Projects & Technology

LEMAN F & G DECOMMISSIONING PROJECT

Leman F & G NUIs Decommissioning Environmental Appraisal

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ABBREVIATIONS

ABBBREVIATION	MEANING
AIS	Automatic Identification System
ALARP	As low as reasonably practicable
API	American Petroleum Institute
AWMP	Active Waste Management Plan
BEIS	Department for Business, Energy and Industrial Strategy
CA	Comparative Assessment
CAPEX	Capital Expenditure
CCUS	Carbon Capture Utilisation and Storage
CH4	Methane
CO	Carbon monoxide
CO2	Carbon dioxide
CO2e	Carbon dioxide equivalent
CoP	Cessation of production
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CFC	chlorofluorocarbon
cST	centistokes
CSV	Construction Support Vessel
CtL	Consent to Locate
Defra	Department for Environment, Food and Rural Affairs
DNV	Det Norske Veritas
DoB	Depth of Burial
DP	Decommissioning Programme
DSV	Dive Support Vessel
DTI	Department of Trade and Industry
EA	Environmental Appraisal

ABBBREVIATION	MEANING
EC	European Commission
ECA	Emission Control Areas
EEZ	European Economic Zone
EF	Emissions Factor
EIA	Environmental Impact Assessment
EIAPP	Engine International Air Pollution Prevention
ENE	East north-east
ENVID	ENVironmental Impact Identification (workshop)
EPS	European Protected Species
ERL	Effects Range Low
ERM	Effects Range Mean
ERRV	Emergency Response and Rescue Vessel
ESE	East south-east
ESHMP	Environmental, Social And Health Management Plan
EU	European Union
EUNIS	European Nature Information System
EWC	European Waste Catalogue
F	Foxtrot
FCS	Favourable Conservation Status
FOCI	Features of Conservation Interest
G	Golf
GHG	Greenhouse Gas
GWP	Global Warming Potential
HSSE & SP	Health, Security, Safety, the Environment and Social Performance
IAPP	International Air Pollution Prevention
ICES	International Council for the Exploration of the Sea

ABBBREVIATION	MEANING
IoP	Institute of Petroleum
IPCC	Intergovernmental Panel on Climate Change
ITOPF	International Tanker Owners Pollution Federation
JNCC	Joint Nature Conservation Committee
km	Kilometre(s)
km^2	Squared kilometre(s)
kt	Kilotonne(s)
LAT	Lowest Astronomical Tide
Leman A	Leman A
Leman F	Leman F
Leman G	Leman G
LTOBM	Low Toxicity Oil-Based Mud
μm	Micro metre(s)
m	Metre(s)
m^3	Cubic metres
MARPOL	International Convention for the Prevention of Pollution from Ships
MCZ	Marine Conservation Zone
MFE	Mass Flow Excavation
MMO	Marine Management Organisation
MoD	Ministry of Defence
MPE	Ministry of Petroleum and Energy
MtC	Megatonnes of Carbon
NAEI	National Atmospheric Emissions Inventory
NECA	Nitrogen Oxides Emissions Control Areas
NFFO	National Federation of Fishermen's Organisations
NNE	North north-east

ABBBREVIATION	MEANING
NNS	Northern North Sea
NNW	North north-west
NORM	Naturally Occurring Radioactive Material
NOx	Nitrous Oxides
NUI	Normally Unmanned Installation
NSTA	North Sea Transition Authority (Formerly OGA)
O_3	Ozone
OGA	Oil and Gas Authority (now referred to as the North Sea Transition Authority or NSTA)
OGUK	Oil and Gas UK (now known as Offshore Energies UK/ OEUK)
OPEP	Oil Pollution Emergency Plan
OPEX	Operating Expenses
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSPAR	Convention for the Protection of the Marine Environment of the Northeast Atlantic ('the Oslo Paris Convention')
OWF	Offshore Wind Farm
P&A	Plug and Abandonment
PAH	Polycyclic aromatic hydrocarbon
PCO	Precipitated carbonates
PETS	Portal Environmental Tracking System
POC	Particulate organic carbon
ROV	Remotely-Operated Vehicle
ROVSV	Remotely-Operated Vehicle Support Vessel
SAC	Special Area of Conservation
SCAP	Supply Chain Action Plan
SECA	Sulphur Oxides Emission Control Area
SHE	Safety, Health and Environmental

ABBBREVIATION	MEANING
SNS	Southern North Sea
SO2	Sulphur dioxide
SOPEP	Shipboard Oil Pollution Emergency Plan
SOSI	Seabird Oil Sensitivity Index
SOx	Sulphur oxides
SPA	Special Protection Area
SSCV	Semi-Submersible Crane Vessel
SSE	South south-east
SSS	Side scan sonar
Te	Tonnes
THC	Total Hydrocarbons
TOC	Total Organic Carbon
TOM	Total Organic Matter
UK	United Kingdom
UKAPP	UK Air Pollution Prevention
UKBAP	UK Biodiversity Action Plan
UKCS	United Kingdom Continental Shelf
UKOOA	UK Offshore Operators Association
VOC	Volatile organic compounds
WNW	West north-west
WRFM	Well Reservoir Facility Management
WSW	West south-west

EXECUTIVE SUMMARY

Introduction and Background

Shell U.K. Limited (Shell) is currently considering a decommissioning strategy for the Leman Foxtrot (F) and Leman Golf (G) infrastructure and the environmental and societal impacts associated with this work. This strategy incorporates the decommissioning of subsea infrastructure associated with the Leman F and G platforms which will be formally applied for under the Decommissioning Programme (DP) process, supported by this Environmental Appraisal (EA).

The Leman F and Leman G infrastructure is located within block 49/26 of the southern North Sea (SNS) and situated approximately 47 km from the UK coastline and 66 km from the UK/Netherlands European Economic Zone (EEZ) boundary line (Figure 0-1). The platforms are both 6-legged steel jacket Normally Unmanned Installations (NUIs), which were installed in 1987. Leman G has 12 production wells and stands in 20 m water depth. Gas is exported to from Leman G to Leman F via a 14-inch carbon steel export pipeline (2.7 km). Leman F has 14 production wells and stands in 35 m water depth. The gas is exported to Leman Alpha (A platform; Figure 0-2) via a 20-inch carbon steel export pipeline (4.8 km). Power is provided via umbilical cables from Leman Alpha to Leman F and from Leman F to Leman G.

Both NUIs are reaching their end-of-life, expected to cease production in the mid-2020s, and therefore are planned to be decommissioned, along with the associated pipelines and cables running between them and Leman Alpha (Figure 0-2).

Regulatory Context

The decommissioning of offshore oil and gas infrastructure on the UKCS is principally governed by the Petroleum Act 1998, as amended by the Energy Act 2008. The Petroleum Act sets out the requirements for a formal DP before the owners of an offshore installation or pipeline may proceed. The responsibility for ensuring that the requirements of the Petroleum Act 1998 are complied with rests with the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) which sits within the Department for Energy Security and Net Zero (formerly the Department for Business, Energy and Industrial Strategy (BEIS)). The Guidance describes a proportionate process that culminates in a streamlined EA Report to support a DP, which focuses on screening out non-significant impacts and a detailed assessment of potentially significant impacts.

The Guidance (OPRED, 2018) also states that surface installations (not subject to derogation) and subsea installations (e.g., manifolds, wellhead protection structures) must, where practicable, be completely removed for reuse or recycling or final disposal on land. With regards to pipelines (including flowlines and umbilicals), these should be considered on a case-by-case basis, and there are instances where pipelines could be decommissioned *in situ*. For example, pipelines that are adequately buried or trenched or which are expected to self-bury could be considered as candidates for *in situ* decommissioning. Where an Operator is considering decommissioning pipelines *in situ*, the decision-making process must be informed by 'Comparative Assessment' (CA) of the feasible decommissioning options to arrive at a preferred decommissioning solution. Finally, the Guidance states that mattresses and grout bags installed to protect pipelines should be considered for removal with the aim to achieve a clear seabed and for disposal onshore.

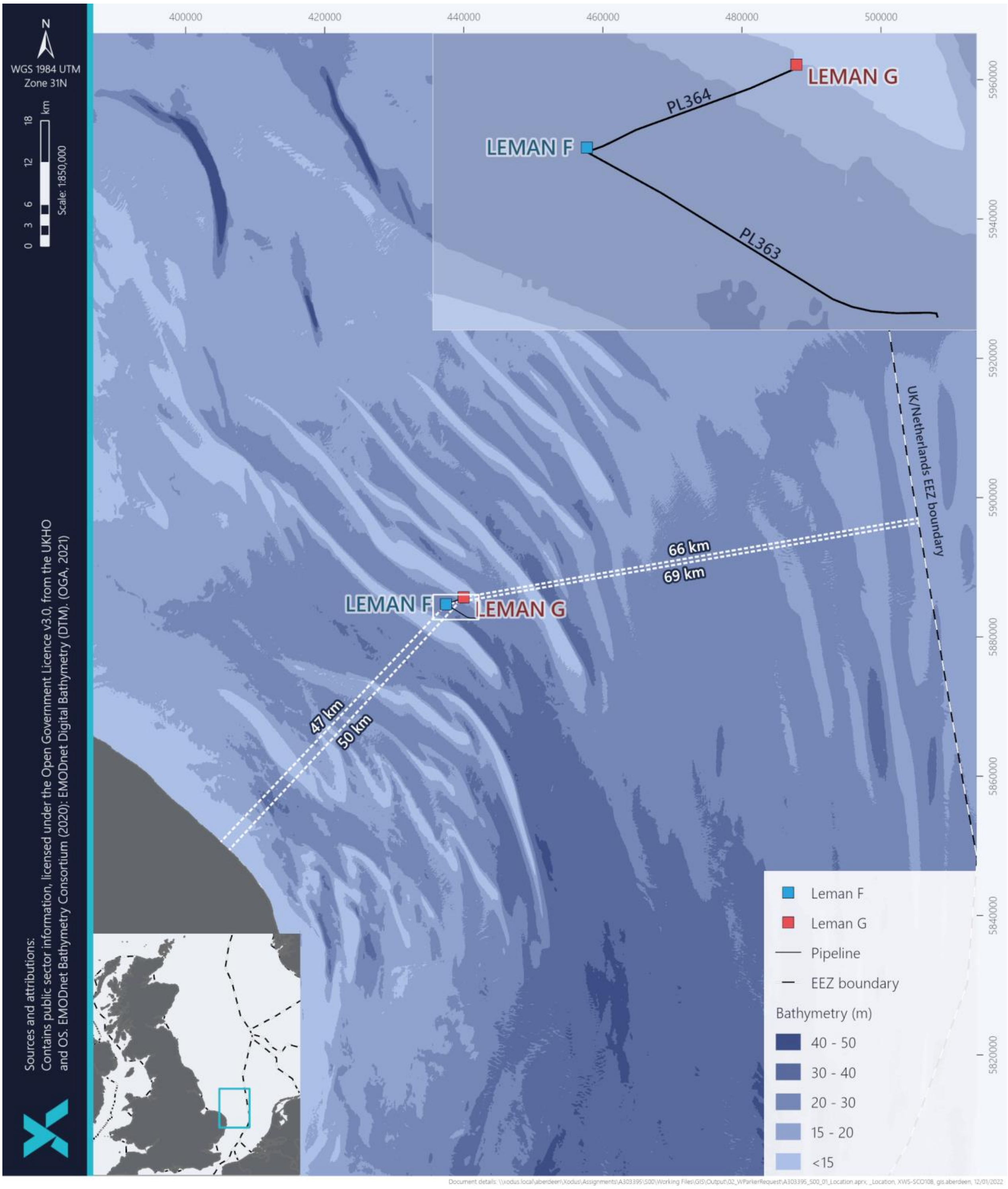

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Figure 0-1 Leman Field Location

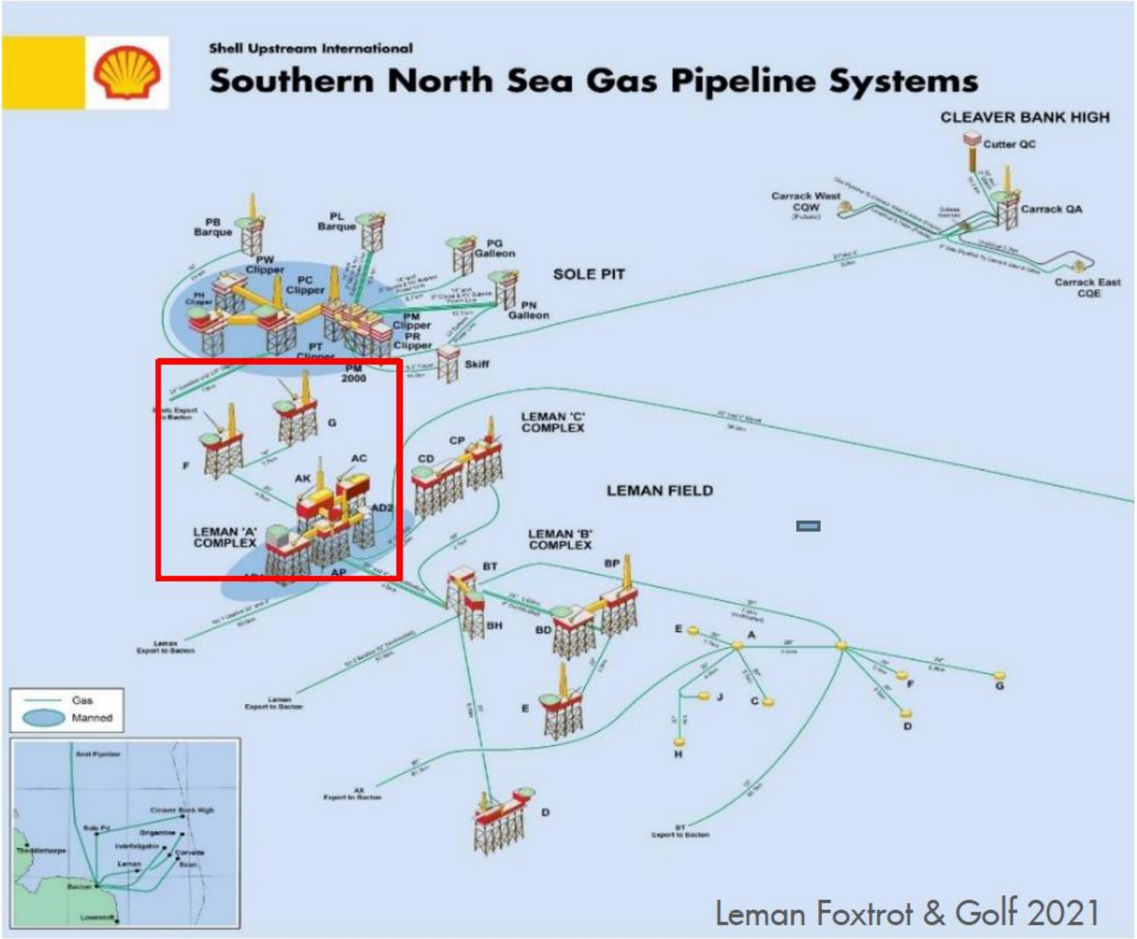

Figure 0-2 Leman Facilities and Pipelines Schematic

Decommissioning Overview

Proposed Schedule

The precise timing of the decommissioning activities is not yet confirmed and will be subject to market availability of decommissioning services and contractual agreements. The potential window for the Leman F & G NUIs decommissioning activity (including removals and onshore disposal) is between Q4 2025 and Q4 2028.

Options for Decommissioning

The Leman infrastructure was assessed for decommissioning against the Guidance Notes: Decommissioning of Offshore Oil and Gas Installations and Pipelines (OPRED, 2018). As prescribed by the Guidance, all installations will be removed and options for pipeline decommissioning have been considered through the CA process.

Each decommissioning option was assessed against five criteria – safety, environment, technical, societal and economic. The CA outlined the decommissioning options available for the various types of pipelines. The preferred option was to decommission the pipelines and cables *in situ* with cut pipeline ends remediated with rock. Stabilisation materials (including Linklok and frond mattresses and grout bags) will be removed from the seabed where it is technically feasible to do-so and in conjunction with discussion with OPRED.

Environmental and Societal Sensitivities

The key environmental and social sensitivities in the Leman Field area are summarised in Table 0-1.

Table 0-1 Environmental and societal receptors associated with the Leman area

Environmental receptors
Physical environment
Leman F and G are located in Block 49/26. The water depth across the surveyed area varies from approximately 20 m below Lowest Astronomical Tide ('LAT') to 49.7 m below LAT.
Protected areas and habitats of conservation importance
Both Leman F and Leman G are located within two conservation sites, the North Norfolk Sandbanks and Saturn's Reef Special Area of Conservation (SAC) and the Southern North Sea SAC. The North Norfolk sandbanks are the most extensive example of the offshore linear ridge sandbank type in UK waters. They are a representative functioning example of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time'. Leman F NUI is located in the trough between the Leman Bank (to the south) and the Ower Bank (to the north). Leman G NUI is located at the southern end of the Ower Bank. The North Norfolk Sandbanks and Saturn's Reef is also protected for Annex I 'Reefs'. The most recent Gardline (2021a) habitat assessment survey identified the presence of exposed or subcropping peat and clay largely corresponded with Ross worm (*S. spinulosa)* reefiness, most notably 1 – 1.5 km south-east of Leman F, where both were noted in highest density. This suggests that these relatively soft and stable clay and peat outcrop features provide an anchor point from which *S. spinulosa* can establish a reef, fed by a supply of nearby sand for tube building. The Southern North Sea SAC has been identified as an area of importance for harbour porpoise, an Annex II species. Other conservation sites that lie within 40 km of Leman platforms are the Haisborough, Hammond and Winterton SAC (10 km SSW), Greater Wash Special Protection Area (SPA) (29 km WSW) and Cromer Shoal Chalk Beds Marine Conservation Zone (MCZ) (41 km WSW). The UK Biodiversity Action Plan (UKBAP) listed priority habitat 'peat and clay exposures with piddocks' has been historically documented within the broader Leman field, in particular within the Leman A area (Fugro, 2019a) and patches of peat outcrops and peat clasts were recorded at Leman F. However, piddocks (clam-like shellfish) and piddock bores were not recorded, with the area unlikely to classify as the UKBAP priority habitat (Fugro, 2020a).
Conservation species
Harbour porpoise have been observed throughout the year within the vicinity of the Leman F and G platforms in variable densities. These sightings peak in the summer months (Reid *et al.*, 2003). The density of harbour porpoise in the project area is estimated to be 0.888 animals/km^2 (Hammond *et al.*, 2021). Harbour porpoise are Annex II listed species and European Protected Species (EPS). Other cetacean species are likely to be absent from the Leman area. Both grey and harbour seal densities are low (0.4 individuals per 25 km^2) across the Leman area due to its distance from shore (Russel *et al.*, 2017). Both seal species are Annex II protected species.

Benthic environment
The seabed around the Leman installations is considered to be made up of largely European Nature Information System (EUNIS) 'Circalittoral mixed sediment' (A5.44) and 'Circalittoral find sand' (A5.25). EUNIS 'Infralittoral fine sand' (A5.23) was found at the shallower stations within the survey area and of *S. spinulosa* reef were located, EUNIS A5.61 (Sublittoral polychaete worm reefs on sediment) was present. Sediment particle mean diameter identified the sediment to be mainly composed of moderate to well sorted medium sand to gravelly sand (Fugro, 2021a). The most abundant taxa were also some of the most dominant in the Leman G area. The amphipod crustacean was the most abundant and most dominant taxon recorded. The next most abundant taxa were polychaetes and amphipods. The remaining most abundant species identified in the survey included additional polychaetes, urchin, bivalve, crustacean and four amphipods (Fugro, 2019). At Leman F, the most abundant taxon overall were annelids. More than half of the dominant taxa reported within the current survey comprised polychaetes. The annelids found are typically an opportunistic order of bristle worms and are commonly found in the North Sea in a range of sediment types. Actiniaria were highly abundant throughout the survey; their presence being indicative of a shift to coarser sediments allowing for attachment of these taxa (Fugro, 2020b). The polychaetes found at Leman G, were also present in significant numbers at Leman F (Fugro, 2020b). Benthic epifauna were sparse across the survey area with Arthropoda, namely Crustacea, being the most abundant taxonomic group. Annelida, was the second most abundant taxonomic group (Gardline, 2021b). These results are to be expected considering the sediment type. Within areas of *S. spinulosa* reef formations epifauna were observed in lager numbers. Overall, the epifauna observed was typical of background conditions for SNS (Fugro, 2020a).
Fish
Leman F and Leman G are located in an area of high concentration spawning for plaice, cod, lemon sole, mackerel, Norway lobster and sandeels also use the area for spawning. Additionally, both installations are located in a high nursery intensity area for Cod. Herring, lemon sole, mackerel, Norway lobster, sandeels, sprat, tope shark, and whiting have nursery grounds near the project area Aires *et al.* (2014) provide modelled spatial representations of the predicted distribution of juvenile fish (less than one year old). The modelling indicates the presence of multiple juvenile species in Block 49/26 including: anglerfish, blue whiting, European hake, haddock, herring, mackerel, Norway Pout, plaice, sprat and whiting. The probability of juvenile aggregations across the project area is low for all species (<0.15).
Seabirds
The area surrounding Leman F and G is utilised by the following species at points in the year: sooty shearwater (*Puffinus griseus)*, Manx shearwater (*Puffinus puffinus)*, northern gannet (*Morus bassanus)*, pomarine skua (*Stercorarius pomarinus)*, Arctic skua (*Stercorarius parasiticus)*, great skua (*Stercorarius skua)*, black-legged kittiwake (*Rissa tridactyla)*, little gull (*Larus minutes),* great black-backed gull (*Larus marinus)*, common gull (*Larus canus)*, lesser black-backed gull (*Larus fuscus)*, herring gull (*Larus argentatus),* sandwich tern (*Sterna sandvicensis)*, common tern (*Sterna hirundo)*, Arctic tern (*Sterna paradisaea)*, common guillemot (*Uria aalge)*, razorbill (*Alca torda)* and Atlantic puffin (*Fratercula arctica;* Kober *et al.*, 2010). In recent years, there has been an increase in the number of seabirds utilising offshore installations for nesting. Opportunistic species such as kittiwake and herring gull are utilising artificial nest

locations and successfully rearing chicks. In some instances, colonies of several hundred birds have established and return each year. Currently there are no birds utilising either NUI's as a nesting site however this will continue to be monitored moving forward.

The Seabird Oil Sensitivity Index (SOSI) identifies areas at sea where seabirds are likely to be most sensitive to surface pollution (Webb *et al*., 2016). Seabird sensitivity to oil within Block 49/26 varies throughout the year, from low in the summer months (May-September) to extremely high in January and February (Webb *et al*., 2016).

Societal receptors

Commercial fisheries

The North Sea is one of the world's most important fishing grounds (CEFAS, 2001). The southern North Sea sector however provides a relatively low contribution to the commercial fishery compared to areas such as the northern North Sea and west of Scotland (MMO, 2017). In addition, there are fewer key ports located along the east coast of England (MMO, 2017).

The Leman NUIs are situated within International Council for the Exploration of the Sea (ICES) Block 35F2 which is an area of moderate fishing activity (targeted by both UK and international vessels). The most frequently used gear type in ICES Rectangle 35F2 is trawls, specifically beam trawls. Both shellfish and demersal species are targeted however, demersal value far exceeds that of shellfish, comprising 3% and 97% respectively of the average landings value from 2016 to 2020, with the dominant species caught including plaice, turbot and sole (MMO, 2021). Pelagic species have only recorded landings and therefore value within the years 2017 and 2020, however these values are still negligible accounting for <0.01% of the average landings value from 2016 to 2020.

Other sea users

Shipping activity within Block 49/26 is considered to be high (OGA, 2016). There are multiple surface installations within 40 km of Leman F and Leman G; the closest to both being Leman AD1 platform operated by Shell (3 km ESE from Leman F and 5 km SE from Leman G).

The nearest active cable is located 22 km ENE of the Leman platforms. There are some historic cables in the vicinity of the project location – though disused, sections of these cables may remain on the seabed. Block 49/26 does not lie within training ranges that are areas of concern to the MoD (OGA, 2019). There are no renewable energy sites within 40 km of the project area. The nearest wreck is located approximately 4 km ENE of the project area and is classified as non-dangerous.

Impact Assessment

The environmental impact assessment has been informed by a number of different processes, including identification of potential environmental issues through project engineer and marine environmental specialist led Environmental Identification (ENVID) workshop and scoping consultation with key stakeholders.

Impact Assessment during the ENVID workshop addressed the proposed decommissioning activities and any potential impacts these may pose. This discussion identified eleven potential impact areas based on the chosen proposed removal method. Five potential impacts were screened out of further assessment based on the low level of severity, or low likelihood of significant impact occurring and six were carried forward for further assessment. An overview of the potential impacts is provided in Table 0-2, together with justification statements for the screening decisions.

Table 0-2 Environmental Impact Screening Summary

Environmental/ Social Aspect	Further Assessment?	Rationale
Emissions to air	Yes	To account for potential venting of gas in combination with other emissions
Energy consumption	No	Limited raw materials required (largely restricted to vessel fuel use).
Waste materials	No	Well-controlled waste management process
Onshore impact	**No**	Established port infrastructure, dismantling sites and disposal routes will be used
Physical presence (seabed)	**Yes**	Snagging Risk for fisheries/ stakeholder concern
Physical presence (sea surface)	**No**	Vessel presence during decommissioning is not expected to be higher than operational levels Vessel (including fishing vessel) density in the immediate Leman area is very low
Noise and vibrations	**No**	Noise would be derived from vessels and mechanical cutting operations. Neither of these are perceived to be significantly damaging to the marine mammals or fish in the Leman area.
Discharges to sea	**No**	To be considered under the individual permit consent applications for the decommissioning activities through the Portal Environmental Tracking System (PETS)
Seabed disturbance	**Yes**	Multiple seabed activities requiring quantification:
Disturbance to nesting seabirds	Yes	No evidence of nesting birds to date on NUIs, however a monitoring plan should be in place prior to commencement of decommissioning activity.
Accidental events	**Yes: Vessel Collision** **No: Dropped objects**	**Vessel Collision:** Low likelihood but high magnitude scenario deemed to require further investigation **Dropped Objects:** Dropped object procedures are industry-standard and there is only a very remote probability of any interaction with any live infrastructure. The in-situ decommissioning of some infrastructure will also limit the potential for dropped objects or dislodged materials/objects.

Conclusions

Having reviewed the project activities within the wider regional context and taking into consideration the mitigation measures to limit any potential impacts, the findings of this EA conclude that the activities do not pose any significant threat to environmental or societal receptors within the UKCS.

This EA has also considered the relevant Marine Plans, adopted by the UK Government to help ensure sustainable development of the marine area. Shell consider that the proposed decommissioning activities are in alignment with its objectives and policies.

1. INTRODUCTION

In accordance with the Petroleum Act 1998, Shell U.K. Limited (Shell), an established United Kingdom Continental Shelf (UKCS) operator and on behalf of the Section 29 notice holders, is applying to the Department for Energy Security and Net Zero to obtain approval for decommissioning the Leman Foxtrot (F) and Leman Golf (G) topsides and jackets and the subsea infrastructure associated with both NUIs.

This Environmental Appraisal (EA) has been conducted to assess the potential environmental impacts that may result from undertaking the activities as part of the decommissioning of the Leman topsides, jackets and associated pipelines, cables and protective materials. This EA supports the combined Decommissioning Programmes (DPs) submitted to the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED), the offshore decommissioning regulator under the Department for Energy Security and Net Zero.

1.1. Background

The Leman F and Leman G platforms are both 6-legged steel jacket Normally Unmanned Installations (NUIs), installed in 1987. Leman G has 12 production wells and stands in 20 m water depth. Gas is exported to Leman F via a 14-inch carbon steel export pipeline (2.7 km). Leman F has 14 production wells and stands in 35 m water depth. The gas is exported to Leman A (Alpha platform; Figure 0-2) via a 20-inch carbon steel export pipeline (4.8 km). Power is provided via umbilical cables from Leman A to Leman F and from Leman F to Leman G. Both NUIs are reaching their end-of-life, expected to cease production in the mid-2020s, and therefore are planned to be decommissioned, along with the associated pipelines and cables running between them and towards Leman A (Figure 1-1).

1.2. Location

Leman F and Leman G NUIs and their associated pipelines and cables, are located within block 49/26 of the southern North Sea (SNS) and situated approximately 47 km from the UK coastline and 66 km from the UK / Netherlands European Economic Zone (EEZ) boundary line. Both Leman F and Leman G are located within the two conservation sites, the North Norfolk Sandbanks and Saturn Reef Special Area of Conservation (SAC) and the Southern North Sea SAC. Leman F NUI is located in the trough between the Leman Bank (to the south) and the Ower Bank (to the north). Leman G NUI is located at the southern end of the Ower Bank (Figure 1-1).

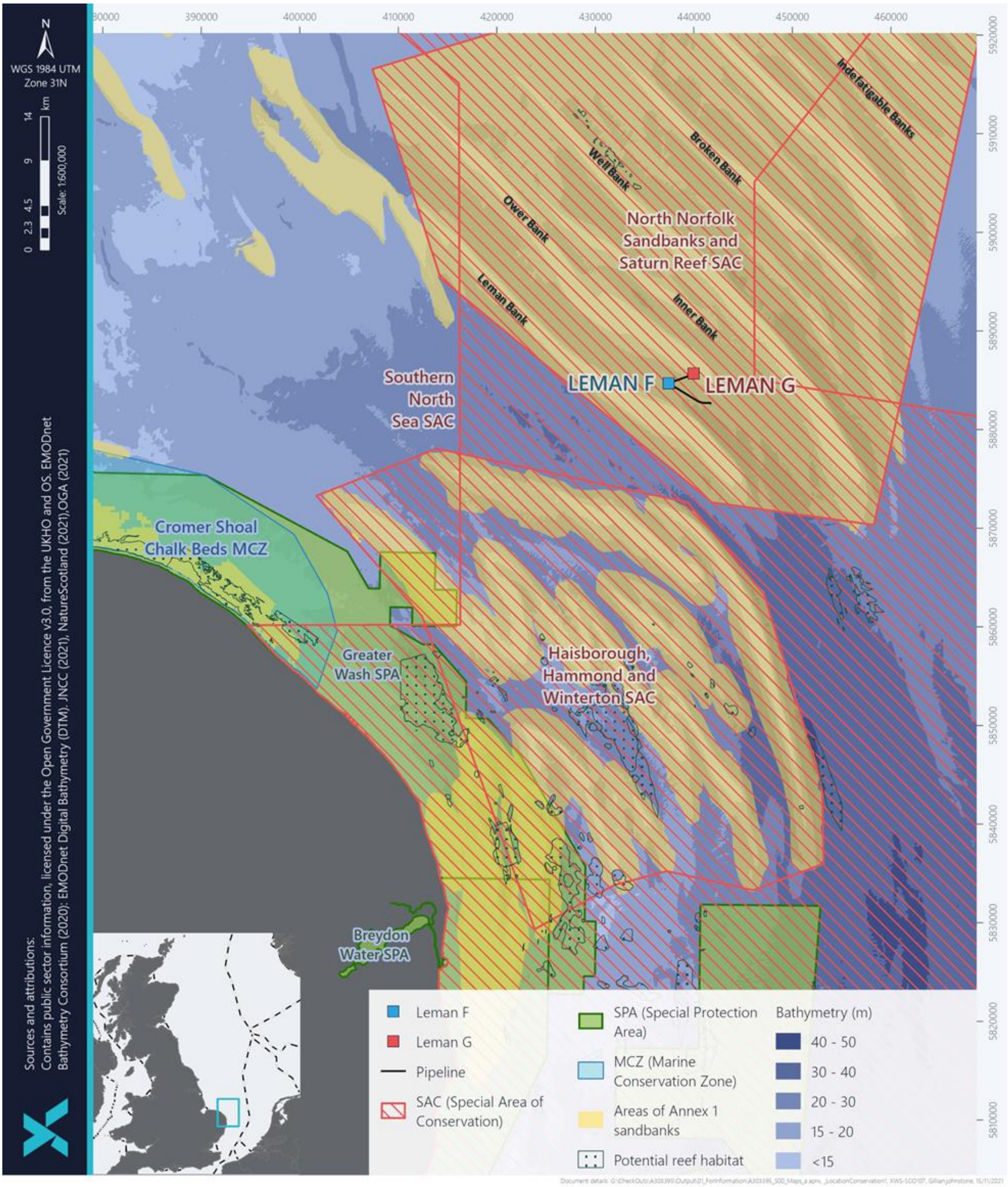

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Figure 1-1 Leman Field location

1.3. Regulatory context

The decommissioning of offshore oil and gas installations and pipelines on the UKCS is controlled through the Petroleum Act 1998. Decommissioning is also regulated under the Marine and Coastal Act 2009 and Marine (Scotland) Act 2010. The UK's international obligations on decommissioning are primarily governed by the 1992 Convention for the Protection of the Marine Environment of the Northeast Atlantic ('the Oslo Paris (OSPAR) Convention'). The responsibility for ensuring compliance with the Petroleum Act 1998 rests with the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED), part of the Department for Energy Security and Net Zero.

1.3.1. Decommissioning Programme

The Petroleum Act 1998 requires the operator of an offshore installation or pipeline to submit a draft DP for statutory and public consultation, and to obtain approval of the DP from OPRED before initiating decommissioning work. The DP must outline in detail the infrastructure being decommissioned and the method by which the decommissioning will take place.

OPRED (2018) Guidance states that subsea installations (e.g. protective structures, production manifolds) must, where practicable, be completely removed for reuse, recycling or final disposal on land. The Guidance states that any piles used to secure such installations in place should be severed below the natural seabed level at such a depth to ensure that any remains are unlikely to become uncovered. Operators should aim to achieve a cut depth of 3m below the natural seabed level, however consideration will be given to the prevailing seabed conditions and currents and this should be detailed in the DP and discussed with OPRED. The Guidance also states that mattresses and grout bags installed to protect pipelines should be removed for disposal onshore if their condition allows. If the condition of the mattresses or grout bags is such that they cannot be removed safely or efficiently, any proposal to leave them in place must be discussed with OPRED.

With regards to pipelines, (including umbilicals and cables), these should be considered on a case-by-case basis. The guidance provides general advice regarding removal for two categories of pipelines:

- For small diameter pipelines (including flexible flowlines and umbilicals) which are neither trenched nor buried, the guidance states that they should normally be entirely removed; and
- For pipelines covered with rock protection, the guidance states that these are expected to remain in place unless there are special circumstances warranting removal.

1.3.2. Comparative Assessment

The Guidance also highlights instances where pipelines could be decommissioned *in situ*. For example, pipelines that are adequately buried or trenched or which are expected to self-bury could be considered as candidates for *in situ* decommissioning. Where an Operator is considering decommissioning pipelines *in situ*, the decision-making process must be informed by Comparative Assessment (CA) of the feasible decommissioning options. The CA takes account of safety, environmental, technical, societal and economic factors to arrive at a preferred decommissioning solution.

1.3.3. Environmental Appraisal

Under the OPRED Guidance Notes, Decommissioning of Offshore Oil and Gas Installations and Pipelines (OPRED, 2018) under the Petroleum Act 1998, the DP should be supported by an EA.

The Guidance sets out a framework for the required environmental inputs and deliverables throughout the approval process. The guidance outlines that an EA should be a document providing necessary content in proportion to the complexity and magnitude of a project and should carry forward the emerging option from a CA. Decom North Sea's Environmental Appraisal Guidelines for Offshore Oil and Gas Decommissioning provide further definition on the requirements of EA Reports (Decom North Sea, 2018a). Shell will use a risk assessment process in line with the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment/ EIA) Regulations 2020, to assess the potential environmental impact of the decommissioning activities.

In terms of activities in the SNS, The East Offshore Marine Plan has been developed by the Department for Environment, Food and Rural Affairs (Defra) to help ensure sustainable development of the marine area beyond 12 nautical miles. Although the Plan does not specifically address decommissioning of oil and gas, it does note the challenges that such activities can introduce. Shell will ensure activities are considered in line with the key objectives of the Plan during the project decision making process, which aim ensure the sustainable development of the marine area whilst respecting the needs of local communities and protecting the marine ecosystem (Defra, 2014). As part of the conclusions to this assessment (Section 6), Shell has considered the broader aims of the Plans and made a statement on alignment with the aims.

1.4. Environmental Appraisal Approach

This EA report sets out to describe, in a proportionate manner, the potential environmental impacts of the proposed activities (including the emerging options from CA) associated with decommissioning of the Leman infrastructure and to demonstrate the extent to which these can be mitigated and controlled to an acceptable level. An overview of the impact identification and assessment process is provided in Figure 1-2 in context with the CA component and in parallel with the overall project concept, definition and design with underlies the DP. Stakeholder consultation is an important ongoing process lasting for the duration of the overall project. The results of this interaction also drive decision making during the impact assessment. Formal stakeholder consultation will begin with the submission of the draft DPs (supported by this EA report) to OPRED.

The impact identification and assessment process also includes the results of supporting studies and surveys, the outcome of the ENVID (based on expert judgement) and experience from similar decommissioning projects undertaken on the UKCS.

1.4.1. EA Scope and Structure

The EA report sets out to describe the potential environmental impacts of proposed activities associated with decommissioning of the Leman infrastructure and aims to demonstrate the extent to which these impacts can be mitigated and controlled to an acceptable level. This is presented in the following sections, which will cover:

- The process by which Shell has arrived at the selected decommissioning strategy and a description of the proposed decommissioning activities (Section 2);
- Description of the environment and identification of the key environmental sensitivities which may be impacted by the proposed decommissioning activities (Section 3);
- A review of potential impacts from the proposed decommissioning activities and justification for the assessments that support this EA (Section 4);
- Assessment of the key environmental impacts (Section 5); and
- Conclusions (Section 6).

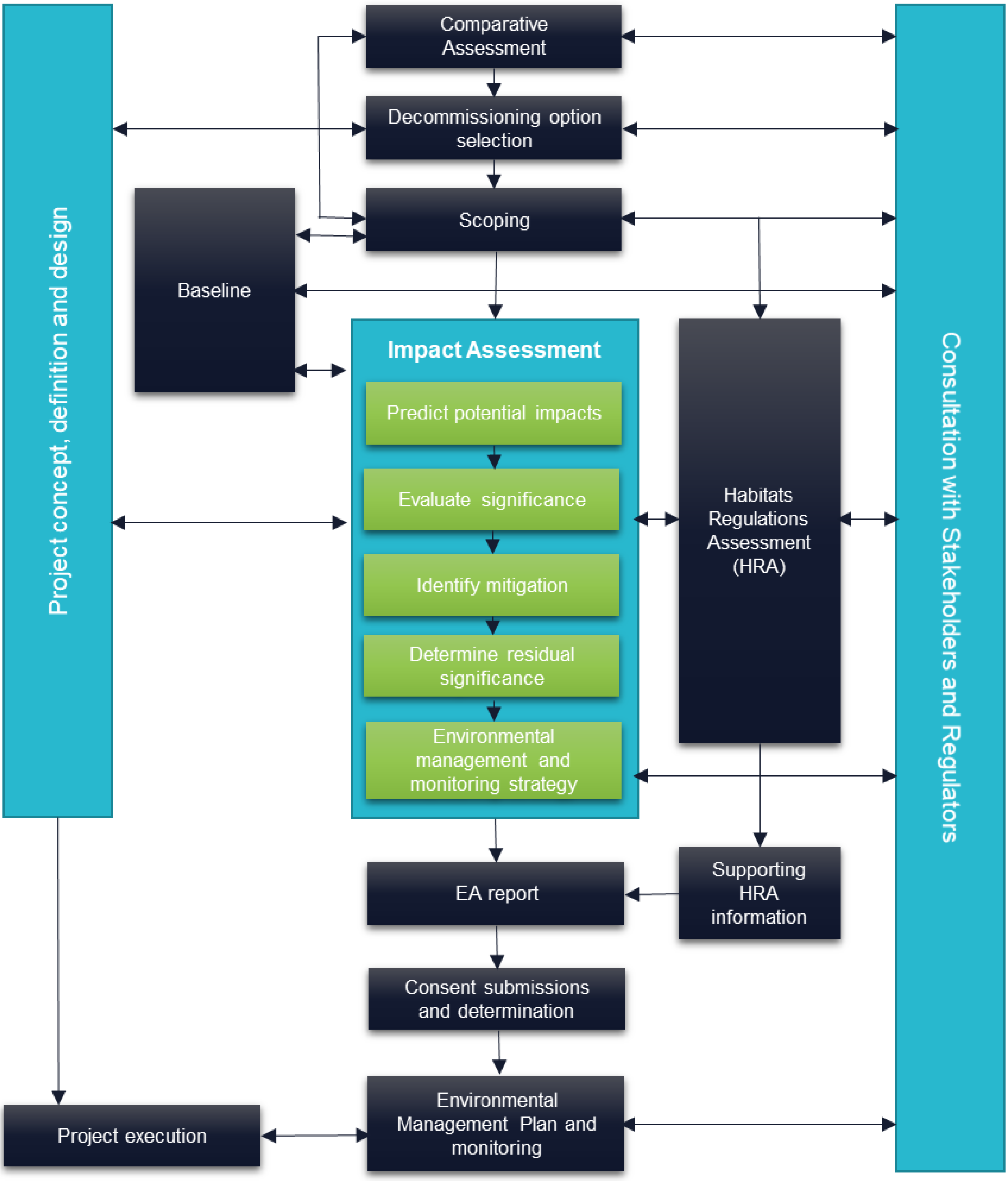

Figure 1-2 The EA/ impact assessment process

1.4.2. Informal Stakeholder engagement

Key stakeholder concerns have been reviewed and taken into account in defining potential impact significance. An overview of stakeholder interests, concerns and opinions gathered through informal consultation, CA workshop feedback and scoping report responses are listed in Table 1-1, alongside Shell's proposed response/ course of action.

Table 1-1 Stakeholder feedback to-date

Stakeholder	Date	Stakeholder Feedback	Shell Response
National Federation of Fishermen's Organisations (NFFO)	24/08/2021	1. Recommended to avoid installation of frond mattresses 2. NFFO highlighted concerns with pipeline removal causing seabed debris 3. NFFO advised concerns with additional rock as protective measure for pipeline ends - scouring	1. Shell do not intend to install frond mattresses 2. Shell will undertake a clear seabed verification survey following all decommissioning activity to ensure there is no residual risk to other sea users 3. Any rock placement will be minimized to pipeline end remediation and will be assessed in the context of current seabed movement in the local area prior to installation
Centre for Environment, Fisheries and Aquaculture Science (CEFAS)	24/08/2021	1. If there are chemicals in the jacket legs, these would have to be risk assessed 2. CEFAS want to see risk assessment on chemical in the well annulus if these need to be discharged	1. Shell can clarify that the are no chemicals stored in the jacket legs 2. Risk assessments will be undertaken as part of the permitting process under the well decommissioning scope of work
Joint Nature Conservation Committee (JNCC)	04/10/2021 29/04/2022 (Scoping response)	1. The condition of the *S. spinulosa* reef in this area is the best of the SAC 2. JNCC feel it would be beneficial to specify what infrastructure has been grouped under "Substructure	1. Shell is very aware of the good condition of reef in this area and have considered this throughout the decision-making process, to ensure the minimisation of impact on the reef. Shell will also be applying the biodiversity

Stakeholder	Date	Stakeholder Feedback	Shell Response
		removal (dredging and cutting activities)". The removal of infrastructure from the seabed and localised dredging activities will result in temporary seabed disturbance, and therefore we would expect to see this scoped in for further assessment. 3. JNCC agree with the aspects scoped out of further assessment in the scoping report 4. [JNCC] request that maps are included clearly showing all survey stations and transects in the context of proposed operations and highlighting the locations of any features of conservation interest recorded [within the EA]. 5. [JNCC] take this opportunity to request Shell UK give sufficient consideration to Conservation Objective 3 Southern North Sea SAC. 6. As OPRED no longer support the use of chain mats for over-trawl in environmentally-designated sites, we assume that non-intrusive methods will be used, however request that this, and the methods to be used, are clarified in the upcoming EA. 7. Should rock deposits be required we would welcome detailed commentary on these operations to allow further understanding of their actual nature conservation impact. 8. JNCC considers is best practice to consider the impacts of the realistic worst-case scenario of each decommissioning option, to enable a meaningful assessment of the full environmental impacts of a project.	action hierarchy of 'Avoid, Minimise, Restore and Offset'. 2. The Aspects and Impacts table presented in the scoping report (and Appendix B) has since been updated to specify the NUIs as the 'substructures' and to include this aspect for further consideration as part of the 'Seabed disturbance' impact assessment (Section 5.3). 3. Noted. 4. Figure 3-1 provides an overview of the survey stations and transects. Further information on the conservation interests in the area is provided throughout Section 3. 5. Shell have considered the conservation objects of the Southern North Sea SAC within the impact assessment (Table 3-4). 6. Non-intrusive verification techniques will be used to confirm that the seabed is clear of snag hazards (e.g. berms, dropped objects etc), such as side scan sonar (SSS) and Remotely-Operated Vehicle (ROV) surveys. The chosen method of verification will be agreed with OPRED. 7. Shell have outlined the approach to rock placement in Section 5.3.2.4 8. Where there are uncertainties, Shell has taken a precautionary approach and has presented a

Stakeholder	Date	Stakeholder Feedback	Shell Response
		9. JNCC suggest that the impacts of the proposed operations are assessed alongside approved developments under constructions, developments that have not yet commenced construction and other decommissioning operations for which information is available, specifically in relation to cumulative impacts on both the North Norfolk Sandbanks and Saturn Reef SAC and the Southern North Sea SAC.	realistic worst-case scenario for the impact of decommissioning activities. 9. Shell have considered the cumulative impacts of the decommissioning activities throughout the Impact Assessment (Section 5) and have specifically considered the impact of other oil and gas and renewables activity in Section 5.3 in the context of Norfolk Sandbanks and Saturn Reef SAC/ Southern North Sea SAC.
Department for Energy Security and Net Zero (EMT & ODU)	24/11/2020 13/10/2021 03/05/2022 (Scoping response)	1. Include as much detail as possible 2. Align timing of DP, CA and EA submission 3. Look at other options other than overtrawl for the 500m safety exclusion zone 4. OPRED agree with the aspects to be scoped out with the exception of *Nesting Seabirds,* due to the potential for nesting seabirds post CoP (reduced activity and noise). [OPRED] would advise Shell reconsider this position.	1. Shell have endeavoured to include as much detail as possible within this EA. 2. Timing of submission will be aligned. 3. Non-intrusive verification techniques will be used in the first instance to confirm that the seabed is clear of snag hazards (e.g. berms, dropped objects etc), such as SSS and ROV surveys. The chosen method of verification will be agreed with OPRED. 4. Shell have included an approach to bird survey and management techniques in Section 5 of this EA.
NSTA (formerly OGA)	14/10/2020 13/04/2021 23/09/2021	1. Guidance provided on cessation of production (CoP) document and Supply Chain Action Plan (SCAP) templates 2. Positive feedback on collaboration efforts	1. Noted with thanks 2. Noted with thanks

2. PROJECT DESCRIPTION

This section outlines the infrastructure being decommissioned as part of the Leman F and G decommissioning project and describes the decommissioning approach for the various assets. The location of the Leman F and G infrastructure in context with the Leman Field (and associated infrastructure) can be seen in Figure 2-1.

