Preliminary Environmental Information Report Volume 2

Appendix 20.1 Atlantic Herring and Sandeel Habitat Study

LLK1-CEA-REP-ENV-000003_AP1

Revision 0.0

October 2025

Contents

1 Introduction

1.1 Purpose of the report

1.1.1 This report has been prepared during the pre-application stage in parallel with the Preliminary Environmental Information Report (PEIR) and is an appendix to **Chapter 20 Fish and Shellfish** and should be read alongside this chapter.

1.1.2 The purpose of the report is to support the Environmental Impact Assessment (EIA) process by establishing, based on literature review and analysis of site specific marine survey data, the suitability of sediments to support sandeel sp. (Ammodytidae) and to act as spawning habitat for Atlantic herring (*Clupea Dharengus*) within the Draft Order Limits of the Proposed Offshore Scheme. It has been used to inform the description of the baseline allowing the Applicant to make informed decisions regarding significance of effects and potential mitigation.

1.1.3 Sandeel and Atlantic herring are deemed to be vulnerable to activities which cause seabed disturbance as they require certain habitat conditions for spawning, nursery grounds and, in the case of sandeel, seabed burial (Ref 1). In addition, the species are of regional importance because of their role as a key prey species for birds, fish and marine mammals. In addition, sandeel have been identified by the UK Government as critical in enabling resilience and recovery in seabirds from outbreaks of avian influenza (Ref 2).

1.1.4 The scope of the technical study is from mean high-water springs (MHWS) at the proposed Landfall Site (Walberswick, Lincolnshire) to the limit of the UK Exclusive Economic Zone (EEZ) (the extent of the Proposed Offshore Scheme).

1.1.5 This report should be read in conjunction with **Chapter 2 Description of the Proposed Scheme** of this PEIR.

1.1.6 Kilometre points (KP) have been used as a frame of reference to discuss sections of the Proposed Offshore Scheme. Kilometre points begin at KP0 at the MHWS of the proposed Landfall and extending to KP 180 where the Draft order Limits reaches the limits of the UK EEZ border with the Netherlands. The 12 nautical mile (NM) limit falls between KP31 and KP32.

1.2 Report structure

1.2.1 This report is divided into four sections:

a. **Section 2** provides the data sources and limitations used in the assessment;
b. **Section 3** and **Section 4** describe the assessments for sandeel and Atlantic herring respectively and are subdivided as follows:
   i. Overview
   ii. Baseline

iii. Life cycle
iv. Habitat preference
v. Existing habitat

c. **Section 5** presents the conclusions of the study.

2 Data sources and limitations

2.1 Publicly available data

2.1.1 The sandeel and Atlantic herring habitat study presented has made use of publicly available GIS data (**Table 2.1**) and literature reviews which are referenced throughout.

Table 2.1: Primary GIS data sources

Data type	Application	Reference
Atlantic herring larvae data	The International Herring Larval Survey (IHLS) carried out in the International Council for the Exploration of the Sea (ICES) areas indicate the distribution of Atlantic herring larvae recorded during past surveys (2007 – 2017) to provide an indication of potential areas of investigation.	ICES (Ref 3)
Atlantic herring and sandeel spawning and nursery grounds	Provide indicative areas where Atlantic herring and sandeel may spawn or which may be used as nursery areas. Starting point for area of search.	Coull *et al.* (Ref 4)
Marine Scotland lesser sandeel (*Ammodytes marinus*) species distribution model	Marine Scotland developed distribution models to predict the occurrence and density of sandeels in the Scottish North Sea (extending into English waters and Celtic Sea) based on predictions of the probability of presence of suitable habitat for sandeel to bury. It should be noted that the model does not extend over the entire Proposed Offshore Scheme but does incorporate KP50 – KP170, the results of which have been discussed as part of this report.	Langton *et al.* (Ref 5)
Seabed sediments	Data from EMODnet (2019) has been used to determine areas of potentially suitable seabed habitat for Atlantic herring and sandeel spawning, use as nursery grounds or, in the case of sandeel, for burial. This data has been used in conjunction with datasets such as spawning and nursery grounds from previous surveys.	EMODnet (Ref 6)
Bathymetry and geomorphology	Data from EMODnet used in conjunction with seabed sediment data to identify any areas which may be preferable for Atlantic herring and/or sandeel based on water depth.	EMODnet (Ref 7)
Seafloor temperature	Environmental data used in conjunction with species distribution models and seabed sediment data to identify areas which may be preferable for Atlantic herring and/or sandeel based on seafloor temperature.	Lewis et al. (Ref 8); Tonani et al. (Ref 9); Crocker et al. (Ref 10); Bruciaferri et al. (Ref 11)

Data type	Application	Reference
Seafloor dissolved oxygen	Environmental data used in conjunction with species distribution models and seabed sediment data to identify areas which may be preferable for Atlantic herring and/or sandeel based on seafloor dissolved oxygen concentrations.	EMODnet (Ref 12)

2.2 Project specific survey data

2.2.1 Marine characterisation surveys consisting of geophysical, geotechnical and environmental survey techniques were undertaken by Next Geo Solutions on a nominal 500m wide corridor between May 2024 and February 2025. The area of seabed surveyed by the marine characterisation survey has been taken forward as the extent of the Draft Order Limits. Survey scopes were agreed with Cefas, JNCC and Natural England prior to commencing work. The dates for survey campaigns are provided in **Table 2.2.**

Table 2.2: Marine survey dates

Survey	Date
Geophysical – nearshore	20/05/2024 – 29/05/2024 (onboard *Shore Presence*)
Geophysical – offshore	19/05/2024 – 10/06/2024 (Ievoli Amber and Ievoli Cobalt)
Environmental Baseline and Habitat Assessment – nearshore	31/01/2025 – 04/02/2025 (onboard *Isle of Jura*)
Environmental Baseline and Habitat Assessment - offshore	03/09/2024 -21/09/2024 (onboard *Ievoli Grey*)

2.2.2 Environmental baseline stations were positioned based on a sampling strategy agreed with Cefas, Natural England and JNCC. Exact positions were refined based on review of geophysical data to ensure that stations were positioned on sediment representative of the area. Sampling frequency was increased in areas where sandeel or herring was thought to occur (based on review of publicly available spawning ground maps from Coull et al. (Ref 4) and Ellis et al (Ref 37). In these areas sample station spacing was reduced from 5km to every 2.5km.

2.2.3 The surveys were undertaken by Next Geo Solutions. The environmental data acquisition sampling was carried out in accordance with the JNCC marine monitoring handbook, relevant procedural guidelines and sidescan sonar / multibeam echosounder data review (Davies (Ref 63); Turner et al., (Ref 64) and Coggan et al., (Ref 65)).

2.2.4 A total of 84 grab stations were completed during the survey, which were processed for particle size analysis. Please refer to **Appendix 19.1 Benthic Survey Report** of this PEIR for further details of the survey.

2.2.5 This report has used particle size data from the environmental baseline stations and the specific herring and sandeel spawning stations to inform the assessment.

2.3 Data limitations

2.3.1 The desktop study is limited by the age of certain datasets, in particular the Coull et al. (Ref 4) spawning and nursery grounds data. There is a risk that the age of this dataset is such that there is lower confidence in the accuracy of the data, necessitating a more precautionary approach by consenting bodies and statutory nature conservation bodies (SNCBs) such as the Centre for Environment, Fisheries and Aquaculture Science (Cefas) and Marine Management Organisation in their advice and decision making. The use of site-specific data to ground-truth the literature review assists in providing higher confidence in the conclusions made.

2.3.2 The ICES collect fish egg and larvae data (Ref 3) and publish International Bottom Trawl Survey (IBTS) data within the Database of Trawl Surveys (DATRAS) database (Ref 41). The limitations of the method of bottom trawl surveys to adequately target some species (i.e., clupeids, sandeels) is widely recognised, particularly for sandeel (Ref 28). Alternative methods of surveying for sandeels including acoustic, dredge and grab/core sample surveys can also be used (Ref 17; Ref 40).

2.3.3 Survey effort for the IHLS surveys has shifted away from the Downs spawning grounds since 2017 and so herring larvae would be under-represented in data collected since 2017 and would not be comparable to earlier data to enable analysis of the period 2014-2024 (Ref 58). Therefore, the data studied for this report covers the period 2007 – 2017. This is in line with the methodology proposed in Kyle-Henney et al., (Ref 58).

3 Sandeel Assessment

3.1 Overview

3.1.1 Raitt's sandeel *(Ammodytes marinus)* is listed as a Species of Principal Importance under Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006 (formerly a UK Biodiversity Action Plan (BAP) priority marine species) meaning that they are of principal importance for the purpose of conserving or enhancing biodiversity (Ref 14; Ref 15). Specifically sandeel require conservation due to their ecological importance as a prey species and their marked decline within the UK (a decline of 50% or more over the past 25 years or deterioration or loss of habitat) (Ref 13).

3.1.2 Sandeel are widely recognised as a critical food source for many seabirds, fish and marine mammals (Ref 16; Ref 17; Ref 18; Ref 19) and have been identified as the most important forage fish in the North Sea (Ref 20;Ref 21). A reduction in the availability of sandeel can lead to increased mortality in harbour porpoise (*Phocoena phocoena*), reduced reproductive performance in seabirds and reduction in animals' condition (Ref 21). Sandeel have historically been intensively fished for oils and animal feed, with stocks in the North Sea landed at levels of over 1 million tonnes in the late 1990s (Ref 21), however more recent management regimes have reduced this. The UK government has restricted sandeel fishing since 2019 in an effort to increase stocks and benefit the wider ecosystem (Ref 22); UK fishers are not allowed to catch or swap any of the pre-agreed quota for sandeel fishing in the North Sea, which totals 5,773 tonnes annually (Ref 18). Following a public consultation led by Defra in 2023, the UK Government has made the decision to permanently prohibit the fishing of sandeel within English waters of ICES Area 4 (North Sea) (Ref 2). This measure came into force on 26 March 2024 and applies to vessels of all size and nationality. A primary motivation for the closure of the sandeel fishery is to support seabirds amidst the ongoing avian flu outbreak and improve their resilience and overall health, with the hope that population recovery will be facilitated as a result.

3.1.3 In recognition of the importance of sandeel, it is important that the Applicant identifies the potential key areas for spawning and nursery habitat across the Proposed Offshore Scheme. This is to ensure that a sufficient level of data is obtained to inform environmental impact assessment and understand the potential for any seasonal constraints to the construction, operation & maintenance and decommissioning phases of the Proposed Offshore Scheme. Particle size distribution (PSD) data was collected as part of the benthic ecology characterisation survey and was used to inform the location of potential sandeel habitats across the Proposed Offshore Scheme. PSD data provides information on sediment characteristics that influence habitat suitability for sandeels. This data, combined with other physical and hydrodynamic properties of an area, is

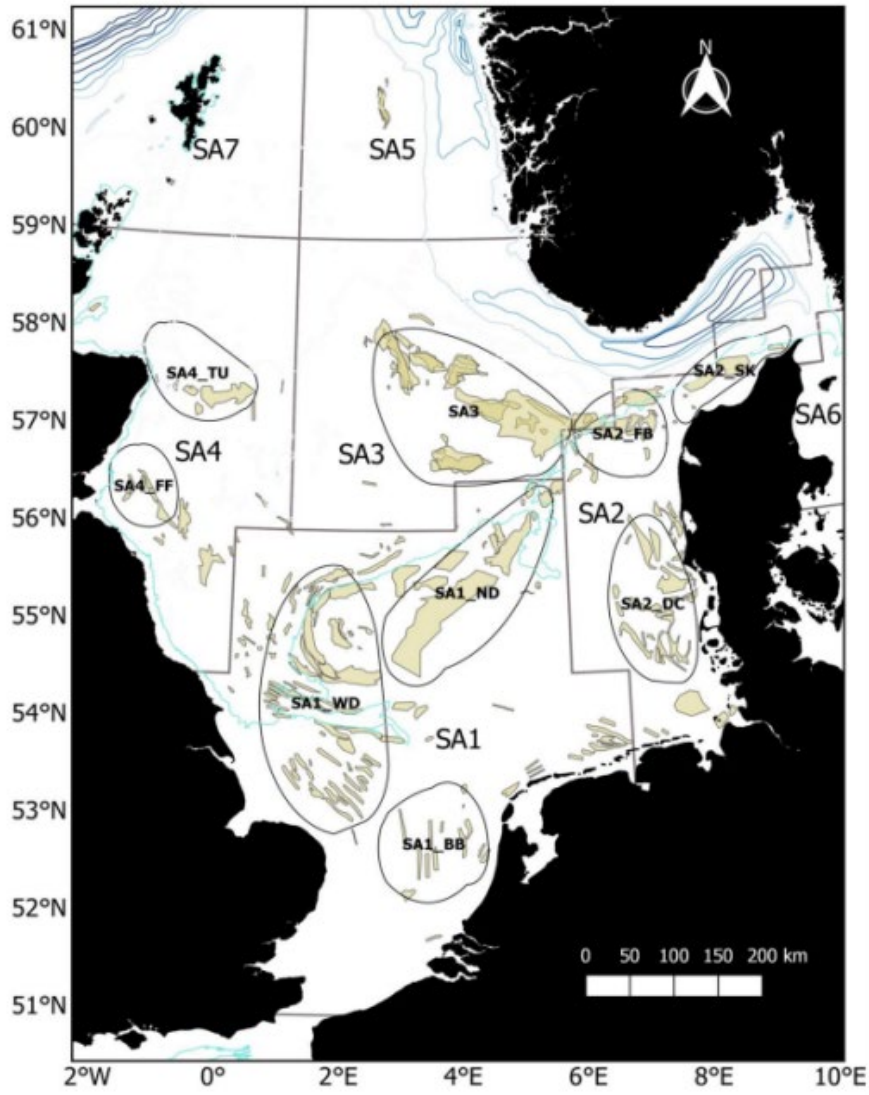
used to assess whether the environment is suitable for supporting sandeel populations.

3.2 Baseline

3.2.1 There are three predominant sandeel species which inhabit the North Sea: greater sandeel (*Hyperoplus lanceolatus*), lesser sandeel (*Ammodytes tobianus*) and Raitt's sandeel (*Ammodytes marinus*). A further two species have also been identified as potentially present within the North Sea, although they are less abundant: Corbin's sandeel (*Hyperoplus immaculatus*) and smooth sandeel (*Gymnammodytes semisquamatus*). Hereafter 'sandeel' in this report represents all five species, since all sandeel species have similar habitat requirements (Ref 1). Sandeel account for around 25% of the entire North Sea fish biomass (Ref 23). Of the five sandeel species inhabiting the North Sea, the lesser sandeel is the most abundant, comprising over 90% of sandeel fishery catches (Ref 24; Ref 23).

3.2.2 Sandeel populations have historically been divided into ICES sandeel assessment and management areas (Ref 25), however these covered large areas and were considered to overrepresent suitable sandeel habitat within the North Sea (Ref 1). The approach described by Reach et al. (Ref 1) has been followed within this report, which uses sandeel fishing grounds as a baseline for sandeel distribution. **Inset 3-1** shows the distribution of sandeel fishing grounds and the associated ICES Sandeel Areas (SAs) within the North Sea. The Proposed Offshore Scheme intersects fishing grounds SA1_WD which lies on the UK 'side' of the EEZ.

Inset 3.1: Sandeel fishing grounds within the North Sea and associated ICES Sandeel Areas (Ref 2; Ref 27).



3.3 Sandeel lifecycle

3.3.1 Sandeel are a shoaling, semi-pelagic fish species which can grow to lengths of up to 30cm and are characterised by their slender, eel-like appearance. They feed primarily on phytoplankton and zooplankton and are diurnal, hunting in the water column during the day during late spring and summer, and returning to bury into the seabed at night. Adult sandeel remain dormant buried in the seabed throughout winter (September – March), emerging to spawn between November and February (Ref 27). Sandeel eggs are adhesive and attach in clumps onto sandy substrate, often being partially buried. Hatching occurs approximately four weeks later during February and March (Ref 19). The larvae are planktonic for between two and five months, after which they settle into the seabed, actively searching for areas of suitable substrate (Ref 27; Ref 28; Ref 19) once they have attained a length of approximately 75-80mm (Ref 29).

3.4 Sandeel habitat preference

3.4.1 Sandeel are substrate specific (Ref 30; Ref 31) and show a preference for sediments containing less than 4% silt and higher proportions of coarse sand with fine to medium gravel. This is to facilitate burial within sediments and avoid clogging their gills with fine particles whilst buried, as interstitial water is used for respiration (Ref 32). Sediments with a higher proportion of silt (above 10%) have been shown to contain lower concentrations of oxygen due to smaller interstitial spaces (Ref 31), whereas those with higher proportions of coarse sand contain oxygen at similar concentrations to the overlying water (Ref 30; Ref 32).

3.4.2 In addition, sandeel have been observed to prefer hydrographically active areas (Ref 31) with current flows greater than 0.6m/s at depths between 30-70m (Ref 30; Ref 32) as these dynamic environments reduce the accumulation of silt and promote aeration. Langton et al. (Ref 33) identified that buried sandeel tend to avoid strongly sloping areas such as the edges of sandbanks and that their preferred water depth ranged between approximately 30m – 50m.

3.4.3 A study by van der Kooij et al. (Ref 31) identified that there is a clear relationship between sandeel distribution in the water column, availability of suitable night-time seabed habitat and bottom temperature, with optimum water temperatures between 8.3°C and 9.0°C. The same study also identified a preference for saline waters, with highest numbers of sandeel sampled in waters with salinities between 34.9 and 35.0.

3.4.4 Sandeel have been observed to remain within proximity to their spawning grounds, likely due to a combination of finding optimal conditions for burial, their diurnal lifestyle, the need to bury themselves to avoid predators and their lack of a swim bladder making longer range foraging energetically costly (Ref 31). The high site fidelity displayed by sandeel makes them particularly vulnerable to habitat disturbance or removal (Ref 34).

3.4.5 Although sandeel populations are known to naturally fluctuate over time, poor management and human exploitation has led to past stock collapses. Sandeel require specific sediment conditions for key periods of their life cycle, making them particularly vulnerable to environmental changes and habitat alterations from anthropogenic activities affecting the seabed, such as seabed disturbance from cable trenching. It is important to maintain the status of suitable habitats to sustain sandeel populations and thus support those species which depend on them for their survival.

3.4.6 Greenstreet et al. (Ref 35) categorised seabed sediments into four sandeel sediment preference groups based on hydroacoustic seabed surveys and nocturnal grab sampling. These categories are dependent on the percentage of silt, fine sand and coarse sand in the sediment, and are summarised in **Table 3.1.** These have been translated into habitat sediment classes based on the Folk classification (Ref 36) as described by Reach et al. (Ref 1) which is used in this report.

Table 3.1: Sandeel sediment preferences

Sandeel Habitat Preference	Coarse Sand Content (% by weight)	Silt and Fine Sand Content (% by weight)
Prime	>70% coarse sand	>20% silt and fine sand
Sub Prime	>50% coarse sand	>30% silt and fine sand
Suitable	>50% coarse sand	>50% silt and fine sand
	>40% coarse sand	>20% silt and fine sand
	>20% coarse sand	<10% silt and fine sand
Unsuitable	<40% coarse sand	>10% silt and fine sand

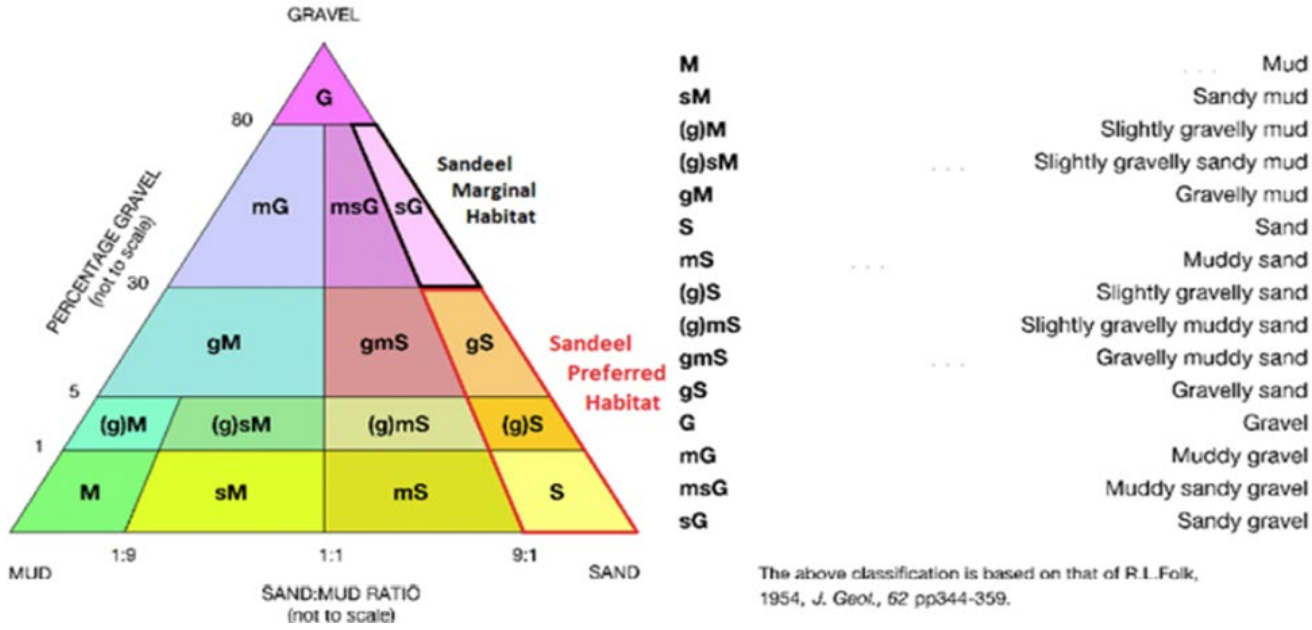
3.4.7 The Folk sediment classes which are considered to describe the preferred or "Prime" (See Table 3.1) habitat for sandeel species in UK waters are:

a. Sand, S
b. slightly gravelly Sand, (g)S
c. gravelly Sand, gS

3.4.8 The sediment class 'sandy Gravel, sG' is also included as marginal habitat for sandeel, however it should be recognised that this category contains up to 80% gravel. Although recognised as 'suitable' habitat by Greenstreet et al. (Ref 35) and therefore having the potential to support sandeel populations, it would be unlikely to be used by sandeel unless in the absence of Prime habitat.

