocarbons	Reservoir hydrocarbons	Where possible, on-board hydrocarbons will be pumped into a donor well. Should this approach be unsuccessful, on-board hydrocarbons will be returned to shore for separation and use.
Other hazardous materials	The presence of Naturally Occurring Radioactive Material (NORM) will be identified.	NORM, if present, will be disposed of in accordance with the appropriate permit. Sealed sources will be returned to their owner or supplier.
Original paint coating	The presence of hazardous materials such as for example chromate- and chromium VI compounds in paint will be identified.	Painted items will be disposed of onshore with consideration given to any toxic components. May give off toxic fumes / dust if flame-cutting or grinding / blasting is used so appropriate safety measures will be taken.

Table 4.4.1: Cleaning of topsides for removal

4.4.2 Ensign installation jacket

The Ensign jacket will be removed and recovered to shore for recycling, most likely in a single lift[2]. Assuming there would be no technical issues the piles will be cut internally 3.0m below the seabed unless unforeseen difficulties are encountered, and external cutting is deemed necessary. For external cutting, excavation of the seabed around the piles is required for access to enable a cut 3.0 m below the seabed. Possible methods of removal are presented in Table 4.4.2.

4.4.3 Pipelines and umbilical[3]

Gas pipeline PL2828 and methanol pipeline PL2839 currently contain inhibited seawater and gas pipeline PL2841 currently contains filtered seawater. These pipelines will not require any further cleaning to be undertaken. The hydraulic fluid cores of the umbilical PLU2840 will not be flushed. Any residual fluids from within these pipelines or umbilical will be released to the marine environment under permit. The pipeline and umbilical ends will be removed to shore. Further cleaning and decontamination will take place onshore prior to recycling, as appropriate.

The pipelines and umbilical exhibit a good depth of burial cover and stability along their original trenched and buried lengths. There is a minimum of 0.6m depth of cover along the entire length of the pipelines and umbilical with no spans or exposures (Appendix B).

All exposed pipelines, or pipespools, or umbilicals on approach to the Ensign installation and Audrey A (WD) installation will be completely removed (PL2838 and PL2839). That is, all pipelines and the umbilical buried under concrete mattresses will be removed following recovery of the mattresses. Note that the 10” pipeline PL2841 does not extend past the end of the deposited rock. At the Ensign installation the 10” pipeline (PL2841) where it emerges from the deposited rock will be severed and disconnected from the riser flange. The umbilical (PLU2840) will be disconnected from the Topsides Umbilical Termination Unit (TUTU) and cut where it enters the deposited rock.

[2] The technique adopted for removal of the jacket will be subject to engineering feasibility and any commercial agreements.

[3] Pipespools will be discussed as part of the pipeline, so are not listed separately.

The 10” pipespools (~81.2m) and exposed umbilical pipeline (~131m) will be exposed once the associated stabilisation features have been removed, therefore these will be completely removed. A MAT and the supporting SATs will be submitted to OPRED in support of works carried out.

Once pipelines are decommissioned *in situ,* monitoring to confirm the pipelines remain buried will be completed to a schedule agreed with OPRED.

4.4.4 Pipeline and umbilical stabilisation features

All exposed concrete mattresses will be recovered to shore (Table 4.4.2). Grout bags if found and exposed, will be recovered to shore otherwise they will be left *in situ*. Concrete plinths and mattresses buried under deposited rock at the pipeline crossing will be left *in situ*. All deposited rock will be left *in situ*.

A summary of the preferred Ensign decommissioning solution is presented in Table 4.4.2. Several removal methods exist for the topsides and a final decision will be made following a commercial tendering process.

Option	Method
Ensign Topsides	
Removal of topsides followed by recovery to shore for re-use, recycling or disposal.	1. Single lift removal by Heavy Lift Vessel (HLV); 2. Single lift removal of topsides and then removal of jacket by HLV and transfer to transport barge; 3. Piece-small or piece-large removal using a transport barge.
Ensign Jacket	
Removal of jacket followed by recovery to shore for re-use, recycling or disposal.	Single lift removal by HLV.
Pipelines PL2838 and PL2839	
Leave most of the pipelines *in situ*.	At Ensign installation and Audrey A (WD) installation sever the pipelines where they emerge from the deposited rock and disconnect them from the riser flanges. Completely remove otherwise exposed 10” pipespools and exposed 2” methanol pipespools once the associated stabilisation features have been removed. At the pipeline ends the deposited rock will be redistributed slightly to ensure that the pipeline ends remain buried; as a contingency measure, it may be necessary to deposit up to 2Te of loose rock over each of the pipeline ends on top of existing rock such that a maximum of 8Te will be laid in total.
Pipeline PL2841 and Umbilical PLU2840	
Leave most of the pipelines *in situ*.	On approach to the Ensign ED well only the umbilical is protected by the concrete mattresses; completely remove the section of umbilical as it exits the deposited rock to the end of the concrete mattresses (approximately 114m long). The 10” pipeline does not extend past the deposited rock. At Ensign installation sever the 10” pipeline where it emerges from the deposited rock and disconnect it from the riser flange. Disconnect the umbilical from the TUTU and cut umbilical where it enters the deposited rock. Completely remove otherwise exposed 10” pipespools (approximately 81.2m) and exposed umbilical pipeline (approximately 131m; this dimension excludes length between TUTU and bottom of J-tube approximately 50m long) once the associated stabilisation features have been removed. At the pipeline and umbilical ends the deposited rock will be redistributed slightly to ensure that the pipeline ends remain buried; as a contingency measure, it may be necessary to deposit up to 2Te of loose rock over each of the pipeline ends on top of existing rock such that a maximum of 8Te will be laid in total.
Concrete Mattresses Underneath Pipeline and Cable Crossings	
Leave the concrete mattresses buried under deposited rock at the pipeline and cable crossings *in situ*.	No activity.

Option	Method
Concrete Mattresses on Top of Pipespools	
Recover all exposed concrete mattresses to shore for re-use, recycling or disposal.	The mattresses will be lifted from the seabed using lifting frames or baskets and recovered for onshore disposal.
Concrete Plinths	
Leave the concrete plinths buried under deposited rock at the pipeline crossing *in situ*.	No activity.
Grout Bags, Commonly Placed Adjacent to Or Over Concrete Mattresses.	
If found, recover to shore for re-use, recycling or disposal. If not found due to being buried leave *in situ*.	Grout bags will be lifted using grappling tools from the seabed and recovered for onshore disposal.
Deposited Rock	
Leave *in situ.*	No activity.

Table 4.4.2: Summary of Ensign preferred decommissioning solution

4.5 Surveys

Surveys will be undertaken before, during and after the decommissioning project execution phase.

4.5.1 Pre-decommissioning environmental survey

A pre-decommissioning environmental and debris survey has been undertaken in advance of the execution phase to inform this EA, decommissioning plans, permits, licences and consent applications and to provide a baseline against which to reference the results of any post-decommissioning environmental surveys. The environmental survey data will be used in the planning of any legacy surveys.

4.5.2 Execute phase and legacy surveys

When all infrastructure and materials have been either removed, or decommissioned *in situ*, a series of surveys will be undertaken.

1. A Dive Support Vessel (DSV), Remotely Operated Vehicle (ROV) or Construction Support Vessel (CSV) will undertake a visual seabed debris survey before leaving the field and recover any debris;
2. At a time after any debris has been removed, activities to demonstrate a clear seabed will be undertaken. The most likely method will be a non-intrusive sidescan sonar survey, however a seabed over-trawl assessment may be undertaken if it is considered necessary. The method will be agreed with OPRED;
3. A post decommissioning environmental survey may also be undertaken using a survey vessel; and,
4. Depth of burial.

The results of the surveys will identify any changes to the seabed following infrastructure decommissioning, will feed into the project close-out report, and will inform the requirements for possible future legacy surveys. The timing and extent of required legacy surveys will be agreed in conjunction with OPRED.

Table 4.5.1 summarises the anticipated decommissioning survey requirements. The timing and extent of required legacy surveys will be agreed in conjunction with OPRED.

Phase	Survey	Requirement
Execute Phase Decommissioning	**Visual debris survey** DSV or (CSV deploying a Remotely Operated Vehicle (ROV) **Over-trawl assessment or non-intrusive method** to verify absence of snagging hazards (fishing vessel deploying bottom trawling equipment, or a survey vessel using remote sensing technology)	Obtain Clear Seabed Certificate. Feeds into project close-out report.
	Post-decommissioning environmental survey	Feeds into close-out report and informs requirements for future surveys.
Future	**Depth of burial**	Timing and extent dependent on outcome of earlier surveys.

Table 4.5.1: Survey requirements

4.6 Vessel use

Offshore vessel use will take place primarily at the Ensign installation location with transits between ports and this location.

Different vessel types will be required (e.g. DSV, HLV, transport barge) at various times, and for various durations, to undertake the decommissioning activities. At the time of writing the EA, the method of removal and the offshore execution schedule had yet to be confirmed. In absence of this data, engineering judgement has been used to estimate vessel type and schedule based on experience from similar decommissioning projects.

The fuel consumption rate of the generic vessel types required are understood which, in conjunction with a high level and worst-case vessel schedule, has allowed fuel consumption to be estimated (Table 4.6.1). Estimates of fuel use are based on Institute of Petroleum Guidelines [36].

Vessel Type	Duration In Transit To And From Field (Days)	Duration In Field (Days)	Fuel Usage Per Day In Transit (Te)	Fuel Usage Per Day In Field (Te)	Total Fuel Usage (Te)
HLV	2	7	50	30	310
Transport barge	8.5	5.5	25	30	378
Tugs (3 needed to mobilise barge)	8.5	5.5	14	25	770
DSV	4	16	22	18	385
Emergency Response and Rescue Vessel (ERRV)	2	7	3.5	0.8	13
Fishing vessel (seabed over-trawl assessment)	2	4	8	4	32
Survey vessel (post decommissioning surveys)[4]	6	12	22	18	348
Total					**1,983**

Table 4.6.1: Estimated fuel usage by vessels required for decommissioning project

[4] Based on the assumption that three legacy surveys will be carried out.

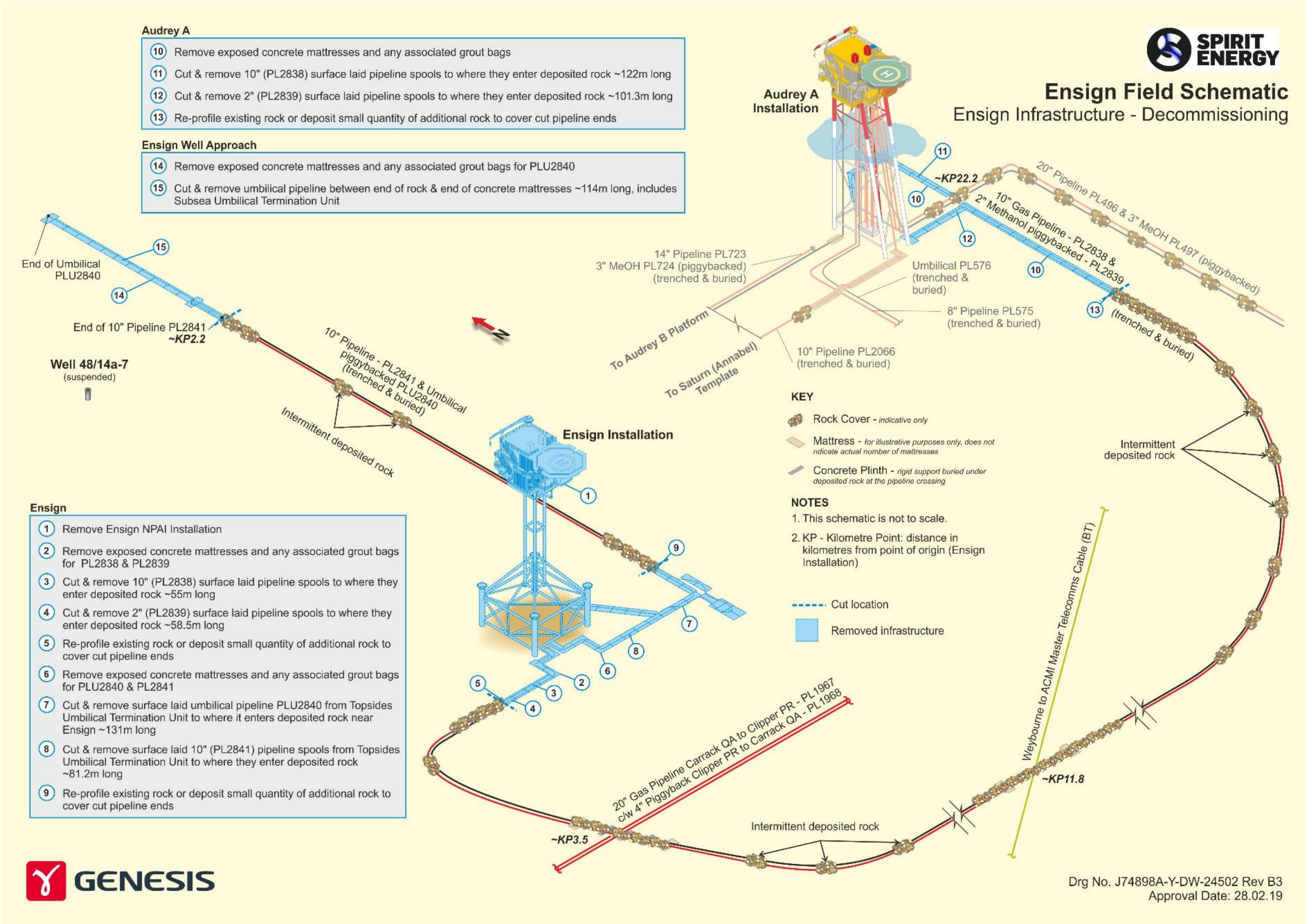


Figure 4.6.1: Overview of Ensign decommissioning project

4.7 Management of waste and recovered materials

All material recovered will be returned to a shore base for initial laydown.

Non-hazardous material includes scrap metals (steel, aluminium and copper), concrete and plastics that are not cross-contaminated with hazardous material. Marine growth on the jacket is classed as non-hazardous and some of this may need to be removed offshore to allow access for decommissioning works. The remainder of marine growth will be brought to shore and disposed of according to guidelines and company policies. Hazardous materials will include oil contaminated material, chemicals, potentially NORM and potentially chromate or chromium VI-based paint. An estimate of the proportions of the materials that comprise the installation, pipelines and umbilical and stabilisation features is provided in Table 4.7.1.

Item/Feature	Inventory (Te)					
	Total	**Steel**	**Plastic/ Rubber**	**Non-Ferrous Metals**	**Concrete/ Grout**	**Deposited Rock**
Installation[5]						
Total	1,496.58	1409.19	6.89	28.80	51.70	0.00
Recovered	1,224.64	1169.72	6.89	28.80	19.23	0.00
Decommissioned *in situ*	271.94	239.47	0.00	0.00	32.47	0.00
Pipelines and Umbilical						
Total	3,212.76	3151.73	93.85	0.76	0.00	0.00
Recovered	32.43	64.63	0.95	0.01	0.00	00.00
Decommissioned *in situ*	3,180.33	3087.10	92.90	0.75	0.00	0.00
Pipespools						
Total	34.21	33.15	0.70	0.35	0.00	0.00
Recovered	34.21	33.15	0.70	0.35	0.00	0.00
Decommissioned *in situ*	0.00	0.00	0.00	0.00	0.00	0.00
Pipeline Anodes						
Total	0.94	0.41	0.00	0.52	0.00	0.00
Recovered	0.00	0.00	0.00	0.00	0.00	0.00
Decommissioned *in situ*	0.94	0.41	0.00	0.52	0.00	0.00
Concrete Mattresses and Plinths						
Total	884.31	0.00	44.22	0.00	840.09	0.00
Recovered	784.50	0.00	39.23	0.00	745.28	0.00
Decommissioned *in situ*	99.81	0.00	4.99	0.00	94.82	0.00
Grout Bags						
Total	8.99	0.00	0.09	0.00	8.90	0.00
Recovered	8.99	0.00	0.09	0.00	8.90	0.00
Decommissioned *in situ*	0.00	0.00	0.00	0.00	0.00	0.00
Deposited Rock						
Total	21,951	0.00	0.00	0.00	0.00	21,951
Recovered	0	0.00	0.00	0.00	0.00	0
Decommissioned *in situ*	21,951	0.00	0.00	0.00	0.00	21,951
ALL MATERIALS						
All Materials	**27,588.79**	**4,560.92**	**145.74**	**30.43**	**900.70**	**21,951.00**
All Materials Recovered	**2,084.76**	**1,234.35**	**47.85**	**29.16**	**773.40**	**0.00**
All Materials Decommissioned *in situ*	**25,504.03**	**3,326.57**	**97.89**	**1.27**	**127.29**	**21,951.00**

Table 4.7.1: Summary of Ensign material inventory

Hazardous wastes will be recovered to shore and disposed of according to guidelines and company policies and under appropriate permit. Pipework that has been exposed to produced fluids may be contaminated by NORM. Tests for NORM will be undertaken offshore by the Radiation Protection Supervisor and any NORM encountered will be dealt with and disposed of in accordance with guidelines and company policies and under appropriate permits. Spirit have an existing permit for the accumulation and disposal of radioactive wastes (permit number

[5] The 271.9 tonnes decommissioned *in situ* is an estimate of the weight of the jacket piles remaining in the seabed after cutting. The installation weight is inclusive of risers and J-tubes.

EPR/XB3735DX). Any NORM associated with items decommissioned *in situ* will degrade naturally. No asbestos is expected, but if any is found it will be dealt with and disposed of in accordance with guidelines and company policies.

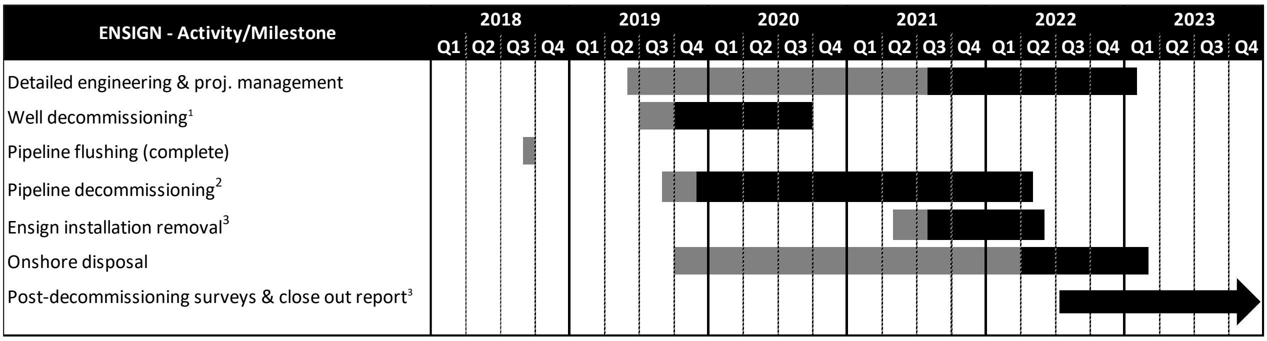
The project aspiration is that the waste arising from the decommissioning project will be managed and processed entirely by licensed contractors in the UK. There is a possibility that some of the waste could be shipped outside of the UK depending upon the type of waste and availability of UK facilities at the time of decommissioning.

A Waste Management Plan (WMP) for the DPs will be prepared and implemented in line with the Waste Framework Directive. The WMP will be a live document that specifies where all waste will be sent from offshore and the end point of the waste streams. If waste is shipped internationally, the WMP will present the responsibilities Spirit Energy has under the 'Duty of Care' legislation and identify appropriately licenced international onshore facilities where the waste can be treated. Appropriate licensed sites will be selected for the handling, treatment and disposal of the waste. The selected dismantling site will be able to demonstrate a proven disposal track record and waste stream management throughout the deconstruction process and demonstrate their ability to deliver re-use and recycling options.

4.8 Schedule

A proposed project schedule is provided in Figure 4.8.1. The activities are subject to the acceptance of the DPs [101] & [102] and any unavoidable constraints (e.g. vessel availability) that may be encountered while executing the decommissioning activities. Therefore, activity schedule windows have been included to account for this uncertainty.

The commencement of offshore decommissioning activities will depend on commercial agreements and commitments.



Notes / Key

Earliest potential activity

Activity window to allow commercial flexibility associated with well abandonment and decommissioning activities

1. Current indications are that well decommissioning will be carried out in 2019
2. Current intention is that Ensign pipelines at Audrey 'A' be decommissioned at the same time as the pipelines at Audrey 'A'
3. Removal of Ensign installation will be done sometime after well decommissioning activities have been completed
4. Post decommissioning surveys and close out reports will be prepared on completion of decommissioning activities

Figure 4.8.1: Gantt chart of project plan

4.9 Summary of planned decommissioning activities

Table 4.9.1 presents a summary of the planned decommissioning activities and the aspects from those activities that have the potential to interact with the environment and are included within the scope of the EA. Where more than one method could be used to undertake the activity, that which presents the worst case potential environmental impact has been presented and assessed.

Planned Decommissioning Activities	Description
Removal of Topsides and Jacket for recovery to onshore.	Use of HLV and transport barge, both anchored at the installation. The HLV and transport barge will both set their anchors and then the HLV will lift the topsides and place on the anchored transport barge. The HLV and transport barge will then reposition their anchors and the HLV will lift the jacket onto the transport barge. Cutting of jacket piles will be done internally using an abrasive water jet cutter. In case internal cutting fails the contingency will be external cutting, which will involve excavation of the seabed around the jacket legs to allow access.
Sever pipelines where they emerge from the deposited rock and disconnect from riser flanges. Removal of pipespools and section of umbilical from where it exits the deposited rock. Leave most of the pipelines *in situ.*	Severing of pipeline and umbilical will be undertaken using hydraulic shears. Discharge of pipeline and umbilical contents to the marine environment. The pipespools and umbilical section will be recovered using a grappling tool and baskets. Permanent presence of the buried pipelines in the seabed.
Deposit up to 2Te of loose rock over each of the pipeline ends (contingency measure).	Up to 2Te rock may be placed on existing rock using a fall pipe at each of the four pipeline ends.
Recovery of all exposed concrete mattresses to onshore.	Concrete mattresses will be recovered from the seabed using a lifting frame or baskets.
Leave *in situ* concrete mattresses and concrete plinths buried under deposited rock.	Permanent presence of the concrete mattresses and concrete plinths buried under deposited rock on the seabed.
Leave *in situ* existing deposited rock.	Permanent presence of the deposited rock on the seabed.
Removal of any exposed grout bags that are found for recovery to onshore.	Grout bags will be lifted using grappling tools from the seabed and placed in baskets for recovery to onshore.
Clear seabed assessment	Potential use of fishing gear to demonstrate a clear seabed. As this is a non-preferred method of verification, use of non-intrusive techniques such as SSS and ROV will be explored.
Onshore processing of removed infrastructure	The onshore transport and processing of removed facilities (cleaning, cutting etc.) at a shore-based waste processing facility, in preparation for transport to an appropriately licenced facility for recycling or disposal to landfill.

Table 4.9.1: Planned decommissioning activities

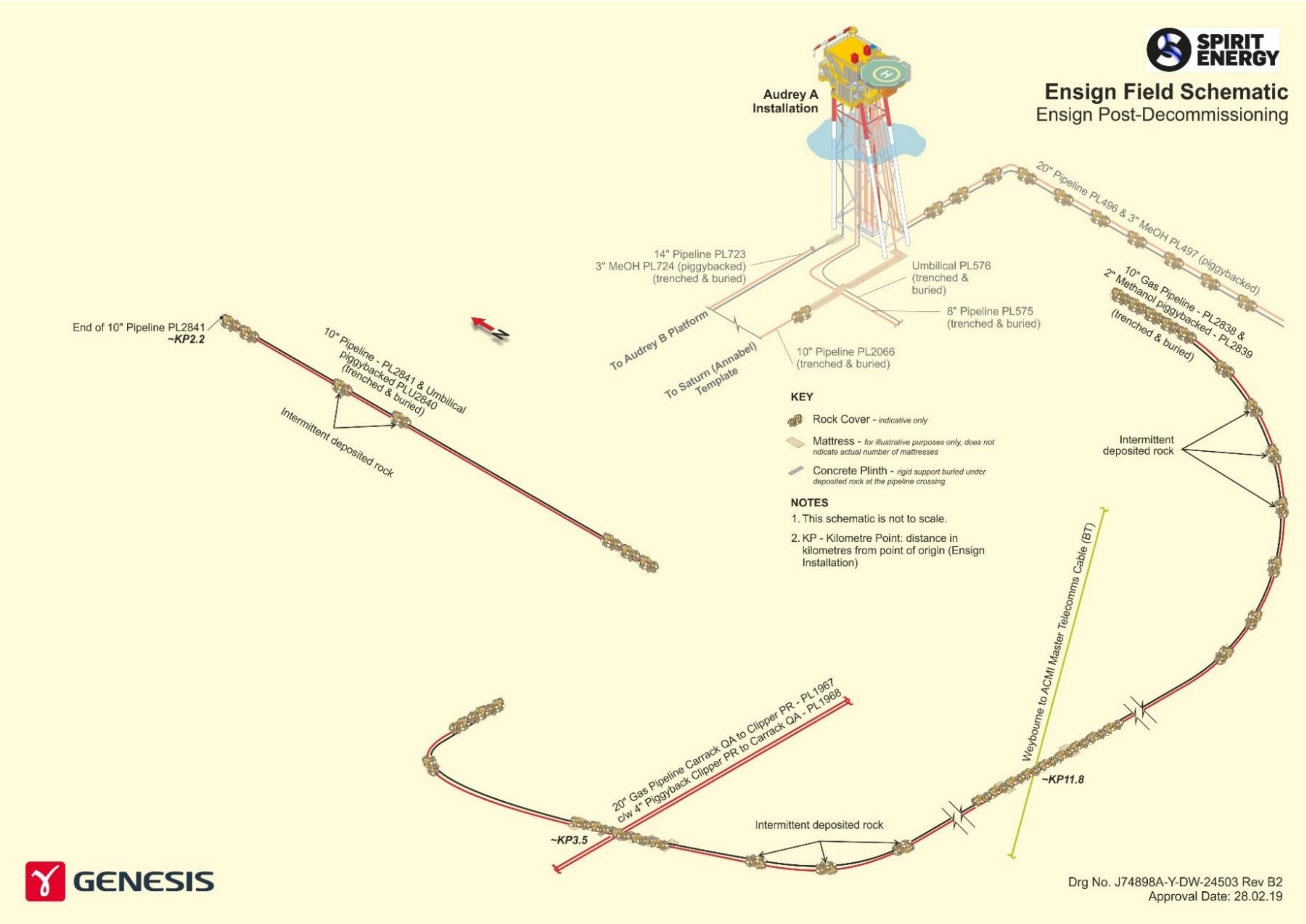


Figure 4.9.1: Ensign facilities following removal

5. ENVIRONMENTAL BASELINE

This section provides an overview of the key environmental features in the vicinity of the Ensign infrastructure that may be affected by the proposed decommissioning works. The information will be used to assess the level of impact that the aspects (activities with the potential to impact the environment) have on the environment.

5.1 Environmental Surveys

Several surveys have been undertaken at the Ensign field in preparation for the development and most recently in preparation for decommissioning. The location and key findings of these surveys are shown in Figure 5.1.1 and Table 5.1.1 respectively. More detail on the pre-decommissioning environmental and debris survey undertaken in 2018 is presented in Section 5.1.1.

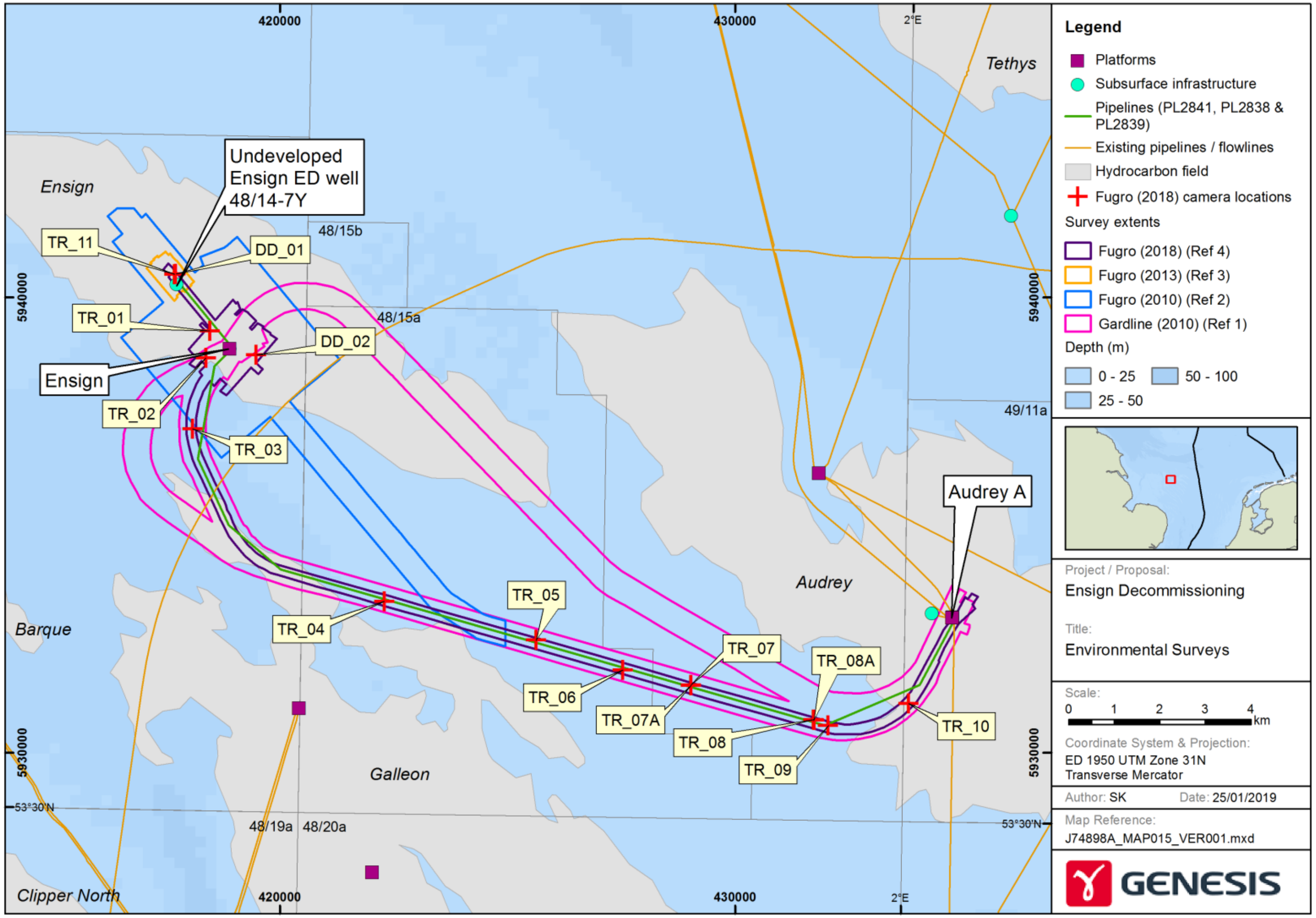


Figure 5.1.1: Location of past and most recent Ensign surveys[6]

[6] DD = Drop-down camera station and TR = Transect. DD and TR locations presented were part of the 2018 survey. Information on the surveys is presented in Table 5.1.1.

Survey Details	Key Findings	Figure 5.1.1 Reference Number[7]
Ensign Pre-Decommissioning Environmental and Debris Survey October 2018 UKCS Blocks 48/14a, 48/15 and 49/11a	The Ensign geophysical survey comprised a 1.2km x 1.2km survey area centred on the Ensign installation. The Ensign environmental survey was undertaken at the Ensign installation, along the pipelines from Ensign installation to Audrey A (WD) and the pipelines from Ensign ED well to the Ensign installation. The environmental survey comprised camera investigations of areas of potential conservation value, areas characteristic of the general background conditions of the site and areas of mottled and high reflectively to identify any potential *S. Spinulosa* reef and coarse sediments which may be potential herring spawning grounds. The sample locations drop down camera locations and transect locations are presented in Figure 5.1.1. Seabed sediments within the Ensign installation survey area were interpreted to comprise sand and gravelly sand. The sand was typically megarippled. Along the Ensign ED well to the Ensign installation pipeline corridor sediments comprised predominantly sand and gravel. Seabed sediments along most of the Ensign installation to Audrey A (WD) installation pipeline corridor were interpreted to comprise predominantly megarippled sand and gravelly sand. No *S. Spinulosa* aggregations were observed within the Ensign installation survey area and the area was described as unsuitable for herring spawning. Along the Ensign ED well to the Ensign installation pipeline corridor the overall *S. spinulosa* assessment 'Not reef' was assigned to transect TR_11 and 'Low reef' were assigned to station DD_01. The survey area was described as unsuitable for herring spawning, except for transect TR_11, where it was described as marginal. Along the Ensign installation to Audrey A (WD) installation pipeline corridor the overall *S. Spinulosa* assessment 'Not Reef' was assigned to six of the ten transects. Along these transects the reef was characterised by *S. spinulosa* in the form of thin and thick crusts and small and large clumps. The overall assessment 'Low Reef' was assigned to sections of two transects where the reef was characterised by clumps of consolidated upright *S. spinulosa.* The overall assessment 'Medium Reef' was assigned to one transect (TR_09) where large clumps of *S. spinulosa* at the beginning of the transect appear more consolidated and continuous and with higher elevation as the transect progressed. 'Medium Reef' was also assigned to sections of three transects where the reef was characterised by large clumps and larger patches of consolidated *S. spinulosa*, in places embedded with the substrate.	Ref 4
Ensign Development – Post operational Environmental survey including habitat assessment July 2013 UKCS Block 48/14 at and downstream of the 48/14a-7 ED Well	The site consisted of a 500m x 650m grid encompassing the Ensign ED well location. The survey was conducted to determine the physico-chemical and biological status of the seabed, and to re-examine areas of *S. spinulosa* reef encountered during a previous Fugro Survey LTD survey (2010). Digital photographic stills and video footage were successfully acquired along two transects and partially along a third. Photographic data were also acquired from four drop-down video stations. Environmental grab samples were acquired at five sampling stations within the survey area. The SSS and bathymetry data revealed a seabed characterised by low to medium reflectivity, with irregular seabed topography associated with bottom current features (ripples). An extensive scoured area was present to the north. No sensitive habitats were considered to be present within the current survey area. A comparison of the potential *S. spinulosa* patches delineated during the previous 2010 survey with this survey data indicated a distinct change in seabed conditions. A single small patch of possible *S. spinulosa* was delineated from this survey data whilst several small aggregations of *S. spinulosa* were observed in the 2010 survey data. Epifaunal diversity and abundance varied across the site. The survey area was characterised by a polychaete-dominated infaunal community with moderate diversity. Mean particle size showed little variation across the survey area from -0.03phi (very coarse sand) to - 1.63phi (granules). Sediments across the survey area were dominated by sand (63µm to 2mm) and coarse (>2mm) material Total Hydrocarbon Content (THC) were low throughout the site, ranging from 0.70µg.g-1 to 1.90µg.g-1	Ref 3

[7] Reference numbers relate to survey areas presented in Figure 5.1.1.

Survey Details	Key Findings	Figure 5.1.1 Reference Number[7]
Ensign Development Environmental Baseline survey (EBS) including herring spawning ground survey and habitat assessment November 2010 UKCS Block 48/14. Proposed ED Well, proposed alternative ED Well and proposed Ensign installation	A rig site survey comprising a 2.5 km by 1.5 km analogue and digital survey area covering both proposed well locations. Three pipeline route corridors (500m width) were surveyed (1.9km; 1.5km; 8.6km). A debris survey area of 1.7km by 1.7km. Seabed sediments were classified as two distinct European Nature Information System (EUNIS) habitats ('A5.2: Sublittoral sand' (occurred at all transects) and 'A5.4 Sublittoral mixed sediment' (occurred at several transects). One biotope of conservation importance was identified ('A5.611 *S. spinulosa* on stable circalittoral mixed sediment') which occurred in association with sublittoral mixed sediments in the vicinity of the proposed ED Well location. The seabed within the route corridor from the ED well to the Ensign installation location deepened very gently from a minimum depth of 22.4 m below LAT in the northwest near the ED well, to 25.2m below LAT in the southeast near the proposed Ensign installation location. The maximum gradient along the route was <1º. Ground-truthing data showed no areas exhibiting 'high' suitability as herring spawning grounds and only three stations were assigned moderate or low/moderate potential as herring spawning grounds. THC were moderately variable and generally low throughout the Ensign survey area. The majority of the THC at the sampled stations comprised Unresolved Complex Mixtures (UCM). The benthic macrofauna was found to be moderately diverse and of moderate density throughout the survey area, and generally showed no discernible anthropogenic effects.	Ref 2
Ensign pipeline route EBS and habitat assessment May/June 2010 Ensign development area in Block 48/14 – proposed 4, 6a and 6b pipeline route options	A total of 16 stations along potential pipeline route options were investigated using camera/video images and grab samples. Although situated in the North Norfolk Sandbanks and Saturn Reef SAC no indication of the presence of any potential Annex I habitats featured. Several small aggregations of possible *S. spinulosa* were identified to the south along two of the three routes but did not represent a biogenic reef feature. Northeast-southwest sand waves were observed to the northwest of the Audrey A (WD) installation. Maximum sand wave height was 4.9 m. Seabed sediments comprised mainly sand with a variable portion of gravel. A series of seven depressions with sharply defined edges were observed along one route; rippled gravel was expected within these depressions. Seabed sediments composition ranged between medium to very coarse sand, and from poorly to moderately sorted. The area comprised mainly silty sand with possible coarser sediments. Total Organic Matter (TOM) and Total Organic Carbon (TOC) were typical of the wider area ranging between 0.6 to 1.5% and 0.1 to 0.4%, respectively. THC observed at all stations were below that reported by UKOOA (2001) for the area. A total of 2,827 valid individuals representing 163 taxa were observed of which 14% were juveniles.	Ref 1

Table 5.1.1: Summary of Ensign field surveys

5.1.1 Ensign pre-decommissioning environmental and debris survey

Spirit Energy commissioned an environmental and debris survey at the Ensign installation and along the pipeline and umbilical routes [27].

The environmental survey was carried out to determine the presence of any Annex 1 habitats or potential stony reef habitats close to the Ensign installation or within 75 m of the pipelines and umbilicals.

The survey comprised a 1.2km x 1.2km survey area centred on the Ensign installation and a 150m wide survey corridor centred on the pipelines and umbilicals.

The environmental survey comprised ten transects and drop-down camera stations (Figure 5.1.1) and was carried out to describe the habitats recorded within the study area and to identify any potentially sensitive habitats or species, if present. Focus was placed on the Annex I habitats '*S. Spinulosa* reef' and 'Sandbanks which are slightly covered by sea water all the time' and areas of coarse sediment. The latter could present characteristics of potential herring spawning grounds.

5.2 Metocean conditions

Metocean (meteorological and oceanographic) conditions including seabed sediment type, currents, tides and circulation patterns all influence the type and distribution of marine life and the behaviour of emissions and discharges (including spills) from offshore facilities. For example, the speed and direction of water currents have a direct effect on the transport, dispersion and ultimate fate of any discharges from an installation while sediment type can influence the levels of contaminants that may be retained in an area.

5.2.1 Bathymetry

The minimum water depth recorded within the 2018 survey area was 19.7m LAT recorded along the pipeline route from the Ensign installation to Audrey A (WD).

The maximum water depth recorded was 29.4m LAT recorded within an area of inferred gravel extraction, 640m west south west of the Ensign installation (Figure 5.2.1). The seabed within the vicinity of the survey area was generally found to undulate gently, with an average seabed gradient of <1° and a maximum natural seabed gradient of 16° associated with megaripples. These survey findings align with those of past surveys (Table 5.1.1).