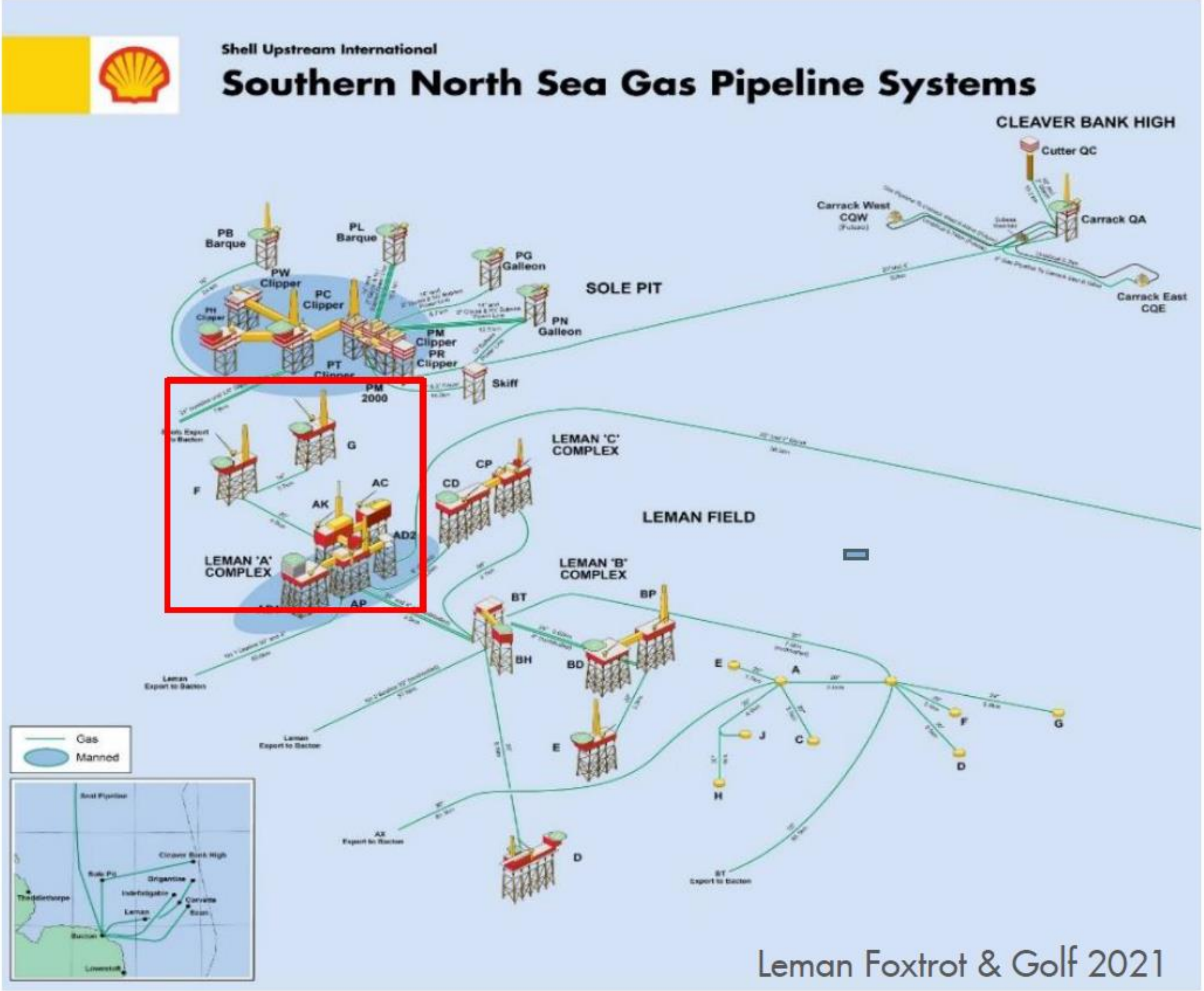

Figure 2-1 Overview of the Leman infrastructure

NUIs

Table 2-1 summarises the Leman F and G NUI components.

Table 2-1 Leman F & G Facilities

	Leman F	Leman G
Water depth (m)	35	22
Wells	14	12
Number of piles	6	6
Total weight (Te)*	4,104	4,042

*Includes topsides, jacket and pile weight

2.1. Pipelines

Table 2-2 summarises the Leman F and G pipelines and umbilicals. The Leman F & G pipelines and cables (PL363, PL364, PL5147 and PL5148) were installed in 1986. Both the pipelines and cables were trenched and buried on installation, achieving a target burial depth of ~1 m depth-of-cover. Over the course of operations, regular surveys have identified areas of lower depth-of-cover including exposures and some non-reportable spans, particularly at the platform tie-in locations.

There are no third-party pipeline crossings associated with the Leman F & G pipelines and umbilicals; although the lines do cross each other on approach to Leman G, Leman F and Leman A. Rock cover is in place at several point along the length of PL364 with a total length of 67 m. The approximate exposure and freespan lengths are based on data from a Gardline (2021a) pipeline survey report and are presented here as preliminary indicators of burial status. A more detailed outline of the burial status of these pipelines will be available in due course, but it should be noted that none of the freespans exceed the Kingfisher reportable thresholds of >10 m long and >0.8 m in high. In line with the OPRED (2018) Guidance, a CA of the feasible pipeline decommissioning options has been undertaken (Section 2.4).

Table 2-2 Leman F & G Pipelines and Umbilicals

Name	Diameter (inch)	Approx. Length (m)	Exposures (m)	Freespans (m)	Total exposed (m)*	% exposed
Leman F to Leman A Production Pipeline (PL363)	20	4,800	475	36	511	11
Leman A to Leman F Cable (PL5148)	4	4,800	406	24	430	6
Leman F to Leman G Production Pipeline (PL 364)	14	2,700	164	0	164	9
Leman F to Leman G Cable (PL5147)	4	2,700	126	22	148	5

*These lengths include exposures following trench transition (i.e. adjacent to Leman AK, F and G platforms)

2.2. Mattresses, Grout Bags and Stabilisation Features

Prior to installing the tie-in spools between the main pipelines (PL363 and PL364) and the four risers at Leman A (one riser), Leman F (two risers) and Leman G (one riser), Shell installed seabed stabilisation mattresses. These consist of a number of LinkLok mattresses shackled together to form a stable surface on which the tie-in spools were to be laid and the dimensions are provided in Table 2-3. The mattresses were installed in pairs, before being shackled together subsea into larger surfaces up to 100 m long. The mattresses consist of polyethylene segments cast on a synthetic rope network and filled with high density concrete mix.

Grout bags have been installed in conjunction with the mattress arrangements and at specific locations to support the tie-in spools and mitigate against pipeline scouring. A number of frond and bitumen mattresses were also installed alongside and over the surface-laid sections of tie-in spools to mitigate against pipeline scouring. The only known area of rock dump associated with the pipelines and cables is installed at the Leman G tie-in flange to mitigate against pipeline scouring. The volume is unknown at this stage and so is conservatively estimated at 100 Te (Table 2-3).

There are three crossings of note associated with the Leman pipelines, including various stabilisation features which are also presented in Table 2-3:

- PL363 (Leman A to F Power Cable) is crossed by PL5148 approximately 300m from the Leman A Platform, within its 500m safety zone. PL363 is buried at this location.
- PL363 is also crossed by PL5147 approximately 20m from the Leman F Platform, within its 500 m safety zone. The crossing consists of a roller-bridge installed over PL363.
- PL364 (Leman F to G Power Cable) is crossed by PL5147 approximately 350 m from the Leman G Platform, within its 500 m safety zone. PL364 is buried at this location.

Table 2-3 Pipeline stabilisation

Location	Item(s)	Quantity	Weight per item (Te)	Dimensions per item (m)
Tie-in to Leman A	LinkLok mattresses	14.5	11.4	10 x 2.5
	Large grout supports (SS50)	2	1.8	0.5 x 1.3 x 2.3
	Frond mattresses	4	8	5 x 5
	Bitumen mattresses	6	6	5 x 2
	Large grout bags	12	0.5	2 x 2
	Small grout bags	100	0.025	0.5 x 0.5
PL5148 crossing of PL363	LinkLok mattresses	2	11.4	10 x 2.5
	Bitumen mattresses	3	6	5 x 2
	Frond mattresses	2	8	5 x 5
Tie-in to Leman F	LinkLok mattresses	23.5	11.4	10 x 2.5
	Large grout supports (SS50)	3	1.8	0.5 x 1.3 x 2.3
	Large grout support (FB75)	1	2	0.75 x 1.5 x 1.5
	Large grout support (FA50)	1	1.6	0.5 x 2 x 1.5
	Frond mattresses	1	10	7.5 x 5
		3	8	5 x 5

Location	Item(s)	Quantity	Weight per item (Te)	Dimensions per item (m)
	Small grout bags	200	0.025	0.5 x 0.5
PL5147 crossing of PL363	Concrete roller-bridge	1	13.2	3.2 x 2.2 x 1.3
	Small grout bags	25	0.025	0.5 x 0.5
PL5147 crossing of PL364	LinkLok mattresses	2	11.4	10 x 2.5
	Bitumen mattresses	3	6	5 x 2
	Frond mattresses	2	8	5 x 5
	Small grout bags	25	0.025	0.5 x 0.5
Tie-in to Leman G	LinkLok mattresses	11	11.4	10 x 2.5
	Frond mattresses	2	10	7.5 x 5
		3	8	5 x 5
	Bitumen mattress	1	6	5 x 2
	Rock placement	unknown	100	unknown
	Large grout supports (SS75)	2	2.8	0.75 x 1.4 x 2.5
	Small grout bags	110	0.025	0.5 x 0.5

2.3. Consideration of alternatives and selected approach

2.3.1. Alternatives to decommissioning

The Leman Field will continue to be produced through the other Leman platforms (A, B, C, D and E). The area around Leman F and G has poorer reservoir properties compared to the other parts of the Leman Field. As a result, the production performance of the F and G wells is lower compared to the other wells in the field. Liquid loading issues require the wells to be closed in for long pressure build ups, resulting in low uptimes or being unable to produce at all.

Foam has been injected to lighten the liquid column in the wells which helped sustain production for many years, but due to pressure decline this Well Reservoir Facility Management (WRFM) solution is no longer feasible. In 2012/2013, Shell performed an economic screening exercise to assess the viability of velocity string installation at Leman F. All candidate wells were screened out for economic reasons at the time and, due to the increasing age of the wells and increasing stringency of assessment criteria, has not been considered a credible option since.

Shell undertook an integrated study to identify and assess all future opportunities pertaining to the Leman F and G facilities. A summary of the options identified and the rationale for not proceeding is provided below.

2.3.1.1. Exploration Opportunities

Currently there are no nearby field developments that could be produced through the Leman F and G platforms. If, in the future, other (third-party) fields in the vicinity of the Leman Field are identified, tie-in directly to the Leman A Complex and associated export pipelines is the most likely option to be considered. It is therefore Shell's view that the removal of these facilities has no impact on future tie-in opportunities.

2.3.1.2. Development Opportunities

Due to the pressure depletion in the Leman Field as a result of historical production, there is no longer a drilling window to drill new wells into the Leman Field. Therefore, there are no plans to drill new wells into the Leman Field and no material development opportunities are within drilling reach of Leman F or G.

2.3.1.3. New Energy or Energy Transition Opportunities

There are currently no reuse opportunities for the F and G facilities. No energy transition opportunities have been identified requiring the Leman F and G facilities, pipelines or parts thereof. Any re-use of the facilities would require significant fabric maintenance to extend safe production beyond the end of 2023, making any re-use opportunities very unlikely.

2.3.1.4. Re-Use Opportunities

In accordance with the North Sea Transition Authority (formerly the OGA) Stewardship Expectation 11 (NSTA, 2021), specifically article D28, and informed by the OGA's UKCS Energy Integration Report (OGA, 2020a), Shell has considered re-use opportunities for the various elements of Leman F and G infrastructure. A summary of these considerations is provided below, outlining why no feasible re-use opportunities have been identified and therefore Shell intends to proceed with decommissioning the facilities.

2.3.1.4.1. Reservoir and Wells

One credible re-use opportunity for the Leman reservoir was identified – as a repository for Carbon Capture Utilisation and Storage (CCUS) opportunities. Shell is seeking approval to cease production from Leman F and G only, hydrocarbon production from the Leman reservoir will continue from other installations operated by both Shell and Perenco. CO_2 injection at the Leman F and G sites would be likely to migrate through the reservoir, increasing CO_2 through the remaining producing wells in the Leman Field, negatively impacting sales gas quality and increasing the risk of wells, pipeline and facilities integrity issues. Therefore, suitability of the Leman reservoir for CCUS can only be properly considered when all wells have ceased production from the Field. Decommissioning of the Leman F and G facilities does not preclude any re-use opportunities of the reservoir for CCUS in future.

2.3.1.4.2. Pipelines

One credible re-use opportunity for the Leman Foxtrot and Golf pipelines was identified – to support injection of CO_2 into the Leman reservoir as part of a CCUS Project. As detailed above, CCUS opportunities at Leman can only be considered when the other producing wells have ceased production. The Leman Foxtrot and Golf pipelines connect the Foxtrot and Golf facilities to the Leman Alpha hub – there are no to-shore export pipelines within this scope. Therefore, decommissioning of the Leman Foxtrot and Golf pipelines does not preclude any re-use of the Field for CCUS opportunities in future.

2.3.1.4.3. Topsides and Jacket

One credible re-use opportunity for the Leman F and G facilities was identified – potential re-use of the jackets to support windfarm installation. Windfarm opportunities are becoming economically feasible without subsidies when conducted at scale to reduce installation and operating costs. Re-use of the F and G jackets as windfarm hosts is therefore not viable as each jacket would be able to support only one mill. Re-use of an aging jacket for a single mill was uneconomical both for Capital Expenditure (CAPEX) installation costs and higher Operating Expenses (OPEX) maintenance costs during operation.

Any other re-use opportunities for the F and G topsides were discounted due to the limited remaining design life of the facilities. One of the main drivers to cease production from the Leman F and G facilities is cost of the significant fabric maintenance scope that would be required to maintain the topsides in a safe, accessible manner. This same driver would also apply to any potential re-use opportunities.

2.3.2. Platform decommissioning

As a Contracting Party of the Convention for the Protection of the Marine Environment of the North-East Atlantic ('OSPAR'), the UK has agreed to implement OSPAR Decision 98/3, which prohibits leaving offshore installations wholly or partly in place. The legal requirement for Operators to comply with the OSPAR Convention is affected through the Petroleum Act 1998 (as amended by the Energy Act 2008), the Guidance Notes for which outline the expectations of the UK regulator in terms of complying with the relevant OSPAR decisions. OSPAR Decision 98/3 states that the topsides of all installations should be returned to shore and that all jackets with a weight of less than 10,000 tonnes (Te) are completely removed for reuse, recycling or final disposal on land. The Leman F and G jackets both weigh less than 10,000 Te, therefore in compliance with OSPAR Decision 98/3, the topsides and jackets will be fully removed and disposed of appropriately onshore.

2.3.3. Mattresses

All the mattresses installed in association with the Leman F and G pipelines and cables have become buried beneath the seabed sediment. The latest available survey of the lines was unable to identify the location of any mattress along the pipeline route. The integrity of the mattresses is therefore unknown.

Installed in 1986, the Linklok mattresses were shackled together subsea to form large stable 'platforms' on which to lay the tie-in spools. In the intervening 35 years, marine growth and significant seabed sediment deposits have buried the mattresses and tie-in spools. As per the OPRED (2018) Guidance, Shell aim to achieve complete removal of the mattresses by whatever means would be most practicable and acceptable from a technical perspective. Where technical and safety concerns complicate this process, Shell will liaise with OPRED in the first instance to discuss the best course of action.

2.3.4. Grout bags

Ordinarily, the intention would be to leave all fully buried grout bags *in situ* when decommissioning the pipelines, but should they be disturbed as part of decommissioning operations they will be removed. Although several different methods could theoretically be used to remove the grout bags, from a practical perspective it is not known whether the bag material has remained intact.

2.4. Comparative Assessment

Environmental data was used to inform the CA and was considered when comparing options including seabed disturbance and habitat loss in line with the conservation objectives and sensitivities of protected sites in the vicinity. Economic factors were only considered if there was no obvious differentiation between options.

2.4.1. *Pipeline and cable decommissioning*

The pipelines within and associated with the Leman F and G NUIs have been considered within a CA to arrive at an optimal decommissioning method. The CA methodology is described fully within the CA submitted along with this EA.

2.4.1.1. Pipelines

Following an initial screening exercise, the pipeline decommissioning options taken forward for consideration in the CA workshop included:

1. Decommission *in situ* with surface-laid tie-ins removed and ends remediated
2. Decommission *in situ* with surface-laid tie-ins removed and ends remediated; with areas of insufficient depth-of-cover remediated by re-trenching
3. Total removal – assumed cut-and-lift

The emerging option (based on consideration of safety, environmental, technical, societal and economic factors) was Decommission *in situ* with surface-laid tie-ins removed and ends remediated. This EA will therefore consider the activities associated with this pipeline decommissioning option and the potential impacts on environmental and societal receptors.

2.4.1.2. Cables

Following an initial screening exercise, the cable decommissioning options taken forward for consideration in the CA workshop included:

1. Decommission *in situ* with surface-laid tie-ins removed and ends remediated
2. Decommission *in situ* with surface-laid tie-ins removed and ends remediated; with areas of insufficient depth-of-cover remediated by re-trenching
3. Total removal – assumed cut-and-lift

The selected option (based on consideration of safety, environmental, technical, societal and economic factors) was Decommission *in situ* with surface-laid tie-ins removed and ends remediated. This EA will therefore consider the activities associated with this cable decommissioning option and the potential impacts on environmental and societal receptors.

2.5. Proposed Schedule

The precise timing of the decommissioning activities is not yet confirmed and will be subject to market availability of decommissioning services and contractual agreements. The potential window for the Leman F & G NUIs decommissioning activity (including removals and onshore disposal) is between Q4 2025 and Q4 2028.

2.6. Decommissioning Activities

This section outlines the section the proposed decommissioning activities for the Leman infrastructure. The activities described within include activities that are outwith the scope of this EA, however they are included within this section to provide an overview of all decommissioning activities.

2.6.1. Preparation for decommissioning

2.6.1.1. Well decommissioning

All wells will be decommissioned to current industry standard, this means that each well will be systematically and permanently closed in accordance with well decommissioning best practice; these activities will be carried out using a jack up rig. Well decommissioning (plug and abandonment/ P&A) is not within the scope of this environmental appraisal, and it will be assessed as part of well intervention and marine licence applications.

2.6.1.2. Flushing and cleaning operations

Flushing and cleaning operations for subsea flowlines and subsea installations will also have been completed under existing operational permits prior to commencement of decommissioning activities.

Prior to commencement of decommissioning activities, Shell will flush all the infield production pipelines with seawater. There is currently no intention to use pigs. This activity is designed to remove mobile hydrocarbons and achieve a cleanliness of less than 30 ppm oil in pipeline flush fluids.

Following isolation from the wells, gas (nitrogen) will be passed through the platform processing systems to ensure that minimal hydrocarbons remained in the system prior to the final cleaning and disconnect. During the final cleaning and disconnect activities, all the processing systems on the platform are progressively depressurised, purged with gas (nitrogen) and rendered safe for removal operations. All bulk chemicals surplus to requirement will be backloaded onshore for disposal. The pipework and tanks will be visually inspected where possible and may be further treated should any sources of potential spills of oils and other fluids be identified.

2.6.2. Platform decommissioning

2.6.2.1. Cold suspension

Once hydrocarbon free and isolated from hydrocarbon sources, power links will be retained from Leman AK for the duration of cold suspension, until topsides lift is undertaken. There may also be a potential for use of standalone solar powered NAVAIDs to put into place. Should this be the case, or if the topsides and jackets are lifted in separate campaigns, Shell will engage with OPRED and the Lighthouse Board to discuss the appropriate means of ensuring the safety of other users of the sea. Options include affixing a NAVAID to the jacket or deploying a guard vessel, until jacket removal.

During cold suspension, it is assumed that:

- The assets will be marked accordingly in line with a Consent to Locate (CtL);
- No further activities are to be undertaken at the assets during cold suspension ahead of the removals phase apart from subsea surveys;
- There is the potential for flights to land on some NUIs pre-cold suspension. However, once the installations are in lighthouse mode, no personnel will re-board the topsides. The platform removal techniques planned will be similar for all platform types.
- Both jackets are secured to the seabed by piles. All piles securing the jackets will be cut below the natural seabed level at a depth that will ensure they remain covered. The depth of cutting is dependent upon the prevailing seabed conditions and currents. Shell will ensure that this is at least 3 m below the natural seabed level.

2.6.2.2. Platform removal

Shell will most likely remove the NUIs using the single lift method. A semi-submersible crane vessel (SSCV) capable of lifting the entire topsides in one lift will be used. The SSCV will most likely be equipped with an anchoring spread. The topsides will be prepared for this by a combination of making sure modules are secured for transport and structural strengthening of the topsides.

The removal process the NUIs is expected to be:

- Cutting of the lines that connect the platform to the subsea infrastructure (risers);
- Cutting of the piles that secure the jacket to the seabed; and
- Removal of each platform jacket by heavy lift vessel (including risers).

Jacket piles will be internally cut (where possible), if this is not possible the area around the piles will be excavated and the piles will be cut externally. Should excavation be required, a suitable method (Mass Flow Excavation/MFE or suction dredging) will be used. As a worst-case/conservative approach, it has currently been assumed the NUIs are expected to require excavation to a maximum of -7.5 m to allow for cutting equipment to reach the piles at -3 m.

2.6.3. Pipeline and cable decommissioning

The recommendation from the CA is to decommission the pipelines and cables *in situ* with surface-laid tie-ins removed and ends remediated. A cable removal study undertaken by Xodus (2022a) considered the feasibility of removing the PL5147 and PL5148 submarine power cables by accounting for burial status, cable and reef integrity and recovery load. The study concluded that the recovery options considered carry inherent risk and would have an associated seabed (reef) impact. The continued presence of the cables also carries limited risk to other users of the sea, given that they are buried for the most part.

Prior to decommissioning *in situ*, pipeline and cable ends will be cut and remediated using a localised cut and lift methodology. A suitable construction support vessel (CSV) will be used to undertake the subsea intervention scopes associated with pipeline disconnection and remediation, removal of stabilisation materials (where appropriate) and debris clearance activities. The cut pipeline ends will be remediated by placing a suitably graded rock over the pipeline ends (as a worst-case) where reburial is not possible. Base case assumption for installing new rock cover is to use a fall pipe vessel, as shown in Figure 2-2. Table 2-4 lists the length of each pipeline/cable end being removed and the area of rock required to remediate pipeline/cable ends. As a worst-case, a 10 m corridor and a 20 m length of rock remediation has been assumed for each pipeline end. This configuration allows for a 1:3 slope which would be overtrawlable, making any risk of net snagging negligible. As a worst-case, it is estimated that 100 Te of rock would be required for remediation on each pipeline end.

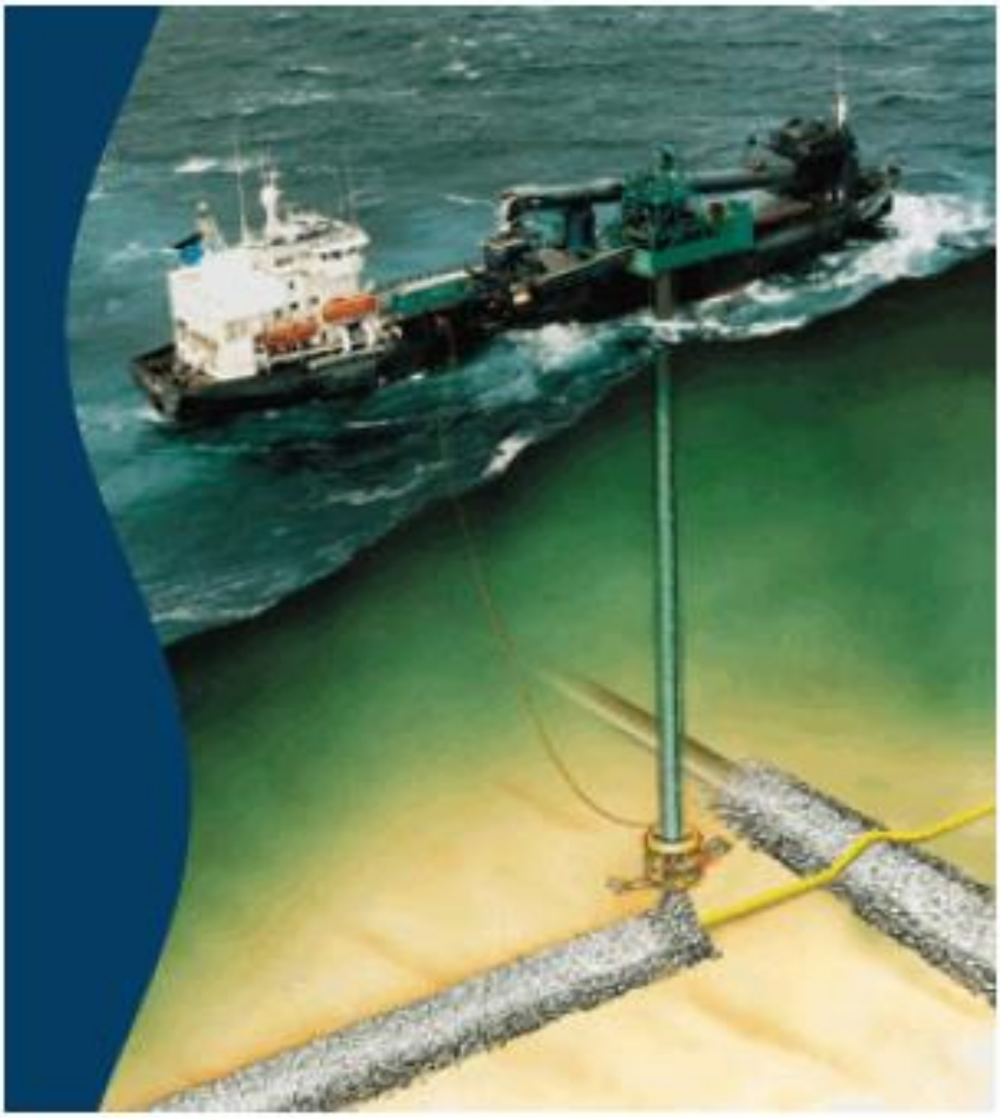

Figure 2-2 Remedial Rock Cover Installation Illustration

Table 2-4 Length of cut ends and rock remediation

Name	Adjacent to platform?	Spools to be removed (m)	Pipeline ends to be removed (m)	Area of rock remediation at cut end (m^2)	Tonnage of rock at cut end (Te)
Production Pipeline (PL363)	Leman F	36	24	200	100
	Leman A	36	24	200	100
Cable (PL5148)	Leman F	-	24	200	100
	Leman A	-	24	200	100
Production Pipeline (PL 364)	Leman F	12	24	200	100
	Leman G	12	24	200	100
Cable (PL5147)	Leman F	-	24	200	100
	Leman G	-	24	200	100

Total		**96**	**198**	**1,600**	**800**

2.6.4. Post-decommissioning activity

Following decommissioning activities, a seabed clearance survey will identify any debris related to the Leman F and G operations on the seabed within a 500 m radius of each platform and within the corridor of any pipelines and cables decommissioned in situ. Owing to the environmental sensitivities, the project base case is that non-intrusive means (e.g. SSS and/ or ROV surveys) will be employed to demonstrate that no snagging risks remain on the seabed. Only as a last resort would overtrawl surveys would be undertaken within the Leman F and G 500m zones, considered the project worst-case scenario, to demonstrate that no snagging risks remain on the seabed. In the unlikely scenario that this is the case, consultations would be held with the NFFO and OPRED to discuss the best way to approach this while taking the environmental sensitivities of the area into account. Verification of seabed clearance will be issued to OPRED for acceptance within the Close Out Report and future monitoring agreed as required.

A post-decommissioning monitoring programme covering the pipelines and associated stabilisation features remaining *in situ* is to be agreed with OPRED. The proposed approach includes the following:

- A pre-decommissioning survey has been undertaken, covering the full length of each pipeline;
- A risk assessment for each pipeline (and associated stabilisation materials) has been undertaken to inform the minimum agreed extent and frequency of future surveying. This takes account of pipeline burial, exposure and spanning derived from the initial baseline survey, historical survey information and fisheries impact assessment;
- Provision has been included for remediation where such a requirement is identified. Appropriate remediation will be discussed and agreed with OPRED;
- Where remediation is undertaken, a follow up survey of the remediated area will be required;
- In the event of a reported snagging incident on any section of pipeline, the requirement of any additional survey and/or remediation will be discussed and agreed with OPRED;
- Monitoring will become reactive following completion of the agreed survey programme and OPRED agreement; and
- Pipeline information will be recorded on navigation charts where required.

2.7. Environmental Management

2.7.1. Environmental Management Approach

Shell has an established and independently verified Health, Security, Safety, the Environment and Social Performance (HSSE & SP) Control Framework which describes the means of compliance with Safety, Health and Environmental (SHE) legislation and industry standards, and manages SHE risks and which operates in accordance with the requirements of ISO14001:2015. Relevant to the EA, and to all of Shell's activities, is identify and assess the potential SHE impacts of the Leman F and G Decommissioning Project and to implement measures so that negative impacts are minimised and positive impacts are optimised. Continuous improvement in environmental performance is sought through effective project planning and implementation, emissions reduction, waste minimisation and waste management; this mindset has fed into the development of the mitigation measures developed for the Project; these include both industry-standard and project specific measures. A signed copy of HSSE & SP Policy is presented in Appendix A.

2.7.2. Waste management and the waste hierarchy

Shell will comply with the Duty of Care requirements under the UK Waste Regulations and The Environmental Protection (Duty of Care) Act (1991). The hierarchy of waste management will also be followed at all stages of disposal (Figure 2-3) and industry best practice will be applied (Decom North Sea, 2018b). Driving waste management up the waste hierarchy is central to the development of sustainable waste management.

Preventing waste is ultimately the best option, achieved through reducing consumption and using resources more efficiently. However, this is followed by re-use and recycling of goods (Figure 2-3). If all re-use opportunities have been taken by Shell, the next preferable option is for recycling of materials

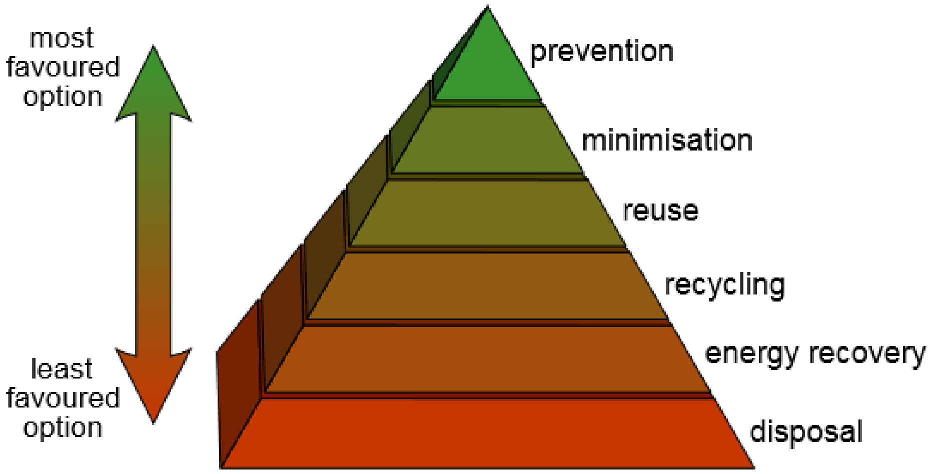

Figure 2-3 Waste management hierarchy

All waste will be managed in compliance with relevant waste legislation by a licenced and/or permitted waste management contractor. The selected contractor will be assessed for competence through due diligence and duty of care audits. Until a waste management contractor has been selected and disposal routes identified, the final disposal options for waste materials are unknown. The project aspiration is that all ferrous and non-ferrous metals, concrete and plastics will be recycled where possible. Approximately 5% of the material will be reused, approximately 95% of material will be recycled and the remaining material will be sent for disposal. There may be instances where infrastructure returned to shore is contaminated (marine growth, hydrocarbons, paints etc) and cannot be recycled, but the weight/volume of such material is not expected to result in substantial landfill use.

2.7.3. Waste Tracking

The Material Inventory has also classified each material according to the European Waste Catalogue (EWC) Codes as required for disposal of wastes within the European Union (EU) and a further categorisation of hazardous/special or non-hazardous/non-special wastes. The EWC is a standardised way of describing waste and was established by the European Commission (EC). The use of EWC codes to describe waste is a legal requirement of the Duty of Care for waste which requires the holder of waste to take all reasonable steps to ensure that waste is described in a way that permits its safe handling and management. The EWC approach remains in place following Brexit to enable continuity of waste tracking and to account for the potential for the Trans-frontier shipment of waste.

Most of the material recovered during the Leman F & G NUI's decommissioning activities (Table 2-5) will be non-hazardous, including steel, non-ferrous metals, plastic and concrete. Should hazardous materials, for example (Naturally Occurring Radioactive Material (NORM)) be encountered, Shell will ensure the disposal site is suitably licenced to accept the waste arising from the decommissioning of the subsea infrastructure. An Active Waste Management Plan (AWMP) including an inventory of hazardous waste will be compiled to aid the segregation and recycling of waste.

Shell is committed to working towards the government policy of Net Zero in line with the NSTA Stewardship Expectation 11 (NSTA, 2021). This commitment includes decommissioning activities and is intended to drive increased energy efficiencies and minimise emissions. Shell seeks to influence our joint venture partners and suppliers to ensure that everyone is striving to reduce and manage associated emissions.

2.7.4. Materials Inventory

Table 2-5 outlines the material breakdown of the various components and intended destination(s) of the Leman infrastructure due for decommissioning. Figure 2-4 and Figure 2-5 show the percentages of the various materials recovered to shore and decommissioned *in situ*, respectively.

Table 2-5 Leman infrastructure materials inventory

Material type	**Quantity (Te) and destination**										
	Leman F NUI		**Leman F pipelines**		**Leman G NUI**		**Leman G pipelines**		**Total to shore**	**Total *in situ***	**Total**
	Pipelines to shore	**Pipelines *in situ***	**Cables to shore**	**Cables *in situ***	**Pipelines to shore**	**Pipelines *in situ***	**Cables to shore**	**Cables *in situ***			
Carbon steel	4021.7	521.0	61.0	1037.5	3522.7	463.1	30.1	300.3	7635.5	2321.9	**9957.4**
Stainless steel	25.1	0.0	0.0	0.0	21.5	0.0	0.0	0.0	46.5	0.0	**46.5**
Non-ferrous	118.7	0.0	0.4	11.9	122.9	0.0	0.3	4.6	242.3	16.5	**258.8**
Concrete	0.0	0.0	482.7	484.1	0.0	0.0	326.6	441.4	809.3	925.5	**1734.8**
Plastics	32.2	0.0	21.6	58.9	34.4	0.0	45.2	0.0	133.3	58.9	**192.2**
Haz mat/NORM	3.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	6.0	0.0	**6.0**
Other non-hazardous	105.8	0.0	0.0	0.0	95.4	0.0	0.0	0.0	201.1	0.0	**201.1**
Total	**4306.4**	**521.0**	**565.6**	**1592.4**	**3799.8**	**463.1**	**402.2**	**746.3**	**9074.0**	**3322.7**	**12396.8**

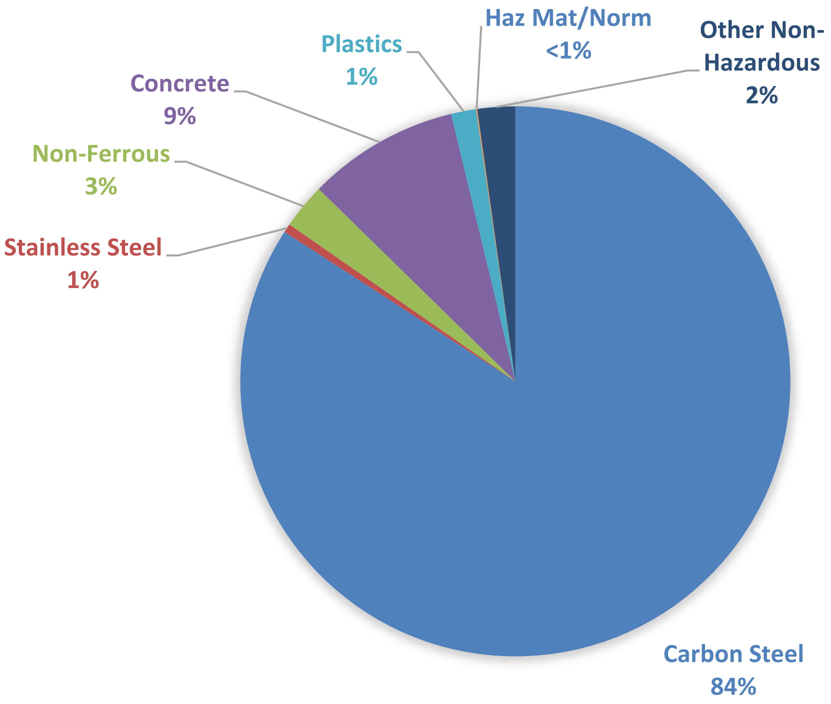

Figure 2-4 Percentage of material components recovered to shore

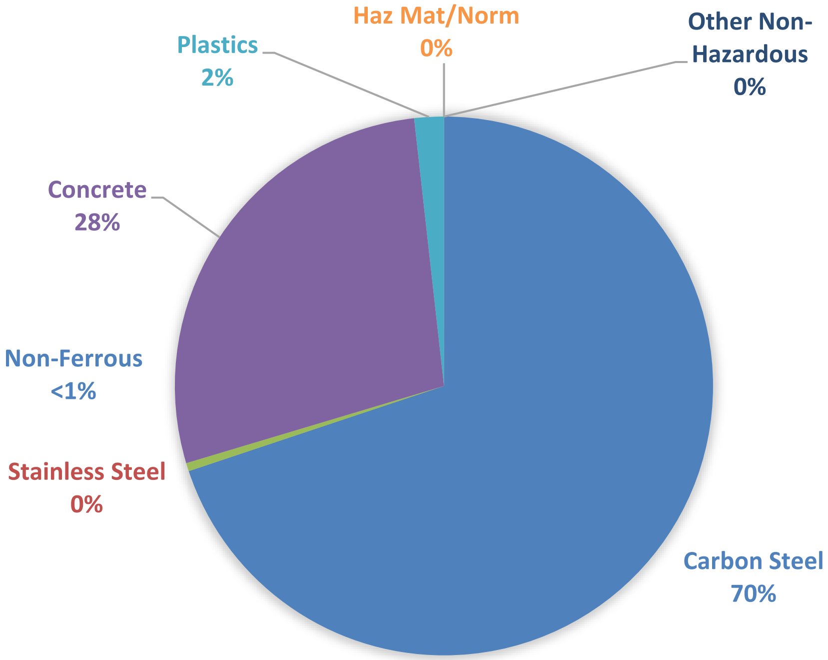

Figure 2-5 Percentage of material components decommissioned *in situ*

3. ENVIRONMENTAL BASELINE

3.1. Environmental surveys

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

Multiple site surveys have been undertaken in and around the Leman area; this includes site-specific pre-decommissioning environmental surveys conducted by Gardline in 2021 centred on the Leman F and G areas (Gardline, 2021a, 2021b). The sampling locations of the environmental surveys undertaken in the area are presented in Figure 3-1. The results of the following surveys were used to inform the environmental description:

- The Pipeline Pre-Decommissioning Environmental Survey and Habitat Assessment: Leman Alpha to Leman Foxtrot and Leman Foxtrot to Leman Golf (Gardline, 2021a, 2021b) was undertaken on 12th to 14th of May 2021 along the pipeline routes between Leman A and F and between Leman F and G. The surveys aimed to provide an assessment of the benthic environment and seabed physico-chemical characteristics of the area and provide evidence any spatial and temporal changes of pollution/disturbance along the pipeline corridors. The survey was conducted to inform the planned decommissioning process with regards to potential disturbance of sediments, species and habitats. Figure 3-1 indicates the survey sample locations. The survey involved the collection of environmental seabed samples, and video and photography of the seabed.
- The Environmental Monitoring and Habitat Assessment Surveys (Fugro, 2020a, 2020b) centred on the Leman F platform and were undertaken from the 27th of April to the 2nd of May 2020.
- The Environmental Baseline Survey UKCS Block 49/26 (Fugro, 2019a) centred on the Leman G platform and was conducted from the 29th of March to the 9th of April 2019.
- The Leman A Habitat Assessment Survey UKCS Block 49/26a (Fugro, 2019b) centred on the Leman A platform and was conducted from the 29th of March to the 9th of April 2019.

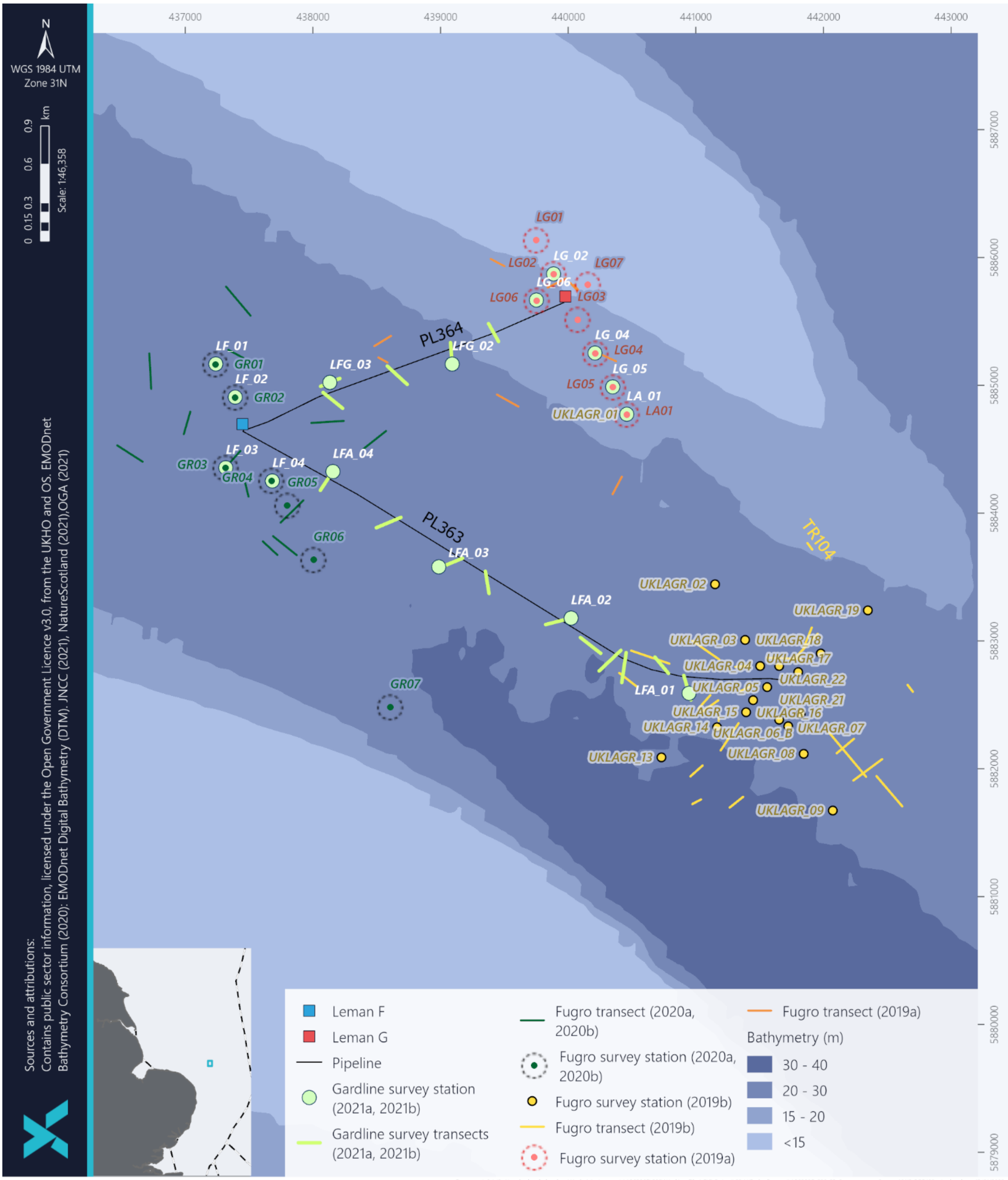

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Figure 3-1 Location of environmental survey sites in the Leman area

3.2. Physical Environment

Characteristics of currents and wave action, bathymetry, seabed sediments and features in the Leman area are described in the following subsections.

3.2.1. Current and wave action

The Leman infrastructure is located in an area influenced by southern North Sea current and Channel currents. The cyclonic, counter current created from the ingress of water through the channel drives the near surface current towards a more easterly direction. The shallower waters of the SNS remain permanently mixed throughout the year due to the influence of tidal currents (OSPAR, 2000; OESEA, 2016). This prevents the formation of a thermocline and results in a highly dynamic marine environment (OESEA, 2016).

Currents in the vicinity of sandbanks, such as those around the Leman infrastructure, can be highly affected by their presence. Residual currents near the seabed have been shown to be strongest towards the crest of a sandbank and in opposing directions on either side of the bank running in a clockwise direction, i.e., from southwest on the southern side and from the northwest on the north residual circulation around the bank. Episodic currents, induced by wave action and storm surges, also influence sandbank development (OESEA, 2016).

Wave direction is variable throughout the year, but in the later part of the year these are predominantly from the southwest. Wave energy at the seabed shown to be moderately high between 0.21 – 1.2 N/m^2 and increasing above 1.2 N/m^2 towards shore (OESEA, 2016).

3.2.2. Bathymetry

The North Sea is a large shallow sea with a surface area of around 750,000 km^2. The SNS is particularly shallow, with water depths of approximately 50 m or less (OESEA, 2009). Around the Leman infrastructure, the seabed deepens gently from the northwest to the southeast of the, with an average gradient of 4° (Fugro, 2020a). Benthic sediments in the SNS consist largely of sand or muddy sand, with significant areas of coarse sediment, the latter mostly closer to shore (OESEA, 2016).

3.2.2.1.1. Drill cuttings piles

Geophysical data collection at the Leman F and G platforms provides some physical evidence of drill cuttings piles adjacent to the drill centres. Some evidence can be seen of a potential cuttings pile to the east-southeast of the Leman F platform (Figure 3-2) and a more distinct pile can be discerned to the northeast of the Leman G platform (Figure 3-3; Fugro, 2020a)). The positioning of the piles is in line with the predominant current and wave directions in the region (Section 3.2.1).

3.2.2.1.2. Sandbank systems

Seabed features in the SNS include active sandbanks and sandwaves which are maintained by the tidal and current regimes. An example is the North Norfolk sandbanks which is an active sandbank system thought to be progressively elongating in a north-easterly direction, maintained and developed by sediment transported offshore (JNCC, 2022a).

Sandbanks, particularly those in the North Norfolk area of the SNS, are large-scale mobile seabed forms in dynamic equilibrium with the environment. They can have a wavelength between 1 – 10 km, and they can achieve a height of several tens of metres (van der Veen and Hulscher, 2009).

Sandbank systems are found widely on shallow continental shelves where there is an abundance of sand and where currents exceed a certain speed (Kenyon and Cooper, 2005). The sandbank systems arise from an inherent instability of a seabed subject to tidal flow and mass transport. Superimposed on this sandbank morphology are megaripples and sandwaves. The seabed along the Leman F to G pipeline route is undulating with northeast to southwest trending megaripples and sandwaves transecting the route (Gardline, 2021a). There is a general decrease in depth from 35 m LAT at Leman F to 22 m LAT at Leman G in the northern part of the survey area. Leman G is situated on the southeastern end of the Ower sandbank (part of the North Norfolk sandbank system; Gardline, 2021b).