3.4.9 **Inset 3.2** summarises the sediment classes which provide sandeel habitat in the form of a Folk triangle indicating preferred and marginal habitat for sandeel (Ref 1).

Inset 3.2: Folk triangle highlighting preferred and marginal habitat for sandeel (Ref 2; Ref 37; Ref 33; Ref 36).



3.5 Existing habitat

Spawning and nursery grounds

3.5.1 According to Ellis et al. (Ref 37), understanding the distribution and abundance of spawning and nursery grounds is key for the management of prey species' habitats. As described above, sandeel require specific hydrological conditions for key periods of their life cycle and are therefore vulnerable to seabed disturbance from activities such as cable trenching.

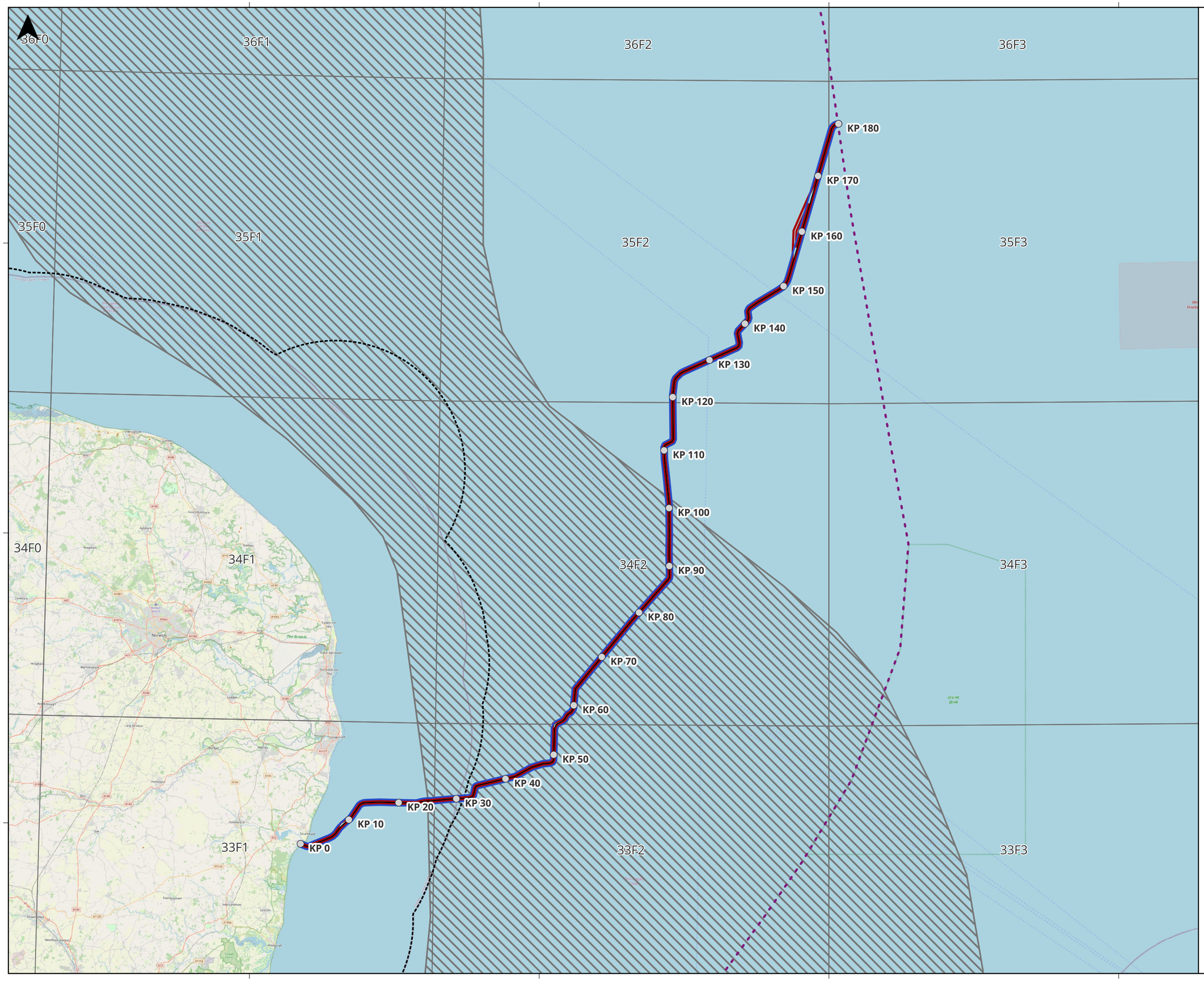
3.5.2 In line with the updated methodology for identifying potentially suitable habitat for sandeel described by Reach et al. (Ref 1), spawning grounds identified by Coull et al. (Ref 4) have been used without the additional nursery ground intensity assessed by Ellis et al. (Ref 37). It is considered that the Ellis et al. (Ref 37) datasets replicate the findings of the Coull et al. (Ref 4) reports but relate them to ICES rectangles rather than preferred benthic habitat. Assessment in relation to preferred benthic habitat is considered to be of greater value to this report.

3.5.3 The Draft Order Limits for the Proposed Offshore Scheme crosses one sandeel spawning ground identified by Coull et al. (Ref 4): off the Norfolk coast (**Inset 3.3:**)

3.5.4 **Table 3.2** provides the length of Proposed Offshore Scheme within the spawning ground, giving KPs as location references. To ensure the whole spawning ground was considered, the nearest KP to the outermost boundary of the spawning ground was used.

Table 3.2: Extent of Draft Order Limits within sandeel spawning ground as defined by Coull et al. (Ref 4)

KP at start point	KP at end point	Length of cable route (km)
25	102	76.5



A3

- Proposed Offshore Scheme Draft Order Limits
- Cable Route
- KP
- 500m Study Area
- ICES Statistical Rectangle
- Sandeel Spawning Ground (Coull et al., 1998)
- 12NM Limit
- EEZ

Coordinate System: ETRS89 / UTM zone 31N

Kilometres

0 10 20 30

Rev	Date	By	Chkd	Appd	Authd
P01	15/07/2025	AN	JC	AC	DS

collaborative environmental advisers

Project Name

LIONLINK

Client

National Grid LionLink Limited (NGLLL)

Drawing Title

Inset 3-3 Sandeel Spawning Grounds

Scale at A3

1:600,000

Role

Environment

Suitability

S2

Project Number

C01467

Rev

P01

Drawing Number

LLK1-CEA-DWG-ENV-00101

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Suitability of seabed sediments

3.5.5 Latto et al. (Ref 34) developed a method statement to identify areas of preferred and marginal habitat for sandeel for use within the aggregates industry, following on from the work presented by Greenstreet et al. (Ref 35). This method was recommended by the MMO in feedback provided as part of the Hornsea Four Offshore Wind Farm Scoping Opinion (Ref 38). The Latto et al. (Ref 34) method begins with analysis of British Geological Survey (BGS) seabed sediment data to identify areas with the potential to support sandeel habitat. These areas can then be 'ground-truthed' during site-specific surveys. The Latto et al. (Ref 34) method statement has since been updated by Reach et al. (Ref 1) to use the Folk sediment classifications rather than BGS as described above in **Paragraph 3.4.6**, however the premise of the assessment remains the same. Cefas has recommended the approach set out by Reach et al. (Ref 39; Ref 1) for identification of potential sandeel habitat for submarine cable projects.

Table 3.3: Sandeel ground assessment categories specified by Latto et al (Ref 34)

Folk Categories	Habitat Preference
Sand	Preferred
Gravelly Sand	Preferred
Slightly Gravelly Sand	Preferred
Sandy Gravel	Marginal
Other	Unsuitable

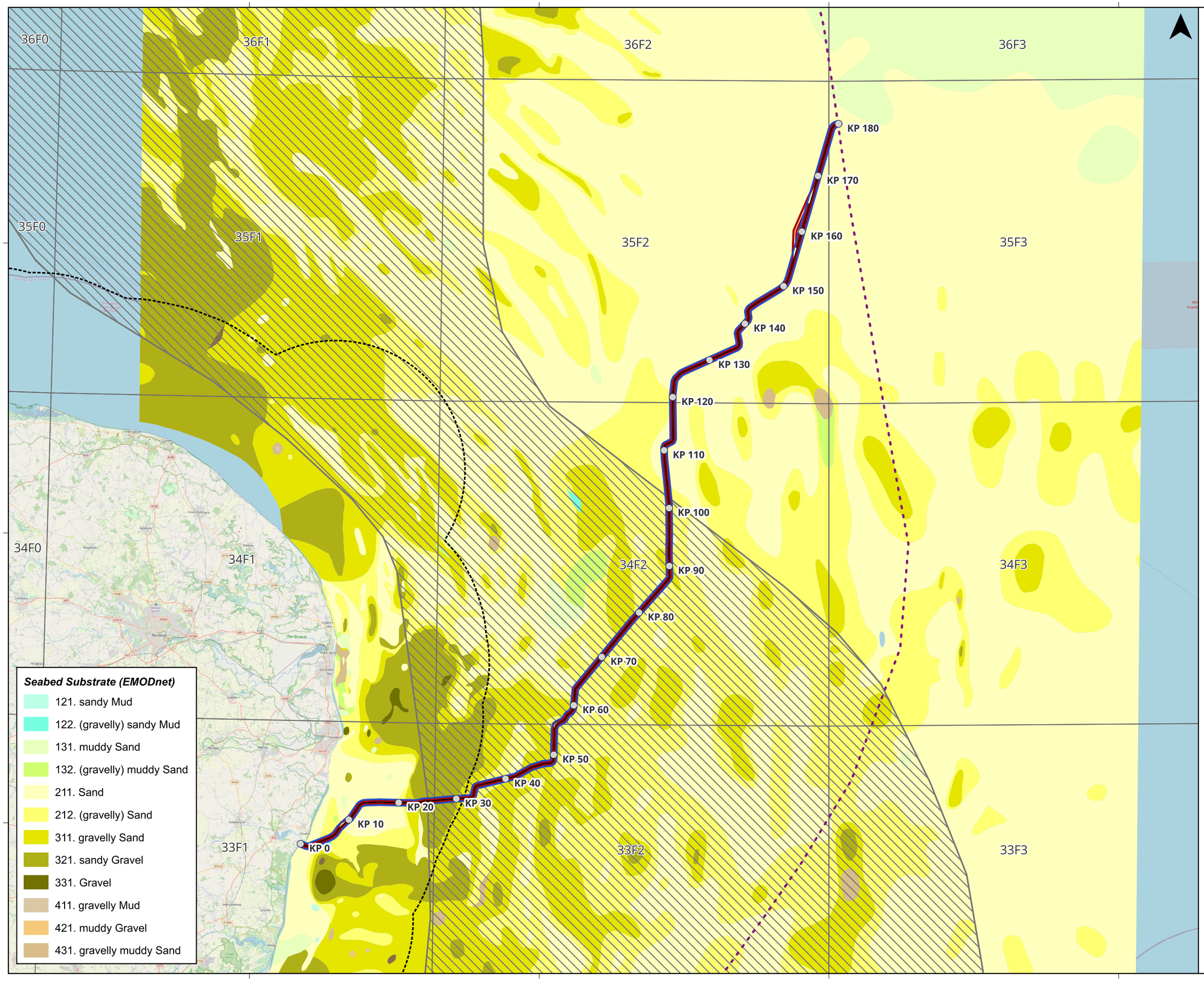
3.5.6 Publicly available seabed sediment data from the EMODnet seabed substrate Folk 16 (1:250k) (Ref 6) has been analysed using GIS software (QGIS) to provide an overview of seabed sediment types across the Proposed Offshore Scheme.

3.5.7 Inset 3-4 below identifies areas of potentially suitable seabed sediments for sandeel which are within the Proposed Offshore Scheme. The dominant habitat types identified across much of the Proposed Offshore Scheme are 'Sand' and 'slightly gravelly Sand', which are both likely to be suitable habitat for sandeel, additionally 'sandy Gravel' is present as a marginal sandeel habitat.

3.5.8 Based on sediment suitability alone, the entirety of the Draft Order Limits of the Proposed Offshore Scheme between the proposed Landfall at Walberswick (KP0) extending out to around KP160 towards the EEZ have the potential to provide preferred habitat for sandeel, with the exception of the areas between KP4 and KP5 which is comprised of slightly gravelly sandy Mud.

3.5.9 **Table 3.4** provides a detailed breakdown of the sections of the Proposed Offshore Scheme which cross various sediment types which have been identified as potentially suitable for sandeel. Those sections of the Proposed Offshore

Scheme which cross areas of sandy gravel have been greyed out of the table, as it is considered unlikely that these areas would be utilised by sandeel given the availability of preferred habitat in the immediate area. All other unsuitable sediment types have not been included in the table.



A3

- Proposed Offshore Scheme Draft Order Limits
- Cable Route
- KP
- 500m Study Area
- ICES Statistical Rectangle
- Sandeel Spawning Ground (Coull et al., 1998)
- 12NM Limit
- EEZ

Coordinate System: ETRS89 / UTM zone 31N

Kilometres

0 8 16 24

P01	15/07/2025	AN	JC	AC	DS

Rev	Date	By	Chkd	Appd	Authd

collaborative environmental advisers

Project Name

LIONLINK

Client

National Grid LionLink Limited (NGLLL)

Drawing Title

Inset 3-4 Sandeel Habitat Suitability

Scale at A3

1:600,000

Role

Environment

Suitability

S2

Project Number

C01467

Rev

P01

Drawing Number

LLK1-CEA-DWG-ENV-00102

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Table 3.4: Extent of Draft Order Limits within EMODnet Folk 16 seabed sediments identified as providing habitat potentially suitable for sandeel as per Latto et al (Ref 34)

Location (KPs)	EMODnet Folk 16 Sediment Type
0 - 3	Sand
3 - 4	slightly gravelly Sand
4 - 8	slightly gravelly Sand
8 – 9.5	Sand
9.5 - 14	slightly gravelly Sand
14 - 18	Sand
18 - 20	gravelly Sand
20 – 28	sandy Gravel (marginal)
28 - 29	gravelly Sand
29 - 37	slightly gravelly Sand
37 - 39	Sand
39 - 51	gravelly Sand
51 - 54	slightly gravelly Sand
54 - 57	gravelly Sand
57 - 59	slightly gravelly Sand
59 - 61	Sand
61 - 72	slightly gravelly Sand
72 - 76	gravelly Sand
76 - 82	slightly gravelly Sand
82 - 84	Sand
84 - 85	slightly gravelly Sand
85 - 89	gravelly Sand
89 - 90	slightly gravelly Sand
90 - 93	Sand
93 - 101	slightly gravelly Sand
101 - 115	Sand
115 - 117	slightly gravelly Sand
117 – 177.154	Sand

3.5.10 It is noted that the EMODnet Folk 16 sediment data is only predicted data and does not require sampled sediment to ground truth the predictive mapped data (Ref 6). Although sandeel sediment suitability can be further classified into

'Prime', 'Sub-prime' and 'Suitable' habitats (after Greenstreet et al. (Ref 35)) as described in **Paragraph 3.4.6**, this cannot be done with publicly available data. Sediments along the Proposed Offshore Scheme have been further analysed and classified in **Paragraph 3.5.23** using site specific PSD data.

Sandeel egg and larvae data

3.5.11 ICES collect fish egg and larvae data (Ref 3) and the ICES Database on Trawl Surveys (Ref 41) publish IBTS data within the DATRAS database online. The limitations of bottom trawl surveys to adequately target some species (i.e., clupeids, sandeels) is recognised. From review of the online portal, there is very limited sandeel egg data, but there is data available on the presence of adult sandeel in the areas corresponding with the spawning areas identified by Coull et al. (Ref 4) within the English waters that the Proposed Offshore Scheme passes through.

Marine Scotland statistical model

3.5.12 Marine Scotland developed a model to predict the occurrence and density of sandeel within parts of the North Sea and Celtic Sea using habitat data (Ref 33; Ref 42) with support from the European Union's INTERREG VA Programme, managed by the Special EU Programmes Body. The model found that 'percentage silt' was the most important variable in predicting occurrence, aligning with previous findings, discussed in **Paragraph 3.4.6**, which found that sandeel show a preference for sediments containing less than 4% silt and actively avoid those containing more than 10% silt. The model also found that the percentage of sand within seabed sediments had a strong influence on the density of sandeel and that buried sandeel strongly avoided areas which were steeply sloped. Areas identified by the model are shown in **Inset 3.5:**, however it is recognised that the model does not encompass the entire Proposed Offshore Scheme.

3.5.13 Publicly available GIS data generated by the model has been used in conjunction with EMODnet Folk 16 seabed sediment data to identify potential areas of suitable habitat for sandeel (Ref 6). **Inset 3-5** shows the probability of presence of buried sandeel along the section of the route covered by the model (approximately KP51 to KP176). The areas of probable sandeel presence which overlap with the Proposed Offshore Scheme are outlined in **Table 3.5**.

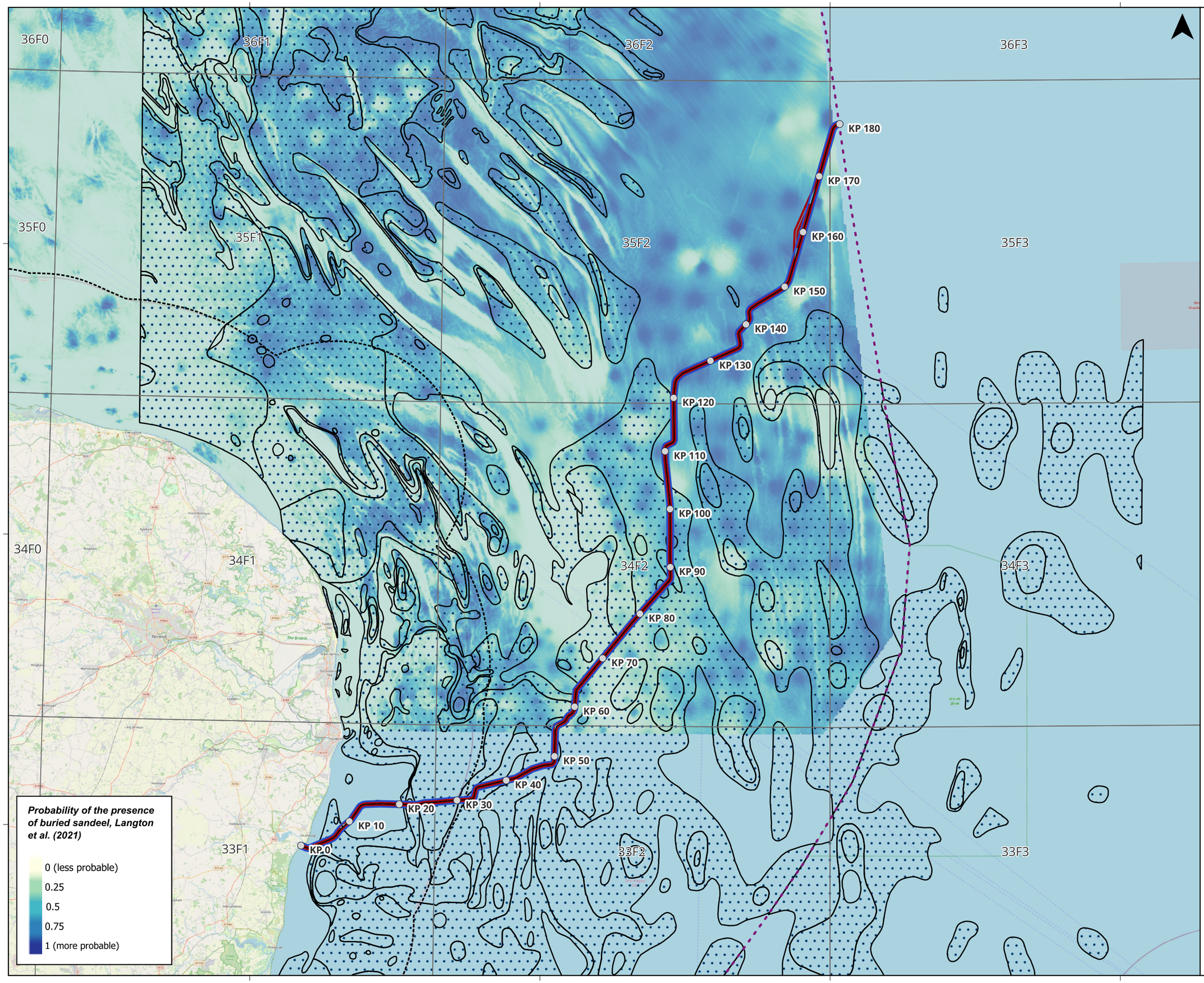
Table 3.5: KPs between which the Langton et al. (Ref 33) model predicts the presence of buried sandeel within the Draft Order Limits

Location (KPs)
60 - 61
81 - 84

Location (KPs)
89 - 98
105 - 109
119 - 146
149 - 165
175 - 176

3.5.14 It should be noted that the areas identified by the model as having over 50% probability of sandeel presence (up to KP98) are within the boundary of the sandeel spawning ground identified by Coull et al. (Ref 4). Areas further along the Proposed Offshore Scheme which have been identified by the model as having over 50% probability of sandeel presence are located in areas of predicted sand seabed substrate and at relatively shallow depths (between 30 – 40m) which are suitable habitats for sandeel.