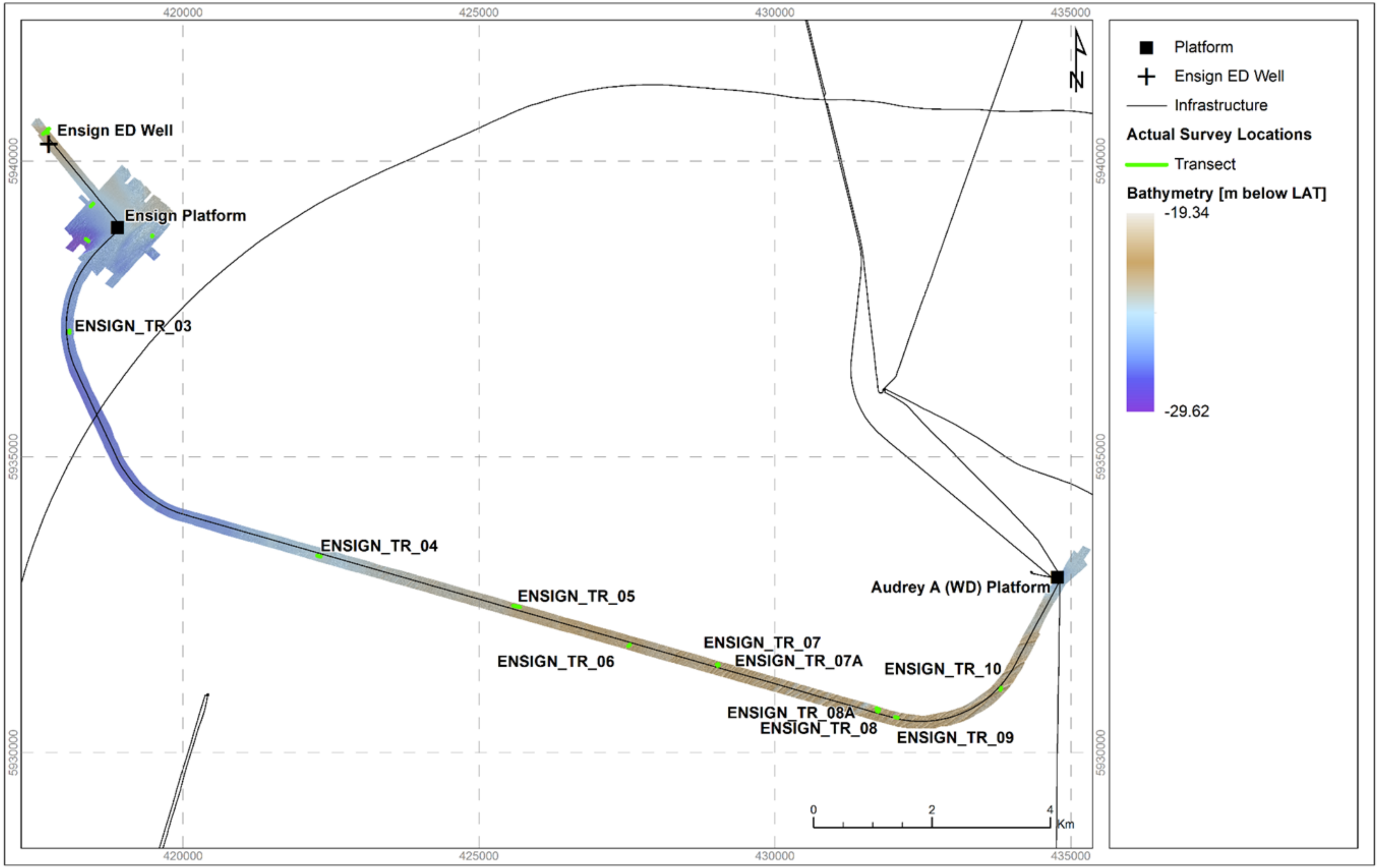


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Figure 5.2.1: Bathymetry in Ensign Development area [27]

5.2.2 Hydrology

Water circulation in the North Sea is anticlockwise, with the main inflow occurring along the western slopes of the Norwegian Trench. Minor inflows from the English Channel and the Baltic Sea supplement this flow, as shown in Figure 5.2.2. Frontal zones, marking boundaries between water masses including tidally mixed and stratified (layered) water are numerous in the North Sea. The water column of the SNS remains mixed throughout the year while to the north it becomes layered (stratified) in summer [19].

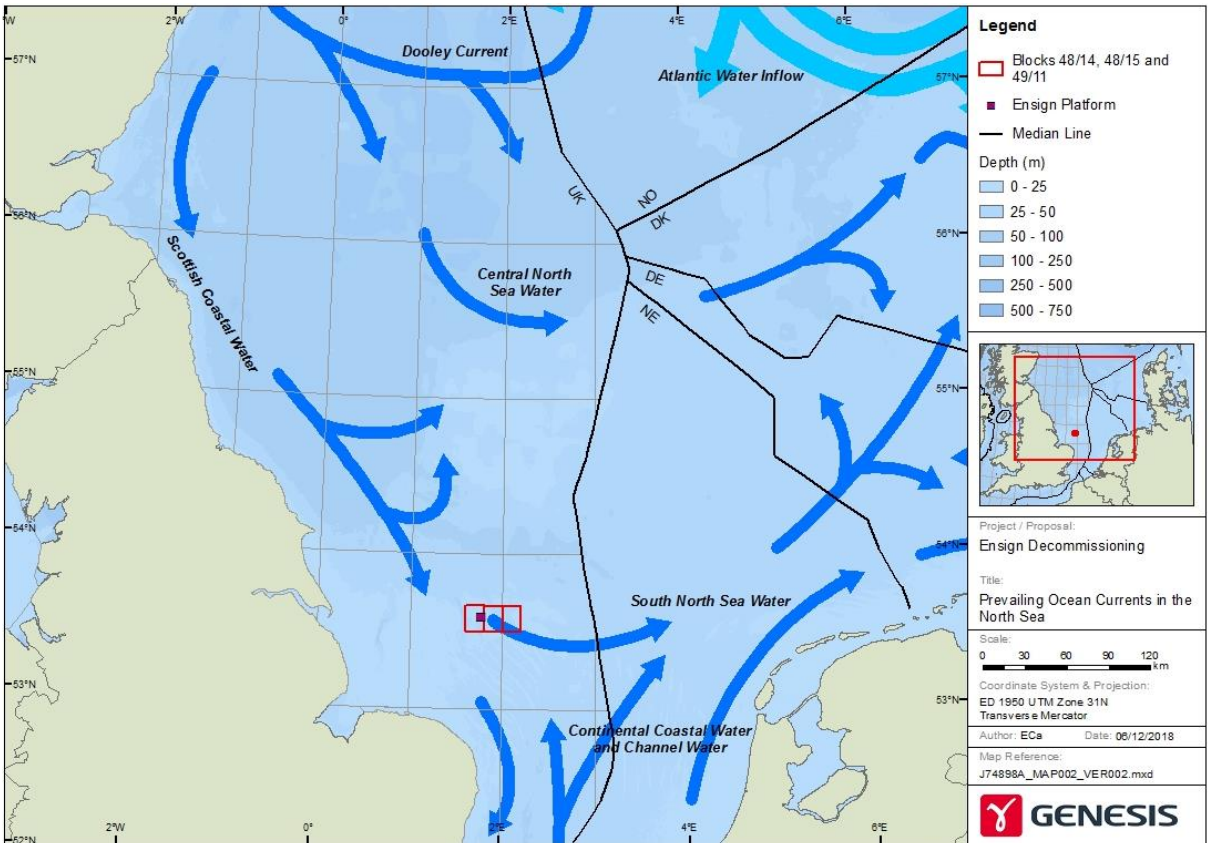

Figure 5.2.2: General water circulation of the SNS [111]

The maximum tidal current speed in the project area during mean spring tides is 0.63m/s [5]. Surge and wind–driven currents, caused by changes in atmospheric conditions, can be much stronger and are generally more severe during winter. The annual mean significant wave height is 1.4m [4]. During storms, the re-suspension and vertical dispersion of bottom sediments due to waves and currents affects most of the North Sea.

5.2.3 Meteorology

Wind speed and direction directly influence the transport and dispersion of atmospheric emissions. These factors are also important for the dispersion of water borne emissions, including oil, by affecting the movement, direction and break up of substances on the sea surface.

Winds in the area occur from all directions, but are predominantly from the south-west, with a mean wind speed of 8.0m/s [4].

5.2.4 Temperature and salinity

There is little difference between water temperatures on the sea surface and sea bottom in this shallow water area. Annual mean temperatures are between 10-11°C for both surface and seabed temperatures [92].

Salinity in the area shows little seasonal variation, with water salinities reported as *c.*34.5‰ throughout the year [92].

5.3 The seabed

The nature of seabed sediments is an important factor in providing information to help assess the potential for re-suspension and transport of sediments. It is also a determining factor in the flora and fauna present and for their suitability as spawning and nursery grounds.

Sediment erosion and transport in the SNS is driven by the strength and direction of tides and currents, and is influenced by the susceptibility of the source rock type to erosion [7]. The shallow water and active current regime in the SNS produces a high energy environment which results in a relatively thin sediment layer. Sands and gravelly sands are the principal component in nearshore areas, with finer sediments becoming dominant as the water deepens further offshore [34].

The seabed at the Ensign location is characterised by coarse sediments and is located within the North Norfolk Sandbanks and Saturn Reef Special Area of Conservation (SAC), details of which can be found in Section 5.5.1. The formation of the different sedimentary features depends on current strength and sand availability [85]. With increasing currents, the following series of bedforms is observed: megaripples, sandwaves, sand banks, sand ribbons and finally sand streams. If the sand supply decreases, sand banks will be cannibalised to form sand ribbons and sand streams, sand patches replace fields of megaripples and the other types of bedforms will appear less frequently (Figure 5.3.1).

Sandbanks are found widely on shallow continental shelves where there is an abundance of sand and where currents exceed a certain speed [72] (Figure 5.3.1). This speed is much more than is needed to move seabed sediment, and sand banks arise from an inherent instability of a seabed subject to tidal flow and mass transport. They can go from being active to a dying state, stranded in weak currents as the sea level rises. The majority of sandbanks in the North Norfolk area of the SNS are considered to be large-scale mobile seabed forms in dynamic equilibrium with the environment. They can have a wavelength between 1 and 10 km, and they can achieve a height of several tens of metres [32].

Sandwaves comprise a periodic bottom waviness generated by tidal currents in shallow tidal seas. Typical wavelength ranges from 100 to 800m and height ranges between 1 and 5m (Figure 5.3.1). The crests are almost orthogonal to the direction of tide propagation. They are not static bed forms and can migrate tens of metres per year. When local tidal flows interact with a bottom waviness it generates a steady streaming in the form of recirculating cells. When the steady velocity drags the sediment from the troughs towards the crests of the waviness, sandwaves tend to appear. They can be complex to model, and subtle changes to the environment can change the dynamics of the local interaction between the tidal flows and the seabed.

Megaripples are large sandwaves or ripple-like features with wavelengths greater than 1m or a ripple height greater than 100mm. Megaripples are formed in a subaqueous environment, and are also known as subaqueous dunes. They may be superimposed with smaller bedforms [25].

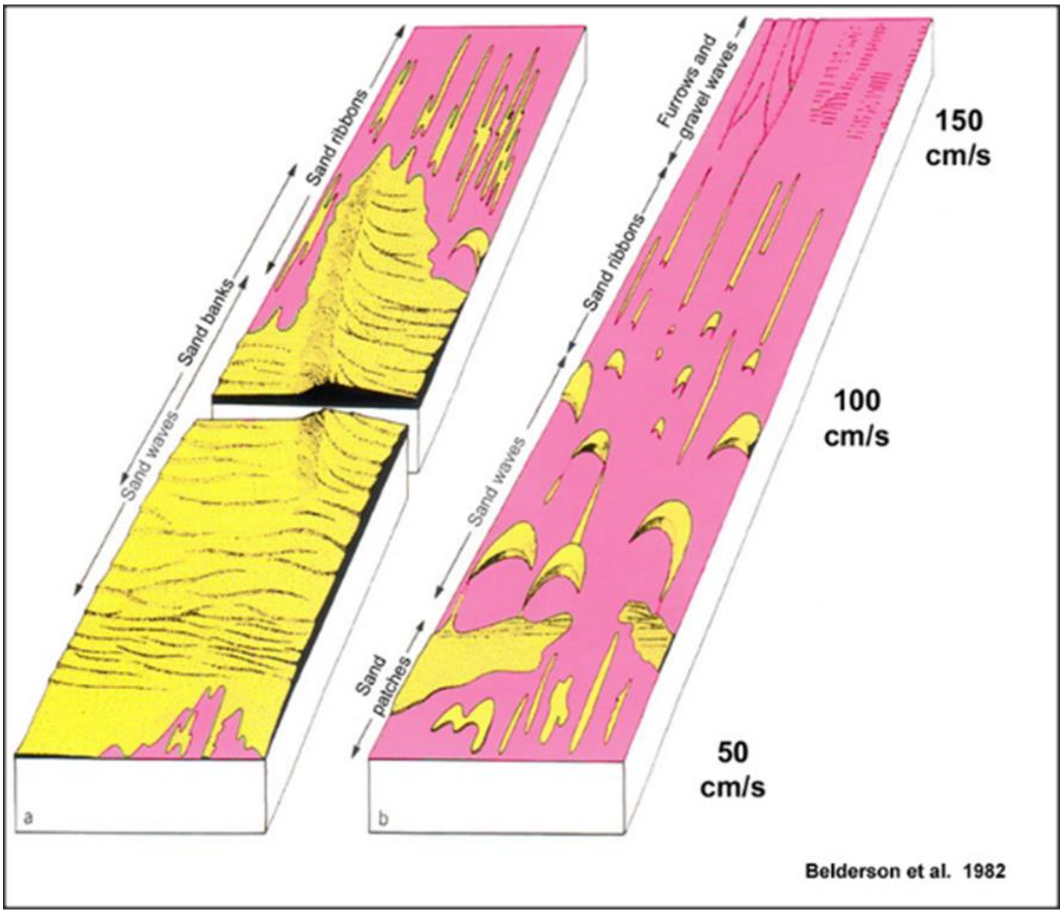

Figure 5.3.1: Sandwaves and sandbanks

5.3.1 Sediment characteristics

Sediment interpretation from the 2018 pre-decommissioning survey [27] is consistent with the sediment findings of the 2010 and 2013 Ensign environmental baseline surveys. Seabed sediments within the 1.2km x 1.2km survey area around the Ensign platform were interpreted to comprise sand and gravelly sand, based on environmental photographs, acoustic character, background information and previous survey results. The seabed sediments within the bathymetric lows caused by gravel extraction were expected to comprise sand and gravel.

Seabed sediments along most of the Ensign ED well to Ensign installation pipeline corridor were interpreted to comprise predominantly sand and gravel whilst along the Ensign installation to Audrey A (WD) pipeline corridor sediments were interpreted to comprise predominantly megarippled sand and gravelly sand with occasional areas of sand and gravel.

5.3.2 Sediment chemistry

The 2018 survey [27] did not include sediment sampling for analysis of hydrocarbon and metal concentrations. Information presented below on hydrocarbon and metal concentrations was taken from the 2010 [23] and the 2013 [21] surveys.

5.3.2.1 Hydrocarbon concentrations

From the 2010 survey samples THC were found to range between 1.1µg.g^{-1} and 6.1µg.g^{-1}; with the exception of one station which displayed a dramatically increased THC of 19.8µg.g^{-1}, likely to be indicative of contamination from shipping activity as this station was located within an aggregate extraction site. The majority of the THC at the sampled stations comprised unresolved complex mixtures (UCM). No significant correlations existed between THC and granulometric parameters [23].

From the 2013 survey samples, THC were found to be low throughout the site, ranging from 0.70µg.g^{-1} to 1.90µg.g^{-1}. Mean levels of THC were found to be lower than those encountered at the installation area and comparable to levels recorded along the pipeline and umbilical route.

5.3.2.2 Metal concentrations

From the 2010 survey samples, barium levels displayed moderate variability throughout the site with concentrations ranging between 171µg.g^{-1} and 401µg.g^{-1}, with the majority of stations exceeding mean background levels for the SNS (218µg.g^{-1}; [109]). Nickel followed the same trend with the majority of stations displaying concentrations which exceeded the United Kingdom Offshore Operators Association (UKOOA) (2001) [21] mean background concentrations for the SNS (8.0µg.g^{-1}). Mean concentrations for most heavy and trace metals marginally exceeded their respective SNS background concentrations (as published by UKOOA, 2001). Consequently, contamination can be considered minimal within the survey area [23].

Concentrations of heavy and trace metals from 2013 survey samples generally showed minimal variability between stations. Barium levels (mean 236µg.g-^{1}) were comparable to the mean background levels for the SNS (218µg.g-1; [109]). The majority of heavy and trace metals normalised to 5% aluminium exceeded the OSPAR background concentration at most stations. Barium, iron, mercury, lead and vanadium fell below the background concentration and background assessment concentration levels at all stations. Comparison of the 2013 metal concentrations to the previous 2010 surveys [23] and [29] showed that most metals were present at comparable or higher levels.

5.3.3 Seabed characteristics

Seabed characteristics observed during the 2018 survey [27] are presented below. The seabed features interpretation for the survey is presented in Figure 5.3.2.

In the vicinity of the Ensign platform, a total of eight sonar contacts, interpreted to represent boulders with heights of up to 0.8m, were identified within the 1.2km x 1.2km Ensign installation survey area. Seabed sediments were interpreted to comprise sand and gravelly sand and the sand was typically megarippled over much of the survey area but was smooth to the north and north-east of the Ensign installation.

Along the Ensign ED well to Ensign installation pipeline corridor, numerous boulders were observed within the pipeline survey corridor. The largest of these boulders occur within 50m of the pipeline and umbilical corridor. Seabed sediments were interpreted to comprise predominantly sand and gravel. Small areas of megarippled sand and gravelly sand were found to be present to the east of the Ensign installation, and around the Ensign ED well. The 10" gas pipeline and umbilical from the Ensign ED well to Ensign installation were found to be buried with little surface expression for most of the survey corridor and no observed exposures. Pipeline features identified along the corridor included short mattressed sections adjacent to the Ensign installation, and close to the Ensign ED well; and several areas of deposited rock.

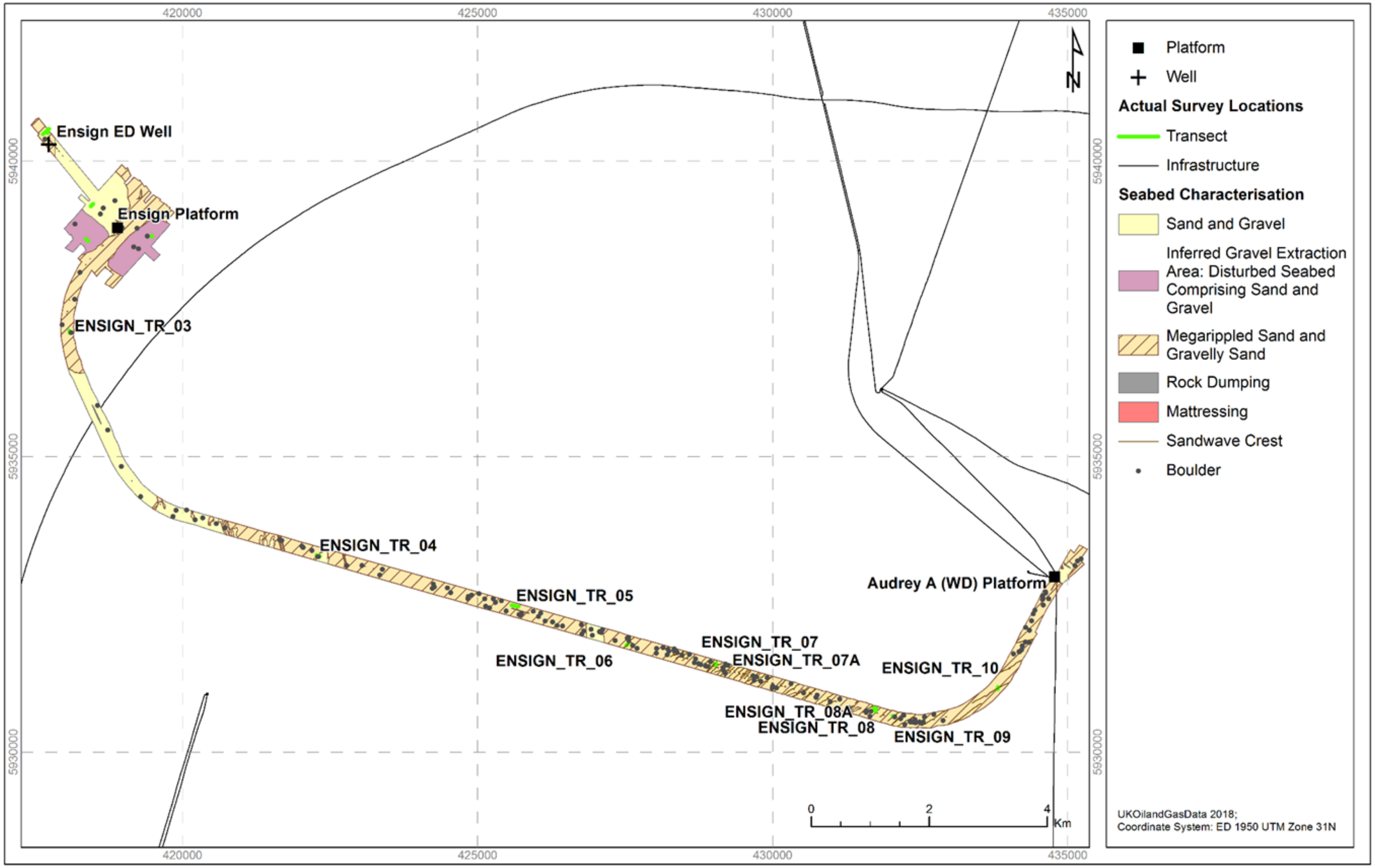

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Figure 5.3.2: Ensign 2018 survey area interpreted seabed features [27]

Numerous boulders also occur within 50m of the Ensign installation to Audrey A (WD) pipeline corridor. The largest of these boulders is approximately 3.8m long x 1.1m wide x 0.6m high. The gas and methanol pipelines were found to be buried with little surface expression for most of the survey corridor and no observed exposures. Pipeline features identified along the survey corridor included short mattressed sections adjacent to the Ensign and Audrey A (WD) installations, and numerous areas of deposited rock (Figure 5.3.3).

Sandwaves were also recorded from sidescan sonar data collected within 75m of the Ensign to Audrey A (WD) pipeline route (Figure 5.3.3).

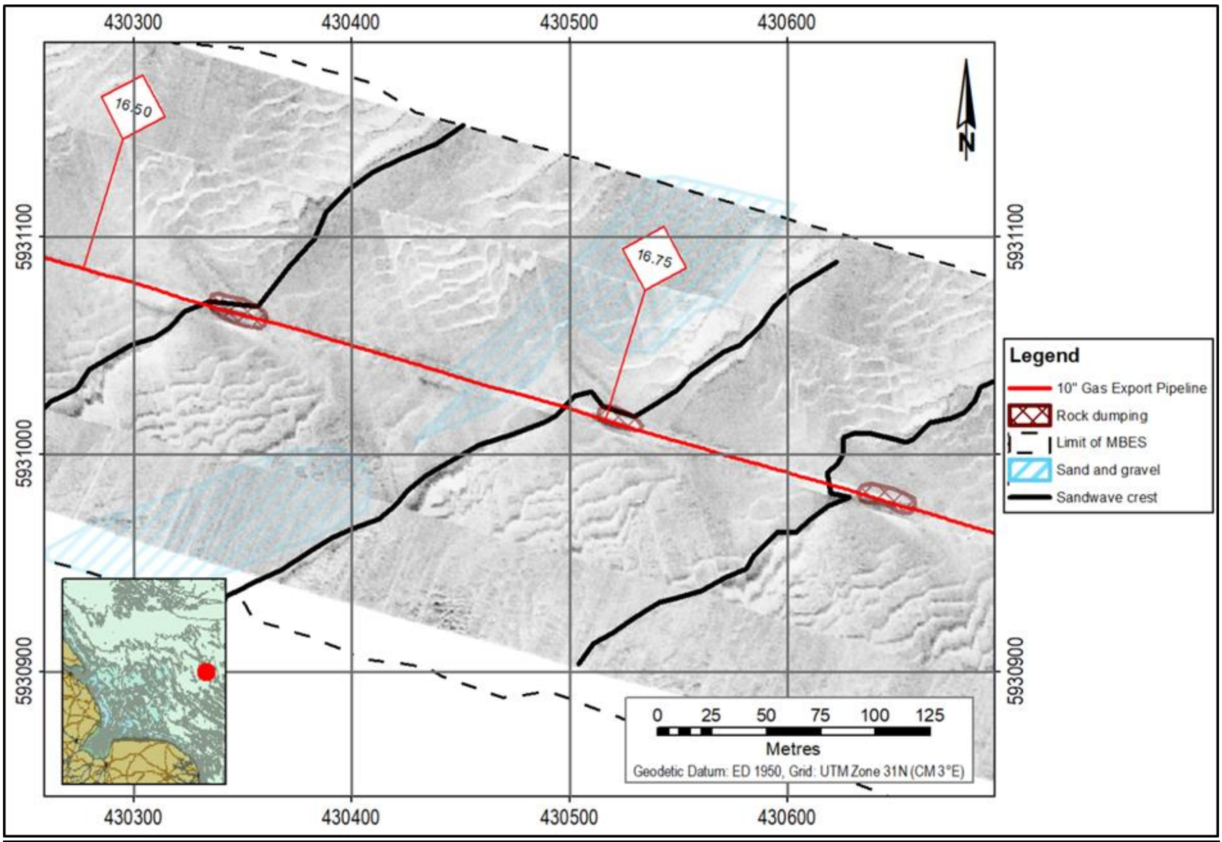

Figure 5.3.3: Sidescan sonar mosaic data showing sandwaves and deposited rock [27]

A comparison of the Ensign to Audrey A (WD) pipelines (PL2838 and PL2839) as-laid bathymetry 2010 survey data [25] with the 2018 pre-decommissioning environmental and debris survey bathymetry data is presented in Figure 5.3.4. Sandwaves are clearly visible running in a north easterly to south westerly direction across the pipeline route in 2010. The location of the crests of the sandwaves in 2010 have been overlaid on the 2018 survey bathymetry data. From this the sandwave crests can be seen to have moved in a north-west direction and may continue to do so. It is therefore possible that the pipelines could become exposed over time. However as can be seen in Figure 5.3.4 when the pipelines were installed the area was pre-swept to the trough of the sandwaves and the depth of pipeline lowering was measured from the bottom of the trough of the sandwave.

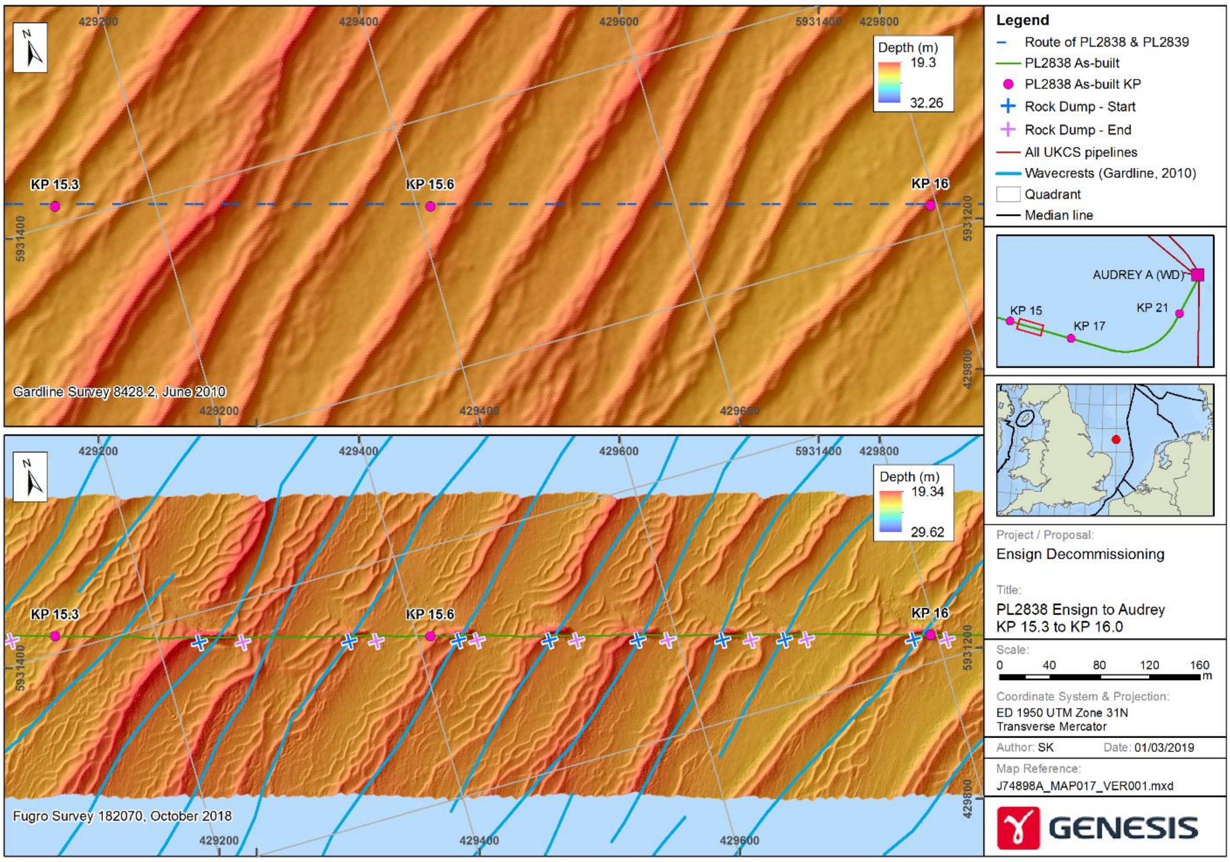

Figure 5.3.4: Seabed bathymetry along pipeline route PL2838 and PL2839

5.3.5 Seabed habitats

The Ensign infrastructure is in an area characterised by circalittoral sand and circalittoral coarse sediment as shown in Figure 5.3.5 below.

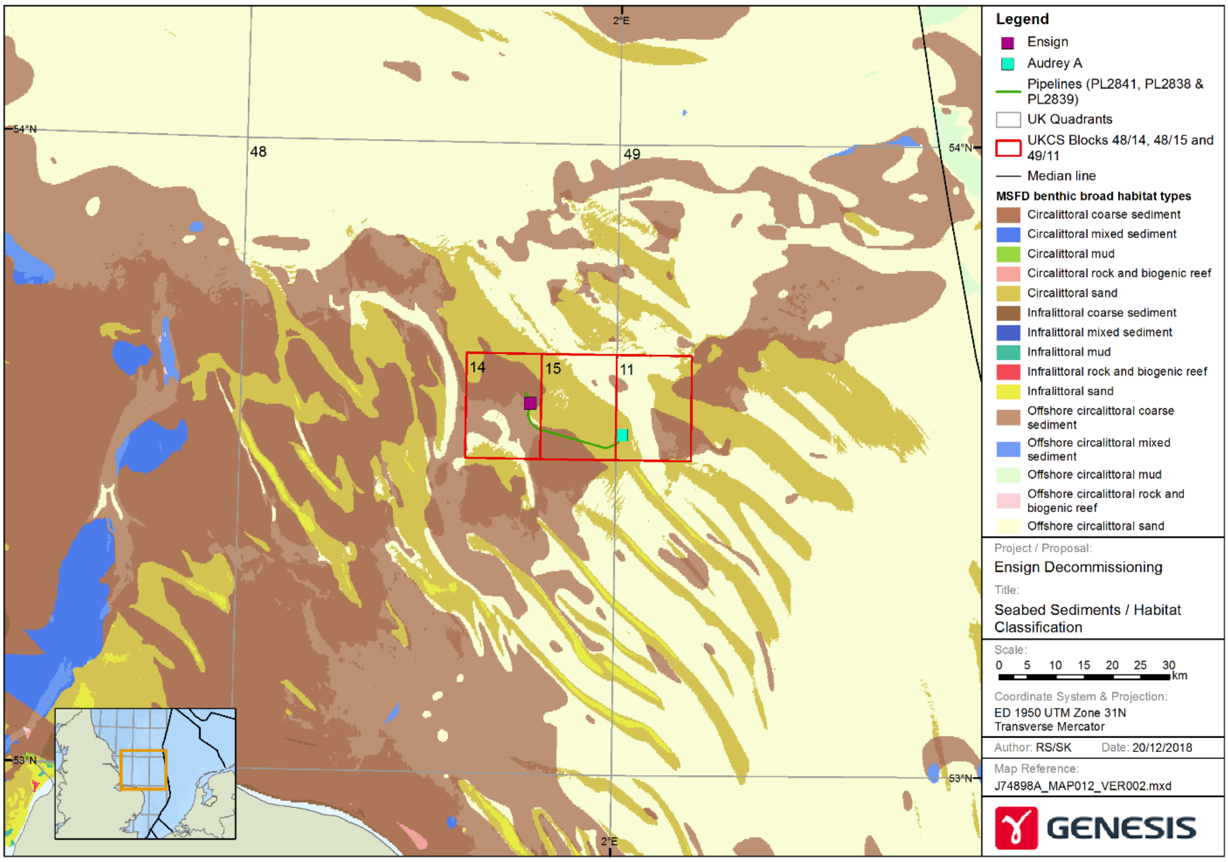

Figure 5.3.5: Marine Strategy Framework Directive predominant habitat classification) [1]

Video and stills photography were analysed in conjunction with the geophysical data and seabed features to identify potential habitats within the Ensign 2018 survey area [27].

Within the 1.2km x 1.2km survey area around the Ensign installation, review of the video photography confirmed the seabed primarily consisted of gravelly sand with shell fragments, described as ‘Circalittoral coarse sediment (European Nature Information System (EUNIS) classification: A5.14)’.

Along the Ensign ED well to Ensign installation pipeline (PL2841) corridor, analysis of photography in conjunction with the geophysical data concluded the presence of two habitat types: ‘*S. spinulosa* on stable circalittoral mixed sediment (EUNIS classification: A5.611)’ and ‘Circalittoral coarse sediments (EUNIS classification: A5.14)’.

Photographic stills and video footage were successfully acquired along all eight proposed transects (TR_03 to TR_10) within the Ensign installation to Audrey A (WD) pipeline corridor (Figure 5.1.1). As *S. spinulosa* was observed along transects TR_07 and TR_08, two additional transects (TR_07A and TR_08A) were run perpendicularly to delineate the boundaries of the potential habitat. *S. spinulosa* was also observed along transects TR_05 and TR_09, however, no additional transects were proposed as the boundaries could be confidently mapped from the video and side-scan sonar mosaic in the field.

Analysis of video and stills photography in conjunction with the geophysical data and identified seabed features from the survey area concluded the presence of four habitat types: ‘Circalittoral coarse sediment (EUNIS classification: A5.14)’, low level ‘*S. spinulosa* on stable circalittoral mixed sediment (EUNIS classification: A5.611)’, ‘Circalittoral muddy sand (EUNIS classification: A5.26)’ and ‘Sublittoral mixed sediments (EUNIS classification: A5.4)’

***S. spinulosa* on stable circalittoral mixed sediment (EUNIS classification: A5.611)**

No areas of ross worm *S. spinulosa* were observed along any of the transects within the 1.2km x 1.2 km Ensign installation survey area.

Along the Ensign ED well to Ensign installation pipeline (PL2841) corridor, aggregations of *S. spinulosa* were observed in the forms of crust, clumps and potential reef features on mixed sediment at station DD_01 and along transect TR_11 (Figure 5.1.1). Where the mixed sediment was visible amongst the patches of *S. spinulosa* reef it comprised gravelly sand with shell fragments.

Along the Ensign installation to Audrey A (WD) pipeline, aggregations of *S. spinulosa* were observed in the forms of crust, clumps and potential reef features on mixed sediment along transects TR_05, TR_07, TR_07A, TR_08, TR_08A and TR_09. Where the mixed sediment was visible it comprised gravelly sand with shell fragments. Along transects TR_08 and TR_09 *S. spinulosa* aggregations were also associated with small clay outcrops.

Epifaunal taxa encountered within this habitat included ross worm (*S. spinulosa*), bryozoan (*F. foliacea* and *A. diaphanum*), hermit crabs (Paguridae), crabs (Brachyura including *Cancer pagurus*, *Necora puber*, and *Liocarcinus sp*,), lobster (*Homarus gammarus*), shrimp (Caridea), starfish (*A. rubens*), brittlestars (Ophiuridae), hydroids (Hydrozoa), soft coral (*A. digitatum*), anemone (*Metridium dianthus* and *Urticina felina*), encrusting yellow sponge (Porifera) and hydroid/bryozoan turf (Hydrozoa/Bryozoa). Fish species included catshark (*Scyliorhinus sp.*) and dragonet (*Callionymus sp*.).

Example seabed photographs of this habitat along the Ensign ED well to Ensign installation pipeline are presented in Appendix E, Figure E.1.2: *S. spinulosa* on stable circalittoral mixed sediment. At station DD_01 and transect TR_11, *S.spinulosa* aggregations were assessed for the presence of reef. The details of this analysis are presented in Section 5.3.6.

Example seabed photographs along the Ensign installation to Audrey A (WD) pipeline are presented in Appendix E, Figure E.1.4: *S. spinulosa* on stable circalittoral mixed sediment (A5.611). Along transects TR_05, TR_08, TR_08A and TR_09 *S. spinulosa* was observed as a crust covering cobbles. Example photos of this are presented in Appendix E, Figure E.1.5: *S. spinulosa* crusts on cobbles.

Circalittoral coarse sediments (EUNIS classification: A5.14)

Epifaunal species encountered within the habitat ‘Circalittoral coarse sediment’ included ross worm (*S. spinulosa*), starfish *Asterias rubens*, bryozoans (*Flustra foliacea*, *Alcyonidium diaphanum*), hermit crabs (Paguridae), crabs (Brachyura including *Liocarcinus* sp.), soft coral (*Alcyonium digitatum*), shrimp (Caridae), hydroid/bryozoan turf (Hydrozoa/Bryozoa) soft coral (*A. digitatum*), dragonet (*Callionymus sp*.) and dab (*Limanda limanda*). Flatfish (Pleuronectiformes) were also seen. Faunal tracks were also observed.

Low-lying clumps and crusts of *S. spinulosa* which did not form a continuous feature were also observed within this habitat.

Example seabed photographs of this habitat are presented in Appendix E, Figure E.1.1: Circalittoral coarse sediment at the Ensign installation. Mixed sediment with high percentage of gravel are areas of potential herring spawning. An assessment for the presence of this sensitive habitat is presented in Section 5.4.3.

Example seabed photographs of this habitat are presented in Appendix E, Figure E.1.3: Circalittoral coarse sediment and Figure E.1.6: Circalittoral coarse sediment (A5.14).

This habitat is potentially associated with the presence of Annex I habitat ‘Sandbanks slightly covered by sea water all the time’, however no features suggesting the presence of this habitat were observed within the Ensign survey area.

A discussion of potential sensitive habitats and species in the survey area is presented in Section 5.5.

Subtidal sands and gravels

Areas of seabed along the pipeline routes were classified as the EUNIS biotope 'Circalittoral coarse sediment (A5.14)', which is categorised within the broad habitat of 'subtidal sands and gravels', a priority habitat within UK waters. However, this habitat is thought to be of low conservation significance in the area as this sediment type is widely distributed and will be represented elsewhere in the Marine Protected Area (MPA) network.

Circalittoral muddy sand (A5.26)

This habitat was described for areas of transects TR_08, TR_08A and TR_10 along the Ensign installation to Audrey A (WD) pipeline corridor. The sediment appeared to comprise sand and a higher proportion of silt.

Generally, no visible fauna was observed in these areas except for small clumps or crusts of the ross worm *S. spinulosa* covering isolated cobbles.

Example seabed photographs of this habitat are presented in Appendix E, Figure E.1.7: Circalittoral muddy sand.

Sublittoral mixed sediment (A5.4)

For small parts of transects TR_08 and TR_09 along the Ensign installation to Audrey A (WD) pipeline corridor the sediment comprised gravelly sand with pebbles and cobbles.

Fauna encountered within this habitat included *S. spinulosa* in the form of a crust covering cobbles, starfish (*A. rubens*) and bryozoan (*F. foliacea*).

Example seabed photographs of this habitat are presented in Appendix E, Figure E.1.8: Sublittoral mixed sediment (A5.4).

5.3.6 *S. spinulosa* reef assessment

S. spinulosa reefs are listed under Annex I of the Habitats Directive (1992), as implemented by the Offshore Marine Conservation (Natural Habitats, &c.) Regulations (2007 (as amended)). The distinction between what is or is not a *S. spinulosa* 'reef' is imprecise. The methodology used to assess the presence of a reef is presented in Appendix F.

Of the combined 12 video transects and drop-down camera stations undertaken within the Ensign survey, nine presented forms of *S. spinulosa* aggregations with characteristics of patchiness, elevation and consolidation, and were therefore assessed for the presence of *S. spinulosa* reef using the criteria presented in Table F.1.1, Appendix F. Scores were assigned for each transect and drop-down camera station as presented in Table 5.3.1.

Examples of the different assessment categories assigned are presented in Appendix D.

Figure 5.3.6 displays the *S. spinulosa* reef assessment from Ensign Installation to Audrey A (WD) pipeline corridor.

Measure of 'Reefiness'	Elevation (mm) (Average Tube Height)	Patchiness (% cover)	Consolidation	Overall Assessment
DD_01	Low	Low	Not Reef	Low
TR_04	Not Reef	Not Reef	Not Reef	Not Reef
TR_05	Not Reef/ Low/Low/Medium and Medium	Not Reef/ Medium	Not Reef/ Medium	Medium*
TR_07	Not Reef /Low/ Medium	Not Reef /Low/High	Not Reef	Medium*
TR_07A	Not Reef /Medium	Not Reef/ High	Not Reef/ Medium	Medium
TR_08	Low	Not Reef	Not Reef	Not Reef
TR_08A	Medium	Not Reef	Not Reef	Not Reef
TR_09	Low/Medium	High	Medium	Medium
TR_11	Not Reef	Not Reef	Not Reef	Not Reef

Notes: DD = Drop–down camera station and TR = Transect.
* Sections of these transects were assessed as not reef, low reef, medium reef, medium/ high reef and high reef. (Figure 5.3.6)

Table 5.3.1: Ensign survey *S. spinulosa* assessment scores

5.3.6.1 *S. spinulosa* reef historical comparison

Figure 5.3.7 presents the changes in the *S. spinulosa* reef observed near the Ensign ED well from 2010 to 2018. The figure indicates that the presence of *S. spinulosa* aggregations and the extent of possible areas of reef have reduced over time.

Previous surveys of the Saturn reef within the protected area showed similar temporal and spatial changes. In 2003, an extended high reef was observed, and its location was included as part of the “North Norfolk Sandbanks and Saturn Reef” SAC. Subsequent surveys have however showed that in the same location patchy aggregations of *S. spinulosa* tubes were present, until a survey carried out in 2006 found no evidence of a *S. spinulosa* reef. It is well known that this fragile sabellid worm is easily disturbed by natural and anthropogenic sources and wave action and substrate are suggested to be the dominant natural factors affecting the stability of reefs, with more ephemeral reefs occurring on mobile substrate and longer-lasting reefs being limited to more stable substrate [26].