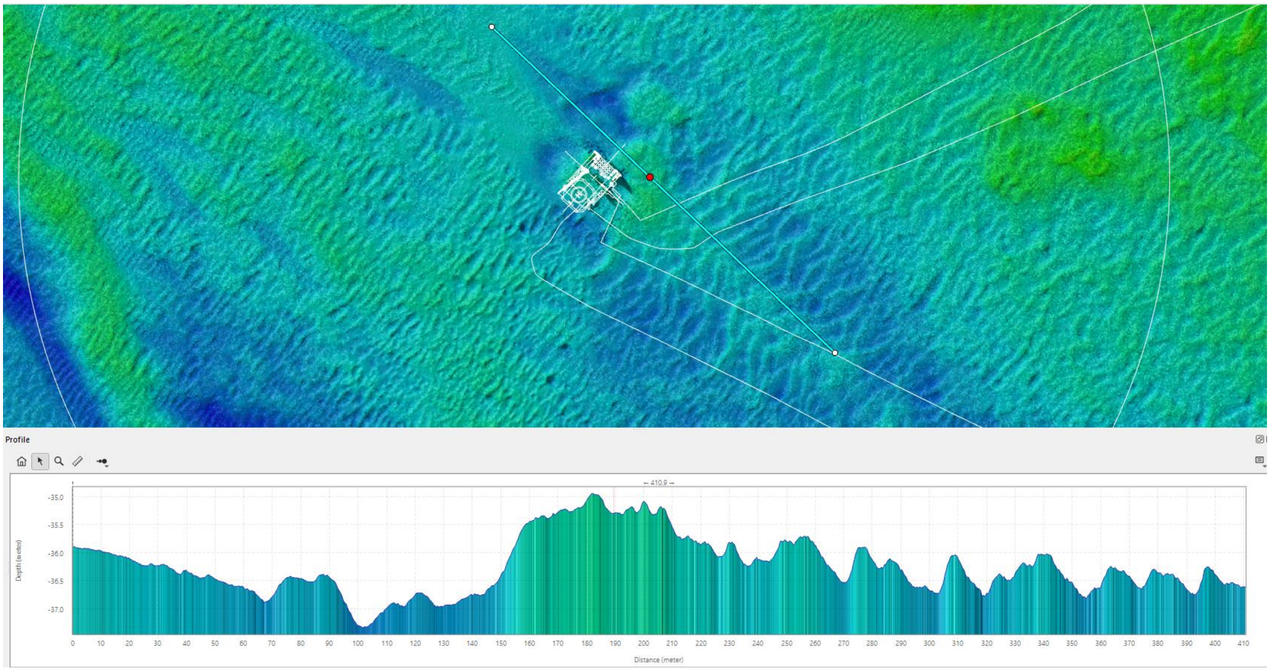
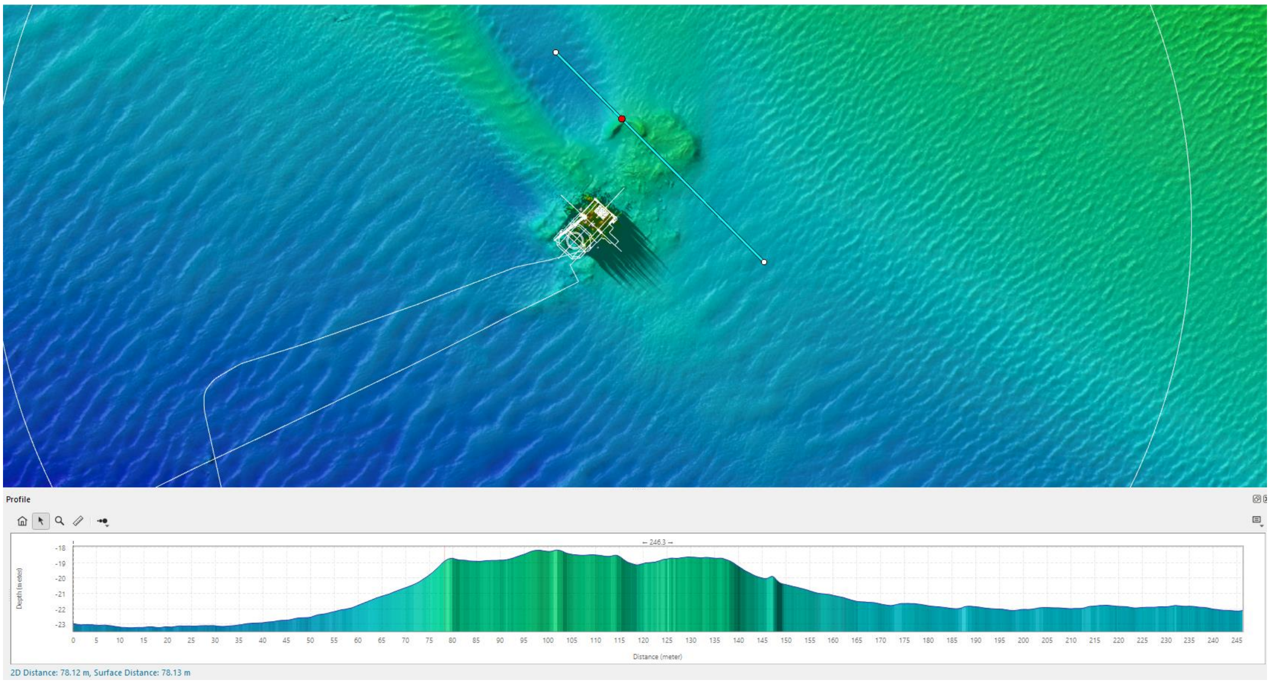


Figure 3-2 Bathymetry around the Leman F platform (Fugro 2020a)



2D Distance: 78.12 m, Surface Distance: 78.13 m

Figure 3-3 Bathymetry around the Leman G platform (Fugro 2020a)

Typical sandwave wavelengths range from 100 m to 800 m and they can be up to between 1 – 5 m high. The crests are almost orthogonal to the direction of tide propagation. Sandbanks, particularly those in the North Norfolk area of the SNS, are large-scale mobile seabed forms in dynamic equilibrium with the environment. They can have a wavelength between 1 – 10 km, and they can achieve a height of several tens of metres (van der Veen and Hulscher, 2009). Sandbanks are found widely on shallow continental shelves where there is an abundance of sand and where currents exceed a certain speed (Kenyon and Cooper, 2005). The sandbanks arise from an inherent instability of a seabed subject to tidal flow and mass transport.

A series of sand waves can also be observed on top of the sandbank at Leman G with a northeast to southwest orientation (Figure 3-3). These sand waves have wavelengths of up to 464 m and are up to 3 m high. Seabed scouring was identified in the immediate vicinity of the Leman F platform and this scouring is also evident in Figure 3-2. Scouring was up to approximately 2 m deep and extended for a distance of 50 m, 20 m and 15 m from the platform towards the north, northeast and southwest respectively (Fugro, 2020b). Some seabed features were identified at the Leman A platform, including sandbars up to 4.5 m in height to the northwest, a 4 m deep depression approximately 1 km west of the platform, and a northwest to southeast oriented scarp slope to the west (Gardline, 2021a).

3.2.3. *Seabed sediments*

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

3.2.3.1. Sediment particle size

The sediment particle mean diameter along the Leman F to G pipeline corridor was 486.0 µm. Sediments were broadly consistent with previous surveys in the area, in which the sediments were generally described as moderate to well sorted medium sand to gravelly sand (Gardline, 2021b). Station LG_02 (Figure 3-1) was somewhat distinct in that it recorded well sorted fine sand (mean particle diameter 228 µm) with no fines or gravel. This is consistent with its location near the crest of the sandbar extending northwest from the Leman G platform (Figure 3-3). Station LFG_03 (Figure 3-1) was also an exception, with a mean diameter of 2380 µm due to the dominance of pebble-sized material. This corresponds with sampling in an area of high reefiness and peat outcrops (Gardline, 2021a). Bathymetric and side scan sonar (SSS) data featured areas of higher acoustic reflectivity to the north and west of the existing Leman A infrastructure, which have also been interpreted as areas of high reefiness (Fugro, 2019b). In 2016, reef was identified on the majority of the environmental transects in vicinity of Leman A (Fugro, 2017).

3.2.3.2. Organic content

In line with trends noted in the particle size data, concentrations of both total organic matter (TOM) and total organic carbon (TOC) along the Leman F to G pipeline route were relatively uniform, with only minor variations across the survey area. TOM ranged from 0.4% to a maximum of 1.1%, corresponding with where the sediment was finest. Across the survey area, TOM recorded a mean of 0.6% (Gardline, 2021a). The mean organic content (equivalent to TOM) recorded in the SNS as presented by UKOOA (2002) was 1.2% for stations over 5 km from existing infrastructure in the SNS. Relative to this wider context, TOM content in the current survey was broadly consistent with the regional background (Gardline, 2021a).

3.2.3.3. Hydrocarbon indicators

3.2.3.3.1. *Leman F*

Total hydrocarbon (THC) is used to describe the quantity of the measured hydrocarbon impurities present. Trends in THC concentrations corresponded with where TOM, TOC and/or fines were also at their highest concentrations, in the area of relatively stable and mixed sediments nearer the Leman F platform. The highest THC was recorded at the Station LF_02, which is the close to a number of existing wells at Leman F (Figure 3-1; Gardline, 2021a).

The occurrence and concentration of Polycyclic Aromatic Hydrocarbons (PAHs) in the environment is of concern since many possess mutagenic, carcinogenic and toxic properties and are readily bioaccumulated through the food web (McDougall, 2000; Neff, 2004). Volatile, low molecular weight PAHs of peterogenic origin are often related to the presence of point sources of hydrocarbon input, including oil spills, natural seeps, drilling activity and produced water outfalls (Neff, 2004). A major source of such PAHs is the discharge of drill cuttings on the seabed (Breuer *et al.,* 2004). The concentrations at which individual PAHs produce toxic effects vary widely (Long *et al.,* 1995) and are dependent on their type and bioavailability. Among the four stations with the highest total PAH concentrations (i.e. >0.070µg g^{-1} at Stations LFA_02, LFA_03, LF_02 and LF_04; Figure 3-1) the dominance of low molecular weight compounds at LFA_02 indicated a low-level petrogenic signature at this station (Gardline, 2021a).

3.2.3.3.2. *Leman G*

Evidence of the presence of low toxicity oil-based mud (LTOBM) was found at station LG03 during a previous survey of the area surrounding Leman G (Figure 3-1; Fugro, 2019a).

PAH concentrations tended to be lowest (≤0.004 µg g^{-1}) on the Ower sandbank around Leman G where water was shallowest (<32 m LAT), consistent with the retention properties of the more mobile sandy sediment recorded there. Previous surveys have shown that most stations within the Leman G survey area had a mixed source of aromatic material with both pyrolytic and petrogenic sources (Fugro, 2019a).

3.2.3.3.3. *Heavy metals*

Metals are generally persistent and at elevated concentrations most are toxic to varying degrees. They can be absorbed and stored in organisms over time leading to potential high concentrations capable of causing lethal and sub-lethal toxic effects in benthic organisms even when found in low concentrations in sediment. Several metals are found in high concentrations in drilling muds and produced water. Some of these metals are added intentionally to drilling muds as metal salts or organo-metallic compounds whilst others are present as trace impurities in major mud ingredients, particularly barite and clay. Those metals most characteristic of contamination of the sediment with drilling muds or cuttings are barium, chromium, lead and zinc (Neff, 2005). By far the most abundant metal in most drilling muds is barium.

Barium concentrations were highest at Station LG_02 (218 µg g^{-1}; Figure 3-1), however it was not significantly elevated relative to other stations; the mean concentration across samples was 117 µg g^{-1}. The higher concentrations observed are expected given proximity to wells, however, there were no abnormalities in the hydrocarbon composition at this station to suggest the presence of oil-based drilling mud.

During the most recent Gardline (2021a) survey effort, all other metal concentrations, with the exception of arsenic, were below their respective Effects Range Low (ERL) suggesting toxic effects would rarely be observed. Concentrations of arsenic were below the Effects Range Mean (ERM), suggesting toxic effects on the faunal community may occasionally occur due to the concentrations of this metal (Gardline, 2021a). Comparison to the wider field demonstrated that the mean metals concentrations for the current survey were broadly comparable to, or slightly lower than the mean concentrations from earlier surveys of the Leman A area (Fugro, 2019a; Gardline, 2021a).

3.3. Biological Environment

3.3.1. Benthic fauna

The most abundant taxa were also some of the most dominant in the Leman G area. The amphipod crustacean *Urothoe brevicornis* was the most abundant and most dominant taxon recorded. The second, third and fourth most abundant taxa were the polychaetes *Nephtys cirrhosa* and *Ophelia borealis* and the amphipod *Bathyporeia elegans*. The remaining most abundant species identified in the survey included the polychaete *Scoloplos armiger*, the urchin *Echinocardium cordatum*, the bivalve *Tellimya ferruginosa* and the crustacean cumacean *Monopseudocuma gilsoni* and four amphipods (Fugro, 2019a). The macrofaunal community identified from Leman G bore some similarity to that of the adjacent Leman A area (Fugro, 2019a; Fugro, 2019b).

At Leman F, the most abundant taxon overall was the annelid oligochaete Enchytraeidae. More than half of the dominant taxa reported within the current survey comprised polychaetes. Enchytraeidae is typically an opportunistic order of bristle worms and is commonly found in the North Sea in a range of sediment types. Actiniaria were highly abundant throughout the survey; their presence being indicative of a shift to coarser sediments allowing for attachment of these taxa (Fugro, 2020a). As at Leman G, *N. cirrosa*, *U. brevicornis* were present in significant numbers (Fugro, 2019a; Fugro, 2020a). Along with the presence of the polychaetes *Spiophanes bombyx* and *Hesionura elongata*, these species are associated with sand and coarse sand sediments. All taxa recorded within the most numerous and dominant taxa are widely distributed around the North Sea and are typical for the region and sediment type (Fugro, 2019a; Fugro, 2019b; Fugro, 2020a).

The results from the more recent surveys along the Leman F to Leman G pipeline were comparable to those of previous surveys undertaken in the area. Amongst the adult individuals identified during sampling, Arthropoda, namely Crustacea, was the most abundant taxonomic group (n=1591). Annelida (Polychaeta; n=929) was the second most abundant taxonomic group accounting for 32% of the individuals and 37% of taxa (Gardline, 2021a).

Benthic epifauna were sparse across the Leman F survey area, with the exception of *Sabellaria spinulosa* and crabs (including *Cancer pagurus*, *Liocarcinus spp.* and *Necora puber*; Fugro, 2020b). Epifauna were more often observed in areas of '*Sabellaria spinulosa* on stable circalittoral mixed sediment' and included anemone (Actiniaria) and hydroids (Tubulariidae). *S. spinulosa* reef formations are known for being locally diverse; the presence of the habitat will be fully addressed in Section 3.3.2. Little epifauna was observed in areas of sand and mixed sediments, although some fish and crab taxa were present. Overall, the epifauna observed was typical of background conditions for SNS (Fugro, 2020b).

As at Leman F, epifauna abundance and diversity was generally consistent throughout the biotope complex identified during the recent Gardline survey (2021b). *S. spinulosa* and the crabs *N. puber*, *Liocarcinus spp.*, *C. pagurus* and those of the family Paguridae were the most frequently observed taxa. Other mobile epifauna observed infrequently included a starfish (*Asterias rubens*) and brittlestars (Ophiuroidea). Where shell debris were present for epilithic attachment, sessile epifauna such as hydroid/bryozoan turf (Hydrozoa/Bryozoa) and anemones (Actiniaria) were present (Gardline, 2021b).

3.3.2. Benthic habitats

The following EUNIS habitats were identified during the most recent Gardline (2021b) survey along the Leman F to G pipeline route:

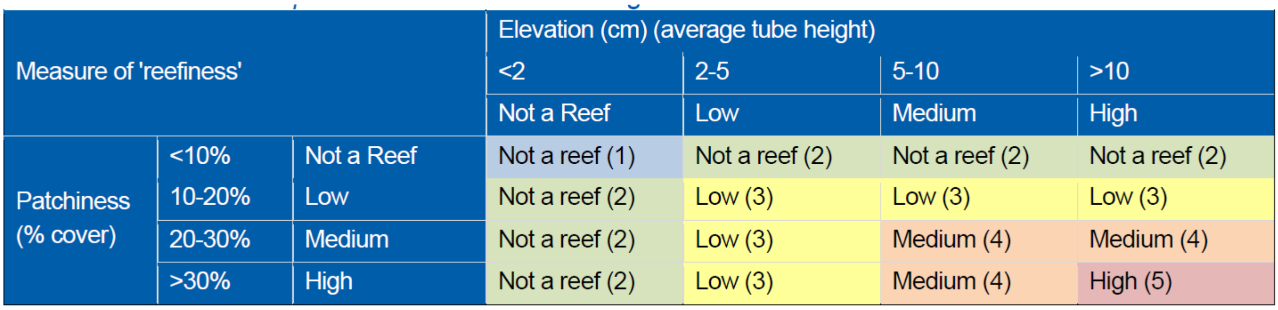
- EUNIS biotope complex A5.44 (Circalittoral mixed sediment) was relevant at all locations. It is described as offshore circalittoral habitats with coarse sands and gravel or shell. This habitat is quite diverse compared to shallower versions of this habitat and generally characterised by robust infaunal polychaete and bivalve species;
- EUNIS biotope complex A5.23 (Infralittoral fine sand) was the seabed type at the shallower stations and is described as sands characterised by robust fauna, particularly amphipods (Bathyporeia) and robust polychaetes including *N. cirrosa*;
- EUNIS biotope complex A5.25 (Circalittoral fine sand) was the dominant seabed type elsewhere and is described as fine sands with <5% fines. This habitat is characterised by a wide range of echinoderms, polychaetes and bivalves;
- In areas of *S. spinulosa* reef, EUNIS biotope complex A5.61 (Sublittoral polychaete worm reefs on sediment) applies. Polychaete worm reefs often support a diverse flora and fauna. Additionally, given the presence of exposed or subcropping clay and peat at these locations, the following EUNIS biotope complexes were also considered possible:
    - A4.22 (*Sabellaria* reefs on circalittoral rock) which is characterised by dense crusts of the polychaete *S. spinulosa* covering the hard substratum.
    - A4.23 (Communities on soft circalittoral rock) which typically occurs on moderately wave-exposed, circalittoral soft bedrock (Gardline, 2021b).

The area surrounding, and to the north of, the Leman G platform is situated on the southeastern extent of the Ower sandbank. Ower sandbank, and those around it which form the North Norfolk sandbank system are located within the North Norfolk Sandbanks and Saturn Reef SAC, designated for the presence of 'Sandbanks which are slightly covered by sea water all the time' and 'Reefs'. According to the findings of the Fugro (2019a) survey of the Leman G area, sandwaves were present however, the sediment ridge to the north of the Leman G survey area was not considered to be an example of the Annex I sandbank habitat (Fugro, 2019a). Despite this, the whole SAC is classified and to be managed as sandbank habitat; therefore, the Leman A, F and G platforms, and associated pipelines, are all located within an area constituting the habitat 'Sandbanks which are slightly covered by sea water all the time'.

S. spinulosa reefs are classified as a United Kingdom Biodiversity Action Plan (UKBAP) listed priority habitat, an OSPAR threatened and/or declining habitat and are covered by the Annex I habitat 'Reefs', another feature of designation within the North Norfolk Sandbanks and Saturn Reef SAC. The Ross worm, *S. spinulosa*, is the most common biogenic reef building species in the northeast Atlantic. The polychaete creates reef-like or encrusting accretions of sandy tubes on gravel and cobble substrates. These aggregations form solid structures that can extend up to 30 cm above the seabed and be several metres across (Jackson and Hiscock, 2008; JNCC, 2016). *S. spinulosa* is a common species throughout the UKCS.

As such, the method used in Jenkins *et al.*, (2015) was utilised to create a measure of reef structure (Table 3-1). Video transects of areas of potential reef were split by distance intervals to allow for a quantitative assessment of 'reefiness' to be undertaken and scores were assigned to each segment. 'Reefiness' is defined as a combination of *S. spinulosa* reef elevation and percentage cover at a given point along each video transect.

Table 3-1 *S. spinulosa* reef structure scoring matrix



Measure of 'reefiness'			Elevation (cm) (average tube height)			
			<2	2-5	5-10	>10
			Not a Reef	Low	Medium	High
Patchiness (% cover)	<10%	Not a Reef	Not a reef (1)	Not a reef (2)	Not a reef (2)	Not a reef (2)
	10-20%	Low	Not a reef (2)	Low (3)	Low (3)	Low (3)
	20-30%	Medium	Not a reef (2)	Low (3)	Medium (4)	Medium (4)
	>30%	High	Not a reef (2)	Low (3)	Medium (4)	High (5)

Of the 1,268 segments analysed across the survey area in the Gardline (2021b) survey, 366 contained *S. spinulosa*, of which 12% did not form a patch size longer than a single 5 m segment. The largest patch size (24 segments) was recorded along transect LFATR_01, across the pipeline route, to the east of the Leman A platform, accounting for 120 m of camera track, the majority of which exhibited a 'high' reefiness score. This is consistent with the transect crossing a clearly defined reef feature on the SSS data (Figure 3-4).

Around the Leman A platform *S. spinulosa* was generally interpreted in lower densities with local areas of high density (Figure 3-5), whereas in the west near the Leman F platform the species was considered to be present at a high density, with some areas of moderate and low density (Figure 3-6). Beyond this, towards Leman G, little or no evidence of *S. spinulosa* was present on the survey geophysical data, which corresponded to areas of seabed characterised by sand waves (Figure 3-4; Gardline, 2021b).

The Fugro (2020b) Leman F habitat assessment survey identified an increase in reefiness and extension of *S. spinulosa* reef when compared against an earlier 2017 survey; 'High' reefiness was assigned to patches on eight transects, while in the 2017 survey 'High' reefiness was only reported on three transects (Fugro, 2020b; Figure 3-4). The most recent Gardline (2021b) habitat assessment survey identified the presence of exposed or subcropping peat and clay largely corresponded with high density *S. spinulosa* reefiness. This suggests that these relatively soft and stable clay and peat outcrop features provide an anchor point from which *S. spinulosa* can establish a reef, fed by a supply of nearby sand for tube building (Gardline, 2021b).

The UKBAP listed priority habitat 'peat and clay exposures with piddocks' has been historically documented within the broader Leman field, in particular within the Leman A area (Fugro, 2019b) and patches of peat outcrops and peat clasts were recorded at Leman F. However, piddocks and piddock bores were not recorded, with the area unlikely to classify as the UKBAP priority habitat (Furgo, 2020b).

No other habitats or seabed features of conservation importance were observed during surveys in the area.

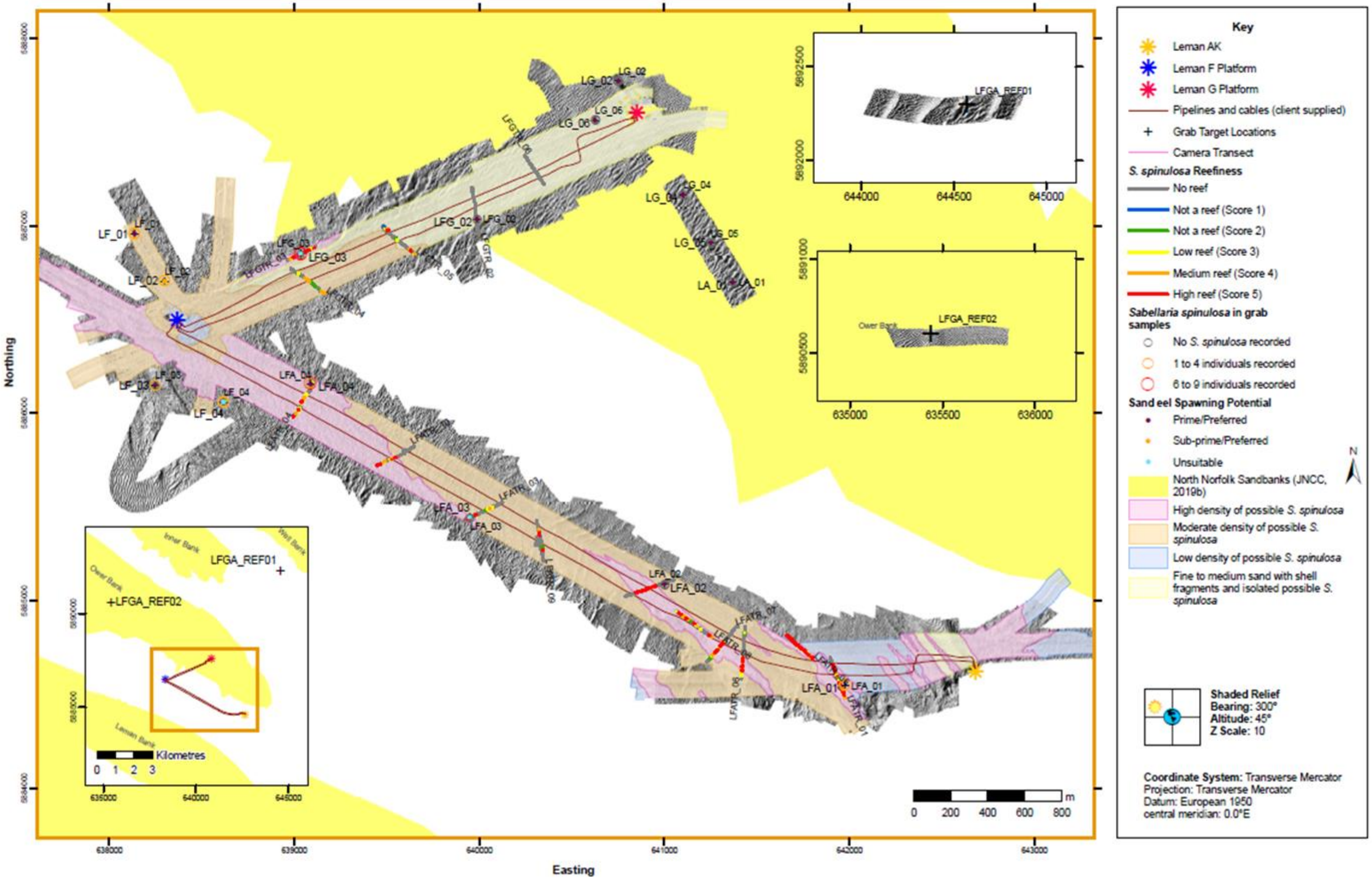


Figure 3-4 Overview of reef density and sandeel habitat along the Leman pipeline corridors (Gardline, 2021a)

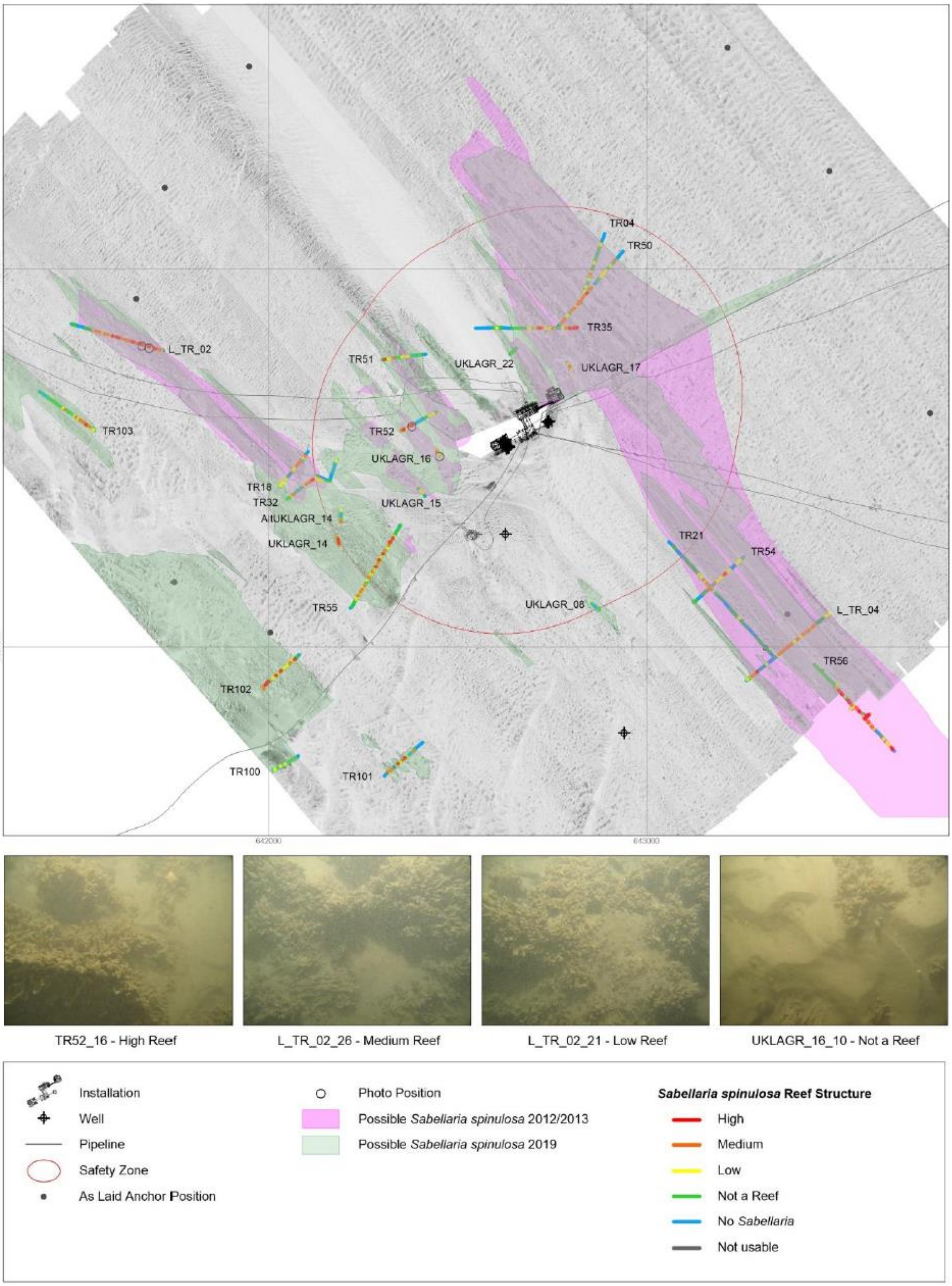
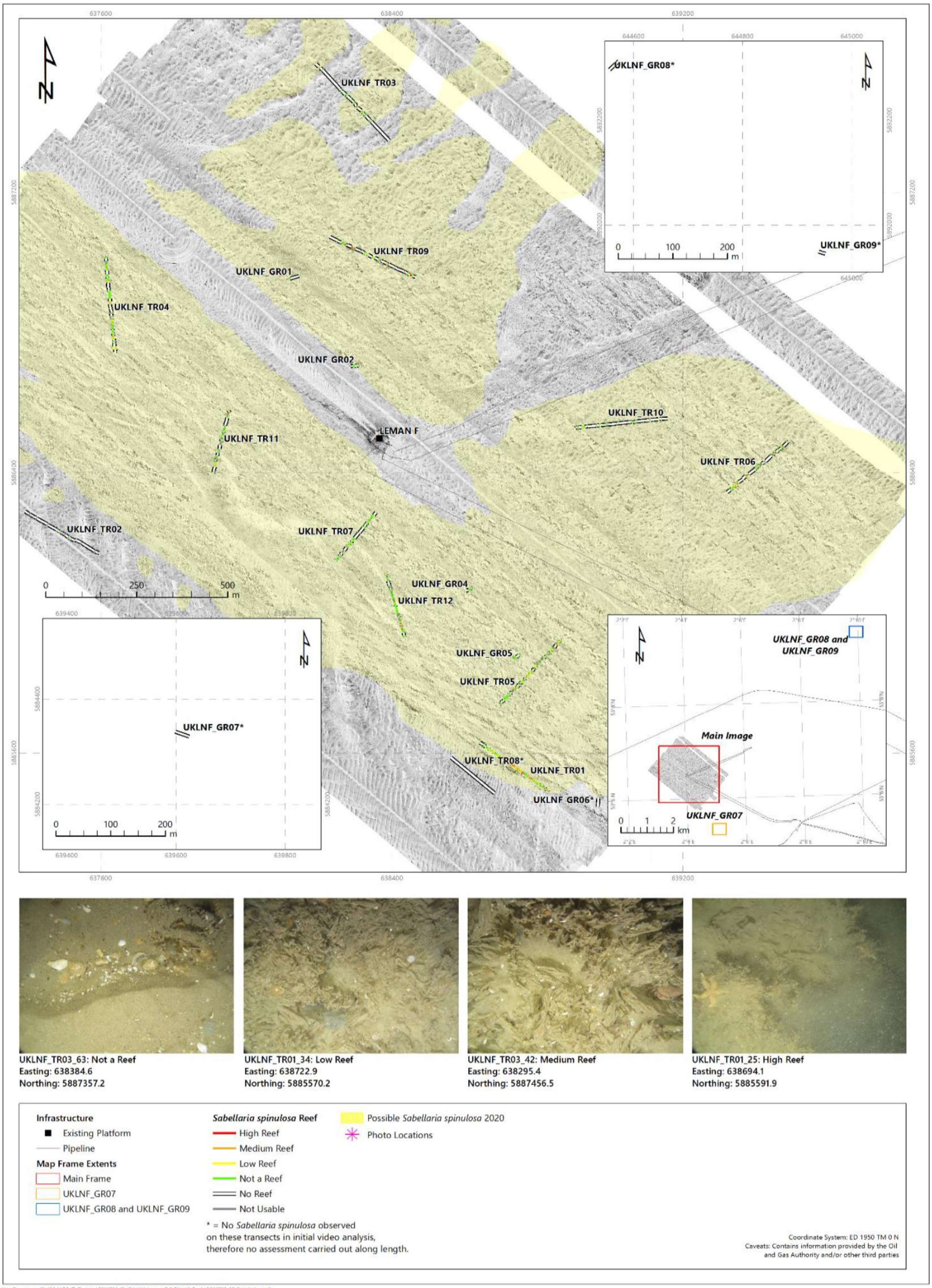


Figure 3-5 **Potential extent of *S. spinulosa* and reef classification around the Leman A platform (Gardline, 2021a).**



UKLNF_TR03_63: Not a Reef
Easting: 638384.6
Northing: 5887357.2

UKLNF_TR01_34: Low Reef
Easting: 638722.9
Northing: 5885570.2

UKLNF_TR03_42: Medium Reef
Easting: 638295.4
Northing: 5887456.5

UKLNF_TR01_25: High Reef
Easting: 638694.1
Northing: 5885591.9

Figure 3-6 Potential extent of *S. spinulosa* and reef classification around the Leman F NUI (Gardline, 2021a)

3.3.3. *Fish and shellfish*

Leman F and G are located within ICES Rectangle 35F2 which experiences high intensity spawning by plaice *Pleuronectes platessa* over the winter months (December-March). Other species which use the area to spawn include cod *Gadus morhua*, lemon sole *Microstomus kitt*, mackerel *Scomber scombrus*, Norway lobster *Nephrops norvegicus*, sandeels *Ammodytidae spp.*, sprat *Sprattus sprattus* and whiting *Merlangius merlangus*. Table 3-2 shows the species which use the area as spawning grounds throughout the year.

Cod, herring *Clupea harengus*, lemon sole, mackerel, Norway lobster, sandeels, sprat, tope shark *Galeorhinus galeus* and whiting all use the area as nursery grounds throughout much of the year (Table 3-2).

Table 3-2 Fish nursery and spawning in Block 49/26 throughout the year (Coull *et al.*, 1999; Ellis *et al.*, 2012)

35F2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cod	SN	S*N	S*N	SN	N	N	N	N	N	N	N	N
Herring	N	N	N	N	N	N	N	N	N	N	N	N
Lemon sole	N	N	N	SN	SN	SN	SN	SN	SN	N	N	N
Mackerel	N	N	N	N	S*N	S*N	S*N	SN	N	N	N	N
Norway lobster	SN	SN	SN	S*N	S*N	S*N	SN	SN	SN	SN	SN	SN
Plaice	S*	S*	S									S
Sandeels	SN	SN	N	N	N	N	N	N	N	N	SN	SN
Sprat	N	N	N	N	S*N	S*N	SN	SN	N	N	N	N
Tope shark	N	N	N	N	N	N	N	N	N	N	N	N
Whiting	N	SN	SN	SN	SN	SN	N	N	N	N	N	N

Key	S = Spawning	S* = Peak spawning	N = Nursery	High intensity spawning as per Ellis *et al.* (2012)

Aires *et al.* (2014) provides modelled spatial representations of the predicted distribution of 0 age group fish. The modelling indicates the presence of juvenile fish (less than one year old) for multiple species: anglerfish *Lophius piscatorius*, blue whiting *Micromesistius poutassou*, European hake *Merluccius merluccius*, haddock *Melanogrammus aeglefinus*, herring, mackerel, horse mackerel *Trachurus trachurus*, Norway pout *Trisopterus esmarkii*, plaice, sprat and whiting. Across the project area, the probability of juvenile fish aggregations occurring is low for all species (<0.15).

Sandeels were observed in the seabed imagery along transects LFATR_04 and LFGTR_04 (Figure 3-4). Sandeel species are listed as Features of Conservation Interest (FOCI) defined in relation to the MCZ network (Natural Environment and Rural Communities Act, 2006). There are two *Ammodytes sp.* in UK waters and both are protected by legislation with *A. marinus* listed as a priority species under UK Post 2010 Biodiversity Framework. As sandeels were observed outside of their spawning season (November to February), a sandeel spawning assessment was conducted (Gardline, 2021b).

According to criteria defined by Latto *et al.* (2013; cited in Gardline, 2021b), thirteen of the seventeen stations during the Gardline (2021b) habitat assessment survey along the Leman F to G pipeline route

(LFA_01, LFA_02, LFA_04, LF_01, LF_03, LFG_02, LG_02, LG_04 to LG_06, LA_01, LFGA_REF01 and LFGA_REF02, see Figure 3-4) met the 'Prime' habitat sediment preference for sandeel spawning, taking into account the percentage of both sand (>85%) and fine material (<1%). Each of these thirteen stations met the 'Preferred' habitat sediment classification for sandeel spawning according to their modified Folk classification of sand, slightly gravelly sand and gravelly sand (Gardline, 2021b).

A number of pelagic/demersal fish taxa were also observed during the recent pipeline survey, including dragonets (*Callionymus spp.*), flatfish (Pleuronectiformes) and pogges (*Agonus cataphractus*; Gardline, 2021b).

3.3.4. Marine mammals

3.3.4.1. Cetaceans

Harbour porpoise (*Phocoena phocoena)* are frequently found throughout UK waters. They typically occur in groups of one to three individuals in shallow waters, although they have been sighted in larger groups and in deep waters. They are present in UK waters throughout the year. They are common throughout the year within the vicinity of Leman F and G in variable densities, peaking in the summer months (Reid *et al.*, 2003). The density of harbour porpoise in the project area is estimated to be 0.888 animals/km^2 (Hammond *et al.*, 2021). Harbour porpoise are Annex II listed species and European Protected Species (EPS). No other cetacean species are likely to be present in the Leman area.

3.3.4.2. Pinnipeds

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

Approximately 38% of the world's grey seal population breeds in the UK, however the majority of these breed in Scotland. Donna Nook, Blakeney Point and Horsey are the three best established breeding colonies on the east coast of England. Most grey seals forage within 100 km of haul out sites, although they are capable of travelling many hundreds of kilometres. The estimated density of grey seals within the Leman area is thought to be up to one individual per 25 km^2 (Russell *et al.*, 2017).

The population of harbour seals in English waters is currently estimated to be approximately 5,400 individuals, equating to 12% of the UK population (approximately 44,000 individuals; SCOS, 2020). Generally, harbour seals forage around their haul out sites throughout the year and are not normally recorded more than 60 km from shore, although tagging studies have shown that they may occasionally forage at much greater distances. Due to this, the estimated density of harbour seals in Leman area is low at 0.4 individuals per 25 km^2 (Russel *et al.*, 2017; Figure 3-9).

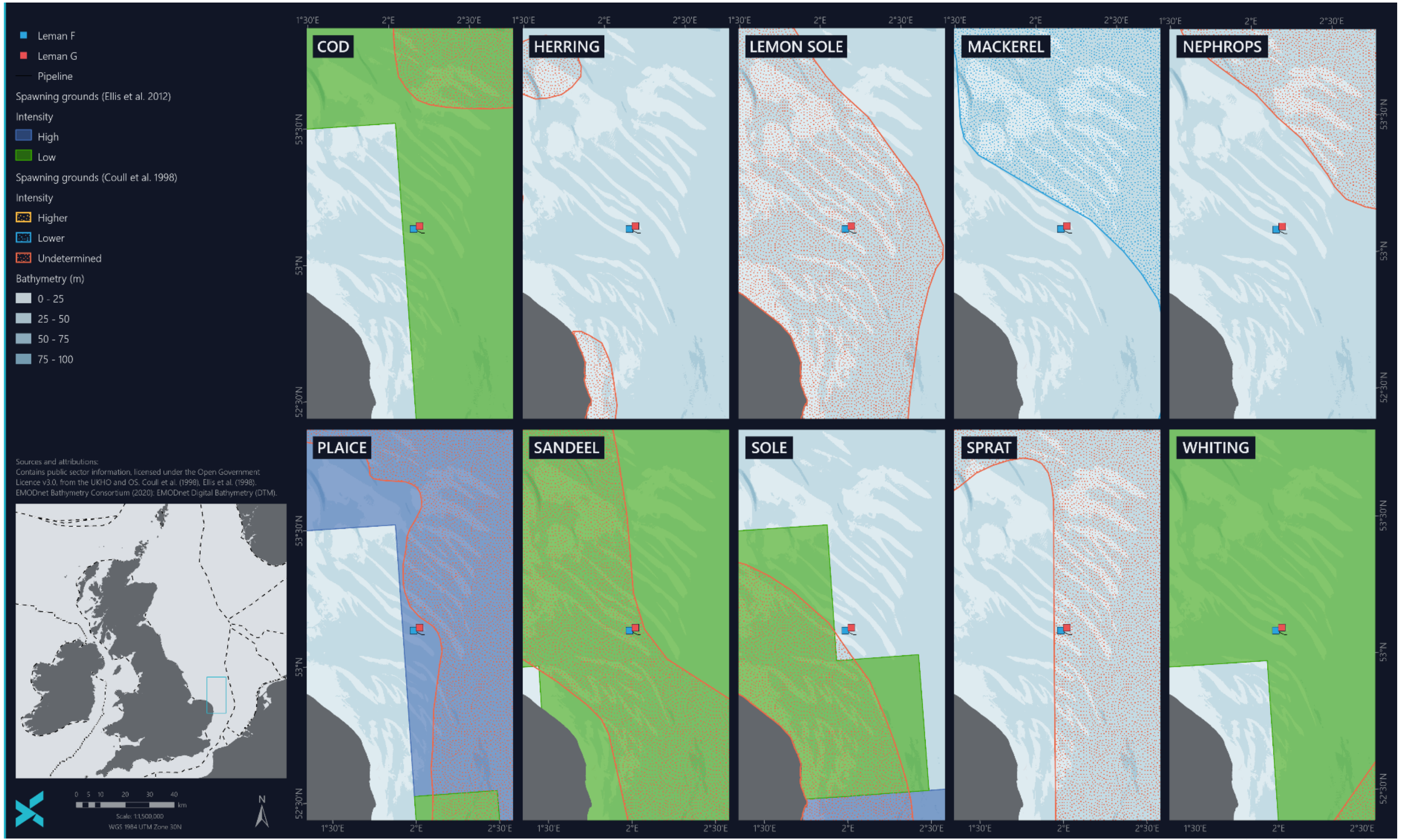


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Figure 3-7 Potential fish spawning grounds (adapted from Coull *et al.*, 1998 and Ellis *et al.*, 2012)

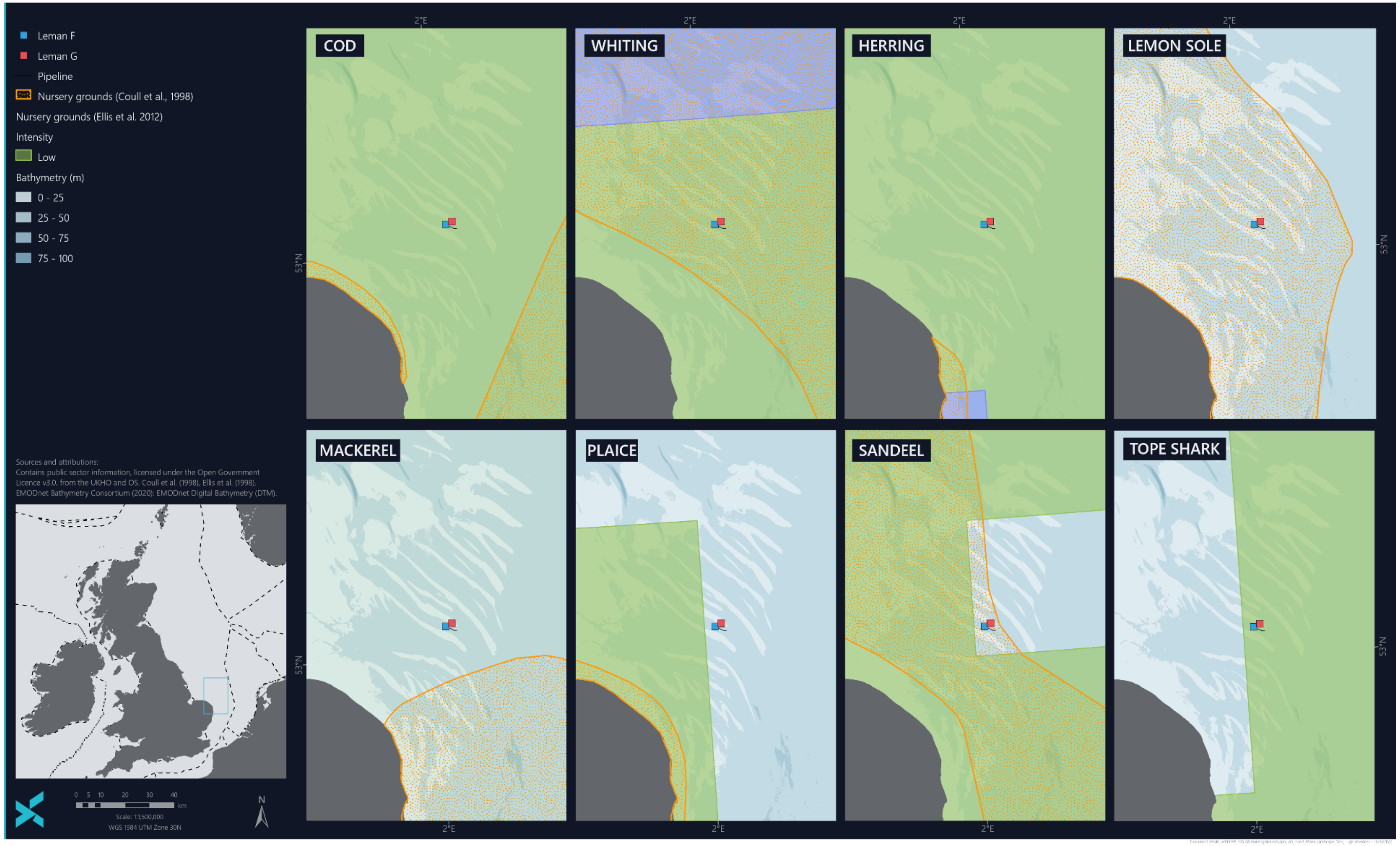

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Figure 3-8 Potential fish nursery habitats (adapted from Coull *et al.,* 1998 and Ellis *et al.*, 2012)

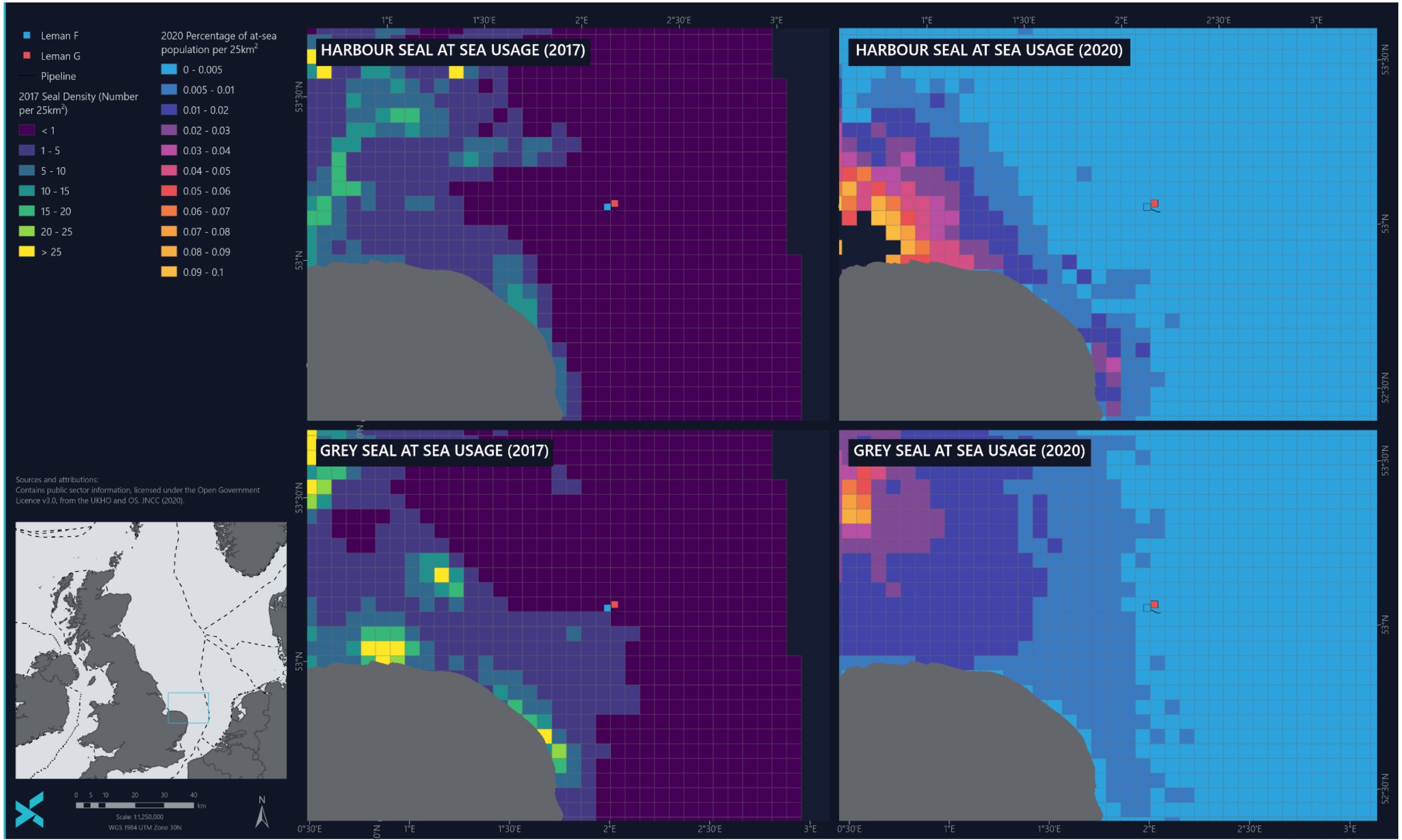

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Figure 3-9 Densities of pinnipeds in the Leman decommissioning area (Russel *et al.*, 2017)

3.3.5. Seabirds

The area surrounding Leman F and G is utilised by the following species at points in the year: sooty shearwater (*Puffinus griseus)*, Manx shearwater (*Puffinus puffinus)*, northern gannet (*Morus bassanus)*, pomarine skua (*Stercorarius pomarinus)*, Arctic skua (*Stercorarius parasiticus)*, great skua (*Stercorarius skua)*, black-legged kittiwake (*Rissa tridactyla)*, little gull (*Larus minutes)*, great black-backed gull (*Larus marinus)*, common gull (*Larus canus)*, lesser black-backed gull (*Larus fuscus)*, herring gull (*Larus argentatus*), sandwich tern (*Sterna sandvicensis)*, common tern (*Sterna hirundo)*, Arctic tern (*Sterna paradisaea)*, common guillemot (*Uria aalge)*, razorbill (*Alca torda)* and Atlantic puffin (*Fratercula arctica*; Kober *et al*., 2010).