3.5.15 The areas shown in **Table 3.5** have also been compared with the areas identified as potential suitable habitat for sandeel from the EMODnet Folk 16 seabed sediment data described above. Areas which are common to both analyses are presented in the conclusion of this assessment.



Proposed Offshore Scheme Draft Order Limits

Cable Route

KP

500m Study Area

ICES Statistical Rectangle

12NM Limit

EEZ

Sand (Seabed Substrate- Folk classification 2.1.1., (gravelly) Sand 2.1.2., gravely sand 3.1.1., sandy Gravel 3.2.1.)

A3

Coordinate System: ETRS89 / UTM zone 31N

Kilometres

0 8 16 24

Rev	Date	By	Chkd	Appd	Authd
P01	15/07/2025	AN	JC	AC	DS

collaborative environmental advisers

Project Name

LIONLINK

Client

National Grid LionLink Limited (NGLLL)

Drawing Title

Inset 3-5
Probability of the Presence of Buried Sandeel

Scale at A3

1:600,000

Role

Environment

Suitability

S2

Project Number

C01467

Rev

P01

Drawing Number

LLK1-CEA-DWG-ENV-00103

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Bathymetry

3.5.16 **Inset 3.6:** shows the Proposed Offshore Scheme in relation to regional bathymetry to determine whether there are any areas which have the potential to provide more favourable habitat for sandeel based on water depth. Publicly available bathymetry data was downloaded from EMODnet (Ref 7) and analysed within GIS software (QGIS). As previously discussed, sandeel have been observed to prefer a depth range of approximately 30 – 70m (Ref 32; Ref 30; Ref 33).

3.5.17 As expected, shallower areas are apparent closer to the coast, with the area extending offshore from the proposed Landfall remaining below 30m water depth until approximately 10km offshore. This area immediately offshore is therefore unlikely to provide a suitable habitat for sandeel from the perspective of water depth. The Proposed Offshore Scheme is partially within the sandeel spawning area identified by Coull et al. (Ref 4) from approximately KP25 to KP102, within which water depth ranges from 35 to 50m.

Environmental data

3.5.18 Sandeel require areas of higher dissolved oxygen content at the seafloor to promote survival within buried sediments and to ensure egg development. It is understood that lowered oxygen concentration can delay egg development (Ref 42, Ref 43).

3.5.19 **Inset 3.7** shows seafloor dissolved oxygen data gathered from EMODnet (Ref 12) and seafloor temperature (Ref 8; Ref 9;Ref 10; Ref 11) in relation to the Proposed Offshore Scheme. Predictably, higher dissolved oxygen concentrations are recorded within shallower water depths and closer to the coast, which are dynamic environments at approximately 274.75µmol/l. The sandeel spawning ground identified by Coull et al. (Ref 4) aligns with deeper water near the centre of the Proposed Offshore Scheme in line with predicted suitable seabed sediment (Ref 6). Along the Proposed Offshore Scheme there is little deviation in oxygen concentration, with it ranging from 273.98µmol/l (KP145 – KP170) to 274.75µmol/l (KP0 – KP11).

3.5.20 There is some evidence that sandeel prefer slightly higher seafloor temperatures (Ref 31), with optimum bottom water temperatures between 8.3°C and 9.0°C. This aligns with the sandeel spawning area near the centre of the Proposed Offshore Scheme identified by Coull et al. (Ref 4) and predicted seafloor temperatures ranging from 8.9°C to 9.3°C within this area. The highest water temperatures were found in shallower waters nearer the coast and proposed Landfall. It is of particular note that the area of optimum temperature for sandeel spawning off the coast of Norfolk align with the preferred water depth highlighted by the bathymetry data, the EMODnet Folk 16 seafloor sediment data, high dissolved oxygen concentrations, and the sandeel spawning area identified

by Coull et al. (Ref 4). It should be noted that thermal resistivity was measured across the site as part of the geotechnical survey scope acquired in summer summer/early autumn 2024.

3.5.21 A study by MacDonald et al. (Ref 43) found that there was no evidence that spawning is triggered by environmental cues. Rather, spawning may be associated with sandeel length/size. The study suggested that egg hatch dates may be associated with the shift from decreasing to increasing temperature in spring, however there was insufficient data for certainty. Median hatch dates occurred in March, the time of peak egg production in the calanoid copepod *Calanus finmarchicus* which is a critical food source for newly hatched sandeel.

400000
450000
500000
550000
5900000
5850000
5800000

KP 180
KP 170
KP 160
KP 150
KP 140
KP 130
KP 120
KP 110
KP 100
KP 90
KP 80
KP 70
KP 60
KP 50
KP 40
KP 30
KP 20
KP 10
KP 0

Bathymetry (m)
-100
-80
-70
-60
-50
-40
-30
-20
-10
-5

Proposed Offshore Scheme Draft Order Limits
Cable Route
KP
500m Study Area
Sandeel spawning ground (Coull et al., 1998)
12NM Limit
EEZ

A3

Coordinate System: ETRS89 / UTM zone 31N

Kilometres
0 8 16 24

Rev	Date	By	Chkd	Appd	Authd
P01	15/07/2025	AN	JC	AC	DS

collaborative environmental advisers

Project Name

LIONLINK

Client
National Grid LionLink Limited (NGLLL)

Drawing Title
Inset 3-6
Bathymetry Across the Study Area in Relation to the Spawning Area

Scale at A3
1:600,000

Role
Environment

Suitability
S2

Project Number
C01467

Rev
P01

Drawing Number
LLK1-CEA-DWG-ENV-00104

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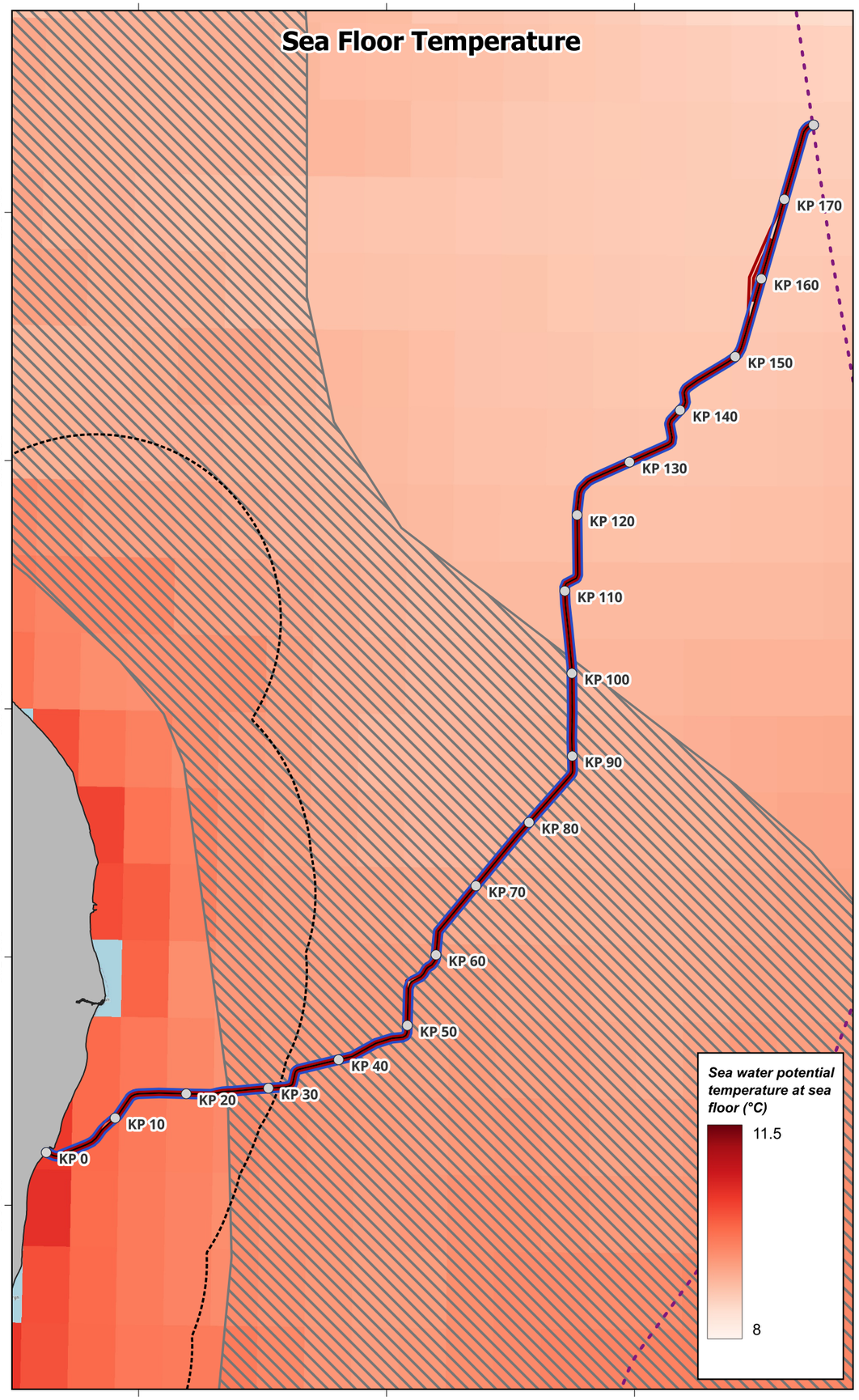
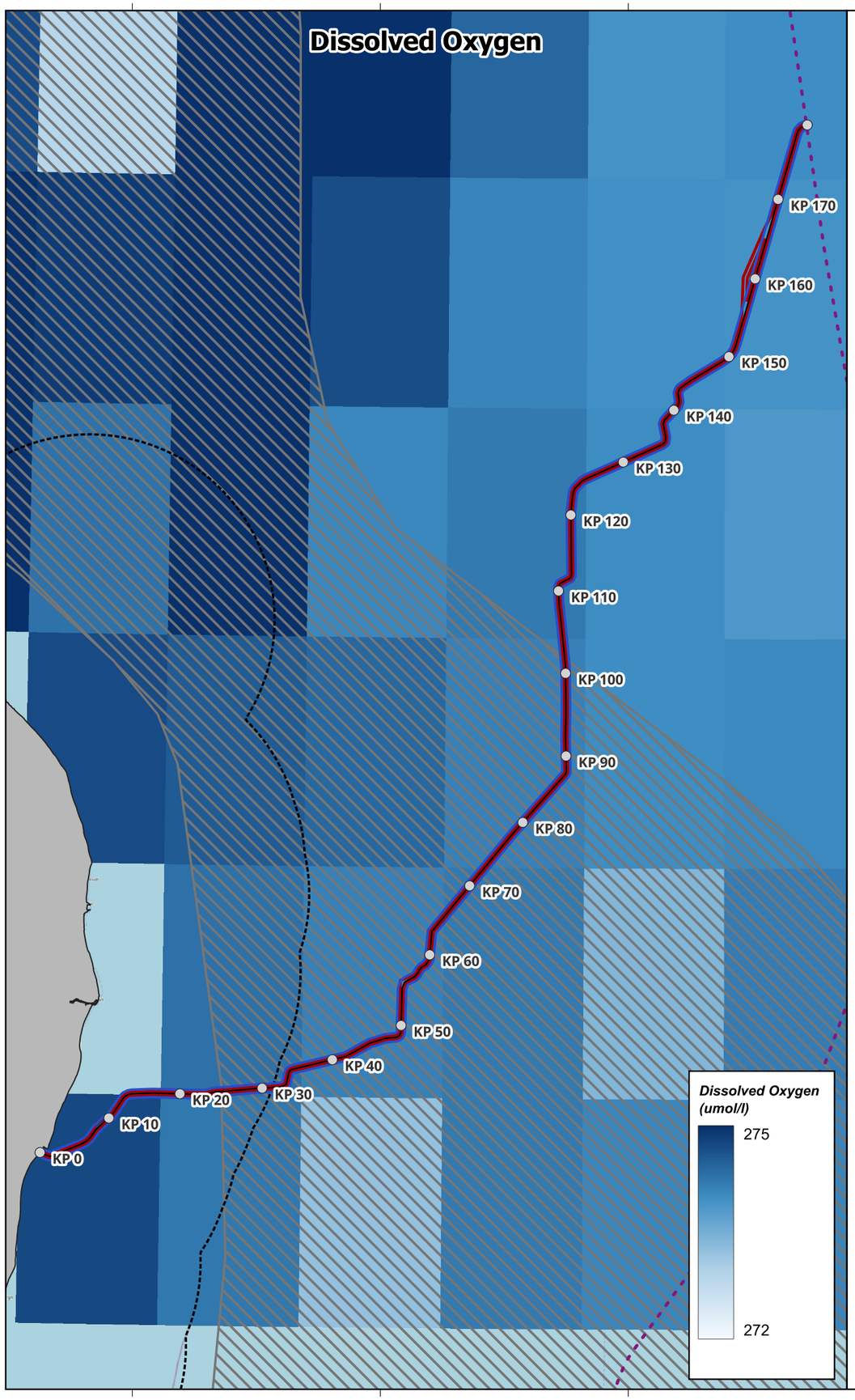




A3

- Proposed Offshore Scheme Draft Order Limits
- Cable Route
- KP
- 500m Study Area
- Sandeel spawning ground (Coull et al., 1998)
- 12NM Limit
- EEZ

Coordinate System: ETRS89 / UTM zone 31N

Kilometres

0 8 16 24

Rev	Date	By	Chkd	Appd	Authd
P01	03/07/2025	AN	JC	AC	DS

collaborative environmental advisers

Project Name

LIONLINK

Client

National Grid LionLink Limited (NGLLL)

Drawing Title

Inset 3-7
Seafloor temperature (°C) and dissolved oxygen levels (µmol/l)

Scale at A3

1:600,000

Role

Environment

Suitability

S2

Project Number	Rev
C01467	P01

Drawing Number

LLK1-CEA-DWG-ENV-00105

Project specific survey data analysis

3.5.22 Thirty instances of sandeel were observed in camera transects taken during the environmental baseline survey, along with a single instance recorded during grab sampling at station LL_108_EBS.

Particle size analysis

3.5.23 Particle size distribution (PSD) varied along the Draft Order Limits: the nearshore region (stations LL_01_EBS to LL_17_EBS) comprised mainly of fines (mean: 52.7%±26.0SD), with smaller proportions of sands (mean 33.3%±15.8SD) and gravel (mean 14.2%±23.6SD); the offshore sediments (stations LL_21_EBS to LL_138_EBS) comprised mainly of sands (mean: 86.5%±15.3SD), with smaller proportions of fines (mean: 7.79%±10.5SD) and gravel (mean: 5.69%±10.1SD).

3.5.24 Using the Latto et al. (Ref 34) method, sample stations were categorised into 'Preferred', 'Marginal' or 'Unsuitable' for sandeel grounds. 'Preferred' sediments for sandeel grounds were identified at 46 stations, with most stations occurring within offshore circalittoral sand habitats along the northern extent of the Proposed Offshore Scheme (Folk sediment classifications include: Sand, slightly gravelly Sand and gravelly Sand). 'Marginal' conditions were identified at two stations (LL_03_TR and LL_42_SG) within the offshore circalittoral sand habitat, with various patches of offshore circalittoral coarse sediment within the same area (Folk sediment classification: sandy Gravel). The remaining 36 stations were characterised as 'Unsuitable' for sandeel grounds due to the predominant proportions of mud and coarse sediments (Folk classifications: muddy sand and gravelly muddy sand.

3.5.25 However due to presence of coarser sand, of these 36 'Unsuitable' stations, 13 stations were reclassified as 'Suitable', 'Sub-Prime' or 'Prime' after applying the Greenstreet at al. (Ref 35) method to the PSD data, and of the 46 stations identified as 'Preferred' by Latto et al. (Ref 34), 35 retained a classification of 'Sub-Prime' to 'Prime' under the Greenstreet methodology whilst the remaining 11 stations were reclassified to 'Suitable' or 'Unsuitable', due to a significant contribution of fines to the sediment composition at those stations.

3.5.26 A full breakdown of the Proposed Offshore Scheme by Latto et al and Greenstreet classifications is presented in **Table 3.6.**

3.5.27 **Inset 3.8** to **Inset 3.15** show the stations where grab samples were acquired and their subsequent sandeel habitat classification. Insets are taken directly from the benthic survey report which can be found in full in **Appendix 19.1 Benthic Survey Report** of this PEIR.