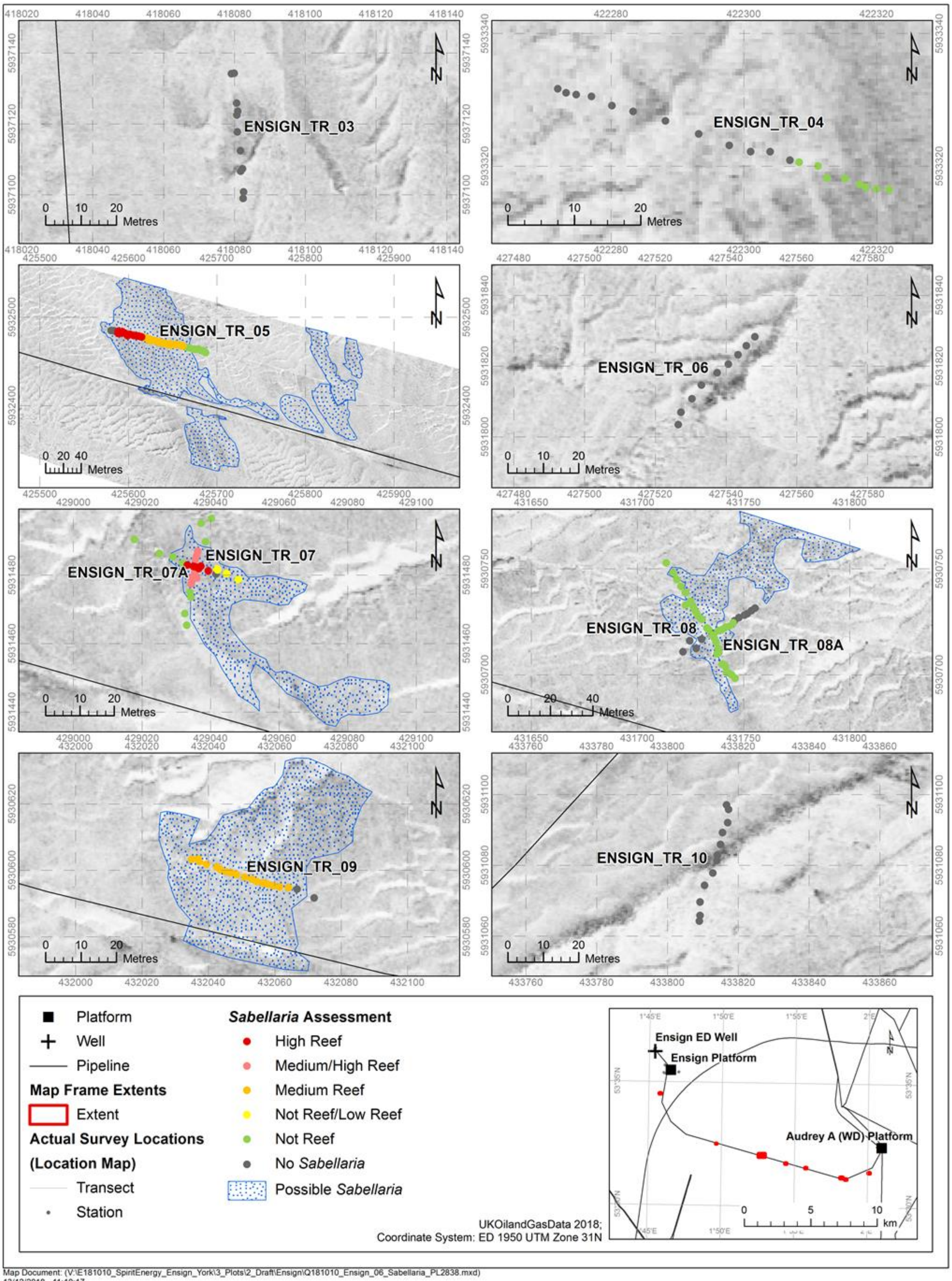

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Figure 5.3.6: Ensign Installation to Audrey A (WD) pipeline corridor *S. Spinulosa* assessment

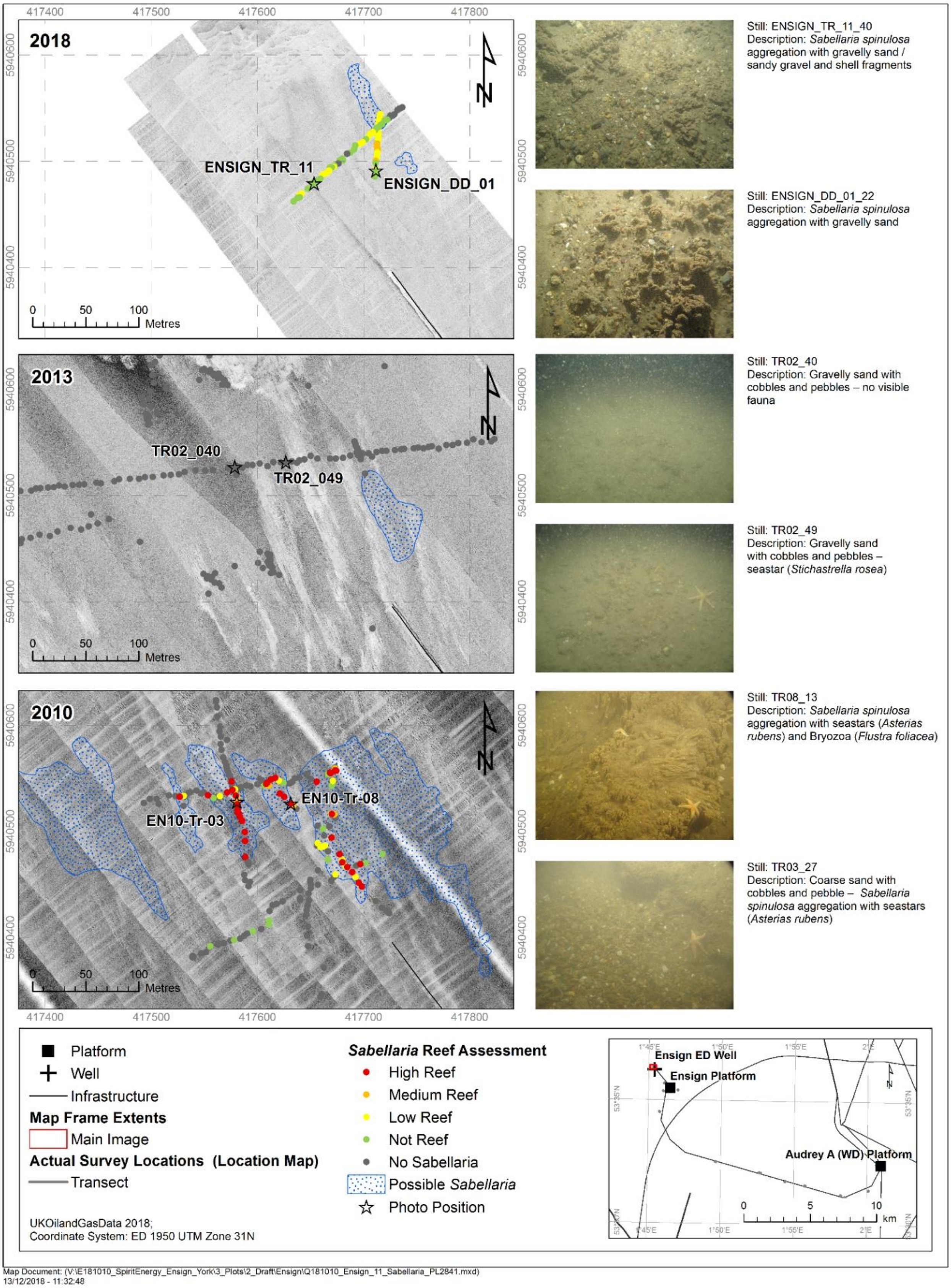


Figure 5.3.7: Ensign ED well *S. Spinulosa* assessment

5.4 Marine flora and fauna

5.4.1 Plankton

Within the North Sea, planktonic assemblages are influenced mainly by vertical mixing and the availability of light and nutrients for growth [67]. During the winter months the rate of phytoplankton production decreases and increased concentrations of key nutrients i.e. phosphorus, ammonia, nitrogen and silicate, can be recorded as these are no longer used up during the production of phytoplankton. However, during the spring months, the rate of primary production increases significantly, coupled with a reduction in the available nutrients, which is subsequently followed in August by a smaller peak in abundance of phytoplankton [15]. These large phytoplankton blooms which occur in the North Sea during the spring and autumn support the majority of marine food chains in the area.

The SNS is characterised by shallow, well-mixed waters, which undergo large seasonal temperature variations [48]. The region is largely enclosed by land and, as a result, the environment here is dynamic with considerable tidal mixing and nutrient-rich run-offs from the land (eutrophication). Under these conditions, there is relatively little stratification of the water column throughout the year and constant replenishment of nutrients, so opportunistic organisms such as diatoms are particularly successful (Margalef 1973, cited in [88]); diatoms comprise a greater proportion of the phytoplankton community than dinoflagellates from November to May, when mixing is at its greatest [12]. The phytoplankton community is dominated by the dinoflagellate genus *Ceratium* (*C. fusus, C. furca, C. lineatum*), along with higher numbers of the diatom, *Chaetoceros* than are typically found in the Northern North Sea (NNS). Harmful algal blooms caused by *Noctiluca* sp. are often observed in the region.

The zooplankton community comprises *Calanus helgolandicus* and *C. finmarchicus* as well as *Paracalanus* sp., *Pseudocalanus* sp., *Acartia* sp., *Temora* sp. and cladocerans such as *Evadne* sp. There has been a marked decrease in copepod abundance in the SNS in recent years [65], possibly linked to the North Atlantic Oscillation index, which has a significant impact in the SNS, where the interface between the atmosphere and the sea is most pronounced [110].

5.4.2 Benthos

Bacteria, plants and animals living on or within the seabed sediments are collectively referred to as benthos. Species living on top of the sea floor may be sessile (e.g. seaweeds) or freely moving (e.g. starfish) and collectively are referred to as epibenthic organisms. Animals living within the sediment (e.g. clams, tubeworms and burrowing crabs) are termed infaunal species. Semi-infaunal animals, including sea pens and some bivalves, lie partially buried in the seabed.

The structure and distribution of North Sea benthic communities can be explained by the environmental parameters including temperature, salinity, tidal/wave-induced seabed stress, stratification, depth, and sediment type. Their relative importance varies spatially, and many are inter-correlated [33].

The 2018 survey [27] did not include an EBS and therefore a description of the Ensign infaunal benthos has been presented in this section using the EBS data collected during the 2010 and 2013 surveys. The epifaunal benthic species observed during the 2018 survey [27] are presented in Section 5.1 and were consistent with the species observed in the 2010 and 2013 surveys.

5.4.2.1 Ensign installation

The majority of the dominant taxa recorded from the survey area have previously been identified from surveys undertaken in similar SNS habitats [23]. Overall the Ensign Installation site was characterised by a moderate density, moderately diverse macrofaunal community, dominated by the bristleworm polychaete *Ophelia borealis*, the proboscis worm phylum Nemertea and the sand hopper crustacean *Bathyporeia elegans*.

Multivariate statistical analysis of the macrofaunal station data identified three statistically significant clusters (P<0.05). Further analyses showed that this differentiation was driven by an accumulation of a number of variations in the abundance of taxa between clusters, with a small number of taxa being present in the top ten contributors of all clusters. This suggested that these clusters represented variants of a single community rather than discrete benthic assemblages. Further analysis suggested that this differentiation may have been at least partly attributable to differences in sediment composition, which was further supported by a review of the granulometry multivariate data in conjunction with the significant fauna clusters. Spatial heterogeneity or 'patchiness' was also thought to contribute to differences between community variants. Overall the infaunal community observed was typical of that expected for coarse sandy sediments, and no effects of contamination on the community were identified [23].

5.4.2.2 ED well

In terms of infauna abundance, the phylum Annelida accounted for 86.8% (5,697) of the 6,563 individual animals recorded. Crustacea and Mollusca represented just 7.3% and 3.6% of individuals respectively, while members of the 'other' group made up 2.3% of the total abundance [21]. Rank dominance was used to examine which species were consistently dominant throughout the survey area. Rank abundance and dominance were relatively similar for the majority of the top 10 most abundant taxa, suggesting that community composition was relatively homogenous across the site [21]. Generally, the faunal community within the Ensign ED well site was found to be of moderate to high diversity and equitability, indicating relatively low dominance. Variation in the univariate analyses indicated patchy distributions of some taxa across the site.

Multivariate statistical analysis of the macrofaunal station data identified two statistically significant clusters. Further analysis showed that the clusters were characterised by the same dominant taxa, and that the minor differences between the faunal assemblages were generally attributable to variations in abundance of their constituent taxa, suggesting the occurrence of a single distinct macrofaunal community within the field [21]. This suggested that the identified clusters represented spatial variations within a single broad macrofaunal assemblage, and not discrete communities. Heterogeneous or 'patchy' distribution of particular taxa is a typical phenomenon in the benthic environment [21]. Sediment composition was considered to have had a subtle influence on the observed community structure, as granulometry clusters identified by multivariate analysis loosely matched the macrofaunal community clusters [21].

Macrofaunal data from the 2010 Ensign development EBS suggested similar community composition, dominated by Annelida. In contrast with the 2013 survey, multiple highly divergent clusters were observed within the previous data, and the differentiation was likely to be influenced by the sediment granulometry. The 2013 survey covered a larger area and encountered a greater range of sediment and habitat types compared to those observed during the 2010 survey.

5.4.2.3 Ensign pipelines (PL2838 and PL2839) to Audrey A (WD)

In terms of infauna abundance, the phylum Annelida accounted for 67% (1881) of the 2,827 individual animals recorded. Crustacea, Mollusca and Echinodermata represented 10%, 7% and 8% of individuals respectively, while members of the 'other' group made up 8% of the total abundance [29]. The results of species ranking on the survey station data found that the deposit-feeding polychaete *Ophelia borealis* was the most abundant taxon overall, with Ophiuridae (juveniles) being the second most abundant taxon overall. This taxon represents juvenile individuals of the family Ophiuridae (brittle stars) and encompasses a potentially wide range of species [29]. *S. spinulosa* was recorded in low abundances (1 to 4 individuals) at 4 stations out of the 10 stations sampled on the pipelines route.

5.4.3 Fish populations

Fish occupying areas near offshore oil and gas activities could be exposed to aqueous discharges and may accumulate hydrocarbons and other contaminating chemicals in their body tissues.

At present, more than 330 fish species are thought to inhabit the shelf seas of the UKCS [44]. Finfish species can broadly be divided into pelagic and demersal species. Pelagic species e.g. herring, mackerel, blue whiting and sprat are found in mid-water and typically make extensive seasonal movements or migrations. Demersal species e.g. cod, haddock, sandeels, sole and whiting live on or near the seabed and, similar to pelagic species, many are known to passively move (e.g. drifting eggs and larvae) and/or actively migrate (e.g. juveniles and adults) between areas during their lifecycle.

The most vulnerable stages of the life cycle of fish to general disturbances, such as disruption to sediments and oil pollution, are the egg and larval stages. Hence, recognition of spawning and nursery grounds within a project area is important. Table 5.4.1 shows approximate spawning times of some of the commercial fish species occurring in the region of the Ensign field and identifies some species known to use the area as a nursery ground [41] and [59].

Species	J	F	M	A	M	J	J	A	S	O	N	D
Mackerel[2]					S*	S*	S*	S				
Herring[2]								S	S	S		
Plaice[1,2]	S*	S*	S									S
Lemon sole[2]	N	N	N	SN	SN	SN	SN	SN	SN	N	N	N
Sandeel[2]	SN	SN	N	N	N	N	N	N	N	N	SN	SN
Sprat[2]	N	N	N	N	S*N	S*N	SN	SN	N	N	N	N
Nephrops[2]	SN	SN	SN	S*N	S*N	S*N	SN	SN	SN	SN	SN	SN
Whiting[1,2]	N	SN	SN	SN	SN	SN	N	N	N	N	N	N
Cod[1]	S	S*	S*	S								

Key: S = Spawning, * = Peak Spawning, N = Nursery
Sources:
(1) [41] *Note: only the spawning species and high intensity nursery species identified by Ellis et al., are included in the table*
(2) [59]

Table 5.4.1: Known spawning and nursery areas in the vicinity of the Ensign field.

Spawning and nursery areas cannot be defined with absolute accuracy and are found to shift over time. Recognised spawning and nursery grounds of some commercially important species occurring within the area are shown in Figure 5.4.1 [41] and [59].

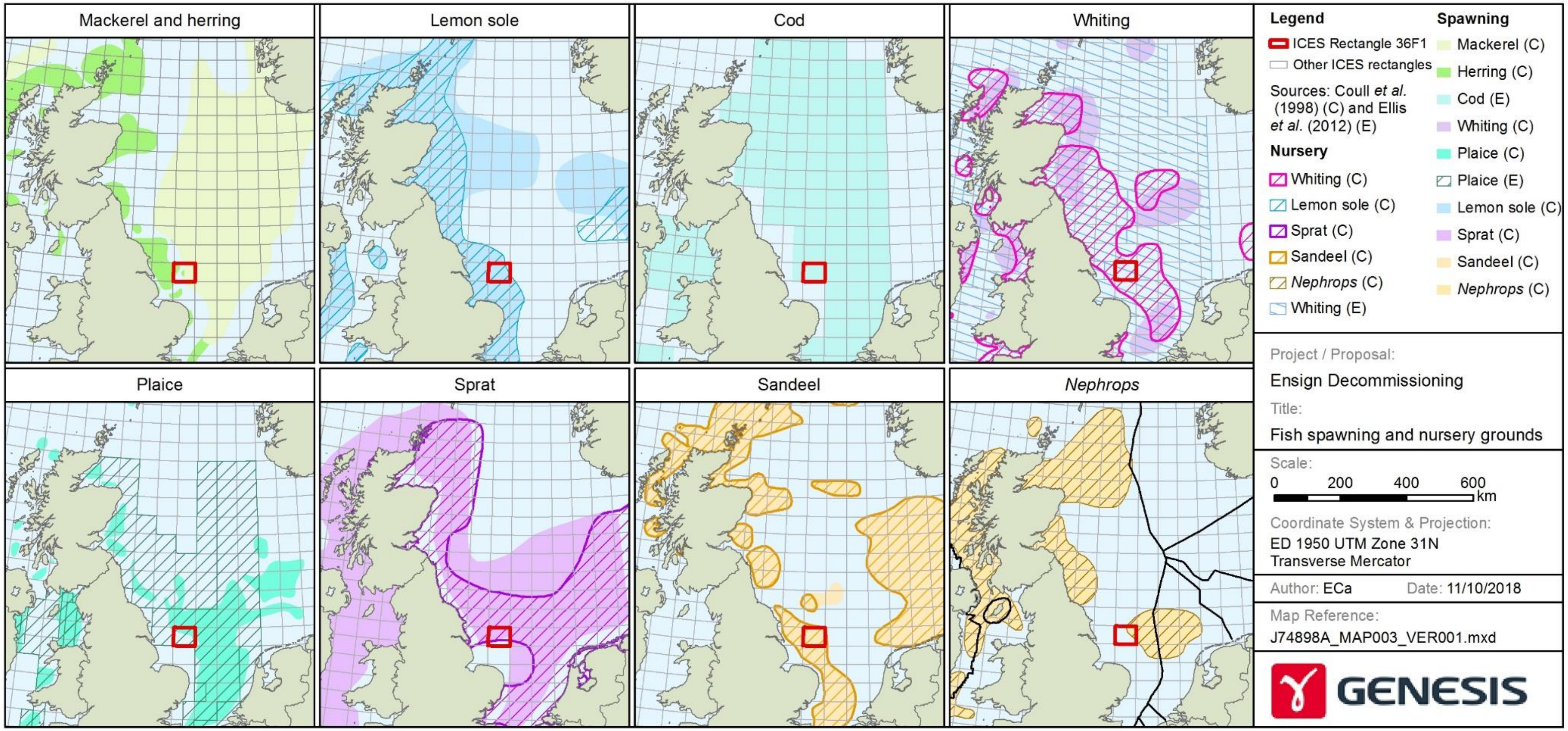


Figure 5.4.1: Spawning and nursery grounds in the vicinity of the Ensign field

5.4.3.1 Herring spawning grounds

Herring *(Clupea harengus)* is an UK Biodiversity Action Plan (BAP) priority species and spawning areas for this species are known to occur on specific gravelly substrate [37].

From the data collected in the 2018 survey, a herring spawning ground preference based on the proportional content of gravel was assigned to each seabed still photograph. This was achieved by calculating the percentage of seabed surface gravel observed in each photographic still along each transect; the average calculated along the entire transect was then considered for the assessment of the ground preference. The preference was assigned following the categories presented in Marine Space Ltd *et al*. (2013) [70]. Fines content for the Ensign installation survey area was inferred based on available historical survey data [25] and [26].

The presence of 'preferred' grounds for herring spawning are preferably assessed by the distribution of sediment particle sizes using the Folk sediment triangle [53], based on the methodology presented in Marine Space Ltd et al. (2013) [70] and summarised in Table 5.4.2. The categories range from 'Prime', which indicate preferred grounds with the highest percentage of gravel and very little mud content, gradually reducing the gravel content to 'Unsuitable' with the lowest gravel content and higher percentage of muds.

% Particle Contribution	Habitat Preference	Folk 1954 Sediment Unit	Habitats Sediment Classification
<5% muds >50% gravel	Prime	Gravel and part sandy Gravel	Preferred
<5% muds >25% gravel	Sub-prime	Part sandy Gravel and part gravelly Sand	Preferred
<5% muds >10% gravel	Suitable	Part gravelly Sand	Marginal
>5% muds <10% gravel	Unsuitable	All other sediment types	Unsuitable

Table 5.4.2: Sediment sizes indicating 'preferred' spawning habitat [70]

Photographic data was analysed to assess the surface sediment composition of the Ensign survey area. The average gravel content was below the 10% threshold along the majority of transects. Only along transect TR_11 the average gravel content was 13.8%. The sediment along transect TR_11 was classified as 'Marginal' for herring spawning. All other transects and stations were considered 'Unsuitable' habitat for herring spawning ground.

These findings were consistent with the herring spawning ground survey undertaken in 2010 that found only three stations were assigned moderate or low/moderate potential as herring spawning grounds [22].

5.4.4 Marine mammals

Marine mammals include cetaceans (whales, dolphins and porpoises), pinnipeds (seals) and mustelids (otters), all of which are susceptible to anthropogenic stresses.

5.4.4.1 Cetaceans

Sightings of numerous species of cetacean have been recorded on the European continental shelf. However, in many instances within the North Sea, recorded sightings are associated with single individuals [45]. All cetacean species occurring in UK waters are afforded European Protected Species (EPS) status.

The JNCC has compiled an atlas of cetacean distribution in north-west European waters [45] which gives an indication of the types of cetaceans and times of the year that they are likely to frequent areas of the North Sea.

Harbour porpoise, and white-beaked dolphin have been sighted near the Ensign field as shown in Table 5.4.3 [45].

Species	J	F	M	A	M	J	J	A	S	O	N	D
Harbour Porpoise						3	2	2	3			
White-beaked dolphin	3											
Key	1= High; 2= Moderate; 3= Low; Blank= No. individuals recorded											

Table 5.4.3: Cetaceans sighted in the vicinity of the Ensign field [45]

The Habitats Directive lists those habitats and species (Annex I and II respectively) whose conservation requires the designation of special areas of interest. Harbour porpoise are listed under Annex II of the Habitats Directive (Section 5.5.1). Candidate SACs (cSACs) have been identified for harbour porpoise in UKCS waters and are currently under public consultation [53]. The Ensign field facilities are in one of these identified areas and is discussed further in Section 0.

5.4.4.2 Pinnipeds

Two species of seal reside in UK coastal waters; the grey seal (*Halichoerus grypus*) and the common seal (*Phoca vitulina*).

Both species will feed in both inshore and offshore waters depending on the distribution of their prey, which changes both seasonally and yearly. Both species tend to be concentrated close to shore, particularly during the pupping (October and November for grey seals and June and July for common seals) and moulting (generally January to April for grey seals and August and September for the common seal) seasons. Seal tracking studies from the Moray Firth have indicated that the foraging movements of common seals are generally restricted to within a 40 to 50km range of their haul-out sites [98].

The movements of grey seals can involve larger distances than those of the common seal, and trips of several hundred kilometres from one haul-out to another have been recorded. Figure 5.4.2 shows that the mean density of seals expected near the Ensign field is low for both harbour seals and grey seals (1 - 5 per 25km^2) [94]. As such it is possible that seals may pass through the area around the Ensign field, but they are unlikely to spend significant periods of time there, particularly during the pupping and moulting seasons when they will spend more time ashore.

Both grey seals and harbour seals are listed under Annex II of the Habitats Directive (Section 5.5).

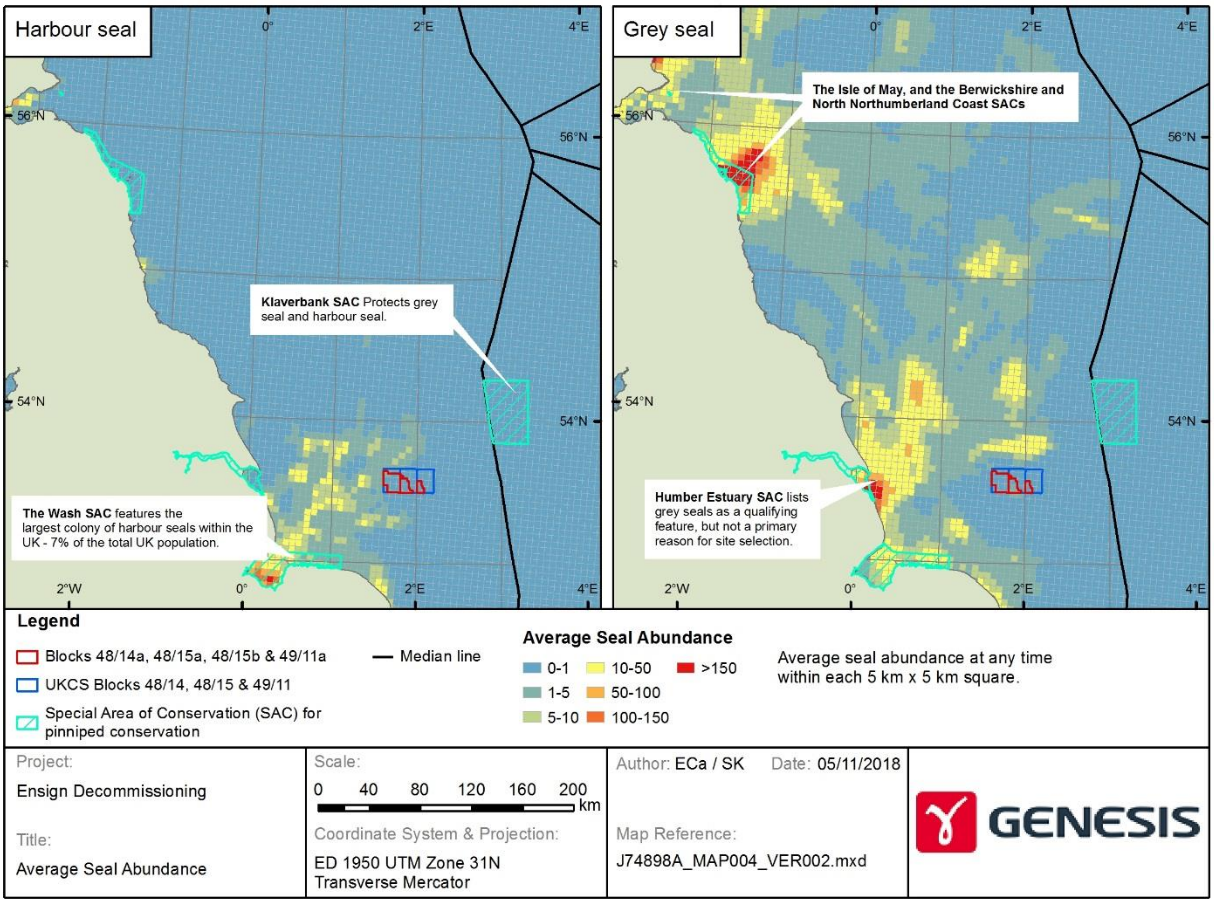


Figure 5.4.2: Average seal abundance in the vicinity of Ensign field [94]

5.4.5 Seabirds

The UK and its surrounding seas are very important for seabirds. The extensive network of cliffs, sheltered bays, coastal wetlands and estuarine areas, provide breeding and wintering grounds for national and internationally important bird species and assemblages[17].

Predicted maximum monthly abundance of seabirds in the Ensign area is based on an analysis of the European Seabirds at Sea data collected over 30 years [60]. Continuous seabird density surface maps were generated using the spatial interpolation technique 'Poisson kriging' and 57 seabird density surface maps were created to show particular species distribution in specific areas. Data from the relevant maps has been summarised for the area in Table 5.4.4.

Distribution and abundance of these bird species vary seasonally and annually. Seabird densities such as black-legged kittiwake are generally higher in the breeding season (May to September), whereas other species such as the common guillemot have higher densities in other seasons (August to September).

Species	Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern gannet	Breeding					≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0			
	Winter	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0						≤ 1.0	≤ 1.0	≤ 1.0
Northern fulmar	Breeding			1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0					
	Winter	1.0 – 5.0	1.0 – 5.0						1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0
Arctic skua	Additional									≤ 1.0	≤ 1.0	≤ 1.0	
Pomarine skua	Additional			≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0						
Lesser black-backed gull	Breeding					≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0				
Black-legged kittiwake	Breeding					5.0 – 10.0	5.0 – 10.0	5.0 – 10.0	5.0 – 10.0	5.0 – 10.0			
	Winter	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0						1.0 – 5.0	1.0 – 5.0	1.0 – 5.0
Common gull	Breeding					≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0				
	Winter	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0					≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0
Great black-backed gull	Breeding				≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0				
	Winter	≤ 1.0	≤ 1.0	≤ 1.0						≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0
Razorbill	Breeding					≤ 1.0	≤ 1.0						
	Winter	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0						≤ 1.0	≤ 1.0	≤ 1.0
	Additional								1.0 – 5.0	1.0 – 5.0			
Herring gull	Winter	≤ 1.0	≤ 1.0	≤ 1.0						≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0
	Breeding				≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0				
Manx shearwater	Breeding					1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0			
Sandwich tern	Breeding					≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0				
Common guillemot	Breeding					1.0 – 5.0	1.0 – 5.0						
	Additional								10.0 - 15.0	10.0 - 15.0			
	Winter	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0						1.0 – 5.0	1.0 – 5.0	1.0 – 5.0
Atlantic puffin	Breeding				1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0					
	Winter	≤ 1.0	≤ 1.0	≤ 1.0					≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0
All species combined	Breeding				5.0 – 10.0	5.0 – 10.0	5.0 – 10.0	5.0 – 10.0	5.0 – 10.0	5.0 – 10.0			
	Summer							15.0 - >20.0	15.0 - >20.0				
	Winter	10.0 - 15.0	10.0 - 15.0	10.0 - 15.0								10.0 - 15.0	10.0 - 15.0

KEY	Not recorded	≤ 1.0	1.0 – 5.0	5.0 – 10.0	10.0 - 15.0	15.0 - >20.0

Table 5.4.4: Predicted seabird surface density (maximum number of individuals/km^2) [1]

Seabirds are generally not at risk from routine offshore operations. However, they may be vulnerable to pollution from less regular activities, for example from accidental hydrocarbon releases.

The Seabird Oil Sensitivity Index (SOSI) is a tool which aids planning and emergency decision making with regards to oil pollution. It identifies areas at sea where seabirds are likely to be most sensitive to oil pollution. It is based on seabird survey data collected from 1995 to 2015, from a wide survey area extending beyond the UKCS using boat-based, visual aerial, and digital video aerial survey techniques.

This seabird data was combined with individual seabird species sensitivity index values. These index values are based on a number of factors which are considered to contribute towards the sensitivity of seabirds to oil pollution. Factors such as:

1. Habitat flexibility (a species ability to locate to alternative feeding sites);
2. Adult survival rate;
3. Potential annual productivity; and,
4. The proportion of the biogeographical population in the UK were classified following the methods developed [28].

The combined seabird data and species sensitivity index values are subsequently summed at each location to create a single measure of seabird sensitivity to oil pollution. This is presented as a series of fine scale density maps for each month that show the median, minimum and maximum seabird sensitivity to oil pollution, and an indication of data confidence. The index is independent of where oil pollution is most likely to occur; rather, it indicates where the highest seabird sensitivities might lie if there were to be a pollution incident. The mean sensitivity SOSI data for the area surrounding the Ensign field is shown in Figure 5.4.3 and Table 5.4.5. To reduce the extent of data gaps, guidance from JNCC has been followed. In general, seabird sensitivity to oil pollution near the Ensign field is considered low to medium in June, August and September and high/very high and extremely high during October to May and during July.

Block	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
48/8	1*	1	1*	N	3*	3	1	3	2	2*	1*	1
48/9	1*	1**	3**	N	4*	4	1	4	3	3*	1*	1
48/10	1*	1**	5**	N	5*	5	1	4	4*	N	1*	1
49/6	1*	1**	5**	N	N	1*	1	5	5*	N	1*	1
48/13	1	2	3	3*	3	5	5	3	3	1*	1	2
48/14	1	2	3	3*	3	5	2	3	5	1*	1	2
48/15	1*	1	1*	N	3**	5**	4*	4	4*	N	1**	1*
49/11	1*	1	1*	N	N	1*	1	5	5*	N	N	1**
48/18	1	2	3	3*	5	5	5	3	3	1*	1	1
48/19	1	1	3	3*	3	5	5	3	3	1*	1	1
48/20	1*	1	1*	N	3**	5**	5*	5	5*	N	1*	1
49/16	2*	2	2*	N	N	N	5*	5	5*	N	N	1**

KEY	
	1 Extremely High; 2 Very High; 3 High; 4 Medium; 5 Low; N = No Data
	Indirect Assessment – data gaps have been populated following guidance provided by the JNCC [10] ** Data gap filled gap filled using data from the same block in adjacent months.* *** Data gap filled using data from the adjacent blocks within the same month.*

Table 5.4.5: SOSI results for Blocks 48/14, 48/15 and 49/11 and adjacent blocks [57]

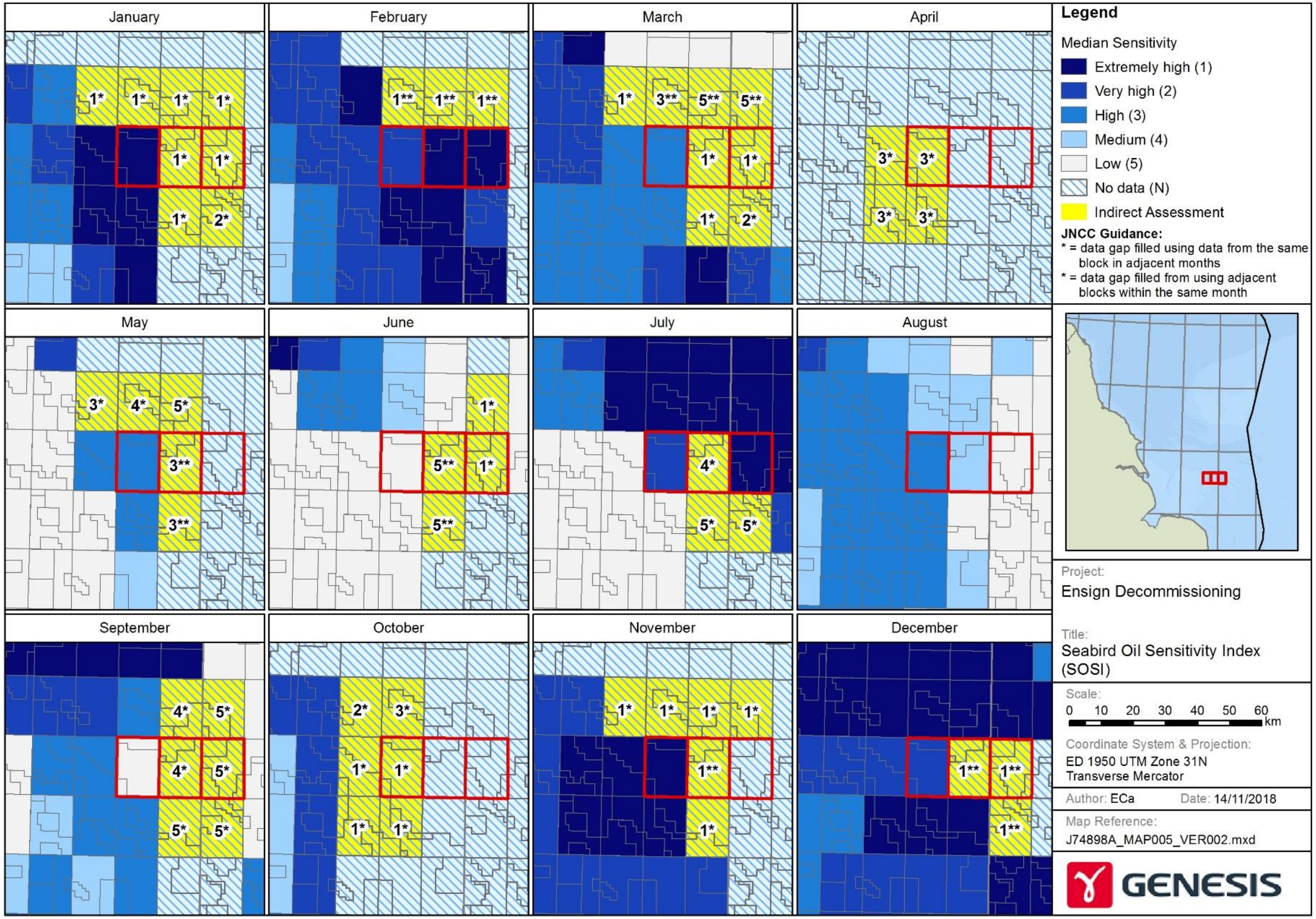


Figure 5.4.3: Median seabird oil sensitivity index in the vicinity of the Ensign field [3]

5.5 Habitats and species of conservation concern

The EU Habitats Directive (92/43/EEC) and the EU Birds Directive (79/409/EEC) are the main driving forces for safeguarding biodiversity in Europe.

Through the establishment of a network of protected sites these directives provide for the protection of animal and plant species of European importance and the habitats that support them.

The EU Habitats Directive 92/43/EEC and the EU Birds Directive 79/409/EEC have been enacted in the UK by the following legislation:

1. The Conservation (Natural Habitats, and c.) Regulations 1994 (as amended) transpose the Habitats and Birds Directives into UK law. They apply to land and to territorial waters out to 12nm from the coast and have been subsequently amended several times;
2. The Conservation of Habitats and Species Regulations 2010: The Conservation of Habitats and Species Regulations 2010 consolidate all the various amendments made to the Conservation (Natural Habitats, and c.) Regulations 1994 in respect of England and Wales. In Scotland, the Habitats and Birds Directives are transposed through a combination of the Habitats Regulations 2010 (in relation to reserved matters) and the 1994 Regulations;
3. The Offshore Marine Conservation (Natural Habitats, and c.) Regulations 2007 (as amended 2009 and 2010): These regulations are the principal means by which the Birds and Habitats Directives are transposed in the UK offshore marine area (i.e. outside the 12nm territorial limit) and in English and Welsh territorial waters; and,
4. The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended 2007): These regulations apply the Habitats Directive and the Wild Birds Directive in relation to oil and gas plans or projects wholly or partly on the United Kingdom Continental Shelf and adjacent waters outside territorial waters (i.e. outside the 12nm territorial zone).

The Habitats Directive lists those habitats and species (Annex I and II respectively) whose conservation requires the designation of special areas of interest. These habitats and species are to be protected by the creation of a series of SACs, and by various other safeguard measures such as Sites of Community Importance (SCIs) for particular species. SACs are sites that have been adopted by the European Commission (EC) and formally designated by the government of the country where the site lies, and SCIs are sites that have been adopted by the EC but not yet formally designated by the government of the relevant country.

The Birds Directive requires member states to nominate sites as Special Protection Areas (SPAs). Together with adopted SACs, the SPA network forms the 'Natura 2000' network of protected areas in the European Union. Figure 5.5.1 shows the location of the Ensign field and associated facilities in relation to protected areas.