The Seabird Oil Sensitivity Index (SOSI) identifies areas at sea where seabirds are likely to be most sensitive to surface pollution (Webb *et al*., 2016). SOSI is shown by UKCS Block; Leman F and G, and associated pipelines, are located within Block 49/26. SOSI for the Block and surrounding area is shown in Table 3-3. Seabird sensitivity to oil within Block 49/26 varies throughout the year, from low in the summer months (May-September) to extremely high in January and February (Webb *et al*., 2016).

Table 3-3 SOSI for Block 49/26 (Webb *et al*., 2016)

Block	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
48/25	1*	1	1	1*	3*	5*	4*	4	4*	2*	2	2
49/21	1*	1	2	2*	N	N	5*	5	5*	N	1*	1
49/22	1*	3*	3	3*	N	5*	5*	5	3	3*	1*	1
48/30	1*	1	3	3*	4*	5*	5	4	5	3*	3	2
49/26	**1***	**1**	**4**	**4***	**5***	**5***	**5***	**5**	**5**	**3***	**3**	**2**
49/27	1*	4*	4	4*	N	5*	5*	5	5*	N	1*	1
52/5	1	1	3	3*	5	5	5	4	5	3*	3	2
53/1	1	2	3	3*	5*	3*	5*	5	5	3*	3	2
53/2	1	3	3	3*	5*	3*	5*	5	5*	4*	4	2
Key	1 = Extremely high		2 = Very high		3 = High		4 = Medium		5 = Low		N = No data	

3.4. Conservation

The Leman A, F and G platforms and associated pipelines are all located within the North Norfolk Sandbanks and Saturn Reef SAC and the Southern North Sea SAC. Sites of conservation importance within the vicinity of the proposed decommissioning activities are shown in Figure 1-1. Sites for which potential interaction has been identified are described in Table 3-4 along with the sites Conservation Objectives.

Table 3-4 Relevant conservation sites and objectives

Site and reason for designation	Conservation Objectives
North Norfolk Sandbanks and Saturn Reef SAC The North Norfolk sandbanks are the most extensive example of the offshore linear ridge sandbank type in UK waters. They are a representative functioning example of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time'. The banks support communities of invertebrates which are typical of sandy sediments in the SNS such as polychaete worms, isopods, crabs and starfish. Areas of *S. spinulosa* biogenic reef are present within the site, which contribute to the sites designation of Annex I habitat 'Reefs' (JNCC, 2022a).	The Conservation Objectives of the site are for the features to be in favourable condition thus ensuring site integrity in the long term and contribution to the Favourable Conservation Status (FCS) of Annex I 'Sandbanks which are slightly covered by sea water all of the time' and Annex I 'Reefs'. This contribution would be achieved by maintaining or restoring, subject to natural change: • The extent and distribution of the qualifying habitats in the site; • The structure and function of the qualifying habitats in the site; and • The supporting processes on which the qualifying habitats rely (JNCC, 2022a).
Southern North Sea SAC The SNS SAC has been identified as an area of importance for harbour porpoise, an Annex II species. This site includes key winter and summer habitat for this species and covers an area over three times the size of Yorkshire, making it the largest SAC in UK and European waters at the point of designation in 2019. The Leman infrastructure is location within the harbour porpoise summer habitat (JNCC, 2022b).	The Conservation Objectives of the site are to ensure that the integrity of the site is maintained and that it makes the best possible contribution to maintaining FCS for harbour porpoise in UK waters. In the context of natural change, this will be achieved by ensuring that: • Harbour porpoise is a viable component of the site; • There is no significant disturbance of the species; and • The condition of supporting habitats and processes, and the availability of prey is maintained (JNCC, 2022b).

Other designated sites within 40 km of the infrastructure are as follows:

- Haisborough, Hammond and Winterton SAC (10 km SSW of the infrastructure): designated for two Annex I habitats: 'Sandbanks which are slightly covered by sea water all the time', and 'Reefs' (JNCC, 2022c).
- Greater Wash Special Protection Area (SPA) (30 km WSW of the infrastructure): area of importance for over-wintering for the red-throated diver, little gull and common scoter. In addition, the site aims to protect ideal coastal feeding waters used by breeding populations of common tern, sandwich tern and little tern (JNCC, 2022d).
- Cromer Shoal Chalk Beds MCZ (41 km WSW of the infrastructure): designated for a number of features including high and moderate energy circalittoral rock, high and moderate energy infralittoral rock, North Norfolk coast (subtidal), peat and clay exposures, subtidal chalk, subtidal coarse sediments, subtidal mixed sediments and subtidal sands (Natural England, 2016).

3.5. Socio Economic sensitivities

3.5.1. Commercial Fisheries

The North Sea is one of the world's most important fishing grounds (CEFAS, 2001). The southern North Sea sector however provides a relatively low contribution to the commercial fishery compared to areas such as the northern North Sea and west of Scotland (MMO, 2021). In addition, there are fewer key ports located along the east coast of England (MMO, 2021).

The Leman NUI's are situated within ICES Rectangle 35F2 which is an area of moderate fishing activity (targeted by both UK and international vessels). The most frequently used gear type in ICES Rectangle 35F2 is trawls, specifically beam trawls. Both shellfish and demersal species are targeted however, demersal value far exceeds that of shellfish. Average landings value from 2016 to 2020 comprised 3% shellfish and 97% demersal species respectively, with the dominant species caught including plaice, turbot and sole (MMO, 2021). Pelagic species have only recorded landings and therefore value within the years 2017 and 2020, however these values are still negligible accounting for <0.01% of the average landings value from 2016 to 2020. The species with the greatest value landed from ICES Rectangle 35F2 in 2020 was sole, with a value of £31,098.77 contributing 49% of the value of landings followed by plaice with a value of £9,088.66 accounting for 14% of the value of landings. However, in terms of landed weight plaice was the most landed species comprising 31% of landings (MMO, 2021; Table 3-5).

In the immediate vicinity of the Leman infrastructure (Figure 3-10) no landings data was recorded. The lack of data can further be explained by looking at trawling intensity and Automatic Identification System (AIS) data (Figure 3-11 and Figure 3-12). Trawling intensity across pipelines is very low; between 0 – 12 trawl passes across the ICES sub-blocks associated with the Leman pipelines per year on average (between 2007 – 2015). AIS vessel tracking data also shows that trawling activity in the vicinity of the Leman pipelines is negligible. In contrast, the area to the south and east of the Leman facilities have high densities of vessel tracks, suggesting that trawling fisheries are active in the surrounding areas but are not currently active in the immediate Leman F, G and A areas.

3.5.2. Commercial Shipping

The density of shipping traffic in the SNS is relatively high due to the presence of fishing vessels, some ferries between the UK and the rest of Europe and cargo and offshore support vessels (DECC, 2016). Shipping activity within Block 49/26 is considered to be high (OGA, 2016).

Table 3-5 Landings weight and catch value in ICES Rectangle 35F2 between 2016-2020 (MMO, 2021)

Species type	2020		2019		2018		2017		2016	
	Live weight (Te)	Value (£)	Live weight (Te)	Value (£)	Live weight (Te)	Value (£)	Live weight (Te)	Value (£)	Live weight (Te)	Value (£)
Demersal	33.5	53,104.85	6.2	24,645.52	6.96	15,678.92	63.2	235,570.7	84.1	366,215.5
Pelagic	0.061	44.53	0	0	0	0	0.01	0.2	0	0
Shellfish	5	10,551.41	6.4	9,116.51	3.2	4,411.88	0.09	416.77	0.03	129.8
Total	**38.561**	**63,700.79**	**12.6**	**33,762.03**	**10.16**	**20,090.8**	**63.3**	**235,987.67**	**84.13**	**366,345.3**

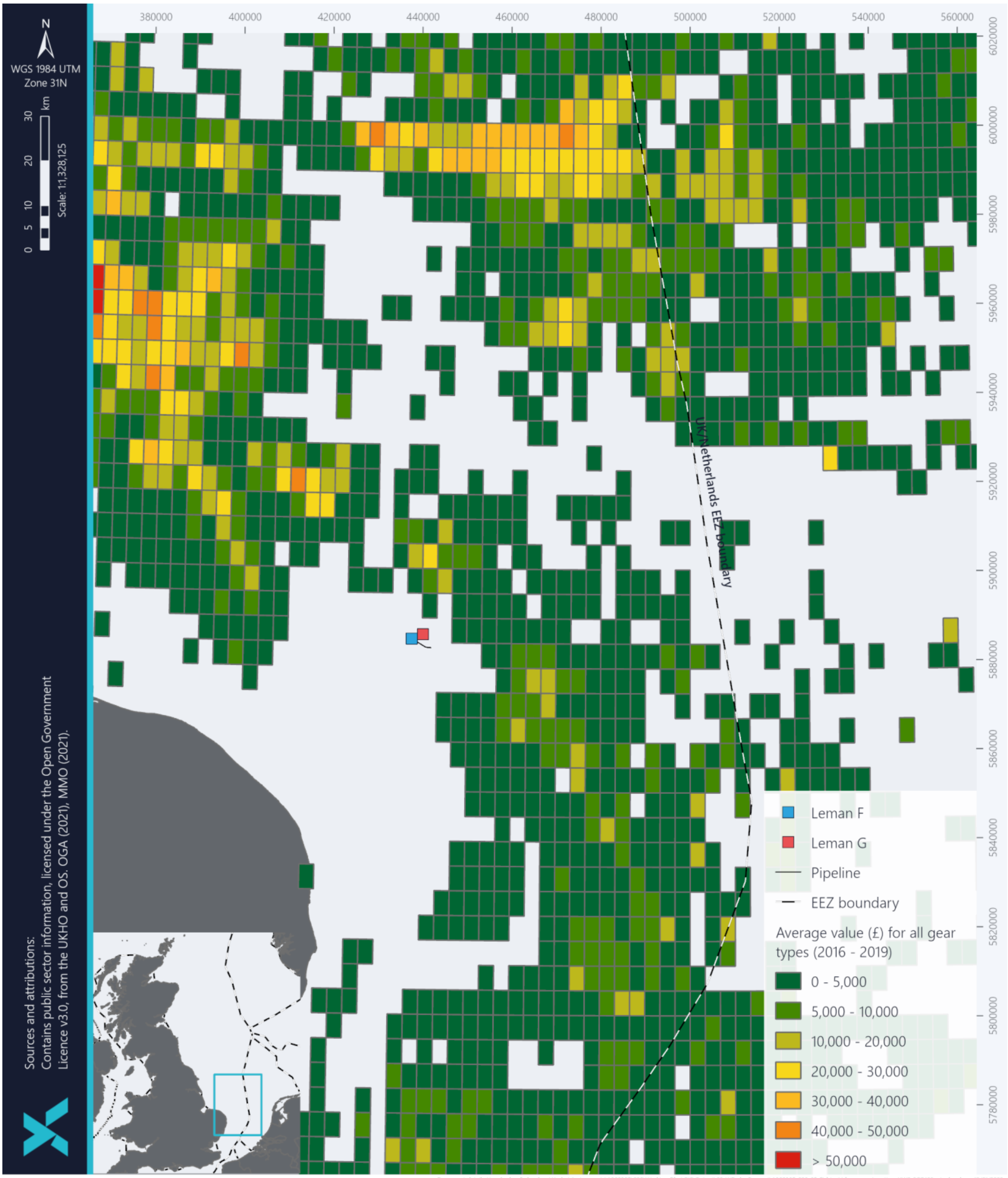

Figure 3-10 Average landings (for all gear types) between 2015-2019 (MMO, 2021)

Figure 3-11 Fishing intensity and AIS fishing tracks in the area surrounding the Leman infrastructure

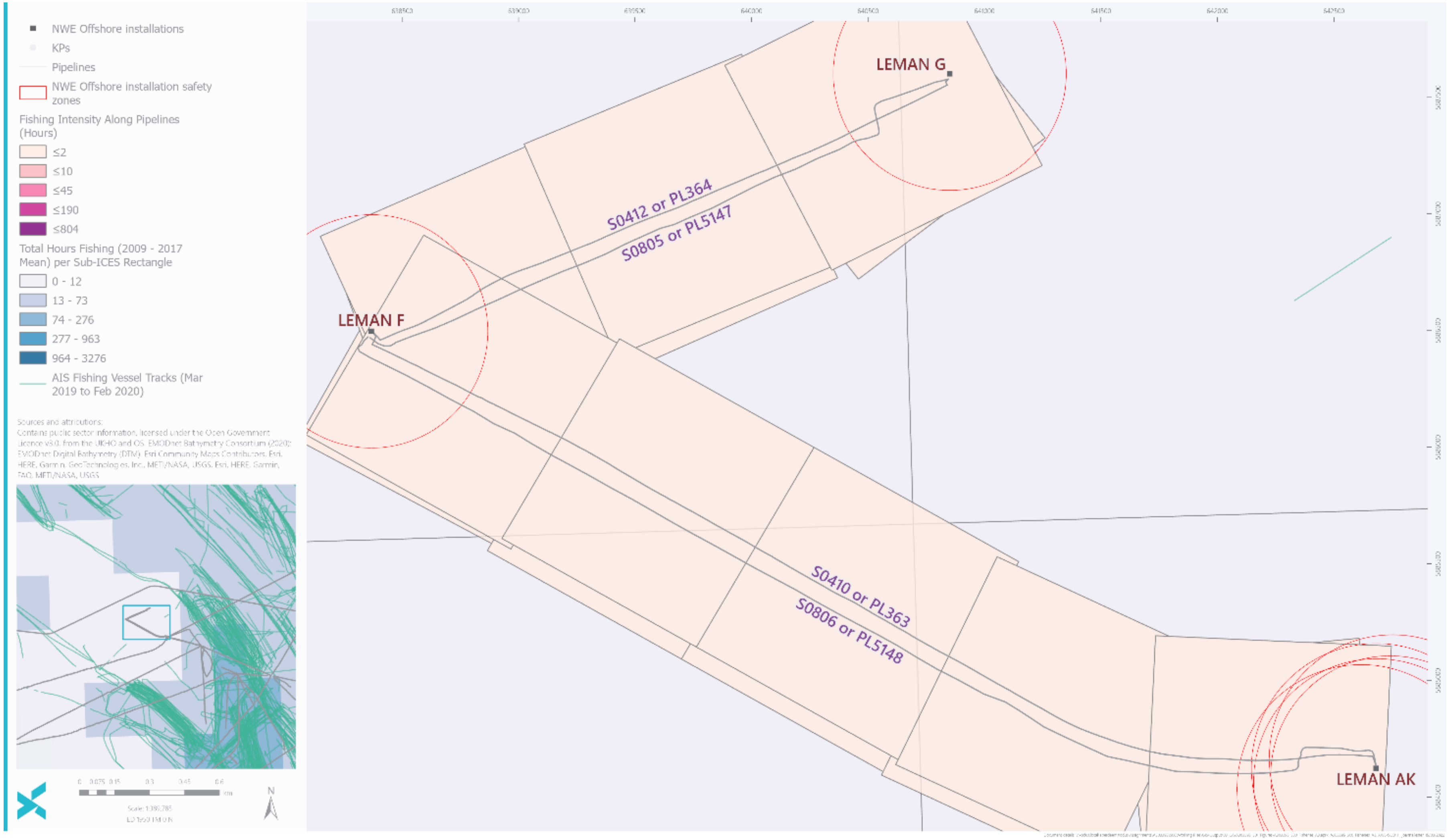

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Figure 3-12 Fishing intensity and AIS fishing tracks adjacent to the Leman infrastructure

3.5.3. Oil and Gas Activity

The project area is located in the SNS within an area of extensive oil development. There are numerous oil and gas surface installations within 40 km of the project area (Table 3-6).

Table 3-6 Oil and Gas Activity Within 40 km of Leman G

Installation Name	Installation type	Operator	Distance and direction from Leman G (Shell) NUI
Leman AD1, AK, AP, AC, AD2	Platforms	Shell	~3.5 km SSE
Leman CD, CP (Shell)	Platforms	Shell	~4.5 km ESE
Leman BT	Platforms	Shell	6.5 km SE
Leman BP, BD (Shell)	Platforms	Perenco	7 km ESE
Leman AD, AX, AP, AC, AQ,	Platforms	Perenco	11 km ESE
Leman E	Platform	Perenco	9.2 km SE
Leman EP, ED	Platforms	Perenco	9.6 km SE
Leman J	Platform	Perenco	12.5 km SE
Leman D	Platform	Shell	13.5 km SSE
Leman H	Platform	Perenco	14.5 km SE
Leman CD, CP (Perenco)	Platforms	Perenco	14.5 km SE
Leman FD, FP	Platforms	Perenco	17 km ESE
Leman G (Perenco)	Platform	Perenco	21 km ESE
Leman DD, DP	Platforms	Perenco	20 km ESE
52/5A, 48/29C, 48/29A-Q, 48/29A-P, 48/29A-FTP, 48/29B	Platforms	ENI	22 – 29 km WSW
UK BLK 53/2 ARTHUR 2	Platform	Perenco	27 km SSE
Bessemer A	Platform	Perenco	27 km ENE
Inde D, CD, CP, AT, AC, AQ	Platform	Perenco	34 - 39 km ENE
Corvette	Platform	Shell	37 km ENE
Clipper South	Platform	INEOS	38 km NNW
Skiff	Platform	Shell	40 km NNW

3.5.4. Renewable Energy Activities

There are no operational offshore wind farms (OWFs) in the vicinity of the Leman NUI's (<40 km). The closest proposed OWF is the Norfolk Vanguard Transmission Asset, which is located to the SE of the Leman NUI's (Figure 3-13). The Norfolk Vanguard Transmission Asset has recently received development consent.

3.5.5. *Submarine Cables*

There is one disused telecommunication running approximately 28 km WNW of the project area, which is the STRATOS cable. It appears to run a route from Weybourne to an offshore location not marked by any infrastructure. Though disused, sections of this cables may remain on the seabed. The nearest telecommunications cable is the NORSEA COM Tampnet Lowestoft to Murdoch cable which is currently active; it is located approximately 22 km ENE of the Leman NUI's (Figure 3-13; NMPi, 2020).

3.5.6. *Military Activities*

Block 49/26 does not lie within training ranges that are areas of concern to the Ministry of Defence (MoD; OGA, 2019).

3.5.7. *Marine Archaeology and Wrecks*

There are several wrecks recorded in the vicinity of the proposed operations. The closest wrecks are unknown wrecks located at 4 km ENE, 6 km WNW (dangerous), 7 km ENE (non-dangerous) and Vanilla 7 km WNW (dangerous) (NMPI, 2022).

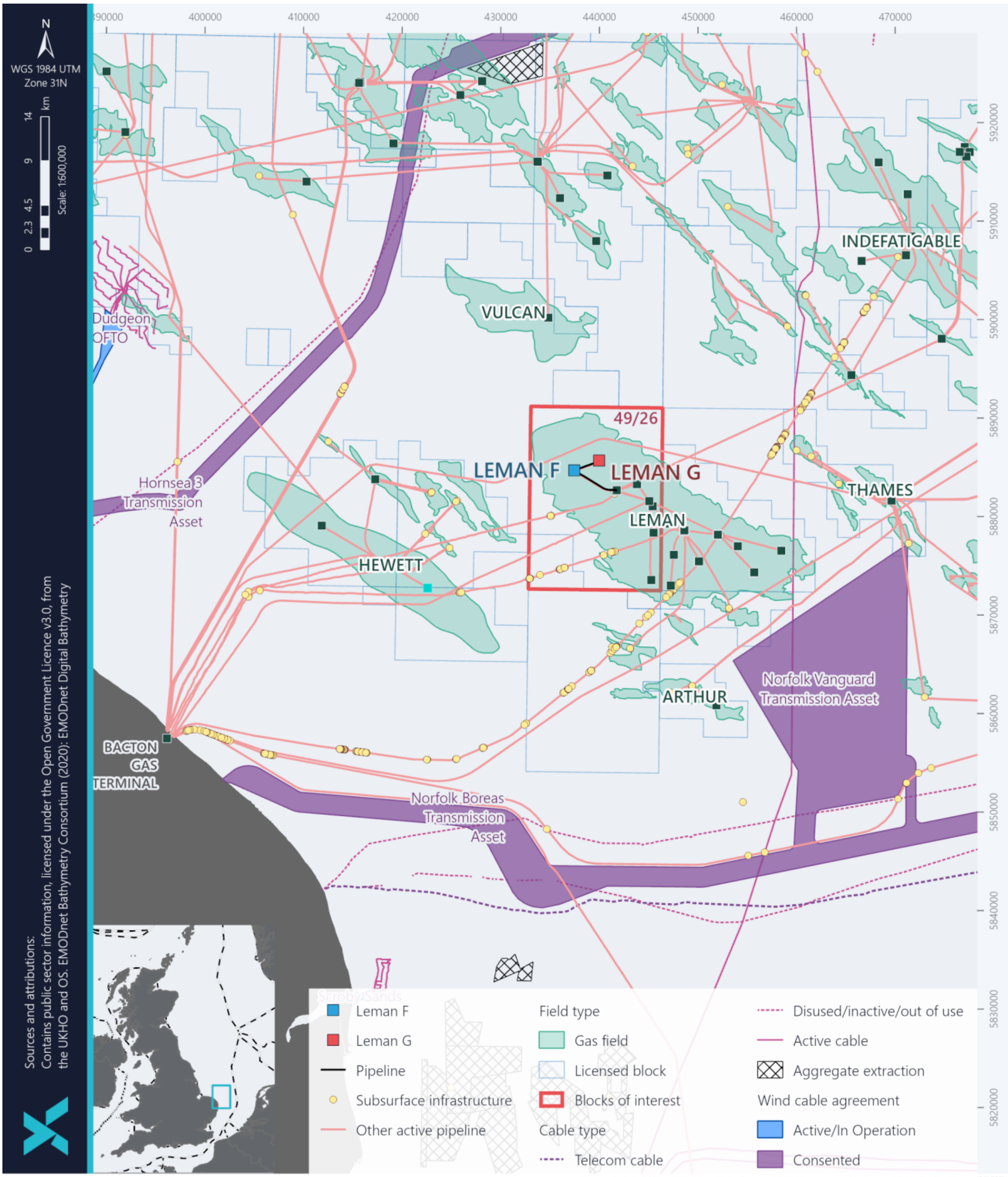

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Figure 3-13 Oil and gas activity within Quadrant 49/26

4. IMPACT ASSESSMENT SCREENING AND JUSTIFICATION

4.1. Assessment of Potential Impacts

4.1.1. ENVID Workshop

In line with the recent OPRED decommissioning guidelines, Shell undertook proportionate ENVironmental Impact IDentification (ENVID) workshop that assessed the significant areas of interest in relation to the proposed decommissioning activities and sensitive receptors. The ENVID workshop was broken down into project activities which were examined sequentially to consider the potential impacts of the decommissioning activities on the environmental and social aspects outlined in Section 3. During the workshop assessment scores, actions and mitigations were recorded in an aspects and impacts matrix, which is presented in Appendix B. The environmental and social aspects with the potential for having an impact were assessed in terms of:

- Magnitude based on the size, extent and duration of the impact (Section 4.1.2);
- The sensitivity of the receiving receptors (Section 4.1.3);
- The significance of the impact (based on magnitude and sensitivity (Section 4.1.4)
- The likelihood of an unplanned event occurring (Section 4.1.5).

4.1.2. Magnitude

Levels of magnitude of environmental impacts are outlined in the Table 4-1 The magnitude of an impact or predicted change takes into account the following:

- Nature of the impact and its reversibility
- Duration and frequency of an impact
- Extent of the change
- Potential for cumulative impacts

The impact magnitude is defined differently according to the type of impact. For readily quantifiable impacts, such as noise or plume extent, numerical values can be used whereas for other topics (e.g. ecology) a more qualitative definition may be necessary. These criteria capture high level definitions. According to the nature of a project some additional factors could be included. More suitable definitions can be added according to the project being pursued but they must be equivalent.

Table 4-1 Magnitude Definition

Definition	Environmental Impact
No effect	• No environmental damage or effects
Slight effect	• Slight environmental damage contained within the premises. Example: Small spill in process area or tank farm area that readily evaporates • Effects unlikely to be discernible or measurable • No contribution to transboundary or cumulative effects • Short-term or localised decrease in the availability or quality of a resource, not affecting usage
Minor effect	• Minor environmental damage, but no lasting effects • Change in habitats or species which can be seen and measured but is at same scale as natural variability • Unlikely to contribute to trans-boundary or cumulative effects • Short-term or localised decrease in the availability or quality of a resource, likely to be noticed by users
Moderate effect	• Environmental damage that will persist or require cleaning up. • Widespread change in habitats or species beyond natural variability • Observed off-site effects or damage, e.g. fish kill or damaged vegetation. • Decrease in the short-term (1-2 years) availability or quality of a resource affecting usage • Local or regional stakeholders' concerns leading to complaints • Minor transboundary and cumulative effects
Major effect	• Severe environmental damage that will require extensive measures to restore beneficial uses of environment. • Widespread degradation to the quality or availability of habitats and/or wildlife requiring significant long-term restoration effort. • Major oil spill over a wide area leading to campaigns and major stakeholders' concerns • Transboundary effects or major contribution to cumulative effects • Mid-term (2-5 y) decrease in the availability or quality of a resource affecting usage • National Stakeholders' concern leading to campaigns affecting Company's reputation
Massive effect (unplanned events only)	• Persistent severe environmental damage leading to loss of use or loss of natural resources over wide area. • Widespread long-term degradation to the quality or availability of habitats that cannot be readily rectified. • Major impact on the conservation objectives of internationally/nationally protected site. • Major trans-boundary or cumulative effects. • Long-term (>5 y) decrease in the availability or quality of a resource affecting usage • International public concern

4.1.3. Sensitivity

Receptors were categorised into different groups:

- Atmosphere
- Water (Marine, Estuarine, river or groundwater)
- Habitat or species
- Community
- Soil or Seabed

Receptor sensitivity criteria (Table 4-2) are based on the following key factors:

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

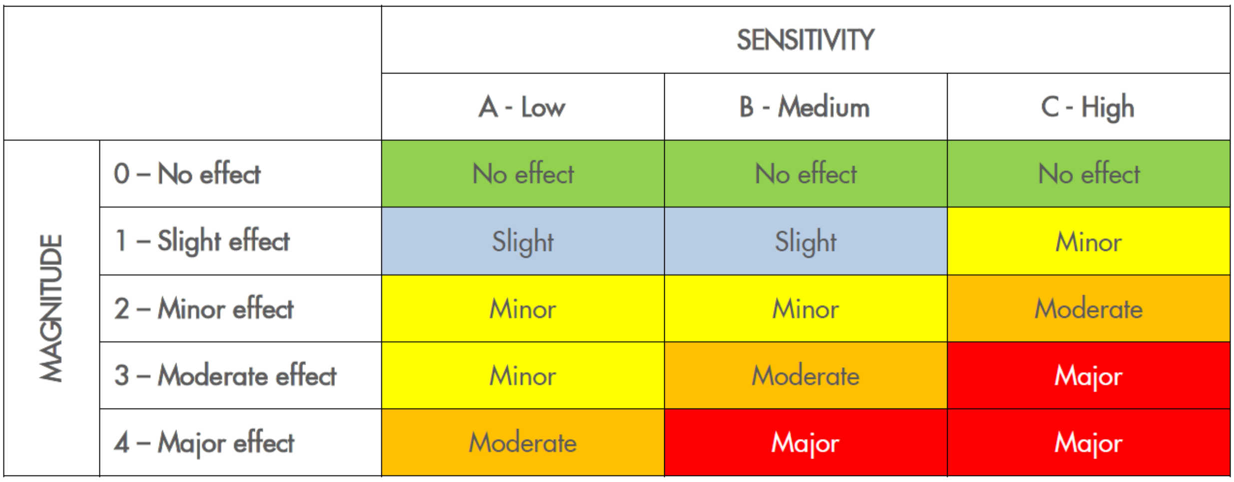
Table 4-2 Sensitivity Definition

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

4.1.4. *Significance criteria for planned/ unplanned events*

The magnitude of the impact and sensitivity of receptor is then combined to determine the impact significance for planned events as shown in Table 4-3. Mitigation measures will then be identified to reduce the risk of such an event occurring in order to determine residual risk.

Table 4-3 Impact Significance Matrix (Planned Events)



		SENSITIVITY		
		A - Low	B - Medium	C - High
MAGNITUDE	0 – No effect	No effect	No effect	No effect
	1 – Slight effect	Slight	Slight	Minor
	2 – Minor effect	Minor	Minor	Moderate
	3 – Moderate effect	Minor	Moderate	Major
	4 – Major effect	Moderate	Major	Major

4.1.5. *Unplanned events likelihood criteria*

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

As with planned activities, the potential impacts of unplanned events will be identified, and their magnitude and the sensitivity of the environment defined and combined to determine the impact significance. The significance of the impact will then be combined with the likelihood of the event occurring (Table 4-4) to determine its overall environmental risk as summarised in Table 4-5. Mitigation measures will then be identified to reduce the risk of such an event occurring, to determine residual risk. Note that 'Massive' events are included in the evaluation of environmental risk for unplanned events. Refer to the magnitude definitions in Table 4-1 for more information.

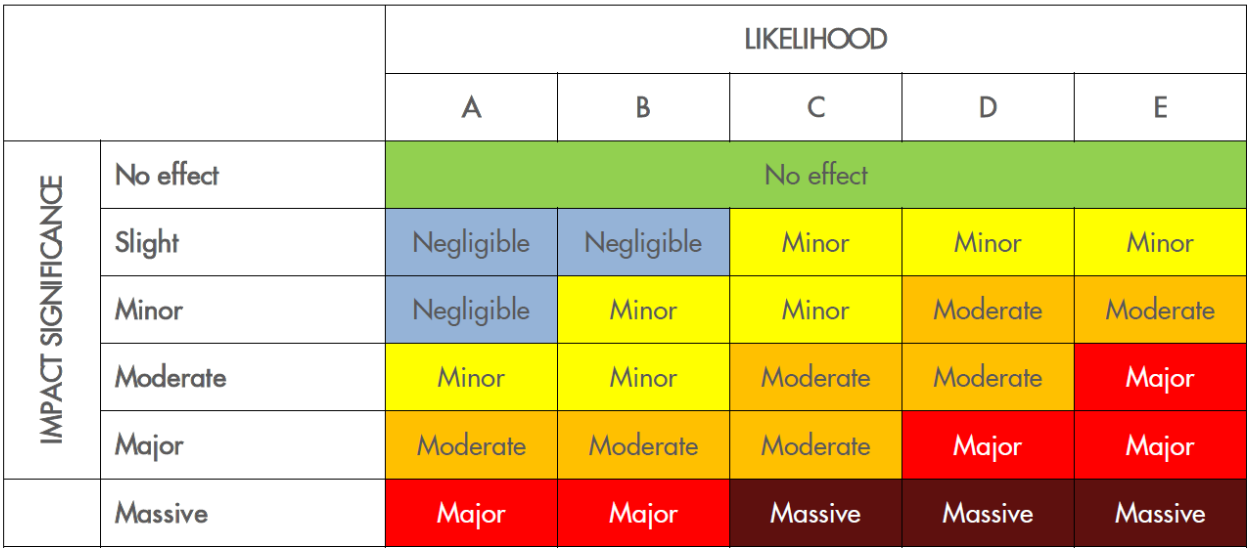
4.2. Impact scoping

Seven potential impacts were screened out of further assessment based on the low level of severity, or low likelihood of significant impact occurring and four were carried forward for further assessment. An overview of the potential impacts is provided in Table 4-6, together with justification statements for the screening decisions. Further information regarding industry standard and project-specific mitigation and controls can be found in the impacts and aspects table in Appendix B

Table 4-4 Likelihood Criteria (Unplanned Events)

Likelihood	Definition
A	• Never heard of in the industry - Extremely remote • <10-^{5} per year • Has never occurred within the industry or similar industry but theoretically possible
B	• Heard of in the industry – Remote • 10^{-5} – 10^{-3} per year • Similar event has occurred somewhere in the industry or similar industry but not likely to occur with current practices and procedures
C	• Has happened in the Organisation or more than once per year in the industry – Unlikely • 10^{-3} – 10^{-2} per year • Event could occur within lifetime of similar facilities. Has occurred at similar facilities.
D	• Has happened at the location or more than once per year in the Organisation – Possible • 10^{-2} – 10^{-1} per year • Could occur within the lifetime of the development
E	• Has happened more than once per year at the location – Likely • 10^{-1} - >1 per year • Event likely to occur more than once at the facility.

Table 4-5 Evaluation of Environmental Risk (Unplanned)



		LIKELIHOOD				
		A	B	C	D	E
IMPACT SIGNIFICANCE	No effect	No effect				
	Slight	Negligible	Negligible	Minor	Minor	Minor
	Minor	Negligible	Minor	Minor	Moderate	Moderate
	Moderate	Minor	Minor	Moderate	Moderate	Major
	Major	Moderate	Moderate	Moderate	Major	Major
	Massive	Major	Major	Massive	Massive	Massive

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Table 4-6 Environmental Impact Screening Summary

Environmental/ Social Aspect	Further Assessment?	Rationale	Proposed mitigation and best practice
Emissions to air	Yes	To account for potential venting of gas in combination with other emissions	Refer to Section 5.1
Energy consumption	No	Limited raw materials required (largely restricted to vessel fuel use).	• Vessel management: Minimal vessel use and vessel sharing where possible. • Engine maintenance.
Waste materials	No	Well-controlled waste management process	• Waste management strategy • Active Waste Management Plan • Hazardous waste permitting • Transfrontier shipment notification (if required). • Contractor 'Duty of Care' • HSE audits if required • Adherence to the waste hierarchy

Environmental/ Social Aspect	**Further Assessment?**	**Rationale**	**Proposed mitigation and best practice**
Onshore impact	**No**	Established port infrastructure, dismantling sites and disposal routes will be used	• Established port infrastructure, dismantling sites and disposal routes will be used • Only fully licensed sites will be used to deal with hazardous and non-hazardous wastes • Pollution, disturbance and/or odours will be minimized and managed within the permitted limits of the onshore dismantling and/ or recycling sites • Contractor 'Duty of Care' • HSE audits if required • Adherence to the waste hierarchy
Physical presence (seabed)	**Yes**	Snagging Risk for fisheries/ stakeholder concern	Refer to Section 5.2
Physical presence (sea surface)	**No**	Vessel presence during decommissioning is not expected to be higher than operational levels Vessel (including fishing vessel) density in the immediate Leman area is very low	• Work within existing 500 m safety exclusion zones • Notices to Mariners • admiralty chart updates. • Campaigning opportunities to be explored to minimize vessel usage.

Environmental/ Social Aspect	Further Assessment?	Rationale	Proposed mitigation and best practice
Noise and vibrations	**No**	Noise would be derived from vessels and mechanical cutting operations relating to the severance and removal activities. None of these are perceived to be significantly damaging to the marine mammals or fish in the decommissioning area.	• No explosives will be used during infrastructure or well decommissioning operations. • Campaigning opportunities to be explored to minimize vessel usage.
Discharges to sea	**No**	To be considered under the permit consent applications for the decommissioning activities through the Portal Environmental Tracking System (PETS)	• MARPOL compliance. • Bilge management procedures. • Contractor management procedures.
Seabed disturbance	**Yes**	Activities requiring quantification: • Substructure removal (dredging and cutting activities) • Spool and pipeline end removal: deburial cut and lift, deburial • Rock placement • Mattress removal • Vessel Anchoring • Degradation of pipelines *in situ* • Potential for overtrawl activities	Refer to Section 5.3

Environmental/ Social Aspect	Further Assessment?	Rationale	Proposed mitigation and best practice
Disturbance to nesting seabirds	Yes	No evidence of nesting birds to date on NUIs, however a Bird Management Plan will be in place prior to commencement of decommissioning activity.	Refer to Section 5.4
Accidental events	**Yes: Vessel Collision** **No: Dropped objects**	**Vessel Collision:** Low likelihood but high magnitude scenario deemed to require further investigation **Dropped Objects:** Dropped object procedures are industry-standard and there is only a very remote probability of any interaction with any live infrastructure. The in-situ decommissioning of some infrastructure will also limit the potential for dropped objects or dislodged materials/objects.	**Vessel Collision:** Refer to Section 5.4 **Dropped objects:** • 500 m zones operational until seabed clearance certified • Contractor management and communication • Lifting operations management of risk • PON2 submission • Careful planning, management and implementation of activities

5. IMPACT ASSESSMENT

The five impacts to be carried forward are assessed in the following sections:

Section 5.1: Emissions to air

Section 5.2: Physical presence (seabed)

Section 5.3: Seabed disturbance

Section 5.4: Disturbance to nesting seabirds

Section 5.4: Accidental events

5.1. Emissions to air

5.1.1. Introduction

On a global scale, concern regarding atmospheric emission of greenhouse gasses (GHGs) (including water vapour, carbon dioxide (CO_2), methane (CH_4), nitrous oxides (NO_x), ozone (O_3), chlorofluorocarbons (CFCs)) and volatile organic compounds (VOCs) is focused on the impact they have on global climate change. The Intergovernmental Panel on Climate Change (IPCC) in its sixth assessment report (AR6) states that it is unequivocal that the increase of CO_2, CH_4 and NO_x in the atmosphere over the industrial era is the result of human activities. Human influence is the principal driver of many changes observed across the atmosphere, ocean, cryosphere and biosphere. (IPCC, 2021). Climate change estimates in the AR6 report state that each of the last four decades have been successively warmer than any decade that preceded it since 1850. IPCC (2021) reports a 47% increase in CO_2 concentrations since 1750 which far exceeds the natural multi-millennial changes between glacial and interglacial periods over at least the past 800,000 years, and states that fossil fuel combustion is the primary contributor to the observed climate change.

The information on the quantification and impact assessment of the emissions is presented in this chapter of the EA represents atmospheric emissions associated with:

- Offshore vessel use for decommissioning activities.
- Lifecycle emissions (onshore transport, recycling, new manufacture of recyclable material decommissioned *in situ*)
- Venting activities.

On a local-scale emissions such as nitrogen and sulphur oxides (NO_x and SO_x) and carbon monoxide (CO) may affect air quality. These emissions may be assessed against onshore local air quality guidelines to understand the potential magnitude of impact on human health and the environment. These guidelines are intended to mitigate the regional, national, and transboundary issues caused by these pollutants such as acid rain and eutrophication.

5.1.1.1. Regulatory Controls

In the UK, there are several atmospheric regulatory controls which apply to offshore developments and require the provision of atmospheric emissions inventories and management. Following the UK's departure from the EU, the atmospherics legislation that is derived from EU regulations was transcribed into UK law.

Relevant legislation for offshore combustion equipment includes:

- Climate Change Act 2008
- The National Emission Ceilings Regulations 2002
- The Greenhouse Gas Emissions Trading Scheme Order 2020
- Pollution Prevention and Control Act 1999
- The Offshore Combustion Installations (Pollution Prevention and Control) Regulations 2013 as amended by The Offshore Combustion Installations (Pollution Prevention and Control) (Amendment) Regulations 2018
- The Pollution Prevention and Control (Designation of Medium Combustion Plant Directive) (Scotland) Order 2017
- The Pollution Prevention and Control (Scotland) Amendment Regulations 2017
- The Pollution Prevention and Control (Designation of the Medium Combustion Plant Directive) (Offshore) Order 2018

The NSTA issued (June 2021) consolidated and updated guidance on flaring and venting, which sets out their approach to driving reductions, through clear principles and using the NSTA consenting regime and stewardship activity. The requirements to have consent to flaring and venting are set out in the Energy Act 1976 and the applicable offshore production license (granted under the Petroleum Act 1998).

The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008 implement MARPOL Annex VI in the UK and establish controls on marine engines and marine fuel in order to limit emissions, in particular NOx and SOx. All vessels used during the proposed project will have the appropriate UK Air Pollution Prevention Certificate (UKAPP) or International Air Pollution Prevention Certificate (IAPP) in place, as required.

- Regulation 14 designated the North Sea for the purposes of SOx and particulate matter control Sulphur Oxides Emission Control Areas (SECA).
- Regulation 13 requires Nitrogen Oxides Emissions Control Areas (NECA) to be included within Emission Control Areas (ECA) as evidenced by the issue of Engine International Air Pollution Prevention Certifications (EIAPP)
- Directive 2005/33/EC amending Directive 1999/32/EC as regards the sulphur content of marine fuels
    - The Sulphur Content of Liquid Fuels (England and Wales) Regulations 2000
    - The Sulphur Content of Liquid Fuels (Scotland) Regulations 2014

5.1.2. Description and quantification of impact

5.1.2.1. Offshore vessel use

Workscopes during decommissioning are predicted to occur periodically and therefore it is considered that increases in vessel emissions will be negligible above the existing emissions inventory in the region.

The emissions of relevant GHGs, for which the global warming potentials are listed in

Table 5-2 have been calculated from the estimated total amount of fuel that will be required by vessels. Vessel emissions for combustion gases other than CO_2 were converted into an overall CO_2e using their GWP as defined by the IPCC. The global warming potential (GWP) factors used to estimate the equivalent CO_2 from fuel use are presented in Table 5-1 (Institute of Petroleum (IoP; 2000) and the National Atmospheric Emissions Inventory (NAEI; 2019)). The emissions of individual GHGs were then summed to a single value of carbon dioxide equivalent (CO_2e), to describe different GHGs in a common unit. For any quantity and type of GHG, CO_2e signifies the amount of CO_2 with the equivalent global warming impact. CO_2e was then used to compare the emissions from the Leman F and G (

Table 5-2, Table 5-3 and Table 5-5) decommissioning vessel activities with total UKCS emissions and the UK carbon budget.

Table 5-1 Global warming potential (100-year horizon) of relevant GHGs – Te CO_2e (IPCC, 2021)

CO_2	CH_4	N_2O	CO	VOC
1	29.7	273	1.6	5.6

Table 5-2 Leman decommissioning vessel activity

Activity	Vessel	Duration (days)			Fuel use (Te)
		Mob/ demob	Transit	Working[3]	
Pre-decom pipeline survey	Survey vessel	5	1	1	50
Debris clearance	Construction Support Vessel (CSV)	5[1]	1	5	162.9
	Guard vessel/ ERRV	3[2]	1	5	
NUI Removal	Semi-Sub Crane Vessel (SSCV)	5	1	3	464.8
	Dive Support Vessel (DSV)	5	1	4	
	Barge	3	1	3	
	Guard vessel/ ERRV	-	1	10	
Spool, pipeline and cable cutting and removal	CSV	-	1	2	137.4
	ROVSV	5.5	1	1	
	Guard vessel/ ERRV	-	1	3	
Mattress removal	CSV	-	1	8	234.4
	Guard vessel /ERRV	-	1	8	
Remediation	Rock placement vessel	5	1	2	52.2
	Guard vessel/ ERRV	-	1	2	
Post-decom survey	Survey vessel	5	1	1	50
Overtrawl[4]	Fishing vessel	0.5	1	1	45.5
Legacy surveys[5]	Survey vessel	5 x 5	1 x 5	1 x 5	250

[1] CSV mob/ demob only required on one occasion, following which it will be on site for the duration of the decommissioning activities

[2] Guard vessel/ ERRV mob/ demob only required on one occasion, following which it will be on site for the duration of the decommissioning activities

[3] Waiting on weather has been accounted for in working days

[4] Overtrawl has been included as a worst-case scenario and is not likely to be required.