Table 3.6: Station suitability for sandeel spawning using metrics from Latto et al. (Ref 34) and Greenstreet et al. (Ref 35)

Station	Water Depth (m)	Modified Folk Scale	Habitat Preference Latto et al. (Ref 34)	Silt and Fine Sands (% by weight)	Medium to Coarse Sands (% by weight)	Habitat Preference Greenstreet et al. (Ref 35)	KP along Proposed Offshore Scheme
LL_04_TR_G	9.7	Sandy Mud	Unsuitable	96.8	3.1	Unsuitable	KP0 to KP9
LL_05_SG	11.5	Slightly Gravelly Sandy Mud	Unsuitable	95	0.1	Unsuitable	
LL_06_TR_G	12.1	Sandy Mud	Unsuitable	90.2	8.9	Unsuitable	
LL_07_TR_G	12.4	Sandy Mud	Unsuitable	91.9	8	Unsuitable	
LL_08_EBS	14	Gravelly Mud	Unsuitable	78.3	15.7	Unsuitable	
LL_09_TR_G	18.4	Sandy Mud	Unsuitable	95.2	4.5	Unsuitable	
LL_11_EBS	19.6	Sandy Mud	Unsuitable	90.6	9.1	Unsuitable	
LL_21_EBS	21.4	Sand	Preferred	81.4	18.6	Unsuitable	KP10 to KP11
LL_23_SG_SS	35.1	Slightly Gravelly Muddy Sand	Unsuitable	37.8	59.9	Suitable	KP12 to KP13
LL_27_EBS	32	Muddy Sandy Gravel	Unsuitable	38.8	28.7	Unsuitable	KP14 to KP21
LL_30_SG	35.1	Muddy Sand	Unsuitable	69.6	30.4	Unsuitable	
LL_32_EBS	33.9	Gravelly Muddy Sand	Unsuitable	51.4	26.9	Unsuitable	
LL_34_SG	24	Sand	Preferred	8.3	91.7	Prime	KP22 to K23
LL_38_EBS	34.5	Muddy Sand	Unsuitable	40.9	59.1	Suitable	KP24 to KP26
LL_42_SG	37.3	Sandy Gravel	Marginal	14.6	46.8	Suitable	KP27 to KP33

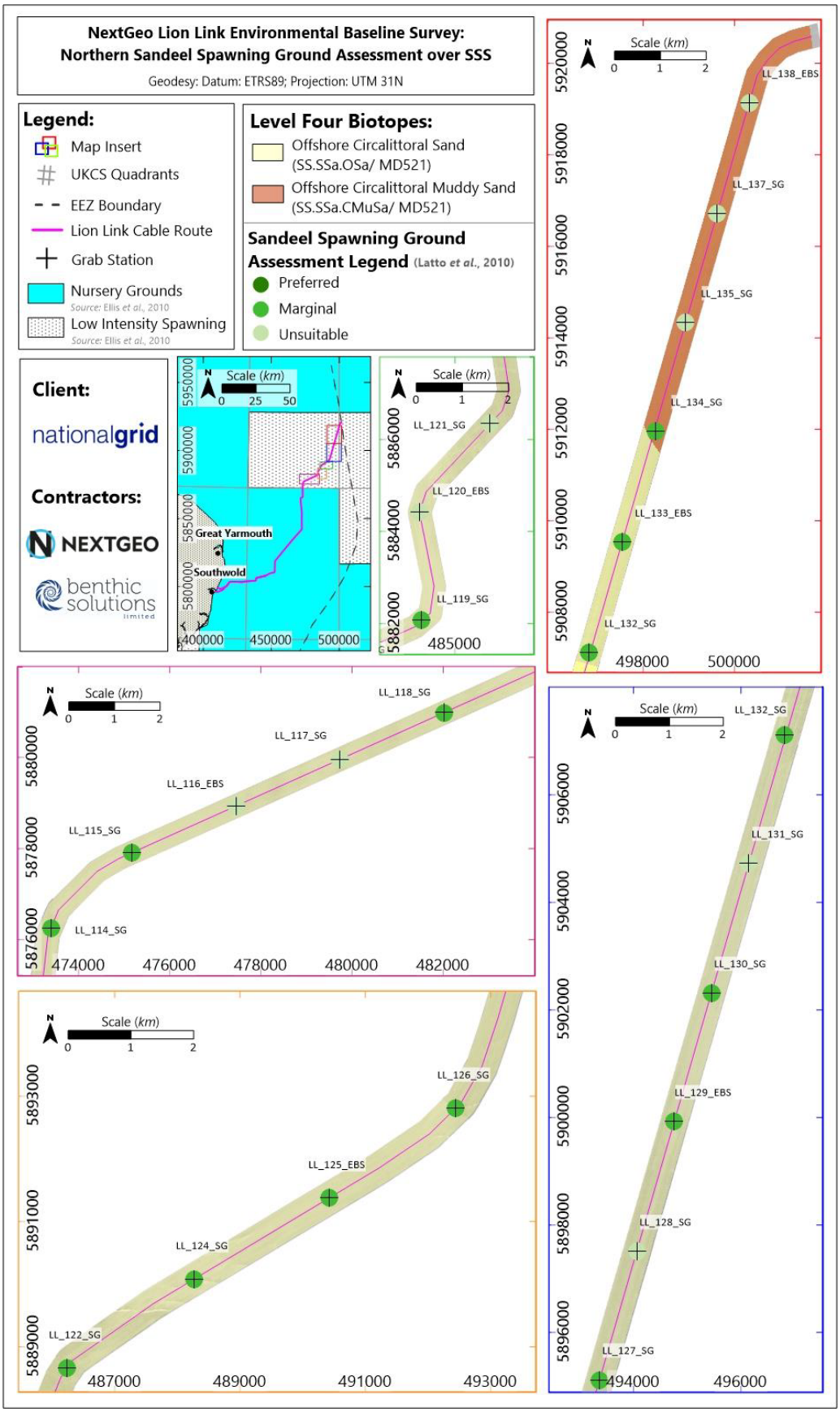
Station	Water Depth (m)	Modified Folk Scale	Habitat Preference Latto et al. (Ref 34)	Silt and Fine Sands (% by weight)	Medium to Coarse Sands (% by weight)	Habitat Preference Greenstreet et al. (Ref 35)	KP along Proposed Offshore Scheme
LL_44_EBS	40.3	Sand	Preferred	12.2	87.6	Prime	
LL_45_SG_SS	40.2	Gravelly Sand	Preferred	6.9	65.3	Sub-Prime	
LL_49_EBS	44	Muddy Sandy Gravel	Unsuitable	15.6	42.6	Suitable	KP34 to KP39
LL_51_SG	38	Muddy Sandy Gravel	Unsuitable	14	44.9	Suitable	
LL_55_EBS_SS	38.6	Slightly Gravelly Sand	Preferred	1.8	94.3	Prime	KP40 to KP56
LL_57_SG	38.8	Slightly Gravelly Sand	Preferred	1.6	93.9	Prime	
LL_60_EBS	41.4	Gravelly Sand	Preferred	6.2	87.9	Prime	
LL_62_SG	43.8	Gravelly Sand	Preferred	1.9	70.5	Prime	
LL_64_EBS	46.4	Gravelly Sand	Preferred	15.9	73.6	Sub-Prime	
LL_67_SG	43.7	Slightly Gravelly Sand	Preferred	0.1	97	Prime	
LL_72_EBS_SS	43.9	Gravelly Sand	Preferred	3.5	90.4	Prime	
LL_73_EBS_SS	45.8	Slightly Gravelly Sand	Preferred	3.1	94.2	Prime	
LL_78_EBS_SS	41.6	Gravelly Sand	Preferred	0.2	93.1	Prime	
LL_82_SG	47.6	Gravelly Muddy Sand	Unsuitable	27.6	61.7	Sub-Prime	KP57 to KP58
LL_85_EBS_SS	45.6	Slightly Gravelly Sand	Preferred	0.9	96.6	Prime	KP59 to KP64

Station	Water Depth (m)	Modified Folk Scale	Habitat Preference Latto et al. (Ref 34)	Silt and Fine Sands (% by weight)	Medium to Coarse Sands (% by weight)	Habitat Preference Greenstreet et al. (Ref 35)	KP along Proposed Offshore Scheme
LL_86_SG	48.3	Slightly Gravelly Sand	Preferred	14.4	84.5	Prime	
LL_87_EBS	50.4	Muddy Sand	Unsuitable	38.9	61	Suitable	KP65 to 66
LL_88_SG	51.3	Slightly Gravelly Sand	Preferred	22.5	74.9	Sub-Prime	KP67 to KP71
LL_89_EBS	51.1	Slightly Gravelly Sand	Preferred	7.8	89.2	Prime	
LL_91_SG	46.3	Gravelly Muddy Sand	Unsuitable	34.4	52.1	Suitable	KP72 to KP73
LL_94_EBS	47.7	Slightly Gravelly Sand	Preferred	18.3	78.9	Sub-Prime	KP74 to KP76
LL_95_SG	47.2	Gravelly Muddy Sand	Unsuitable	36.2	52	Suitable	KP77 to KP 78
LL_97_EBS	43.6	Slightly Gravelly Sand	Preferred	8.1	90.7	Prime	KP79 to KP86
LL_98_SG	42.7	Sand	Preferred	22.8	77	Sub-Prime	
LL_99_EBS	44	Sand	Preferred	12.3	87	Prime	
LL_100_SG	43	Slightly Gravelly Muddy Sand	Unsuitable	60.9	36	Unsuitable	KP87 to KP88
LL_102_EBS	39.2	Gravelly Muddy Sand	Unsuitable	28.6	63.1	Sub-Prime	KP89 to KP91
LL_103_SG	37.2	Gravelly Sand	Preferred	7.5	86.3	Prime	KP92 to 108

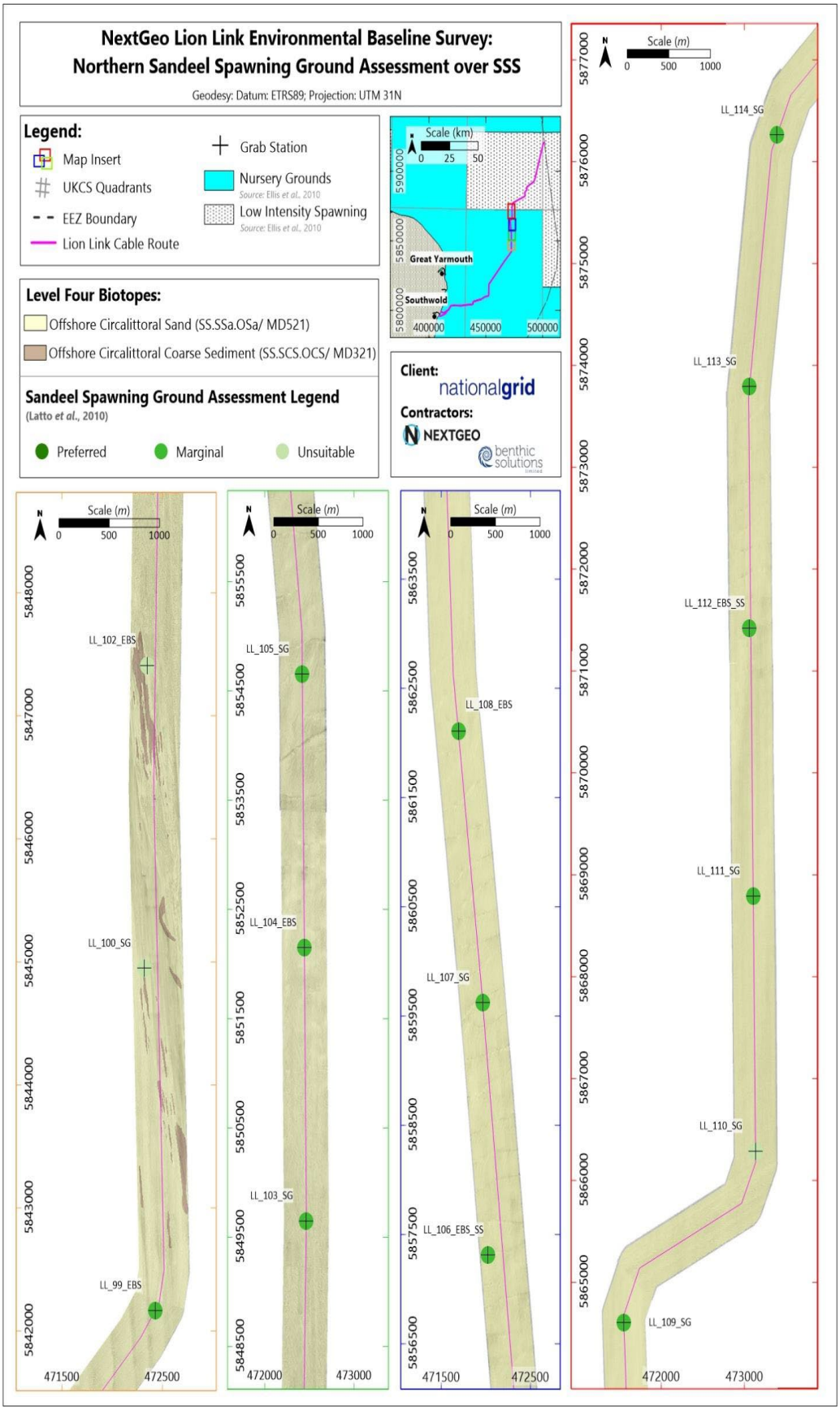
Station	Water Depth (m)	Modified Folk Scale	Habitat Preference Latto et al. (Ref 34)	Silt and Fine Sands (% by weight)	Medium to Coarse Sands (% by weight)	Habitat Preference Greenstreet et al. (Ref 35)	KP along Proposed Offshore Scheme
LL_104_EBS	36.1	Gravelly Sand	Preferred	15.9	77.1	Sub-Prime	
LL_105_SG	37.5	Slightly Gravelly Sand	Preferred	9.2	88.4	Prime	
LL_106_EBS_SS	35.9	Slightly Gravelly Sand	Preferred	10	88.1	Prime	
LL_107_SG	36.6	Slightly Gravelly Sand	Preferred	6.8	92.1	Prime	
LL_108_EBS	36.6	Slightly Gravelly Sand	Preferred	9.6	88.7	Prime	
LL_109_SG	27.5	Sand	Preferred	16.7	82.5	Prime	
LL_110_SG	27.1	Muddy Sand	Unsuitable	41.5	57.6	Suitable	KP109 to KP111
LL_111_SG	35.2	Sand	Preferred	8	91.2	Prime	KP112 to KP123
LL_112_EBS_SS	34.3	Sand	Preferred	15.7	83.3	Prime	
LL_113_SG	35.3	Sand	Preferred	11.6	88.2	Prime	
LL_114_SG	38.5	Sand	Preferred	20.7	78.4	Sub-Prime	
LL_115_SG	34.2	Sand	Preferred	25.6	74	Sub-Prime	
LL_116_EBS	35.2	Muddy Sand	Unsuitable	40.5	59.2	Suitable	KP124 to KP128
LL_117_SG	24.7	Muddy Sand	Unsuitable	40	60	Suitable	
LL_118_SG	32.5	Sand	Preferred	12.5	87.2	Prime	KP129 to KP133
LL_119_SG	23	Sand	Preferred	28.3	71.2	Sub-Prime	
LL_120_EBS	34	Gravelly Muddy Sand	Unsuitable	49.2	38	Unsuitable	KP134 to KP 136

Station	Water Depth (m)	Modified Folk Scale	Habitat Preference Latto et al. (Ref 34)	Silt and Fine Sands (% by weight)	Medium to Coarse Sands (% by weight)	Habitat Preference Greenstreet et al. (Ref 35)	KP along Proposed Offshore Scheme
LL_121_SG	32	Slightly Gravelly Muddy Sand	Unsuitable	32.3	65.4	Suitable	KP137 to KP139
LL_122_SG	20.7	Sand	Preferred	20.2	79.7	Sub-Prime	KP140 to KP151
LL_124_SG	30.4	Sand	Preferred	31.1	68.8	Suitable	
LL_125_EBS	31.4	Sand	Preferred	41.6	57.5	Suitable	
LL_126_SG	30	Sand	Preferred	40.2	59.6	Suitable	
LL_127_SG	22.3	Sand	Preferred	46	53.7	Suitable	
LL_128_SG	30.4	Gravelly Muddy Sand	Unsuitable	47.3	45.5	Unsuitable	KP152 to KP154
LL_129_EBS	31	Slightly Gravelly Sand	Preferred	51.5	47.5	Unsuitable	KP155 to KP158
LL_130_SG	37.7	Sand	Preferred	54.7	45.3	Unsuitable	
LL_131_SG	28.6	Muddy Sand	Unsuitable	70.3	29.2	Unsuitable	KP159 to KP161
LL_132_SG	27.3	Sand	Preferred	59.8	39.4	Unsuitable	KP162 to KP168
LL_133_EBS	27.4	Sand	Preferred	56.8	43.2	Unsuitable	
LL_134_SG	29	Sand	Preferred	71.7	28.1	Unsuitable	
LL_135_SG	29	Muddy Sand	Unsuitable	82.5	17.2	Unsuitable	KP169 to KP177
LL_137_SG	29.7	Muddy Sand	Unsuitable	91.1	8.7	Unsuitable	
LL_138_EBS	29	Muddy Sand	Unsuitable	93.1	6.7	Unsuitable	

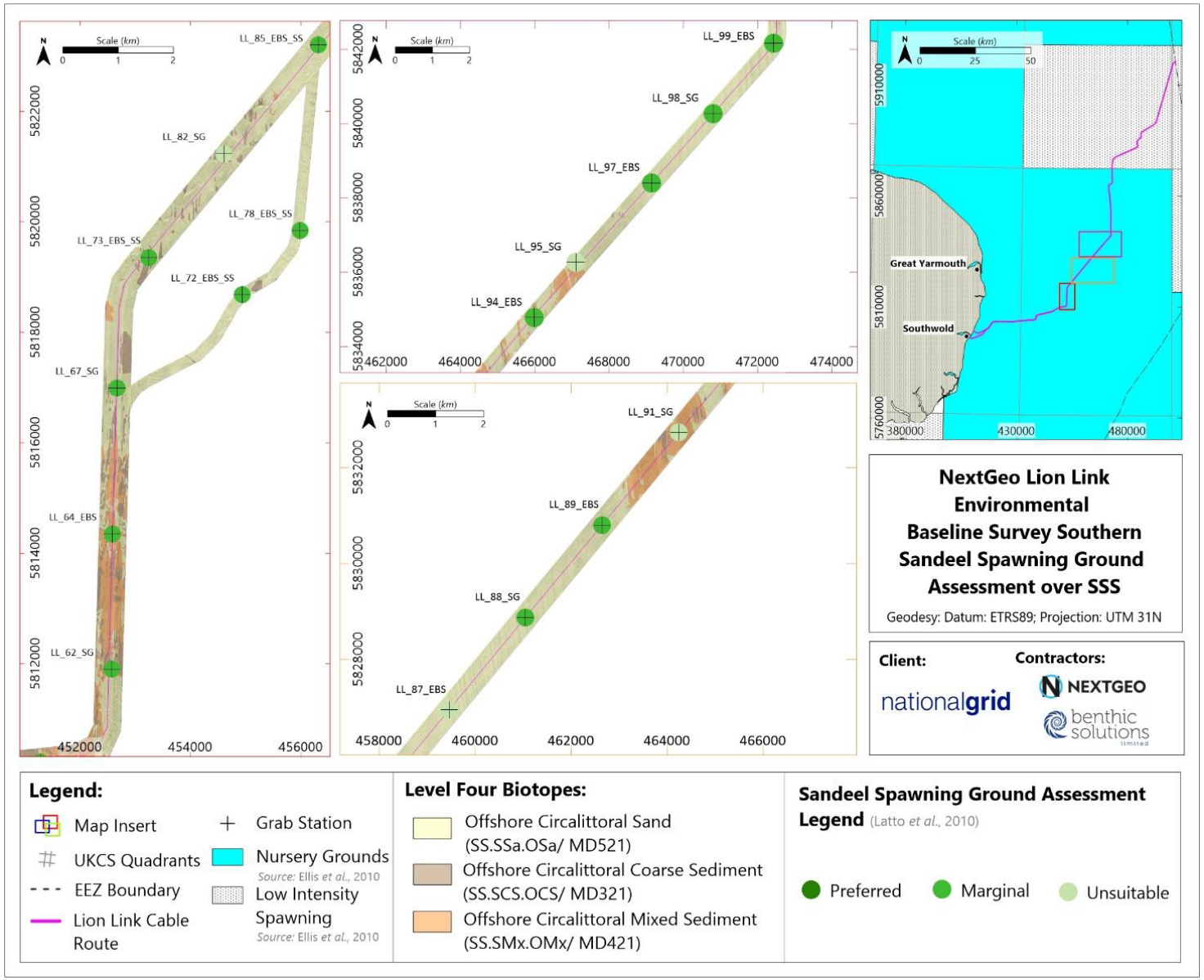
Inset 3.8: Sandeel spawning and nursery grounds per Latto et al. (Ref 34) within survey block 19 to block 14



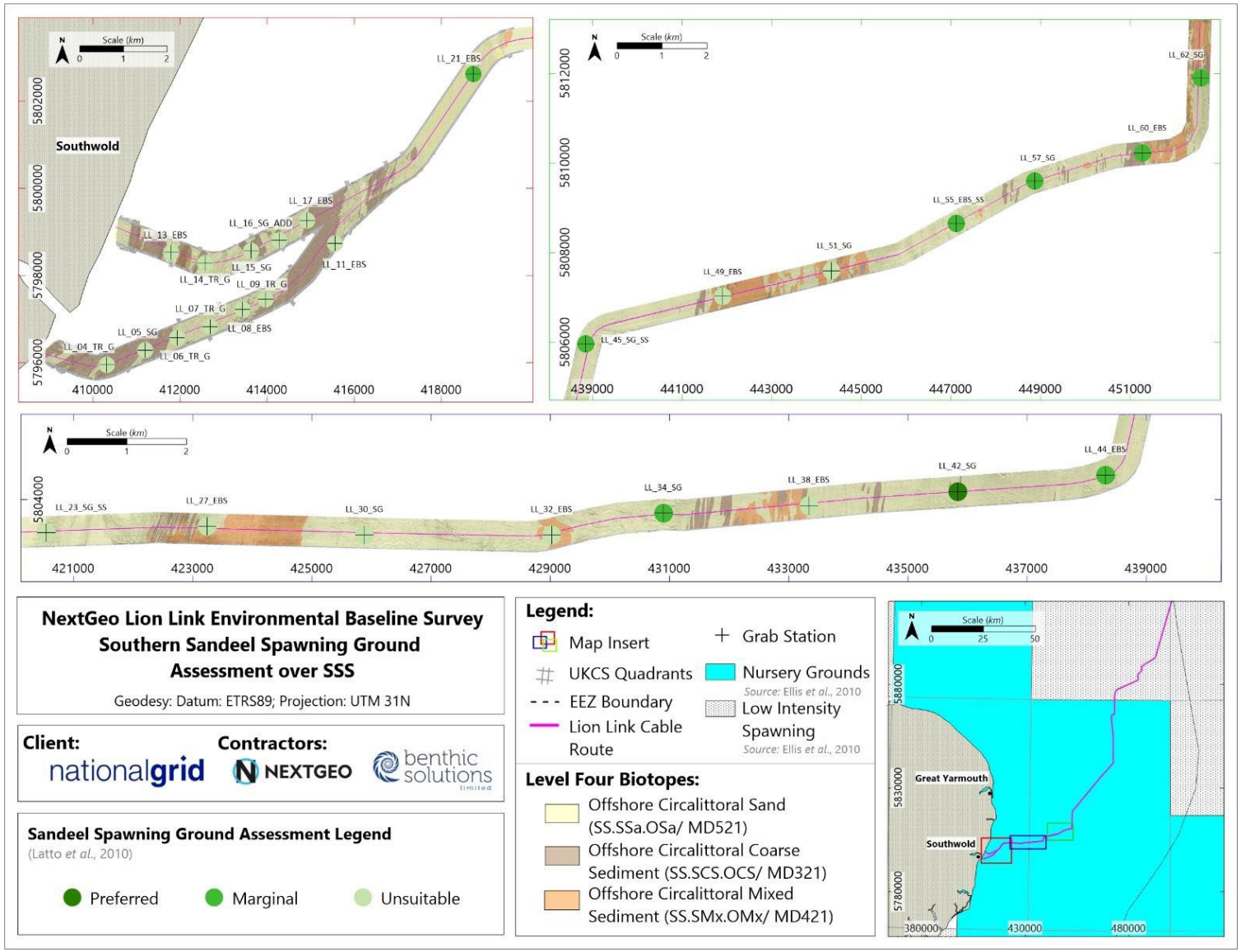
Inset 3.9: Sandeel spawning and nursery grounds per Latto et al. (Ref 34) within survey block 14 to block 11.