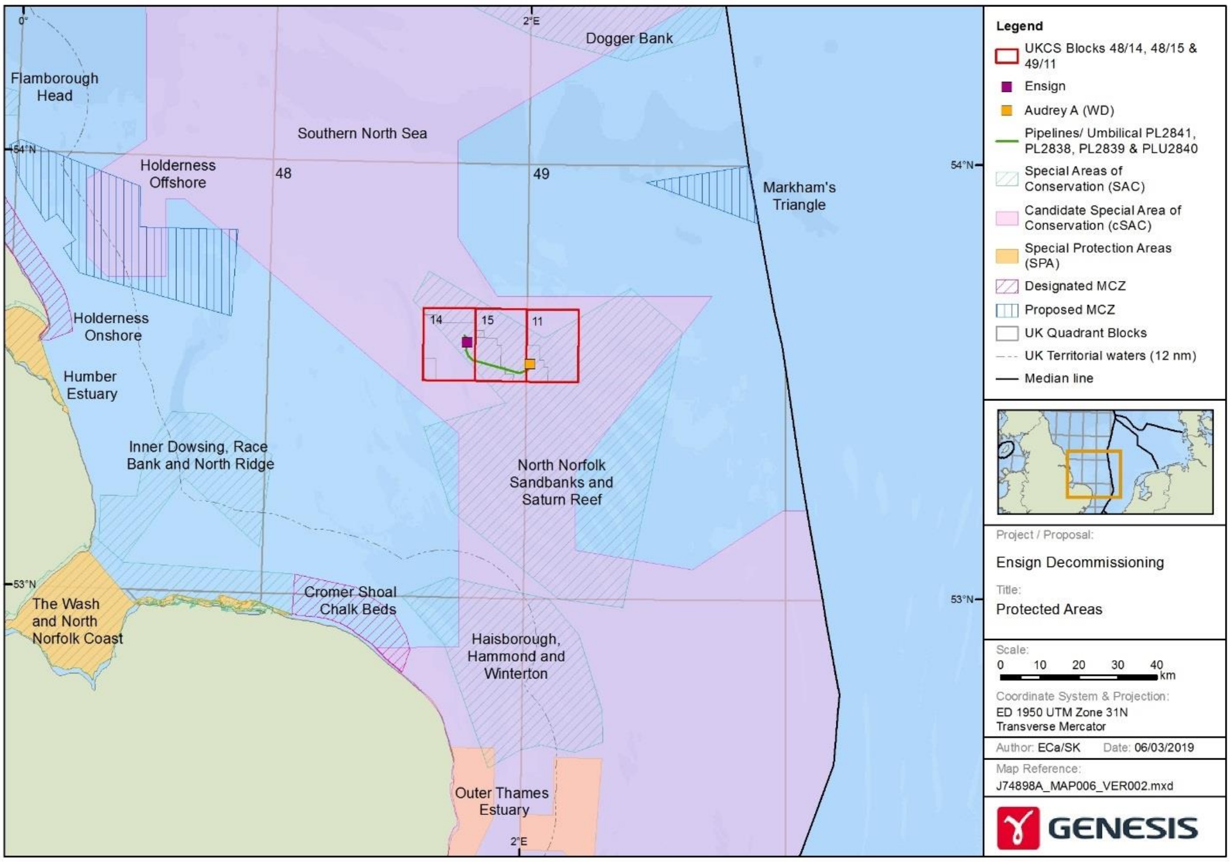


Figure 5.5.1: Protected sites in the vicinity of the Ensign field facilities

5.5.1 Special areas of conservation / sites of community importance

5.5.1.1 North Norfolk Sandbanks and Saturn Reef SAC

The Ensign field lies within the North Norfolk Sandbanks and Saturn Reef SAC (Figure 5.5.1) which covers an area of 3,603 km^2. This site is designated for the presence of the Annex I habitats: sandbanks which are slightly covered by seawater all the time and reefs. The site comprises a series of ten main sandbanks and associated fragmented smaller banks formed as a result of tidal processes (Section 5.3.1) and areas of *S. spinulosa* biogenic reef.

The Conservation Objectives for North Norfolk Sandbanks and Saturn Reef SAC sandbanks which are slightly covered by seawater all the time, and reef, are:

Subject to natural change, restore the sandbanks which are slightly covered by seawater all the time and reefs to favourable condition, such that:

1. *The natural environmental quality, natural environmental processes and extent are maintained; and,*
2. *The physical structure, diversity, community structure and typical species, representative of sandbanks which are slightly covered by seawater all the time and reefs in the SNS are restored [52].*

Sandbanks

The North Norfolk Sandbanks extend from about 40km off the north-east coast of Norfolk out to *c.*110km. The banks are the most extensive example of offshore linear ridge sandbank types in UK waters and the outer banks are the best example of open sea, tidal sandbanks in a moderate current strength in UK waters [10].

The sand banks are subject to a range of current strengths which are strongest on the banks closest to shore and which reduce offshore [63]. The outer banks are the best example of open sea, tidal sandbanks in a moderate current strength in UK waters. Sandwaves are present, being best developed on the inner banks; the outer banks having small or no sandwaves associated with them [63].

The sand banks have a north-west to south-east orientation and are thought to be progressively, though very slowly, elongating in a north-easterly direction (perpendicular to their long axes) [112]. The summits of the banks are in water shallower than 20m below Chart Datum, and the flanks of the banks extend into waters up to 40m deep.

A sandbank by definition is where the top of the sandbank is in less than 20m of water. However, the extent of the Annex I sandbank habitat in the North Norfolk Sandbanks and Saturn Reef area was determined to include flanks and troughs of these banks that are also part of the sandbank feature but extend into deeper waters [50].

Sabellaria sp. reefs

The Saturn *Sabellaria sp.* reef consists of thousands of fragile sand-tubes made by polychaetes which have consolidated together to create a solid structure rising above the seabed. Reef habitats such as those formed by *Sabellaria* sp. are listed within Annex I of the Habitats Directive. Although *Sabellaria sp*. is found widely distributed in UK waters, significant elevated reef structures are rare [51]. *Sabellaria sp.* reef structures can be temporary and unstable but it is generally accepted that broad areas which support reef production typically remain so until hydrographic conditions change [61].

Stony reef

Rocky reefs are one of the habitats of conservation significance listed under Annex I of the Habitats Directive for protection within SACs, however this type of reef is not found in the North Norfolk Sandbanks and Saturn Reef SAC and therefore is not discussed further.

Within the vicinity of the Ensign decommissioning activities the only Annex I habitat present is ‘Sandbanks which are slightly covered by seawater all of the time’.

Southern North Sea cSAC

The Ensign installation and associated pipelines lie within the SNS cSAC designated for the protection of harbour porpoise.

The cSAC is a single feature site, proposed to be designated solely for aiding the management of harbour porpoise populations throughout UK waters, in accordance with EU legislation. The Conservation Objectives for the site are:

To avoid deterioration of the habitats of the harbour porpoise or significant disturbance to the harbour porpoise, thus ensuring that the integrity of the site is maintained, and that the site makes an appropriate contribution to maintaining Favourable Conservation Status for the UK harbour porpoise. The aim is to achieve this by ensuring that:

- *The species is a viable component of the site (e.g. they are able to survive and live successfully within the site);*
- *There is no significant disturbance of the species; and,*
- *The supporting habitats and processes relevant to harbour porpoises and their prey are maintained [54].*

As harbour porpoise are highly mobile species, the areas proposed are large. The SNS cSAC covers 36,958km^2, extending down the North Sea from the River Tyne south to the Thames and includes habitats such as sandbanks and gravel beds (Figure 5.5.1). The water depths within the site range between 10 and 75m.

Tagging studies indicate that harbour porpoises range widely in the North Sea, with individuals tagged in the Skagerrak occurring off the east coasts of Scotland and England [91]. Harbour porpoise densities vary seasonally and across the SNS cSAC. In the central and northern area of the cSAC, the highest densities occur during the summer period with modelled harbour porpoise densities greater than 3.0/km^2 occurring widely across the SNS (Figure 5.5.2). During the winter period, the distribution of harbour porpoise in the SNS changes with reduced densities over the central and northern area but an increase in densities in nearshore waters and the southern part of the cSAC (Figure 5.5.2) [90].

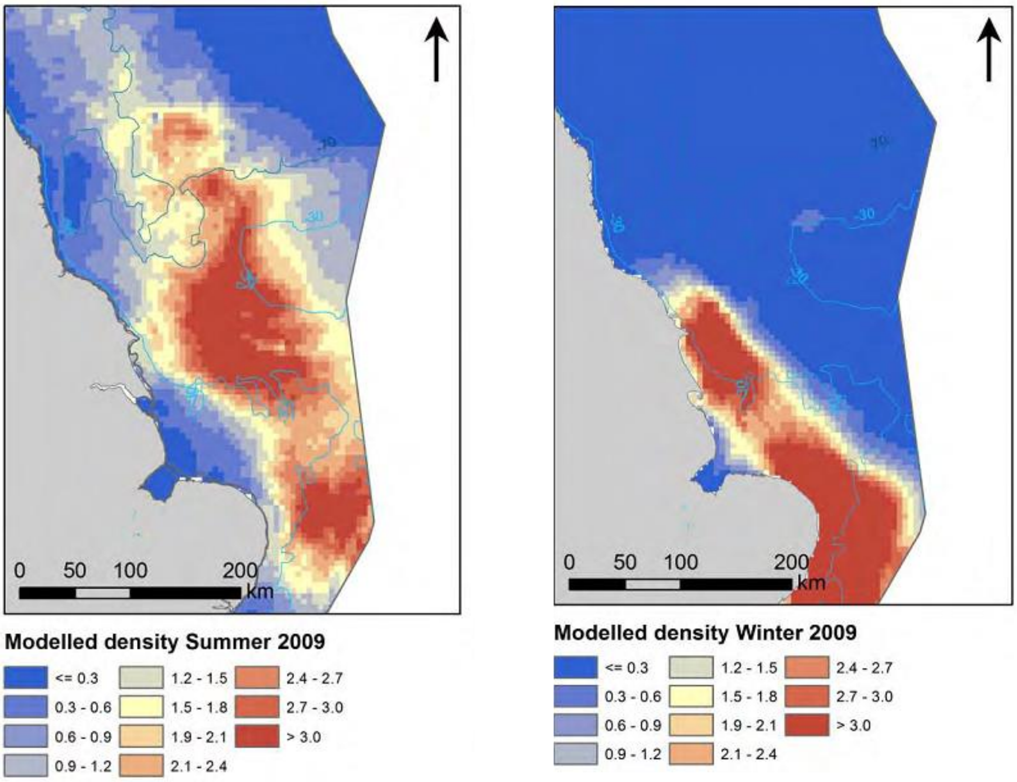


Figure 5.5.2: Estimated densities (no./km^2) of harbour porpoise in the SNS [90]

5.5.2 Special Protection Areas

SPAs are strictly protected sites classified in accordance with Article 4 of the EC Birds Directive. They are classified for rare and vulnerable birds (as listed on Annex I of the Directive), and for regularly occurring migratory species. There is a total of 270 SPAs designated in the UK. The nearest protected site is the North Norfolk Coast SPA, which is over 90km south-west of the blocks (Figure 5.5.1). The proposed decommissioning activities are therefore not expected to impact on any SPAs.

5.5.3 Marine Conservation Zones

Under the Marine and Coastal Access Act (MCAA) (2009) Marine Conservation Zones (MCZs) were set up in English, Welsh and Northern Irish offshore waters. MCZs aim to protect a range of nationally important marine wildlife, habitats, geology and geomorphology.

The nearest MCZ to the Ensign field is the Holderness Offshore recommended MCZ (Figure 5.5.1) which is approximately 55km west of the Ensign installation and designated for broad scale habitat features such as subtidal sand, subtidal mixed sediments and subtidal coarse sediments and the presence of Ocean Quahog (*Arctica islandica*) [18]. The next closest MCZ is the Markham's Triangle recommended MCZ which is approximately 60km north-east of the Ensign installation (Figure 5.5.1). At these distances the proposed decommissioning activities are not expected to impact on any MCZs.

5.5.4 East Offshore Marine Plan

The East Inshore and East Offshore Marine Plans are the first plans produced for English seas and entered into force in April 2014 (Figure 5.5.3).

The aim of marine plans is to help ensure the sustainable development of the marine area through informing and guiding regulation, management, use and protection of the marine plan areas. The

East Marine Plan sets out eleven objectives listed in Table 5.5.1, and these need to be met to deliver the vision for East Marine Plan Areas in 2034. The objectives are supported by cross-sectorial and sector specific policies. The purpose of the policies is to provide direction or guidance on how decisions should be made to ensure the plan objectives are met. The Plan's policies in general apply to new, rather than existing, developments, uses and management measures. However, they may also apply in the review of existing activities or measures [68].

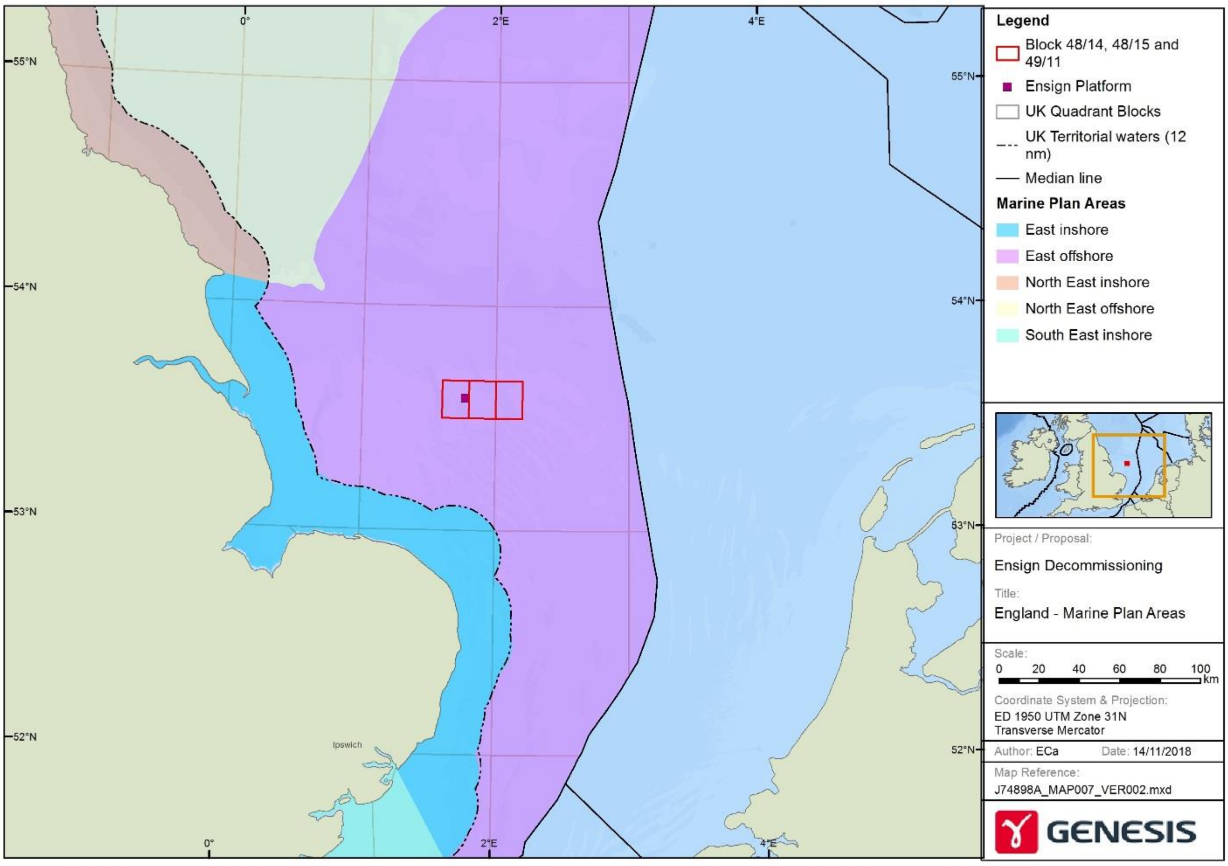


Figure 5.5.3: East Offshore Marine Plan area

Objective	Details
1	To promote the sustainable development of economically productive activities, taking account of spatial requirements of other activities of importance to the East Marine Plan areas.
2	To support activities that create employment at all skill levels, taking account of the spatial and other requirements of activities in the East Marine Plan areas.
3	To realise sustainably the potential of renewable energy, particularly offshore wind farms, which is likely to be the most significant transformational economic activity over the next 20 years in the East Marine Plan areas, helping to achieve the United Kingdom's energy security and carbon reduction objectives.
4	To reduce deprivation and support vibrant, sustainable communities through improving health and social well-being.
5	To conserve heritage assets, nationally protected landscapes and ensure that decisions consider the seascape of the local area.
6	To have a healthy, resilient and adaptable marine ecosystem in the East Marine Plan areas.
7	To protect, conserve and, where appropriate, recover biodiversity that is in or dependent upon the East Marine Plan areas.
8	To support the objectives of MPAS (and other designated sites around the coast that overlap or are adjacent to the East Marine Plan areas), individually and as part of an ecologically coherent network.
9	To facilitate action on climate change adaptation and mitigation in the East Marine Plan areas.
10	To ensure integration with other plans, and in the regulation and management of key activities and issues, in the East Marine Plans, and adjacent areas.
11	To continue to develop the marine evidence base to support implementation, monitoring and review of the East Marine Plans.

Table 5.5.1: Objectives for the East Offshore Marine Plan [68].

The proposed operations have been assessed against the marine plan objectives and cross-sectorial and sectorial policies. In summary, the proposed activities do not contradict any of the marine plan objectives and policies.

5.5.5 Species of conservation concern

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

1. The UK BAP priority fish species [55];
2. The OSPAR List of Threatened and/or Declining Species and Habitats [81];
3. The IUCN (International Union for Conservation of Nature) Red List of Threatened Species [38];
4. The Wildlife and Countryside Act 1981 (which consolidates and amends existing national legislation to implement the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) and the Birds Directive in Great Britain) [56]. The Wildlife and Countryside Act makes it an offence to intentionally kill, injure, possess or trade any animal listed in Schedule 5 and to interfere with places used by such animals for shelter or protection; and
5. The EC Habitats Directive that is transposed into UK law through the Conservation of Habitats and Species Regulations 2010 in England and Wales, and the 1994 Regulations in Scotland.

Those species of fish that could potentially occur in the vicinity of the Ensign field [24] and are listed under the protection measures discussed above are shown in Table 5.5.2.

Species	UK BAP	OSPAR	IUCN	BERN Convention	Habitats Regulations
Allis shad (*A. alosa*)	✓	✓	Least Concern	✓	×
Twaite shad (*A. fallax*)	✓	×	Least Concern	✓	×
Angel shark *(S. squatina*)	✓	✓	Critically Endangered	✓[1]	×
Atlantic salmon (*S. salar*)	✓	✓	Least Concern	✓[2]	×
Atlantic cod *(G. morhua)*	×	✓	Vulnerable	×	×
Common skate (*D. batis*)	✓	✓	Critically Endangered	×	×
Basking shark (*C. maximus*)	✓	×	Vulnerable	✓	×
Porbeagle shark (*L. nasus*)	✓	✓	Vulnerable	✓	×
[1] = Applies in the Mediterranean only. [2] = Does not apply in sea waters.					

Table 5.5.2: Designation of fish species occurring near the decommissioning activities

5.6 Socio-economic

5.6.1 Fishing activity

The physical presence of offshore structures has the potential to interfere with fishing activities by obstructing access to fishing grounds. Knowledge of fishing activities and the location of the major fishing grounds is, therefore, an important consideration when evaluating any potential socio-economic impacts from offshore developments.

The International Council for the Exploration of the Sea (ICES) divides the north-east Atlantic into rectangles measuring 30 nm by 30 nm. Each ICES rectangle covers approximately one half of one oil and gas quadrant i.e. 15 license blocks. ICES rectangles are used to collect statistics describing the distribution of fishing effort and landings across sea areas. The proposed project area is located within ICES rectangles 36F1 and 36F2.

5.6.2 Fishing effort

The importance of an area to the fishing industry can be assessed in terms of fishing effort, measured by the number of days fished in each ICES rectangle. Based on annual fishing effort by UK vessels >10 m in length, the importance of ICES rectangle 36F1 and 36F2 can be considered low when compared to other areas of the UKCS. Fishing effort in 36F1 and 36F2 equated to 167 and 147 days in 2017 respectively. The combined effort of both rectangles constitutes 0.17% of the total UK fishing effort[8] [108]. A more detailed breakdown of fishing effort within ICES rectangle 36F1 and 36F2 is provided in Table 5.6.1.

Year	UK Total Effort (Days)	36F1 Effort (Days)	36F2 Effort (Days)	% of UK Total (ICES Combined)
2013	128,047	167	147	0.25
2014	131,479	456	108	0.43
2015	126,416	554	107	0.52
2016	133,343	410	171	0.44
2017	126,863	475	70	0.43
Average	**129230**	**412**	**121**	**0.41**

Table 5.6.1: Annual fishing effort in the ICES rectangle 36F1 [108]

5.6.3 Fish landings

Landings within ICES 36F1 are dominated by shellfish species in terms of weight and value in all years between 2013 and 2017 whereas demersal species dominated the landings quantity and value in ICES 36F2 in all years between 2013 and 2016. In 2017 shellfish species dominated (Table 5.6.2)[9]. Overall, the combined total landings of shellfish in ICES 36F1 and 36F2 contributed 1.38% of landings quantity and 0.89% of landings value compared to the UK total (Table 5.6.3).

[8] Note this value is based on landing values reported for ICES rectangles within which more than five UK vessels measuring 10 m were active. In those ICES rectangles where < 5 vessels were active the information is considered disclosive and is therefore not available.

[9] As for fishing effort data, reporting landing data provided refers to landings data by UK vessels over 10 m into UK ports where > 5m vessels have been active.

ICES	Species Type	2013		2014		2015		2016		2017	
		Value (£)	Live Weight (Te)	Value (£)	Live Weight (Te)	Value (£)	Live Weight (Te)	Value (£)	Live Weight (Te)	Value (£)	Live Weight (Te)
36F1	Demersal	53,855	36	76,336	44	24,511	10	13,192	6	505	0.5
	Pelagic	7	0.01	-	-	-	-	-	-	-	-
	Shellfish	497,771	320	1,276,886	1,010	1,584,931	1,266	1,405,270	1,050	2,023,677	1,218
	Total	**551,633**	**356**	**1,353,222**	**1054**	**1,609,442**	**1,275**	**1,418,462**	**1057**	**2,024,182**	**1,218**
36F2	Demersal	797,699	409	324,436	197	417,493	230	663,862	335	53,749	32
	Pelagic	93	0.1	24	0.04	1	0.003	124	0.14	2,167	0.9
	Shellfish	90,185	39	107,776	39	144,607	62	271,904	96	154,235	55
	Total	**887,978**	**448**	**432,237**	**235**	**562,101**	**292**	**935,890**	**431**	**210,151**	**88**
Total	**1,439,611**	**804**	**1,785,458**	**1,289**	**2,171,544**	**1,567**	**2,354,352**	**1,488**	**2,234,334**	**1,306**	**1,439,611**

Table 5.6.2: Live weight and value of fish landings by species type [108]

Year	Species Type	Value (£) / Weight (Te)	36F1 Total	36F2 Total	ICES Rectangles Total Combined	UK Total	Rectangle as % of UK Total
2017	Demersal	Value	505	53,749	54254	229,511,730	0.02
		Weight	0.5	32	33	128,952	0.03
	Pelagic	Value	0.00	2,167	2167	243,137,071	0.0009
		Weight	0.00	0.9	0.9	342411	0.0003
	Shellfish	Value	2,023,677	154,235	2177913	244,882,312	0.89
		Weight	1,218	55	1272	92,349	1.38

Table 5.6.3: Percentage of ICES 36F1 and 36F2 to the UK total in 2017 [108]

Data from between 2013 and 2017 shows that traps and trawls are primarily used in the area. Traps were used most of the time in ICES 36F1, with the highest level of trap effort observed in 2015 at 539 days. Conversely, trawls were used most of the time in ICES 36F2, with the highest level of trawl effort observed in 2016 at 169 days. Data is classified as disclosive for other types of gear used for most years and are therefore not available *(i.e. less than five vessels (>10 m) undertook fishing activity)*. The gear types used between 2013 and 2017 in ICES 36F1 and 36F2 are listed in Table 5.6.4.

ICES	Gear Type	2013	2014	2015	2016	2017
36F1	Dredges					25
	Traps	154	439	539	406	449
	Trawls					
	Seine nets		-	-	-	
36F2	Traps		-	-		
	Trawls	143	106	107	169	63
	Gill nets and entangling nets	-		-	-	-

Table 5.6.4: Gear types used within ICES 36F1 and 36F2 (2013–2017) [108]

Figure 5.6.1 presents the intensity of mobile fishing associated with the Ensign pipelines and umbilical between 2007 and 2015 [108]. The data layers were created following the method described in [86]. VMS position data were filtered by speed to distinguish fishing from steaming points. Fishing points were interpolated into tracks, accounting for the speed and heading of the vessel, to obtain a greater spatial resolution of fishing activity. Each pipeline was divided into 1km sections. The total number of fishing tracks that extended 500m either side of the pipelines, was determined for four gear categories: dredging, *Nephrops* (otter and pair trawls), demersal (otter, pair and beam trawls), and all mobile demersal gear. Thereafter the total number of fishing tracks along the entire length of the Ensign pipelines was determined to be between zero and eleven, which is considered low.

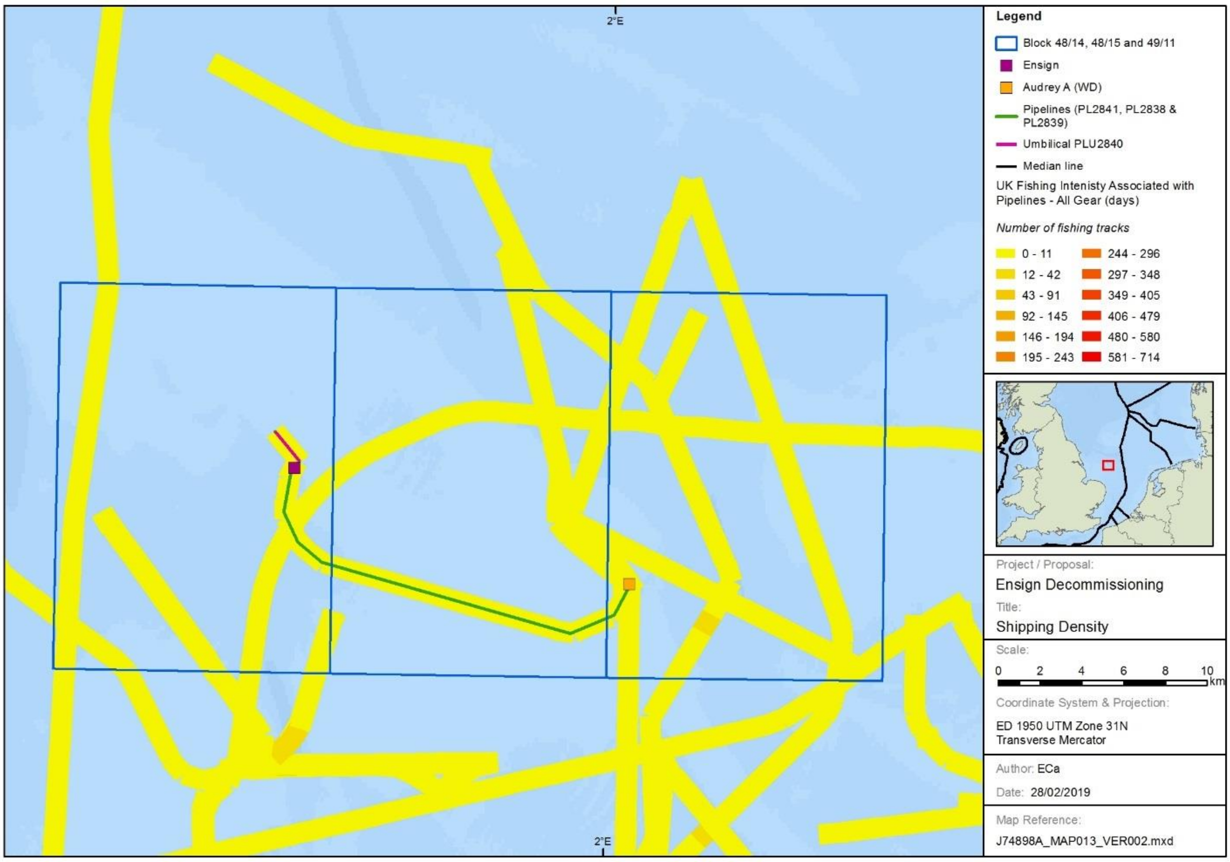


Figure 5.6.1: Fishing intensity along the Ensign pipelines and umbilical [108]

5.6.4 Shipping

Shipping activities in the North Sea are categorised by the Oil and Gas Authority [74] to have either: very low; low; moderate; high; or very high shipping density. Figure 5.6.2 provides an assessment of the level of shipping activity within the area of the Ensign field. As can be seen across the Ensign area, shipping density ranges from moderate to high.

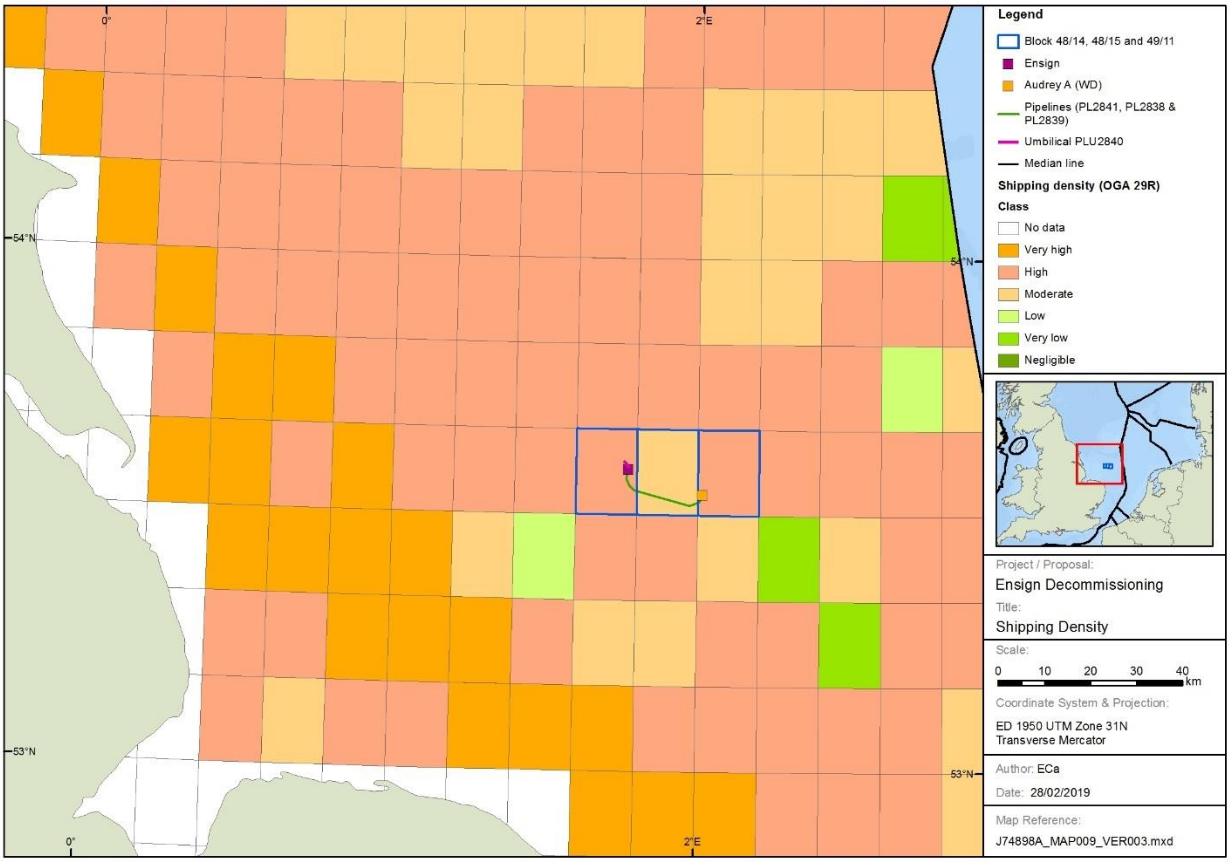


Figure 5.6.2: Shipping density near the Ensign field in 2016 [74]

5.6.5 Existing oil and gas activity

The SNS gas basin in which the Ensign field is located is a region well developed by the oil and gas industry.

Figure 5.6.3 shows surface oil and gas installations near the Ensign field.

Near the project area several oil and gas developments have commenced decommissioning of assets and have an approved DP whilst others are in the decommissioning planning phase (Table 5.6.5). The closest approved decommissioning programmes concern the Audrey A and Audrey B installations and pipelines, located between 17km and 13km east south east of the Ensign installation respectively (Figure 5.6.3) [9]. Ensign pipelines PL2838 and PL2839 are connected to Audrey A.

DP Name	Location (Block/s)	Closest Distance From Project (km)	Proposed Schedule	Within Protected Area	Potential Temporal Overlap With Project
Saturn (Annabel), Spirit Energy	48/10	16	2018 to 2022	✓	Yes
Ann and Alison, Spirit Energy	48/10a, 49/6a, 49/11a	27	2017 to 2024	✓	Yes
Audrey, Spirit Energy	48/15, 49/11	13	2018 to 2024	✓	Yes
Viking Installations, Conoco Phillips	49/12a,49/16a, 49/17a, 49/18a and 49/12a	30	2014 to 2018	✓	No
Viking Satellites CD, DD, ED, GD, HD Infield Pipelines, Conoco Phillips	49/11d, 49/12a,49/16a, 49/17a and 49/12a	30	2016 to 2019	✓	No
Viking Satellites KD, LD, AR, Vixen VM subsea tieback, Viking Bravo Hub and associated pipelines, Conoco Phillips	49/12a,49/17a and 49/12a	30	2016 to 2021	✓	Yes
Victor JD and JM Subsea tie back and associated pipelines, Conoco Phillips	49/17 and 49/22	30	2016 to 2024	✓	Yes
LOGGS Satellites Vulcan UR, Viscount VO, Vampire OD-LDP1, Conoco Phillips	49/21a, 48/25b and 49/16	22	2016 to 2021	✓	Yes

Table 5.6.5: Oil and gas developments with an approved DP [9]

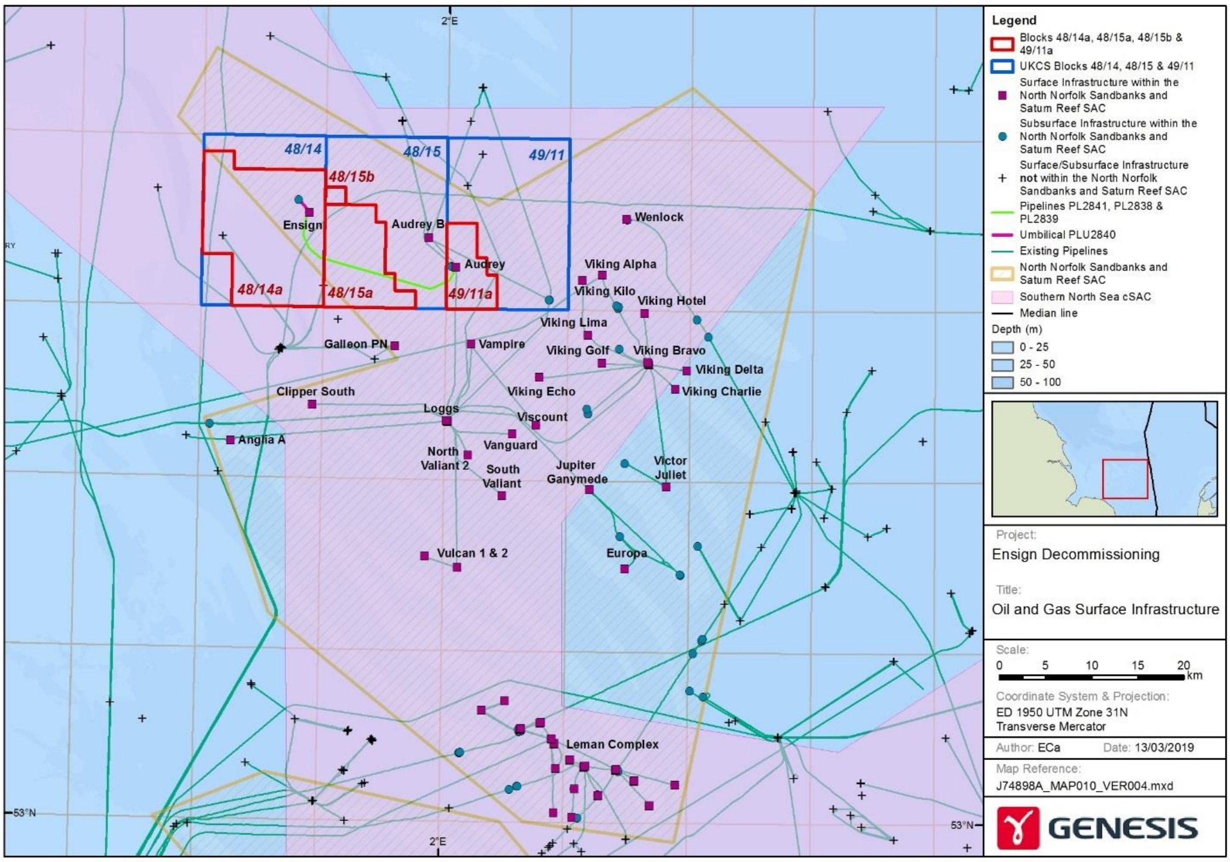


Figure 5.6.3: Oil and gas surface infrastructure within the vicinity of the Ensign field

5.6.6 Offshore renewable energy activity

As shown in Figure 5.6.4, the closest operational wind farm to the Ensign infrastructure is Hornsea One (Heron West, Njord and Heron East) located approximately 26km north of Ensign at the closest point. Although Hornsea One has begun producing power, the construction activities are not yet complete, and are expected to take until 2021. The consented Hornsea Two project (30km north of Ensign) is also under construction and expected to become fully operational in 2022. The application to develop Hornsea Three (50km east of Ensign) is currently being evaluated by the Planning Inspectorate whilst Hornsea Four (35km northwest of Ensign) is in the pre-application phase [78]. The proposed cable route for the Hornsea Project Three (Figure 5.6.4) passes 20km from Ensign to the north-west. Construction for this project is currently expected to occur between 2022 and 2025. The Dudgeon operational windfarm is located 40km to the south-west of Ensign.

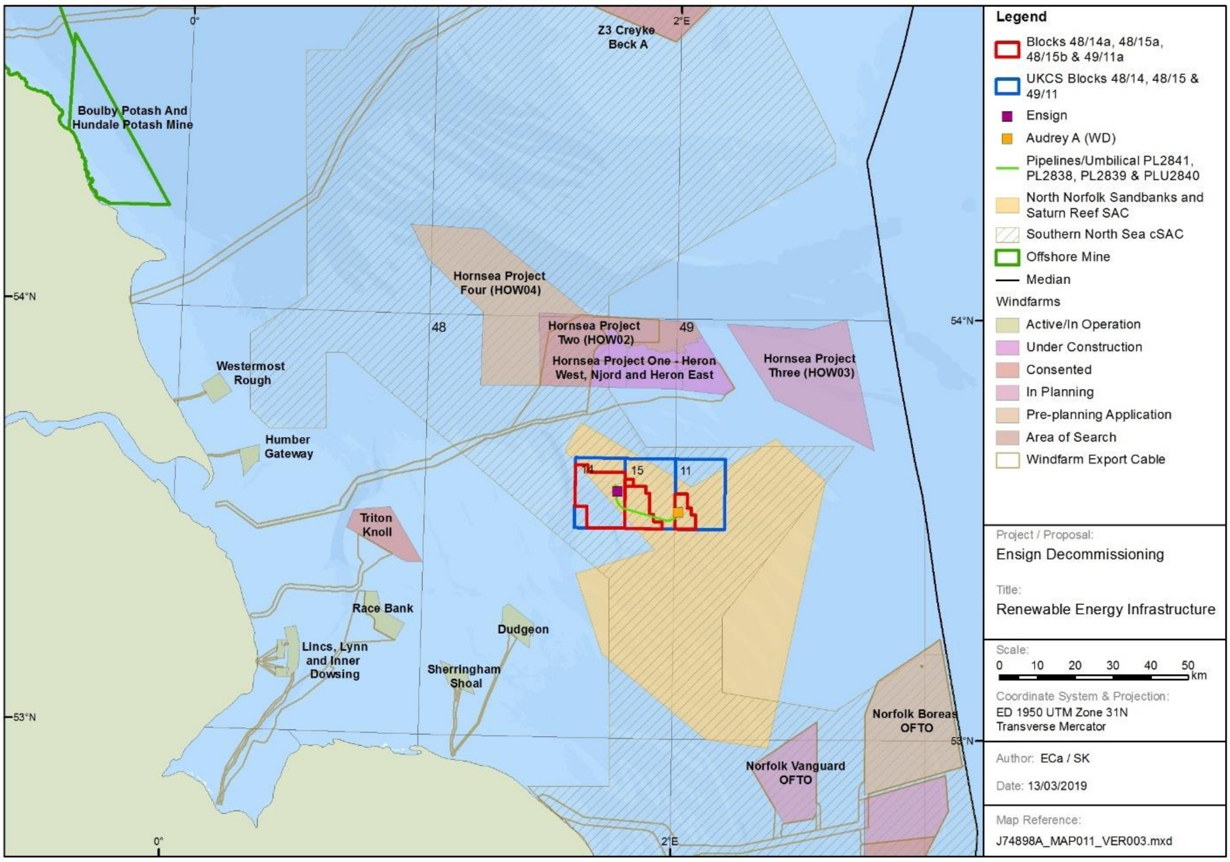


Figure 5.6.4: Location of wind farm projects in the vicinity of the Ensign field [93]

5.6.7 Military exercises

There are no military exercise areas near the Ensign field.

5.6.8 Other offshore activity

There is one disused telecommunications cable which passes the Ensign installation, 8km to the east (Figure 5.6.5). Pipelines PL2838 and piggybacked PL2839 crossover the disused telecoms cable at ~KP11.6 (Figure 4.3.4). The closest active telecommunications cable is the Tampnet Offshore FOC Network which is approximately 40km to the east of the Ensign installation.

Approximately 12km to the south east of the Ensign installation is a production aggregate area (Humber 3) (Figure 5.6.5). Tender rounds offer interested parties the opportunity to bid for rights to prospect the seabed in some or all regions under Crown Estate mineral management and to obtain an option for a production agreement to extract marine aggregate, subject to the terms of a marine licence [13].