[5] Five additional legacy surveys have been accounted for here to include ongoing liability for the pipelines and cables decommissioned *in situ*.

Table 5-3 Leman decommissioning vessel emissions (Te)

Activity	CO_2	N_2O	CH_4	CO	VOC	NO_x	SO_2	CO_2e
Pre-decommissioning pipeline survey	158.5	0.01	0.01	0.8	0.1	3.0	0.6	163.0
Debris clearance	516.4	0.04	0.03	2.6	0.3	9.6	2.0	531.0
NUI Removal	1473.4	0.1	0.08	7.3	0.9	27.4	5.6	1514.8
Spool, pipeline and cable removal	435.6	0.03	0.02	2.2	0.3	8.1	1.6	447.9
Mattress removal	743.0	0.05	0.04	3.7	0.5	13.8	2.8	763.9
Remediation	165.0	0.01	0.01	0.8	0.1	3.1	0.6	169.6
Post-decommissioning survey	158.5	0.01	0.01	0.8	0.1	3.0	0.6	163.0
Overtrawl	150.58	0.75	2.80	0.01	0.57	0.01	0.01	155.42
Legacy surveys	792.5	0.05	0.5	3.9	0.5	14.8	3.0	815.3
Total	**4,593.5**	**1.1**	**3.5**	**22.1**	**3.4**	**82.8**	**16.8**	**4,723.9**

Note: Emissions factors for marine diesel are included in Appendix C

In 2019 commercial fishing in UK waters emitted 782 kt CO_2e, coastal shipping 4,521 kt CO_2e, and leisure craft 186 kt CO_2e (NAEI, 2019). The maximum emissions from the Leman decommissioning vessels would amount to about 4.7 kt CO_2e. This represents about 0.086% of the sum of the emissions from the sources described above for shipping in 2019 (5,489 kt CO_2e).

Impacts on local air quality and global warming due to vessel use in the Leman area are not expected to be detectable above current background levels due to the limited number of vessels and time spent of decommissioning activities. As with all other sectors of UK industry, shipping is identifying opportunities to decarbonize and therefore the atmospheric emissions from the decommissioning vessels may be less than those predicted for installation and commissioning.

5.1.2.2. Lifecycle emissions

5.1.2.2.1. Onshore transport

Onshore transport emissions are those associated with the transport of waste from the arrival port to treatment, landfill and/ or recycling facilities. As waste contractors have not been identified as yet, the distance travelled is based on a worst-case scenario of transport to Norway and onshore transport of waste materials to a recycling and/ or treatment facility within a 20 km radius (40 km round trip) of the port location. The total (worst-case) emissions associated with onshore transport were estimated to be 6.5 tCO_2e (Table 5-5).

Table 5-4 Leman onshore transport emissions (Te)

	CO_2	N_2O	CH_4	CO	VOC	NO_x	SO_2	CO_2e
Emissions	2.6	0.2	0.0006	1.15	0.10	2.4	0.01	**6.5**

Note: Emissions factors for diesel are included in Appendix C

5.1.2.2.2. Recycling

Inevitably, recycling creates carbon emissions as energy is required to re-process recyclable waste. GHG emissions are estimated using EFs that relate the quantity of a pollutant emitted to a unit of activity (e.g., kg fossil CO_2 per tonne of material reprocessed). In the case of waste material recycling, EFs are often expressed per tonne of waste material collected and sent for recycling (kg CO_2e/t). The total emissions associated with recycling of the waste materials listed in Table 2-5, were estimated to be 7,636 tCO_2e, as shown in Table 5-5.

5.1.2.2.3. New manufacture

The manufacture of materials results in the emission of CO_2e, termed embodied carbon. The embodied carbon in the context of the Leman F and G decommissioning project is in relation to the loss to society of otherwise recyclable material decommissioned *in situ*, i.e. that contained within the pipelines and cables. The material quantities were calculated based on the available data with expert engineering knowledge. EFs were applied to obtain the values for the embodied carbon in the materials. The total embodied carbon for the Leman infrastructure (material quantities presented in Table 2-5) was estimated to be 5,447 tCO_2e (Table 5-5).

Table 5-5 Leman decommissioning lifecycle emissions (Te)

Activity	CO_2	N_2O	CH_4	CO	VOC	NO_x	SO_2	CO_2e
Recycling	7,636	ND	ND	ND	ND	13	1	**7,636**
New manufacture	5,447	ND	ND	ND	ND	13	13	**5,447**
Total	**13,083**	-	-	-	-	**26**	**14**	**13,083**

Note: Emissions factors for specific materials and activities are included in Appendix C

5.1.2.2.4. Venting activities

During preparations for decommissioning, the Leman pipelines will be purged of their gaseous contents back to the Leman A platform. It is anticipated that at atmospheric pressure this will constitute a maximum volume of approximately 1,251 m^3 including the contents of PL363 and PL364. To provide a worst-case CO_2e estimate, it is assumed that the gas is composed of CH_4. and VOC (EEMS 2008). Emission factors for these gases are provided in Appendix C. Based on these assumptions, the worst-case volume of CO_2e for the venting of the Leman pipelines is estimated to be 267.9 tCO_2e (Table 5-6).

Table 5-6 Leman pipeline venting emissions (Te)

Activity	CH_4	VOC	CO_2e
Venting of pipeline gas	9.36	1.04	267.90

5.1.2.3. Summary of the atmospheric emissions impact quantification

The maximum emissions from the Leman decommissioning vessels would amount to approximately 4.7 kt CO_2e. This represents about 0.086% of the sum of the emissions from the sources described above for shipping in 2019 (NAEI, 2019).

The embodied carbon associated with the decommissioning of the pipelines and cables *in situ* makes the largest contribution to the carbon inventory for the project with an associated 13.1 ktCO_2e GHG emissions (Table 5-5), is due to the quantity of material to be decommissioned *in situ* (Table 2-5), and also the quantity of emissions generated when manufacturing new material. Despite the release of emissions during recycling activities, international studies have also shown that the recycling of waste materials can result in net savings of GHG emissions in contrast to new manufacture (Björklund and Finnveden, 2005; Franchetti and Kilaru, 2012; Manfredi *et al.*, 2011; Turner *et al.*, 2015; WRAP, 2006). This is because recycling materials into new ("secondary") products can displace production of "primary" products that can require even more significant inputs of energy and raw materials.

The worst-case volume of CO_2e for the venting of the Leman pipeline contents is estimated to be 268 tCO_2e (Table 5-6).

The total GHG emissions, when considering all aspects of the planned decommissioning activities are estimated to be in the region of 18 ktCO_2e

5.1.3. Impacts on sensitive receptors

To determine the significance level of impacts resulting from atmospheric emissions, there is a requirement to understand the sensitive receptors. Gaseous emissions from the proposed decommissioning activities include CO_2, CO, NOx, N_2O, Sox, CH_4 and VOCs. These have the potential to impact sensitive receptors in the area.

The direct effect of the emission of CO_2, CH_4, N_2O and VOCs is the implication for climate change and the contribution to localised air quality deterioration due to low-level ozone (IPCC, 2021). The indirect effects of low-level ozone include deleterious health effects, as well as damage to ecosystems.

The direct effect of NOx, SOx and VOC emissions is the formation of photochemical pollution in the presence of sunlight. Low level ozone is the main chemical pollutant formed, with by-products that include nitric and sulphuric acid and nitrate particulates, contributing to acid rain formation.

The exposed offshore conditions will promote the rapid dispersion and dilution of these emissions. Outside the immediate vicinity of the decommissioning activities, all released gases would only be present in low concentrations. No impact is expected on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC and the Southern North Sea SAC from offshore atmospheric emissions. Harbour porpoise are of conservation interest within the Southern North Sea SAC (Section 3.3.4). Other cetacean species are likely to be absent from the Leman area. In the open conditions that prevail offshore, the atmospheric emissions generated during the decommissioning activities would be quickly dispersed. The atmospheric emissions from the proposed activities are therefore considered unlikely to have any effect on marine mammals. Potential impacts from onshore emissions are likely to be relatively minor and within local and regional air quality criteria.

In summary, the atmospheric emissions from the Leman F and G decommissioning activities are unlikely to have any effect on sensitive receptors. Potential impacts from onshore emissions are likely to be relatively minor and within local and regional air quality criteria.

5.1.4. Cumulative and Transboundary Impacts

5.1.4.1. Local air quality

Throughout the decommissioning activities, atmospheric emissions will be released, which have the potential to have local, regional (including transboundary) effects. As noted in Section 3.5.3 , the closest active oil and gas activities to Leman F and G are those associated with the wider Leman infrastructure (Figure 3-13). There are no offshore windfarms in the direct vicinity (and therefore no associated vessel emissions). There is unlikely to be a noticeable cumulative effect in terms of local air quality given the transitory nature of the decommissioning activities. The main activities and associated emissions arising from the decommissioning activities will be approximately 47 km from the UK coastline and 66 km from the UK/Netherlands European Economic Zone (EEZ) boundary line.

Any releases will be limited to the duration of the decommissioning activities and will be minimised as far as possible following the mitigation approaches outlined in Section 5.1.5.

5.1.4.2. Global Climate Change

Atmospheric emissions from fuel supply (of which production of oil and gas is part) was 39 million tCO_2e in 2018, which represents 7% of the UK total emissions for that year, according to the Committee on Climate Change (CCC) latest Progress report to Parliament (CCC 2019). Of this sector-specific emissions, oil and gas production comprise approximately 40% (16 $MtCO_2e$), including onshore petroleum production. In context, the total offshore emissions from the UKCS (14.63 million tCO_2e) represents only 3% of the UK's total emissions for the same year (OGUK 2019). This means that the emissions associated with the Leman decommissioning activities will amount to approximately 0.1% of the CO_2 generated offshore on the UKCS in 2018.

Any releases will be limited to the duration of the decommissioning activities in contrast to the continuous emissions associated with live production operations and will be minimised as far as possible following the mitigation approaches outlined in Section 5.1.5.

5.1.5. Management and Mitigation

Most emissions in these phases will be the result of combustion of hydrocarbons for power generation related to vessel activities. Vessels will be owned by a 3rd Party and the activities are therefore subject to supply chain processes of contract selection and management. Minimisation of emissions from vessels will form part of the selection criteria for the installation vessels though the tendering and selection process.

- Each vessel will have a Shipboard Energy Efficiency Management Plan (SEEMP) which contains information of minimising fuel consumptions e.g., economical speeds when operationally appropriate.
- Green DP or economical speeds when operationally appropriate
- Developing the decommissioning plan to minimise the number of mobilisations or demobilisations
- Opportunity to incorporate post-decommissioning surveys as part of wider SNS campaigns.
- Streamlining of activities through planning to reduce the time required for vessels will be required for these activities and will support the drive to reduce emissions.

5.1.6. Residual Impacts

The atmospheric emissions from the Leman F and G decommissioning activities will be temporary and limited in nature.

Taking into account the distance from any potentially sensitive receptors, it is not expected that atmospheric emissions will negatively impact local air quality or result in significant local cumulative impacts. In terms of global climate change (i.e. cumulative and transboundary impacts), the decommissioning activities will add a very small (0.1%) contribution to the overall offshore emissions in the UK (based on 2018 reported values) and the release of GHG into the environment. The contribution to global warming will be negligible in relation to those from the wider offshore industry and outputs at a national or international level. However, Shell is aware of the impact of operational emissions, including those which may be an indirect result of decommissioning operations.

The CCC concluded in their 2019 report, that it is achievable for the UK to implement a new target of net-zero GHG emissions by 2050 in England and Wales, and by 2045 in Scotland. To achieve the net-zero goal, the CCC report calls for concerted effort and action by all to reduce emissions and for any remaining emissions in 2050 to be offset. As part of this, the offshore oil and gas industry is focussed on the continued management and reduction of its operational emissions and the recently announced North Sea Transition Deal (BEIS, 2021) further commits the sector to early targets for the reduction of greenhouse gas emissions from production, against a 2018 baseline.

In 2017, Shell announced our 'Net Carbon Footprint' ambition with an intention of reducing our Net Carbon Footprint by around 50% by 2050 and by around 20% by 2035 as an interim measure. In February 2021, Shell announced our intention to be a net-zero emissions energy business by 2050. We have introduced new targets to reduce our carbon intensity by 20% by 2030, 45% by 2035 and by 100% by 2050. Shell's net zero emissions energy business ambitions are aligned with the UK Government's net zero targets and Shell is ready to be a strong delivery partner for the North Sea Transition Deal.

Shell is already taking steps to cut emissions from existing oil and gas operations, and to avoid generating more in the future. In Shell's North Sea operations, this includes evaluation of electrification of new and existing offshore installations, Carbon Capture Utilisation and Storage (CCUS), ongoing efforts to reduce flaring and venting and leakage of methane through improved efficiency/operating measures. In addition, Shell has also developed the Greenhouse Gas Reduction Action Plan, in line with NSTA net zero stewardship expectation 11, to provide an overview of the GHG emissions and highlight plans to reduce these emissions.

In 2017 Shell joined the Climate and Clean Air Coalition Oil & Gas Methane Partnership which brings together industry, governments and non-governmental organisations to improve understanding of methane emissions and work to reduce them. Along with seven energy companies, Shell also signed 'guiding principles for reducing methane emissions', which addresses priority areas for action highlighted in the International Energy Agency's World Energy Outlook 2017, focussing on reducing methane emissions. This includes emissions from incomplete combustion during flaring (Climate and Clean Air Coalition, 2017).

5.2. Physical Presence (seabed)

5.2.1. *Introduction*

The proposed Leman decommissioning activities have the potential to impact upon other users of the sea. This may happen during the decommissioning activities themselves or after decommissioning should any subsea infrastructure decommissioned *in situ* interact with demersal fishing gear. Sea users, other than commercial fisheries, are unlikely to be affected by the proposed decommissioning solution, therefore this section focuses on the impact on the physical presence of subsea infrastructure decommissioned *in situ* posing a potential snagging risk for trawling fisheries.

5.2.2. *Description and quantification of impacts*

5.2.2.1. Fishing vessel use

No landings data was recorded from the immediate vicinity of the Leman infrastructure, which can further be explained by looking trawling intensity data (Figure 3-11 and Figure 3-12). This shows that trawling activity in the vicinity of the Leman pipelines is negligible. In contrast, the area to the south and east of the Leman facilities have high densities of vessel tracks, suggesting that trawling fisheries are active in the surrounding areas and adjacent to other oil and gas installations, but are not currently active in the immediate Leman F, G and A areas.

5.2.2.2. Exposures

Survey data (Appendix D) for the Leman pipelines and cables indicate that the number and length of exposures appears to fluctuate slightly between survey years but are focussed on the same general locations year-to-year. The Leman pipelines and cables have a low percentage of exposure and free spans (Table 2-2), with all exposures and spans for removal located where the pipelines emerge from burial, close to the NUIs (Figure 5-1 and Figure 5-2). These unburied lengths (ranging from <1 m to 88 m in length) will be removed during decommissioning activities.

Between the Leman F and G NUIs, exposures and spans on PL5147 and PL364 tend to be concentrated closer to Leman G and the Ower sandbank, where movement of sediment is likely to be related to morphological change over time (2010 – 2020) around the 'tail' of the sandbank. This will be discussed further in Section 5.2.2.4, which outlines the principal findings of the Leman pipeline morphological study.

Between the Leman F NUI and Leman A platform, exposures and spans on PL5148 and PL363 are more apparent closer to Leman A and the areas of *S. spinulosa* reef identified (Gardline 2021b). Variability in exposure over time is also highest towards the edge of the reef. One FishSAFE (i.e. over 10m long and 0.8m above the seabed) span was reported on PL363 (Leman F to Leman A; Figure 5-2). This FishSAFE span is located close to the trench transition adjacent to the Leman F NUI and will be removed during decommissioning activities.

5.2.2.3. Depth of Burial

5.2.2.3.1. *Burial depth between Leman F and Leman G*

The 2015 depth of burial (DoB) pipeline survey determined the average depth of the PL363 pipeline to be 0.9 m across the whole line, and the average DoB of buried sections alone to be 1.19 m (Xodus, 2022b). The maximum depth along the pipeline was found to be approximately 2.0 m at KP4.65 where megaripples were identified over the stretch of pipeline (Gardline, 2021a). The 2013 DoB data shows that for the majority of the length of PL5148 cable, it is buried. The average DoB along the length of the line is 0.49m and the average DoB of buried sections is 0.56 m (Xodus, 2022a). Full DoB plots can be found in Appendix E.

5.2.2.3.2. Burial depth between Leman F and Leman A

The average DoB across the whole length of the PL364 pipeline was 0.70 m. The average DoB was 0.86 m when only accounting for the buried sections of pipeline (Xodus, 2022b). Most recently, the Gardline (2021a) survey reported a maximum depth of approximately 3.4 m at KP0.870 along the PL364 beneath a prominent north-northeast to south-southwest trending sandwave. The average DoB for the full length of the PL5147 cable is 0.69 m, and the average DoB for the sections which are buried is 0.73 m (Xodus, 2022a). Full cross-sectional D0B profiles are available in Appendix E.

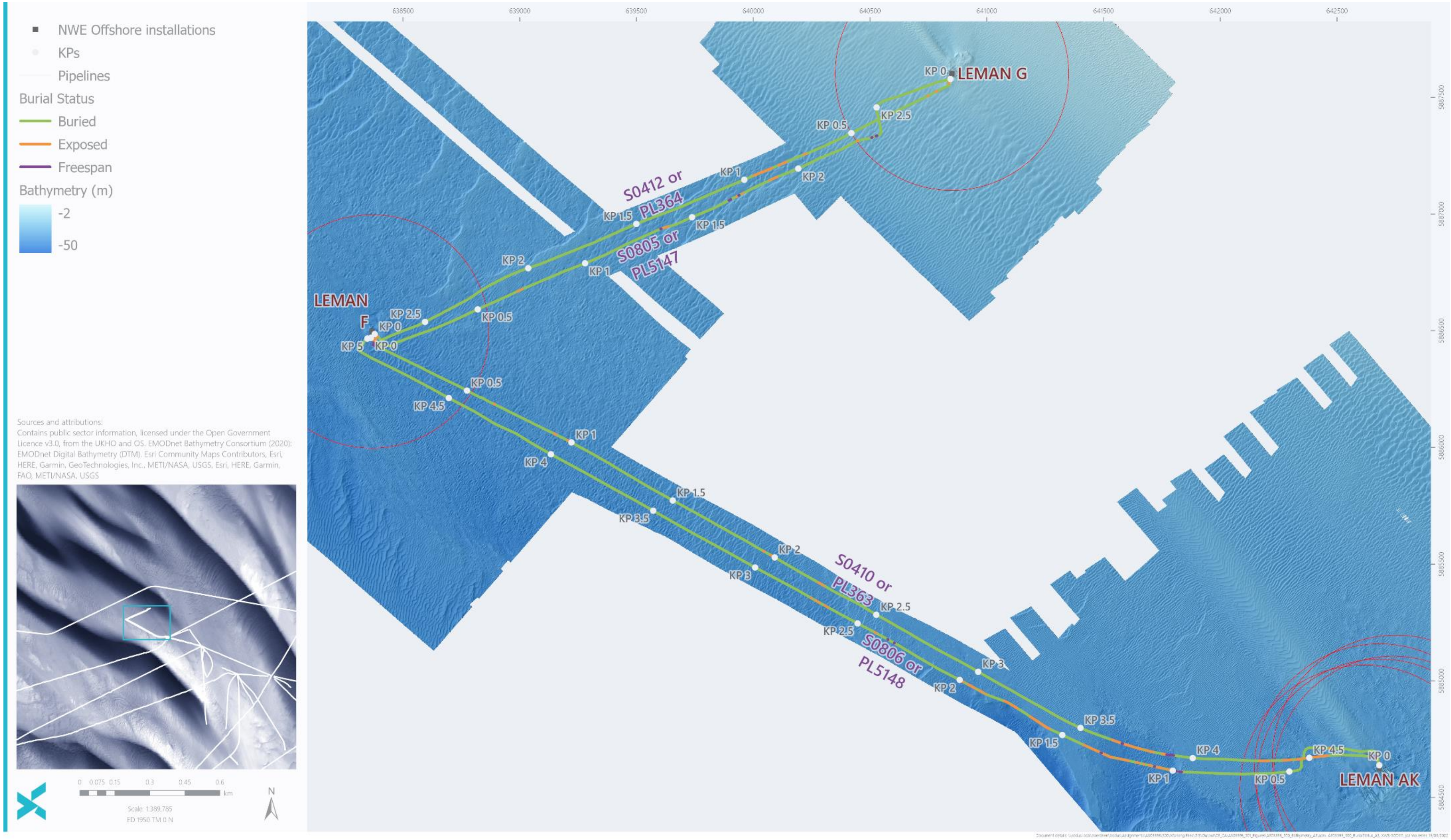

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Figure 5-1 Pipeline and cable burial status in 2021

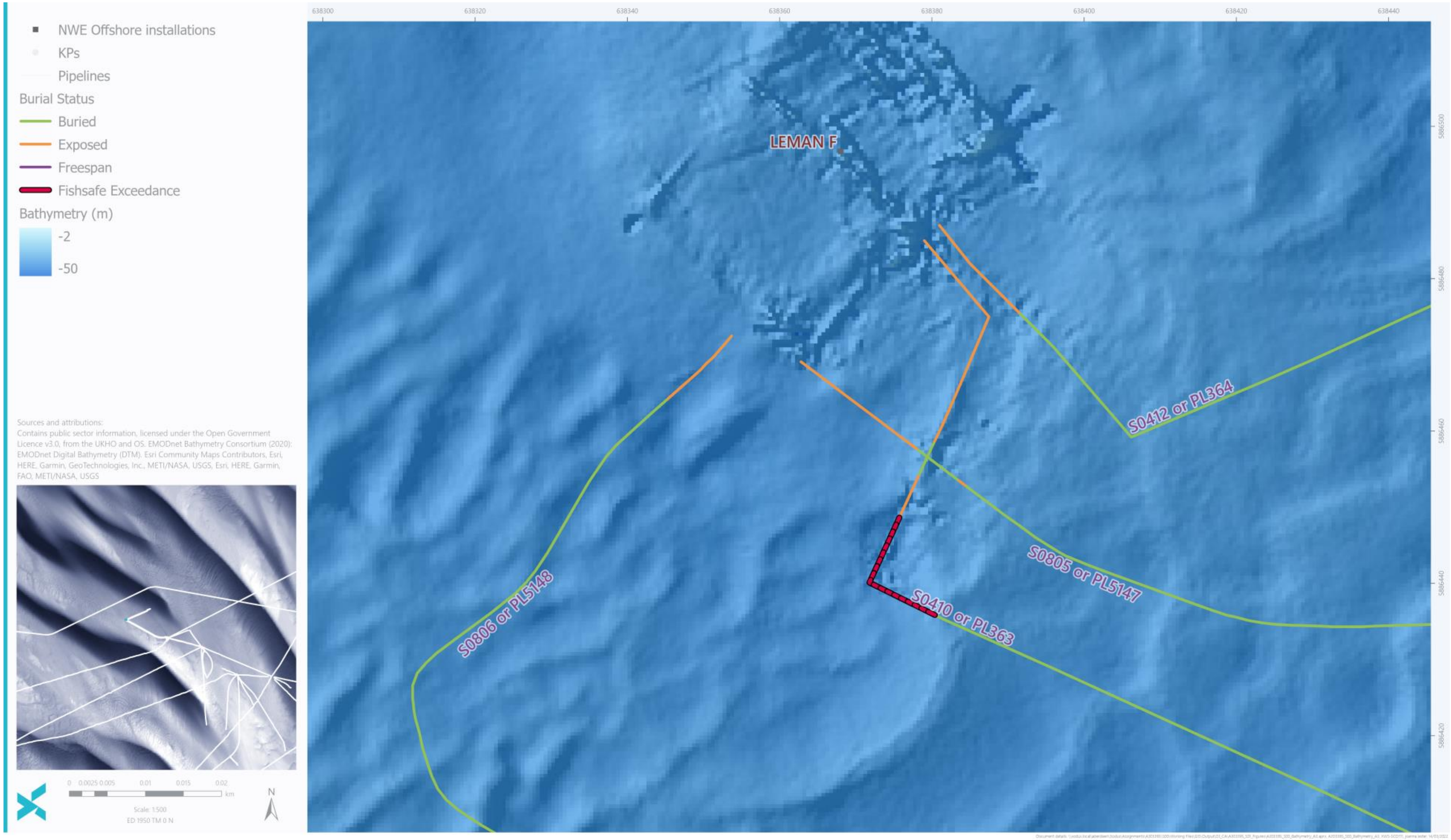

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Figure 5-2 Free span area on PL363 adjacent to the Leman F NUI

5.2.2.4. Morphology Study

The SNS is a highly mobile area generally and characterised by the presence of large sandbank features. The Leman F and G NUIs, and associated pipelines, being located within the North Norfolk Sandbanks and Saturn Reef SAC (Section 3.4). The Leman F NUI is located in the trough between the Leman Bank (to the south) and the Ower Bank (to the north). The Leman G NUI is located at the southern end of the flank of Ower Bank.

Given the dynamic and complex nature of the seabed around the Leman infrastructure, a study was undertaken (Xodus, 2022c) to assesses the properties of the sandbanks and sandwave bedforms and to predict the potential for future changes in seabed morphology. The study used historic bathymetry data of the area to assess historic morphological change, to predict the future evolution of the sandbank and sandwave bedforms in proximity to the pipelines and NUIs and to inform future monitoring regimes for any infrastructure decommissioned *in situ*.

The study determined that the Ower Bank is migrating in a north-easterly direction at the approximate rate of 4.6 m/year ±2.2 m/year. This movement has also resulted in a deepening around the Leman G NUI. Looking to the future, movement of the southwest flank of Ower Bank over the next 50 years is in the order of approximately 200 m ±100 m, which is less than one wavelength of the sandbank (Xodus, 2022c). Additional to this, the sandwaves which are superimposed on the larger Ower Bank feature are migrating in a south-easterly direction, perpendicular to that of the sandbank.

With regards to pipeline burial, it is expected that the historic variability in pipeline exposures, evidenced by the spanogram data in Appendix D, is set to continue. It is likely that while some existing spans and exposures will become buried as sandwaves migrate over them, in other locations, spans and exposures may develop as they move away. As the depth of burial of the Leman pipelines is generally less than a metre, with the natural evolution of the seabed and bedforms in this area, there is potential for exposures of the pipelines and cables. Exposure length would vary depending on the alignment of the pipeline with respect to the sandwave with the largest seabed depth change expected to occur along PL364, due to the presence of the largest sandwaves in the area. The migration of Ower Bank coinciding with the shorter-timescale movement of the sandwaves, could bring about a maximum seabed deepening of up to 9 m. As a result, considerable exposure is guaranteed along both pipelines on a sub-decadal timescale (Xodus, 2022c).

At present, the proposed approach for pipelines and cables is to decommission in their current state to avoid adversely impacting the protected features within the designated sites, in particular the *S. spinulosa* biogenic reef. However, Shell propose that monitoring will be undertaken to observe any future change in burial status, and should any remediation be required as a result of this, a proposed approach will be discussed and agreed with OPRED.

5.2.3. Impacts on sensitive receptors

Demersal fishing gears which interact with the seabed are vulnerable to snagging. Snagging may lead to the loss or damage of catch or fishing gear and may result in vessel destabilisation in extreme circumstances. There have been 15 reported fishing vessel sinkings due to snagged gear between 1989 and 2014 which resulted in 26 fatalities (MATB, 2020). Generally, the patterns in interactions between oil and gas infrastructure and fishing gear are spatially concentrated in the muddy Northern North Sea (NNS) where demersal fishing activity is generally focussed (Rouse *et al*, 2018), in contrast to the SNS where the Leman infrastructure is located.

The Leman NUI's are situated within ICES Block 35F2 which is an area of moderate fishing activity in context with the rest of the UKCS. Fishing in the ICES Block 35F2 is dominated by beam trawling. However, in the immediate vicinity of the Leman infrastructure (Figure 3-10) no landings data was recorded. The lack of data can further be explained by trawling intensity and AIS data (Figure 3-11 and

Figure 3-12). Trawling intensity across the Leman pipelines is very low; between 0 – 12 trawlers passed across the ICES sub-blocks associated with the Leman pipelines per year on average (between 2007 – 2015). AIS data also shows that trawling activity in the vicinity of the Leman pipelines is negligible (Figure 3-11 and Figure 3-12). In contrast, the area to the south and east of the Leman facilities have high densities of vessel tracks, suggesting that trawling fisheries are active in the surrounding areas but are not currently active in the immediate Leman F and G area.

On review of demersal trawling activity in the North Sea, it was determined that a low percentage (0.93%) of demersal trawling trips specifically target oil and gas pipelines compared with surrounding seabed areas (Rouse *et al.*, 2017). As established, trawling intensity is negligible in the immediate Leman F and G areas. While these pipelines are generally trenched and buried to a depth consistent with the 0.6 m accepted 'safe' and stable depth (Appendix E), the morphological study of the seabed features in the Leman area has confirmed the continued change in pipeline exposure years into the future (Xodus, 2022c). However, as proven by historical data of the pipelines, exposures have been present along the pipelines in the past and no snagging incident has occurred.

It is possible that the re-opening of the 500 m zones around the Leman F and G NUIs may encourage trawling activity in the future (approximately 1.6 km^2), however, with the current situation (with the area to the south and east of the Leman facilities have high densities of vessel tracks) it can be presumed the Leman area is not currently desirable fishing ground. Shell will engage with the NFFO throughout decommissioning and ongoing monitoring activities to assess the intensity of demersal fishing activity following decommissioning of the NUIs.

Other than the Leman pipelines and cables, all other Leman infrastructure will be fully removed upon decommissioning, including mattresses. Shell will ensure all areas affected by the proposed Leman decommissioning are left overtrawlable without snagging risks and that any rock placement required will be appropriately graded to allow fishing gear to trawl across it without snagging; though in some instances the placement of rock will coincide with areas of *S. spinulosa* reef. However, given the negligible fishing activity in the vicinity of the infrastructure, the risk of snagging is deemed to be very low. Where required, the method of determining snag risk removal will be determined in consultation with OPRED.

5.2.4. Cumulative and transboundary impacts

When considering the Leman decommissioning within the wider regional context, the proposed decommissioning activities may coincide with other projects in the vicinity. As discussed, the main impact to other sea users associated with the decommissioning is the potential snagging risk to commercial fisheries. As this is the only perceived risk to other sea users, it is the only impact to be assessed in a cumulative context.

All infrastructure within the Leman area will either be removed or decommissioned *in situ* in an overtrawlable condition, and monitoring will be conducted to ensure the decommissioned *in situ* infrastructure remains overtrawlable. Monitoring surveys will ensure that the level of risk for snagging does not become unacceptable and remediative action will be undertaken where required as a preventative measure. While it is not possible to quantify the cumulative snag risk associated with oil and gas activities in the region, active pipelines are managed by the Operators to manage risk to operations and decommissioned pipelines are managed through agreements reached between the Regulator, Stakeholders and Operators, as a DP is put into place. Therefore, there is expected to be no cumulative impact with any of the other projects which are predicted to interact with the seabed in some way within the wider region (cumulative seabed impacts are quantified in Section 5.3.4). Considering the presence of existing infrastructure with regards to snagging risk the proposed decommissioning, in combination with any other nearby developments or other decommissioning projects, should not pose an additional risk to commercial fishing vessels.

In addition, as there is a negligible level of trawling in the immediate area and there are alternative fishing grounds available within the wider region, it is not anticipated that there will be any significant cumulative impacts on fisheries with respect to the long-term presence of subsea infrastructure decommissioned *in situ*.

As the Leman area is beyond the UK's 12 nautical mile limit, foreign national vessels are also permitted to fish in the area. However, Global Fishing Watch reports low fishing presence by international vessels in the area since 2020. Historically, there has been limited effort in the area, and what little fishing occurred was attributed to vessels mostly of Dutch origin (Global Fishing Watch, 2022). Overall. The intensity of fishing activity with the Leman area is very low in comparison to other areas of the North Sea, with principal fishing grounds located relatively far away. Combined with the removal of infrastructure, the intention to monitor pipeline exposures over time, there is no mechanism by which significant transboundary impacts could occur.

5.2.5. Management and mitigation

A number of mitigation measures will be employed to reduce the impact of the presence of infrastructure decommissioned *in situ* on other sea users:

- The Leman subsea infrastructure is currently shown on Admiralty Charts and the FishSAFE system. Once decommissioning activities are complete, updated information on the Leman subsea area (i.e. which infrastructure remains *in situ* and which has been removed) will be made available to allow the Admiralty Charts and the FishSAFE system to be updated;
- The FishSAFE exposure identified close to the trench transition adjacent to the Leman F NUI and will be removed during decommissioning activities.
- Any objects dropped during decommissioning activities or any existing debris identified will be removed from the seabed where appropriate;
- An appropriate vessel will be engaged to carry out survey work within the 500 m zones, at locations where installations have been removed, where cutting or remediation has occurred along the pipeline to evaluate any potential snagging risks. Decommissioning activities will be considered to be complete subject to acceptance of the Decommissioning Close-out Report by OPRED. The existing 500 m zones will then be removed; and
- Shell recognises its commitment to monitor any infrastructure decommissioned *in situ* and therefore intends to set up arrangements to undertake post-decommissioning monitoring on behalf of the Licence Owners. The frequency of the monitoring will be agreed with OPRED and future monitoring will be determined through a risk-based approach using the results of the Xodus (2022c) morphology study and based on the findings from future surveys. A monitoring strategy will be proposed in the Decommissioning Close-out Report. During the period over which monitoring is required, the status of the infrastructure decommissioned *in situ* would be reviewed and any necessary remedial action undertaken to ensure it does not pose a risk to other sea users.

5.2.6. Residual impacts

Of all sea users, commercial fisheries are most likely to be affected by the proposed decommissioning activities. Impacts to fisheries mainly arise from the potential for snagging generated by the decommissioning *in situ* of the Leman pipelines.

Survey data within the Leman area has shown that exposures and changes in burial have been historically present and variable in location and extent. Overall, while the average DOB of the pipelines is >0.6 m, the presence of highly active and mobile morphological features within the Leman area will generate continued exposures over time; these exposures will occur on a sub-decadal scale.

Despite the ongoing potential for exposures along the Leman pipelines, in contrast to the moderate fishing activity in the wider area (in ICES Block 35F2 and as shown in Figure 3-11), fishing intensity in the immediate area around the Leman field, and along the PL363 and PL364 pipelines, is negligible (Figure 3-12); therefore the opportunity of a snagging event occurring is very unlikely. While the consequence of a snagging event may be high, Shell's commitment to manage risk through a monitoring programme to be developed and agreed with OPRED, will ensure that the likelihood of snagging impacts on fisheries is minimised. The risk significance is therefore defined as low and thus not significant.

5.3. Seabed Disturbance

5.3.1. Introduction

This section discusses the potential environmental impacts associated with seabed interaction resulting from the proposed Leman decommissioning activities and the presence of the Leman subsea pipelines and cables decommissioned *in situ*. The measures planned by Shell to minimise these impacts are detailed in Section 5.2.5. The decommissioning activities have the potential to impact the seabed are as follows:

- Removal of NUIs (Section 5.3.2.1);
- Pipeline and cable decommissioning (Section 5.3.2.2);
- Removal of pipeline stabilisation materials (Section 5.3.2.3);
- Rock-placement on pipeline ends (Section 5.3.2.4);
- Vessel anchoring (Section 5.3.2.5); and
- Degradation of the remaining infrastructure *in situ* (Section 5.3.2.6).

Removal, rock-placement and anchoring activities (Sections 5.3.2.1 to Section 5.3.2.5) have the potential impact the seabed species and habitats surrounding the Leman NUIs, pipelines and cables. The activities all represent the 'base-case' for seabed impact. As an absolute 'worst-case' scenario, overtrawl surveys would be undertaken within the Leman F and G 500m zones to demonstrate that no snagging risks remain on the seabed (Section 5.3.2.7). However, Shell will work with the NFFO to avoid this approach and, as a base-case will use non-intrusive and remote methods wherever possible, giving due consideration to the seabed habitats and species.

The following sections also assess the potential area of *S. Spinulosa* which could be impacted by the decommissioning activities. Whilst the *S. spinulosa* reef does not currently cover the whole area subject to decommissioning activities, it is not possible to know with certainty what the extent of the reef will be at the conclusion of the Leman F decommissioning scope. Therefore, Shell has assumed a reasonable worst-case that *S. spinulosa* will, by that time, be present across the full extent of the Leman F and Leman A areas where decommissioning activities will take place. Note that this is likely to be an over-estimate to provide a reasonable worst-case impact, and that Shell expects that the actual area impacted will be less than this.

The seabed impacts resulting from the decommissioning activities can be classified as temporary or permanent. Temporary impacts are defined here as those which have transient impacts lasting a few days to a few years. Permanent impacts are those which will continue to have an impact for decades to centuries following decommissioning. It should be considered that some of the impact footprints will overlap and this has been accounted for throughout.

5.3.2. Description and quantification of impacts

5.3.2.1. Removal of NUIs

As the mass of each of the Leman NUIs is <10,000 tonnes, they fall within the OSPAR 98/3 category of steel structures for which derogation cannot be sought. Therefore, the only option available for the Leman NUIs is full removal.

The piles on the Leman F and G NUI jackets will be removed to at least 3 m below the seabed and should be suitable for removal via internal cutting methods. There is a potential that internal cutting is not possible, in which case external excavation around the piles will be required to allow the cutting of the piles at 3 m below seabed. As this is the worst-case scenario for seabed impact, the external cutting has been allowed for within this section. The area of impact for each pile has been calculated accounting for a 15 m diameter for dredging around each pile. The footprint associated with the impact of the piles excavation will also cover any temporary seabed interactions (e.g. the removal of the risers). The excavation of the seabed around the piles may also result in indirect impacts from the re-settlement of the disbursed sediments during excavation. It is therefore assumed that the indirect impacts cover twice the area of the direct impact as a worst-case scenario (Table 5-7). For excavation, sediment will likely be removed by using MFE and will be deposited down-current of the jacket piles, where it will undergo natural dispersal which will be transient in nature. Given the dynamic nature of the surface sediments in the SNS, it is expected that the displaced sediment will be rapidly incorporated into the local sediment transport regime.

5.3.2.2. Pipeline and cable decommissioning

The spool lengths are provided in Table 2-4 and the length of the ends to be cut from each pipeline and cable is 24 m (with a total of eight ends to be removed) to maximise the distance between connection points and the transition into seabed burial. Where the spools and pipeline ends will be removed, a 10 m corridor centred (5 m each side) around each pipeline and cable has been assumed as a realistic worst-case. Indirect impacts are considered to cover twice the area of the direct impact as a worst-case scenario, to account for any sediment disturbance and resettlement. Table 5-8 outlines the activities and their impact footprints. The spools, pipelines and cables adjacent to the Leman AK platforms are likely to overlap with potential areas of *S. Spinulosa* reef (Figure 3-5) Areas of possible isolated and high-density *S spinulosa* could be temporarily impacted by the removal of the spools and pipeline and cable ends.

5.3.2.3. Removal of pipeline stabilisation materials

A total of 53 LinkLok mattresses, 9 large grout support structures, 17 frond mattresses, 13 bitumen mattresses and an estimated 472 grout bags (large and small) are located within the Leman F, G and A area, including those located at pipeline end and crossing locations. It is proposed that the mattresses and grout bags associated with the pipeline ends (Table 2-3) are removed and the stabilisation material associated with the pipeline crossings are decommissioned *in situ*.

The dimensions have been used to calculate an area for the stabilisation materials to be removed (i.e. those located at the pipeline ends; Table 5-9). which accounts for the stabilisation materials at Leman A only. The method of calculation assumes that all mattresses and grout bags are laid on the seabed in a single layer, however it is important to note that this is highly unrealistic. Mattresses and grout bags are used to stabilise and support infrastructure therefore they are more likely to be piled on top of one another, or even on top of certain items/structures. As such the numbers presented are worst-case estimates. The stabilisation materials adjacent to the Leman F and Leman A platforms are likely to overlap with potential areas of *S. Spinulosa* reef (Fugro, 2019; Fugro, 2020; Figure 3-5 and Figure 3-6). In the area surrounding the Leman F NUI, areas of low, moderate and high possible *S. spinulosa* were identified (Fugro, 2020; Figure 3-6) which constitute the footprints shown in Table 5-9. At Leman A (Figure 3-5), areas of possible isolated and high-density *S spinulosa* could be impacted by the removal of the stabilisation materials listed in Table 5-9.

5.3.2.4. Rock-placement on pipeline ends

Any associated rock placement at the cut ends has been calculated as a source of permanent impact. The expected case and contingency scenarios both assume the need for rock placement at all pipeline ends. As before, the indirect impact area is double the direct impact area (Table 5-10). At Leman F and A, areas of possible isolated and high-density *S. spinulosa* reef could be impacted by the placement of rock, however the exact overlap with this rock remediation is unknown, therefore the whole footprint is considered to represent a worst-case scenario for reef impact.

5.3.2.5. Vessel anchoring

Anchors may be required to position the SSCV during the NUI removal activities, resulting in direct and indirect temporary seabed impacts due to anchoring and anchor chain drag at the Leman F and Leman G locations.

A maximum of six anchors would be deployed to the seabed to position the rig. Each anchor is assumed to be 6 m wide and when the anchor pattern is initially laid out, it is expected that each anchor may be dragged for up to 50 m before it is finally set. Thus, a conservative 10 m by 50 m corridor of disturbance has been assumed for each anchor.

When the SSCV moves it is possible that the anchor wires will drag across the seabed as the vessel moves within its anchor pattern. The area of seabed disturbance considers the entire movement of anchor chain and wires from stand-off position through to the final position. A conservative 10 m by 200 m corridor of disturbance has been assumed for each anchor chain. The use of midline buoys will be considered when the anchor plan is being developed to help reduce the amount of anchor wire drag on the seabed. As a worst-case scenario, none have been assumed at this time (Table 5-11).

5.3.2.6. Degradation of the remaining infrastructure *in situ*.

Structural degradation of the pipelines will be a long-term process caused by corrosion and the eventual collapse of the pipelines under their own weight and that of the overlying pipeline coating and sediment. Cables will undergo a similar process of degradation, but with different material constituents from the pipelines, it is likely that this process will occur on a different timescale. During this process, degradation products derived from the exterior and interior of the pipe and cable will breakdown and potentially become bioavailable to benthic fauna in the immediate vicinity. The primary degradation products will originate from the following pipeline and cable components, as outlined in Table 2-5:

- Steel;
- Copper;
- Concrete coating (and potential pipeline scale coating); and
- Polymer coating (mattresses).

Note: pipeline contents will be limited to treated seawater and are not discussed further herein.

5.3.2.7. Overtrawl surveys

As previously mentioned, the base case for the decommissioning is that non-intrusive survey methods will be used within the 500m zones of Leman F and G. Only as a last resort would intrusive overtrawl surveys be undertaken within the Leman F and G 500m zones to demonstrate that no snagging risks remain on the seabed. In the unlikely scenario that this is the case, consultations would be held with the NFFO and OPRED to discuss the best way to approach this while taking the environmental sensitivities of the area into account. The impact footprints for this activity have been estimated to represent a worst-case scenario.

Overtrawl would be carried out within the 500 m safety exclusion zones around the Leman F and G NUI locations once removal has taken place using a demersal fishing trawler. These impacts would overlap any other removal, remediation and anchoring activities at the Leman F and G NUI locations.

These activities would directly impact the seabed habitats at Leman G and may also impact the potential reef at the Leman F NUI location. A buffer of 15 m has also been assumed around the 500 m zones to account for indirect sediment settling following overtrawl. As there is uncertainty around the extent of the reef at the time of overtrawl, Shell has assumed a reasonable worst-case that *S. spinulosa* will, by that time, be present across the full extent of Leman F 500m zone only, and none within the Leman G 500m zone, as historically has been the case.

Overtrawl activities would lead to a wider impact on the seabed around the Leman F and G NUIs equating to 1.67 km^2, representing 0.046% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC and 0.0045% of the Southern North Sea SAC. Overtrawl would potentially impact 0.84 km^2 of reef or potential reef, which represents 0.15% of the 569.69 km^2 area of known *S. Spinulosa* (MPA Mapper; JNCC, 2023) in the SNS. Under these circumstances, Shell would hold conversations with the NFFO and OPRED to discuss the best way to approach this while taking the environmental sensitivities of the area into account.