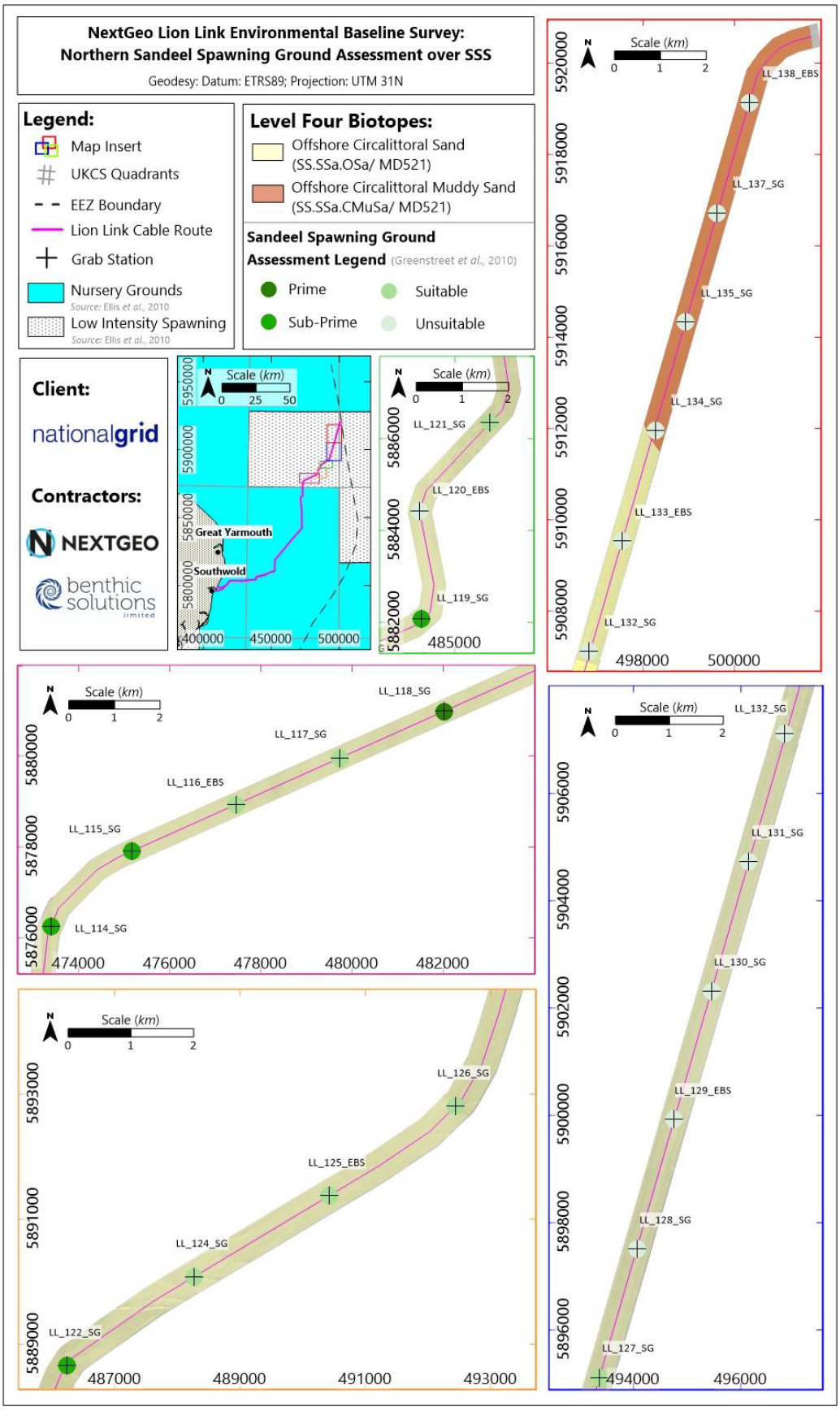
Inset 3.10: Sandeel spawning and nursery grounds per Latto et al. (Ref 34) within survey block 11 to block 9.



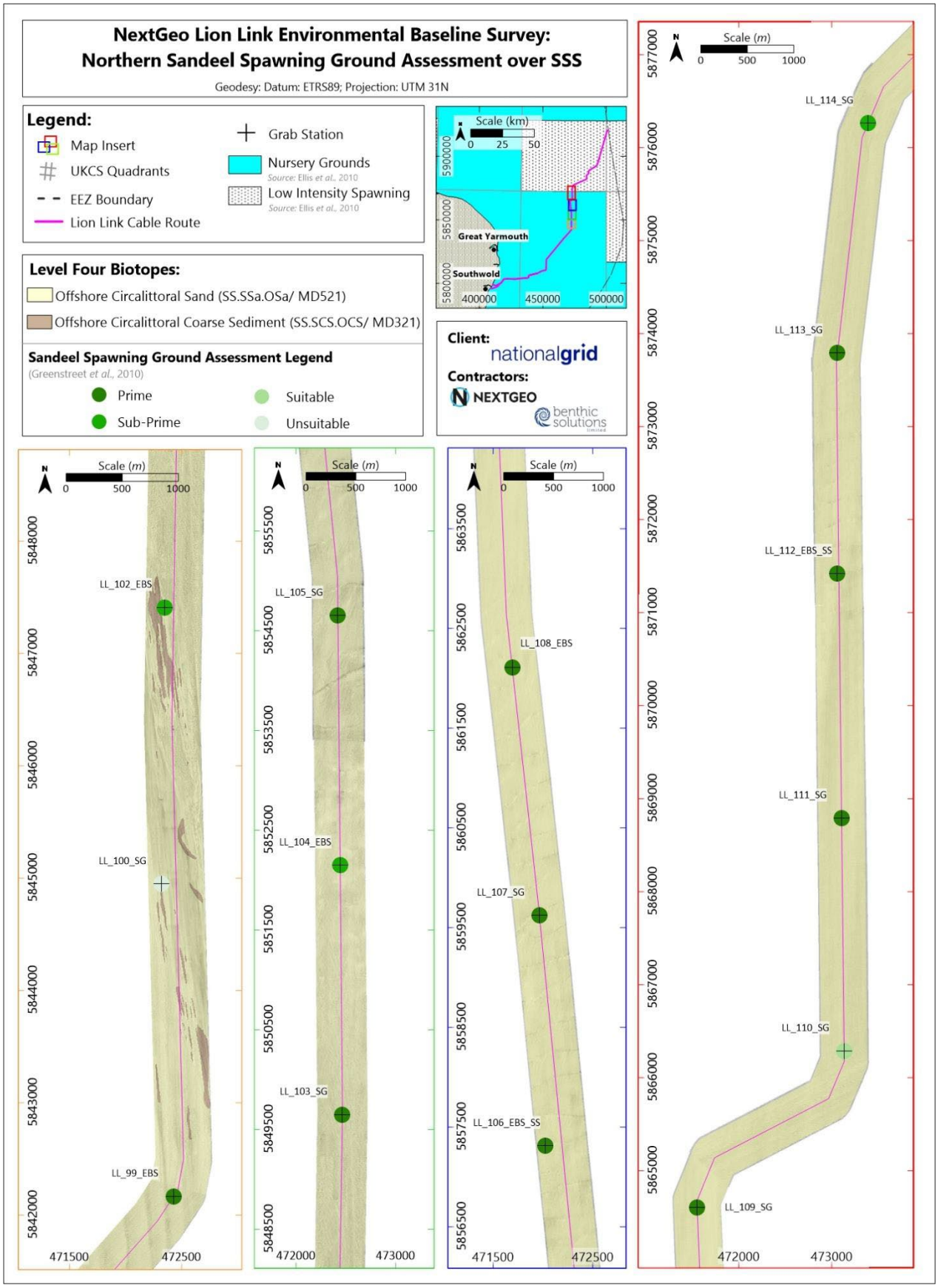
Inset 3.11: Sandeel spawning and nursery grounds per Latto et al. (Ref 34) within survey block 9 to block 3.



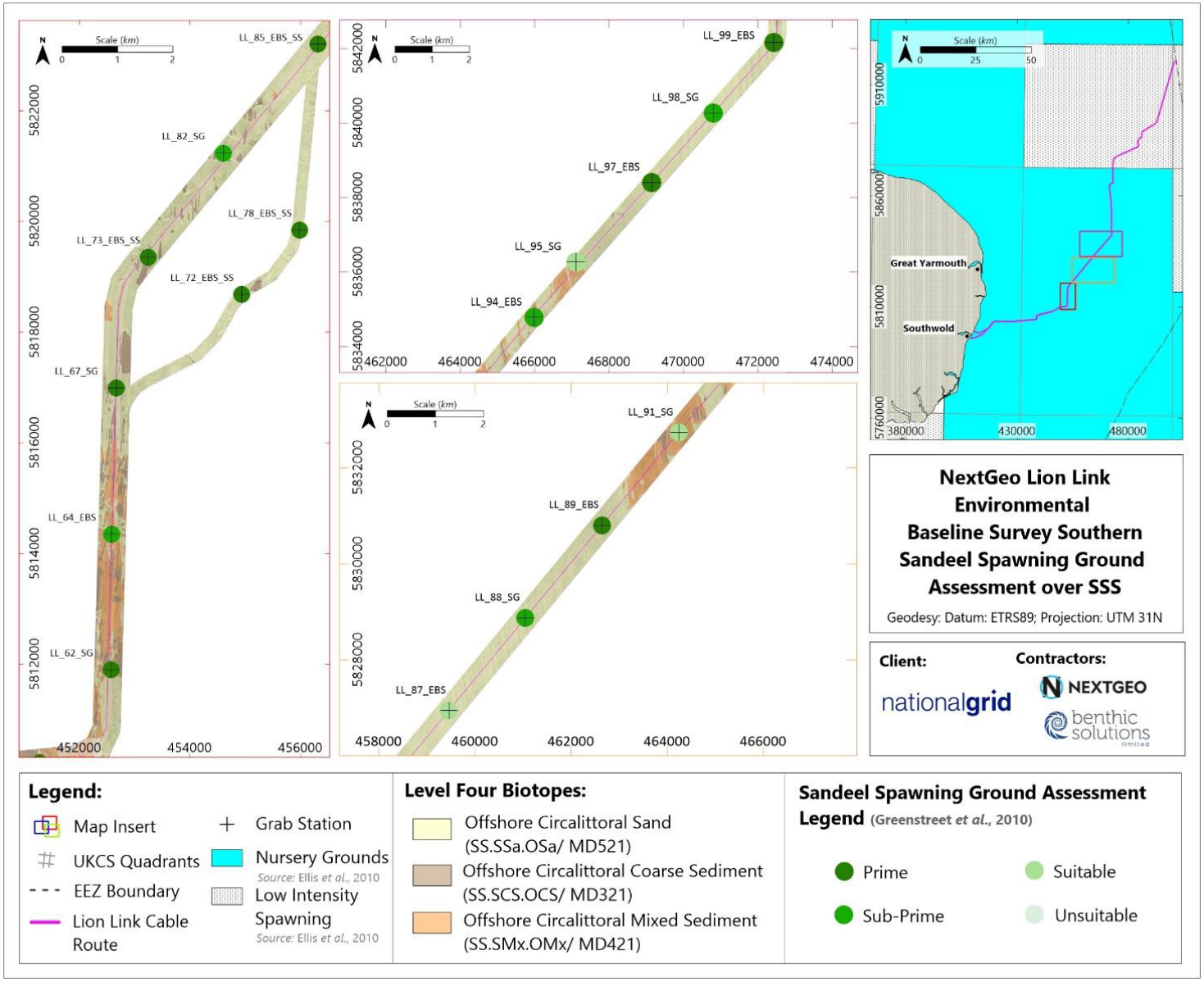
Inset 3.12: Sandeel spawning and nursery grounds per Greenstreet et al. (Ref 35) within survey block 19 to block 14.



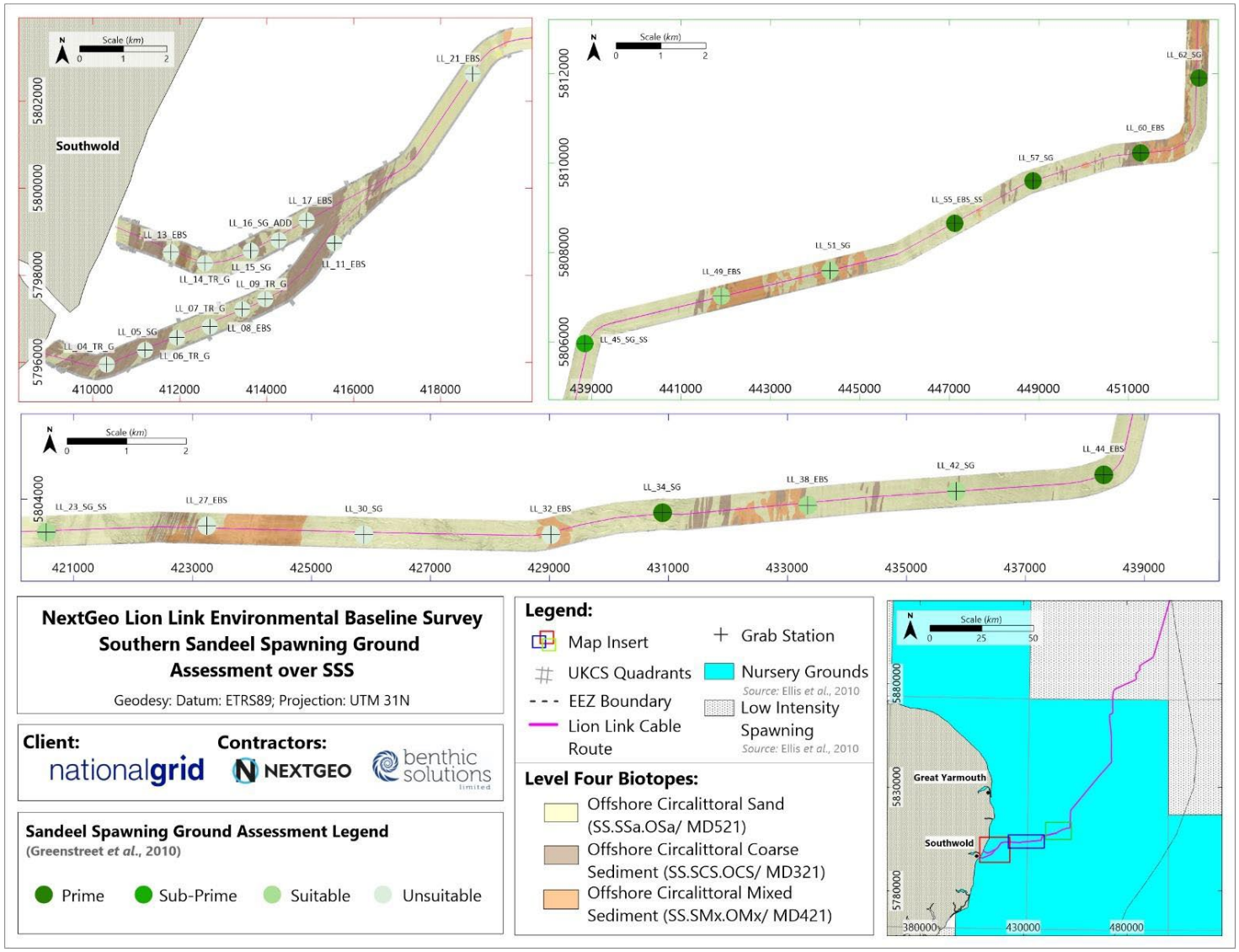
Inset 3.13: Sandeel spawning and nursery grounds per Greenstreet et al. (Ref 35) within survey block 14 to block 11



Inset 3.14: Sandeel spawning and nursery grounds per Greenstreet et al. (Ref 35) within survey block 11 to block 9



Inset 3.15: Sandeel spawning and nursery grounds per Greenstreet et al. (Ref 35) within block 9 to block 3



3.6 Summary

3.6.1 Based on the evidence presented as a results of the Greenstreet (Ref 35) analysis and considering other suitable variables such as temperature and seabed depth, it has been determined that 13 discrete sections along the Proposed Offshore Scheme are potentially prime or sub-prime habitat for sandeel totaling 99km. The majority of the 'Prime' and 'Sub-Prime' locations within the Proposed Offshore Scheme lie within the Norfolk and Suffolk spawning grounds, as defined by Coull *et al*. (Ref 4). The Proposed Offshore Scheme overlaps with the Norfolk and Suffolk spawning ground for approximately 76km; of this 53km has been classified as 'Prime' and/or 'Sub-Prime' sandeel habitat from acquired PSD data. For further detail on the conclusions of this assessment, please see **Section 5.2.**

4 Atlantic Herring Assessment

4.1 Overview

4.1.1 Atlantic herring (*Clupea harengus*) (hereafter referred to as 'herring') are listed as principal species of importance in England under Section 41 of the National Environment and Rural Communities Act (2006), meaning that they are of principal importance for the purpose of conserving or enhancing biodiversity (Ref 44; Ref 15).

4.1.2 Herring are a widespread streamlined pelagic species occurring throughout the northeast Atlantic continental shelf seas to depths of up to 200m (Ref 45). Herring are one of the five clupeids occurring in the North Sea (Ref 46). In the Atlantic Ocean herring are commonly recognised as an important food source for many seabirds, fish, and marine mammals (Ref 47) and have been identified as a key prey species for highly selective birds including Atlantic puffin (*Fratercula arctica*) and terns (Sternidae sp.) during their breeding season (Ref 48).

4.1.3 In recognition of the importance of herring, it is important that the Applicant identifies the potential key areas for spawning and nursery habitat across the Proposed Offshore Scheme. This is to ensure that a sufficient level of data is obtained to inform environmental impact assessment and understand the potential for any seasonal constraints to the construction, operation & maintenance and decommissioning phases of the Proposed Offshore Scheme. PSD data was collected as part of the benthic ecology characterisation survey and was used to inform the location of potential herring spawning habitats across the Proposed Offshore Scheme.