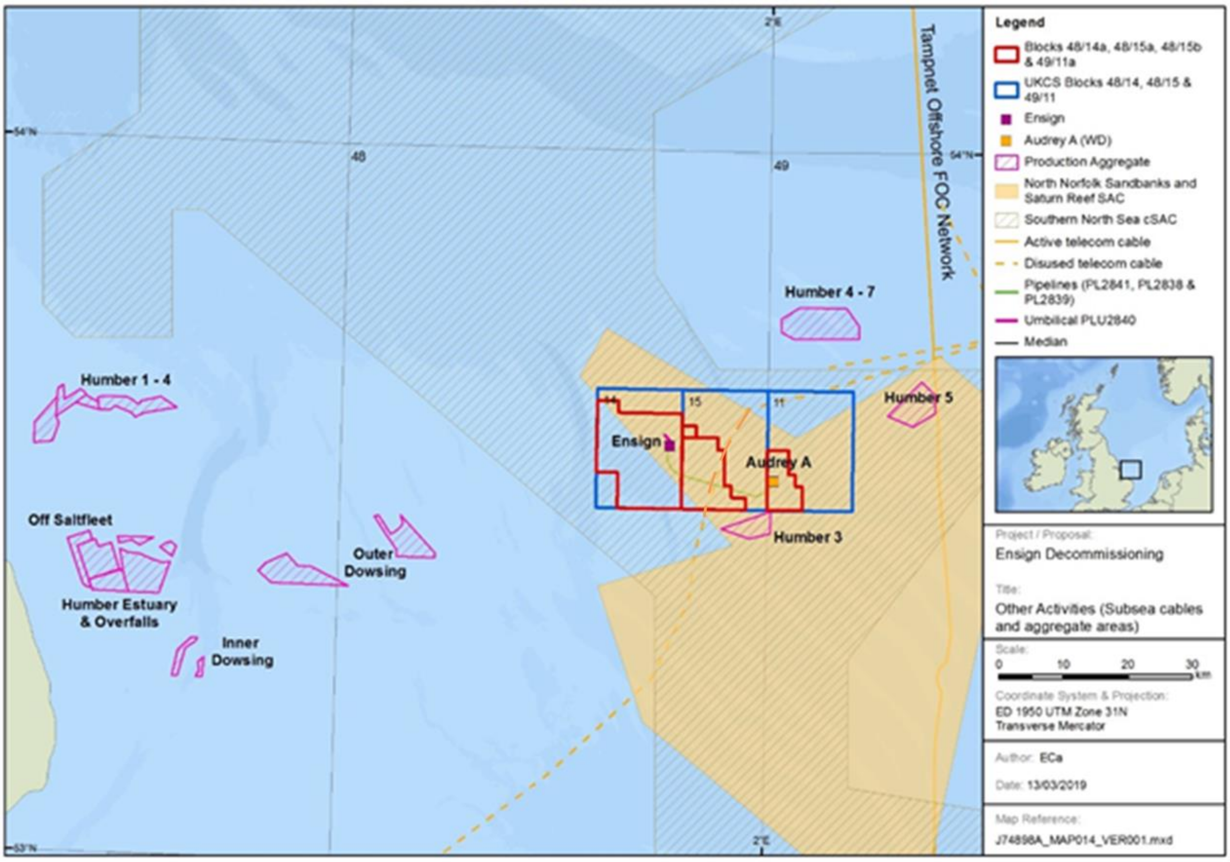


Figure 5.6.5: Other activities within the area [13] & [93]

6. SCOPING PHASE

6.1 Overview

During the scoping phase of this EA the project aspects were identified and assessed (Section 3). The outcome of this scoping phase assessment is summarised in Table 6.1.1 and the worksheet from the workshop is presented in Appendix C. Aspects that were categorised as of **low** significance and therefore 'scoped out' of requiring detailed assessment are discussed below (Sections 6.2 to 6.7). Aspects that were categorised as of **medium** significance were selected for further assessment, are discussed in Section 0.

Activity/Potential Impact	Physical presence	Small releases to Sea	Discharges to sea	Atmospheric emissions	Waste production	Underwater Sound	Resource use	Large releases to sea	Seabed disturbance	Other users of the sea
Vessel presence at site	L	L	L	L	L	L	L	M		L
Vessels transiting	L	L	L	L	L	L	L	M		L
HLV and transport barge presence at site	L	L	L	L	L	L	L	M		L
HLV and transport barge transiting	L	L	L	L	L	L	L	M		L
Flush, clean and purge topsides		L			L					
Movement of radioactive sources					L					
HLV and transport barge anchoring at site						L	L		M	
Manufacture of steel fastenings							L			
Dropped objects from lifting operations									L	
Cutting		L				L				
Internal/external cutting of jacket piles						L			L	
Recovery of installation to onshore					L		L			
Severing pipeline ends					L	L				
Removal and recovery of pipespools, umbilical ends, mattresses and grout bags					L				L	
Addition of rock to pipeline ends							L		L	L
Leak of hydraulic fluid from cutting equipment		L								
Discharge of umbilical and pipeline contents		L								
Removal of 500 m safety zone										P
Breakdown of infrastructure decommissioned *in situ*									L	
Presence of infrastructure decommissioned *in situ* (snagging risk)		L								L
Over-trawl survey									M	P

L	Impact broadly acceptable and considered 'as low as reasonably practicable'
M	Impact is tolerable but to be managed to 'as low as reasonably practicable'
H	Impact intolerable without control and mitigation measures required to reduce impacts to 'as low as reasonably practicable'
P	Positive or beneficial impact
	No interaction

Table 6.1.1: Summary of Ensign scoping phase environmental assessment

6.2 Atmospheric emissions

The principal sources of energy use and atmospheric emissions are associated with vessel use, and the onshore transport and processing of materials and waste.

Vessel activities will be of relatively short duration (worst case approximately 57 days). Total CO_2 emissions were calculated using the total fuel usage presented in Table 4.6.1 and the emissions factor of 3.2 tonnes of CO_2 per tonne of fuel. CO_2 emissions of approximately 6,344Te could be emitted to the atmosphere. To put this into context, the emissions from UK offshore oil and gas installations in 2017 [76] were 14.2MT CO_2. Proportionally, the worst-case vessel emissions from Ensign decommissioning equates to less than 0.04% of the UK offshore oil and gas installations emissions. Vessel use will be optimised for example by partnering with other projects to reduce the number of mobilisations and their operation will be managed under Spirit Energy's existing marine procedures.

A relatively small volume of materials will be disposed of onshore (Table 4.7.1). All material will be handled by licenced waste management contractors at sites that hold Environmental Permits or Pollution Prevention Control (PPC) permits. The impact of energy use and atmospheric emissions will have been assessed as part of obtaining these licences. There will also be a requirement to ensure any impacts are minimised.

Given the above, the significance of this aspect has been assessed as **low**.

6.3 Underwater sound

The principal sources of underwater sound are vessel use, excavation of seabed sediments and cutting.

Vessel activities will be of relatively short duration. Their use will be optimised (e.g. by partnering with other projects to reduce the number of mobilisations) and their operation will be managed under Spirit Energy's Marine Assurance Standard. The duration of vessels being on site is relatively short and will occur in an area of relatively high vessel traffic such that animals in the area are acclimatised to vessel noise (Section 5.6.4), therefore the impact of underwater sound on the receptors is considered 'low'.

A relatively small number of cuts to the pipelines and umbilical will be required. The likely cutting method will be with hydraulic shears. The area excavated will be relatively small and local to the edges of the items to be cut or lifted. Cutting of the Ensign installation jacket piles will also be required to remove the installation. The likely cutting method will either be abrasive water jet or diamond wire.

There is very little information available on underwater sound generated by tools used for underwater cutting operations. Anthony *et al*. [6] present a review of published underwater sound measurements for various types of diver-operated tools. Several of these are underwater cutting tools, including a high-pressure water jet lance, chainsaw, grinder and oxy-arc cutter.

At time of writing, empirical measurements of the underwater noise produced by abrasive jet cutting could not be sourced. Measurements of noise from diamond wire cutting were carried out at distances of 100m, 250m and 800m from the source Pangerc *et al.* [106]. The conclusions of the study indicated that increases of between 4dB and 15dB were detectable for one-third octave band spectral levels at some frequencies, and for frequencies above 5kHz there was generally an observable increase in the spectral levels. The paper also concludes that the sound radiated from the cutting activity was often not easily discernible above the background noise.

There is no published information on the behavioural response of marine mammals to sound generated by underwater cutting. However, reported source levels are relatively low compared with those generated by vessels.

Given the above, the significance of this aspect has been assessed as **low**.

Although the significance of underwater noise generated from the project has been assessed as 'low', further assessment of the cumulative impact of noise has been discussed in Section 7.3.3 given that the Ensign project is located within the SNS cSAC designated for the presence of the Annex II species harbour porpoise which is a potentially noise sensitive species.

6.4 Discharges and small releases to sea

Planned discharges to sea will occur from the use of vessels and from the discharge of the contents of the pipelines and umbilical after having been cut. Small unplanned releases of fuel, hydraulic oil, lubricants or chemicals may occur during decommissioning activities.

The pipelines currently contain inhibited seawater or filtered seawater and so do not require any further cleaning to be undertaken. The topsides will be vented and purged prior to their removal. The use of any chemicals for cleaning and flushing or for any other decommissioning activities will be permitted under the Offshore Chemicals Regulations 2002 (as amended) and the discharge of any residual hydrocarbons from pipeline and riser disconnections and cutting activities will be permitted under The Offshore Petroleum Activities (Oil Pollution Prevention and Control (OPPC)) Regulations 2005 (as amended). Any ballast water discharges will be in line with the International Maritime Organisation ballast water management convention and guidelines. Vessel activities such as the release of drainage water and grey water will be relatively short in duration and will be subject to separate regulatory requirements.

Small unplanned releases will be managed under the existing Ensign field OPEP [103] and the SOPEPs.

There is the potential for the slow release of degradation products from pipelines and mattresses decommissioned *in situ* as they degrade over time. Structural degradation of the pipelines will be a long-term process caused by corrosion and eventual collapse. For most of the pipeline lengths the collapse will be aided by the weight of seabed sediment, although at the pipeline and cable crossings additional materials such as concrete mattresses, concrete plinths and deposited rock will also contribute to their eventual collapse. During this process, degradation products of the mattresses, pipelines and any entrained heavy metals will break down and could potentially become bioavailable to benthic fauna in the immediate vicinity. Contaminants could reach potential environmental receptors via the interstitial spaces in seabed sediments, overlying rock placement where applicable and the water column. The release of degradation products is expected to occur slowly and therefore the impact on the environment is expected to be minimal.

Given the above, the significance of these aspects has been assessed as **low**.

6.5 Waste production

Most of the material recovered during the Ensign decommissioning will be non-hazardous, including steel (installation) or concrete (mattresses, grout bags and gabion sacks) (Table 4.7.1). The end sections of pipelines and umbilical, pipespools and pipeline anodes comprise a mixture of materials including steel, plastics/rubber and non-ferrous metals.

Until a waste management contractor has been selected and disposal routes investigated, the final disposal for the material is unknown. The selected dismantling site will be able to demonstrate a proven disposal track record and waste stream management throughout the deconstruction process and demonstrate their ability to deliver re-use and recycling options. The project aspiration is that all steel and concrete will be recycled, as well as most components of the end sections of pipeline, umbilical, pipespools and pipeline anodes.

A Waste Management Plan for the decommissioning programmes will be prepared and implemented in line with the Waste Framework Directive. All waste will be managed in compliance with relevant waste legislation by a licenced waste management contractor.

As part of Spirit Energy's standard processes, all sites and waste carriers will have appropriate environmental and operating licences to carry out this work and will be closely managed within Spirit Energy's contractor assurance processes.

Should NORM be encountered Spirit Energy will dispose of radioactive waste under their existing permit from the Environment Agency for the accumulation and disposal of radioactive wastes (permit number EPR/XB3735DX). Sealed sources will be moved under an existing permit (permit number EPP/XP3090SG) and returned to their owner or supplier.

Given the above, the significance of this aspect has been assessed as **low**.

6.6 Physical presence

The pipelines and umbilical exhibit a good depth of burial and cover and are stable along their original trenched and buried lengths (Appendix B). Given the sandwaves in the area show evidence of movement it is possible that the pipelines could become exposed over time (Section 5.3.2). However as can be seen in Figure 5.3.4 when the pipelines were installed the area was pre-swept to the trough of the sandwaves and the depth of pipeline lowering was measured from the bottom of the trough of the sandwave to ensure good depth of burial and cover.

Monitoring will be performed to confirm the pipelines and umbilical decommissioned *in situ* remain stable and buried at a frequency to be agreed with OPRED. Pipelines will be marked on admiralty charts and added to the FishSAFE database.

Vessels on transit to the Ensign field and on location present a physical obstruction in the sea and an associated navigational hazard and increased risk of collision with third-party vessels. Vessel collision could potentially lead to elevated impacts such as injury or loss of life to vessel crew members or an unintentional release of hydrocarbons. The potential impact related to the release of hydrocarbons is addressed in Section 7.2.

Shipping densities in the area are moderate/high (Section 5.6.4) however a number of mitigation measures will be in place to minimise the risk of collision including; issuing a notice to mariners prior to operations commencing to give vessels advance warning of the decommissioning operations and kingfisher bulletins issued prior to operations commencing. Additionally, vessels decommissioning the installation are likely to be working within the 500m safety zone which will be patrolled and enforced by an emergency response rescue vessel.

Dependent upon final vessels selection it may be necessary for some vessels involved in the installation decommissioning to be anchored on location. The presence of anchors and chains presents a potential snagging risk although the implementation of an anchor management plan, liaison with regional fishing groups and the same mitigation measures mentioned previously will minimise the risk of snagging. A Collision Risk Assessment and Vessel Traffic Survey have already been undertaken as part of the Consent to Locate for the Ensign installation. If required, the Consent to Locate will be updated prior to bringing an anchored vessel alongside the installation.

The positive impact on other users of the sea - in particular fishing vessels, is associated with the removal of the 500m safety zones at the Ensign installation and Ensign well location and the confirmation of a clear seabed following over-trawl activities. Both activities potentially increase the area of seabed open to fishing activity.

Given the above, the overall significance of both positive and negative impacts associated with these aspects has been assessed as **low**.

6.7 Transboundary

The Ensign field is located approximately 81km, to the west of the nearest international boundary; the UK/Netherlands median line.

Any vessel discharges to sea will be localised in nature and will dissipate to negligible levels within a short distance from their source, before transboundary water quality deterioration is a factor.

Any underwater noise generated by decommissioning activities will be localised in nature and will dissipate to background levels before transboundary impacts are a factor.

The atmospheric emissions from the decommissioning project will result in a minor deterioration of air quality over the local area and will dissipate to negligible levels within a short distance from their source, before transboundary air quality deterioration is a factor. Therefore, transboundary impacts upon air quality are not expected.

The waste arising from the decommissioning project is likely to be managed and processed entirely by contractors within the UK. The onshore locations for waste reception are unknown at the time of writing. There is a possibility that some of the waste could be shipped outside of the UK depending upon the type of waste and availability of UK facilities at the time of decommissioning. The Ensign Waste Management Plan will present the responsibilities Spirit Energy has under the 'Duty of Care' legislation and identify appropriately licenced international onshore facilities where the waste can be treated. Therefore, no significant transboundary impacts from waste arising from the decommissioning project are expected.

Given the above, the significance of this aspect has been assessed as **low**.

The transboundary impact from a large hydrocarbon release to sea is discussed in Section 7.2.

7. ENVIRONMENTAL ASSESSMENT

During initial screening (Section 6), the following potential impacts were selected for a more detailed assessment:

1. Seabed disturbance (Section 7.1);
2. Large releases to sea (Section 7.2); and,
3. Cumulative (Section 7.3).

7.1 Seabed disturbance

This section presents the detailed environmental assessment, undertaken by identifying and assessing the temporary and permanent environmental impacts from the various sources of seabed disturbance associated with the planned decommissioning activities. It also considers potential sources of unplanned seabed disturbance. This section assesses the potential for environmental impacts and outlines mitigation measures to minimise these impacts. To enable an assessment of the cumulative impact to the seabed (Section 7.3), all activities that could disturb the seabed have been assessed.

As there is a degree of uncertainty with regards to type of vessel, assumptions have been made to assess a worst-case seabed disturbance. The impacts are presented in Table 7.1.1 and Table 7.1.2.

7.1.1 Temporary disturbance

Temporary disturbance from decommissioning activities can result in direct mortality or physical injury to benthic species, and in mobilisation and re-suspension of sediment. This can result in indirect impacts from increases in suspended solid concentrations in the water column and subsequent re-deposition on the seabed with the potential to change its physico-chemical characteristics and impact benthic communities.

The sources of temporary seabed disturbance, the estimated area of impact and the volumes excavated (where applicable) are described in Table 7.1.1. A description of the activities and the location of each activity are provided in Section 4.4 and Figure 4.6.1 respectively.

Activity	Source of Disturbance	Description of Impact	Assumptions	Area Impacted (km^2)	Volume Excavated (m^3)
Use of HLV and/or transport barge to remove NPAI topsides and jacket	Eight anchors and anchor chains per vessel will be in contact with the seabed. Anchors will require to be repositioned between lifting the topsides and the jacket	Each anchor will directly cover an area of 30m^2; Each anchor chain will abrade the seabed along the length of chain which is in contact with the seabed.	It is assumed that: • Each anchor chain is in contact with the seabed over a worst-case length of 500m and abrades an area of seabed ≤ 5m on either side of the chain; • 32 anchor /anchor chain placements are made.	0.081	-
External cutting of jacket piles (contingency)	Excavation of material (sediment and marine growth) to access piles. The piles are cut externally using a diamond wire cutter mounted on an ROV.	Sediment removal and resuspension will occur. the extent of the impact depends on: • Number of piles that require external cutting; • Extent of marine growth.	Internal cutting fails on two of the four legs. The area of disturbance is calculated assuming: • Removal of seabed around each of the piles to approx. 3.5m below natural seabed level; • Removal of seabed approximately 12.2m around each leg minus the diameter of the leg (1.7m); • A conservative 5 m zone around each area being impacted.	0.0002	403.2
Removal of exposed concrete mattresses and grout bags	Lifting ~358grout bags and 100[10] concrete mattresses from the seabed. Temporary placement of equipment and items on the seabed.	Extent of disturbance is related to: • Number of grout bags and concrete mattresses to be moved and recovered and their burial status; • Area covered by concrete mattresses and grout bags being removed.	Area impacted is: • 0.25m x 0.25m per grout bag; • 6m x 3m per concrete mattress; • A 5 m zone either side and around the items to be removed could be disturbed by the removal and could be impacted by the temporary placement of equipment and items.	0.014	-

[10] 95 concrete mattresses plus a contingency of 5 concrete mattresses.

Activity	Source of Disturbance	Description of Impact	Assumptions	Area Impacted (km^2)	Volume Excavated (m^3)
Removal of exposed pipeline ends	Excavation of material to access pipeline ends. Sediment will be moved from its current location and deposited either side of the sections that are being removed. The pipeline ends will be cut using shears which are rigged from the vessel and sit vertically above the pipeline with minimal contact. The pipeline ends will be placed on the seabed after cutting.	Extent of disturbance is related to: • Number of locations at which the pipelines and umbilicals will need to be excavated; • Extent to which each location requiring access is buried with sediment; • Length of the pipelines and umbilical sections being removed.	The area of seabed disturbance assumes a corridor width of 10 m. Pipeline sections to be removed are (length quoted is total for both ends): • PL2838: 177m • PL2839: 159.8m • PLU2840: 245m • PL2840: 81.2m	0.007	9,945
Overtrawl assessment (if required)	This typically involves a fishing vessel deploying 'rock hopper' fishing gear with scraper chains to determine if there are any snagging hazards.	Sediment disturbance will depend on extent of overtrawling activity.	The area of impact is based on: • Ensign platform 500m exclusion zone; • Ensign ED well 500m exclusion zone; • 100m corridor for PL2838 and PL2839 (pipeline length minus the sections within the 500m exclusion zones at Ensign and Audrey A (WD) installations) (21,240m); • 100m corridor for PLU2840 and PL2841 (umbilical and pipeline length minus the sections within the 500m exclusion zones at the Ensign installation and Ensign ED well (1,200m).	0.79 0.79 2.12 0.12	-
Unplanned events	During all lifting activities there is the potential for materials and equipment to be accidentally dropped because of a procedural failure, or mechanical failure of the lifting apparatus.	The degree of disturbance will be related to the area of the dropped object.			-
Total				**3.92**	**10,348**
Note: Over-trawl assessment of the 500m safety zone at Audrey A (WD) has not been included in the above as this is assessed as part of the Audrey Decommissioning Programmes.					

Table 7.1.1: Temporary disturbance with area impacted and volumes excavated

7.1.2 Permanent disturbance

The decommissioning of the pipelines and umbilical pipeline *in situ* including any associated protection or stabilisation features, can be considered to cause permanent disturbance to the seabed. The degree of disturbance will be related to the length and diameter of the pipeline or umbilical section being decommissioned and the burial status.

An estimate of the seabed area potentially affected by permanent impacts is presented in Table 7.1.2. It shows that the estimated total area impacted is 0.0242km^2. To put this into context, a licence block is approximately 200km^2 and the North Norfolk Sandbanks and Saturn Reef SAC is 3,603km^2. The area impacted is therefore considered small.

As a contingency, it may be necessary to place up to 2Te additional rock at each of the four pipeline ends, representing a maximum of up to 8Te in total. It will be placed on top of existing rock, therefore no additional area will be impacted. There will, however, be an increase in the volume of rock placed on the seabed. It is assumed that 1Te rock equates to 0.5m^3 therefore a maximum of 4m^3 additional rock may be used.

Source of Permanent Seabed Disturbance	Assumptions Made	Area Impacted (km^2)
Decommissioned piggybacked pipelines PL2838 and PL2839 *in situ*	Area is calculated based on a length of 21,357m and a width of 0.5m	0.0107
Decommissioned piggybacked pipelines PLU2840 and PL2841 *in situ*	Area is calculated based on a length of 1,959m and a width of 0.5m	0.0010
Decommissioning of existing rock *in situ*	Rock deposits on 883m total pipeline length, average of 12.3m wide for PL2838 and PL2839 Rock deposits on 241m total pipeline length, average of 6.6m wide for PLU2840 and PL2841	0.0109 0.0016
Decommissioning of existing concrete mattresses and concrete plinths *in situ*	Concrete mattresses and concrete plinths are buried under the existing rock therefore no additional area is impacted	-
Placement of additional rock at pipeline ends	Additional rock will be placed on existing rock and therefore no additional area will be impacted	-
Total area impacted		**0.0242**

Table 7.1.2: Estimate of the area of permanent seabed disturbance

7.1.3 Impacts and receptors

7.1.3.1 Temporary disturbance

A total area of 3.92km^2 of seabed has been calculated to be temporarily disturbed as a result of the proposed Ensign decommissioning activities. These activities may result in the direct physical injury or mortality of benthic species. Disturbance of seabed sediment will also lead to increases in suspended solid concentrations in the surrounding waters. However, suspended materials will be rapidly dispersed and diluted by prevailing hydrodynamic conditions before settling back to the seabed, so the disturbance will be short-term. Whilst some redistribution of material is to be expected, the impact of this will depend on the sediment characteristics in the area.

Indirect Impacts

Localised disturbance of the ecosystem at the seabed may occur, leading to some degree of community change. It is known that some bottom-dwelling marine organisms are particularly vulnerable to natural or man-made activities which cause disturbances of the seabed, such as deposition of sedimentary material. Most offshore benthic species are recruited from the plankton, and usually recover rapidly once disturbance from the decommissioning activities cease.

It is also possible that bottom-dwelling organisms may be smothered by settlement of suspended solids. However, rapid dispersion and dilution by prevailing hydrodynamic conditions before the material settles back to the seabed will prevent the development of substantial accumulations of re-settled materials far from the disturbance. The risk of smothering is therefore considered to be in line with the normal re-distribution of seabed sediment which occurs because of natural hydrodynamic conditions and is an inherent component of the ecosystem.

As discussed previously (Section 5.4.3) a number of species of fish are known to spawn within the vicinity of Ensign with others using it as a nursery area. Given the widespread spawning and nursery areas of most species in the North Sea, any impact at the individual level is not considered significant.

Direct Impacts

Lifting of materials is likely to damage/destroy any sensitive surface species settled on the sediment. However, this is unlikely to affect mobile species, either on, or under the surface of the sediment as they are likely to move away from the disturbance.

The intentional or unintentional temporary placement of objects on the seabed will result in the effected substrate no longer being available for colonisation by either surface dwelling or burrowing species.

There may be the potential for sub-lethal impacts on benthic and epibenthic fauna as a consequence of physical abrasion from excavation works. Careful management and planning of activities to minimise affected areas will reduce the potential for physical abrasion but it is impossible to eliminate the risk entirely and some impacts on individuals may occur. Since the disturbance will be short-term, and given the strong currents in the SNS, it is expected that any impacts on the wider ecosystem will be minimal and that rapid and complete recovery of the localised seabed community will occur once activities cease.

As discussed in Section 5.3.5 none of the *Sabellaria sp.* observed represented Annex I habitat.

Given that the area of seabed/infrastructure that will be disturbed by the excavation and lifting activities represents only a very small proportion of biotopes available in the SNS, that the *Sabellaria sp.* present do not represent Annex I habitat and that re-colonisation of affected substrate is expected to occur rapidly via recruitment of individuals from adjacent undisturbed areas, the significance of these impact has been assessed as **low**.

7.1.3.2 Permanent disturbance

The decommissioning of infrastructure *in situ* can lead to long term impacts to the seabed and its habitat, especially modifications to seabed dynamics (and morphology) and changes to the benthic fauna.

If the placement of rock is required at the cut pipeline ends, the rock would be placed on top of the existing rock and so there would be no additional permanent loss of habitat expected and this is not considered further.

Under the Ensign DP, the pipelines and umbilical are to be decommissioned *in situ*. The pipelines have been cleaned. Facilities decommissioned *in situ* could become exposed via storm events or severe seabed sediment movements that could result in long-term disturbance to the seabed. The degree of disturbance depends on the footprint of the facilities being decommissioned in situ and on the burial status. Given that the Ensign pipelines are sufficiently and stably buried, exposure of the buried infrastructure is not expected. Nevertheless, the worst case of the footprint of the entire pipelines to be left *in situ* has been calculated (Table 7.1.2.). Further, as exposure of the pipelines is not expected, no remedial actions would be required.

The total area of pipelines and stabilisation materials decommissioned *in situ* is 0.0242km^2 which is 0.0007% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC. An assessment was undertaken to determine the impact of the Scroby Sands offshore windfarm (located 2.3km offshore of Great Yarmouth) on sandbank morphology [11]. The study found no evidence of any changes to sandbank morphology as a result of the 30, 4.2m diameter monopile foundations driven up to 30m into the seabed. This suggests that the decommissioning of the Ensign pipelines and associated stabilisation material including rock protection *in situ* is unlikely to have an impact on the sandbank morphology and dynamics.

7.1.3.3 Impacts on designated sites

The Ensign decommissioning activities will be undertaken within the North Norfolk Sandbanks and Saturn Reef SAC and the SNS cSAC.

The North Norfolk Sandbanks and Saturn Reef SAC is designated due to the presence of the Annex I habitats: sandbanks which are covered by seawater all the time and *Sabellaria sp*. biogenic reef. The SNS cSAC has been identified as an area of importance for the Annex II species, harbour porpoise.

Only the North Norfolk Sandbanks and Saturn Reef SAC is assessed in this section, since harbour porpoise are not considered to be sensitive to seabed disturbance.

The estimated area of seabed disturbed temporarily and permanently within the designated site is 3.92km^2 and 0.0242km^2 respectively. The area of temporary seabed disturbance is a worst-case as it assumes that an over-trawl assessment will be carried out, however Spirit Energy will be exploring the use of non-intrusive techniques.

The North Norfolk Sandbanks and Saturn Reef SAC site covers an area of 3,603km^2. The estimated area of direct impact from temporary sources and permanent sources of seabed disturbance represents an area of 0.1407% and 0.0007% of the site respectively.

The assessment of the potential impact from seabed disturbance on the North Norfolk Sandbanks and Saturn Reef SAC has been undertaken using the JNCC formal conservation advice package [58] for the North Norfolk Sandbanks and Saturn Reef SAC. This was done to enable a decision to be reached as to whether the sources of seabed disturbance from decommissioning activities will have an impact on the conservation objectives and on the qualifying features of the North Norfolk Sandbanks and Saturn Reef SAC. The advice on operations forms part of the conservation advice package and identifies the possible pressures from various industry operations on the site. The identified pressures for oil and gas decommissioning relating to seabed disturbance have been selected and are presented in Table 7.1.3 along with a discussion on how these pressures could be influenced by the Ensign decommissioning seabed disturbance sources.

Identified Pressures	Assessment Discussion
Abrasion/disturbance of the substrate on the surface of the seabed	The seabed over-trawl assessment has the potential to cause physical disturbance or abrasion at the surface of the substratum. The estimated worst-case area of seabed potentially disturbed by this activity is small (3.92km^2) relative to the area covered by the site.
Changes in suspended solids (water clarity)	All activities identified as being a potential source of temporary seabed disturbance could cause sediment to mobilise into the water column. Sandy and gravel sediments should drop out of suspension quickly, and in the immediate area.
Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	The excavation of sediment associated with the external cutting of jacket piles and the anchoring of the HLV and transport barge has the potential to cause physical disturbance or abrasion of the substratum below the surface. The estimated area of seabed disturbed by these activities is small (0.081km^2) and the volume of excavated material is also small (403.2m^3) relative to the area covered by the site. This pressure will be temporary in nature and recovery of the seabed would be expected to occur (refer Section 7.1.1).
Physical change (to another seabed type)	This is the permanent change of one marine habitat type to another marine habitat type, through the change in substratum. Existing rock has been deposited on the pipelines, umbilical and pipeline/cable crossings. This rock has been in place for a significant length of time creating a habitat for benthic organisms that live on hard substrate. The area impacted by existing rock is small in relation to the area of the site (approximately 0.00035% of the total site).
Siltation rate changes (low), including smothering (depth of vertical sediment overburden)	All activities identified as being a potential source of temporary seabed disturbance could cause sediment to mobilise into the water column. Sandy and gravel sediments should drop out of suspension quickly, and in the immediate area. The mobile nature of the seabed within the site will naturally counteract any potential smothering effect brought about by the decommissioning activities.

Table 7.1.3: Assessment of extent of seabed disturbance

7.1.4 Control and mitigation

The following measures will be adopted to ensure that seabed disturbance and its impacts are minimised to 'as low as reasonably practicable':

1. All activities which may lead to seabed disturbance will be planned, managed and implemented in such a way that disturbance is minimised;
2. The careful planning, selection of equipment, and management and implementation of activities;
3. A debris survey will be undertaken at the completion of the decommissioning activities. Any debris identified as resulting from decommissioning activities will be recovered from the seabed where possible; and,
4. Optimise the area that requires an over-trawl assessment through examining ways to carry out verification of the seabed using non-intrusive techniques and discussion with the NFFO and the regulators.

7.1.5 Conclusions

The principal sources of seabed disturbance associated with the Ensign facilities' decommissioning activities concern the over-trawl assessment at the end of decommissioning, positioning of HLV and transport barge anchors and chains and excavation of sediments and the lifting of materials from the seabed during their recovery. These activities will result in the displacement of substrate and the suspension and subsequent settlement of sediment.

Excavation and lifting operations will be undertaken at the pipeline and umbilical ends, for the removal of exposed concrete mattresses and grout bags, for the removal of the umbilical section and the Ensign installation.

Standard measures to control disturbance include operational planning and equipment selection.

The species and habitats observed near the Ensign field are relatively widespread throughout the SNS and the area anticipated to be impacted represents a very small percentage of the available habitat. Furthermore, the environment near the Ensign field is dynamic due to the shallow water depth therefore all disturbed sediments/habitats are expected to recover rapidly, through species recruitment from adjacent undisturbed areas.

Based on as laid bathymetry data (Section 5.2.1) for the Ensign infrastructure there is no evidence of long-term detrimental impact to the North Norfolk Sandbanks and Saturn Reef SAC feature due to the presence of pipelines and stabilisation features. As such, the significance of the impacts of decommissioning pipelines and deposited rock *in situ* has been assessed as **low**.

In summary, due to the localised and relatively short duration of the decommissioning activities, and with the identified control and mitigation measures in place, the overall significance of the impact of seabed disturbance because of the decommissioning of the Ensign facilities has been assessed as **low**.

7.2 Large releases to sea

This section identifies the potential sources of, and assesses the impact of, large unplanned releases ('spills') to the marine environment in connection with the proposed decommissioning activities.

Following the adoption of appropriate prevention and response measures, the overall risk of impact presented by identified release scenarios is assessed in terms of probability of occurrence, and the consequences given the sensitivity of, and the assimilative capacity of, the receiving environment.

7.2.1 Potential sources

The principal planned decommissioning activities are described in Section 4. Of these, the use of vessels and the potential for an unplanned and accidental large volume release of diesel to sea has been identified as the only activity warranting further assessment in terms of the potential impact on the environment.

Unplanned large volume releases of diesel to sea from vessels could occur as a result of:

- Loss of structural integrity of storage tanks following a collision with another vessel or fixed facility; and,
- Loss of structural integrity of storage tanks following corrosion or mechanical failure.

The worst case in terms of volume and rate of release would be the immediate total loss of diesel inventory to sea as a consequence of collision or mechanical failure. This eventuality is considered to be highly unlikely owing to procedural (vessels' management systems) and operational controls that will be applied.

7.2.1.1 Oil spill fate and trajectory modelling

Oil spill modelling was conducted to support the Ensign field OPEP [103] using the Oil Spill Contingency and Response (OSCAR) modelling package. This included modelling an instantaneous release of 3,550m^3 of diesel at the Ensign installation. This is inherently conservative in terms of impact assessment, since the expected maximum diesel release from the vessels required for the Ensign decommissioning work will be significantly less.

7.2.2 Impacts and receptors

The probability of surface oiling is modelled to be 0-20% in the direct vicinity of the discharge point (Figure 7.2.1). The majority of diesel released is likely to rapidly evaporate and a significant proportion will biodegrade.

The maximum probability for shoreline oiling up to 20 days after release is modelled to be 10 to 20% in the east of England between March and May. The maximum mass of accumulated onshore oil from the 100+ simulations modelled was 483m^3. The majority of the locations and seasons modelled show either no shoreline oiling or a maximum probability of shoreline oiling of 10%.

Diesel has very high levels of light hydrocarbons and therefore evaporates quickly on release. The low asphaltene content prevents emulsification reducing its persistence in the environment. The Transocean Winner semi-submersible rig ran aground near the Isle of Lewis, Scotland on 8th August 2016 resulting in the discharge of up to 53m^3 of diesel near the coast. Investigation of the environmental impact is ongoing but an interim report by Marine Scotland has been published [69]. Initial sampling in the days following the incident showed no discernible increase in petrogenic contamination in mussels or salmon with respect to typical farmed concentrations from a clean site. Additionally, a survey undertaken by the Royal Society for the Protection of Birds (RSPB) found no evidence of oiled birds.

The loss of the entire diesel inventory is considered highly unlikely, as a rare combination of factors would be necessary for such an event to occur. No such incident has occurred in the UK oil and gas industry.

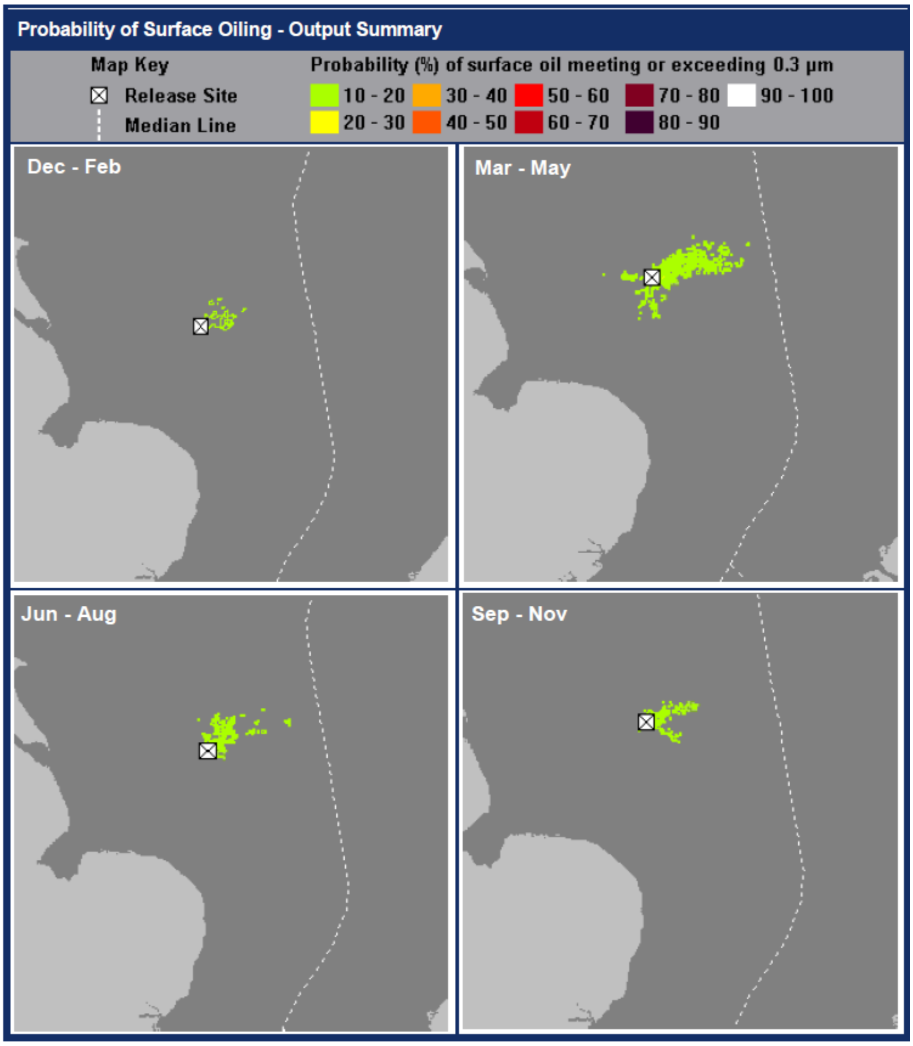


Figure 7.2.1: Probability of surface oiling from an instantaneous diesel release

7.2.2.1 Plankton

As oil can float on the water's surface and disperse within the ocean as it weathers, plankton are exposed to both floating oil slicks and to small dissolved droplets of oil in the water column [19] and [83].

Both oil and oil biodegradation can cause problems for phytoplankton in the immediate vicinity of a spill. Oil slicks can inhibit air-sea gas exchange and reduce sunlight penetration into the water, both essential to photosynthesis and phytoplankton growth [2]. The PAHs in the oil also affect phytoplankton growth, with responses ranging from stimulation at low concentrations of oil (1mg/l i.e. 1,000ppb) to inhibition at higher concentrations (100mg/l i.e. 100,000ppb; [82]).

Zooplankton at the air-sea interface are thought to be particularly sensitive to oil spills due to their proximity to high concentrations of dissolved oil and to the additional toxicity of photo-degraded hydrocarbon products at this boundary [39]. Following an oil spill zooplankton may suffer from loss of food in addition to the direct exposure of oil toxicity resulting in death from direct oiling as well as impaired feeding, growth, development, and reproduction [64].

The limited swimming ability of the free-floating early life stages (meroplankton, i.e. eggs and larvae) of invertebrates such as sea urchins, molluscs and crustaceans renders them unable to escape oil-polluted waters. These early life stages are more sensitive to pollutants than adults and their survival is critical to the long-term health of the adult populations [64].

Given the abundance and widespread distribution of plankton populations, and the high rates of diesel evaporation that would be expected under the prevailing metocean conditions, the consequence of the impact, given its very unlikely probability of occurrence, from a complete loss of diesel inventory has been assessed as minor. The significance of the risk of this impact has been assessed as **low**.

7.2.2.2 Benthos

Oil that becomes emulsified or dissolves in the water column can attach to suspended particles and sink to the bottom thus becoming more bioavailable to benthic species [43]. As stated, the low asphaltene content of diesel prevents emulsification reducing its persistence in the environment and therefore the proportion entering the water column is anticipated to be low.

In response to oil exposure, benthic animals can either move, tolerate the pollutant but with associated impacts on the overall health and fitness, or die [46], [84]. The response to oil by benthic species differs depending on their life history and feeding behaviour as well as the ability to metabolise toxins, especially PAH compounds.

There is little documented evidence on the impact of a diesel spill of the scale which could potentially occur at the Ensign field. Significant negative impacts from larger scale oil spills have been observed on amphipods such as population suppression [16], and [87]. Amphipods can be especially sensitive to the effects of local pollution because of their low dispersal rate, limited mobility and lack of a planktonic larval stage.

Hydrocarbons in the water column could impact on molluscs as filter feeders tend to have a limited capacity to metabolize hydrocarbons such that toxic PAH compounds have been shown to accumulate in them [64], [73].

Polychaetes were the most abundant taxonomic group amongst the benthic species sampled near the Ensign field (Section 5.4.2). The responses of polychaete populations to oil spills are complex and varied and are thought to differ depending on their different feeding strategies and trophic relationships in benthic environments. Some species decrease in abundance after an oil spill whilst others may be the first colonisers in the aftermath of oil spill die-offs [64]. Some polychaetes contribute to biodegradation of oil in sediments whilst some have different abilities to metabolize contaminants [40], [89]. Diesel is known to float and therefore only a little diesel would be expected to end up in the seabed sediments.

Given the low persistence of diesel in the marine environment and the low volumes of diesel entering the water column, the significance of the impact to benthos from a complete loss of diesel inventory has been assessed as moderate. The significance of the risk of this impact, given its very unlikely probability of occurrence, has been assessed as **medium**.

7.2.2.3 Fish

Exposure of fish to contaminants can occur either through uptake of dissolved fractions across the gills or skin or direct digestion of the pollutant. Fish spending the majority of their life-cycle in the water column are likely to receive the highest exposure to contaminants that remain in solution though some will also accumulate sediment bound contaminants indirectly through their diet, by digestion of animals that have accumulated the contaminants in their tissues. Fish associated with the seabed (e.g. flatfish) are more exposed to particle bound contaminants with the main exposure route being either directly through ingestion of contaminated sediments or through their diet. Once the oil disappears from the water column fish generally lose their oil content very quickly. This rapid loss of oil from fish tissue is linked to the fact that fish will metabolise accumulated hydrocarbons very rapidly [66].