Table 5-7 Seabed footprint related to NUI removal

Activity	Piles	Dimensions	Expected duration of disturbance	Total are of seabed (km^2)		Area of *S. spinulosa* reef (km^2)	
				Direct	**Indirect**	**Direct**	**Indirect**
Excavation and removal of Leman F NUI piles	6	15 m diameter	Temporary	0.0011	0.0021	0.0011	0.0021
Excavation and removal of Leman G NUI piles	6	15 m diameter		0.0011	0.0021	0	0
Total				**0.0021**	**0.0042**	**0.0011**	**0.0021**

Table 5-8 Spools and sections of pipeline/ cables to be cut and removed to shore

Pipeline name	Adjacent to platform?	Spools dimensions (m)	Pipeline ends dimensions (m)	Expected duration of disturbance	Total area of seabed (km^2)		Area of *S. spinulosa* reef (km^2)	
					Direct disturbance area	**Indirect disturbance area**	**Direct disturbance area**	**Indirect disturbance area**
Production Pipeline (PL363)	Leman F	36 x 10	24 x 10	Temporary	0.0006	0.0012	0.0006	0.0012
	Leman A	36 x 10	24 x 10		0.0006	0.0012	0.0006	0.0012
Cable (PL5148)	Leman F	-	24 x 10		0.00024	0.00048	0.00024	0.00048
	Leman A	-	24 x 10		0.00024	0.00048	0.00024	0.00048
	Leman F	12 x 10	24 x 10		0.00036	0.00072	0.00036	0.00072

Pipeline name	**Adjacent to platform?**	**Spools dimensions (m)**	**Pipeline ends dimensions (m)**	**Expected duration of disturbance**	**Total area of seabed (km^2)**		**Area of *S. spinulosa* reef (km^2)**	
					Direct disturbance area	**Indirect disturbance area**	**Direct disturbance area**	**Indirect disturbance area**
Production Pipeline (PL 364)	Leman G	12 x 10	24 x 10		0.00036	0.00072	No *S. spinulosa*	
Cable (PL5147)	Leman F	-	24 x 10		0.00024	0.00048	0.00024	0.00048
	Leman G	-	24 x 10		0.00024	0.00048	No *S. spinulosa*	
Total					**0.00288**	**0.00576**	**0.00228**	**0.00456**

Table 5-9 Seabed footprint related to the removal of stabilisation materials

Stabilisation type	**Total number**	**Number to be removed**	**Number with a potential *S. spinulosa* overlap**	**Footprint per item (m^2)**	**Expected duration of disturbance**	**Total area of seabed (km^2)**		**Area of *S. spinulosa* reef (km^2)**	
						Direct disturbance area	**Indirect disturbance area**	**Direct disturbance area**	**Indirect disturbance area**
LinkLok mattresses	53	49	38	25	Temporary	0.0012	0.0025	0.001	0.002
Large grout supports (SS50)	5	5	5	3.25		0.00002	0.00003	0.00002	0.00003
Large grout support (FB75)	1	1	1	2.25		0.000002	0.000005	0.000002	0.000005

Stabilisation type	Total number	Number to be removed	Number with a potential *S. spinulosa* overlap	Footprint per item (m^2)	Expected duration of disturbance	Total area of seabed (km^2)		Area of *S. spinulosa* reef (km^2)	
						Direct disturbance area	**Indirect disturbance area**	**Direct disturbance area**	**Indirect disturbance area**
Large grout supports (FA50)	1	1	1	3		0.000003	0.000006	0.000003	0.000006
Large grout supports (SS75)	2	2	0	3.5		0.00001	0.00001	0	0
Large grout bags	12	12	12	4		0.00005	0.0001	0.00005	0.0001
Frond mattresses (7.5 x 5 m)	3	5	5	37.5		0.0002	0.0004	0.0002	0.0004
Frond mattresses (5 x 5 m)	14	3	3	25		0.0001	0.0002	0.0001	0.0002
Bitumen mattresses	13	7	6	15		0.0001	0.0002	0.0001	0.0002
Small grout bags	460	225	125	0.25		0.0001	0.0001	0.00003	0.00006
					Total	**0.0017**	**0.0035**	**0.0014**	**0.0028**

Table 5-10 Rock placement

Pipeline	Adjacent to platform?	Area of rock remediation at cut end (m^2)	Expected duration of disturbance	Tonnage of rock at cut end (Te)	Total area of seabed (km^2)		Area of *S. spinulosa* reef (km^2)	
					Permanent, direct disturbance area	Indirect disturbance area	Permanent, direct disturbance area	Indirect disturbance area
Production Pipeline (PL363)	Leman F	200	Permanent	100	0.0002	0.0004	0.0002	0.0004
	Leman A	200	Permanent	100	0.0002	0.0004	0.0002	0.0004
Cable (PL5148)	Leman F	200	Permanent	100	0.0002	0.0004	0.0002	0.0004
	Leman A	200	Permanent	100	0.0002	0.0004	0.0002	0.0004
Production Pipeline (PL 364)	Leman F	200	Permanent	100	0.0002	0.0004	0.0002	0.0004
	Leman G	200	Permanent	100	0.0002	0.0004	No *S. spinulosa*	
Cable (PL5147)	Leman F	200	Permanent	100	0.0002	0.0004	0.0002	0.0004
	Leman G	200	Permanent	100	0.0002	0.0004	No *S. spinulosa*	
			Total	**800**	**0.0016**	**0.0032**	**0.0012**	**0.0024**

Table 5-11 Anchoring at Leman F and Leman G

NUI	**Activity**	**Expected duration of disturbance**	**Total area of seabed (km^2)**		**Area of *S. spinulosa* reef (km^2)**	
			Temporary direct disturbance area	**Indirect disturbance area**	**Temporary direct disturbance area**	**Indirect disturbance area**
Leman F	6 Anchors	Temporary	0.003	0.006	0.003	0.006
	6 Anchor chains	Temporary	0.0012	0.0024	0.0012	0.0024
Leman G	6 Anchors	Temporary	0.003	0.006	No *S. spinulosa*	
	6 Anchor chains	Temporary	0.0012	0.0024	No *S. spinulosa*	
		Total	**0.0084**	**0.0168**	**0.0042**	**0.0084**

5.3.2.8. Summary (base-case)

Table 5-12 provides a summary of the estimated potential seabed and reef disturbance associated with the various decommissioning activities outlined in Sections 5.3.2.1 to 5.3.2.5, which constitute the base case for the decommissioning activities. The totals are presented as an overall figure of **0.0502 km^2**, which also represents the areas of the North Norfolk Sandbanks and Saturn Reef SAC and the Southern North Sea SAC. The base-case for decommissioning activities would represent 0.001% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC (3,603 km^2) and 0.0001% of the Southern North Sea SAC (36,951 km^2), with the majority of this impact being temporary in nature (0.0486 km^2). Long-term impacts associated with the introduction of additional hard substrate are expected to create a maximum permanent seabed impact of 0.0016 km^2, representing 0.00004% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC and 0.000004% of the Southern North Sea SAC. Given the minimal scale of the footprint, it is not expected that the structure of the sandbanks or the habitat of harbour porpoise prey will be affected. While the addition of 0.0016 km^2 of rock will potentially impact 0.0012 km^2 of reef or potential reef, which represents 0.0002% of the 569.69 km^2 area of known *S. spinulosa* (MPA Mapper; JNCC, 2023) in the SNS.

NUI removal, the removal of spools, pipeline and cable ends, stabilisation materials, the placement of rock on the pipeline ends adjacent to the Leman F and Leman A platforms and the potential anchoring of an SSCV are likely to overlap with potential areas of *S. Spinulosa* reef (Fugro, 2019; Fugro, 2020; Figure 3-5 and Figure 3-6). In the area surrounding the Leman F NUI, areas of low, moderate and high possible *S. spinulosa* may be impacted by these activities (Fugro, 2020; Figure 3-6). At Leman A, areas of possible isolated and high-density *S spinulosa* reef, as well as borders on areas of *S spinulosa* reef identified in the Fugro (2019) survey may be impacted. Temporary disturbance represents majority of the impact to the potential *S. Spinulosa* (0.03 km^2). The overall expected permanent area of disturbance to the reef is expected to be less than 0.0012 km^2 (Table 5-12) which can be attributed to rock placement on pipeline ends adjacent to the Leman F and A platforms. In total, the base-case for decommissioning activities would impact approximately 0.005% of the 569.69 km^2 area of known *S. Spinulosa* (MPA Mapper; JNCC, 2023) in the SNS.

5.3.2.9. Overtrawl surveys (worst-case)

Only as a last resort would overtrawl surveys be undertaken within the Leman F and G 500m zones to demonstrate that no snagging risks remain on the seabed. In the unlikely scenario that this is the case, consultations would be held with the NFFO and OPRED to discuss the best way to approach this while taking the environmental sensitivities of the area into account. The impact footprints for this activity have been estimated to represent a worst-case scenario.

Overtrawl would be carried out within the 500 m safety exclusion zones around the Leman F and G NUI locations once removal has taken place using a demersal fishing trawler. These impacts would overlap any other removal, remediation and anchoring activities at the Leman F and G NUI locations. These activities would directly impact the seabed habitats at Leman G and may also impact the potential reef at the Leman F NUI location. A buffer of 15 m has also been assumed around the 500 m zones to account for indirect sediment settling following overtrawl. As there is uncertainty around the extent of the reef at the time of overtrawl, Shell has assumed a reasonable worst-case that *S. spinulosa* will, by that time, be present across the full extent of Leman F 500m zone. Table 5-13 also accounts for the activities specific to Leman A, as these would occur outwith the 500 m zones, thereby presenting a worst-case scenario.

Table 5-12 Summary of impact associated with decommissioning activities (base case)

Activity	Total area of seabed (km²)			Area of *S. spinulosa* reef (km²)		
	Direct, temporary	**Direct, permanent**	**Indirect, temporary**	**Direct, temporary**	**Direct, Permanent**	**Indirect, temporary**
Removal of NUIs	0.0021	0	0.0042	0.0011	0	0.0021
Pipeline and cable decom	0.0029	0	0.0058	0.0023	0	0.0046
Removal of stabilisation	0.0017	0	0.0035	0.0014	0	0.0028
Rock-placement	0	0.0016	0.0032	0	0.0012	0.0024
Anchoring	0.0084	0	0.0168	0.0042	0	0.0084
Total	**0.0151**	**0.0016**	**0.0335**	**0.009**	**0.0012**	**0.0203**
Total temporary	**0.0486**			**0.0293**		
Total permanent	**0.0016**			**0.0012**		
Grand Total (base case)	**0.0502**			**0.0305**		
% of NNSSR SAC				**0.001**		
% of SNS SAC				**0.0001**		
% of reef area				**0.005**		

Table 5-13 Total impact in an overtrawl (worst-case) scenario

Activity	Total area of seabed (km²)			Area of *S. spinulosa* reef (km²)		
	Direct, temporary	**Direct, permanent**	**Indirect temporary**	**Direct, temporary**	**Direct, permanent**	**Indirect temporary**
Overtrawl	1.57	0	0.096	0.785	0	0.048
NUI Removal	Included in overtrawl footprint					
Pipeline and cable decom.	Included in overtrawl footprint			0.00084	0	0.0017
Removal of stabilisation materials	Included in overtrawl footprint			0.0005	0	0.001
Rock-placement	0	0.0016	0.0032	0	0.0012	0.0024
Anchoring	Included in overtrawl footprint					
Total	**1.57**	**0.0016**	**0.0992**	**0.78634**	**0.0012**	**0.0531**
Total Temporary:	**1.67**			**0.84**		
Total Permanent:	**0.0016**			**0.0012**		
Grand Total (worst- case)	**1.67**			**0.84**		
% of NNSSR SAC				**0.046**		
% of SNS SAC				**0.0045**		
% of reef area				**0.15**		

Overtrawl activities would lead to a wider impact on the seabed around the Leman F and G NUIs equating to 1.67 km^2, representing 0.046% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC and 0.0045% of the Southern North Sea SAC. Overtrawl would potentially impact 0.84 km^2 of reef or potential reef, which represents 0.15% of the 569.69 km^2 area of known *S. Spinulosa* (MPA Mapper; JNCC, 2023) in the SNS. Under these circumstances, Shell would hold conversations with the NFFO and OPRED to discuss the best way to approach this while taking the environmental sensitivities of the area into account.

5.3.3. Impacts on sensitive receptors

5.3.3.1. Temporary disturbance of seabed habitats

Removal of the NUIs, spools, pipeline ends and stabilisation material from the seabed will cause sediment disturbance and re-distribution in the localised area. The area of impact of is expected to be 0.0335 km^2 (base-case).

Sediments that are redistributed and mobilised as a result of the proposed decommissioning activities will be transported by the seabed currents before settling out over adjacent seabed areas. The marine environment in the Southern North Sea is dynamic in nature (Section 3.2.1). The dynamic environment will result in suspended sediment, in particular the fines, being transported away from the source of the disturbance. The natural settling of the suspended sediments is such that the coarser material (sands) will quickly fall out of suspension with the finer material being the last to settle. This natural process will ensure that all the suspended sediment is not deposited in one location. Based on the mobility of the seabed in the area the deposition resulting from the decommissioning activities is likely to be comparable to the background sediment redistribution processes.

A small number of demersal and pelagic fish and their spawning grounds might also be temporarily disturbed by the decommissioning activities. Leman F and G are located within ICES Rectangle 35F2 which experiences high intensity spawning by plaice over the winter months (December-March). Other species which use the area to spawn include cod, lemon sole, mackerel, Norway lobster, sandeels, sprat and whiting. These species also use the area as nursery grounds throughout much of the year (Section 3.3.3; Coull *et al.*, 1998; Ellis *et al.*, 2012). Sandeels (the main prey for harbour porpoise) generally spawn in the winter months and therefore spawning is unlikely to coincide with project activities. The presence of sandeels and the potential impacts of the decommissioning activities on the conservation objectives of the Southern North Sea SAC will be discussed in more detail in Section 5.3.3.3

Mobile benthic organisms will be able to move away from the area of temporary disturbance. Upon completion of the subsea decommissioning activities, it is expected that the resettled sediment will be quickly recolonised by benthic fauna typical of the area. This will occur as a result of natural settlement by larvae and plankton and through the migration of animals from adjacent undisturbed benthic communities (Dernie *et al.,* 2003). A series of large-scale field experiments investigated the response of marine benthic communities within a variety of sediment types (clean sand, silty sand, muddy sand and mud) to physical disturbance (sediment removal down to 10 cm). Of the four sediment types investigated, the communities from clean sands had the most rapid recovery rate of between 0.45 – 0.6 individuals per day following disturbance (Dernie *et al.,* 2003).

In such a high energy area, the expected sediment recovery time from dredging and anchoring activities is approximately within a year (Hill *et al.,* 2011). For example, areas of dredging on sandbanks which are subject to naturally high sediment mobility may disappear within a few tidal cycles (Hill *et al.,* 2011). Infrequent, high-energy (storm) conditions will also result in sediment suspension and redistribution.

Published calculations of wave and tidal current-induced bed shear stress, clearly show that the large waves have the capability to mobilise seabed sediments, increasing sediment suspension particularly for those sizes of coarse sands and smaller (ABPmer Ltd, 2010).

Following completion of the proposed activities, the natural physical processes of sediment transportation and natural backfilling are therefore expected to restore the seabed habitat to its equilibrium state within a year.

5.3.3.2. Permanent change to seabed habitats

The proposed overtrawl and rock-placement activities will cause some direct, long-term (permanent) impact to fauna living on and in the sediments with the impact representing an absolute worst case of 0.0016 km^2.

Benthic epifauna are dominated by *S. spinulosa* and crabs (Fugro, 2020b). Epifauna were more often observed in areas of '*Sabellaria spinulosa* on stable circalittoral mixed sediment' and included anemone (Actiniaria) and hydroids (Tubulariidae). Little epifauna was observed in areas of sand and mixed sediments, although some fish and crab taxa were present. Where shell debris and hard substrates were present for epilithic attachment, sessile epifauna such as hydroid/bryozoan turf (Hydrozoa/Bryozoa) and anemones (Actiniaria) were present (Gardline, 2021b). Mortality is more likely in non-mobile benthic organisms, whereas mobile benthic organisms are more sparsely distributed and may be able to move away from the area of disturbance. The impact on these species and the recoverability of their habitats within the North Norfolk Sandbanks and Saturn Reef SAC and the Southern North Sea SAC is outlined in Section 0

5.3.3.3. Impact on protected habitats and species

Removal of the infrastructure from the seabed will physically disturb the habitats and benthic fauna living within the boundaries of the North Norfolk Sandbanks and Saturn Reef SAC and the Southern North Sea SAC.

5.3.3.3.1. North Norfolk Sandbanks and Saturn Reef SAC

The North Norfolk Sandbanks and Saturn Reef SAC is designated for Annex I 'Sandbanks which are slightly covered by sea water all of the time' and Annex I 'Reefs'. The conservation objectives of the site are to maintain favourable conservation status incorporating the extent, distribution, structure function and supporting processes for the qualifying habitats (Table 3-4).

Bathymetry data (Figure 1-1) shows evidence of sandwaves along the pipeline route. The presence and continuation of these features in areas containing subsea installations suggests that small scale installations do not present barriers to individual sandbank maintenance or formation. DoB data along the pipeline route (Appendix E) indicates that they have mostly remained stably buried over time, however, pipeline exposures can arise as a result of sand wave migration as well as the sand bank system, which further suggests that the sand formations in the area are not impeded by the presence of the pipeline (Section 5.2.2.4). As such, it is not expected that the elongation and subsequent alteration in structure of the sandbanks, or the structure of the sandbank system, will be compromised by the decommissioning of the pipelines and cables *in situ*. As described above, the predicted recovery of a dynamic area from disturbance is likely to be relatively rapid. Overall, in considering the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC, the decommissioning activities and the long-term presence of the pipeline and umbilical is unlikely to affect the extent and distribution of the sandbank habitat, nor its natural functionality.

S. spinulosa are tolerant of both smothering and an increase in suspended sediment and are ephemeral in nature. Winter storm events often periodically break down *S. spinulosa* reefs, which may rebuild within the same area or move (Fugro, 2020b). Laboratory experiments have suggested that larvae settle preferentially on old tubes and it is thought that the presence of old tubes, in favourable environmental conditions, stimulates the recovery of senescent or significantly degraded reefs through larval settlement. Recruitment rates are high, meaning that recovery could be quite rapid with timescales often within one year (Fugro, 2020b). However, life cycles of *S. spinulosa* are still not clear and strongly depend on environmental conditions.

S. spinulosa are sensitive to substrate loss which may arise due to overtrawl, rock placement and anchoring (Jackson and Hiscock, 2008). Given the presence of (Figure 3-5 and Figure 3-6, respectively) it is likely that there will be some interaction with existing reef. The footprint calculated within this EA represents a of 0.03 km^2 of temporary and 0.0012 km^2 of permanent impact (base-case) on reef and potential reef (Table 5-13). Surveys by various oil and gas operators as well as research studies have been undertaken; these have enabled JNCC to define a total area of known reef in the North Sea of 569.69 km^2, as presented in its MPA Mapper (JNCC 2023), having consolidated areas of known biogenic reefs, based on various sources, including Ellwood (2013) and OSPAR (2013). Based on the findings of the survey and the assumptions mentioned in previous sections, a total of 0.03 km^2 (base-case) of *S. spinulosa* reefs may be impacted from the planned activities. This equates to 0.005% of the identified reefs in the SNS.

A habitat survey completed in 2012/2013 (Fugro, 2013) in the vicinity of the Leman A complex identified several potential reef areas to the east and west, which happened to be where several anchors and anchor wire drags were going to be placed. The condition of the *S. spinulosa* in the 2012/2013 survey was described as in the form of moribund tubes, reef rubbles and/or covered in hydroids and/or sand (Fugro, 2016). A post installation survey was then carried out in 2016, which replicated seven transects that were included as part of the 2012/2013 survey. A total of 356 occurrences of *S. spinulosa* were identified, all of which were deemed 'Low Reef or 'Not a reef' (Fugro, 2016). During the 2019 (Fugro, 2020a) survey, the same seven transects that were analysed in the 2016 survey were repeated to assess the temporal changes in *S. spinulosa*. These same transects were all subsequently defined at a maximum reefiness of 'High' or 'Medium' (Fugro, 2019). Therefore, there is clear evidence to suggest an increase in presence and reefiness between 2013 and 2019 in the area, despite impacts to the seabed. Review of the above results indicates that the reefs in the vicinity of the Leman A complex had the capacity to recover from temporary physical disturbance.

Overall, the proposed *in situ* decommissioning of the pipelines is not likely to negatively impact the *S. spinulosa* community (Fugro, 202b) and may even encourage its growth. Schramm *et al.*, (2021) studied the growth of biomass on shallow water subsea pipelines in Australia and biomass of species (considered an important feeding ground for to fish) and recorded on the pipelines was, on average 3.5 times greater than reef and 44.5 times greater than soft sediment habitats. Such structures may even have conservation benefits (Bell and Smith, 1999; Macreadie *et al.*, 2011 and Scarborough-Bull *et al.*, 2008) and following the initial placement of rock, it is likely that the existing communities will expand and colonise this additional hard substrate.

5.3.3.3.2. Southern North Sea SAC

The Southern North Sea SAC is designated for the protection of the Annex II species, harbour porpoise. The conservation objectives of the site are to maintain favourable conservation status for harbour porpoise, including ensuring that the condition of supporting habitats and processes, and the availability of prey is maintained (Table 3-4).

There are five species of sandeels known to occur in the North Sea, with the majority (90%) of the commercial catch made up of the lesser sandeel *Ammodytes marinus*. They are restricted to sandy sediments (Holland *et al*., 2005; Mazik, *et al.,* 2015, OESEA, 2016). Sandeels usually spawn between November and February and lay eggs in clumps on sandy substrates (OESEA, 2016). The larvae are pelagic for approximately two to five months after hatching and are believed to over-winter buried in the sand (OESEA, 2016).

As a prey species which supports the harbour porpoise population, the preservation of sandeel habitat is a conservation objective of the Southern North Sea SAC. The decommissioning activities associated with this infrastructure will take up a small area of the Southern North Sea SAC (0.0001%). Given the dynamic seabed conditions, re-burial and recovery of the surface seabed and associated fauna is expected to take approximately one year. Overall, no significant impacts are expected on the conservation objectives (Table 3-4) of the Southern North Sea SAC. Given the limited scale and temporary nature of the decommissioning operations, it is not expected that the structure of the sandeel habitat (and therefore the sandeel and harbour porpoise population) will be compromised.

5.3.3.4. Heavy metals

Metals with a relatively high density or a high relative atomic weight are referred to as heavy metals. It is expected that these metals will be released into the sediments and water column during the breakdown of the components of the pipeline scale and pipeline and cable steel. The toxicity of a given metal varies between marine organisms for several reasons, including their ability to take up, store, remove or detoxify these metals (Kennish, 1997). Concentrations of the metals are not expected to exceed acute toxicity levels at any time. However, chronic toxicity levels may be reached for short periods within the interstitial spaces of the sediments or near the pipelines. At these levels, heavy metals act as enzyme inhibitors, adversely affect cell membranes, and can damage reproductive and nervous systems. Changes in feeding behaviour, digestive efficiency and respiratory metabolism can also occur. Growth inhibition may also occur in crustaceans, molluscs, echinoderms, hydroids, protozoans and algae (Kennish, 1997). It is expected that any toxic impacts will be short lived and localised with minimal potential to impact populations of marine species. The potential for uptake and concentration of metals would also be limited to the local fauna and due to the slow release of these chemicals not likely to result in a significant transfer of metals into the food chain.

A benthic species of concern in the area is *S. spinulosa*. Some practitioners consider *S. spinulosa* relatively insensitive to metal or chemical contaminants (Holt *et al*., 1998), although direct evidence is limited. Studies of the response of *S. spinulosa* to an outfall from a bromide extraction works containing free halogens (Hoare and Hiscock, 1974) suggest that it is generally tolerant of changes in water quality (UK Biodiversity Group, 1999). A further study recorded that down-tide of a sewage discharge in Dublin Bay *S. spinulosa* was present in greater densities and diversities than elsewhere in the bay, indicating a level of tolerance for environmental change (Walker and Rees, 1980). Given its few key environmental requirements, and its tolerance of poor water quality, *S. spinulosa* is naturally common around the British Isles. *S. spinulosa* are also known to have life history strategies which enable them to exist in variable or unpredictable environments, responding to suitable conditions with a high rate of reproduction and rapid development (Krebs, 1985; MacArthur and Wilson, 1967).

The slow release of the metals associated with the pipeline steel and steel associated with the concrete coating and cables is expected to have a negligible impact on the local environment. It is anticipated that failure of the pipelines due to through-wall degradation would only begin to occur after many decades (of the order of 60 to 100 years; HSE, 1997). Along buried pipeline and cable corridors there may be accumulations of heavy metals in the sediments. Where present, the finer fraction of these sediments (silts and clays) are likely to form bonds with these metals, making them less bioavailable to marine organisms. The sandy (coarser fraction) of the sediments surrounding the pipelines are less likely to retain metals (MPE, 1999). Much of the surrounding seabed is composed of sand and will therefore release any metals to the surrounding seawater, making them bioavailable, but also diluting them into the wider environment.

Due to the highly localised nature of any degradation products within the seabed sediments and the low concentrations of contaminants being released over an elongated period it is highly unlikely that these products will be detectable above current background conditions in the area given the proximity to other oil and gas activity. As a result, no likelihood of significant effect is expected to any of the designated sites within which the pipelines and cables would be decommissioned *in situ*.

5.3.3.5. *Natura*lly Occurring Radioactive Material (NORM)

Naturally occurring radioactive material (NORM) contaminants can be found in some oil and gas infrastructure. It generally includes radionuclides of uranium, thorium, radium, radon, lead and polonium. NORM is ubiquitous in oil and gas reservoirs around the world and is known to form contamination products (scales and sludges) in pipelines (Koppel *et al.,* 2022).

Marine organisms can potentially bioaccumulate radium from solution in seawater, from ingested seabed sediments or from their food. Studies of the impacts of ^{226}Ra released into the North Sea via produced water and natural processes indicate that it is unlikely that observed levels of radioactive substances entrained in sediments or found in seawater will cause effects on marine organisms (Hylland and Erikson (2013). NORM scale discharged from offshore installations is known to be insoluble in seawater and when produced water rich in barium and radium is discharged to sulphate rich seawater, the radium precipitates rapidly as a complex of barium, radium and sulphate which is also insoluble. ^{226}Ra therefore has a very low concentration in solution in seawater and has a low bio-availability to marine organisms. Dissolved cations in seawater, particularly calcium and magnesium, also inhibit the bioaccumulation of NORM (OGUK, 2015)

Due to the highly localised nature of any degradation products and the potentially very low concentrations of NORM being released over an elongated period it is highly unlikely that these will be detectable above current background conditions in the area. As a result, no likelihood of significant effect is expected on the environment generally or to any designated site.

5.3.3.6. Polycyclic Aromatic Hydrocarbons

The likely base material of some of the concrete coated pipelines is coal tar. There is no standardised formula for the composition of coal tar, but it is thought that its constituents are over 60% inert and may comprise up to 15% of PAHs (MPE, 1999).

The coal tar coating degrades when the internal pipeline steel corrodes or if the concrete coat is damaged. There are no known records of concrete durability, but it is expected that the concrete will decay at a very slow rate. It is presumed that PAH will be released once the coal tar layer is open to the seawater, and over time will be released into the surrounding environment. PAHs in marine sediments will have a low biodegradation potential due to low oxygen and low temperatures (Cerniglia, 1992). PAHs are almost insoluble and only become available to marine organisms through ingestion of particulate matter (MPE, 1999; Cox and Gerrard, 2001). Due to their poor solubility in water these substances will partition in organic material including plankton and marine snow (cell water release) and marine sediments (cell water and sediment release). All substances in this group are persistent with a half-life in the marine environment ranging from weeks (water column) to several years (sediments). Evidence of carcinogenicity, mutagenicity or teratogenicity attributable to PAHs in the marine environment is limited and are not thought to pose a threat to marine organisms (MPE, 1999).

Two factors, lipid and organic carbon, control to a large extent the partitioning behaviour of PAHs between sediment, water, and tissue. Accumulation of PAHs occurs in all marine organisms; however, there is a wide range in tissue concentrations from variable environmental concentrations, level and time of exposure, and a species' ability to metabolize these compounds. There are many variables, such as chemical hydrophobicity, uptake efficiency, feeding rate, and ventilatory volume, which may affect the outcome. The route of uptake may be an important issue for short-term events; however, under long-term exposure and equilibrium conditions between water, prey, and sediment, the route of uptake may be immaterial because the same tissue burdens will be achieved regardless of uptake routes (Meador *et al.*, 1995). 1999). Given that PAHs are expected to be released in very low concentrations during the deterioration of the coating over time, it is unlikely that marine organisms will accumulate them to a significant extent.

5.3.3.7. Plastics

Cables in the Leman area are coated with Polyethylene which is considered non-toxic in the marine environment (DNV, 2006). However, as no micro-organisms have evolved to utilise the chemically resistant polymer chains as a carbon source, these plastics can be expected to persist in the environment for centuries (OGUK, 2013). As biodegradability in the marine environment is also low, it can be assumed that the environmental effect of leaving these plastics in place is insignificant (MPE, 1999).

Due to the highly localised nature of any degradation products and the low concentrations of contaminants being released over an elongated period it is highly unlikely that these products will be detectable above current background conditions in the area. As a result, no likelihood of significant effect is expected to any designated sites.

5.3.3.8. Blue Carbon

Marine sediments are the primary store of biologically derived carbon (mostly inorganic carbon). In the UK's biogenic marine habitats are highly productive places, with a very high rate of assimilation of carbon into plant material (662 gC/m^2/yr), mostly in coastal areas. However, their overall contribution to the carbon budget is relatively small compared to sediments (Burrows *et al.*, 2014; 2017). Carbon stored in organisms can be broadly defined as either 'transient', such as the carbon stored in seagrass beds, kelp and macroalgae; or 'long term', such as biogenic structures (e.g. coral reefs, serpulid reefs).

Carbon may be sequestrated in marine sediments as precipitated carbonates (PCO) or as particulate organic carbon (POC). While it is known that sediment accumulation rates tend to be faster nearer to land (e.g. in estuaries), it is unclear what processes maintain the accumulation basins on the shelf, or whether any of the rich supply of organic material from phytoplankton in productive shelf waters becomes refractory and remains there (Burrows *et al.*, 2014). The principal threat to long term carbon burial in sediments is any process that stirs up the sediment, particularly the top few millimetres of sediment. Resuspension of sediment allows rapid consumption of buried carbon by organisms and its subsequent release as carbon dioxide. This effectively reduces the carbon burial rate significantly and reduces the blue carbon inventory.

Patterns of standing stocks and sequestration capacity of organic carbon follow the distribution of mud and mud-sand-gravel combinations. Most organic carbon and the largest capacity for sequestration of organic carbon appears to be in deep mud off the continental shelf (Burrows *et al.*, 2014).

A review of sediment accumulation rates in the North Sea showed that the burial rates for organic carbon are strongly dependent on sediment type. The seabed type within the Leman area is primarily classified under the habitat complex EUNIS biotope complex A5.44 (Circalittoral mixed sediment) with areas of EUNIS biotope complex A5.23 (Infralittoral fine sand) and EUNIS biotope complex A5.25 (Circalittoral fine sand).

The average percentage carbonate in the top 10 cm of superficial sediments in Leman area (BGS, 2022), is <10% which is below average for the UKCS more generally (Burrows *et al.*, 2014; NMPi, 2022). However, different habitats offer additional sequestration capacity. Typically, these habitats are associated with shallower or coastal habitats (e.g. seagrass and kelp beds) or biogenic reef features such as those found on and around the Leman infrastructure.

Overall, the sediments in the Leman area are considered to have a low carbonate value. Biogenic reefs are believed to contribute via the build-up of sedimentary carbon but the extent to which this is the case for *S. spinulosa* is currently not well documented (Lovelock & Duarte, 2019). Burrows *et al* (2014) deduce that the tubes constructed by the reef-building polychaetes *S. spinulosa* consolidate sediments (Naylor & Viles, 2000), rather than accreting calcium carbonate. Burrows *et al* (2014) conclude that *S. spinulosa* reefs should be considered to have the same blue carbon potential as the surrounding sediments. As no contradictory studies could be found in the literature, these reefs will not be considered further.

5.3.3.9. Drill Cuttings

The highest THC (3.77µg g^{-1}) was recorded at the Station LF_02, which is within 250m of 19 wells at Leman F (Figure 3-1; Gardline, 2021a) and corresponding with where TOM, TOC and/or fines were also at their highest concentrations. To put these results into a wider context, UKOOA (2001) reported a mean THC concentration of 4.34µg $g^{-}$for background stations (Based on U.K. Offshore Oil and Gas Environmental Surveys 1975-95; UKOOA, 2001). All stations in the Leman area recorded THC concentrations below the UKOOA regional average.

The best estimates of the potential toxicity of PAHs in marine sediments are Effects Range Low (ERL) and Effects Range Median (ERM) concentrations (Neff, 2004). Long et al. (1995) gives ERL and ERM concentrations for total PAH concentration in sediments are 4.022 and 44.792µg g-1, respectively. Among the four stations with the highest total PAH concentrations (i.e. >0.070µg g^{-1} at Stations LFA_02, LFA_03, LF_02 and LF_04; Figure 3-1) the dominance of low molecular weight compounds at LFA_02 indicated a low-level petrogenic signature at this station (Gardline, 2021a).

Evidence of the presence of low toxicity oil-based mud (LTOBM) was found at station LG03 during a previous survey of the area surrounding Leman G (Figure 3-1; Fugro, 2019a). However, all THC values recorded across the Leman G survey area were below the SNS mean background concentration (4.34 µg g^{-1}; UKOOA, 2002) and the 95th percentile value (11.39 µg g^{-1}; UKOOA, 2002).

Barium concentrations were highest at Station LG_02 (218 µg g^{-1}; Figure 3-1), however it was not significantly elevated relative to other stations; the mean concentration across samples was 117 µg g^{-1}. The higher concentrations observed are expected given proximity to wells, however, there were no abnormalities in the hydrocarbon composition at this station to suggest the presence of oil-based drilling mud. This inconclusive evidence may be indicative of a diffuse water-based drilling mud or a general ubiquitous presence of this form of barium across the region (Gardline, 2021a). Due to its low solubility and the fact that it is not toxic in its sulphate form (Gerrard *et al.,* 1999), elevated barium concentrations are rarely of toxicological concern. Overall, barium concentrations were at or below the UKOOA (2001) mean background value of 218 $\mu g\ g^{-1}$ at all stations. These concentrations are considered typical of background for sediments in the wider area (Gardline, 2021a).

During the most recent Gardline (2021a) survey effort, all other metal concentrations, with the exception of arsenic, were below their respective ERL suggesting toxic effects would rarely be observed. Concentrations of arsenic were above ERL at several stations; however, concentrations were below the ERM, suggesting toxic effects on the faunal community may occasionally occur due to the concentrations of this metal (Gardline, 2021a). Comparison to the wider field demonstrated that the mean metals concentrations for the current survey were broadly comparable to, or slightly lower than the mean concentrations from earlier surveys of the Leman A area (Fugro, 2019a; Gardline, 2021a).

5.3.4. Cumulative and transboundary impacts

5.3.4.1. Cumulative impact

In addition to Shell's decommissioning activities occurring in the North Norfolk Sandbanks and Saturn Reef and Southern North Sea SACs, proposed and approved activities submitted to the Department for Energy Security and Net Zero by Shell and other operators indicate further activities which have been, and will be, undertaken in within these defined areas (Table 5-14).

The Leman decommissioning activities, in combination with the ongoing and previous stabilisation works, will increase the temporary and permanent seabed impact within the wider SAC areas. However, decommissioning much of the infrastructure *in situ*, with minimal introduction of additional material, minimises the cumulative impact of these activities.

Table 5-14 Past and future activities in the area with potential for cumulative effects

Project	Operator	Total Area Impact (km^2)	Within NNSSR SAC (km^2)	Within *S. spinulosa* aggregations (km^2)	% of total NNSSR SAC area[1]	% of known *S. spinulosa* aggregation[2]	Within SNS SAC (km^2) [3]	% of total SNS SAC area[4]
Leman F and G Decommissioning (This EA)	**Shell**	0.055	0.055	0.03	0.0015	0.005	0.055	0.00014
Galleon PN Well Drilling		0.0134	0.0134	0	0.00037	0	0.0134	0.00004
Leman Delta Decomplexing		0.0369	0.0369	0	0.00102	0	0.0369	0.0001
Leman A Turnaround		0.0152	0.0152	0.0047	0.00042	0.00083	0.0152	0.00004
Leman F Simplification		0.0112	0.0112	0.01	0.00031	0.00177	0.0112	0.00003
Leman G Simplification		0.0184	0.0184	0	0.00051	0	0.0184	0.00005
Brigantine BG Simplification		0.0146	0	0	0	0	0	0
Leman-Bacton Freespan Mitigation		0.0145	0.00691	0.00691	0.00019	0.00003	0.00939	0.00003
Freespan Mitigation Phase 2		0.06026	0.02705	0.01353	0.00075	0.00239	0.02611	0.00007
Galleon PN Well Intervention, 2022-23		0.024	0.024	0	0.00067	0	0.024	0.00006
Deposit Consent, 2024		0.003	0.003	0.003	0.00008	0.00053	0.003	0.00001
Galleon PN CTCO Well Intervention, 2022		0.0165	0.0165	0	0.00046	0	0.0165	0.00004
VDP1 and LOGGS LDP1	**ConocoPhillips**	0.0663	0.0663	0.0663	0.00184	0.0117	0.0663	0.00018
Marine Licence, 2018 x2	**Spirit Energy**	0.0003	0.0003	0	0.00005	0	0.0003	0.000001
Deposit Consent, 2019	**ENI**	0.000697	0.000697	0	0.00012	0	0.000697	0.000002
Consent to Locate, 2019	**Fraser Well**	0.00302	0.00302	0	0.00053	0	0.00302	0.00001
Marine Licence, 2019	**INEOS**	0.000002	0.000002	0	0	0	0.000002	1E-08
Consent to Locate, 2019	**Ithaca Energy**	0.0006	0.0006	0	0.00011	0	0.0006	0.000002

Project	Operator	Total Area Impact (km^2)	Within NNSSR SAC (km^2)	Within *S. spinulosa* aggregations (km^2)	% of total NNSSR SAC area[1]	% of known *S. spinulosa* aggregation[2]	Within SNS SAC (km^2) [3]	% of total SNS SAC area[4]
Consent to Locate, 2019	**Spirit Energy**	0.00302	0.00302	0	0.00053	0	0.00302	0.00001
Consent to Locate, 2019 x 2	**Petrofac**	0.00604	0.00604	0	0.00107	0	0.00604	0.00002
Marine Licence Application, 2019 x 4	**Petrofac**	0.000638	0.000638	0	0.00011	0	0.000638	0.000002
Deposit Consent, 2020	**Perenco**	0.06638	0.06638	0	0.01172	0	0.06638	0.00018
LOGGS Area Decommissioning, 2020	**Chrysaor**	0.15274	0.03288	0.03586	0.0058	0.00633	0.15274	0.00041
Marine Licence, 2020	**Spirit Energy**	0.00289	0	0	0.00051	0	0.00289	0.00001
Marine Licence, 2020	**Tullow Oil**	0.000051	0.000051	0	0.00001	0	0.000051	0.0000001
Thames pipeline Deposit Consent	**Perenco**	0.009828	0.009828	0.009828	0.0017	0.00173	0.009828	0.0000266
Pickerill pipeline cutting	**Perenco**	0.00018	0	0	0	0	0.00018	0.0000005
PL253 Deposit Consent 2019-2022	**Perenco**	0.000372	0	0	0	0	0.000372	0.000001
PL22 Deposit Consent 2019 -2022	**Perenco**	0.004713	0.004713	0.004713	0.00083	0.00083	0.004713	0.0000128
PL23 Deposit Consent 2022	**Perenco**	0.001025	0.001025	0.001025	0.00018	0.00018	0.001025	0.0000028
PL24 Deposit Consent 2019 -2021	**Perenco**	0.001808	0.001808	0.001808	0.00032	0.00032	0.001808	0.0000049
Hornsea Offshore Windfarm Project Three	**Dong Energy**	0.01	0.00	0.00	0.0068	0.000	0.00	0.0000001
Total area disturbed (Shell)		**0.28**	**0.23**	**0.07**	**0.006**	**0.01**	**0.23**	**0.0006**
Total area disturbed (non-Shell)		**0.33**	**0.20**	**0.12**	**0.03**	**0.02**	**0.32**	**0.0009**
Total cumulative area disturbed		**0.61**	**0.43**	**0.19**	**0.04**	**0.03**	**0.55**	**0.0015**

Notes:

1 Area of the North Norfolk Sandbanks and Saturn Reef (NNSSR) SAC is 3,603 km^2

2 Known *S. spinulosa* (MPA Mapper (JNCC, 2023)

3 Where it was not possible to find out what area of the project impacted the SNS SAC, it has been assumed that the total area disturbance was inside the SNS SAC entirely.

4 Area of the Southern North Sea (SNS) SAC is 36,951 km^2

The North Norfolk Sandbanks and Saturn Reef SAC is designated for the presence of Annex I habitats 'sandbanks, which are slightly covered by seawater all the time' and biogenic 'reefs'. The whole site is classified as Annex I sandbank habitat with conservation objectives aiming to ensure long term integrity of the site. The Shell activities listed in Table 5-14, will affect up to 0.006% of the SAC and the sandbank habitat. These activities are also expected to impact a maximum of 0.07 km^2 of *S. spinulosa* aggregations, representing 0.01% of the known *S. spinulosa* coverage in the SNS. Third-party activities listed in Table 5-14, will affect up to 0.03% of the SAC and the sandbank habitat. These activities are also expected to impact a maximum of 0.12 km^2 of *S. spinulosa* aggregations, representing 0.02% of the known *S. spinulosa* coverage in the SNS. Cumulatively all impacts will affect up to 0.04% of the SAC and the sandbank habitat. These activities are also expected to impact a maximum of 0.19 km^2 of *S. spinulosa* aggregations, representing 0.03% of the known *S. spinulosa* coverage in the SNS.

The Southern North Sea SAC is designated for the protection of the Annex II Harbour porpoise population. The Shell activities outlined here will affect up to 0.0006% and third-party activities will affect up to 0.0009% of the area of the SAC. In combination these activities will affect up to 0.0015% of the habitat represented by the Southern North Sea SAC which supports sandeel, the main prey of harbour porpoise (Table 5-14).

5.3.4.2. Transboundary impact

The Leman decommissioning activities are located approximately 66 km east of the UK/ Netherlands European Economic Zone (EEZ) boundary line at the closest point (Leman G). Decommissioning activities are not anticipated to create any transboundary impacts with regards to seabed.

5.3.5. Management and mitigation

Mitigation measures to minimise seabed impacts within the Leman F and G NUI area are detailed below:

- Cutting and lifting operations will be carefully controlled and monitored to ensure accurate placement of cutting and lifting equipment and minimise any impact on seabed sediment;
- The requirements for further excavation will be assessed on a case-by-case basis and will be minimised to provide access only where necessary. Internal cutting will be used preferentially where access is available;
- The SSCV for NUI lifts is most likely to be equipped with dynamic positioning rather than relying on anchors to remain in position which interact with the seabed. If anchors are required their placement will account for the location of potential reef around the Leman F NUI.
- The rock mass will be carefully placed over the designated areas of the pipelines and seabed in order to ensure rock is only placed within the planned footprint with minimal spread over adjacent sediment, minimising seabed disturbance and with the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC and Southern North Sea SAC in mind;
- Survey data collected in the area will be reviewed for potential sensitive seabed habitats (in particular the location of areas of *S. spinulosa*) prior to the commencement of operations; and

- Post decommissioning debris clearance surveys and monitoring shall be carried out using non-intrusive methodologies such as side scan sonar, using ROVs etc. Where this is not possible Shell will give due consideration to the seabed habitats and species and would consult with the NFFO and OPRED should a more intrusive approach be deemed necessary.

5.3.6. *Residual impacts*

The proposed, excavation, cutting, item removal and anchoring activities will physically disturb the sediment in the local area. The seabed sediment disturbance will be temporary, localised and confined to an estimated area of, approximately, 0.045 km^2. This represents 0.001% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC (3,603 km^2; JNCC, 2022a) and 0.0001% of the total area of the Southern North Sea SAC (36,951 km^2; JNCC, 2022b). Removal of exposed (and potential future exposures) pipeline and umbilical sections, and the decommissioning of the remaining pipeline and umbilical infrastructure *in situ* will minimise the disturbance to the environment and hence should have little or no impact on sandwave morphology.

Temporary seabed impacts are expected to be short-term and not significantly impact the conservation features of either SAC. Given the dynamic seabed conditions, the habitat recovery from the disturbance in the SNS is predicted to occur relatively rapidly, through re-distribution of the sediment by currents and subsequent migration and larval settlement of benthic population

Overall, no significant impacts are expected on the benthic fauna and associated habitats underpinning the conservation objectives (Table 3-7) of either SAC. Given the limited scale, temporary nature of the decommissioning operations and the large areas of undisturbed seabed that surround the areas of disturbance which are likely to facilitate the recovery processes, it is not expected that the structure of the sandbanks or sandeel habitat will be compromised.

Long-term impacts associated with the introduction of additional hard substrate are expected to create a maximum permanent seabed impact of 0.0016 km^2, representing 0.00004% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC and 0.000004% of the Southern North Sea SAC. Given the minimal scale of the footprint, it is not expected that the structure of the sandbanks or the habitat of harbour porpoise prey will be affected. While the addition of 0.0016 km^2 of rock will potentially impact 0.0012 km^2 of reef or potential reef, which represents 0.0002% of the 569.69 km^2 area of known *S. spinulosa* (MPA Mapper; JNCC, 2023) in the SNS.

While the addition of rock will potentially impact *S. spinulosa* reef, this represents a small area in proportion to the area of current reef habitat with recovery expected to be rapid (less than 10 years) as shown by the analysis of sequential survey data. The slow release of the metals and plastics associated with the pipeline sand umbilical is also expected to have a negligible impact on the local environment.

Non-intrusive and remote post-decommissioning survey methods will be used in the Leman F and G NUI 500m safety exclusion zones in the first instance. In the unlikely scenario that overtrawl is required following removal and remediation and anchoring activities, the impact footprints for this activity have been estimated to represent a worst-case scenario. Overtrawl activities would lead to a wider impact on the seabed around the Leman F and G NUIs equating to 1.67 km^2, representing 0.046% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC and 0.0045% of the Southern North Sea SAC. Overtrawl would potentially impact 0.84 km^2 of reef or potential reef, which represents 0.15% of the 569.69 km^2 area of known *S. spinulosa* (MPA Mapper; JNCC, 2023) in the SNS. Under these circumstances, Shell would hold conversations with the NFFO and OPRED to discuss the best way to approach this while taking the environmental sensitivities of the area into account to minimise any residual impacts.

Other projects contributing to the cumulative impact within the North Norfolk Sandbanks and Saturn Reef SAC and Southern North Sea SAC include a number of oil and gas and renewable developments. In combination with the decommissioning activities outlined herein, an anticipated 0.6 km^2 is expected to be impacted., a cumulative 0.04% of the North Norfolk Sandbanks and Saturn Reef SAC and 0.0015% of the Southern North Sea SAC is thought to be affected by current and future developments.

Due to the distance of the Leman decommissioning activities from the UK/ Netherlands median line, (approximately 66 km) no transboundary impacts are likely to occur.

5.4. Disturbance to nesting seabirds

5.4.1. *Introduction*

As oil and gas infrastructure in the North Sea ages out, the role these structures occupy in seabird ecology, and the subsequent impact of their decommissioning on seabirds, is coming under increasing scrutiny. In recent years, there has been an increase in the number of seabirds utilising offshore installations for nesting. Opportunistic species such as kittiwake and herring gull are utilising artificial nest locations and successfully rearing chicks. In some instances, colonies of several hundred birds have established and return each year. Although for most offshore platforms, the number of breeding birds remains very low.

Prior to the commencement of decommissioning activities, assurances must be made that any potential adverse impacts associated with the activities will be minimised with respect to protected species such as seabirds.

5.4.1.1. Legislative Context

Shell is fully aware of their responsibilities under the following legislative expectations and requirements. The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended) transpose the European Union (EU) Wild Birds Directive and secure protection of wild birds, their eggs and nests in the offshore marine area, including offshore marine installations. It is an offence under Regulation 40 to deliberately injure, kill or disturb any wild bird or take, damage or destroy the nest whilst in use or being built or take or destroy an egg.

The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 amend the 2017 Regulations to ensure that the transposition of the Wild Birds Directive (and Habitats Directive) continues to be operable upon the UK's exit from the EU. The transposition note for the 2017 Regulations indicates that it was intended that Regulation 40 would transpose Article 5 of the Wild Birds Directive so despite deliberate disturbance not being specified it is intended it should be included (JNCC, 2021).

5.4.1.2. Guidance Recommendations

Recent decommissioning operations in the UKCS have reported significant numbers of kittiwake nests on the cardinal faces and undersides of certain platforms. They are colonial nesters and readily utilise offshore platforms as an artificial cliff habitat.

Current advice from JNCC requests that all platforms that will have significant decommissioning operations planned within the following years breeding period, should have a survey undertaken to assess the extent of kittiwakes nesting on the platform. The survey methodology however is applicable to all potential nesting seabirds offshore.

An awareness of the birds utilising the platform will allow the operator the opportunity to implement a deterrence and nesting prevention strategy. This will be outlined in the Bird management plan developed by Shell which will include the approach to pre-decommissioning bird/ nest surveys and deterrence strategies, including a final pre-decommissioning survey in the year of NUI removal activities. Shell is aware that in the circumstance that protected birds are found to be nesting on either platform, any planned lift may need to be delayed. In the instance that all potential deterrence strategies and mitigation measures fail, Shell will engage with OPRED to discuss path forward and the potential to apply for a licence to disturb.