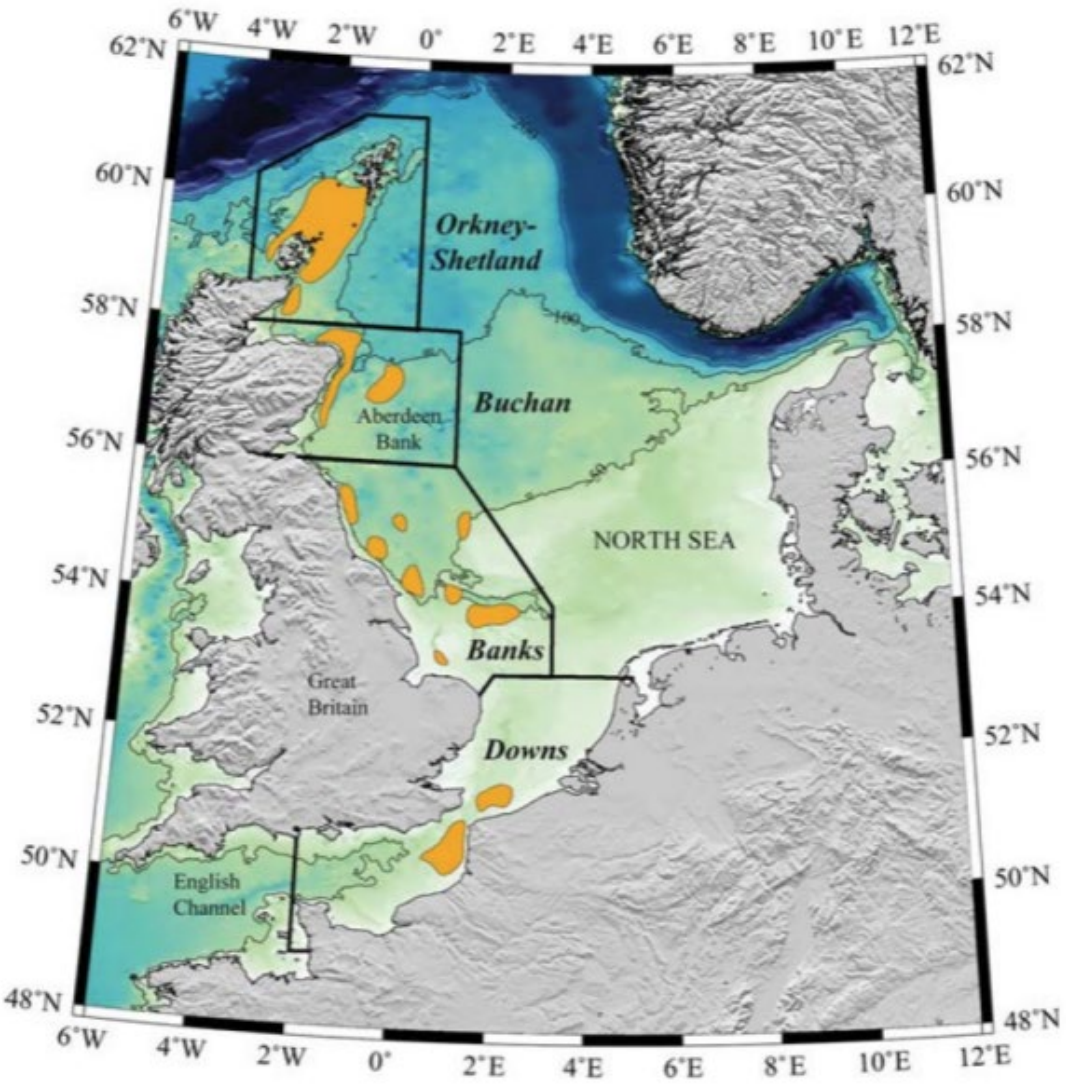
4.2 Baseline

4.2.1 Herring share foraging grounds, but stocks are identified through discrete spawning grounds. There are four main autumn/winter-spawning populations of herring located across the North Sea (**Inset 4.1**), alongside several discrete spring-spawning stocks. The autumn-spawning grounds include the Orkney-Shetland population, the Buchan population, the Banks (or Dogger) population and the Downs / Southern Bight population (Ref 37; Ref 49) and are characterised by different growth rates, recruitment patterns and migration routes. The Proposed Offshore Scheme crosses the Downs autumn spawning grounds (Ref 50).

4.2.2 Herring form dense shoals which lay their eggs on a variety of substrates ranging from boulders and rocks to gravel. The species has a strong preference to several factors in particular substrate type. Gravels and coarse sands are favoured; thus, herring spawn preferentially on specific substrate which makes the species' spawning grounds vulnerable to seabed disturbance.

4.2.3 Herring are a highly commercial fish and have provided coastal communities with economic benefits for many years (Ref 51). Although herring populations are known to naturally fluctuate over time, poor management and human exploitation has led to past stock collapses. They require specific sediment conditions for key periods of their life cycle and are therefore vulnerable to seabed disturbance from activities such as cable trenching. Following the decline of herring, management regimes have been implemented to stabilise the species' populations and sustain habitats. ICES implemented a long-term recovery plan in 1996 for herring across the North Sea. These measures aim to reduce fishing mortality and limit the overall annual catch. 'Atlantic herring boxes' exist along the Danish northwest coast to protect juvenile herring from being caught, and along the Northumberland and North Yorkshire coast of England to protect vulnerable spawning grounds (Ref 52).

Inset 4.1: Distribution of herring spawning populations recorded in UK waters (Ref 49)



4.3 Atlantic herring lifecycle

4.3.1 Herring are a foraging fish species which can grow up to lengths of 40cm and are characterised by their silver colouring and bluish back (Ref 53). The species tends to migrate between spawning, overwintering and feeding grounds, maintaining a similar migration pattern from year to year (Ref 54). Herring are seabed spawners and traditionally spawn along shallow coastal areas (15-40m depth) or offshore banks down to 200m, where they deposit dense mats of sticky eggs on to coarse sand and gravel. Depending on water temperature eggs hatch after 1-3 weeks (Ref 55; Ref 4). Herring larvae that have hatched in the autumn are usually 4-9mm long, tend to drift landwards during their first winter as a result of the prevailing water currents, and end up in the Western North Sea nursey grounds. Juveniles are found in shallow waters and move into deeper waters after two years, joining large shoals. However, this movement is dependent on the abundance and composition of zooplanktonic food organisms (Ref 57). Herring shoals tend to remain close to the seafloor or in deep waters during the day. The species perform diurnal vertical migrations through the water column, moving up towards the surface at twilight and dispersing near the surface over a wide area during the night when light intensity is low (Ref 49). These movements are thought to be related to the maturation cycle, or the availability of key prey species (Ref 55, Ref 56).

4.3.2 The species are often found in vast shoals in near-surface waters during spawning seasons, which occur at different times throughout the year depending on the spawning area.

4.4 Atlantic herring habitat preference

4.4.1 Herring rely on specific benthic habitats to reproduce. The species typically spawn on coarse substrates (e.g., gravel, coarse sand, fragmented shell, shingle and macrophytes), in environments with well oxygenated waters, high aeration, strong currents and low proportions of fine sediment (Ref 58). Although deeper spawning grounds have been recorded, herring spawning generally occurs in relatively shallow depths of between 15m and 40m (Ref 59). These dynamic environments reduce the accumulation of silt and provide aeration (Ref 60). Stevenson & Scott (Ref 60) observed that herring eggs covered by a ‘thin film’ of sediment were subject to an 85% mortality rate, whilst a 1cm covering of sediment resulted in 100% mortality. The high structural complexity of spawning habitats for herring are considered to lower egg mortality and provide juvenile fish species with the optimal habitat to survive (Ref 61). This makes herring particularly vulnerable to environmental changes and habitat alterations from anthropogenic activities affecting the seabed (Ref 58). Herring populations naturally fluctuate annually, and the species often leave and later return to suitable habitats (Ref 49), and therefore it is important to maintain the status of suitable habitats to sustain herring populations.

4.4.2 Sediment particle size alongside other influencing factors, determines the suitability of the seabed substrates as a spawning ground for herring. Kyle-Henney et al., (Ref 58) categorise seabed substrates into four herring sediment preference groups following the Folk (Ref 36) classification. Preferred spawning habitat for herring has been identified as a 'high gravel content' where the majority (>50%) of the sediments are comprised of gravel with minimal (<5%) fines such as mud, silt and clay (Ref 58) (**Table 4.1**).

4.4.3 The Folk sediment classes which are considered to describe the preferred habitat for herring in UK waters are:

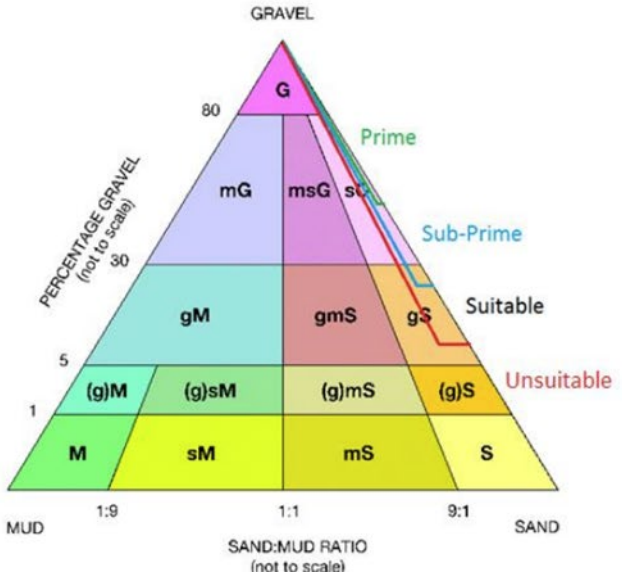
a. Gravel, G
b. sandy Gravel, sG
c. gravelly Sand, gS

4.4.4 It should be noted that gravelly Sand, denoted as (g)S is considered to be unsuitable substrate for herring due to its higher sand and lower gravel content (Ref 58).

Table 4.1: Herring spawning ground assessment categories specified by Reach et al (Ref 39)

Herring Habitat Sediment Preference	Mud Content (% by weight)	Gravel Content (% by weight)	Habitat Sediment Classification	Folk (Ref 36) Sediment Unit(s)
Prime	<5% Mud	>50% gravel	Preferred	Gravel and part sandy Gravel
Sub Prime	<5% Mud	>25% gravel	Preferred	Part sandy Gravel and part gravelly Sand
Suitable	<5% Mud	>10% gravel	Marginal	Part gravelly Sand
Unsuitable	>5% Mud	<10% gravel	Unsuitable	Everything excluding Gravel, part sandy Gravel and part gravelly Sand

Inset 4.2: Folk triangle highlighting preferred habitats for herring (Ref 34; Ref 62; Ref 37).



M	Mud
sM	Sandy mud
(g)M	Slightly gravelly mud
(g)sM	Slightly gravelly sandy mud
gM	Gravelly mud
S	Sand
mS	Muddy sand
(g)S	Slightly gravelly sand
(g)mS	Slightly gravelly muddy sand
gmS	Gravelly muddy sand
gS	Gravelly sand
G	Gravel
mG	Muddy gravel
msG	Muddy sandy gravel
sG	Sandy gravel

4.5 Existing habitat

Spawning and Nursery Grounds

4.5.1 According to Ellis et al. (Ref 37), understanding the distribution and abundance of spawning and nursery grounds is key for the management of key prey species' habitats. Seasonal restrictions have been implemented on many offshore wind farms' activities to limit disturbances from anthropogenic activities on spawning fish and to protect eggs and stages of larval development.

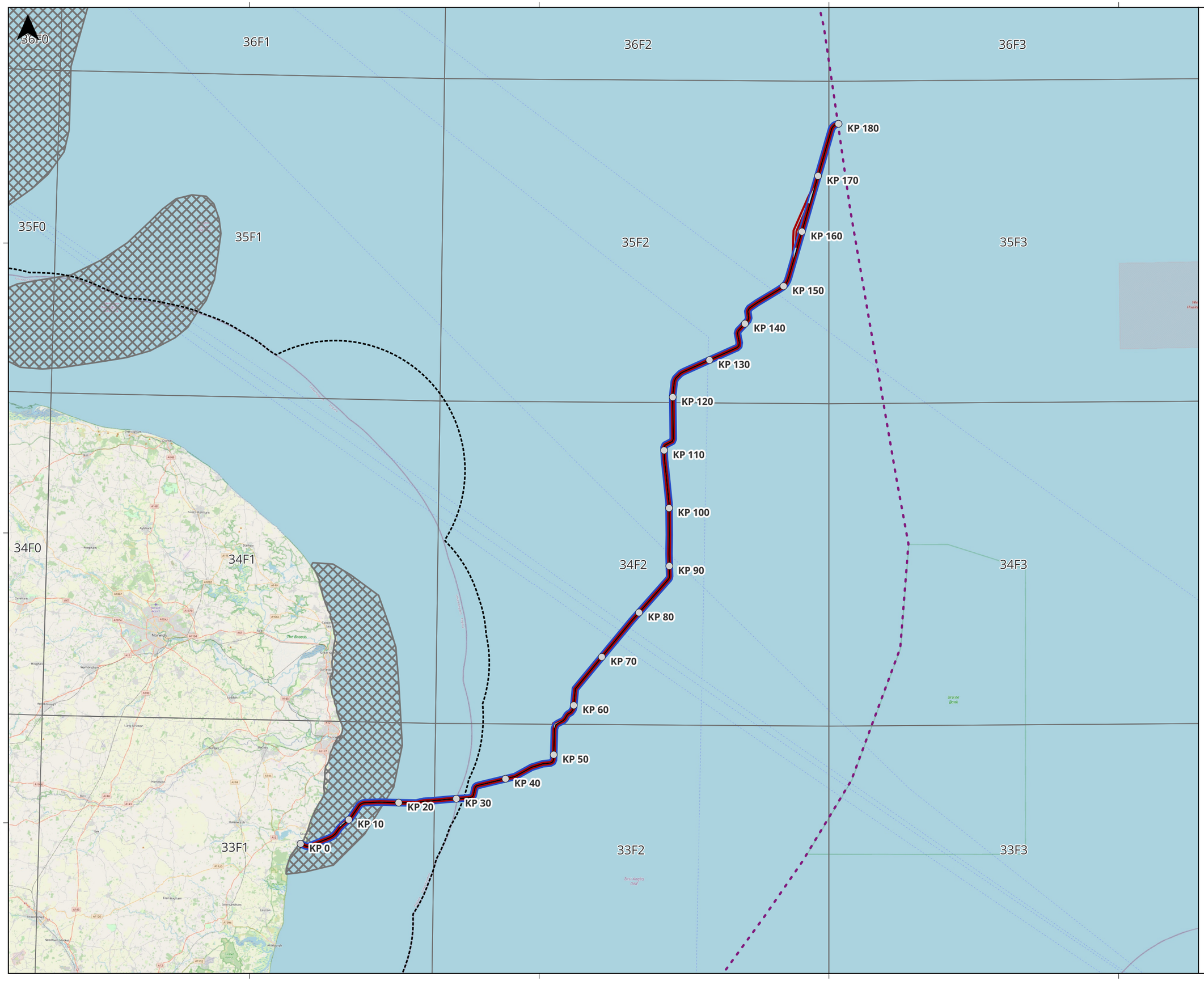
4.5.2 In line with the updated methodology for identifying potentially suitable habitat for herring described by Kyle-Henney et al. (Ref 58), spawning grounds identified by Coull et al. (Ref 4) have been used without the additional nursery ground intensity assessed by Ellis et al. (Ref 37). It is considered that the Ellis et al. (Ref 37) datasets replicate the findings of the Coull et al. (Ref 4) reports but relate them to ICES rectangles rather than preferred benthic habitat. Assessment in relation to preferred benthic habitat is considered to be of greater value to this report.

4.5.3 The Proposed Offshore Scheme crosses one herring spawning ground identified by Coull et al. (Ref 4): the Norfolk coast (part of the Downs grounds) (**Inset 4.3**).

4.5.4 **Table 4.2** provides the length of the Proposed Offshore Scheme within the spawning ground, giving KPs as location references. To ensure the whole spawning ground was considered, the nearest KP to the outermost boundary of the spawning grounds was used.

Table 4.2: Extent of Proposed Offshore Scheme within herring spawning grounds as defined by Coull et al. (Ref 4)

KP at start point	KP at end point	Length of Proposed Offshore Scheme (km)
0	15	15



A3

- Proposed Offshore Scheme Draft Order Limits
- Cable Route
- KP
- 500m Study Area
- ICES Statistical Rectangle
- Herring Spawning Ground
- 12NM Limit
- EEZ

Coordinate System: ETRS89 / UTM zone 31N

Kilometres

0 10 20 30

Rev	Date	By	Chkd	Appd	Authd
P01	15/07/2025	AN	JC	AC	DS

collaborative environmental advisers

Project Name

LIONLINK

Client

National Grid LionLink Limited (NGLLL)

Drawing Title

Inset 4-3 Herring Spawning Grounds

Scale at A3

1:600,000

Role

Environment

Suitability

S2

Project Number

C01467

Rev

P01

Drawing Number

LLK1-CEA-DWG-ENV-00106

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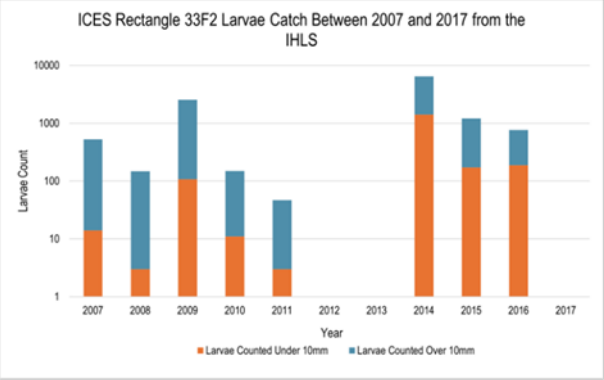
International Herring Larvae Surveys (IHLS)

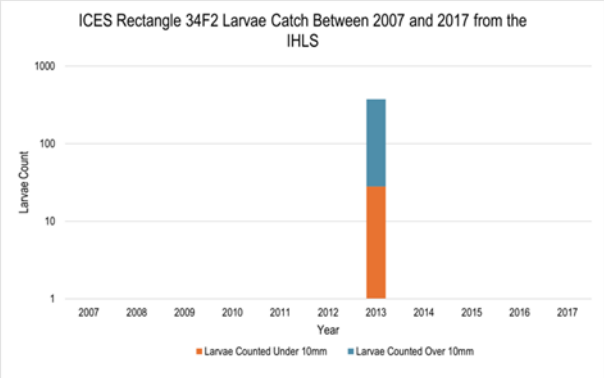
4.5.5 It is noted that the Coull et al., (Ref 4) data is relatively old and requires ground truthing, therefore the IHLS has been used as a data source to assess spawning activity in the Proposed Offshore Scheme and support observations from older datasets. The ICES programme of IHLS in the North Sea and adjacent areas has been in operation since 1967. The main purpose of the programme is to provide quantitative estimates of herring larval abundance, which are used as a relative index of changes of the herring spawning-stock biomass in the assessment. The database contains information from surveys conducted since 1972 (Ref 3).

4.5.6 The Proposed Offshore Scheme crosses five ICES rectangles namely: 33F1, 33F2, 34F2, 35F2 and 35F3 (see **Figure 24.1 Commercial Fisheries Study Area** of this PEIR). It should be noted that IHLS survey data is not available for all of the rectangles. It should also be noted that this report has used the most recent data accessible. It is recognised that it would be preferable to analyse at least 10 years' worth of data in order to identify trends. However, survey effort for the IHLS surveys has shifted away from the Downs spawning grounds since 2017 and so herring larvae would be under-represented in data collected since 2017 and would not be comparable to earlier data to enable analysis of the period 2014-2024 (Ref 58). Therefore, the data studied for this report covers the period 2007 – 2017.

4.5.7 The surveys collect herring larvae, which are measured to record the proportion of the catch which is over or under 10mm in length. Larvae that are <10mm, often with the yolk sac still attached and linked with the benthos are classed as 0-ringer larvae (Ref 58). This is a known indicator of herring spawning. The larvae surveys are carried out in specific periods and areas, following autumn and winter spawning activity of herring from north to south. **Inset 4-4** provides figures for IHLS data between 2007 and 2017 for the relevant ICES rectangles. Broadly, ICES rectangle 33F1 represents the proposed Landfall. ICES rectangles 33F2, 34F2, 35F2 and 35F3 contain the remaining length of the Proposed Offshore Scheme, with 35F3 also marking the EEZ limit. The location of the ICES rectangles in relation to the Proposed Offshore Scheme is presented in **Inset 4-3**.

Inset 4.4: IHLS larvae records for ICES rectangles 33F2 and 34F2 between 2007 and 2017 (Ref 3).