Given the anticipated rapid rate of evaporation, the wide distribution of fish populations in the North Sea and the evidence for rapid recovery of fish following hydrocarbon releases, the significance of the impact from a complete loss of diesel inventory has been assessed to be minor. The significance of the risk of this impact, given its very unlikely probability of occurrence, has been assessed as **low**.

7.2.2.4 Marine mammals

Marine mammals may be exposed to oil either internally (swallowing contaminated water, consuming prey containing oil-based chemicals, or inhaling of volatile oil related compounds) or externally (swimming in oil or oil on skin and body).

The effects of oil on marine mammals are dependent upon species but may include:

1. Hypothermia due to conductance changes in skin;
2. Toxic effects and secondary organ dysfunction due to ingestion of oil, congested lungs;
3. Damaged airways;
4. Interstitial emphysema due to inhalation of oil droplets and vapour;
5. Gastrointestinal ulceration and haemorrhaging due to ingestion of oil during grooming and feeding;
6. Eye and skin lesions from continuous exposure to oil;
7. Decreased body mass due to restricted diet; and,
8. Stress due to oil exposure and behavioural changes.

Cetaceans known to inhabit the Ensign area are harbour porpoise and white-beaked dolphins (Section 5.4.3.1).

Low numbers of grey and harbour seals are associated with the area (Figure 5.4.2).

There is little documented evidence of cetaceans being affected by oil spills. Smultea and Wursig [97] found that bottlenose dolphins apparently did not detect sheen oil and that although they detected slick oil, they did not avoid traveling through it. Evans [20] observed that gray whales *Eschrichtius robustus* typically swam through oil seeps off California. Lack of an olfactory system likely contributes to the difficulty cetaceans have in detecting oil. Waves and darkness can reduce their visual ability at the surface, and it is possible that individuals could resurface within a fresh slick and find it difficult to locate oil-free water [71].

Cetaceans can be susceptible to inhaling oil and oil vapour. This is most likely to occur when they surface to breathe. Inhaling oil and oil vapour may lead to damaging of the airways, lung ailments, mucous membrane damage or even death. A stressed or panicking dolphin tends to move faster, breathe more rapidly and therefore surface more frequently into oil and increase exposure.

Cetaceans have mostly smooth skins with limited areas of pelage (hair covered skin) or rough surfaces. Oil tends to adhere to rough surfaces, hair or calluses of animals, so contact with oil by cetaceans may cause only minor oil adherence.

Seals are very vulnerable to oil pollution because they spend much of their time near the surface and regularly haul out on beaches. Seals have been seen swimming in oil slicks during a number of documented spills [30]. Most pinnipeds scratch themselves vigorously with their flippers but do not lick or groom themselves so are less likely to ingest oil from skin surfaces. However, a pinniped mother trying to clean an oiled pup may ingest oil. The risk of oiling increases for pinniped pups. They spend much of their time in rocky shore areas and tidal pools where spilt oil can accumulate. Recent evidence suggests that pinniped pups are very vulnerable during oil spills because the mother/pup bond is affected by the odour and pinnipeds use smells to identify their young. If the mother cannot identify its pup by smell in the large colony, it may not feed it and this leads to abandonment and starvation.

Given the relatively low probability (10% to 20%) of surface oiling meeting or exceeding 0.3µm, the rapid evaporation expected, the expected low concentrations of diesel in the water column and the presence of the SNS cSAC the significance of the environmental impact of a diesel inventory loss on marine mammals has been assessed to be moderate. The significance of the risk of this impact, given its very unlikely probability of occurrence, has been assessed as **medium**.

7.2.2.5 Seabirds

In general, seabird sensitivity to oil pollution is considered to be extremely high from October to February on the Ensign field blocks. From March to September sensitivity is generally high to low except for July where sensitivity is extremely high (Section 5.4.5).

Birds are vulnerable to oiling from surface oil pollution, which can cause direct toxicity through ingestion and hypothermia as a result of a bird's inability to waterproof their feathers. Oil pollution can also impact birds indirectly through contamination of their prey. Seabird species vary greatly in their responses and vulnerability to surface pollution, therefore in assessing their vulnerability it is important to consider species-specific aspects of their feeding, breeding and population ecology [113].

Species that spend a greater proportion of their time on the sea surface are more at risk from the effects of surface pollution; for example, puffins are more likely to be affected than the highly aerial petrels. Species that are wholly dependent on the marine environment for feeding and resting are considered more vulnerable to the effects of surface pollution than species that use offshore areas only seasonally or move offshore only to rest or roost. Additionally, the potential reproductive rate of a species will influence the time taken for a population to recover following a decline. Other factors such as mortality and migration rates, species abundance and conservation status (e.g. globally threatened) also determine the effects of an oil spill on seabird populations.

The probability of surface oiling is relatively low (10% to 20%) (Figure 7.2.1). A full release of diesel inventory is considered highly unlikely however, if it did occur, rapid evaporation of diesel would occur.

Given that the area of a potential spill coincides with areas of extremely high seabird sensitivity, the significance of the environmental impact of a diesel inventory loss on seabirds has been assessed as moderate. The significance of the risk of this impact, given its highly unlikely probability of occurrence, has been assessed as **low**.

7.2.2.6 Coastal protected areas

As presented in Figure 5.5.1 there are several protected areas along the UK coast.

The probability of diesel beaching close to SPAs around the Humber Estuary, The Wash and the Outer Thames Estuary SPAs is less than 10%.

Given the probability of shoreline beaching is relatively low, the significance of the impact of a diesel inventory loss on coastal protected areas has been assessed to be moderate. The significance of the risk of this impact, given its very unlikely probability of occurrence, has been assessed as **medium**.

7.2.2.7 Offshore protected areas

A number of offshore protected areas could potentially be affected by accidental hydrocarbon releases at the Ensign field;

1. North Norfolk Sandbank and Saturn Reef SAC – Ensign field is within the SAC;
2. SNS cSAC for harbour porpoise – Ensign field is within the SAC;
3. Holderness Offshore recommended MCZ – 55 km from Ensign field.

Diesel will evaporate quickly on release and the low asphaltene content prevents emulsification reducing its persistence in the environment. The impact of a diesel inventory loss on the sandbanks and reefs is therefore expected to be moderate. The significance of the risk of this impact, given its very unlikely probability of occurrence, has been assessed as **medium.**

As previously discussed, cetaceans can be susceptible to inhaling oil and oil vapour, principally when they surface to breathe. Inhaling oil and oil vapour may lead to damaging of the airways, lung ailments, mucous membrane damage or even death. The modelled area of surface oiling within the SNS cSAC for harbour porpoise with a 10% to 20% probability of surface oil meeting or exceeding 0.3 µm is very small with respect to the total cSAC area of 36,958 km^2 (Figure 7.2.1). The significance of the environmental impact of a diesel inventory loss on offshore protected areas has therefore been assessed to be moderate. The significance of the risk of this impact, given its very unlikely probability of occurrence, has been assessed as **medium**.

7.2.3 Transboundary impact

The Ensign field is located approximately 81 km, to the west of the nearest international boundary, the UK/Netherlands median line. There is low probability of surface oiling occurring in Dutch waters.

The modelling shows a probability of between 1% and 5% between September and February and a probability of between 5% and 10% between March and August. Therefore, the significance of transboundary impacts is assessed to be moderate. Given its very unlikely probability of occurrence the significance of the risk of this impact is considered to be **low**.

7.2.4 Control and mitigation

The following measures will be adopted to ensure that impacts from large releases to sea are minimised to 'as low as reasonably practicable':

1. Releases will be managed under the existing OPEP and under the MEI management process which will be updated if required;
2. All vessel activities will be planned, managed and implemented in such a way that vessel durations in the field are minimised; and,
3. Spirit Energy's existing marine standard will be followed to minimise risk of hydrocarbon releases.

These control measures are considered to be effective in reducing and minimising the risk of release during the decommissioning activities to 'as low as reasonably practicable'.

7.2.5 Conclusions

The sole source of a potential unplanned large volume release of diesel to sea is associated with loss of containment from a vessel. The worst case in terms of volume and rate of release would be the immediate total loss of diesel inventory to sea as a consequence of collision or mechanical failure. This eventuality is considered to be highly unlikely owing to the procedural (vessels' management systems) and operational controls that will be applied.

Diesel has very high levels of light hydrocarbons and therefore evaporates quickly on release. The low asphaltene content prevents emulsification reducing its persistence in the environment.

The modelling of the probability of surface oiling has shown that there is a low probability (10% to 20%) of surface oil meeting or exceeding 0.3µm.

In summary, given the low likelihood of such a release and the rapid evaporation rate of diesel, low environmental persistence, and with the identified control and mitigation measures in place, the significance of impact from a large unplanned release of diesel to sea is considered to be moderate. The significance of the risk of this impact, given its very unlikely probability of occurrence, is considered to be **medium**.

7.3 Cumulative

7.3.1 Physical presence

The following socio-economic activities, if they occur at the same time, and in the same area as the decommissioning activities, could result in an 'in-combination' effect:

1. Oil and gas production (including inspection, maintenance, supply);
2. Oil and gas development (surveys, drilling, installation of infrastructure);
3. Oil and gas decommissioning (installation or pipelines removal and recovery);
4. Wind farm development and operation; and
5. Aggregate extraction.

The third-party oil and gas infrastructure in the vicinity of the Ensign field is mature. There is no known planned installation of oil and gas infrastructure that would lead to construction activity taking place at the same time as the decommissioning of the Ensign field.

The impacts associated with the proposed decommissioning activities have been assessed to be localised and therefore no substantive in-combination effects of physical presence are anticipated with respect to neighbouring oil and gas surface installations, the closest of which is the Galleon Installation approximately 7km from the Ensign installation.

A number of decommissioning activities are planned for developments in the vicinity of the Ensign platform, many of which also fall within the North Norfolk Sandbanks and Saturn Reef SAC. Spirit Energy is planning to decommission the ‘A-fields’ comprising the Ann, Alison, Saturn (Annabel) subsea installations and the Audrey platforms. Conoco Phillips have an extensive campaign in the area to decommission seventeen small platforms at the Vampire, Victor, Vixen, Viking, Viscount and Vulcan fields).

These decommissioning activities have the potential to overlap temporally with the decommissioning of the Ensign field. Although there is the possibility that other fields may be decommissioned at the same time as Ensign, the scopes of work will be similar both spatially and temporally. In addition, most activities will occur within the already existing 500m safety zones at all locations and therefore no additional impact on fisheries is expected. Cumulative impacts on the fishing industry from physical presence are therefore not expected.

The pipelines associated with all of these projects will primarily by decommissioned *in situ*. These pipelines are under sufficient and stable existing burial cover. The total area potentially affected by pipelines decommissioned *in situ* is considered relatively small.

As shown in Figure 5.6.4, the closest operational wind farm to the Ensign infrastructure is Hornsea One (Heron West, Njord and Heron East) located approximately 26km north of Ensign at the closest point. Although Hornsea One has begun producing power, the construction activities are not yet complete, and are expected to take until 2021 which may coincide with Ensign decommissioning activities. The consented Hornsea Two project (30km north of Ensign) is also under construction and expected to become fully operational in 2022 therefore construction activities at this site (adjacent to Hornsea One) may also coincide with Ensign decommissioning activities. The application to develop Hornsea Three (50km east of Ensign) is currently being evaluated by the Planning Inspectorate whilst Hornsea Four (35km northwest of Ensign) is in the pre-application phase [78]. The Dudgeon operational windfarm is located 40km to the south-west of Ensign.

There are several aggregate extraction areas within about 40km of the Ensign installation as shown in Figure 5.6.5 and these may be operational at the same time as the Ensign decommissioning activities.

Although there are other activities in the area, the duration of the Ensign decommissioning activities is short and will take place mostly within the existing 500m exclusion zone. There will be little additional obstruction to fishing vessels, and as fishing activity in the area is relatively low, this is not expected to be significant. The potential significance of the cumulative impact has therefore been assessed as **low**.

7.3.2 Seabed disturbance

Cumulative seabed disturbance will occur due to oil and gas activities, wind farm construction and operations and aggregate extraction. As an example, the worst-case seabed take for the Hornsea One wind farm including turbines, transmission systems, cabling and accommodation is estimated to be 12.7km^2 which is approximately 3% of the overall windfarm area (407km^2) [95]. Given the considerable development in the area and the limited area of disturbance associated with the proposed activities, the cumulative seabed disturbance is assessed as **low**, and the Ensign decommissioning activities are not considered to be a significant contributor.

7.3.2.1 Seabed disturbance in the North Norfolk Sandbanks and Saturn Reef SAC

The cumulative area of seabed disturbed due to currently planned decommissioning and other offshore activities within the North Norfolk Sandbanks and Saturn Reef SAC is shown in Table 7.3.1.

LOCATION	AREA IMPACTED (km²)		
	TEMPORARY	PERMANENT	
	Total[1]	Total	Deposited Rock
Ensign	5.07	0.0117	0.0125
A-Fields well decommissioning	0.0029	0	0
Ann and Alison	15.3924	0.0252	0.0111
Annabel and Audrey	11.6754	0.0810	0.0627
Viking and LOGGS	0.0144	0.6208	0.0754
Viking, Vixen and Victor	18.9285	1.1062	0.032106
Leman BH	0.4058	0	0
Humber 3 Aggregate area	16.7	-	-
Humber 5 Aggregate area	27.8	-	-
Total	**95.9901**	**1.8449**	**0.1938**

[1] Note that only the A-Fields and Ensign temporary values include for potential over-trawl impacts.

Table 7.3.1: Cumulative impacts within North Norfolk Sandbanks and Saturn Reef SAC

The total cumulative area of seabed identified which may experience temporary impacts is 95.9901 km^2 which comprises 2.66% of the North Norfolk Sandbanks and Saturn Reef SAC. The majority of the area impacted is attributed to the over-trawl assessment which is an impact equivalent to fishing activities that are currently undertaken in the area. In addition, operators are exploring the use of a non-invasive techniques to get verification of a clean seabed, so the overall area of seabed disturbance may be a lot less. The timing of these temporary impacts is unlikely to overlap, and they will not occur in close proximity. Due to the short duration and localised nature of the activities with the potential to temporary disturb the seabed, significant cumulative impacts are not anticipated.

The area of infrastructure and protection and stabilisation features, including deposited rock, decommissioned *in situ* from the Ensign field and other projects in the surrounding area are shown in Table 7.3.1. The total area equates to 0.06% of the area of the North Norfolk Sandbanks and Saturn Reef SAC. As discussed in Section 7.1.3.2, there is currently no evidence from survey analysis to suggest that changes to the sandbank morphology and dynamics are likely to occur.

The potential significance of the cumulative impact within the SAC has therefore been assessed as **low**.

7.3.3 Underwater sound

In isolation, the significance of any impact from underwater sound from the proposed decommissioning project has been assessed as ‘low’ (Section 6.2). However, consideration of potential cumulative or in-combination effects from other activities and developments in the area is required by current EIA guidance [8].

The Ensign field is part of the highly developed SNS hydrocarbon basin which currently has 140 surface installations (Section 5.6.5). The closest approved decommissioning project to the Ensign field is Spirit Energy Audrey, located approximately 13km from the Ensign installation. There is the possibility that the Audrey, LOGGS, Viking, Vixen and Victor assets may be decommissioned at the same time as Ensign. For the purposes of this assessment, the scope of work activities with the potential to create underwater noise are expected to be similar. The Audrey A (WD) installation is located approximately 13 km from Ensign and served as the gas export route. Given the distance and based on the relatively short duration of underwater noise from both projects there is not expected to be any potential for cumulative noise impacts.

At the time of writing the Hornsea Project One offshore wind farm is under construction and lies approximately 26km north of Ensign at the closest point (Figure 5.6.4). The consented Hornsea Project Two offshore wind farm site lies approximately 29km north of Ensign at the closest point and is due to commence construction in 2020 [77]. There is the potential for the temporal overlap of the decommissioning project with the construction periods for both Hornsea Project One and Hornsea Project Two.

Hornsea Project One are using piles for the construction of the wind turbine foundations, the installation of which will create underwater noise. These have the potential to create a cumulative impact in combination with the proposed decommissioning activities, if the construction phase of Hornsea Project One is still ongoing at the time of the decommissioning project and that the construction phase of Hornsea Project Two has commenced. The noise modelling undertaken for the piling operations at Hornsea Project One and Hornsea Project Two has been consulted. The estimated areas of impact for the highest energy pile hammer types that could be used for pile driving during construction at Hornsea Project One [95] and Hornsea Project Two [96] are presented in Table 7.3.2.

Windfarm	Hammer Energy (KJ)	Species	Instantaneous Injury Range	Fleeing/ Startle Response	Possible Avoidance of Area (Marine Mammals)/ General Behavioural Response (Fish) (km)
Hornsea Project One	2,300	Harbour porpoise	<600m	<4.6km	28.8 – 46.6
		Mid Frequency Cetaceans	<50m	<100m	7.1 – 7.7
		Low Frequency Cetaceans	<50m	<300m	31.7 – 57.5
		Fish (Pelagic)	<150m	<500m	11.9 – 27.9
		Fish (Demersal)	<150m	<500m	9.5 – 21.2
Hornsea Project Two	3,000	Harbour porpoise	Mitigated by soft-start (<1km)[11]	5 – 7km	29 - 62
		Mid Frequency Cetaceans	Mitigated by mitigation zone (< 500m)[12]	<500m	8 - 11
		Low Frequency Cetaceans	Mitigated by mitigation zone (< 500m)[12]	<500m	36 - 82
		Fish	<200m	<600m	13 - 34

Table 7.3.2: Estimated pile driving impact ranges for Hornsea windfarms

Based on the distances of the Hornsea Project One site and the Hornsea Project Two site from the proposed decommissioning activities and the estimated impact ranges for pile driving at the windfarms (Table 7.3.2), no cumulative impact is expected with regard to injury to cetaceans. The possible avoidance area and general response ranges calculated for both windfarm projects and for all species are greater than the distance to Ensign and so there is the potential for in combination noise impacts. The sources of underwater noise from the decommissioning activities are expected to be localised and relatively short compared to the Hornsea pile driving. Therefore, they are not expected to create an in combination effect for harbour porpoise. Marine mammal and fish species are highly mobile meaning they are not restricted to the possible area of avoidance. Their occurrence in the vicinity is also seasonal whereby they may or may not be present at the time of the operations. Cumulative behavioural impacts on fish and marine mammal species from these activities are possible but are not expected to be significant.

The underwater sound generated from vessels and in the use of underwater excavation and cutting tools are expected to be localised and of relatively short duration. Hence, no substantive cumulative impacts are anticipated.

There is potential for noise generating activities associated with the proposed decommissioning activities to cause an in-combination impact with noise generated from other industries (e.g. windfarms under construction) and other decommissioning projects on the SNS cSAC designated for the protection of the Annex II species harbour porpoise. The impact of sound generated by the decommissioning activities has been assessed as of low significance with no detrimental impact to the conservation objectives of the site being anticipated (Section 6.3). It is acknowledged that

[11] Assumes a fleeing animal and a 500m mitigation zone [49]
[12] Assumes a 500m mitigation zone is employed [49]

noise sources associated with the Hornsea Project One and Hornsea Project Two windfarms and other oil and gas decommissioning activity in the vicinity may cause some displacement of harbour porpoise from particular areas. The sources of noise - for example from vessels and cutting activities, are of relatively short duration for the decommissioning activities. The area covered by the cSAC is relatively large, and given the mobile nature of harbour porpoise, any in combination effect on the conservation objectives of the cSAC are not considered significant.

The potential significance of the cumulative impact has therefore been assessed as **low**.

8. <u>CONCLUSIONS</u>

Subject to regulatory approvals it is expected that Ensign will be decommissioned sometime between 2019 and 2023. The Ensign installation will be completely removed and transported to onshore. The CA for the Ensign pipelines concluded that most of the pipelines will be left *in situ*, apart from a section of umbilical on approach to the Ensign subsea well that is protected by concrete mattresses. This section of umbilical and the associated mattresses will be completely removed and transported to onshore with the remainder of the umbilical being decommissioned *in situ* under the existing deposited rock. At the Ensign installation and the Audrey A (WD) installation the pipelines will be severed where they emerge from the deposited rock and disconnected from the riser flanges. Complete removal of otherwise exposed pipespools once the associated stabilisation features have been removed will be undertaken. All exposed concrete mattresses will be removed and transported onshore and all concrete mattresses buried under deposited rock at the pipeline and cable crossings will be left *in situ.* Concrete plinths buried under deposited rock at the pipeline crossing will be left *in situ* as will all deposited rock. Grouts bags where found and exposed will be removed and transported to onshore.

This EA report documents the results of the EA process undertaken to consider the impact of the planned activities and possible unplanned events associated with the decommissioning of the Ensign field. The significance of impacts was assessed using the method described in Spirit Energy's Guidance for Environmental Management in Capital Projects. This evaluates the impacts (on a scale of **low** to **high** significance) as a function of their extent and duration (recovery time) given the application of industry routine control and mitigation measures. An environmental workshop was undertaken, during which project aspects were identified and assessed taking existing and standard control and mitigation measures into consideration. All potential impacts were categorised as being of **low** significance and therefore 'scoped out' of requiring detailed assessment apart from disturbance to the seabed, an accidental release of fuel inventory, and cumulative impact. These impacts were categorised as of **medium** significance, and therefore selected for further assessment

Following further assessment and implementation of additional control and mitigation measures where necessary, the significance of the impacts from seabed disturbance was assessed as **low** and the significance of the risk of the impacts from a large unplanned release of diesel to sea was assessed to be **low**. In addition, the cumulative impact from physical presence and seabed disturbance was assessed and determined to be **low** and not significant. No substantive cumulative impacts from underwater sound are anticipated.

8.1 Summary of control and mitigation measures

Spirit Energy will follow routine environmental management activities. For example, contractor vessel audits and legal requirements to report discharges and emissions, such that the environmental impact of the decommissioning activities will be minimised. Following the EA process, it can be concluded that activities associated with the decommissioning of Ensign field are unlikely to significantly impact the environment or other sea users, for example shipping traffic and fishing, provided that the proposed mitigation and control measures are put in place.

A summary of proposed control and mitigation measures is shown in Table 8.1.1.

Mitigation and Control Measures
General and Existing
Lessons learnt from previous decommissioning scopes will be reviewed and implemented.
Vessels will be managed in accordance with Spirit Energy's Marine Assurance Standard.
The vessels' work programme will be optimised to minimise vessel use.
The OPEP is one of the controls included in a comprehensive management and operational controls plan developed to minimise the likelihood of large hydrocarbon releases and to mitigate their impacts should they occur.
All vessels undertaking decommissioning activities will have an approved Shipboard Oil Pollution Emergency Plan (SOPEP).
Existing processes will be used for contactor management to assure and manage environmental impacts and risks.
Spirit Energy management of change process will be followed should changes of scope be required.
Atmospheric Emissions
All material taken onshore will be handled by licenced waste management contractors at sites that hold Environmental Permits or Pollution Prevention Control (PPC) permits.
Discharges and Small Releases to Sea
The topsides will be vented and purged prior to their removal.
The use of any chemicals for cleaning and flushing or for any other decommissioning activities will be permitted under the Offshore Chemical Regulations 2002 (as amended) and the discharge of any residual hydrocarbons from pipeline and riser disconnections and cutting activities will be permitted under The Offshore Petroleum Activities (Oil Pollution Prevention and Control (OPPC)) Regulations 2005 (as amended).
Any ballast water discharges will be in line with the International Maritime Organisation ballast water management convention and guidelines.
Vessel activities such as the release of drainage water and grey water will be subject to separate regulatory requirements.
Waste Production
The selected dismantling site will be able to demonstrate a proven disposal track record and waste stream management throughout the deconstruction process and demonstrate their ability to deliver re-use and recycling options.
A Waste Management Plan for the decommissioning programmes will be prepared and implemented in line with the Waste Framework Directive.
All waste will be managed in compliance with relevant waste legislation by a licenced waste management contractor.
As part of Spirit Energy's standard processes, all sites and waste carriers will have appropriate environmental and operating licences to carry out this work and will be closely managed within Spirit Energy's contractor assurance processes.
Physical Presence
Monitoring will be performed to confirm the pipelines and umbilical decommissioned *in situ* remain stable and buried at a frequency to be agreed with OPRED.
Pipelines will be marked on admiralty charts and added to the FishSAFE database.
A notice to mariners will be issued prior to operations commencing to give vessels advance warning of the decommissioning operations.
Kingfisher bulletins issued prior to operations commencing.
Transboundary
If waste is shipped internationally, the Ensign Waste Management Plan will present the responsibilities Spirit Energy has under the 'Duty of Care' legislation and identify appropriately licenced international onshore facilities where the waste can be treated.
Seabed Disturbance
All activities which may lead to seabed disturbance will be planned, managed and implemented in such a way that disturbance is minimised.
The presence of anchors and chains will be managed using an anchor management plan and liaison with regional fishing groups.
A debris survey will be undertaken at the completion of the decommissioning activities. Any debris identified as resulting from decommissioning activities will be recovered from the seabed where possible.
Optimise the area that requires an over-trawl assessment through discussion with the NFFO and the regulators. Investigate the use of non-intrusive survey method rather than an over-trawl assessment.
Large Releases to Sea
All vessel activities will be planned, managed and implemented in such a way that vessel durations in the field are minimised.
Spirit Energy's existing marine standard will be followed to minimise risk of hydrocarbon releases.

Table 8.1.1: Summary of proposed control and mitigation measures

9. REFERENCES

[1] “EMODnet,” [Online]. Available: https://www.emodnet-seabedhabitats.eu/. [Accessed January 2018];

[2] A. McQuatters-Gollop, D. E. Raitsos, M. Edwards and M. J. Attrill (2007) Spatial patterns of diatom and dinoflagellate seasonal cycles in the NE Atlantic Ocean. Marine Ecology Progress Series, vol. 339, pp. 301-306;

[3] A. Webb, M. Elgie, C. Irwin, C. Pollock and C. Barton (2016) Sensitivity of offshore seabird concentrations to oil pollution around the United Kingdom. Report to Oil and Gas UK;

[4] ABPmer (2018) Data Explorer [Online]. Available: https://www.seastates.net. [Accessed December 2018];

[5] ABPmer, “Atlas of UK Marine Renewable Energy Resources,” 2008. [Online]. Available: https://www.renewables-atlas.info/explore-the-atlas/. [Accessed December 2018].

[6] Anthony T.G, Wright N.A and M. A. Evans (2009) Review of diver noise exposure. Research report no. RR735. QinetiQ for the health and safety executive;

[7] B. G. Survey (2002) North Sea Geology, Technical Report TR_008_Rev1 produced for Strategic Environmental Assessment SEA2 & SEA3;

[8] BEIS (2018) The Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999 (as amended) - A Guide. March 2018 Revision 4;

[9] BEIS (2019) Oil and Gas: decommissioning of offshore installations and pipelines. [Online]. Available: https://www.gov.uk/guidance/oil-and-gas-decommissioning-of-offshore-installations-and-pipelines#table-of-draft-decommissioning-programmes-under-consideration;

[10] C. Graham, E. Campbelle, J. Cavill, E. Gillespie and R. Williams (2001) JNCC Marine Habitats GIS Version 3: its structure and content. British Geological Survey Commissioned Report, CR/01/238. [Online]. Available: http://jncc.defra.gov.uk/pdf/CR_-1_238.pdf;

[11] Cefas (2006) Scroby Sands offshore wind farm - coastal processes monitoring, Final Report for the Department of Trade and Industry;

[12] Centrica (2010) Ensign Field Development Environmental Statement;

[13] Crown Estate (2018) Maps and GIS data;

[14] D. Cormack (1999) Response to Marine Oil Pollution - Review and Assessment (volume 2). Springer Kluwer Academic;

[15] D. G. Johns and P. C. Reid (2001) An overview of plankton ecology in the North Sea., Strategic Environmental Assessment - SEA2 Technical Report 005 – Plankton;

[16] D. J.C, (1982) Impact of Amoco Cadiz oil spill on the muddy fine sand Abra alba and Melinna palmata community from the Bay of Morlaix. Estuarine, Coastal and Shelf Science, vol. 14, pp. 517-531;

[17] DECC (2016) The UK Offshore Energy Strategic Environmental Assessment 3 (OESEA3). [Online]. Available: https://www.gov.uk/government/consultations/uk-offshore-energy-strategic-environmental-assessment-3-oesea3. [Accessed November 2018];

[18] Department for Environment, Food and Rural Affairs (2018) Holderness Offshore Recommended Marine Conservation Zone. Consultation on Sites Proposed for Designation in the Third Tranche of Marine Conservation Zones;

[19] DTI (2002) Strategic Environmental Assessment of Parts of the Central and Southern North Sea (SEA 3);

[20] E.W. Geraci J.R., St. Aubin D.J. (eds). (1982) A study to determine if gray whales detect oil. Study on the effects of oil on cetaceans;

[21] F. EMU (2014) Ensign Development UKCS Block 48/14 Survey period: 27 July - 29 July 2013. FSLTD Report No. 130891.3V2.2. Volume 2 of 2: Post operational environmental survey;

[22] F. S. Limited (2011) Ensign Development Block 48/14. FSLTD Report No. 00409.5V6.2 Volume 6 of 7: Herring Spawning Ground Survey Report;

[23] F. S. Limited, (2011) Ensign Development UKCS Block 48/14. Survey Period: 21 November - 14 December 2010. FSLTD Report Number: 00409.5V7.1 Volume 7 of 7: Environmental Baseline Survey Results;

[24] FishBase (2016). [Online]. Available: http://www.fishbase.org.

[25] Fugro (2010) Ensign Development UKCS Block 48/14. Habitat Investigation/ Volume 5 of 7. Fugro Document No.:00409.5V5.1," Portchester: Fugro GB Marine Limited;

[26] Fugro (2013) Ensign Development UKCS Block 48/14. Environmental Habitat Report. Volume 1 of 2. Document No. 130891.3V1.2., Portchester: Fugro GB Marine Limited;

[27] Fugro (2018) Pre-decommissioning and environmental debris survey Ensign UKCS Blocks 48/14a,48/15 and 49/11a. Report No.: 182070.2V1.2. Final Report;

[28] G. Certain, L. Jorgensen, I. Christel, B. Planque and V. Bretagnolle (2015) Mapping the vulnerability of animal community to pressure in marine systems: disentangling pressure types and integrating their impact from the individual to the community level. ICES Journal of Marine Science, p. 13;

[29] G. E. Limited (2011) Ensign Development Pipeline Route Survey Environmental Baseline Report June 2010. Final Report;

[30] Geraci J.R and St Aubins D.J. (1990) Sea mammals and oil. Confronting the risks., Academic Press ISBN-0-12-280600-X;

[31] Gubbay. S. (2007) Defining and Managing Sabellaria spinulosa Reefs: Report of an Inter-agency workshop. 1-2 May 2007. JNCC Report No. 405;

[32] H. H. van der Veen and S. Hulscher (2009) Predicting the occurrence of sand banks in the North Sea," Ocean Dynamics, vol. 59, no. 689;

[33] H. L. Rees, J. D. Eggleton, E. Rachor and E. Vanden Berghe (2007) Structure and dynamics of the North Sea benthos. ICES Cooperative Research Report No. 288;

[34] HRWallingford, CEFAS/UEA, P. Haskoning and B. D'Olier (2002) Southern North Sea Sediment Transport Study Phase 2," Great Yarmouth Borough Council;

[35] HSE (1996) Offshore Installations and Wells (Design and Construction etc.) Regulations;

[36] Institute of Petroleum (2000) Guidelines for calculation of estimates of energy use and gaseous emissions in the decommissioning of offshore structures.," Institute of Petroleum, London, 2000.

[37] International Council for the Exploration of the Sea (2006) Clupea harengus;

[38] IUCN (2016) IUCN Red List of Threatened Species. [Online]. Available: http://www.iucnredlist.org/;

[39] J. Bellas, L. Saco-Alvarez, O. Nieto, J. M. Bayona, J. Albaiges and R. Beiras (2013) Evaluation of artificially-weathered standard fuel oil toxicity by marine invertebrate embryo-genesis bioassays.," Chemosphere, vol. 90, pp. 110-1108;

[40] J. E. Bauer, R. P. Kerr, M. F. Bautista, C. J. Decker and D. G. Capone (1988) Stimulation of microbial activities and polycyclic aromatic hydrocarbon degradation in marine sediments inhabited by Capitella capitata. Marine Environmental Research, vol. 25, pp. 63-84;

[41] J. Ellis, S. Milligan, L. Readdy, A. South, N. Taylor and M. Brown (2012) Spawning and Nursery Grounds of Select Fish Species in UK Waters," Science Search Technology, no. 147:56;

[42] J. Gonzalez, F. G. Figueiras, M. Aranguren-Gassis, B. G. Cresop, E. Fernadez, X. A. Moran and M. Nieto-Cid (2009) Effect of a simulated oil spill on natural assemblages of marine

phytoplankton enclosed in microcosms. Estuarine and Coastal and Shelf Science, vol. 83, pp. 265-276;

[43] J. Meador (2003) Bioacculmulation of PAHs in marine invertebrates, In PAHs: An Ecotoxicological Perspective, edited by P.E.T Douben. pp. 147-171;

[44] J. Pinnegar, T. Blasdale, N. Campbell, S. Coates, S. Colclough, H. Fraser, C. Greathead, S. Greenstreet, F. Neat , R. Sharp, D. Simms, H. Stevens and A. Waugh (2010) Charting Progress 2 Healthy and Biologically Diverse Seas Feeder Report: Section 3.4: Fish. Department of Environment, Food and Rural Affairs on behalf of UKMMAS;

[45] J. Reid, P. Evans and S. Horthbridge (2003) Atlas of Cetacean Distribution in North West European Waters. JNCC;

[46] J. S. Gray, M. Aschan, M. R. Carr, k. r. clarke, t. h. green, R. Pearson and R. M. Warwick, (1998) Analysis of community attributes of the benthic macro-fauna of Frierfjord-Langesundfjord and in mesocosm experiment. Marine Ecology Progress Series, no. 46, pp. 151-165;

[47] Jenkins C, Eggleton J, J. Albrcht, J. Barry, Duncan G, Golding N and O'Connor J. (2015) North Norfolk Sandbank and Saturn Reef cSAC/SCI Managemengt Investigation Report, JNCC/Cefas partnership report No. 7 pp 86, ISSN 2051-6711. JNCC/Cefas;

[48] JNCC (2004) Developing regional seas for UK waters using biogeographic principles. Department for Environment, Food and Rural Affairs (DEFRA);

[49] JNCC (2010) Natural England and Countryside Council for Wales. The protection of marine European Protected Species from injury and disturbance - Guidance for the marine area in England and Wales and the UK offshore marine area.

[50] JNCC (2010a) JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys. [Online]. Available: http://jncc.defra.gov.ukpdf/JNCC_Guidelines_Seismic%20Guidelines_Aug%202010.pdf;

[51] JNCC (2010b) "Offshore Special Area of Conservation: North Norfolk Sandbanks and Saturn Reef. SAC Selection Assessment. Version 5.0, 21pp. [Online]. Available: http://jncc.defra.gov.uk/pdf/NNSandbanksAndSaturnReef_SAC_SAD_5.0.pdf;

[52] JNCC (2012) Offshore Special Area of Conservation: North Norfolk Sandbanks and Saturn Reef Conservation Objectives and Advice on Operations. [Online]. Available: http://jncc.defra.gov.uk/pdf/NNSandbanksandSaturnReef_ConservationObjectives_AdviceonOperations_6.0.pdf;

[53] JNCC (2016) Harbour porpoise (Phocoena phocoena) possible Special Area of Conservation: Southern North Sea Draft Conservation Objectives and Advice on Activities..

[54] JNCC (2016a) Harbour Porpoise (Phocoena phocoena) possible Special Area of Conservation: Southern North Sea Draft Conservation Objectives and Advice on Activities. [Online]. Available: http://jncc.defra.gov.uk/pdf/SoutherNorthSeaConservationObjectivesAndAdviceOnActivities.pdf;

[55] JNCC (2016b) UK BAP priority fish species (excluding purely marine species). [Online]. Available: http://jncc.defra.gov.uk/page-5164;

[56] JNCC (2016c) Wildlife and Countryside Act 1981. [Online]. Available: http://jncc.defra.gov.uk/page-3614;

[57] JNCC (2017) Using the Seabird Oil Sensitivity Index to Inform Contingenncy Planning. [Online]. Available: http://jncc.defra.gov.uk/page-7373 . [Accessed 2018];

[58] Joint Nature Conservation Committee (2018) North Norfolk Sandbanks and Saturn Reef MPA. 1 May 2018. [Online]. Available: http://jncc.defra.gov.uk/page-6537. [Accessed January 2019].

[59] K. Coull, R. Johnstone and S. I. Rogers (1998) Fisheries Sensitivity Maps in British Waters;

[60] K. Kober, A. Webb, I. Win, M. Lewis, S. O'Bien, L. J. Wilson and J. B. Reid (2010) An Analysis of the Numbers and Distribution of Seabirds within the British Fishery Limit Aimed at Identifying Areas that Qualify as Possible Marine SPAs. JNCC Report, vol. 431, no. 0963-8091;

[61] L. A. Jones, K. Hiscock and D. W. Connor (2000) Marine habitat reviews. A summary of ecological requirements and sensitivity characteristics for the conservation and management of marine SACs," UK Marine SACs Project Report;

[62] Limpenny D.S, Foster-Smith R.L, Edwards T.M, Hendrick V.J, Diesing M, Eggleton J.D, Meadow W.J, Crutchfield Z, Pfeifer S and Reach I.S. (2010) Best Methods for Identifying and Evaluating Sabellaria spinulosa and Cobble Reef. Aggregate levy sustainability fund project. MAL0008. Joint Nature Conservation Committee;

[63] M. B. Collins, S. J. Shimwell, S. Gao, H. Powell, C. Hewitson and J. A. Taylor (1995) Water and sediment movement in the vicinity of linear sandbanks: the Norfolk Banks, southern North Sea. Marine Geology, no. 123, pp. 125-142;

[64] M. Blackburn, C. A. Mazzacano, C. Fallon and S. H. Black (2014) Oil in Our Oceans. A review of the impacts of oil spills on marine invertebrates. Portland OR: The Xerces Society for Invertebrate Conservation, p. 152;

[65] M. Edwards, G. Beaugrand, P. Helaouet, J. Alheit and S. Coombs (2013) Marine ecosystem response to the Atlantic Multidecadal Oscillation," PLoS ONE, vol. e57212;

[66] M. M. Krahn, G. M. Ylitalo, S. Buzitis, S. Chan and U. Varanasi (1993) Rapid High-performance Liquid Chromatographic Methods that Screen for Aromatic Compounds in Environmental Samples. Journal of Chromatography, vol. 642, pp. 15-32;

[67] M. Striebel, R. Ptacnik, H. Stibor, S. Behl, U. Berninger, F. Haupt, P. Hingsamer, C. Mangold, R. Ptacnikova, M. Steinböck, M. Stockenreiter, S. Wickham and S. Wollrab (2010) Water column stratification, phytoplankton diversity and consequences for resource use and productivity. Proceedings of the HYDRALAB III Joint User Meeting, Hannover;

[68] Marine Management Organisation (2014) East Inshore and East Offshore Marine Plans. [Online]. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/312496/east-plan.pdf.

[69] Marine Scotland (2016) Incident Support Information - Transocean Winner, Interim Report;

[70] Marine Space Ltd., AMPmer Ltd., ERM Ltd., Fugro EMU Ltd. and marine ecological surveys limited (2013) Environmental Effect Pathways between Marine Aggregate Application Areas and Atlantic Herring Potential Spawning Habitat: Regional Cumulative Impact Assessments, version 1.0. A report for the British Marine Aggregates Producers Association;

[71] Matkin C.O, Saulitis E.L, Ellis G.M, Olesiuk P and Rice S.D. (2008) Ongoing population-level impacts on killer whales Orcinus orca following the Exxon Valdez' oil spill in Prince William Sound, Alaska. Marine Ecology Progress Series, vol. 356, pp. 269-281;

[72] N. H. Kenyon and B. Cooper (2005) Sand banks, sand transport and offshore wind farms Kenyon MarineGeo & ABP Marine Environmental Research Limited;

[73] N. N. Menon and N. R. Menon (1999) Uptake of polycyclic aromatic hydrocarbons from suspended oil borne sediments by the marine bivalve Sunetta scripta.," Aquatic Toxicology, vol. 45, pp. 63-69;

[74] Oil and Gas Authority (2016) Information on levels of shipping activity;

[75] Oil and Gas UK (2018) Guidelines for decommissioning of wells, Issue 6;

[76] Oil and Gas UK (2018) Environment Report 2018;

[77] Orsted Hornsea Project 3 Ltd (2018) Environmental Impact Statement, Planning Inspectorate;

[78] Orsted (2019) Hornsea Wind Farms information pages at hornseaprojects.co.uk [accessed August 2019]

[79] OSPAR (1992) OSPAR convention;

[80] OSPAR (1998) OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations. Decision. Sintra;

[81] OSPAR (2016) List of Threatened and/or Declining Species and Habitats. [Online]. Available: http://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats.

[82] P. J. Harrison, W. p. Cochlan, J. C. Acreman, T. R. Parsons, P. A. Thompson, H. M. Dovey and C. Xiaolin (1986) The effects of crude oil and Corexit 9527 on marine phytoplankton in an experimental enclosure. Marine Environmental Research, vol. 18, pp. 93-109;

[83] R. Almeda, Z. Wambaugh, Z. Wang, C. Hyatt, Z. Liu and E. J. Buskey (2013) Interactions between zooplankton and crude oil: toxic effects and bioaccumulation of polycyclic aromatic hydrocarbons. PloS ONE, vol. 8, no. 6;

[84] R. F. Lee and D. S. Page (1997) Petroleum hydrocarbons abd their effects in subtidal regions after major oil spills. Marine Pollution Bulletin, vol. 34, pp. 928-940;

[85] R. H. Belderson, M. A. Johnson and N. H. Kenyon (1982), “Bedforms,” in Offshore tidal sands. Processes and deposits., A. H. Stride, Ed., London, Chapman and Hall, pp. 27-57;

[86] Rouse Sally, Kafas A, Catarino R and Hayes P. (2017) Commercial fisheries interactions with North Sea pipelines: considerations for decommissioning. ICES Journal of Marine Science, 2017.