5.4.2. *Description and quantification of impact*

The SNS is an important foraging ground for a number of seabird species. Table 5-15 shows a list of common species typically recorded in the SNS. Of these species only two have been recorded nesting on offshore platforms: kittiwake and herring gull.

Table 5-15 List of common seabird species recorded in the SNS

Species common name	Scientific name
Arctic skua	*Stercorarius parasiticus*
Arctic tern	*Sterna paradisaea*
Atlantic puffin	*Fratercula arctica*
Black-headed gull	*Chroicocephalus ridibundus*
Black-legged kittiwake	*Rissa tridactyla*
Common guillemot	*Uria aalge*
Common gull	*Larus canus*
Common tern	*Sterna hirundo*
European herring gull	*Larus argentatus*
European storm petrel	*Hydobates pelagicus*
Great black-backed gull	*Laurus marinus*
Great cormorant	*Phalacrocorax carbo*
Great skua	*Stercorarius skua*
Lesser black-backed gull	*Larus fuscus*
Manx shearwater	*Puffinus puffinus*
Northern fulmar	*Fulmarus glacialis*
Northern gannet	*Morus bassanus*
Razorbill	*Alca torda*

Nesting Bird Surveys

APEM (2021) was contracted by Ørsted Hornsea Four Ltd (Hornsea Four) to use aerial digital survey methods to collect data on the nesting population of kittiwakes that have colonised artificial structures in the North Sea. The aerial digital surveys of 21 SNS platforms (including Leman F and Leman G NUIs) were carried out on the 15th and 16th July 2021 to coincide with kittiwake main attendance at their colonies during the UK breeding season. No kittiwakes were recorded on either Leman platform.

5.4.3. *Mitigation measures*

Shell have implemented an internal team to discuss all aspects of bird management applicable to decommissioning operations. The remit of this team's work is to:

- Plan and arrange seasonal surveys. Currently, the nesting surveys will be scheduled, as per regulations, one year prior to any decommissioning activities taking place and a final pre-decommissioning survey in the year of the lift.
- Explore technological opportunities for evidence gathering; and
- Develop bird management plans.

Shell will liaise with OPRED and JNCC to confirm expectations and licensing requirements based on the nest status and scheduling, as appropriate.

5.4.4. Cumulative impact

There are no clear cumulative impacts associated with the disturbance or abandonment of nests on platforms in the SNS.

5.4.5. Transboundary impact

There are no transboundary impacts associated with the disturbance or abandonment of nests on platforms in the SNS.

5.4.6. Residual impact

The Leman F and G decommissioning activities will result in the disturbance/abandonment of nests if works or removal operations coincide with breeding periods of seabird species in UK waters and evidence of nests are found at the platforms via planned surveys. The main receptors for this disturbance will most likely be kittiwakes and/ or herring gulls, although other species cannot be discounted. In the instance that pre-decommissioning bird surveys do not identify the presence of nests, the consequence on seabird populations is ranked as negligible.

There is currently no evidence of nesting birds on the Leman F and G NUIs, however a Bird Management Plan will be in place prior to commencement of decommissioning activity. The Plan will include an outline of the approach to nesting surveys to be undertaken prior to decommissioning activities to identify the potential for the presence of nesting birds in the years prior and the year of the lift, and the deterrence strategies that will be put in place to prevent nesting during the lift year.

Following considered remedial strategies outlined in the Bird Management Plan, including deterrent strategy, and scheduling to avoid bird breeding periods where possible, the likelihood of occurrence is rare. This impact would be reassessed should nests appear prior to decommissioning activities and should any potential deterrence strategies fail.

5.5. Accidental Events

5.5.1. Introduction

This section evaluates the potential impacts of accidental events and the proposed mitigation measures Shell will implement to reduce the probability of occurrence and ensure that the impact to the environment is reduced as low as reasonably practicable (ALARP).

Shell has an Oil Pollution Emergency Plan (OPEP) in place for the Leman Field (Shell, 2020), which has been prepared in accordance with:

• The Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998; and

• The Guidance Notes for Preparing Oil Pollution Emergency Plans - For Offshore Oil and Gas Installations and Relevant Oil Handling Facilities (BEIS, 2019).

With regard to general offshore operations, potential sources of accidental release include:

- Well blow out
- Failure of diesel storage tanks on infield vessel at Leman A.
- Rupture of the Leman / Bacton Pipeline at mid-point and nearshore point.

It should be noted here that the Leman wells will no longer be producing at the time of decommissioning activities and will be plugged and abandoned, therefore the likelihood of a well blow out is negligible. A release of the Leman/Bacton pipeline inventory at the pipeline start point (Leman A) has not been modelled as a diesel spill of far greater volume has been modelled at the same location, therefore the focus of this section is potential the failure of diesel storage tanks on infield vessel at Leman A.

5.5.2. Description and quantification of impacts

5.5.3. Sources of Potential Impacts

The potential sources of hydrocarbon spillages have been identified through knowledge and experience developed from Shell oil and gas operations in the North Sea. The volume of diesel modelled is based on the largest diesel inventory onboard any vessels currently or previously under contract with Shell and therefore represents a worst-case diesel spill scenario.

5.5.3.1. Hydrocarbon properties

Diesel fuel has a very high proportion of volatile components, which evaporate quickly on release and don't form emulsions. The low asphaltene content in these fuels prevent emulsification, reducing their persistence in the marine environment. The specific hydrocarbon properties modelled are presented in Table 5-16.

Table 5-16 **Hydrocarbon properties**

Oil	IOTPF category	API (°)	Specific Gravity	Viscosity (cST / °C)	Pour point (°C)	Asphaltene content (% mass)	Wax content (% mass)
Marine Diesel	II	38.2	0.83	2.76 / 25°C	-50	0	1.7

5.5.4. *Impact assessment and oil spill modelling*

An accidental hydrocarbon release can result in a complex and dynamic pattern of pollution distribution and impacts in the marine environment. As there are a variety of natural and anthropogenic factors that can influence an oil spill, each one is unique. The extent of an oil spills environmental impact depends on variables including:

- Location and time of the spill;
- Spill volume;
- Hydrocarbon properties;
- Prevailing weather/ metocean conditions;
- Environmental sensitivities; and
- Efficacy of the contingency plans.

5.5.4.1. Overview of the modelling undertaken

Oil spill modelling was conducted to predict the probable locations where an oil slick may cross the median line or impact an area of coastline, and in what quantities. The modelling is useful to plan the response strategies in the event of an oil spill incident. It is however recognized by Shell that this is a decision support tool and not a decision-making tool and would be supported with aerial surveillance during a response. The software used for modelling is the RPS ASA Oilmap Spill Modelling Application, Version 7.

Stochastic (probability) modelling has been carried out based on the specific worst case oil spill incident scenarios. Stochastic modelling simulations predict probable behaviour of potential oil spills under historical meteorological and oceanographic conditions. The stochastic modelling uses historical metocean data to provide a probability range of sea surface oiling / beaching. Spill trajectory modelling scenarios were undertaken from the Leman A platform location (53° 05' 22" N; 02° 07' 45" E) and an instantaneous loss of 2,695 m^3 of diesel at the surface was modelled and the simulation time was seven days. Scenarios were run to investigate the potential for beaching, crossing the median line and to estimate arrival times during for winter, spring, summer and autumn (Figure 5-3, Figure 5-4 and Table 5-17).

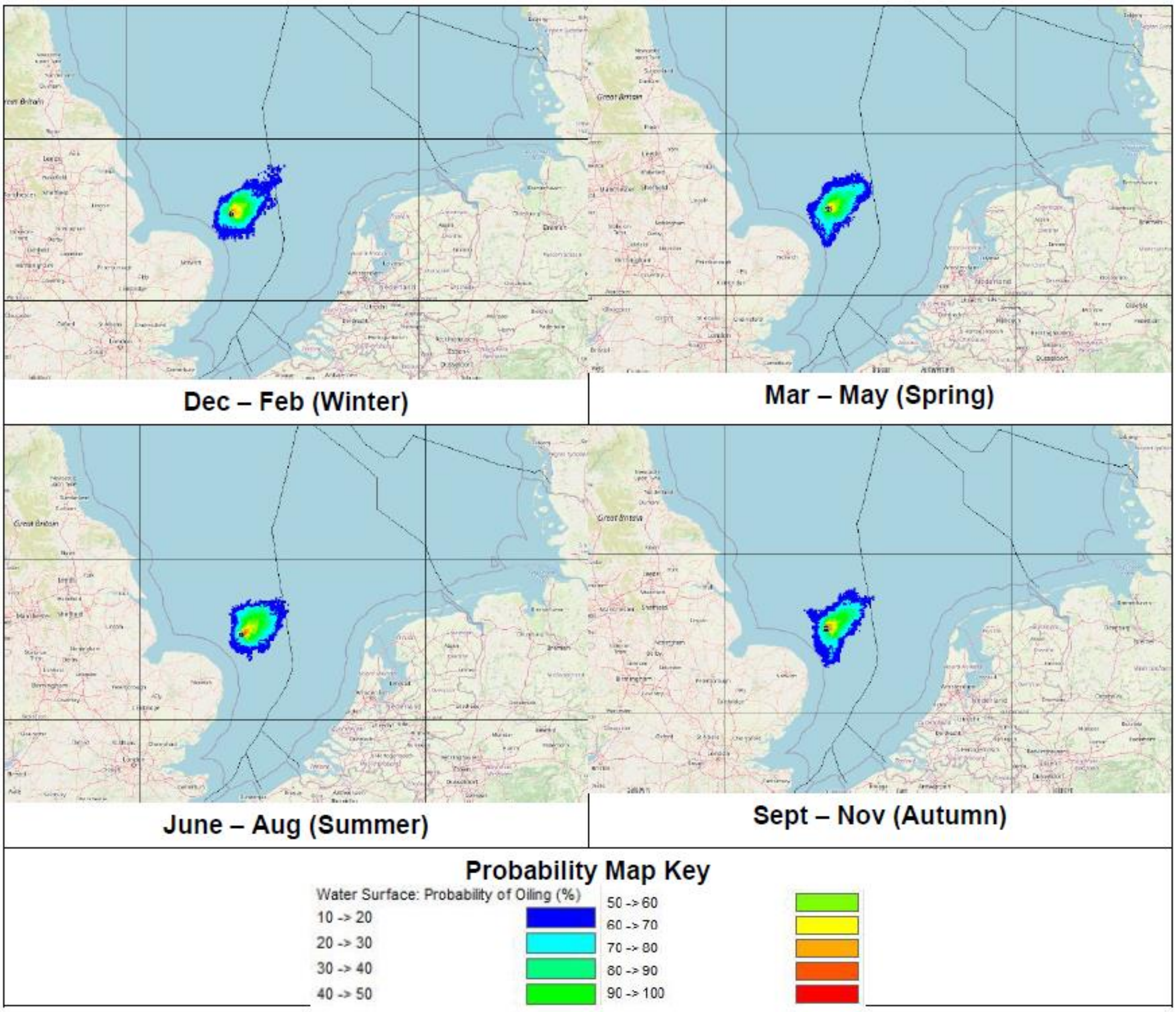

Figure 5-3 Probability of beaching and crossing the median line following a diesel spill from infield vessel at Leman A (Shell, 2020)

Diesel is a non-persistent hydrocarbon therefore its residence in the marine environment is low. Under worst case conditions, stochastic modelling results show that there is up to a 12% probability of a diesel spill at the Leman A complex crossing the UK/Netherlands median line within 121 to 144 hours. There is also a very low probability (2-4%) of beaching in very low volumes along the East Anglian coastline, with the quickest beaching predicted to occur approximately 164.5 hrs after the spill incident (Table 5-17).

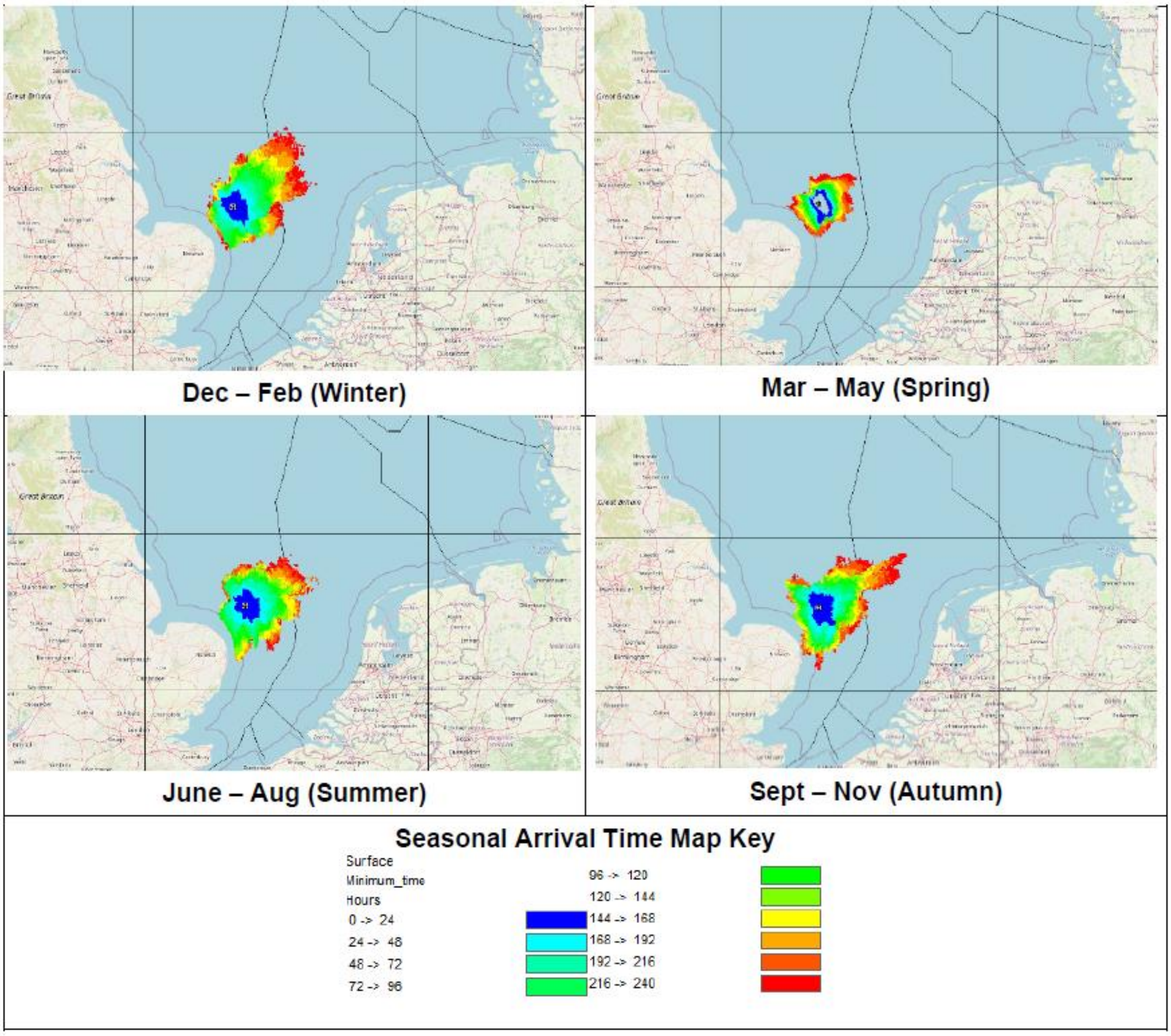

Figure 5-4 Seasonal arrival time (hrs) plot for a diesel spill from infield vessel at Leman A (Shell, 2020)

Table 5-17 Key results for diesel spill modelling

Maritime boundaries	**Probability and shortest time to reach median line**			
	Dec- Feb	**March- May**	**June - Aug**	**Sept - Nov**
Netherlands median line	11%	11%	12%	11%
	144 hrs	121 hrs	121 hrs	121 hrs
Landfall	**Probability and shortest time to beach**			
	Dec- Feb	**March- May**	**June - Aug**	**Sept - Nov**
East Anglia coastline	0%	2%	0%	4%
	-	230.5 hrs	-	164.5 hrs
Volume beached		0.25 m^3		1.69 m^3

5.5.5. *Impacts on sensitive receptors*

5.5.5.1. Biological Receptors

Although there is only a small likelihood of a diesel spill in the Leman Field, there is a potential risk to organisms in the surrounding seabed environment and water column if a spill were to occur (Table 5-18).

Table 5-18 Summary of potential impacts to main biological receptors

Receptor	Impacts to biological receptors at risk
Plankton	Localised effects to plankton community due to toxicity. Impacts on communities are unlikely due to natural variability, high turnover and seasonal fluctuation.
Benthos	The impact from diesel to benthic species or the seabed would be localised. Benthic communities may be affected by gross contamination, with recovery taking several years. Mortality would be dependent on oil sensitivity potentially leading to structural change in the community. The surface release of diesel is unlikely to impact benthic communities and therefore the risk is considered minimal.
Fish, spawning and nursery grounds	Adult fish are expected to avoid the affected area, but if affected, hydrocarbons may result in tainting of the fish, and hence in a reduction of commercial value. Eggs and larvae may be affected, but such effects are generally not considered to be ecologically important because eggs and larvae are distributed over large sea areas. Demersal species may be influenced by habitat pollution.
Seabirds	Seabird sensitivity to oil within Block 49/26 varies throughout the year, from low in the summer months (May-September) to extremely high in January and February (Webb *et al.*, 2016). The timing of decommissioning operations is very unlikely to coincide with the very high period of offshore bird sensitivity. The Greater Wash Special Protection Area SPA (31 km WSW of Leman A) borders the spill trajectory and is area of importance for over-wintering and coastal feeding waters (JNCC, 2022d). Diesel spills can affect marine birds by direct contact and mortality is caused by ingestion during preening and hypothermia. Few birds are directly affected by diesel spills from vessel spills. However, small spills could result in serious impacts to birds under the unfavourable conditions, such as a grounding right next to a large nesting colony or transport of sheens into a high bird concentration area (NOAA, 2006). Given that the low probability (maximum 4%) and the maximum quantity predicted to beach would be 1.69 m^3 in the Autumn, when decommissioning operations would be very unlikely to be taking place, any quantity likely to enter the SPA would be low and well dispersed by the time it arrives. It is therefore very unlikely that any impact would be felt by the bird populations residing in close to the beach and in the nearshore waters.
Marine mammals	Cetaceans and seals are generally accepted to be able to avoid hydrocarbon spills. However, should contact occur, effects include irritation and respiratory problems. Hypothermia effects are generally avoided due to a thick layer of blubber.
Offshore protected habitats	An accidental release of hydrocarbons is very unlikely to impact any designated seabed features of the North Norfolk Sandbank and Saturn Reef SAC or the The Haisborough, Hammond and Winterton SAC, which also lies within the spill trajectory. Diesel oil is much lighter than water (specific gravity is between 0.83 and 0.88), compared to 1.03 for seawater). It is not possible for

Receptor	Impacts to biological receptors at risk
	this oil to sink and accumulate on the seafloor as pooled or free oil unless adsorption occurs with sediment (NOAA, 2006). Though the harbour porpoise in the Southern North Sea SAC is susceptible hydrocarbons, they would likely avoid an area affected by a spill.

5.5.5.2. Shoreline Impacts

Spill modelling undertaken for the Shell Leman OPEP (Shell, 2020), predicts that the maximum quantity predicted to beach would be 1.69 m^3 in the Autumn, with a probability of 4%, when decommissioning operations would be very unlikely to be taking place. The quantity likely to reach the shoreline would be low and dispersed and well dispersed by the time it arrives at the shoreline in East Anglia. It is therefore very unlikely that any impact would be felt by any sensitive receptors residing in close to the beach and in the nearshore waters.

5.5.5.3. Socioeconomic Receptors

Socioeconomic receptors may be impacted by a potential spill from the proposed decommissioning activities (Table 5-19).

Table 5-19 Summary of main socioeconomic receptors

Receptor	Impacts to socioeconomic receptors at risk in the Leman area
Fisheries	Fishing is one of the primary economic activities in the EU and it supports other shore-based activities including fish processing and boat construction. The impacts to offshore fishing are limited to the period that oil remains on the surface as access to fishing grounds would be limited. There is the potential for fish that come into contact with oil to become tainted precluding commercial sale. There is no UKCS evidence of any long-term effects of oil spills on offshore fisheries. The UK landings within the decommissioning area are negligible and therefore there not anticipated to be any impact.
Tourism	Coastal tourism can be adversely affected by oil pollution events owing to reduced amenity value. Impact can be further influenced by public perception and media coverage. Given to the offshore location of the Leman infrastructure (48 km offshore) and the anticipated spill trajectory, there is unlikely to be any impact on tourism.
Shipping	Shipping density in the decommissioning area is high due to the presence of fishing vessels, some ferries between the UK and the rest of Europe and cargo and offshore support vessels (BEIS, 2017; OGA, 2016). Shipping lanes are also used by shuttle tankers, supply and standby vessels serving the offshore oil installations in the area. Although all may potentially be impacted by an oil spill, the impacts likely last only while oil is on the sea surface, as this may restrict access. However, it is unlikely that there will be any long-term impacts on this industry.
Oil and gas	The oil and gas industry is well established in the North Sea. Although the receptors may potentially be impacted by an oil spill, the impacts would likely last only whilst there is oil on the sea surface, as this may restrict access to installations for instance However, it is unlikely that there will be any long-term impacts on this industry.

5.5.6. Cumulative and transboundary impacts

Impacts arising from the proposed decommissioning activities have the potential to act cumulatively other oil and gas activities. The Leman area is an extensively developed area, including both existing activities and new activities run in parallel with those of other human activities (e.g. fishing and marine transport of crude oil and refined products) (DTI, 2004).

Any diesel discharge as a result of a vessel collision would be expected to disperse rapidly in the immediate environment without the potential to combine with other discharges from concurrent incidents. It is difficult to predict whether the impacts from an oil spill to the marine ecology of the affected area would be cumulative. This would depend on previous disturbances or releases at specific locations. Cumulative effects of overlapping "footprints" for detectable contamination or biological effects are considered to be unlikely.

According to the oil spill modelling presented here, the probability for a diesel spill to cross to the UK/ Netherlands median line is highly unlikely (<12%). In the event of any oil slick crossing it the Maritime and Coastguard Agency (MCA) Counter Pollution and Response Branch has agreements with equivalent organisations in other North Sea coastal states, under the Bonn Agreement 1983.

5.5.7. Management and mitigation

Mitigation and management primarily focus on preventing or minimising the probability of an accidental spill and secondly, reducing the consequences of the event through optimum and efficient containment and release response. During decommissioning, minor non-routine and emergency events such as minor leaks, drips and spills from machinery and hoses on the platform, from vessels or at onshore sites, could cause a localised impact. The accidental release of small quantities of oil would be minimised as far as possible through appropriate management procedures and mitigation measures. The effects of such releases could be rectified quickly on site and they would be managed through vigilance, operational, inspection and emergency procedures, and specific safeguards such as on-site clean-up equipment and containment measures. For these reasons, such minor events have been excluded from this assessment as they will be managed under normal operational procedures and controls.

The Shell Leman OPEP (Shell, 2020) has been produced in accordance with the Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998; and the Guidance Notes for Preparing Oil Pollution Emergency Plans - For Offshore Oil and Gas Installations and Relevant Oil Handling Facilities (BEIS, 2019). The OPEP details responsibilities for initial response and longer-term management and will be updated as needed to reflect any change in operations and activities associated with decommissioning. There are three planned levels of response, depending on the size of the spill (Table 5-20) In the event of an accidental spill to sea beyond the 500 m zone, vessels will implement their Shipboard Oil Pollution Emergency Plan (SOPEP).

Table 5-20 Response strategy options for Leman Field system operations

Tier level	Response Strategy
Tier 1	• Monitor and Evaluate • Natural Dispersion or Enhanced Natural Dispersion
Tier 2	As Tier 1, plus: • Mobilisation of Onshore Emergency Response Team • Oil Spill Modelling • Potential re-tasking of infield resources to investigate • Aerial Surveillance
Tier 3	As Tier 1 and 2, plus: • Offshore Mechanical Containment and Recovery • Potential deployment of Cap and Shut-off device • Relief Well Drilling • Shoreline Protection and Shoreline Clean-up • Mobilisation of Shell's Global Response Support Network

5.5.8. Residual impacts

Spill modelling undertaken for the Shell Leman OPEP (Shell, 2020), predicts that the maximum quantity predicted to beach would be 1.69 m^3, with a probability of 4%, in the Autumn when decommissioning operations would be very unlikely to be taking place. The quantity likely to reach the shoreline would be low and dispersed and well dispersed by the time it arrives at the shoreline in East Anglia. It is therefore very unlikely that any impact would be felt by any sensitive receptors residing in close to the beach and in the nearshore waters. A diesel spill is very unlikely to impact any designated seabed features or conservation objectives of the North Norfolk Sandbank and Saturn Reef SAC, Southern North Sea, The Haisborough, Hammond and Winterton SAC or the Greater Wash SPA, which lie within the spill trajectory.

According to the oil spill modelling presented here, the probability for a diesel spill to cross to the UK/ Netherlands median line is highly unlikely (<12%) and there would be no transboundary beaching

Based on the modelling results and the Shell response capability for both counter pollution and containment, the mitigation measures and contingency plans in place to consider all foreseeable spill risks, this will ensure that the spill risk is reduced to ALARP.

6. Conclusions

EIA forms an integral part of the Shell ESHMP ensuring that adequate environmental considerations are incorporated into the DP for the Leman F and G decommissioning activities. This EA presents the findings of the EIA, providing sufficient information to enable a robust evaluation to be made of the potential environmental and socioeconomic consequences of the proposed decommissioning activities.

The Leman infrastructure is in a relatively sensitive area of the southern North Sea (Section 3). Most notably within the North Norfolk Sandbank and Saturn Reef SAC and Southern North Sea SAC, which are designated for the protection of Annex I habitats (sandbanks which are slightly covered by sea water all of the time and biogenic reefs formed by cold water corals) and Annex II species (harbour porpoise), respectively.

Following the identification of the interactions between the proposed Leman decommissioning activities and the local environment, the assessment of all potentially significant environmental and socioeconomic impacts, and key environmental concerns identified as requiring consideration for impact assessment (including those raised by stakeholders) were investigated in the following sections:

- Emissions to air (Section 5.1)
- Physical presence (seabed) (Section 5.2)
- Seabed disturbance (Section 5.3)
- Disturbance to nesting seabirds (Section 5.4)
- Accidental events (Section 5.5)

Mitigation to avoid and/or reduce the environmental concerns highlighted throughout this EA is in line with industry best practice. Shell has an established SHE management process (Section 2.7), which will ensure that proposed mitigation measures are implemented and monitored to achieve or better the outcome presented in this EA.

As part of the Leman F and G decommissioning, the NUIs, risers and spools will be fully removed. The main length of the pipelines and umbilicals will be decommissioned *in situ*. The pipeline and umbilical ends will also be cut and removed and as worst – case remediated using rock. Mattresses and grout bags will be fully removed where safe to do so, with the exception of those associated with the crossing and those protecting the umbilical whilst at full trench depth prior to the start of the trench transition. Where this is not possible, Shell will refer to OPRED to discuss the technical and/ or safety issues associated with these operations. Shell will ensure that, per industry guidance, the seabed will be left in a state which minimises any perceived risk to the environment or key stakeholders.

Shell is aware that a number of oil and gas fields/ installations in the southern North Sea are currently being decommissioned or are reaching the end of their operational life. As a consequence, the potential for additive or cumulative impacts within the southern North Sea will be increased in the short-term. Decommissioning activities may temporarily contribute to overall gaseous emissions in the SNS, but the impact of this is estimated to be negligible in context with total UKCS emissions associated with the oil and gas industry (Section 5.1). In February 2021, Shell announced our intention to be a net-zero emissions energy business by 2050. Shell's net zero emissions energy business ambitions are aligned with the UK Government's net zero targets and Shell is ready to be a strong delivery partner for the North Sea Transition Deal. In addition, Shell has also developed the Greenhouse Gas Reduction Action Plan, in line with NSTA net zero stewardship expectation 11, to provide an overview of the

GHG emissions and highlight plans to reduce these emissions, and are part of the Climate and Clean Air Coalition Oil & Gas Methane Partnership.

Of all sea users, commercial fisheries are most likely to be affected by the proposed decommissioning activities. Impacts to fisheries mainly arise from the potential for snagging generated by the decommissioning *in situ* of the Leman pipelines. Exposures and changes in burial have been historically present and variable in location and extent. Overall, while the average DOB of the pipelines is >0.6 m, the presence of highly active and mobile morphological features within the Leman area may generate continued exposures over time on a sub-decadal scale.

Despite the ongoing potential for exposures along the Leman pipelines, fishing intensity in the Leman field, and along the PL363 and PL364 pipelines, is very low therefore the opportunity of a snagging event occurring is negligible. While the consequence of a snagging event may be high, Shell's commitment to leaving the seabed in an overtrawlable condition, and to conduct pipeline monitoring, will ensure that the likelihood of snagging impacts on fisheries is minimised.

The proposed excavation, cutting, anchoring and item removal activities will physically disturb the sediment in the local area (Section 5.3). As a base-case, the seabed sediment disturbance will be temporary, localised and confined to an estimated area of, approximately, 0.045 km^2. This represents 0.001% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC (3,603 km^2; JNCC, 2017c) and 0.0001% of the total area of the Southern North Sea SAC (36,951 km^2; JNCC, 2017d). The decommissioning of the remaining pipeline and umbilical infrastructure *in situ* will minimise the disturbance to the environment and is very unlikely to impact on sandwave and sandbank morphology, the maintenance of which is a conservation objective for the North Norfolk Sandbanks and Saturn Reef SAC. Given the limited scale and temporary nature of the decommissioning operations, it is not expected that the long- term viability of the *S. spinulosa* or sandeel habitat conservation objectives will be compromised either. Given the dynamic seabed conditions, re-burial and recovery of the surface seabed and associated fauna is expected to take approximately one year.

Where rock protection is required for pipeline end protection, this may create some permanent, yet recoverable, disturbance of seabed sediments, over an estimated area of 0.0016 km^2, Given the minimal scale of the footprint, it is not expected that the structure of the sandbanks or the habitat of harbour porpoise prey will be affected. While the addition of rock will potentially impact *S. Spinulosa* reef (0.0012 km^2), this represents a small area in proportion to the area of current reef habitat with recovery expected to be rapid (less than 10 years). The slow release of the metals and plastics associated with the pipeline sand umbilicals is also expected to have a negligible impact on the local environment.

Overtrawl activities would lead to a wider impact on the seabed around the Leman F and G NUIs equating to 1.67 km^2, representing 0.046% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC and 0.0045% of the Southern North Sea SAC. Overtrawl would potentially impact 0.84 km^2 of reef or potential reef, which represents 0.15% of the 569.69 km^2 area of known *S. Spinulosa* (MPA Mapper; JNCC, 2023) in the SNS. In the unlikely scenario that these activities would be required, Shell would hold conversations with the NFFO and OPRED to discuss the best way to approach this while taking the environmental sensitivities of the area into account.

Other projects contributing to the cumulative impact within the North Norfolk Sandbanks and Saturn Reef SAC and Southern North Sea SAC include multiple oil and gas and renewable developments. In combination with the decommissioning activities outlined herein, an anticipated 0.6 km^2 is expected to be impacted. Overall, a cumulative 0.04% of the North Norfolk Sandbanks and Saturn Reef SAC and 0.0015% of the Southern North Sea SAC is thought to be affected by current and future developments.

The Leman F and G decommissioning activities may result in the disturbance/abandonment of nests if works or removal operations coincide with breeding periods of seabird species in UK waters. During all operations, disturbance or forced nest abandonment will be reduced to ALARP. The risk of either loss of nesting habitat or abandonment of eggs/ fledglings is sufficiently low and localised that the impact to the local population is considered temporary, highly localised and largely undetectable against natural variation. The consequence on seabird populations is ranked as negligible. However, the results of future nesting surveys will also be taken into consideration. Following considered remedial strategies and scheduling to avoid bird breeding periods where possible, the likelihood of occurrence is rare. This impact can only happen should any potential deterrence strategies fail.

The worst-case scenario for an accidental event in the Leman decommissioning area would result from a loss of diesel from an infield vessels. Shell have modelled this scenario and have concluded that a diesel spill would disperse and dilute quickly, with a very low probability reaching coastline or the Netherlands transboundary line in any significant quantity. A diesel spill is also very unlikely to impact any designated seabed features or conservation objectives of the North Norfolk Sandbank and Saturn Reef SAC, Southern North Sea, The Haisborough, Hammond and Winterton SAC or the Greater Wash SPA, which lie within the spill trajectory. The likelihood of a diesel spill occurring in the first instance is low and is very unlikely contribute to the overall spill risk in the area and the OPEP will provide the direction to effectively manage the spill in case of an accidental event.

Overall, decommissioning activities will have negligible impact on the qualifying features or conservation objectives of the North Norfolk Sandbank and Saturn Reef SAC and Southern North Sea SAC. Seabed disturbance may result in temporary changes to sandbanks, *S. spinulosa* reef and the supporting habitat of harbour porpoise, but disturbed areas will recover quickly due to the currents and tidal characteristics of the area. The recovery of benthic communities will be relatively rapid. Any permanent disturbance caused by the placement of rock will be minimal and will be carefully controlled to minimise impacts to sensitive receptors. The decommissioning of the Leman pipelines and umbilicals *in situ* will not only prevent a large area of temporary disturbance, it will also help to ensure the preservation of the *S. spinulosa* reef which is growing on and around them. Shell will ensure that monitoring surveys are in place (timeline to be discussed and agreed with OPRED) going forward to identify areas of exposure (based on morphological movement) and to observe the state of the *S. spinulosa* reef.

This EA has evaluated the environmental risk reduction measures and this document concludes that Shell have, or intend to, put in place sufficient safeguards to mitigate the potential environmental and societal risk and to monitor the implementation of these measures, a programme of which will be agreed with the Regulator.

This EA has also considered the relevant East Offshore Marine Plan, adopted by the UK Government to help ensure sustainable development of the marine area. Shell consider that the proposed decommissioning activities are in alignment with its objectives and policies.

The conclusion of this EA is that the recommended options presented for the decommissioning of the Leman F and G infrastructure can be completed without causing significant adverse impact to the environment.

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APPENDIX A SHELL'S HSSE & SP POLICY

SHELL COMMITMENT AND POLICY ON HEALTH, SECURITY, SAFETY, THE ENVIRONMENT AND SOCIAL PERFORMANCE

COMMITMENT

In Shell we are all committed to:

- Pursue the goal of no harm to people;
- Protect the environment;
- Use material and energy efficiently to provide our products and services;
- Respect our neighbours and contribute to the societies in which we operate;
- Develop energy resources, products and services consistent with these aims;
- Publicly report on our performance;
- Play a leading role in promoting best practice in our industries;
- Manage HSSE & SP matters as any other critical business activity; and
- Promote a culture in which all Shell employees share this commitment.

In this way we aim to have an HSSE & SP performance we can be proud of, to earn the confidence of customers, shareholders and society at large, to be a good neighbour and to contribute to sustainable development.

POLICY

Every Shell Company:

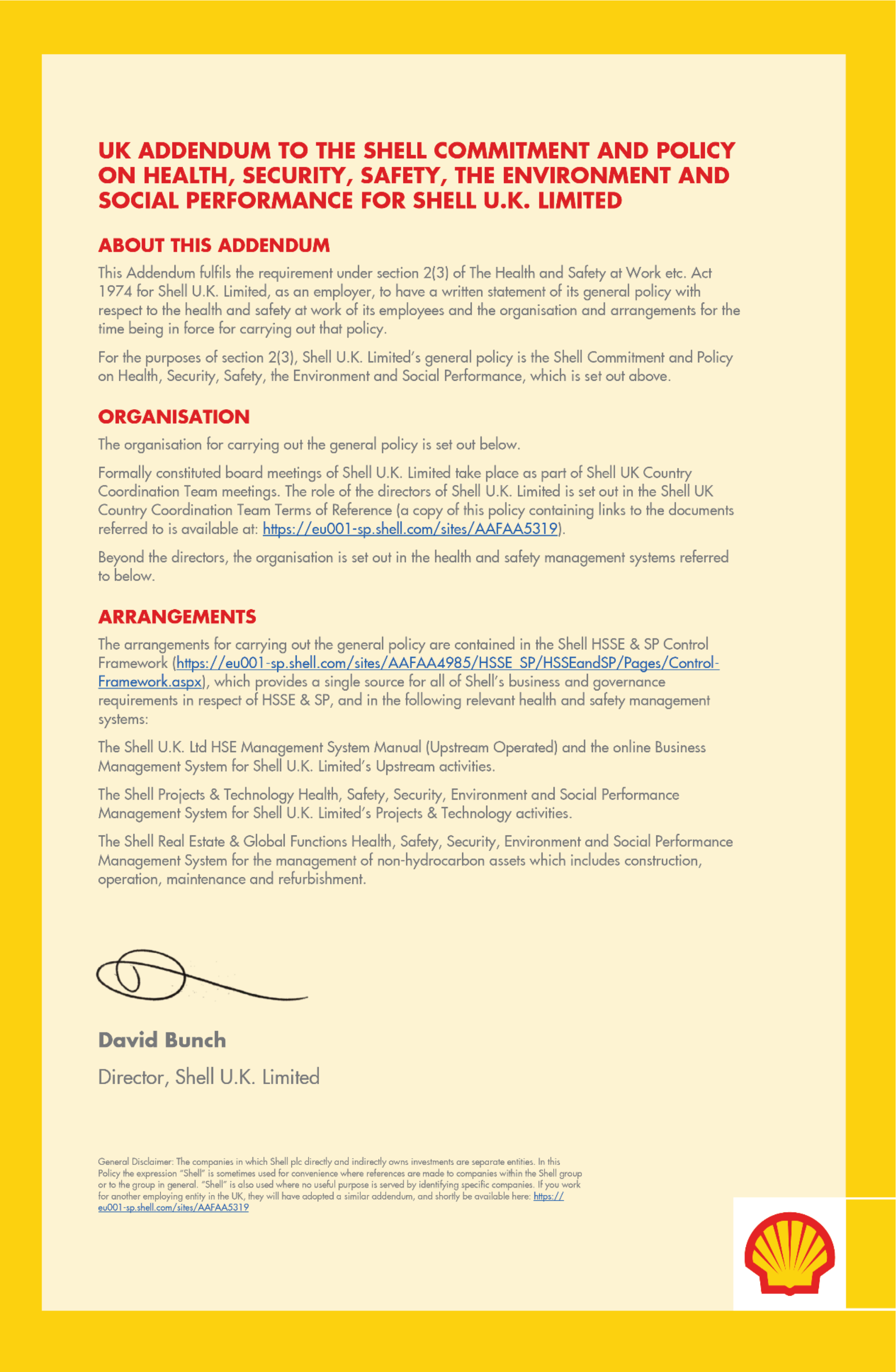
- Has a systematic approach to HSSE & SP management designed to ensure compliance with the law and to achieve continuous performance improvement;
- Sets targets for improvement and measures, appraises and reports performance;
- Requires contractors to manage HSSE & SP in line with this policy;
- Requires joint ventures under its operational control to apply this policy, and uses its influence to promote it in its other ventures;
- Engages effectively with neighbours and impacted communities; and
- Includes HSSE & SP performance in the appraisal of staff and rewards accordingly.

Ben van Beurden
Chief Executive Officer

David Bunch
UK Country Chair

Originally published in March 1997 and updated by the Executive Committee December 2009.

General Disclaimer: The companies in which Shell plc directly and indirectly owns investments are separate entities. In this Policy the expression "Shell" is sometimes used for convenience where references are made to companies within the Shell group or to the group in general. Likewise, the words "we", "us" and "our" are also used to refer to Shell companies in general or those who work for them. These expressions are also used where no useful purpose is served by identifying specific companies.



UK ADDENDUM TO THE SHELL COMMITMENT AND POLICY ON HEALTH, SECURITY, SAFETY, THE ENVIRONMENT AND SOCIAL PERFORMANCE FOR SHELL U.K. LIMITED

ABOUT THIS ADDENDUM

This Addendum fulfils the requirement under section 2(3) of The Health and Safety at Work etc. Act 1974 for Shell U.K. Limited, as an employer, to have a written statement of its general policy with respect to the health and safety at work of its employees and the organisation and arrangements for the time being in force for carrying out that policy.

For the purposes of section 2(3), Shell U.K. Limited's general policy is the Shell Commitment and Policy on Health, Security, Safety, the Environment and Social Performance, which is set out above.

ORGANISATION

The organisation for carrying out the general policy is set out below.

Formally constituted board meetings of Shell U.K. Limited take place as part of Shell UK Country Coordination Team meetings. The role of the directors of Shell U.K. Limited is set out in the Shell UK Country Coordination Team Terms of Reference (a copy of this policy containing links to the documents referred to is available at: https://eu001-sp.shell.com/sites/AAFAA5319).

Beyond the directors, the organisation is set out in the health and safety management systems referred to below.

ARRANGEMENTS

The arrangements for carrying out the general policy are contained in the Shell HSSE & SP Control Framework (https://eu001-sp.shell.com/sites/AAFAA4985/HSSE_SP/HSSEandSP/Pages/Control-Framework.aspx), which provides a single source for all of Shell's business and governance requirements in respect of HSSE & SP, and in the following relevant health and safety management systems:

The Shell U.K. Ltd HSE Management System Manual (Upstream Operated) and the online Business Management System for Shell U.K. Limited's Upstream activities.

The Shell Projects & Technology Health, Safety, Security, Environment and Social Performance Management System for Shell U.K. Limited's Projects & Technology activities.

The Shell Real Estate & Global Functions Health, Safety, Security, Environment and Social Performance Management System for the management of non-hydrocarbon assets which includes construction, operation, maintenance and refurbishment.

David Bunch

Director, Shell U.K. Limited

General Disclaimer: The companies in which Shell plc directly and indirectly owns investments are separate entities. In this Policy the expression "Shell" is sometimes used for convenience where references are made to companies within the Shell group or to the group in general. "Shell" is also used where no useful purpose is served by identifying specific companies. If you work for another employing entity in the UK, they will have adopted a similar addendum, and shortly be available here: https://eu001-sp.shell.com/sites/AAFAA5319

APPENDIX B ENVID TABLE – ASPECTS AND IMPACTS REGISTER

ACTIVITY	ENVIRONMENTAL ASPECT	RECEPTOR & Sensitivity ▨ Potential minor significance ■ Potential large significance □ No interaction															POTENTIAL IMPACTS / OBSERVATIONS	MITIGATION BUILT IN TO DESIGN	Magnitude (No, Slight, Minor, Moderate, Major, Massive)	Sensitivity (A: Low, B: Medium, C: High)	Impact Significance (No, Slight, Minor, Moderate, Major, Massive)	Likelihood (Unplanned; A, B, C, D, E)	Risk (Unplanned; No, Slight, Minor, Moderate, Major, Massive)	POTENTIAL ADDITIONAL MITIGATION	COMMENT / ACTIONS
		Environmental											Societal												
		Water quality	Seabed features/ profile/ sediments	Air Quality	Climate	Plankton	Fish and pelagic communities	Benthic fauna	Marine mammals	Seabirds	Protected areas/ sensitive habitats	Resource use	Navigation/ traffic and transport	Fisheries	Other industries	Onshore communities									
General Decommissioning Activities																									
Vessel activity	Emissions to air			▨	▨												Gaseous emissions to atmosphere cause increased degradation of local/regional air quality (NOx and particulates). Contributing to global warming (CO_2).	Minimise vessel movement Emissions in accordance with Air Quality Standards and within limits set under MARPOL.	Slight	Medium	Slight			Campaigning opportunities will be explored to minimize vessel usage. Emissions to be assessed with OGA SE 11 in mind	Scoped in due to potential cumulative impact from venting.
	Energy consumption			▨	▨							▨					Impact on climate change and reduction of resources of hydrocarbons.	Minimise vessel movement	Slight	Medium	Slight			Campaigning opportunities will be explored to minimize vessel usage. Energy use to be assessed with OGA SE 11 in mind	Scoped in due to potential cumulative impact from venting.
	Physical presence (sea surface)												▨	▨	▨		Disturbance to vessel operations offshore (e.g. fisheries and other maritime users)	Existing controls through positioning systems. Appropriate notifications to mariners will be issued and application will be submitted to update admiralty charts. 500m exclusion zone	Slight	Low	Slight			Stakeholder engagement and engagement with other users. Campaigning opportunities will be explored to minimize vessel usage.	Scoped out of further assessment

RECEPTOR & Sensitivity

▨ **Potential minor significance** ■ **Potential large significance** ☐ **No interaction**

ACTIVITY	ENVIRONMENTAL ASPECT	Environmental											Societal				POTENTIAL IMPACTS / OBSERVATIONS	MITIGATION BUILT IN TO DESIGN	Magnitude (No, Slight, Minor, Moderate, Major, Massive)	Sensitivity (A: Low, B: Medium, C: High)	Impact Significance (No, Slight, Minor, Moderate, Major, Massive)	Likelihood (Unplanned; A, B, C, D, E)	Risk (Unplanned; No, Slight, Minor, Moderate, Major, Massive)	POTENTIAL ADDITIONAL MITIGATION	COMMENT / ACTIONS
		Water quality	Seabed features/ profile/ sediments	Air Quality	Climate	Plankton	Fish and pelagic communities	Benthic fauna	Marine mammals	Seabirds	Protected areas/ sensitive habitats	Resource use	Navigation/ traffic and transport	Fisheries	Other industries	Onshore communities									
	Vessel noise and vibrations						▨		■	▨	■						Behavioural modifications to marine mammals and potentially fish. Area located within the Southern North Sea SAC which is designated for Harbour Porpoise.	Vessel noise will not have significant sound levels - unlikely to be far above ambient noise levels.	Slight	High	Minor			Campaigning opportunities will be explored to minimize vessel usage. Nesting bird surveys will be carried out prior to operation start.	Scoped out of further assessment
	Geophysical surveys noise and vibrations						▨		■		■						Behavioural modifications to marine mammals and potentially fish. Area located within the Southern North Sea SAC which is designated for Harbour Porpoise.	Noise impacts to marine species from use of seismic, sub-bottom profiler, and other survey equipment. JNCC (2017) Guidelines will be employed for mitigation of noise impacts to marine mammals for future survey work involving seismic survey equipment. Future permitting will cover post-decommissioning geophysical surveys.	Slight	High	Minor			Any surveys will require PETS marine survey license.	Scoped out of further assessment
Waste Management	Emissions to air			▨	▨											▨	Gaseous emissions to atmosphere cause increased degradation of local/regional air quality (NOx and particulates). Contributing to global warming (CO_2). Potential transboundary and cumulative impacts.	Contractor Duty of Care	Slight	Medium	Slight			Look for low carbon and energy efficient approaches to recycling and treatment. Emissions to be assessed with OGA SE 11 in mind	Scoped in due to potential cumulative impact from venting.