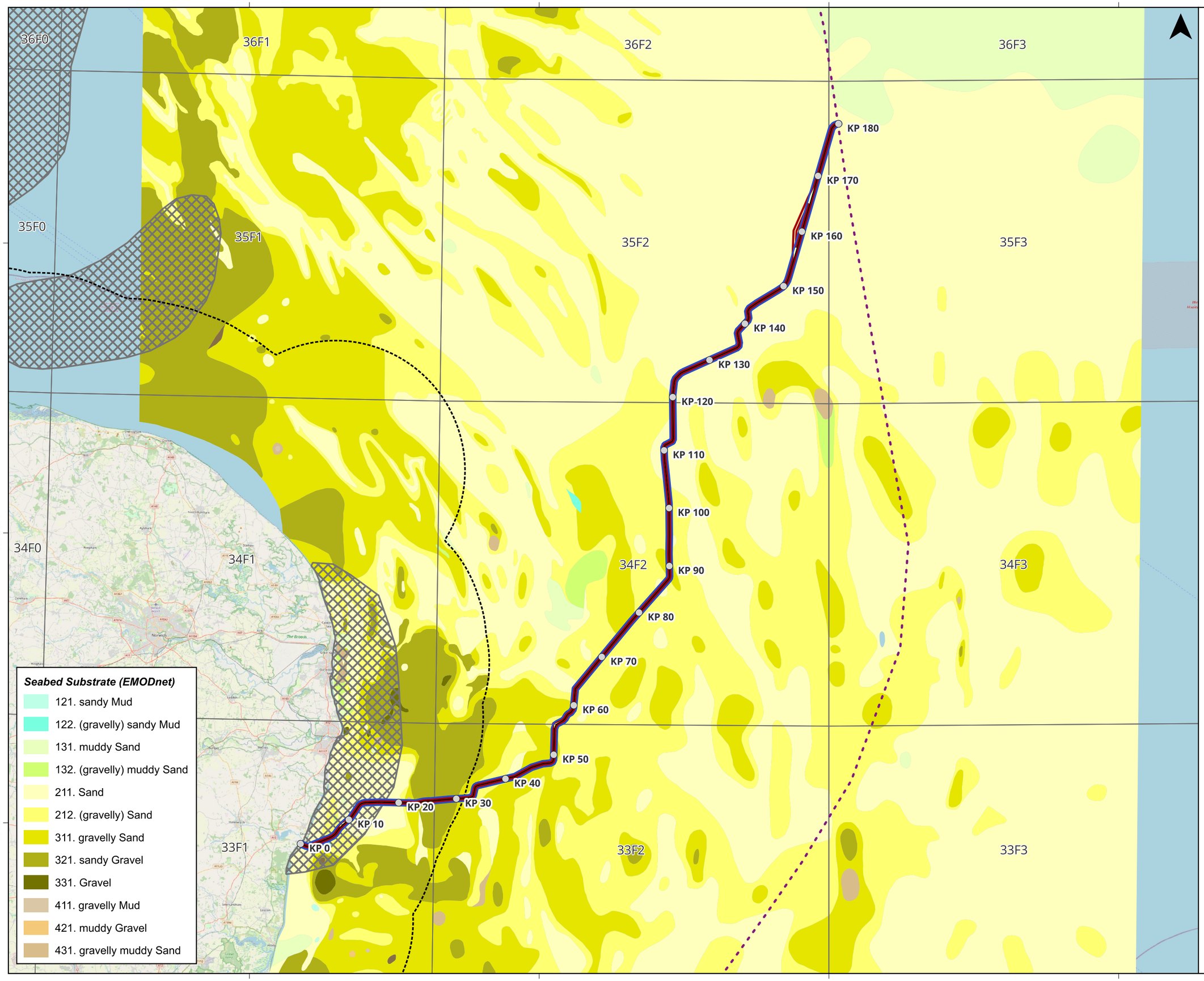


4.5.8 The data broadly suggests that the area between KP23 and KP52 (i.e., within ICES rectangle 33F2) has been consistently associated with larval counts under 10mm since approximately 2014, indicating that this area may be used as a spawning ground. Prior to 2014, larval counts over 10mm were dominant, indicating a shift from non-spawning to spawning ground over this area. This does not overlap with the recorded Coull et al. (Ref 4) spawning grounds, highlighting the necessity for ground-truthing the area.

Suitability of seabed sediments

4.5.9 Publicly available seabed sediment data from the EMODnet Geology Folk 16 classification has been analysed using GIS software (QGIS) to provide an overview of seabed sediment types within the Proposed Offshore Scheme (Ref 6) following the methodology described by Kyle-Henney et al. (Ref 58).

4.5.10 **Inset 4.5** identifies areas of potentially suitable seabed sediments for herring which are crossed by the Proposed Offshore Scheme. The dominant habitat type identified across much of the Proposed Offshore Scheme is Sand, which is unlikely to be suitable habitat for herring, as discussed above. However, there are some areas of preferred and marginal habitats interspersed, consisting of gravelly Sand (marginal) and sandy Gravel (preferred) (Ref 58).



A3

- Proposed Offshore Scheme Draft Order Limits
- Cable Route
- KP
- 500m Study Area
- ICES Statistical Rectangle
- Herring Spawning Grounds
- 12NM Limit
- EEZ

Coordinate System: ETRS89 / UTM zone 31N

Kilometres

0 8 16 24

Rev	Date	By	Chkd	Appd	Authd
P01	15/07/2025	JC	AN	AC	DS

collaborative environmental advisers

Project Name

LIONLINK

Client

National Grid LionLink Limited (NGLLL)

Drawing Title

Inset 4-5 Identification of potentially suitable areas of herring habitat along the proposed LionLink cable route using EMODnet Folk 16 seabed sediment data

Scale at A3

1:600,000

Role

Environment

Suitability

S2

Project Number

C01467

Rev

P01

Drawing Number

LLK1-CEA-DWG-ENV-00107

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4.5.11 The inlays on **Inset 4.5**: identify areas of 'gravelly Sand' and 'sandy Gravel' at different points along the Proposed Offshore Scheme (approximately between KP18 – KP58). Near to the proposed Landfall, the seabed sediments primarily consist of 'Sand' and 'slightly gravelly Sand', which are considered unlikely to provide suitable habitat for herring, shown in the bottom left inlay in **Inset 4.5:**, although it should be noted that this area is identified by Coull et al. (Ref 4) as a herring spawning ground.

4.5.12 **Table 4.3** provides a detailed breakdown of the sections of the Proposed Offshore Scheme which cross various sediment types which have been identified as potentially suitable for herring.

Table 4.3: Extent of Proposed Offshore Scheme within sediments suitable for herring habitat based on seabed sediment data (Ref 6)

Location (KPs)	EMODNet Folk 16 Sediment Type
0 - 3	Sand
3 – 4	gravelly Sand
4 – 5	gravelly sandy Mud
5 – 8	gravelly Sand
8 – 13	Sand
13 -14	gravelly Sand
14 – 18	Sand
18 - 20	gravelly Sand (marginal)
20 - 27	sandy Gravel
27 – 29	gravelly Sand (marginal)
29 - 37	gravelly Sand
37 – 39	Sand
39 - 51	gravelly Sand (marginal)
51 – 54	gravelly Sand
54 - 57	gravelly Sand (marginal)
57 – 59	gravelly Sand
59 – 61	Sand
61 – 72	gravelly Sand
72 - 76	gravelly Sand (marginal)
76 – 82	gravelly Sand
82 – 84	Sand

Location (KPs)	EMODNet Folk 16 Sediment Type
84 – 85	gravelly Sand
85 - 89	gravelly Sand (marginal)
89 – 90	gravelly Sand
90 - 92	Sand
92 – 101	gravelly Sand
101 – 177.154	Sand

Bathymetry

4.5.13 **Inset 4-6** shows the Proposed Offshore Scheme in relation to regional bathymetry to determine whether there are any areas which have the potential to provide more favourable habitat for herring based on water depth. Publicly available bathymetry data was downloaded from EMODnet (Ref 7) and analysed within GIS software (QGIS). As previously discussed, herring have been observed to prefer relatively shallow water depths for spawning of between 15m - 40m (Ref 59).

4.5.14 As expected, shallower areas are apparent closer to the coast, with the area extending offshore from the proposed Landfall remaining below 10m water depth until approximately 1km offshore. This area immediately offshore is therefore likely to provide the most suitable habitat for herring from the perspective of water depth. The Proposed Offshore Scheme is partially within a herring spawning area identified by Coull et al. (Ref 4) from approximately KP0 to KP15, within which water depth increases to approximately 30m.

Environmental data

4.5.15 When spawning, herring prefer environments with highly oxygenated waters as it is understood that egg survival and hatching success is improved with increasing concentrations of dissolved oxygen (Ref 1). Recent data released by EMODnet (Ref 12) displays the seafloor dissolved oxygen levels in **Inset 4.7**. There are higher levels of seafloor dissolved oxygen nearer to shore from KP0 to KP15 (**Inset 4.7**) likely as a result of dynamic physical conditions (e.g., currents and mixing) and photosynthesising plankton. Beyond KP15, the seafloor dissolved oxygen levels gradually reduce from 274.75 µmol/l to 273.94 µmol/l. This demonstrates the potential correlation between the herring spawning grounds defined by Coull et al. (Ref 4) with the higher levels of seafloor dissolved oxygen nearshore.

4.5.16 Seafloor temperatures have been observed to be of importance for herring spawning and hatching (Ref 54). Preferred spawning temperatures range from 5-14°C. Embryo mortality can occur at temperatures below 1.3°C or above 22°C.

Inset 4.7 suggests that the entire extent of the Proposed Offshore Scheme is appropriate for herring spawning from a temperature perspective.

400000
450000
500000
550000

5900000
5850000
5800000

KP 180
KP 170
KP 160
KP 150
KP 140
KP 130
KP 120
KP 110
KP 100
KP 90
KP 80
KP 70
KP 60
KP 50
KP 40
KP 30
KP 20
KP 10
KP 0

Proposed Offshore Scheme Draft Order Limits
Cable Route
KP
500m Study Area
Herring Spawning Grounds
12NM Limit
EEZ

A3

Coordinate System: ETRS89 / UTM zone 31N

Kilometres
0 8 16 24

Rev	Date	By	Chkd	Appd	Authd
P01	15/07/2025	JC	AN	AC	DS

collaborative environmental advisers

Project Name

LIONLINK

Client
National Grid LionLink Limited (NGLLL)

Drawing Title
Inset 4-6
Bathymetry across the Study Area in relation to the Herring spawning area

Scale at A3
1:600,000

Role
Environment

Suitability
S2

Project Number
C01467

Rev
P01

Drawing Number
LLK1-CEA-DWG-ENV-00108

Bathymetry (m)
-100
-80
-70
-60
-50
-40
-30
-20
-10
-5

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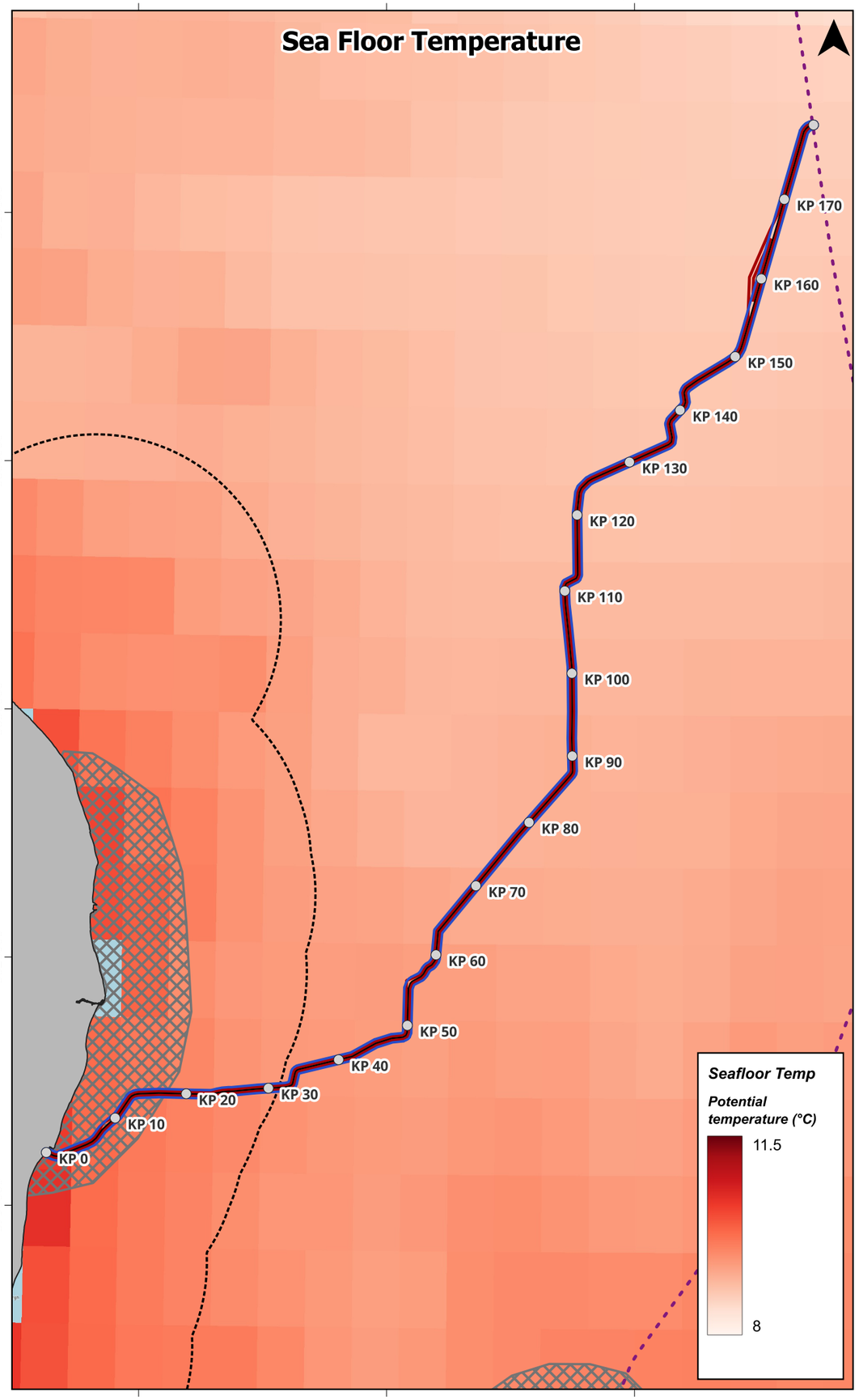

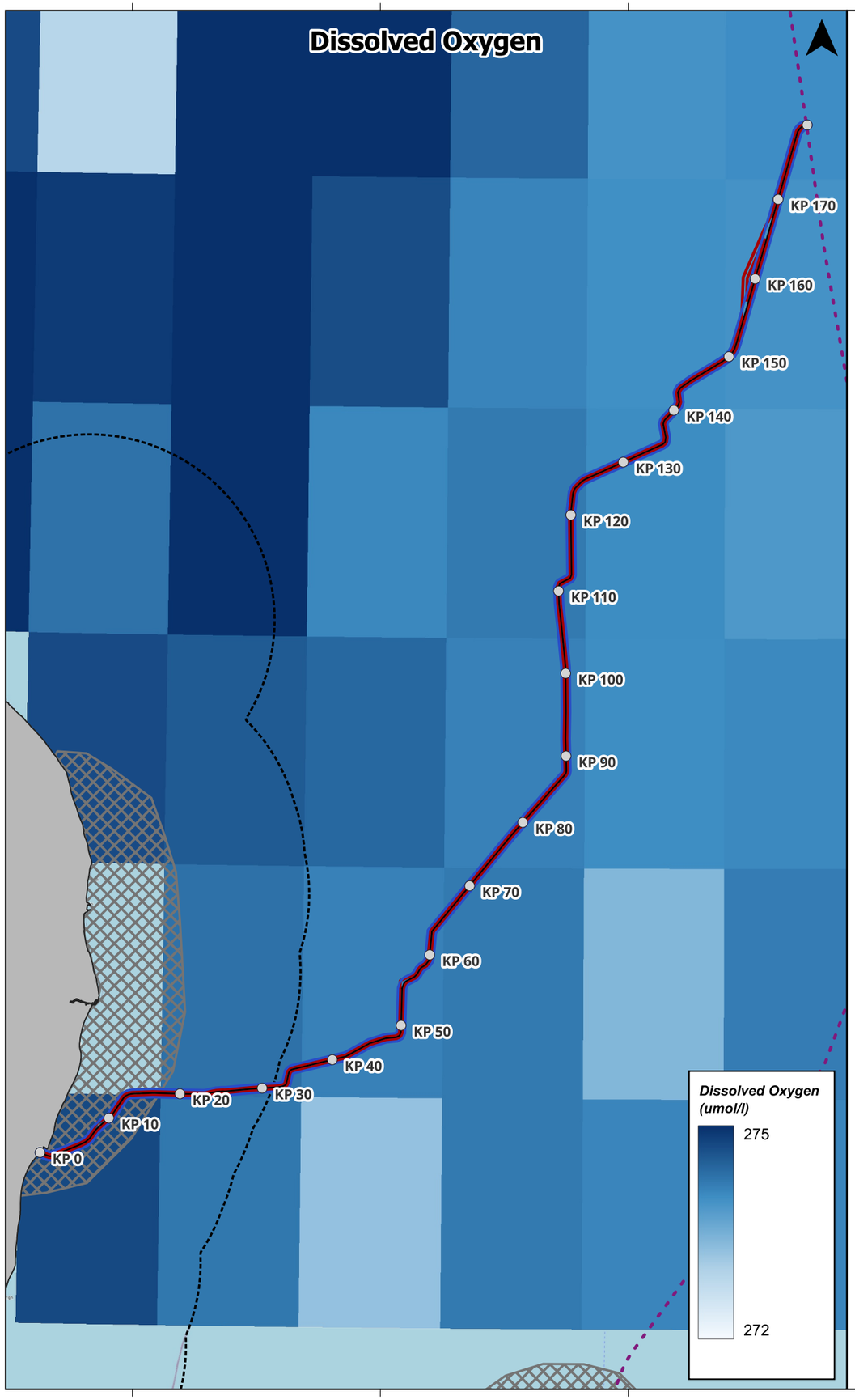

420000 450000 480000

5910000 5880000 5850000 5820000 5790000

A3

Proposed Offshore Scheme Draft Order Limits
Cable Route
KP
500m Study Area
Herring Spawning Grounds
12NM Limit
EEZ

Coordinate System: ETRS89 / UTM zone 31N

Kilometres
0 8 16 24

Rev	Date	By	Chkd	Appd	Authd
P01	02/07/2025	JC	AN	AC	DS

collaborative environmental advisers

Project Name

LIONLINK

Client
National Grid LionLink Limited (NGLLL)

Drawing Title
Inset 4-7
Seafloor temperature (°C) and seafloor dissolved oxygen levels (µmol/l) in relation to herring spawning grounds

Scale at A3
1:600,000

Role
Environment

Suitability
S2

Project Number
C01467

Rev
P01

Drawing Number
LLK1-CEA-DWG-ENV-00109

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Project specific survey data analysis

4.5.17 The presence of Atlantic Herring was noted in a single camera transect taken during the environmental baseline survey LL_23_TR taken at KP16.

Particle size analysis

4.5.18 Particle size distribution varied along the Proposed Offshore Scheme: the nearshore region (stations LL_01_EBS to LL_17_EBS) comprised mainly of fines (mean: 52.7%±26.0SD), with smaller proportions of sands (mean 33.3%±15.8SD) and gravel (mean 14.2%±23.6SD); the offshore sediments (stations LL_21_EBS to LL_138_EBS) comprised mainly of sands (mean: 86.5%±15.3SD), with smaller proportions of fines (mean: 7.79%±10.5SD) and gravel (mean: 5.69%±10.1SD).

4.5.19 Using the herring spawning ground assessment categories set out by Reach et al. (Ref 39), sample stations were categorised into 'Prime, 'Sub-Prime', 'Suitable or 'Unsuitable' for herring spawning (as per Table 4-1). 'Preferred' sediments for herring spawning grounds were identified at four stations, a single station was identified as 'Prime' (LL_03_TR) located within the nearshore section of the proposed Landfall approach in an area considered as high intensity nursery by Ellis et al (Ref 37). Three of these stations (LL_42_SG, LL_44_EBS and LL_62_SG) were defined as 'Sub-Prime' and occurred within offshore circalittoral coarse sediment habitats along the central section of the Proposed Offshore Scheme in an area defined for low intensity spawning by Ellis et al. (Ref 37). A single marginal station was identified at Station LL_01_EBS and was considered 'Suitable' on the basis of the low fines content but relatively lower proportion of Gravel at (c.17%).

4.5.20 All remaining stations were characterised as 'Unsuitable' for herring grounds due to the predominant proportions of sand and fine sediments. **Inset 4.8** to **Inset 4.11** show the stations where grab samples were acquired and their subsequent herring spawning classification as set out by Reach et al. (Ref 39). Very few stations were classified as a preferred sediment type for herring spawning and no consecutive stations were recorded suggesting that any sediment potentially suitable for herring spawning is infrequent and patchy along the Proposed Offshore Scheme **Inset 4.8** to **Inset 4.11** are taken directly from the benthic survey report which can be found in full in **Appendix 19.1 Benthic Survey Report** of this PEIR.