[87] S. C. Jewett and T. A. Dean (1997) The Effects of the Exxon Valdez Oil Spill on the Eelgrass Communities in Prince William Sound, Alaska, 1990-95. Alaska Department of Fish and Game, Habitat and Restoration Division, Restoration Project Final Report 95106;

[88] S. C. Leterme, L. Seuront and M. Edwards (2006) Differential contribution of diatoms and dinoflagellates to phytoplankton biomass in the NE Atlantic Ocean and the North Sea, Marine Ecology Progress Series, vol. 312, pp. 57-65;

[89] S. Driscoll and McElroy A.E. (1997) Elimination of sediment-associated benzo(a)pyrene and its metabolites by polychaete worms exposed to 3-methylcholanthrene. Aquatic Toxicology, vol. 39, pp. 77-91;

[90] S. Heinanen & H. Skov (2015) The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area,” [Online]. Available: http://jncc.defra.gov.uk/pdf/JNCC_Report%20544_web.pdf;

[91] S. Sveegaard, J. Teilmann, J. Tougaard, R. Dietz, K. N. Mouritsen, G. Desportes and U. Siebert (2011) High density areas for harbour porpoises (Phocoena phocoena) identified by satellite tracking. Marine Mammal Science, no. 27, pp. 230-246;

[92] Scottish Government (2018) National Marine Plan interactive (NMPi). [Online]. Available: https://marinescotland.atkinsgeospatial.com/nmpi/. [Accessed December 2018];

[93] Scottish Government (2018) Scottish Government National Marine Plan Interactive (NMPi);

[94] Sea Mammal Research Unit (2017) Estimated at-sea distribution of grey and harbour seals - updated maps 2017. [Online]. Available: https://data.marine.gov.scot/dataset/estimated-sea-distribution-grey-and-harbour-seals-updated-maps-2017;

[95] Smartwind (2013) Hornsea offshore windfarm. Project One Environmental Statement Annex 4.3.2. Subsea Noise Technical Report;

[96] SmartWind (2015) Hornsea offshore wind farm. Project Two Environmental Statement Annex 4.3.2. Subsea Noise Technical Report;

[97] Smultea M.A and Wursig B. (1995) Behavioral reactions of bottlenose dolphins to the Mega Borg oil spill, Gulf of Mexico 1990. Aquatic Mammal, vol. 21, pp. 171-181;

[98] Special Committee on Seals (2012) Scientific Advice on Matters Related to the Management of Seal populations;

[99] Spirit Energy (2017) Environmental Policy (CEU-HSEQ-GEN-POL-0001);

[100] Spirit Energy (2018) Ensign Comparative Assessment, SPT-DCM-SNS0104-REP-0003;

[101] Spirit Energy (2018) Ensign Installation Decommissioning Programme, SPT-DCM-SNS0104-REP-0004;

[102] Spirit Energy (2018) Ensign Pipeline Decommissioning Programme, SPT-DCM-SNS0104-REP-0005;

[103] Spirit Energy (2018) Ensign Field Oil Pollution Emergency Plan;

[104] Spirit Energy (2018) Ensign Portal Environmental Tracking System Master Application;

[105] Spirit Energy North Sea Limited (2016), Ensign Field Oil Pollution Emergency Plan;

[106] T. Pangerc, S. Robinson and P. Theobald (2016) Underwater sound measurement data during diamond wire cutting: First description of radiated noise. Proceedings of Meetings on Acoustics. Acoustical Society of America, Vols. 27, 040012 (2017);

[107] The Offshore Petroleum Regulator for the Environment and Decommissioning (2017), Oil and gas decommissioning of offshore installations and pipelines;

[108] The Scottish Government (2018) Fishing Effort and Quantity and Value of Landings by ICES Rectangle. [Online]. Available: http://www.gov.scot/Topics/Statistics/Browse/Agriculture-Fisheries/RectangleData. [Accessed 2018].

[109] UKOOA (2001) An Analysis of UK offshore oil and gas environmental surveys 1975-95. Heriot-University;

[110] V. Harris, M. Edwards and S. C. Olhede (2013) Multidecadal Atlantic climate variability and its impact on marine pelagic communities. Journal of Marine Systems, vol. 133, pp. 55-69;

[111] W. R. Turrell, E. W. Henderson, G. Slesser, R. Payne and R. D. Adams (1992) Seasonal changes in the circulation of the northern North Sea, Continental Shelf Research, 12, 257–286;

[112] W. S. Cooper, I. H. Townsend and P. S. Balson (2008) A synthesis of current knowledge on the genesis of the Great Yarmouth and Norfolk Bank Systems. The Crown Estate, p. 69;

[113] White R.W, Gillion K.W, Black A.D and Reid J.B. (2001) Vulnerability concentrations of seabirds in Falkland Island Waters. JNCC, Peterborough.

APPENDIX A SPIRIT ENERGY RISK ASSESSMENT MATRIX

Appendix A.1 Environmental Impact Table and Risk Matrix

APPENDIX 1 ENVIRONMENTAL IMPACT TABLE AND RISK MATRIX

							Benefit	Duration of harmful effect / recovery (c. 80% of damage rectified)				
Land and air								within 1 month	within 1 year	≤3 years	>3 years or >2 growing seasons	>20 years
Surface water (any harm of drinking water source or ground water would be cat 4 or above)								Immediate	< 1 month	≤1 years	>1 year	>10 years
Reinstatement of Built Environment - Can be repaired								immediately	in <1 year	in <3 years	in >3 years	Cannot be rebuilt
Recovery for Societal - Decrease in the availability or quality of a resource								Access immediately	Short term decrease	Medium term decrease	Medium to long term decrease	Long term decrease
Habitats / Species	**Air**	**Soil or sediment**	**Water**	**Built Environment**	**Societal**		+1	1	2	3	4	5
Large area of habitat and/or large number or proportion of population or species impacted.	Large increase in contaminants in the air exceeding quality limits	Large area with contamination resulting in hazardous soil to humans (e.g. skin contact) or the living environment, remediation available (but difficult).	Drinking water standards breached for a large number of properties. Large groundwater body effected. Large water body exceeds a water quality guideline or objective.	Complete destruction of an area of built importance	Large population with high dependence on the impacted resource or large loss for other users.	5	-	6 Minor	10 Moderate	15 Significant	20 Major	25 Catastrophic
Moderate area of habitat and/or moderate number or proportion of population or species impacted.	Moderate increase in contaminants in the air exceeding quality limits.	Moderate area with contamination sufficient to be environmental damage[4] or in alignment with contaminated land legislation.	Drinking water standards breached for a moderate number of properties. Moderate groundwater body effected. Moderate water body exceed a water quality guideline or objective.	Loss of integrity to an area of built importance or nationally registered building leading to de-registering / categorisation with a need for remedial / restorative work.	Moderate population with moderate dependence on the impacted resource or moderate loss for other users.	4	-	4 Negligible	8 Minor	12 Moderate	16 Significant	20 Major
Small area of habitat impacted and/or small number or proportion of population or species impacted.	Small Increase in contaminants in the air exceeding quality limits	Contamination not leading to environmental damage	Drinking water standards breached for a small number of properties. Small groundwater body effected. Small water body exceed a water quality guideline or objective.	Loss of integrity to an area of built importance or nationally registered building with a need for remedial / restorative work.	Small population with small dependence on the impacted resource or small loss for other users.	3	-	3 Negligible	6 Minor	9 Minor	12 Moderate	15 Significant
Change is within scope of existing variability (or acceptable mixing zone) but potentially detectable or all within the site boundary / 500m zone (78.5 hectares).				Loss of integrity to an area of built importance or nationally registered building need for remedial / restorative work.	A small population with some dependence on the impacted resource. Negligible loss to other users.	2	-	2 Negligible	4 Negligible	6 Minor	8 Minor	10 Moderate
Effects are unlikely to be noticed or detectable.						1	-	1 Negligible	2 Negligible	3 Negligible	4 Negligible	5 Negligible

Low	Impact broadly acceptable and considered 'as low as reasonably practicable'	High	Impact intolerable without control and mitigation measures required to be reduce impacts to 'as low as reasonably practicable'
Medium	Impact is tolerable but to be managed to 'as low as reasonably practicable'	P	Positive – Positive or beneficial impact

The translation for the impact table to the severity scale is as shown below.

SCALE of IMPACT	Severity ranking in myHSES (High, Medium and Low)	SEVERITY SCALE (Risk Assessment Matrix[5])	ENVIRONMENTAL DESCRIPTION (FROM THE RISK MATRIX) N/A to built env or societal in RAM
25	H	Catastrophic	Catastrophic environmental impact which is widespread or affects a highly sensitive valuable environment requiring long term remediation.
20	H	Major	Major environmental impact to regional or high value environment requiring protracted remediation.
15-16	H	Significant	Significant environmental impact on local area. Long term natural recovery or moderate remediation intervention.
10-12	M	Moderate	Moderate environmental impact in neighbouring area. Longer term natural recovery or minor remediation intervention.
6-9	M	Minor	Minor environmental impact on site or to lower value environment with short term natural recovery.
1-5	L	Negligible	Negligible environmental impact.

		Frequency (per yr) and Likelihood					
		$\leq 1x10^{-5}$	$>1x10^{-5}$ to $1x10^{-4}$	$>1x10^{-4}$ to $1x10^{-3}$	$>1x10^{-3}$ to $1x10^{-2}$	$>1x10^{-2}$ to $1x10^{-1}$	$> 1x10^{-1}$
		Highly Unlikely	Very Unlikely	Unlikely	Possible	Moderately Likely	Likely
Consequences – Environment (E)		1	2	3	4	5	6
Catastrophic environmental impact which is widespread or affects a highly sensitive / valuable environment requiring long term remediation.	6	6	12	18	24	20	36
Major environmental impact to regional or high value environment requiring protracted remediation.	5	5	10	15	20	25	30
Significant environmental impact on local area. Long term natural recovery or moderate remediation intervention.	4	4	8	12	16	20	24
Moderate environmental impact in neighbouring area. Longer term natural recovery or minor remediation intervention.	3	3	6	9	12	15	18
Minor environmental impact on site or to lower value environment with short term natural recovery.	2	2	4	6	8	10	12
Negligible environmental impact.	1	1	2	3	4	5	6

Table A.1.1: Risk Assessment Matrix

APPENDIX B BURIAL PROFILES

Appendix B.1 PL2838 and PL2839 Burial Profile

PL2838 is the 10” gas export pipeline approximately 22.3 km long overall, and it is piggybacked with PL2839 (22.2 km long). That is, PL2839 is connected to PL2838 using clamps. PL2838 is routed from the Ensign installation to Audrey A (WD). At ~KP11.8 the pipelines cross over the Weybourne to ACMI Master cable. Both pipelines exhibit a good depth of burial and cover along their original trenched and buried lengths.

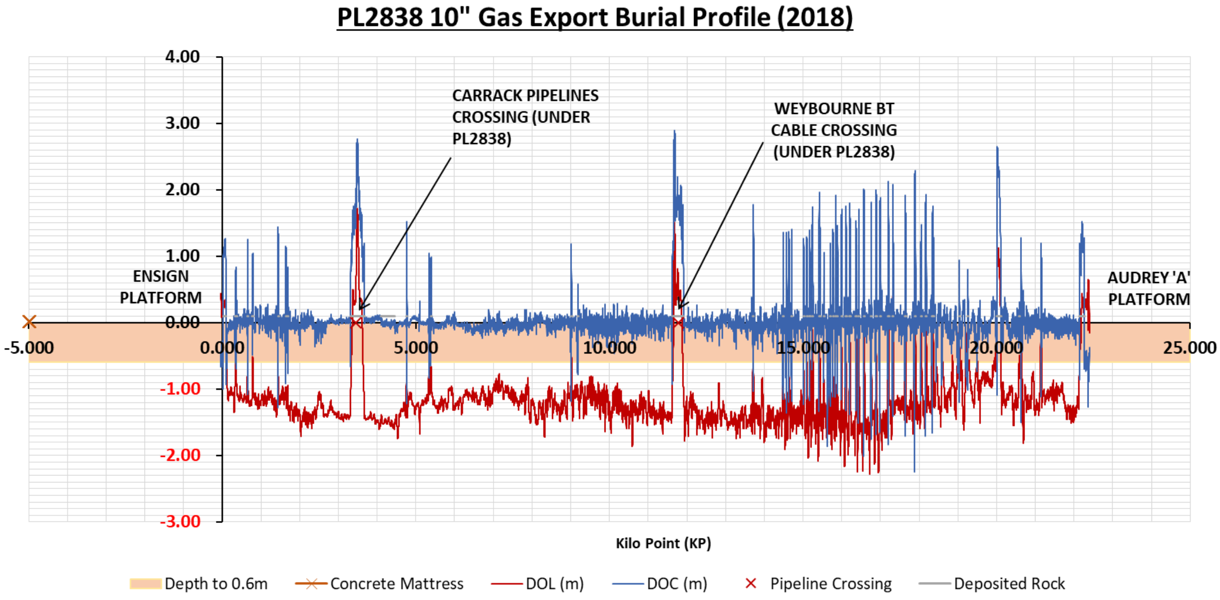


Figure B.1.1: PL2838 (and PL2839) burial profile

Appendix B.2 PLU2840 and PL2841 Burial Profile

PL2841 is the 10” gas export pipeline approximately 2.2 km long overall, and it is piggybacked by PLU2840, an umbilical pipeline. That is, PLU2840 is connected to PL2841 using clamps. PLU2840 is routed to the end of the concrete mattresses on approach to the suspended subsea well, whereas PL2840 terminates at the end of the deposited rock. Both pipelines exhibit a good depth of burial and cover along their original trenched and buried lengths.

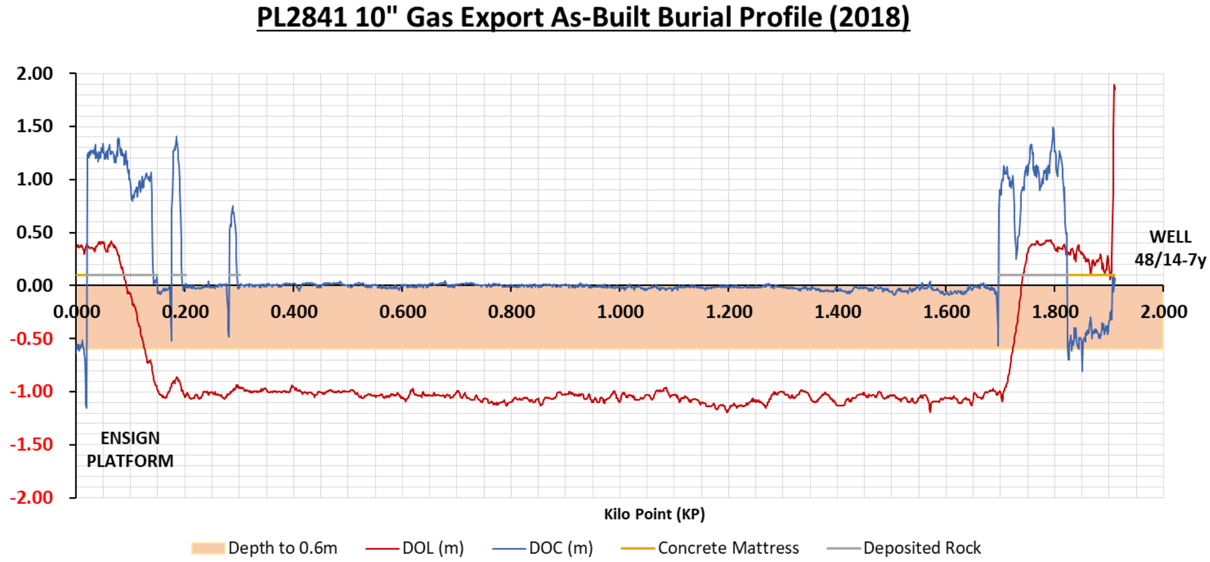


Figure B.2.1: PL2841 (andPLU2840) burial profile

APPENDIX C ENVIRONMENTAL WORKSHOP WORKSHEET

Appendix C.1 Environmental Management Worksheet

				Planned Activities			Unplanned Activities										
ASPECT	PROJECT ACTIVITY / SOURCE OF IMPACT	POTENTIAL IMPACTS / OBSERVATIONS	EXISTING MITIGATION MEASURES, SAFEGUARDS AND CONTROLS	Effect	Duration	Impact	Estimation of consequence	Estimation of likelihood	Environmental risk level	COMPANY OR PROJECT SPECIFIC MITIGATION	Effect	Duration	Impact	Estimation of consequence	Estimation of likelihood	Environmental risk level	COMMENTS
Vessel use																	
Physical Presence	Vessels on location and transiting from and to port. Vessels dynamically positioned (DP) on location.	Potential for navigation hazard and interference with shipping/fishing activities.	500 m safety zone around platform already in place. Notice to Mariners prior to operations commencing. Kingfisher Bulletins issued prior to operations commencing. Collision Risk Management. Patrol of safety zone by Emergency Response Rescue Vessel (ERRV) where required. Vessel communication systems. Follow Spirit Energy's Marine Assurance Standard.	1	2	2											
Physical Presence	Vessels on location and transiting from and to port	Potential emergency situation due to collision.	500 m safety zone around platform already in place. Notice to Mariners prior to operations commencing. Kingfisher Bulletins issued prior to operations commencing. Collision Risk Management. Patrol of safety zone by ERRV where required. Vessel communication systems. Follow Spirit Energy's Marine Assurance Standard.	1	2	2	2	2	4								
Discharges to Sea	Vessels on location and transiting from and to port discharging grey and black waste water.	Water quality impact and potential seabed deposition. Impact on marine flora and fauna. Localised Impacts.	Operating in line with International Maritime Organisation (IMO) regulations and International Convention for the Prevention and Pollution from Ships (MARPOL) regulations.	1	2	2											
Atmospheric Emissions	Combustion products from vessel engines.	Localised deterioration of air quality for duration of operations and contribution to GHG.	Spirit Energy will carry out vessel assurance.	1	2	2											
Waste Production	Waste from vessels being taken back onshore.	Use of landfill resource and landfill resource take.	Vessel assurance and adherence to IMO standards.	1	2	2											
Sound and Vibration	Noise generated from engine and thrusters (vessels on DP)	Potential disturbance to marine mammals and fish. Potential behavioural changes in fish and marine mammals due to increase in background marine noise levels. Indirect impact to fisheries caused by potential behavioural changes in fish.	Optimise vessel use.	2	2	4											
Resource Usage	Use of diesel for fuel	Impact on climate change and reduction of resources of hydrocarbons	Vessel planning to limit time spent in field and number of journeys required.	1	2	2											

				Planned Activities			Unplanned Activities										
ASPECT	PROJECT ACTIVITY / SOURCE OF IMPACT	POTENTIAL IMPACTS / OBSERVATIONS	EXISTING MITIGATION MEASURES, SAFEGUARDS AND CONTROLS	Effect	Duration	Impact	Estimation of consequence	Estimation of likelihood	Environmental risk level	COMPANY OR PROJECT SPECIFIC MITIGATION	Effect	Duration	Impact	Estimation of consequence	Estimation of likelihood	Environmental risk level	COMMENTS
Small releases to sea	Potential unintentional releases of fuel or other fluids (e.g. diesel, jet fuel, hydraulic oil, lubricants or chemicals) during day-to-day operations (including re-fuelling)	During general operations there is the potential for unintentional releases. These releases have the potential to cause localised toxic effects on marine fauna and flora and localised pollution, which may impact local marine wildlife and rafting seabirds on the sea surface.	Spirit Energy Marine Standard will be adhered to.	2	1	2	1	3	3								
Large releases to sea	An emergency incident (e.g. vessel collision), leading to loss of fuel inventory.	Potential total loss of containment of entire inventories of diesel, utility fuels and chemicals from vessels potentially causing significant hydrocarbon and chemical pollution. Potential impacts on water quality and marine wildlife in the affected area.	Spirit Energy Marine Standard will be adhered to. All contracted vessels will have a ship-board oil pollution emergency plan (SOPEP) in place. An Emergency response plan (ERP) in place prior to operations commencing. A contract with an oil spill response organisation will be in place to ensure a timely and efficient mobilisation of oil spill response resources and competent response personnel. The ERRV will have 5 cubic metres of dispersant on board. Oil spill modelled in Oil Pollution Emergency Plan (OPEP).	4	3	12	3	2	6								Scoring based on Ensign field OPEP. Stochastic modelling shows surface thickness of an instantaneous release of 3,550m3 diesel is minimal. Diesel has a 1-5% probability of crossing into Dutch waters within 15 hours (shortest time) and a 5-10% probability of beaching on the east of England within 2 days.
Topsides Preparation and Removal																	
Physical Presence	HLV in transit/on location	Potential interference with shipping/fishing activities. Anchors will extend outwith the 500m zone. Fishing activity considered relatively low in the area.	500m safety zone around platform already in place. Notice to Mariners prior to operations commencing. Kingfisher Bulletins issued prior to operations commencing. possibly not needed here. Collision Risk Management. Patrol of safety zone by ERRV where required. Vessel communication systems. Follow Spirit Energy's Marine Assurance Standard.	1	1	1											Vessels will be DP.
Physical Presence	HLV in transit / on location	Potential emergency situation due to collision.	500 m safety zone around platform already in place. Notice to Mariners prior to operations commencing. Kingfisher Bulletins issued prior to operations commencing. Collision Risk Management. Patrol of safety zone by ERRV where required. Vessel communication systems. Vessel SOPEPS. Follow Spirit Energy's Marine Assurance Standard.	1	2	2	2	2	4								

				Planned Activities			Unplanned Activities										
ASPECT	PROJECT ACTIVITY / SOURCE OF IMPACT	POTENTIAL IMPACTS / OBSERVATIONS	EXISTING MITIGATION MEASURES, SAFEGUARDS AND CONTROLS	Effect	Duration	Impact	Estimation of consequence	Estimation of likelihood	Environmental risk level	COMPANY OR PROJECT SPECIFIC MITIGATION	Effect	Duration	Impact	Estimation of consequence	Estimation of likelihood	Environmental risk level	COMMENTS
Discharges to Sea	HLV on location and transiting from and to port discharging grey and black waste water.	Water quality impact and potential seabed deposition. Impact on marine flora and fauna. Localised Impacts.	Operating in line with IMO regulations and MARPOL regulations.	1	2	2											
Discharges to Sea	Discharge of fluids when cleaning topsides	Water quality impact and potential seabed deposition. Impact on marine flora and fauna. Localised Impacts. Note it is possible that fluids from cleaning will be put in storage tanks (metals tanks) for treatment onshore or disposed of down a well.	Discharge will be risk assessed for potential significance to the environment through the Chemical Permit process. Assessed assuming discharge to sea. Includes Naturally Occurring Radioactive Material (NORM) and sources which will be disposed of at sea where possible under existing permits.	2	1	2											Cleaning fluid may be skipped and shipped to shore for treatment or disposed of via disposal well
Waste Production	Flush, clean and purge topsides prior to removal. Waste streams to be returned to onshore for treatment as a contingency if discharge offshore not possible.	Minimal use of landfill resource and landfill resource take. Waste streams may include liquid wastes including residual fuel and may be contaminated with NORM and radioactive sources.	Inventory of waste in place. Treatment as per waste hierarchy to minimise resource take. Use of permitted onshore facilities only.	1	1	1											
Waste Production	Topsides equipment returned to onshore. Waste streams to be returned to onshore for treatment.	Use of landfill resource and landfill resource take.	Inventory of waste in place. Treatment as per waste hierarchy to minimise resource take. Use of permitted onshore facilities only.	1	1	1											
Seabed Disturbance	Anchoring of Heavy Lift Vessel and barge for topsides and jacket removal.	Localised physical seabed disturbance resulting in community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant Environmental Impact Assessment (EIA). Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of resuspended particles."	Anchor management plan and results from pre- decommissioning environmental baseline survey.	3	2	6				Spirit Energy will explore ways of optimising operations.							Assessing for both HLV and barge, both will lay their anchors twice. Assume 8 anchors for HLV and 8 anchors for barge. Each anchor covers 30m2 and each chain abrades an area of seabed equal to 5 m on either side of chain which is in contact with seabed for 500m per chain (16 in total). Total seabed disturbed approximately 0.080 km2
Atmospheric Emissions	Combustion products from HLV engines	Localised deterioration of air quality for duration of operations and contribution to Green House Gases (GHG).	Spirit Energy will carry out vessel assurance.	1	2	2											
Resource Usage	Use of diesel for fuel	Impact on climate change and reduction of resources of hydrocarbons	Vessel planning to limit time spent in field.	1	2	2											
Resource Usage	Use of steel for sea fastenings	Resource use and impact on climate change and reduction of resources of steel	Where possible reuse will be identified for sea fastenings. If no reuse can be identified, then they will be recycled.	1	1	1											

				Planned Activities			Unplanned Activities										
ASPECT	PROJECT ACTIVITY / SOURCE OF IMPACT	POTENTIAL IMPACTS / OBSERVATIONS	EXISTING MITIGATION MEASURES, SAFEGUARDS AND CONTROLS	Effect	Duration	Impact	Estimation of consequence	Estimation of likelihood	Environmental risk level	COMPANY OR PROJECT SPECIFIC MITIGATION	Effect	Duration	Impact	Estimation of consequence	Estimation of likelihood	Environmental risk level	COMMENTS
Sound and Vibration	Noise generated from engine and thrusters.	Potential disturbance to marine mammals and fish. Potential behavioural changes in fish and marine mammals due to increase in background marine noise levels. Indirect impact to fisheries caused by potential behavioural changes in fish.	Optimise vessel use.	2	2	4											
Leaks/spills and unplanned events	Dropped object from lifting operations. Assessed assuming dropping of topsides.	Localised physical seabed disturbance. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of resuspended particles."	All items will be securely stowed. Lifting operations will be planned to manage the risk, meet requirements of Lifting Operations and Lifting Equipment Regulations (LOLER) 1998 and will use the correct lifting equipment that is tested and certified. Recovery of dropped objects will take place where practicable. Dropped object reporting as per Petroleum Operations Notice (PON2) requirements. Dropped Object sweep of seabed. Incident log/register.	1	3	3	1	1	1								
Large releases to sea	An emergency incident (e.g. vessel collision), leading to loss of fuel inventory.	Potential total loss of containment of entire inventories of diesel, utility fuels and chemicals from vessels potentially causing significant hydrocarbon and chemical pollution. Potential impacts on water quality and marine wildlife in the affected area.	Spirit Energy Marine Standard will be adhered to. All contracted vessels will have a SOPEP in place. An ERP in place prior to operations commencing. A contract with an oil spill response organisation will be in place to ensure a timely and efficient mobilisation of oil spill response resources and competent response personnel. The ERRV will have 5 cubic metres of dispersant on board. Oil/Diesel spill modelled in OPEP.	4	3	12	3	2	6								
Jacket Removal																	
Physical Presence	HLV on location	Potential for navigation hazard and interference with shipping/fishing activities.	500 m safety zone around platform already in place. Notice to Mariners prior to operations commencing. Kingfisher Bulletins issued prior to operations commencing. Collision Risk Management. Patrol of safety zone by ERRV where required. Vessel communication systems. Follow Spirit Energy's Marine Assurance Standard.	1	1	1											

SPIRIT ENERGY

				Planned Activities			Unplanned Activities										
ASPECT	**PROJECT ACTIVITY / SOURCE OF IMPACT**	**POTENTIAL IMPACTS / OBSERVATIONS**	**EXISTING MITIGATION MEASURES, SAFEGUARDS AND CONTROLS**	**Effect**	**Duration**	**Impact**	**Estimation of consequence**	**Estimation of likelihood**	**Environmental risk level**	**COMPANY OR PROJECT SPECIFIC MITIGATION**	**Effect**	**Duration**	**Impact**	**Estimation of consequence**	**Estimation of likelihood**	**Environmental risk level**	**COMMENTS**
Physical Presence	HLV on location	Potential emergency situation due to collision.	500 m safety zone around platform already in place. Notice to Mariners prior to operations commencing. Kingfisher Bulletins issued prior to operations commencing. Collision Risk Management. Patrol of safety zone by ERRV where required. Vessel communication systems. Vessel SOPEPS. Follow Spirit Energy's Marine Assurance Standard.	1	2	2	2	2	4								
Marine Discharges	Discharges from cutting debris	Water quality impact and potential seabed deposition. Impact on marine flora and fauna. Localised Impacts	Cutting operations to follow standard procedures and be carefully planned to limit duration.	1	1	1											
Seabed Disturbance	Anchoring of Heavy Lift Vessel for jacket removal.	Localised physical seabed disturbance resulting in community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of resuspended particles."	Anchor management plan and results from pre- decommissioning environmental baseline survey.	3	2	6				Spirit Energy will explore optimisations of operations.							Assessing for both HLV and barge, both will lay their anchors twice. Assume 8 anchors for HLV and 8 anchors for barge. Each anchor covers 30 m2 and each chain abrades an area of seabed equal to 5 m on either side of chain which is in contact with seabed for 500m for all 8 chains. Total seabed disturbed approximately 0.080 km2
Seabed Disturbance	External cutting of jacket piles if internal cutting fails. Creation of trench for access by external cutting tool.	Localised physical seabed disturbance resulting in community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of resuspended particles."	Results from pre-decommissioning environmental baseline survey. Naturally left to backfill	1	3	3											
Seabed Disturbance	Internal cutting of jacket piles, removal of soil plugs to allow cutting tool access. Sediment discharged to seabed.	Increased suspended solids in the water column and dilution and dispersion before settling on seabed. Resuspended solids.	Base case is internal cutting with external cutting as a contingency.	1	3	3											Jacket piles will be cut internally in the first instance and if this fails the contingency option would be an external cut.
Atmospheric Emissions	Combustion products from HLV engines	Localised deterioration of air quality for duration of operations and contribution to GHG.	Spirit Energy will carry out vessel assurance.	1	2	2											
Resource Usage	Use of diesel for fuel	Impact on climate change and reduction of resources of hydrocarbons	Vessel planning to limit time spent in field.	1	2	2											

				Planned Activities			Unplanned Activities										
ASPECT	**PROJECT ACTIVITY / SOURCE OF IMPACT**	**POTENTIAL IMPACTS / OBSERVATIONS**	**EXISTING MITIGATION MEASURES, SAFEGUARDS AND CONTROLS**	**Effect**	**Duration**	**Impact**	**Estimation of consequence**	**Estimation of likelihood**	**Environmental risk level**	**COMPANY OR PROJECT SPECIFIC MITIGATION**	**Effect**	**Duration**	**Impact**	**Estimation of consequence**	**Estimation of likelihood**	**Environmental risk level**	**COMMENTS**
Resource Usage	Use of steel for sea fastenings	Resource use and impact on climate change and reduction of resources of steel	Where possible, reuse will be identified for sea fastenings. If no reuse can be identified, then fastenings will be recycled.	1	1	1											
Sound and Vibration	Abrasive water jet cutting noise / diamond wire cutting to cut jacket piles.	Potential disturbance to marine mammals and fish. Potential behavioural changes in fish and marine mammals due to increase in background marine noise levels. Indirect impact to fisheries caused by potential behavioural changes in fish.	Operations will draw on standard methodologies and equipment. Noise generated from cutting operations will be present for a short duration. Jacket recovered as a single lift so any cuttings is below mudline.	1	1	1											
Waste Production	Marine growth and jacket waste streams to be returned onshore for treatment.	Use of landfill resource and landfill resource take.	Inventory of waste in place. Treatment as per waste hierarchy to minimise resource take.	1	1	1											
Waste Production	Movement of radioactive material in the form of sealed sources containing specified radionuclides.	Use of landfill resource and landfill resource take.	Sealed sources will be moved under an existing permit (permit number EPP/XP3090SG) and returned to their owner or supplier.	1	1	1											
Leaks/spills and unplanned events	Dropped objects Assessed assuming dropping of jacket.	Localised physical seabed disturbance resulting in community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of resuspended particles."	All items will be securely stowed. Lifting operations will be planned to manage the risk, meet requirements of LOLER 1998 and will use the correct lifting equipment that is tested and certified. Recovery of dropped objects will take place where practicable. Dropped object reporting as per PON2 requirements. Dropped Object sweep of seabed. Incident log/register.	1	3	3	1	1	1								
Large releases to sea	An emergency incident (e.g. vessel collision), leading to loss of fuel inventory.	Potential total loss of containment of entire inventories of diesel, utility fuels and chemicals from vessels potentially causing significant hydrocarbon and chemical pollution. Potential impacts on water quality and marine wildlife in the affected area.	Spirit Energy Marine Standard will be adhered to. All contracted vessels will have a SOPEP in place. An ERP in place prior to operations commencing. A contract with an oil spill response organisation will be in place to ensure a timely and efficient mobilisation of oil spill response resources and competent response personnel. The ERRV will have 5 cubic metres of dispersant on board. Oil/Diesel spill modelled in OPEP.	4	3	12	3	2	6								

				Planned Activities			Unplanned Activities										
ASPECT	PROJECT ACTIVITY / SOURCE OF IMPACT	POTENTIAL IMPACTS / OBSERVATIONS	EXISTING MITIGATION MEASURES, SAFEGUARDS AND CONTROLS	Effect	Duration	Impact	Estimation of consequence	Estimation of likelihood	Environmental risk level	COMPANY OR PROJECT SPECIFIC MITIGATION	Effect	Duration	Impact	Estimation of consequence	Estimation of likelihood	Environmental risk level	COMMENTS
Pipelines and Umbilical Decommissioning																	
Sound and Vibration	Disconnection of pipelines from riser flanges and sever pipeline ends using hydraulic shears	Potential disturbance to marine mammals and fish. Potential behavioural changes in fish and marine mammals due to increase in background marine noise levels. Indirect impact to fisheries caused by potential behavioural changes in fish.	Operations will draw on standard methodologies and equipment. Noise generated from cutting operations will be present for a short duration.	1	1	1											
Discharges to Sea	Disconnection of pipelines from riser flanges, discharge of residual hydrocarbons.	Water quality impact and potential seabed deposition. Impact on marine flora and fauna. Localised Impacts	Pipelines have undergone a flushing and cleaning campaign to reduce the residual hydrocarbons to As Low As Reasonably Practicable (ALARP). Environmental impact assessment of any discharges will be captured within oil discharge permit.	1	1	1											
Seabed Disturbance	Removal of pipespools and umbilical ends	Increased suspended solids in the water column and dilution and dispersion before settling on seabed.	Optimised work procedures. Any baskets, equipment or items to be recovered etc. will be laid within a 5m work corridor.	1	1	1											
Seabed Disturbance	Removal of mattresses and grout bags	Increased suspended solids in the water column and dilution and dispersion before settling on seabed.	Optimised work procedures. Any baskets, equipment, items to be recovered etc will be laid (if required) will be within a 5m work corridor.	1	1	1											
Seabed Disturbance	Additional rock added to pipeline ends	Introduction of a hard substrate in a predominantly soft sediment environment. Potential smothering of benthic fauna and change in communities.	Where possible Spirit Energy will reprofile existing rock. If necessary small quantities of additional rock will be added (approximately 2 T each end of existing rock) such that around 8 T would be added (four ends).	1	1	1											
Leaks/spills and unplanned events	Dropped objects Assessed assuming dropping of pipeline end	Localised physical seabed disturbance resulting in community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of resuspended particles."	All items will be securely stowed. Lifting operations will be planned to manage the risk, meet requirements of LOLER 1998 and will use the correct lifting equipment that is tested and certified. Recovery of dropped objects will take place where practicable. Dropped object reporting as per PON2 requirements. Dropped object sweep of seabed. Incident log/register.	1	1	1	1	3	3								
Leaks/spills and unplanned events	Leak of hydraulic fluid from cutting equipment	Damage to aquatic environment, impact on marine flora and fauna. Spill volumes expected to be low, resulting in minor localised impacts.	Follow Spirit Energy's Marine Assurance Standard. Pre deployment checks and awareness.	1	1	1	1	3	3								

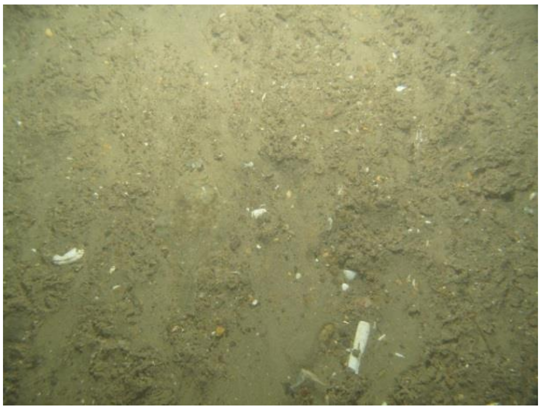
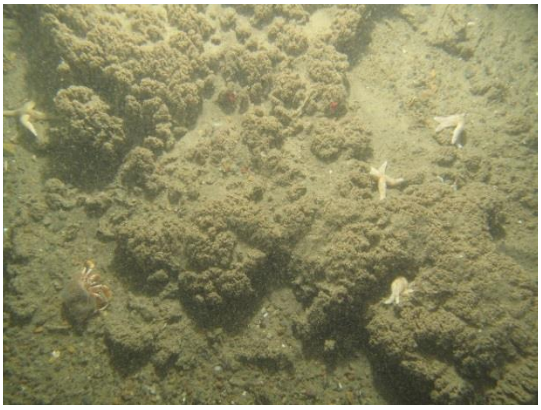
				Planned Activities			Unplanned Activities										
ASPECT	**PROJECT ACTIVITY / SOURCE OF IMPACT**	**POTENTIAL IMPACTS / OBSERVATIONS**	**EXISTING MITIGATION MEASURES, SAFEGUARDS AND CONTROLS**	**Effect**	**Duration**	**Impact**	**Estimation of consequence**	**Estimation of likelihood**	**Environmental risk level**	**COMPANY OR PROJECT SPECIFIC MITIGATION**	**Effect**	**Duration**	**Impact**	**Estimation of consequence**	**Estimation of likelihood**	**Environmental risk level**	**COMMENTS**
Discharges to Sea	Discharge of umbilical and pipeline contents on cutting ends	Water quality impact and potential seabed deposition. Impact on marine flora and fauna. Localised Impacts	Pipelines contain inhibited seawater or filtered treated seawater and umbilicals contain hydraulic oil and aquaglycol. A risk assessment of the release of these products will be undertaken as part of the permitting under the offshore chemical regulations.	1	1	1											
Pipeline Stabilisation Features Decommissioning																	
Waste Production	Recovery of all concrete mattresses to onshore for re-use, recycling or disposal except for mattresses underneath pipeline crossings, underneath or on top of pipespools.	Use of landfill resource and landfill resource take.	As for jackets above. Combine pipeline ends and stabilisation features	1	1	1											
Waste Production	Recovery of exposed grout bags (if found) to onshore for re-use, recycling and disposal.	Use of landfill resource and landfill resource take.	Inventory of waste in place. Treatment as per waste hierarchy to minimise resource take.	1	1	1											
Seabed Disturbance	Removal of mattresses and grout bags	Increased suspended solids in the water column and dilution and dispersion before settling on seabed. Localised physical seabed disturbance resulting in community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of resuspended particles."	Operations will draw on standard methodologies and equipment.	1	1	1											
Leaks/spills and unplanned events	Dropped objects	Localised physical seabed disturbance resulting in community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of resuspended particles."	All items will be securely stowed. Lifting operations will be planned to manage the risk, meet requirements of LOLER 1998 and will use the correct lifting equipment that is tested and certified. Recovery of dropped objects will take place where practicable. Dropped object reporting as per PON2 requirements. Dropped Object sweep of seabed. Incident log/register.	1	1	1	1	4	4								
Post-decommissioning monitoring and legacy																	
Physical Presence	Removal of 500 m safety zones	Positive impact - return area for alternative uses (fishing, windfarms, dredging)	Not Applicable.	Positive Impact													

				Planned Activities			Unplanned Activities										
ASPECT	**PROJECT ACTIVITY / SOURCE OF IMPACT**	**POTENTIAL IMPACTS / OBSERVATIONS**	**EXISTING MITIGATION MEASURES, SAFEGUARDS AND CONTROLS**	**Effect**	**Duration**	**Impact**	**Estimation of consequence**	**Estimation of likelihood**	**Environmental risk level**	**COMPANY OR PROJECT SPECIFIC MITIGATION**	**Effect**	**Duration**	**Impact**	**Estimation of consequence**	**Estimation of likelihood**	**Environmental risk level**	**COMMENTS**
Marine Discharges	Breakdown of infrastructure decommissioned in-situ (metal and plastic pipeline and umbilical coatings and grout bags)	Potential seabed deposition. Impact on benthic marine flora and fauna within sediment.	Pipelines are stably buried under the seabed and therefore no direct pathways to the water column are expected.	1	1	1											
Unplanned events	Infrastructure decommissioned in-situ (presents risk of exposure)	Snagging risk for fishing vessels leading to a small release to sea.	Long term monitoring strategy of pipelines (including crossings) to be agreed with Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) to ensure presence of pipelines does not adversely affect other users of the sea.	3	2	6	2	1	2								

Table C.1.1: Environmental Management Table from Workshop

APPENDIX D EXAMPLES OF *SABELLARIA* REEF, PL2838 CORRIDOR [27]

Appendix D.1 *Sabelleria* Reef

Transect	Sediment Description	Representative Image	Overall Assessment
ENSIGN_TR_04	Gravelly sand		Not Reef
ENSIGN_TR_05	Gravelly sand with shells		Medium
ENSIGN_TR_07	Slightly gravelly sand with shells		Medium