ACTIVITY	ENVIRONMENTAL ASPECT	RECEPTOR & Sensitivity ▧ Potential minor significance ■ Potential large significance □ No interaction															POTENTIAL IMPACTS / OBSERVATIONS	MITIGATION BUILT IN TO DESIGN	Magnitude (No, Slight, Minor, Moderate, Major, Massive)	Sensitivity (A: Low, B: Medium, C: High)	Impact Significance (No, Slight, Minor, Moderate, Major, Massive)	Likelihood (Unplanned; A, B, C, D, E)	Risk (Unplanned; No, Slight, Minor, Moderate, Major, Massive)	POTENTIAL ADDITIONAL MITIGATION	COMMENT / ACTIONS
		Environmental											Societal												
		Water quality	Seabed features/ profile/ sediments	Air Quality	Climate	Plankton	Fish and pelagic communities	Benthic fauna	Marine mammals	Seabirds	Protected areas/ sensitive habitats	Resource use	Navigation/ traffic and transport	Fisheries	Other industries	Onshore communities									
	Energy consumption			▧	▧							▧				▧	Impact on climate change and reduction of landfill resource. Products used for recycling.	Contractor Duty of Care	Slight	Medium	Slight			Look for low carbon and energy efficient approaches to recycling and treatment. Energy use to be assessed with OGA SE 11 in mind Waste Hierarchy will be followed and reuse/recycle will be incentivised.	Scoped in due to potential cumulative impact from venting.
	Waste materials											▧					Use of landfill and landfill resource take (non-hazardous); special disposal (hazardous)	Contractor Duty of Care . All waste will be dealt with and captured in a Waste Management Plan. There will be an accurate Waste inventory- tracking waste from cradle to grave. Use of licensed waste management contractors / sites.	Slight	Low	Slight			Waste Hierarchy will be contracted in and reuse/recycle will be incentivised.	Scoped out of further assessment
	Onshore impact															▧	Potential odours and noise onshore.	Contractor Duty of Care . Audit of dismantling/ disposal site. Use of licensed waste management contractors / sites	Slight	Low	Slight			Dismantling yard general good practice.	Scoped out of further assessment

ACTIVITY	ENVIRONMENTAL ASPECT	RECEPTOR & Sensitivity ▨ Potential minor significance ■ Potential large significance ☐ No interaction															POTENTIAL IMPACTS / OBSERVATIONS	MITIGATION BUILT IN TO DESIGN	Magnitude (No, Slight, Minor, Moderate, Major, Massive)	Sensitivity (A: Low, B: Medium, C: High)	Impact Significance (No, Slight, Minor, Moderate, Major, Massive)	Likelihood (Unplanned; A, B, C, D, E)	Risk (Unplanned; No, Slight, Minor, Moderate, Major, Massive)	POTENTIAL ADDITIONAL MITIGATION	COMMENT / ACTIONS
		Environmental											Societal												
		Water quality	Seabed features/ profile/ sediments	Air Quality	Climate	Plankton	Fish and pelagic communities	Benthic fauna	Marine mammals	Seabirds	Protected areas/ sensitive habitats	Resource use	Navigation/ traffic and transport	Fisheries	Other industries	Onshore communities									
Marine Growth	Waste management											▨				▨	Potential odours, discharges and noise onshore.	Contractor Duty of Care . Audit of dismantling/ disposal site. Use of licensed waste management contractors / sites	Slight	Low	Slight			Investigating potential alternatives to landfill.	Due to the size of the jackets and bathymetry of the area the volume of marine growth is estimated to be minimal. Scoped out of further assessment
Dismantling	Emissions to air			▨	▨												Gaseous emissions to atmosphere cause increased degradation of local/regional air quality (NOx and particulates). Contributing to global warming (CO_2). Potential cumulative impacts.	Contractor Duty of Care Use of licensed waste management contractors / sites	Slight	Medium	Slight			Emissions to be assessed with OGA SE 11 and engagement of the supply chain in mind	Scoped in due to potential cumulative impact from venting.
	Energy consumption			▨	▨							▨					Impact on climate change and reduction of resources of hydrocarbons.	Contractor Duty of Care Use of licensed waste management contractors / sites	Slight	Medium	Slight			Energy use to be assessed with OGA SE 11 and engagement of the supply chain in mind	Scoped in due to potential cumulative impact from venting.
	Onshore impact															▨	Potential odours and noise onshore.	Contractor Duty of Care . Audit of dismantling/ disposal site. Use of licensed waste management contractors / sites	Slight	Low	Slight			Dismantling yard general good practice.	Scoped out of further assessment

NUI Decommissioning Activities

ACTIVITY	ENVIRONMENTAL ASPECT	RECEPTOR & Sensitivity 🟦 Potential minor significance ■ Potential large significance ☐ No interaction															POTENTIAL IMPACTS / OBSERVATIONS	MITIGATION BUILT IN TO DESIGN	Magnitude (No, Slight, Minor, Moderate, Major, Massive)	Sensitivity (A: Low, B: Medium, C: High)	Impact Significance (No, Slight, Minor, Moderate, Major, Massive)	Likelihood (Unplanned; A, B, C, D, E)	Risk (Unplanned; No, Slight, Minor, Moderate, Major, Massive)	POTENTIAL ADDITIONAL MITIGATION	COMMENT / ACTIONS
		Environmental											Societal												
		Water quality	Seabed features/ profile/ sediments	Air Quality	Climate	Plankton	Fish and pelagic communities	Benthic fauna	Marine mammals	Seabirds	Protected areas/ sensitive habitats	Resource use	Navigation/ traffic and transport	Fisheries	Other industries	Onshore communities									
Venting and flaring during depressurisation	Emissions to air			🟦	🟦												Gaseous emissions to atmosphere cause increased degradation of local/regional air quality (NOx and particulates). Contributing to global warming (CO_2 & Methane). Potential transboundary and cumulative impacts.		Slight	Medium	Slight			Emissions to be assessed with OGA SE 11 in mind	Depressurisation will be at Alpha and ambient pressure left in the line may be vented and Foxtrot and/or Golf as part of pipeline flushing. Scoped in due to potential cumulative impact from venting.
Engineering down and cleaning (permitted)	Discharges to sea	🟦				🟦	🟦	🟦	🟦								Liquid discharge to sea - Water quality in immediate vicinity of discharge will be reduced slightly, but effects are usually minimised by rapid dilution in massive receiving body of water; planktonic organisms most vulnerable receptor. Potential NORM impacts.	Discharges will be applied for via the PETs permitting process. Good operating practices, vessel audit procedures and contractor management procedures will all be in place throughout.	Slight	Medium	Slight			Decommissioning activities in the Leman Area will take place after the cleaning and flushing of the NUIs. Any NORM waste will be handled according to Shell Local Rules.	Scoped out of further assessment

RECEPTOR & Sensitivity

░ **Potential minor significance** █ **Potential large significance** ☐ **No interaction**

ACTIVITY	ENVIRONMENTAL ASPECT	RECEPTOR & Sensitivity															POTENTIAL IMPACTS / OBSERVATIONS	MITIGATION BUILT IN TO DESIGN	Magnitude (No, Slight, Minor, Moderate, Major, Massive)	Sensitivity (A: Low, B: Medium, C: High)	Impact Significance (No, Slight, Minor, Moderate, Major, Massive)	Likelihood (Unplanned; A, B, C, D, E)	Risk (Unplanned; No, Slight, Minor, Moderate, Major, Massive)	POTENTIAL ADDITIONAL MITIGATION	COMMENT / ACTIONS
		Environmental											Societal												
		Water quality	Seabed features/ profile/ sediments	Air Quality	Climate	Plankton	Fish and pelagic communities	Benthic fauna	Marine mammals	Seabirds	Protected areas/ sensitive habitats	Resource use	Navigation/ traffic and transport	Fisheries	Other industries	Onshore communities									
NUI removal activities (dredging, cutting, overtrawl)	Seabed disturbance		█				█	█			█						Localised physical seabed disturbance resulting in community change. Recovery time and extent dependent on type of seabed and species present and location specific. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of resuspended particles. Potential for the use of grit during cutting activities. This material is inert and will be used in small quantities having a negligible impact on the surrounding seabed. Impact on North Norfolk and Saturn Reef SAC, particularly the area around Leman F and the pipeline between Leman F and AK, as this area is the remanent of the Saturn Reef.	No use of explosives. PETS permitting approval will be sought for any external disturbance to seabed.	Minor	High	Moderate			Minimise area of disturbance by using internal cutting methods where appropriate. Remediation will be used where necessary.	Ratings have been provided on the assumption of worst-case scenario of external dredging. To be scoped in for further assessment under seabed disturbance aspect
	Noise and vibration						█		█		█				░		Behavioural modifications to marine mammals and potentially fish. Area located within the Southern North Sea SAC which is designated for Harbour Porpoise. Population impacts due to cumulative impact or impacting a reproductively significant number of individuals or location.	Diamond wire cutting noise will not have significant sound levels. Cutting activities will be minimised and carried out in isolation where possible. No use of explosives	Slight	High	Minor			Cutting operations will be planned to ensure as minimal noise and vibration impact as possible.	Scoped out of further assessment

ACTIVITY	ENVIRONMENTAL ASPECT	RECEPTOR & Sensitivity ▨ Potential minor significance ■ Potential large significance □ No interaction															POTENTIAL IMPACTS / OBSERVATIONS	MITIGATION BUILT IN TO DESIGN	Magnitude (No, Slight, Minor, Moderate, Major, Massive)	Sensitivity (A: Low, B: Medium, C: High)	Impact Significance (No, Slight, Minor, Moderate, Major, Massive)	Likelihood (Unplanned; A, B, C, D, E)	Risk (Unplanned; No, Slight, Minor, Moderate, Major, Massive)	POTENTIAL ADDITIONAL MITIGATION	COMMENT / ACTIONS
		Environmental											Societal												
		Water quality	Seabed features/ profile/ sediments	Air Quality	Climate	Plankton	Fish and pelagic communities	Benthic fauna	Marine mammals	Seabirds	Protected areas/ sensitive habitats	Resource use	Navigation/ traffic and transport	Fisheries	Other industries	Onshore communities									
	Disturbance to nesting birds									■	■						Removal of NUIs may lead to the disturbance of nesting birds, protected under The Conservation of Offshore Marine Habitats and Species Regulations 2017	Follow JNCC guidance Lights below the horizontal plane (where appropriate from an H&S perspective)	Minor	Medium	Minor			Bird surveys as recommended by the JNCC, using an experienced ornithologist. Survey timing to align with breeding season for species in question. Following survey results, it can be decided whether a licence is required.	Scoped in to further assessment under OPRED advice
Pipeline Decommissioning Activities																									
Flushing and cleaning (permitted)	Discharges to sea	▨				▨	▨	▨	▨								Liquid discharge to sea - Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in massive receiving body of water; planktonic organisms most vulnerable receptor. Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments. Potential NORM impacts.	Diligent chemical selection will take potential environmental impact into consideration Appropriate environmental risk assessment through MAT / SAT system	Slight	Medium	Slight			Decommissioning activities in the Leman Area will take place after the cleaning and flushing of the NUIs. Any NORM waste will be handled according to Shell Local Rules.	Scoped out of further assessment
Pipeline cut and lift (pipeline sections and/ or ends)	Noise and vibrations						■		■		■				▨		Behavioural modifications to marine mammals and potentially fish. Area located within the Southern North Sea SAC which is designated for Harbour Porpoise. Population impacts due to cumulative impact or impacting a reproductively significant number of individuals or location.	Hydraulic shear (most likely scenario) cutting noise will not have significant sound levels. Cutting activities will be minimised and carried out in isolation where possible.	Slight	High	Minor			Cutting operations will be planned to ensure as minimal noise and vibration impact as possible.	Scoped out of further assessment

		RECEPTOR & Sensitivity ░ Potential minor significance ■ Potential large significance ☐ No interaction																							
		Environmental											Societal												
ACTIVITY	ENVIRONMENTAL ASPECT	Water quality	Seabed features/ profile/ sediments	Air Quality	Climate	Plankton	Fish and pelagic communities	Benthic fauna	Marine mammals	Seabirds	Protected areas/ sensitive habitats	Resource use	Navigation/ traffic and transport	Fisheries	Other industries	Onshore communities	POTENTIAL IMPACTS / OBSERVATIONS	MITIGATION BUILT IN TO DESIGN	Magnitude (No, Slight, Minor, Moderate, Major, Massive)	Sensitivity (A: Low, B: Medium, C: High)	Impact Significance (No, Slight, Minor, Moderate, Major, Massive)	Likelihood (Unplanned; A, B, C, D, E)	Risk (Unplanned; No, Slight, Minor, Moderate, Major, Massive)	POTENTIAL ADDITIONAL MITIGATION	COMMENT / ACTIONS
Pipeline removal: cut and lift, deburial	Seabed disturbance		■				■	■			■						Localised physical seabed disturbance during excavation resulting in community change. Recovery time and extent dependent on type of seabed and species present and location specific. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of resuspended particles. Impact on North Norfolk and Saturn Reef SAC, particularly the area around Leman F and the pipeline between Leman F and AK, as this area is the remanent of the Saturn Reef.	Minimise interaction with the seabed	Moderate	High	Major			Optimisation of methodology for removal.	To be scoped in for further assessment under seabed disturbance aspect

ACTIVITY	ENVIRONMENTAL ASPECT	RECEPTOR & Sensitivity ▨ Potential minor significance ■ Potential large significance □ No interaction															POTENTIAL IMPACTS / OBSERVATIONS	MITIGATION BUILT IN TO DESIGN	Magnitude (No, Slight, Minor, Moderate, Major, Massive)	Sensitivity (A: Low, B: Medium, C: High)	Impact Significance (No, Slight, Minor, Moderate, Major, Massive)	Likelihood (Unplanned; A, B, C, D, E)	Risk (Unplanned; No, Slight, Minor, Moderate, Major, Massive)	POTENTIAL ADDITIONAL MITIGATION	COMMENT / ACTIONS
		Environmental											Societal												
		Water quality	Seabed features/ profile/ sediments	Air Quality	Climate	Plankton	Fish and pelagic communities	Benthic fauna	Marine mammals	Seabirds	Protected areas/ sensitive habitats	Resource use	Navigation/ traffic and transport	Fisheries	Other industries	Onshore communities									
Mattress removal	Seabed disturbance		■				■	■			■						Localised physical seabed disturbance during excavation resulting in community change. Recovery time and extent dependent on type of seabed and species present and location specific. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of resuspended particles. Impact on North Norfolk and Saturn Reef SAC, particularly the area around Leman F and the pipeline between Leman F and AK, as this area is the remanent of the Saturn Reef.	Minimise interaction with the seabed	Minor	High	Moderate			Optimisation of methodology for removal.	To be scoped in for further assessment under seabed disturbance aspect
Decommissioning of pipelines and remediation *in situ*	Seabed Disturbance		■				■	■			■						Influence of sandbank and sandwave morphology Long term presence of pipeline(s). Impact on North Norfolk and Saturn Reef SAC, particularly the area around Leman F and the pipeline between Leman F and AK, as this area is the remanent of the Saturn Reef. Long term degradation of pipelines and cables if decommissioned *in situ*.	Eventual corrosion and collapse of structures. Continued monitoring and remediation will be undertaken where required. Continued monitoring for an agreed period and remediation if required, accurate mapping of decommissioned *in situ* location and state.	Minor	High	Moderate			Seabed morphology study Depth of Burial analysis Pipeline risk tool Reef analysis (in context with fishing activity and location of spans/ exposures)	To be scoped in for further assessment under seabed disturbance aspect

RECEPTOR & Sensitivity

▨ **Potential minor significance** ■ **Potential large significance** □ **No interaction**

ACTIVITY	ENVIRONMENTAL ASPECT	Environmental											Societal				POTENTIAL IMPACTS / OBSERVATIONS	MITIGATION BUILT IN TO DESIGN	Magnitude (No, Slight, Minor, Moderate, Major, Massive)	Sensitivity (A: Low, B: Medium, C: High)	Impact Significance (No, Slight, Minor, Moderate, Major, Massive)	Likelihood (Unplanned; A, B, C, D, E)	Risk (Unplanned; No, Slight, Minor, Moderate, Major, Massive)	POTENTIAL ADDITIONAL MITIGATION	COMMENT / ACTIONS
		Water quality	Seabed features/ profile/ sediments	Air Quality	Climate	Plankton	Fish and pelagic communities	Benthic fauna	Marine mammals	Seabirds	Protected areas/ sensitive habitats	Resource use	Navigation/ traffic and transport	Fisheries	Other industries	Onshore communities									
	Seabed disturbance: Rock Placement	□	■	□	□	□	■	■	□	□	■	□	□	□	□	□	Introduction of new substrate which may alter habitat architecture, influencing water movement, sediment accumulation and light conditions. 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 EA. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of resuspended particles.	Minimise introduction of new material where possible by re-using remediation currently on seabed. If required, the use of rockdump will be minimised where possible.	Moderate	High	Major			Use of flexible fall pipe vessel to maximise accuracy of rockdump (if required). Grade of rock used will be discussed with Stakeholders. Potential re-use of existing frond mattresses.	To be scoped in for further assessment under seabed disturbance aspect
Unplanned Events																									
Vessel collision	Accidental events	■	■	□	□	■	■	■	■	■	■	▨	■	■	■	■	Loss of containment Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments.	OPEP Navaids SOPEP CIP Project Vessels present when activity taking place within 500m safety exclusion zone(s).	Moderate	High	Major	B	Moderate		To be scoped in for further assessment under accidental events aspect

RECEPTOR & Sensitivity

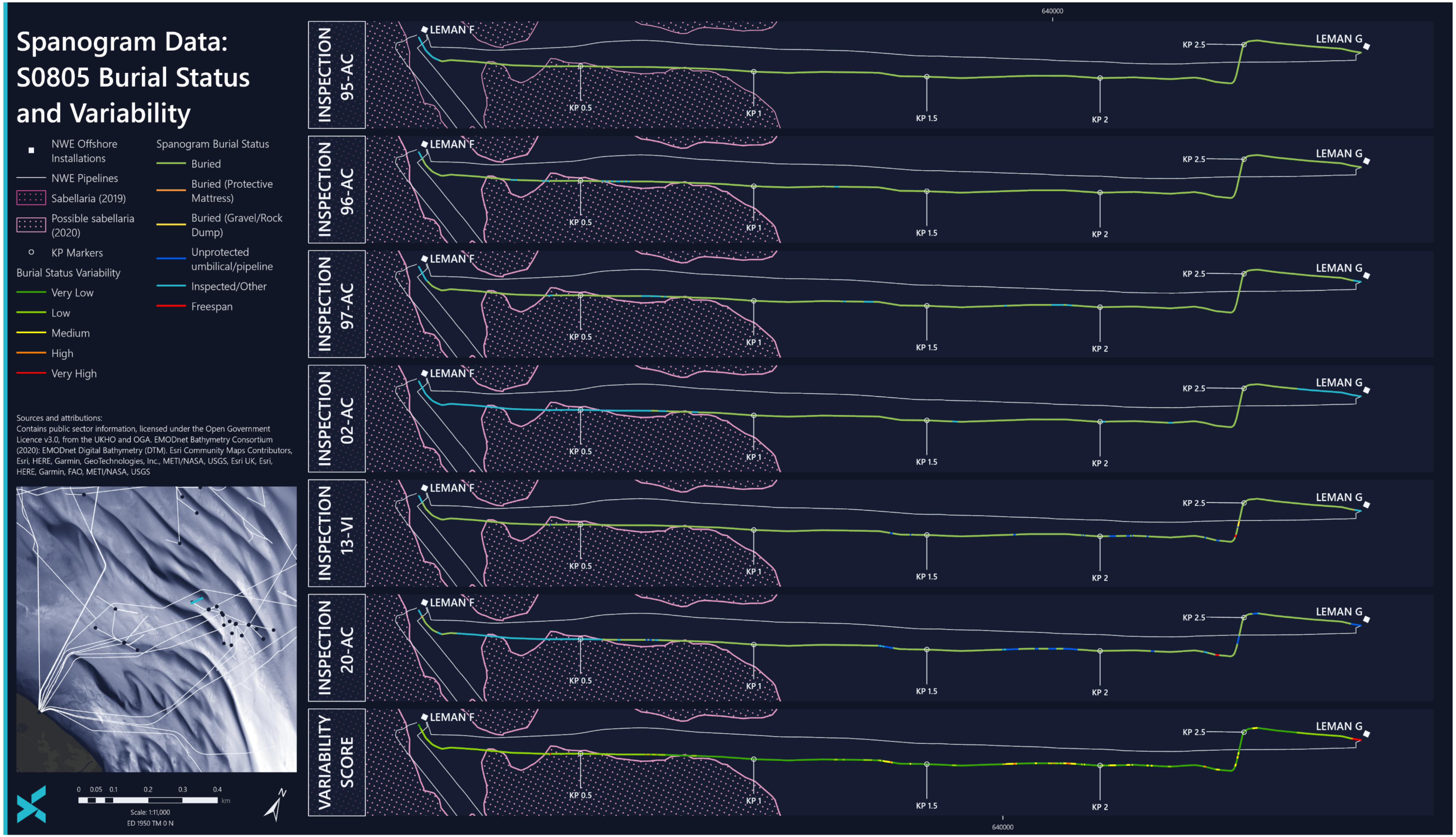
▨ **Potential minor significance** ■ **Potential large significance** ☐ **No interaction**

ACTIVITY	ENVIRONMENTAL ASPECT	Environmental										Societal				POTENTIAL IMPACTS / OBSERVATIONS	MITIGATION BUILT IN TO DESIGN	Magnitude (No, Slight, Minor, Moderate, Major, Massive)	Sensitivity (A: Low, B: Medium, C: High)	Impact Significance (No, Slight, Minor, Moderate, Major, Massive)	Likelihood (Unplanned; A, B, C, D, E)	Risk (Unplanned; No, Slight, Minor, Moderate, Major, Massive)	POTENTIAL ADDITIONAL MITIGATION	COMMENT / ACTIONS
		Water quality	Seabed features/ profile/ sediments	Air Quality	Climate	Plankton	Fish and pelagic communities	Benthic fauna	Marine mammals	Seabirds	Protected areas/ sensitive habitats	Resource use	Navigation/ traffic and transport	Fisheries	Other industries	Onshore communities									
Dropped objects	Accidental events		■				■	■			■		■	■			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 EA. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of resuspended particles. Impact on North Norfolk and Saturn Reef SAC, particularly the area around Leman F and the pipeline between Leman F and AK, as this area is the remanent of the Saturn Reef.	PON2 notification will be submitted in the unlikely event of a dropped object Everything will be endeavoured to be retrieved. All unplanned losses in the marine environment will be attempted to be remediated, and notifications to other mariners will be sent out. Debris clearance surveys will aid in the identification of any dropped objects.	Minor	High	Moderate	A	Minor		No 'Live' infrastructure that may be damaged by any dropped objects. Dropped objects on 'live' pipelines during transit of infrastructure has not been assessed. To be scoped out of further assessment
Snagging Risk	Accidental events		■				■	■			■		■	■			Stakeholder concern PLL	FishSAFE Kingfisher Admiralty Charts Etc…	Major	High	Major	B	Moderate		To be scoped in for further assessment under accidental events aspect

APPENDIX C EMISSIONS FACTORS AND SOURCES

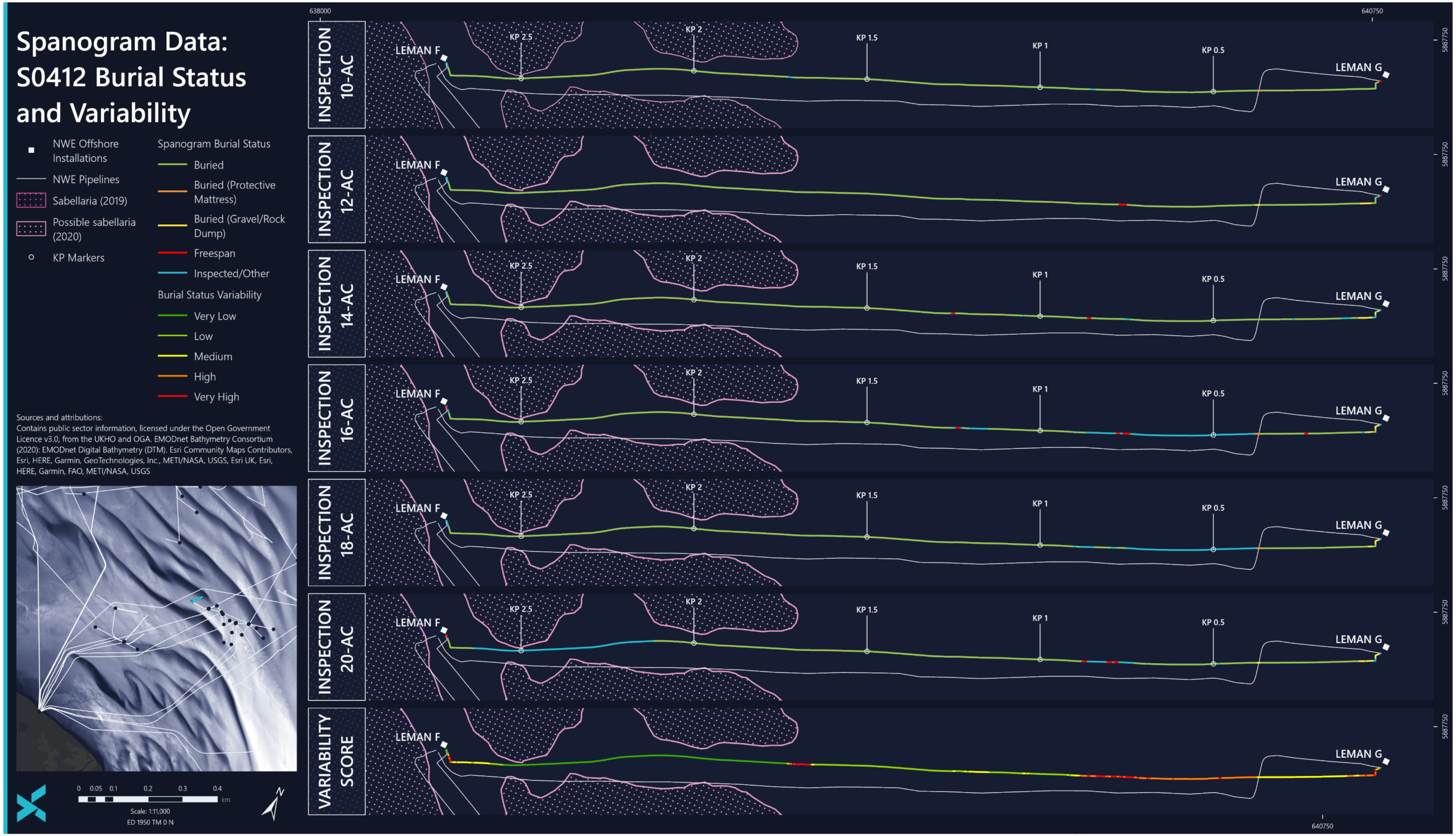
Emissions factors (kg/Te)		CO_2	N_2O	CH_4	CO	VOC	NOx	SO_2	Source data
Marine diesel		3.17	0.00022	0.00018	0.0157	0.0024	0.059	0.000013	**IoP (2000) and EEMS (2008)**
Diesel (Articulated HGV)		0.67	0.05	0.00000032	0.3	0.027	0.6	0.003	**NAEI (2022)**
Recycling	**Steel**	0.96	ND	ND	ND	ND	0.0016	0.0038	**IoP (2000)**
	Non-ferrous (Aluminium)	1.08	ND	ND	ND	ND	0.0013	0.017	**IoP (2000)**
New Manufacture	**Steel**	1.89	ND	ND	ND	ND	0.0035	0.0055	**IoP (2000)**
	Non-ferrous (Aluminium)	3.59	ND	ND	ND	ND	0.0041	0.025	**IoP (2000)**
	Concrete	0.88	ND	ND	ND	ND	0.0054	0.0001	**IoP (2000)**
	Plastics	3.18	ND	ND	ND	ND	ND	ND	**IoP (2000)**
Venting		ND	ND	**0.9**	ND	**0.1**	ND	ND	**EEMS (2008)**

APPENDIX D SPANOGRAMS: PIPELINE ANC CABLE EXPOSURE VARIABILITY (2010 – 2020)



Sources and attributions:
Contains public sector information, licensed under the Open Government Licence v3.0, from the UKHO and OGA. EMODnet Bathymetry Consortium (2020): EMODnet Digital Bathymetry (DTM). Esri Community Maps Contributors, Esri, HERE, Garmin, GeoTechnologies, Inc., METI/NASA, USGS, Esri UK, Esri, HERE, Garmin, FAO, METI/NASA, USGS

FigureC 1 Spanogram for pipeline exposure surveys (2010 – 2020) in context with reef: Cable PL5147



Sources and attributions:
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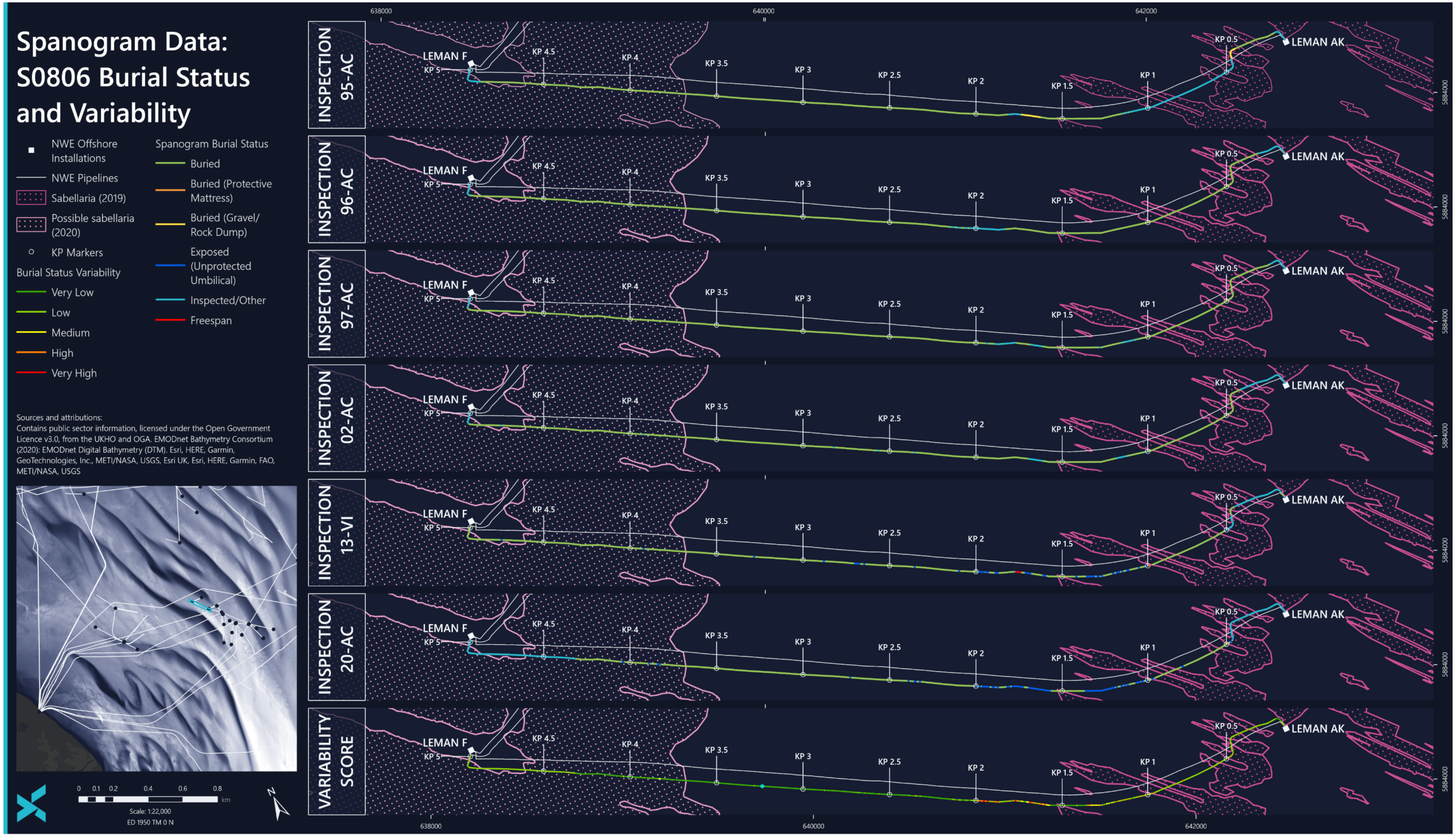
Figure C 2 Spanogram for pipeline exposure surveys (2010 – 2020) in context with reef: Pipeline PL364



Sources and attributions:
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Figure C 3 Spanogram for pipeline exposure surveys (2010 – 2020) in context with reef: Cable PL5148

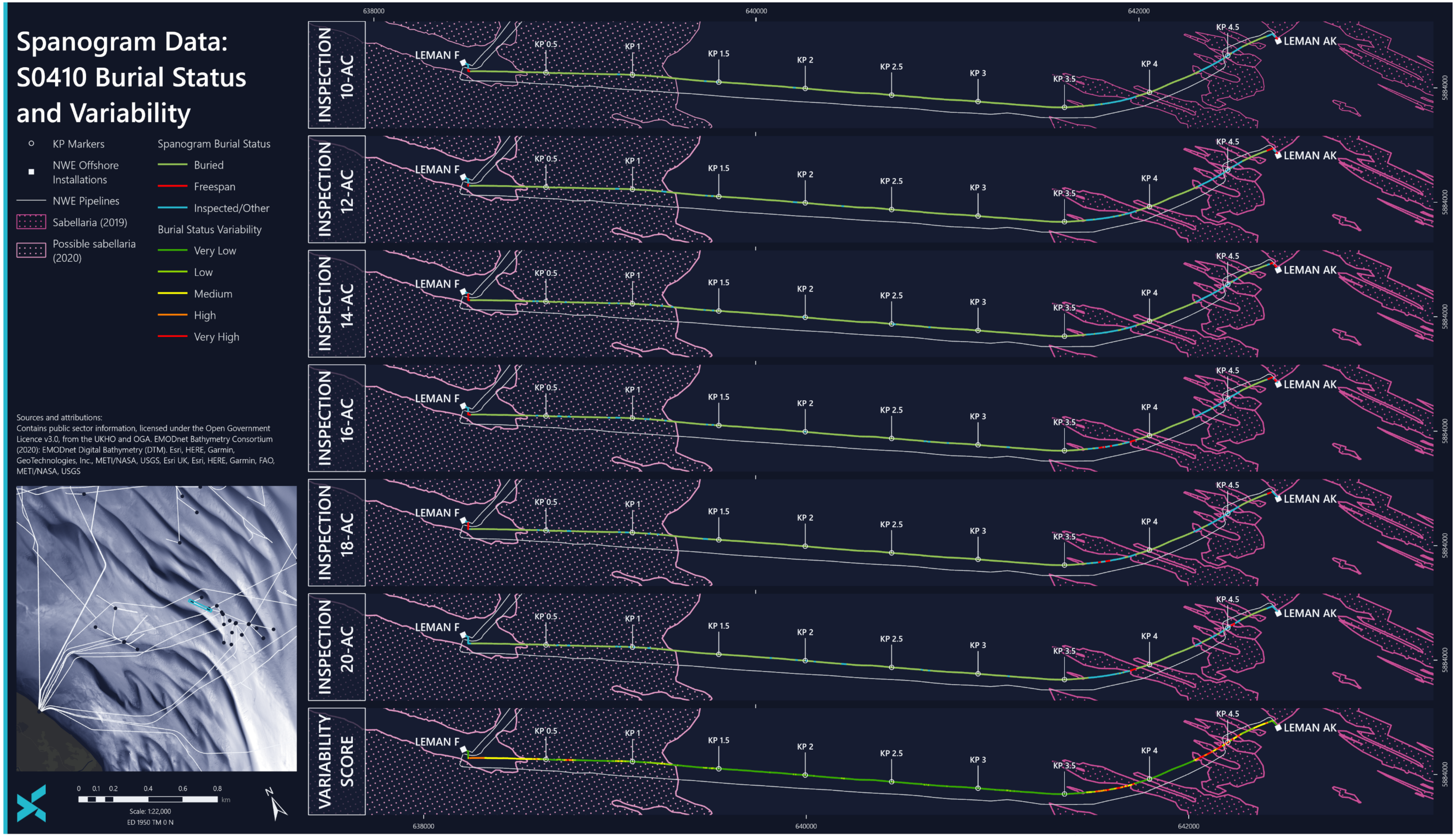

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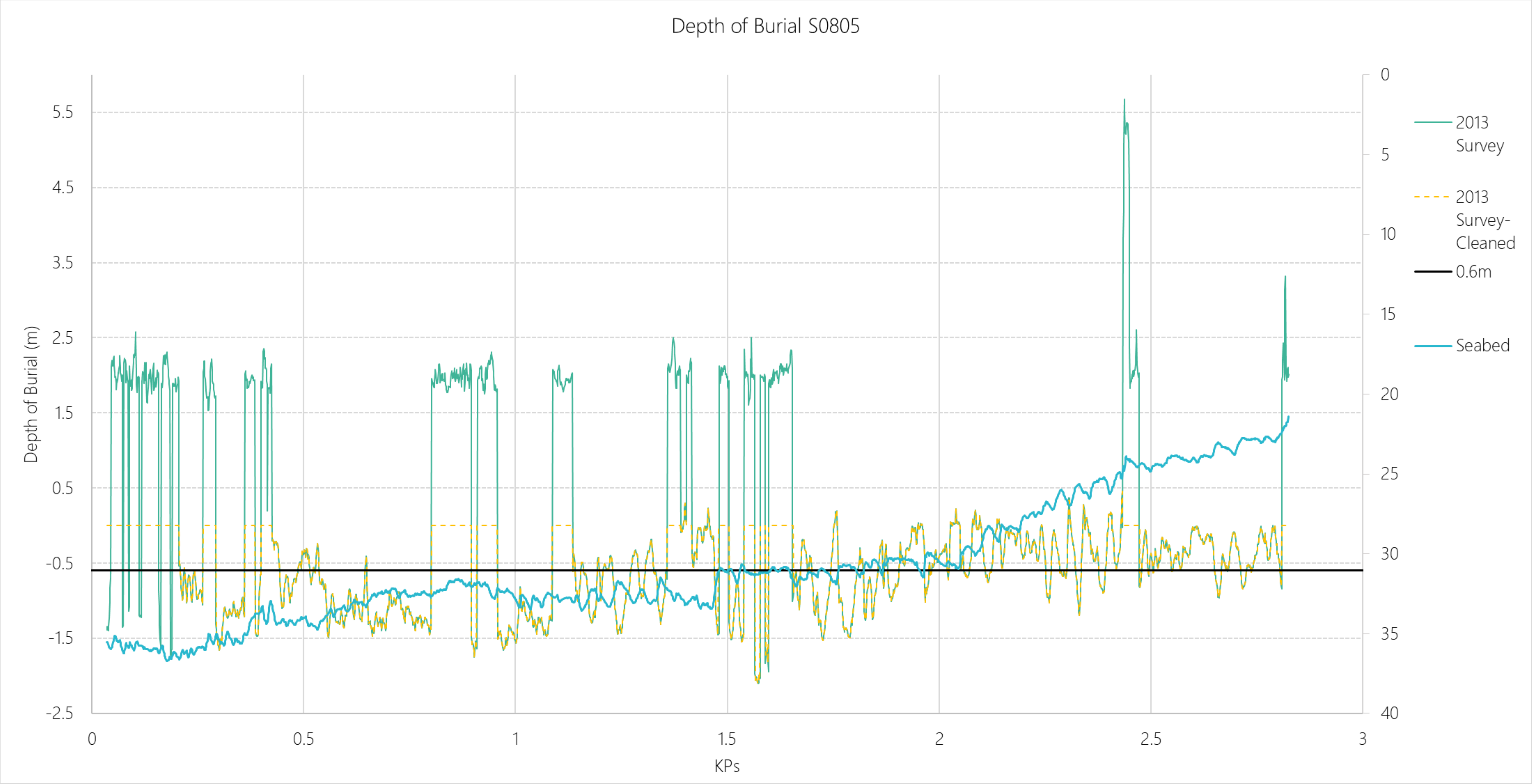
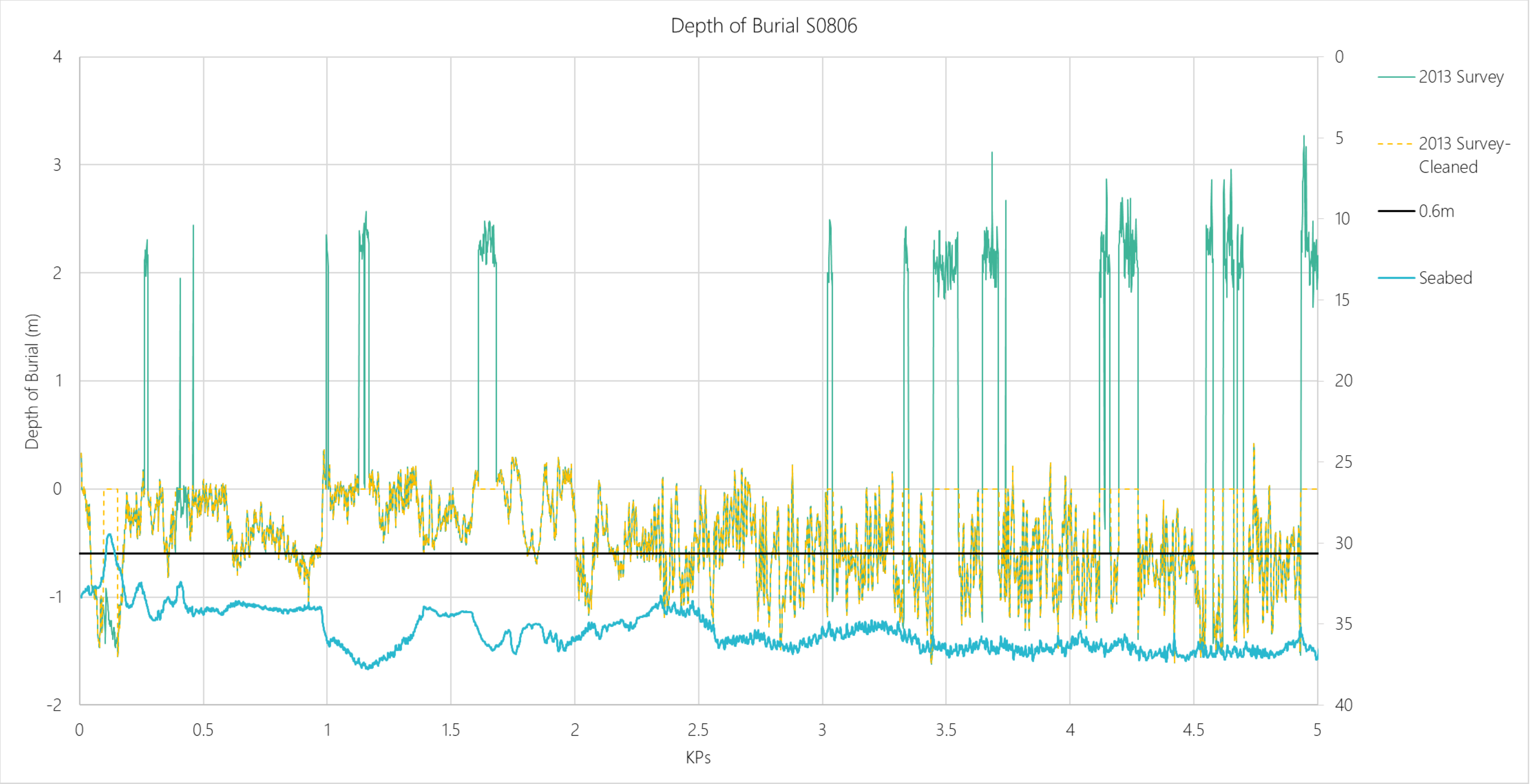
Figure C 4 Spanogram for pipeline exposure surveys (2010 – 2020) in context with reef: Pipeline PL363

APPENDIX E DEPTH OF BURIAL PROFILES

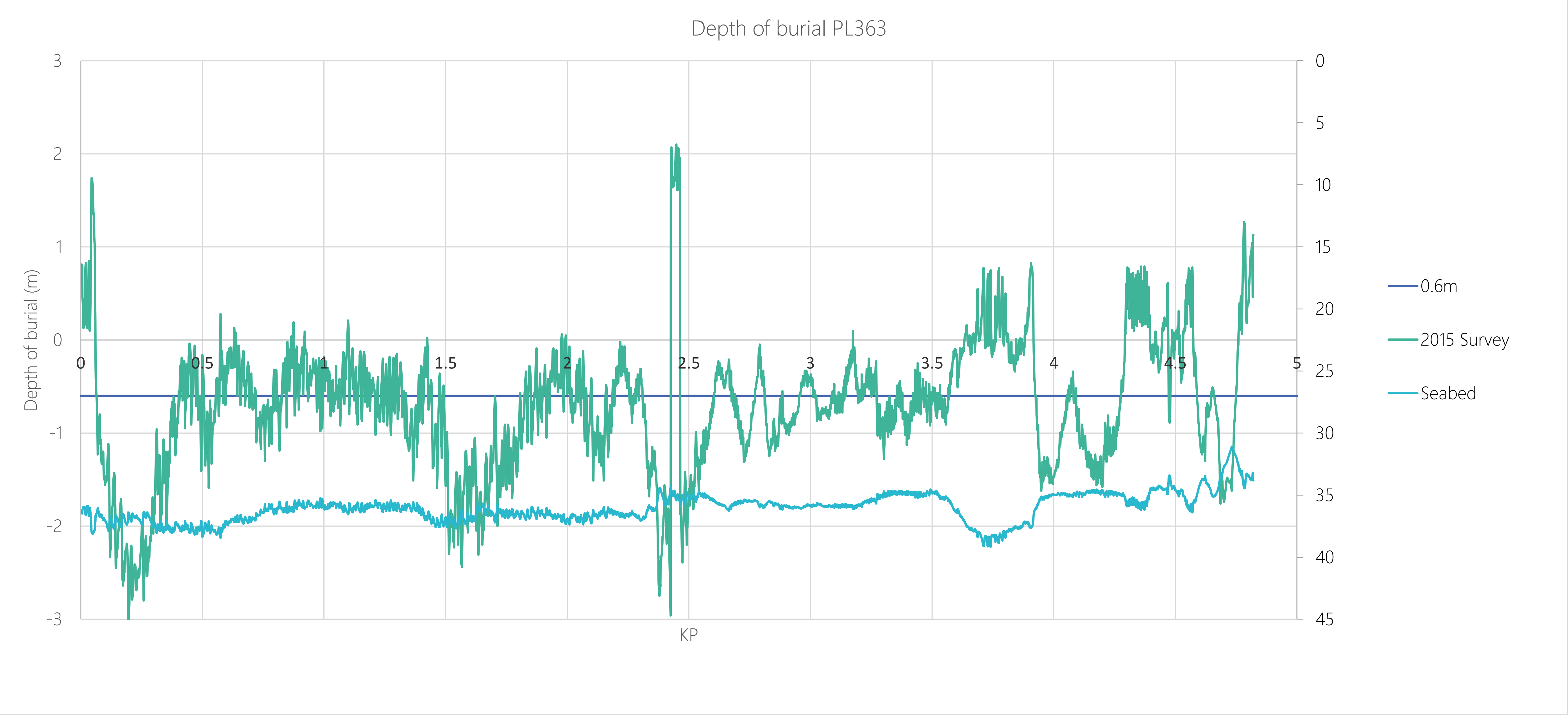


Note: PL5147: Xodus (2022a) cable removal study identified erroneous data in the records provided and have corrected this accordingly. The updated depth of burial plot is shown in yellow


Depth of burial PL364
Depth of burial (m)
3
2
1
0
-1
-2
-3
0
0.5
1
1.5
2
2.5
KP
0
5
10
15
20
25
30
35
40
2015 survey
0.6m
2015 Seabed



Note: PL5148 : Xodus (2022a) cable removal study identified erroneous data in the records provided and have corrected this accordingly. The updated depth of burial plot is shown in yellow


Depth of burial PL363
Depth of burial (m)
3
2
1
0
-1
-2
-3
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
KP
0
5
10
15
20
25
30
35
40
45
0.6m
2015 Survey
Seabed