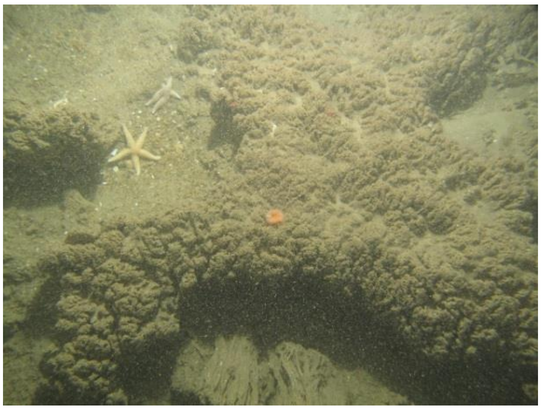
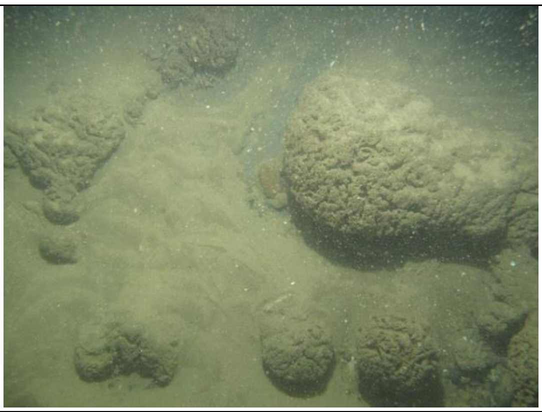
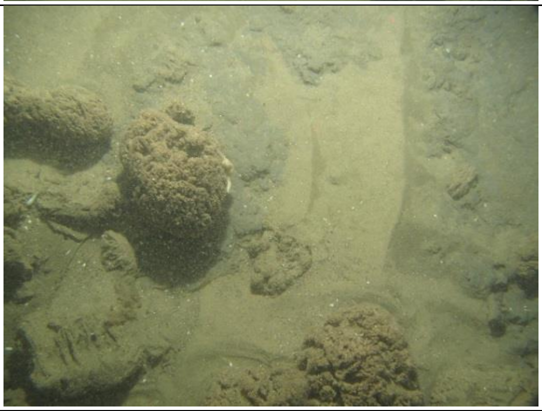
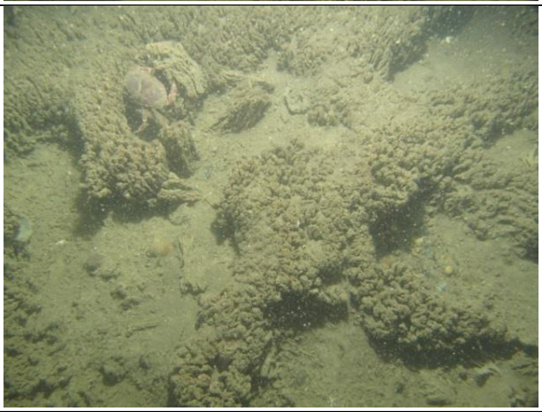
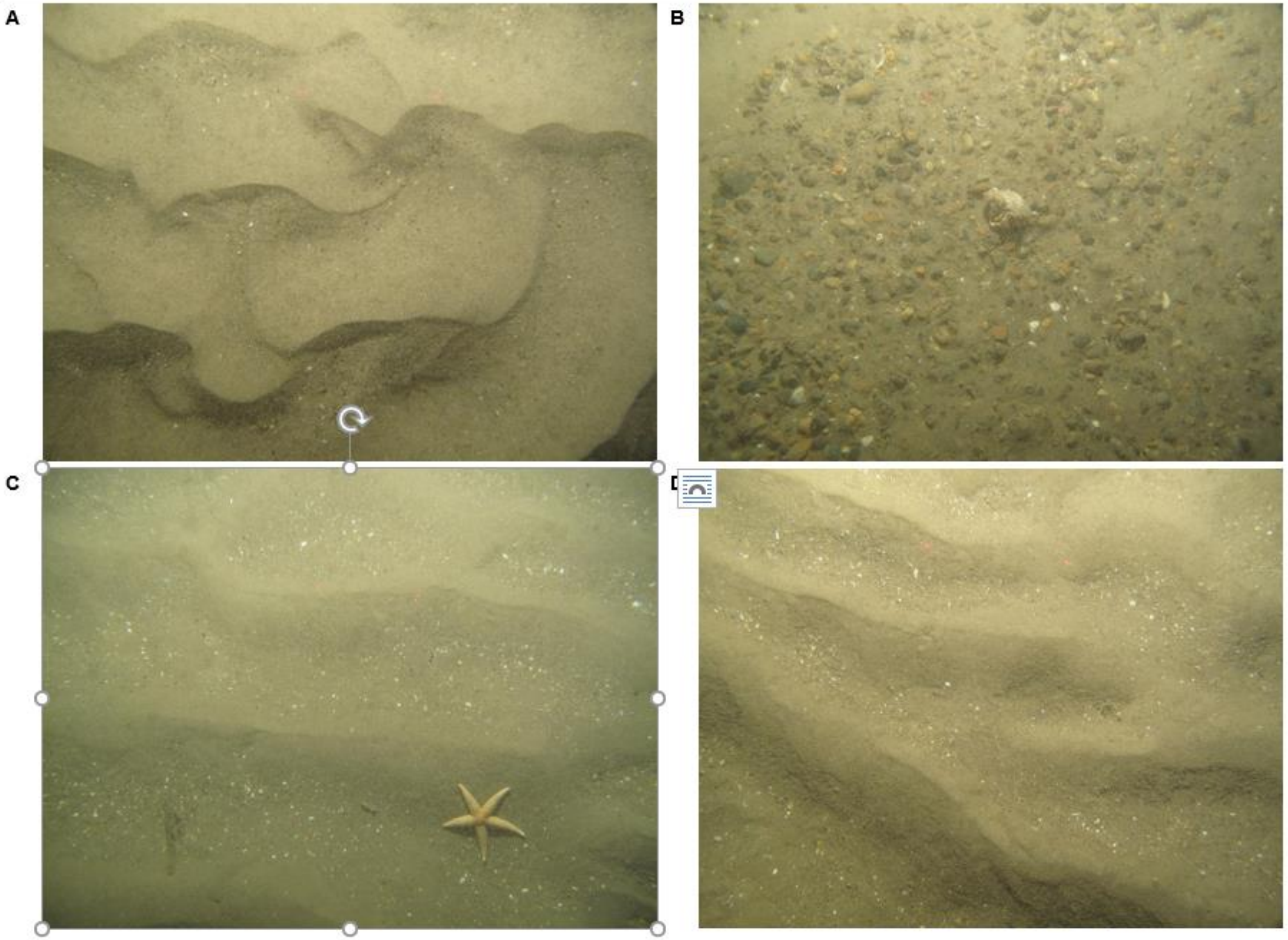
Transect	Sediment Description	Representative Image	Overall Assessment
ENSIGN_TR_07 A	Gravelly sand with shells		Medium
ENSIGN_TR_08	Slightly gravelly muddy sand with patches of clay outcrops		Not reef
ENSIGN_TR_08 A	Muddy sand with shells and clay outcrops		Not reef
ENSIGN_TR_09	Gravelly sand with shells		Medium

Figure D.1.1.1: Examples of Sabellaria Reef PL2838 & PL2839

APPENDIX E EXAMPLES OF SEABED PHOTOGRAPHY [27]

Appendix E.1 Circalittorial sediments and *S. spinulosa*



A: Photograph ENSIGN_DD_02_03

Slightly gravelly sand with shell fragments
No visible fauna

B: Photograph ENSIGN_TR_01_09

Gravelly sand with shell fragments
Hermit crab (Paguridae)

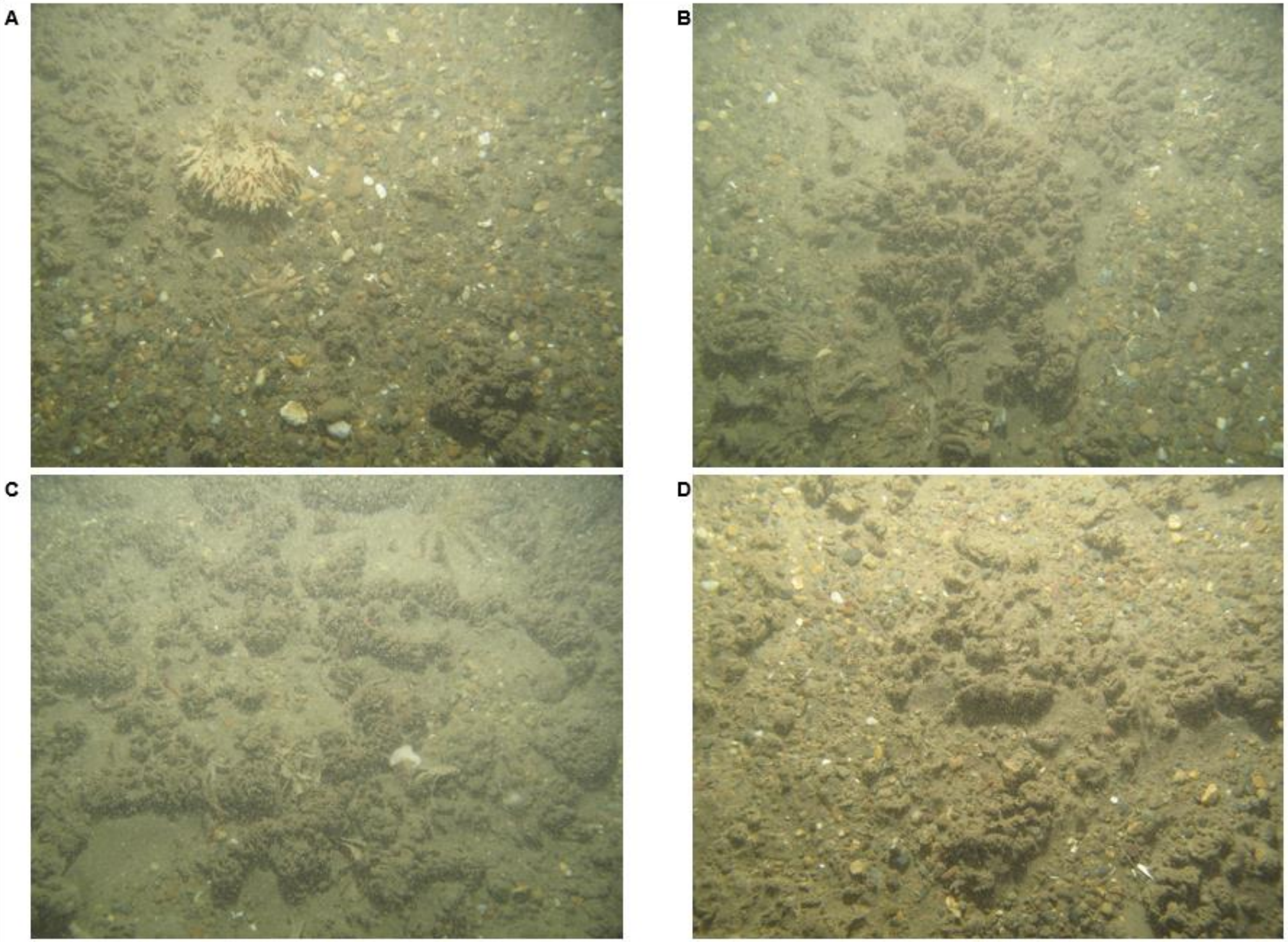
C: Photograph ENSIGN_TR_02_08

Slightly gravelly sand with shell fragments
Starfish *(Asterias rubens)*

D: Photograph ENSIGN_TR_02_13

Slightly gravelly sand with shell fragments
No visible fauna

Figure E.1.1: Circalittoral coarse sediment at the Ensign installation



A: Photograph ENSIGN_DD_01_10

Sand and gravel with *Sabellaria spinulosa* aggregations
Ross worm (*Sabellaria spinulosa*)
Bryozoan (*Flustra foliacea*)

B: Photograph ENSIGN_DD_01_12

Sand and gravel with *Sabellaria spinulosa* aggregations
Ross worm (*Sabellaria spinulosa*)

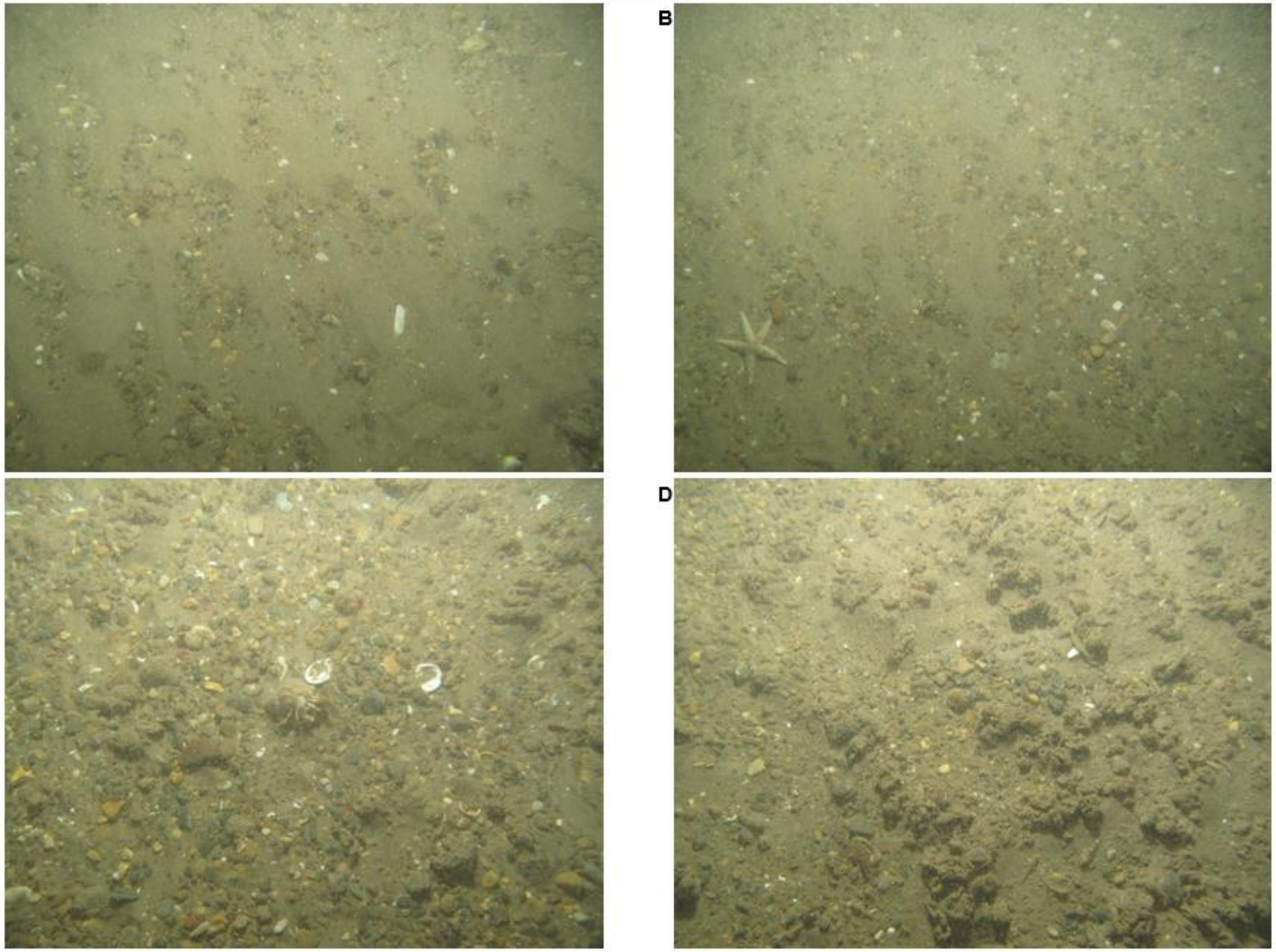
C: Photograph ENSIGN_TR_11_15

Sand and gravel with *Sabellaria spinulosa* aggregations
Ross worm (*Sabellaria spinulosa*)
Bryozoan (*Flustra foliacea*)

D: Photograph ENSIGN_TR_11_33

Sand and gravel with *Sabellaria spinulosa* aggregations
Ross worm (*Sabellaria spinulosa*)

Figure E.1.2: *S. spinulosa* on stable circalittoral mixed sediment



A: Photograph ENSIGN_TR_11_01

Gravelly sand with shell fragments
No visible fauna

B: Photograph ENSIGN_TR_11_06

Gravelly sand with shell fragments
Starfish (*Asterias rubens*)

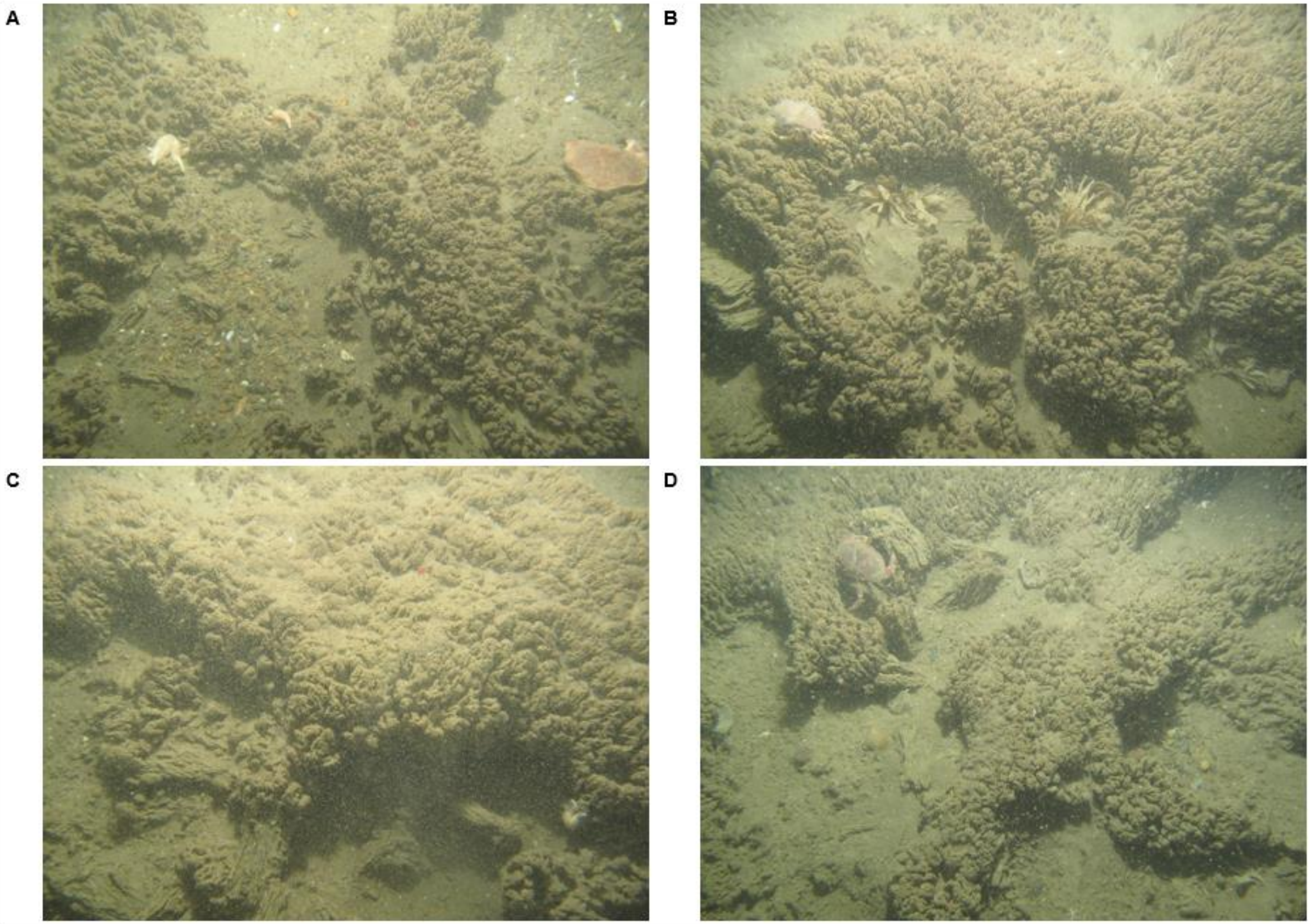
C: Photograph ENSIGN_TR_11_10

Gravelly sand/sandy gravel with shell fragments
Ross worm (*Sabellaria spinulosa*)
Hermit crab (Paguridae)

D: Photograph ENSIGN_TR_11_47

Gravelly sand/sandy gravel with shell fragments
Ross worm (*Sabellaria spinulosa*)

Figure E.1.3: Circalittoral coarse sediment



A: Photograph ENSIGN_TR_05_33

Gravelly sand and *Sabellaria* reef
Ross worm (*Sabellaria spinulosa*)
Crab (*Cancer pagurus*)
Starfish (*Asterias rubens*)

B: Photograph ENSIGN_TR_07_10

Slightly gravelly sand and Sabellaria reef
Ross worm (*Sabellaria spinulosa*)
Hermit crab (Paguridae)
Bryozoan (*Flustra foliacea*)

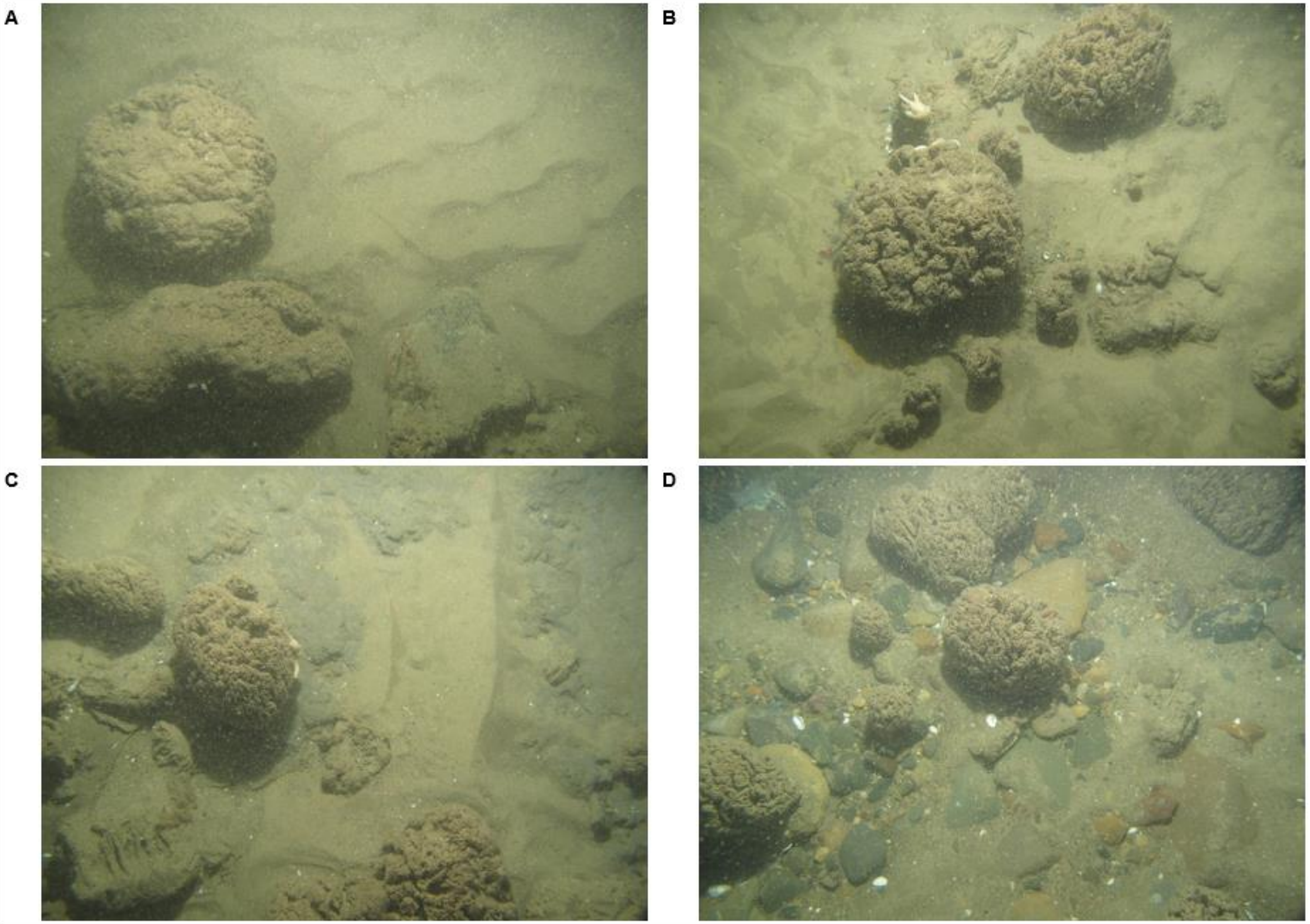
C: Photograph ENSIGN_TR_07A_10

Slightly gravelly sand and *Sabellaria* reef
Ross worm (*Sabellaria spinulosa*)

D: Photograph ENSIGN_TR_09_08

Slightly gravelly sand and *Sabellaria* reef
Ross worm (*Sabellaria spinulosa*)
Crab (*Cancer pagurus*)

Figure E.1.4: *S. spinulosa* on stable circalittoral mixed sediment (A5.611) [27]



A: Photograph ENSIGN_TR_05_06

Sand with cobbles
Ross worm (*Sabellaria spinulosa*)

B: Photograph ENSIGN_TR_08_14

Sand with pebbles and cobbles
Ross worm (*Sabellaria spinulosa*)
Starfish (*Asterias rubens*)

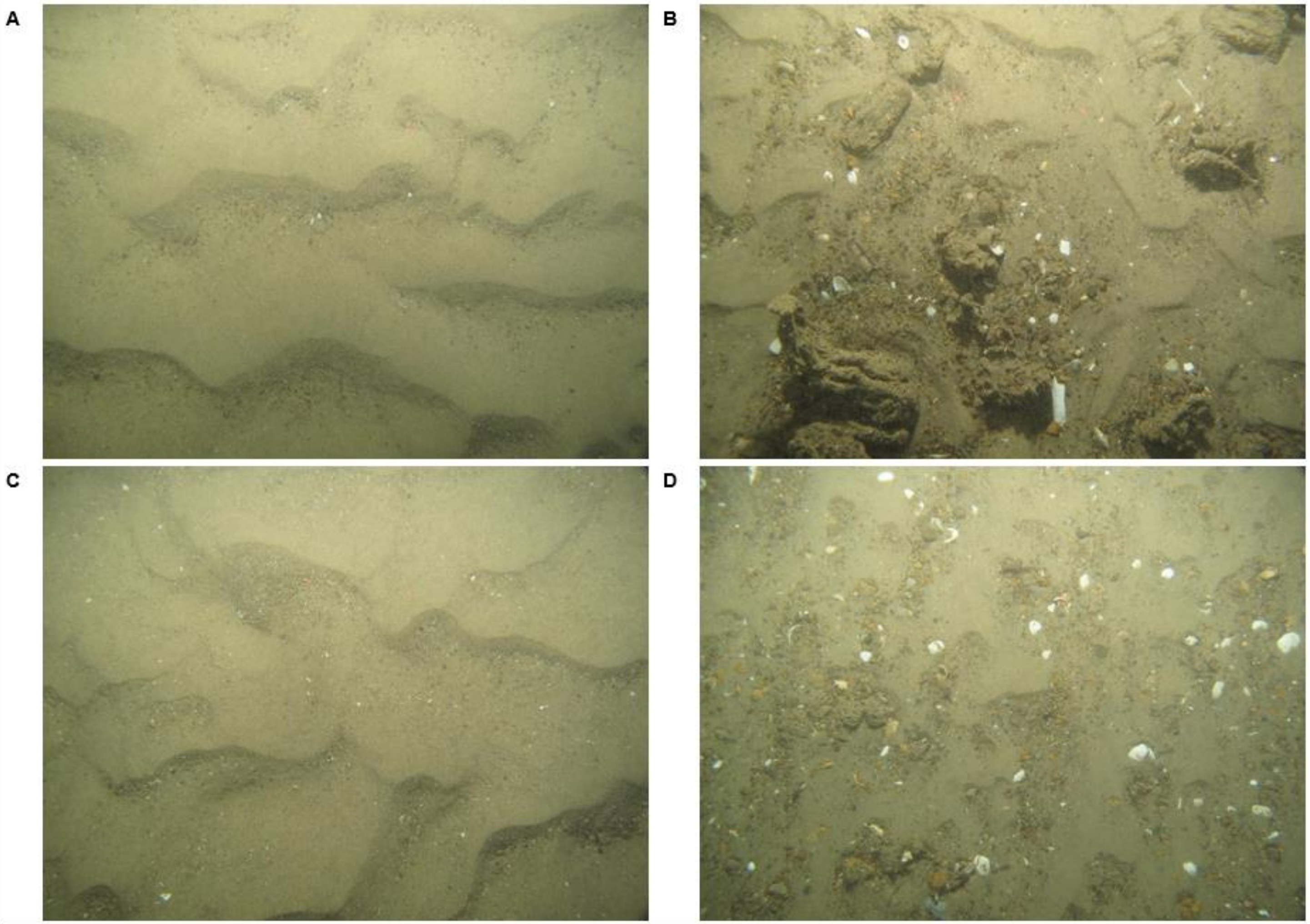
C: Photograph ENSIGN_TR_08A_11

Sand with pebbles and cobbles. Clay outcrop visible
Ross worm (*Sabellaria spinulosa*)
Starfish (*Asterias rubens*)

D: Photograph ENSIGN_TR_09_14

Slightly gravelly sand with pebbles and cobbles
Ross worm (*Sabellaria spinulosa*)

Figure E.1.5: *S. spinulosa* crusts on cobbles [27]



A: Photograph ENSIGN_TR_06_06

Slightly gravelly sand
No visible fauna

B: Photograph ENSIGN_TR_07_14

Gravelly sand
Ross worm (*Sabellaria spinulosa*)

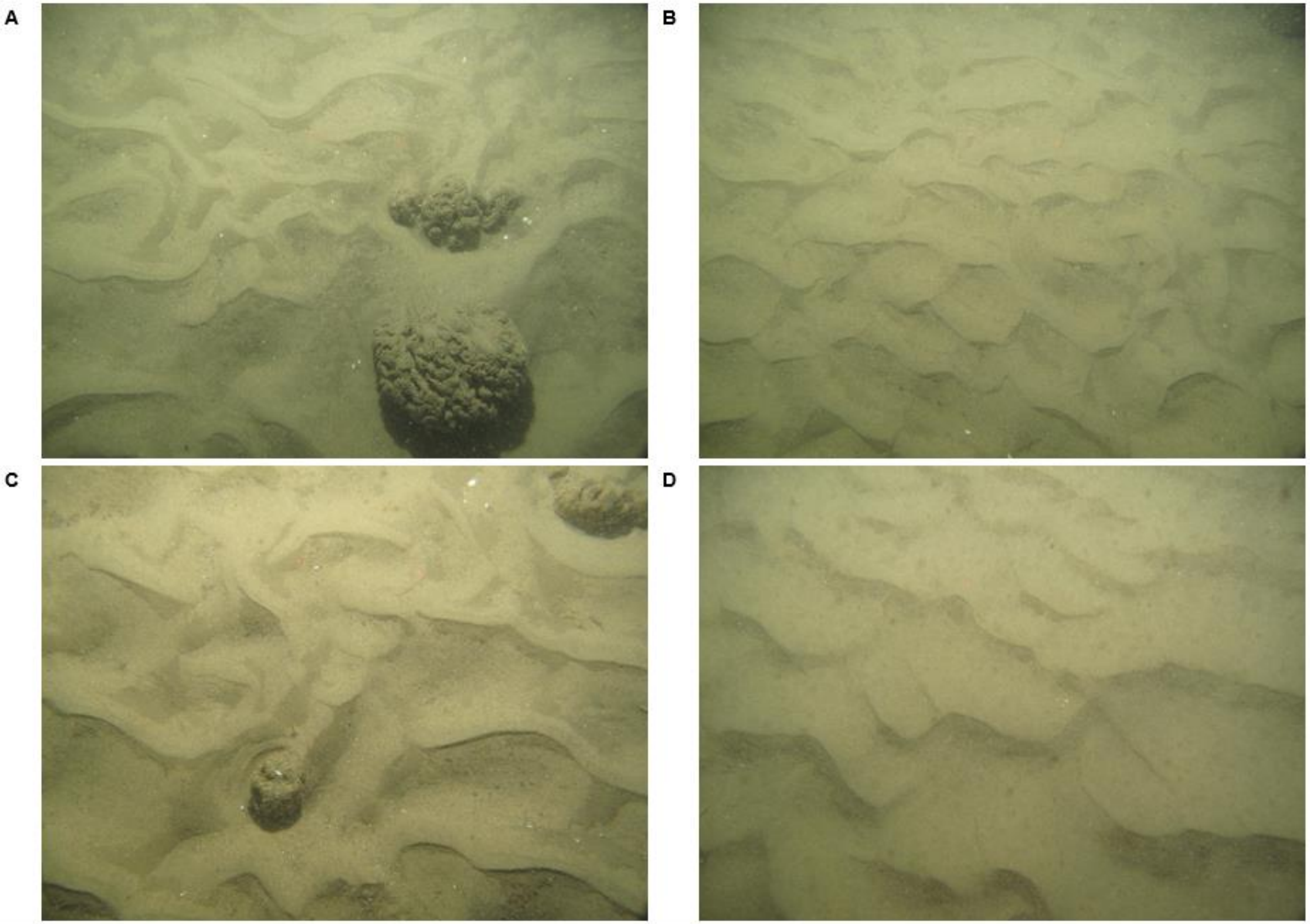
C: Photograph ENSIGN_TR_05_04

Slightly gravelly sand
No visible fauna

D: Photograph ENSIGN_TR_07A_15

Gravelly sand with shell fragments
No visible fauna

Figure E.1.6: Circalittoral coarse sediment (A5.14) [27]



A: Photograph ENSIGN_TR_08_17

Muddy sand
Ross worms (*Sabellaria spinulosa*)

B: Photograph ENSIGN_TR_08A_15

Muddy sand
No visible fauna

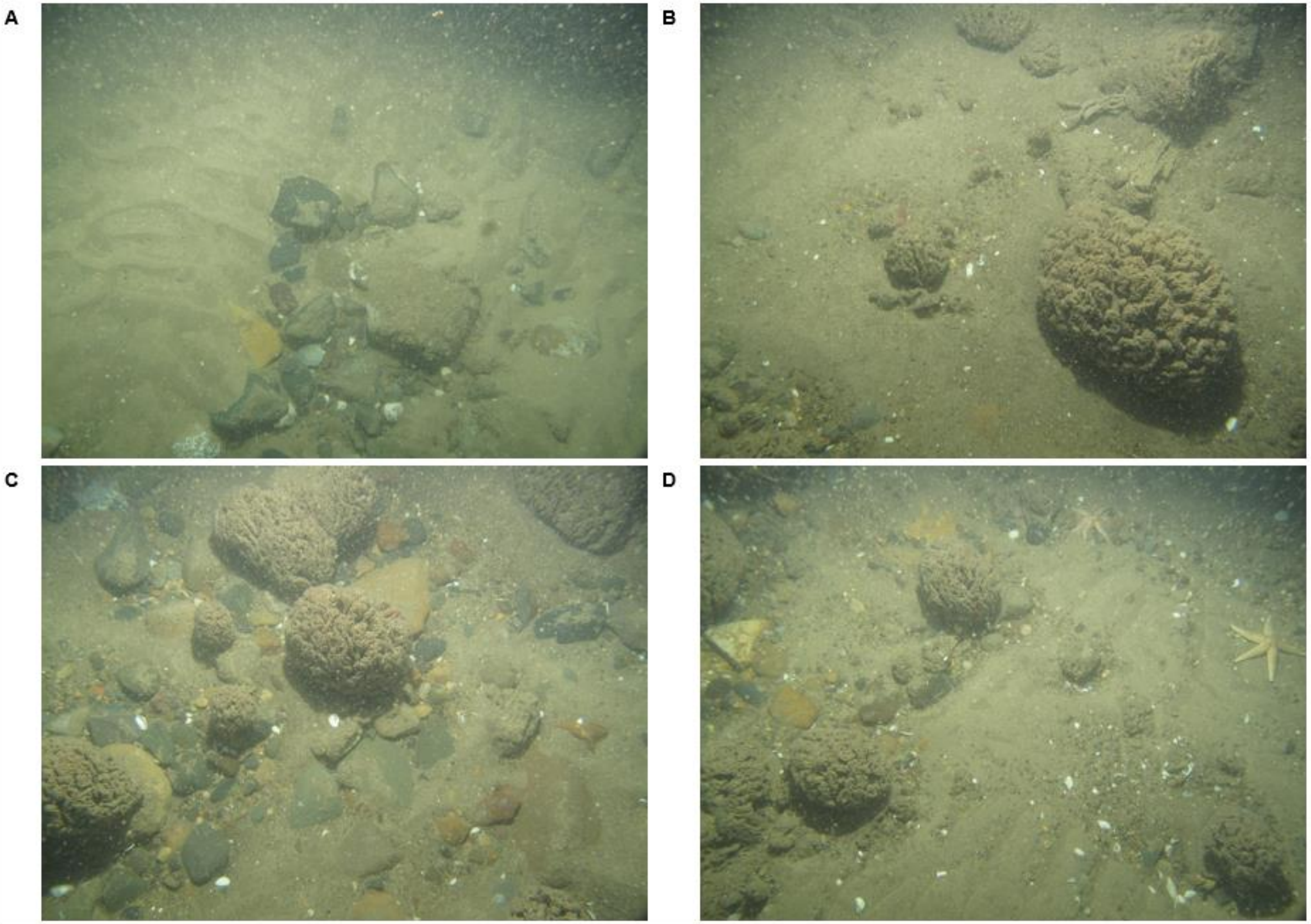
C: Photograph ENSIGN_TR_08A_13

Muddy sand
No visible fauna

D: Photograph ENSIGN_TR_10_01

Muddy sand
No visible fauna

Figure E.1.7: Circalittoral muddy sand [27]



A: Photograph ENSIGN_TR_08_13

Muddy sand with gravel, pebbles and cobbles
No visible fauna

B: Photograph ENSIGN_TR_09_13

Muddy sand with gravel, pebbles and cobbles
Ross worm (*Sabellaria spinulosa*)
Bryozoan (*Flustra foliacea*)

C: Photograph ENSIGN_TR_09_14

Gravelly sand with pebbles and cobbles
Ross worm (*Sabellaria spinulosa*)

D: Photograph ENSIGN_TR_09_17

Gravelly sand with pebbles and cobbles
Ross worm (*Sabellaria spinulosa*)
Starfish (*Asterias rubens*)

Figure E.1.8: Sublittoral mixed sediment (A5.4) [27]

APPENDIX F *S. SPINULOSA* REEF ASSESSMENT [27]

Appendix F.1 JNCC Assessment Method

Video footage and still images from each drop-down camera station and transect were reviewed, noting the type of *S. spinulosa* aggregation present. This reef forming species was classified into the following categories:

1. Absent;
2. Moribund/dead loose tubes;
3. Crusts;
4. Clumps (nodules of reef < 100 mm in diameter);
5. Potential reef.

The Joint Nature Conservation Committee (JNCC) conducted a workshop and produced 'Defining and managing *S. spinulosa* reefs: Report of an inter-agency workshop' [31]. The focus of the workshop was seeking agreement on a definition of *S. spinulosa* reefs. Participants agreed that the simplest definition of *S. spinulosa* reef in the context of the Habitats Directive was considered an area of *S. spinulosa* which is elevated from the seabed and has a large spatial extent. Colonies may be patchy within an area defined as reef and show a range of elevations. In seeking to provide greater guidance, the workshop participants tried to put some figures on the characteristics of elevation and patchiness which could be used in combination to determine whether an area might qualify as a reef. Table F.1.2: Figures proposed at the JNCC workshop to determine measure of reefiness presents the criteria applied to each drop-down camera station and transect analysed.

Measure of 'Reefiness'	Not a Reef	Low	Medium	High
Elevation [mm] (average tube height)	<20	20-50	50–100	>100
Patchiness [% cover]	<10	10-20	20-30	>30
Consolidation♦	<5	5 on Limpenny scale*. Stones joined by tubes that overlap	Upright *S. spinulosa a* including concretion of substrata	Intertwined matrix of upright *S. spinulosa* tubes
Density (maximum/m^2)	<500	500-1700	1700-3500	>3500

Notes:
* = *S. spinulosa* reef scale [62] where:
1. Discreet tubes only; none connected (<10mm thick)
2. Some connection between tubes but not overlapping (accretions <10mm thick)
3. Some tubes on top of each other in three dimensions (accretions 10mm to 20mm thick)
4. Many tubes overlapping but no incorporation or joining of stones (accretions 10mm to 20mm thick)
5. Stones joined by tubes; most tubes overlapping or connected (accretions >20mm thick). (If 5, state maximum thickness)

Table F.1.2: Figures proposed at the JNCC workshop to determine measure of reefiness

The JNCC guidelines [31] do not provide a method for combining the elevation and patchiness measures to provide a single overall 'reefiness' of a potential reef. As such, the method used in Jenkins *et al*. [47] has been used to create a measure of reef structure. As presented in Table F.1.3: *S. spinulosa* reef structure matrix elevation and patchiness has been combined to give a 'reefiness structure'.

Reef Structure [31]			Elevation (mm)			
			< 20	20 - 50	50- 100	> 100
			Not a Reef	Low	Medium	High
Patchiness	< 10%	Not a Reef				
	10% - 20%	Low				
	20% - 30%	Medium				
	> 30%	High				

Not a Reef	Low ‘Reefiness’	Medium ‘Reefiness’	High ‘Reefiness’

Table F.1.3: *S. spinulosa* reef structure matrix

Whilst mainly subjective, the results can allow a basic understanding of the *Sabellaria sp*. colony composition of each survey area to be made, and a measure of its ‘reefiness’ to be arrived at.