Table 4.4: Station suitability for herring spawning using the metric presented in Reach et. al. (Ref 39)

Station	Depth (m)	Fines (%)	Sands (%)	Gravel (%)	Modified Folk Scale	Habitat Sediment Preference	Habitat Sediment Classification
LL_01_EBS	5	0	83.8	17.2	Gravelly Sand	Suitable	Marginal
LL_02_TR	8	33.1	20.2	46.7	Muddy Gravel	Unsuitable	Unsuitable
LL_03-TR	6	1.8	32.2	67.4	Sandy Gravel	Prime	Preferred
LL_04_TR_G	9.7	72.5	27.4	0.1	Sandy Mud	Unsuitable	Unsuitable
LL_05_SG	11.5	64.1	31	5	Slightly Gravelly Sandy Mud	Unsuitable	Unsuitable
LL_06_TR_G	12.1	53.9	45.2	0.9	Sandy Mud	Unsuitable	Unsuitable
LL_07_TR_G	12.4	63.8	36.1	0.1	Sandy Mud	Unsuitable	Unsuitable
LL_08_EBS	14	68.1	25.8	6.1	Gravelly Mud	Unsuitable	Unsuitable
LL_09_TR_G	18.4	71.4	28.3	0.3	Sandy Mud	Unsuitable	Unsuitable
LL_11_EBS	19.6	72.2	27.5	0.4	Sandy Mud	Unsuitable	Unsuitable
LL_13_EBS	11.8	77.8	22.2	0.1	Sandy Mud	Unsuitable	Unsuitable
LL_14_TR_G	13.6	59.1	34.6	6.3	Gravelly Mud	Unsuitable	Unsuitable
LL_15_SG	16.3	21.5	17.9	60.6	Muddy Gravel	Unsuitable	Unsuitable
LL_16_SG_ADD	16	57.3	41.6	1.1	Slightly Gravelly Sandy Mud	Unsuitable	Unsuitable
LL_17_EBS	15.5	74	26	0	Sandy Mud	Unsuitable	Unsuitable
LL_21_EBS	21.4	2	98	0	Sand	Unsuitable	Unsuitable
LL_23_SG_SS	35.1	14.7	83.1	2.3	Slightly Gravelly Muddy Sand	Unsuitable	Unsuitable
LL_27_EBS	32	22.5	45	32.5	Muddy Sandy Gravel	Unsuitable	Unsuitable

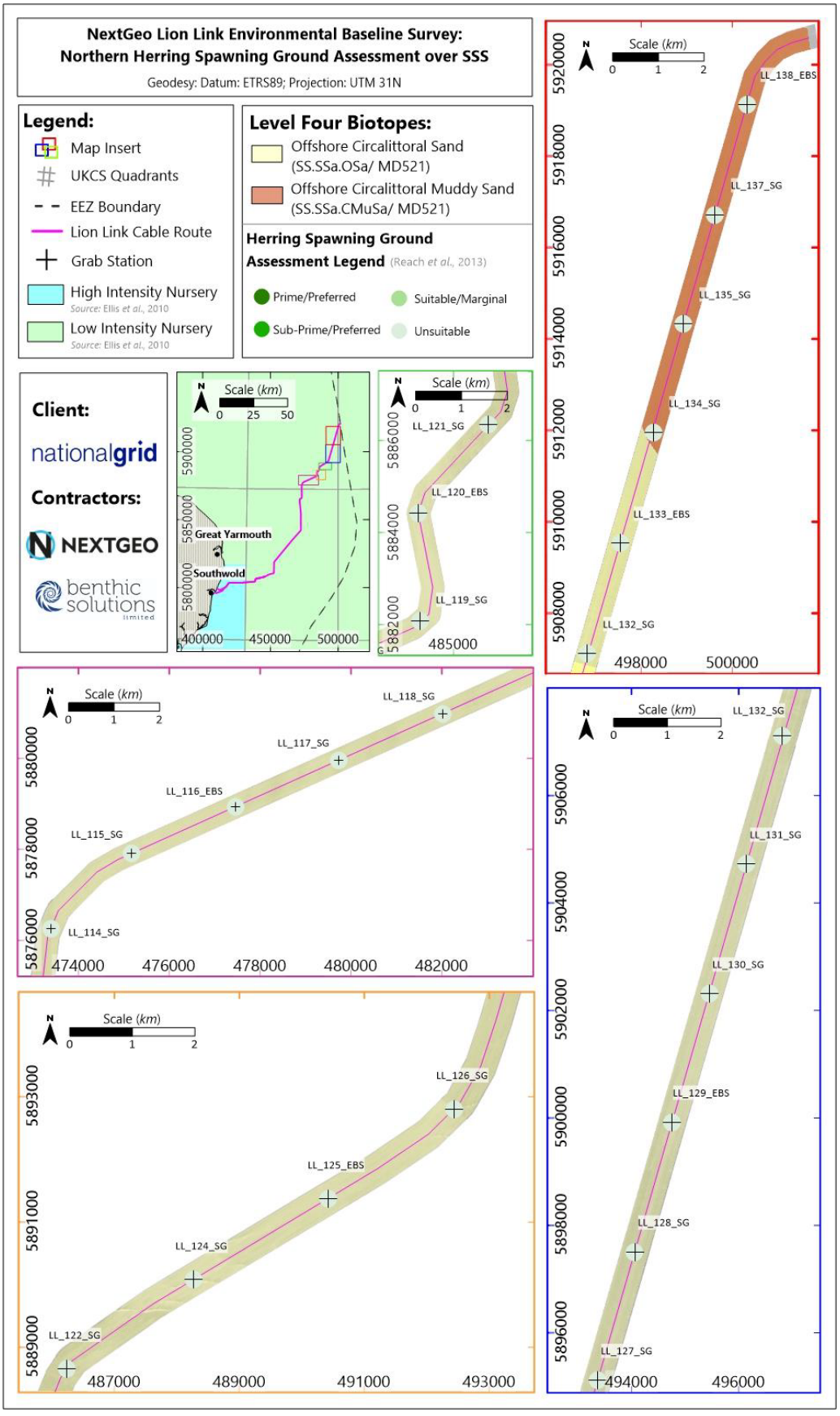
Station	Depth (m)	Fines (%)	Sands (%)	Gravel (%)	Modified Folk Scale	Habitat Sediment Preference	Habitat Sediment Classification
LL_30_SG	35.1	43.7	56.2	0.1	Muddy Sand	Unsuitable	Unsuitable
LL_32_EBS	33.9	30.9	47.4	21.7	Gravelly Muddy Sand	Unsuitable	Unsuitable
LL_34_SG	24	0	100	0	Sand	Unsuitable	Unsuitable
LL_38_EBS	34.5	13.7	86.3	0	Muddy Sand	Unsuitable	Unsuitable
LL_42_SG	37.3	4	57.4	38.6	Sandy Gravel	Sub-prime	Preferred
LL_44_EBS	40.3	0	99.9	0.1	Sand	Unsuitable	Unsuitable
LL_45_SG_SS	40.2	0.8	71.4	27.8	Gravelly Sand	Sub-prime	Preferred
LL_49_EBS	44	9.1	49.1	41.8	Muddy Sandy Gravel	Unsuitable	Unsuitable
LL_51_SG	38	6.1	52.8	41.1	Muddy Sandy Gravel	Unsuitable	Unsuitable
LL_55_EBS_SS	38.6	0	96.2	3.8	Slightly Gravelly Sand	Unsuitable	Unsuitable
LL_57_SG	38.8	0	95.5	4.5	Slightly Gravelly Sand	Unsuitable	Unsuitable
LL_60_EBS	41.4	1.3	92.8	5.9	Gravelly Sand	Unsuitable	Unsuitable
LL_62_SG	43.8	0.7	71.8	27.9	Gravelly Sand	Sub-prime	Preferred
LL_64_EBS	46.4	7.5	82	10.5	Gravelly Sand	Unsuitable	Unsuitable
LL_67_SG	43.7	0	97	3.1	Slightly Gravelly Sand	Unsuitable	Unsuitable
LL_72_EBS_SS	43.9	0	93.9	6.1	Gravelly Sand	Unsuitable	Unsuitable
LL_73_EBS_SS (outside Draft Order Limits)	45.8	2.5	94.8	2.9	Slightly Gravelly Sand	Unsuitable	Unsuitable
LL_78_EBS_SS	41.6	0	93.3	6.7	Gravelly Sand	Unsuitable	Unsuitable

Station	Depth (m)	Fines (%)	Sands (%)	Gravel (%)	Modified Folk Scale	Habitat Sediment Preference	Habitat Sediment Classification
LL_82_SG (outside Draft Order Limits)	47.6	15.1	74.2	10.7	Gravelly Muddy Sand	Unsuitable	Unsuitable
LL_85_EBS_SS	45.6	0	97.4	2.6	Slightly Gravelly Sand	Unsuitable	Unsuitable
LL_86_SG	48.3	0.9	98.1	1.1	Slightly Gravelly Sand	Unsuitable	Unsuitable
LL_87_EBS	50.4	17.4	82.5	0.1	Muddy Sand	Unsuitable	Unsuitable
LL_88_SG	51.3	7.3	90.1	2.6	Slightly Gravelly Sand	Unsuitable	Unsuitable
LL_89_EBS	51.1	0.1	96.9	2.9	Slightly Gravelly Sand	Unsuitable	Unsuitable
LL_91_SG	46.3	19.9	66.6	13.4	Gravelly Muddy Sand	Unsuitable	Unsuitable
LL_94_EBS	47.7	3.1	94.1	2.8	Slightly Gravelly Sand	Unsuitable	Unsuitable
LL_95_SG	47.2	26	62.2	12	Gravelly Muddy Sand	Unsuitable	Unsuitable
LL_97_EBS	43.6	0	98.7	1.3	Slightly Gravelly Sand	Unsuitable	Unsuitable
LL_98_SG	42.7	0	99.8	0.2	Sand	Unsuitable	Unsuitable
LL_99_EBS	44	0	99.4	0.6	Sand	Unsuitable	Unsuitable
LL_100_SG	43	42.8	54.1	3.1	Slightly Gravelly Muddy Sand	Unsuitable	Unsuitable
LL_102_EBS	39.2	15.1	76.6	8.2	Gravelly Muddy Sand	Unsuitable	Unsuitable
LL_103_SG	37.2	0	93.8	6.2	Gravelly Sand	Unsuitable	Unsuitable
LL_104_EBS	36.1	2.8	90.3	6.9	Gravelly Sand	Unsuitable	Unsuitable
LL_105_SG	37.5	0	97.7	2.3	Slightly Gravelly Sand	Unsuitable	Unsuitable
LL_106_EBS_SS	35.9	0	98	2	Slightly Gravelly Sand	Unsuitable	Unsuitable

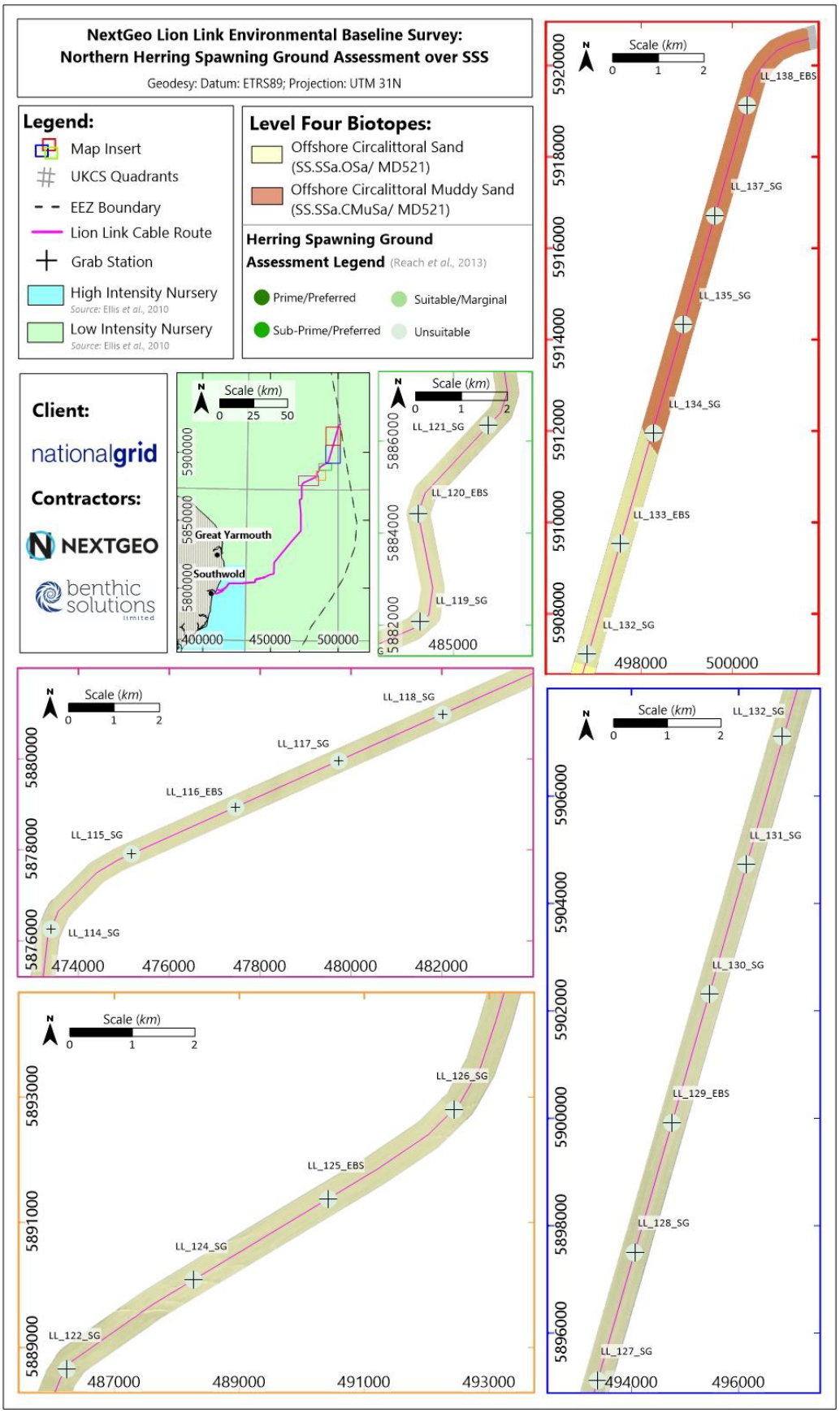
Station	Depth (m)	Fines (%)	Sands (%)	Gravel (%)	Modified Folk Scale	Habitat Sediment Preference	Habitat Sediment Classification
LL_107_SG	36.6	0	98.9	1.1	Slightly Gravelly Sand	Unsuitable	Unsuitable
LL_108_EBS	36.6	0	98.2	1.8	Slightly Gravelly Sand	Unsuitable	Unsuitable
LL_109_SG	27.5	4.5	94.7	0.8	Sand	Unsuitable	Unsuitable
LL_110_SG	27.1	24	75.1	0.9	Muddy Sand	Unsuitable	Unsuitable
LL_111_SG	35.2	0	99.1	0.9	Sand	Unsuitable	Unsuitable
LL_112_EBS_SS	34.3	1.9	97.2	0.9	Sand	Unsuitable	Unsuitable
LL_113_SG	35.3	0	99.8	0.2	Sand	Unsuitable	Unsuitable
LL_114_SG	38.5	0.4	98.8	0.8	Sand	Unsuitable	Unsuitable
LL_115_SG	34.2	3.2	96.3	0.5	Sand	Unsuitable	Unsuitable
LL_116_EBS	35.2	13.1	86.6	0.3	Muddy Sand	Unsuitable	Unsuitable
LL_117_SG	24.7	14.6	85.3	0	Muddy Sand	Unsuitable	Unsuitable
LL_118_SG	32.5	0	99.7	0.3	Sand	Unsuitable	Unsuitable
LL_119_SG	23	0	99.6	0.4	Sand	Unsuitable	Unsuitable
LL_120_EBS	34	19.4	67.7	12.8	Gravelly Muddy Sand	Unsuitable	Unsuitable
LL_121_SG	32	10.2	87.4	2.4	Slightly Gravelly Muddy Sand	Unsuitable	Unsuitable
LL_122_SG	20.7	1.2	98.7	0.1	Sand	Unsuitable	Unsuitable
LL_124_SG	30.4	0	99.9	0.1	Sand	Unsuitable	Unsuitable
LL_125_EBS	31.4	1.7	97.4	0.9	Sand	Unsuitable	Unsuitable
LL_126_SG	30	2.7	97.1	0.2	Sand	Unsuitable	Unsuitable

Station	Depth (m)	Fines (%)	Sands (%)	Gravel (%)	Modified Folk Scale	Habitat Sediment Preference	Habitat Sediment Classification
LL_127_SG	22.3	2.3	97.4	0.3	Sand	Unsuitable	Unsuitable
LL_128_SG	30.4	14.8	77.9	7.2	Gravelly Muddy Sand	Unsuitable	Unsuitable
LL_129_EBS	31	6.5	92.5	1	Slightly Gravelly Sand	Unsuitable	Unsuitable
LL_130_SG	37.7	2	98	0	Sand	Unsuitable	Unsuitable
LL_131_SG	28.6	16.2	83.3	0.5	Muddy Sand	Unsuitable	Unsuitable
LL_132_SG	27.3	4.6	94.6	0.8	Sand	Unsuitable	Unsuitable
LL_133_EBS	27.4	3.9	96	0.1	Sand	Unsuitable	Unsuitable
LL_134_SG	29	8.7	91.1	0.2	Sand	Unsuitable	Unsuitable
LL_135_SG	29	18.3	81.4	0.3	Muddy Sand	Unsuitable	Unsuitable
LL_137_SG	29.7	32.2	67.6	0.2	Muddy Sand	Unsuitable	Unsuitable
LL_138_EBS	29	20.5	79.3	0.2	Muddy Sand	Unsuitable	Unsuitable

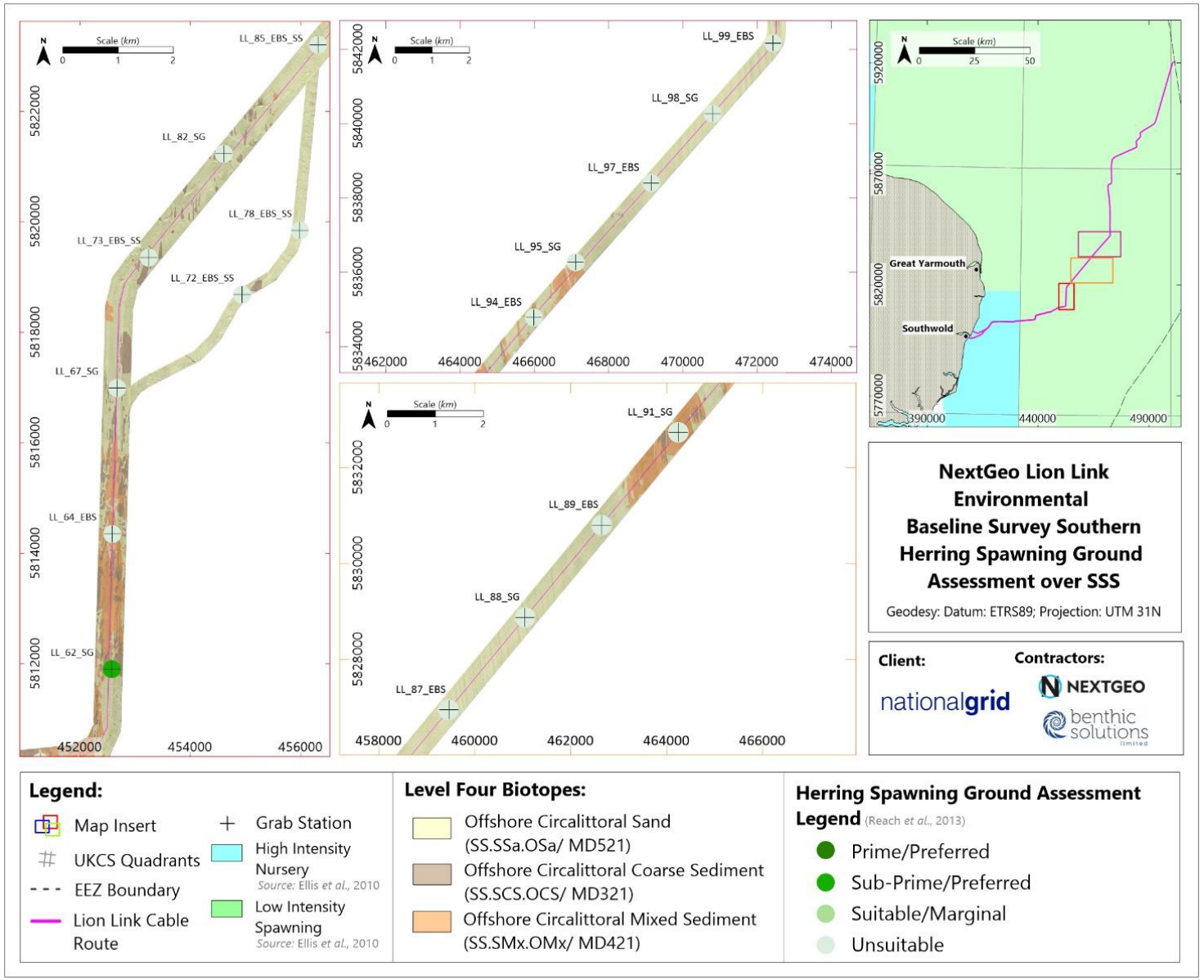
Inset 4.8: Herring spawning and nursery grounds per Reach et al. (Ref 39) within survey block 19 to block 14



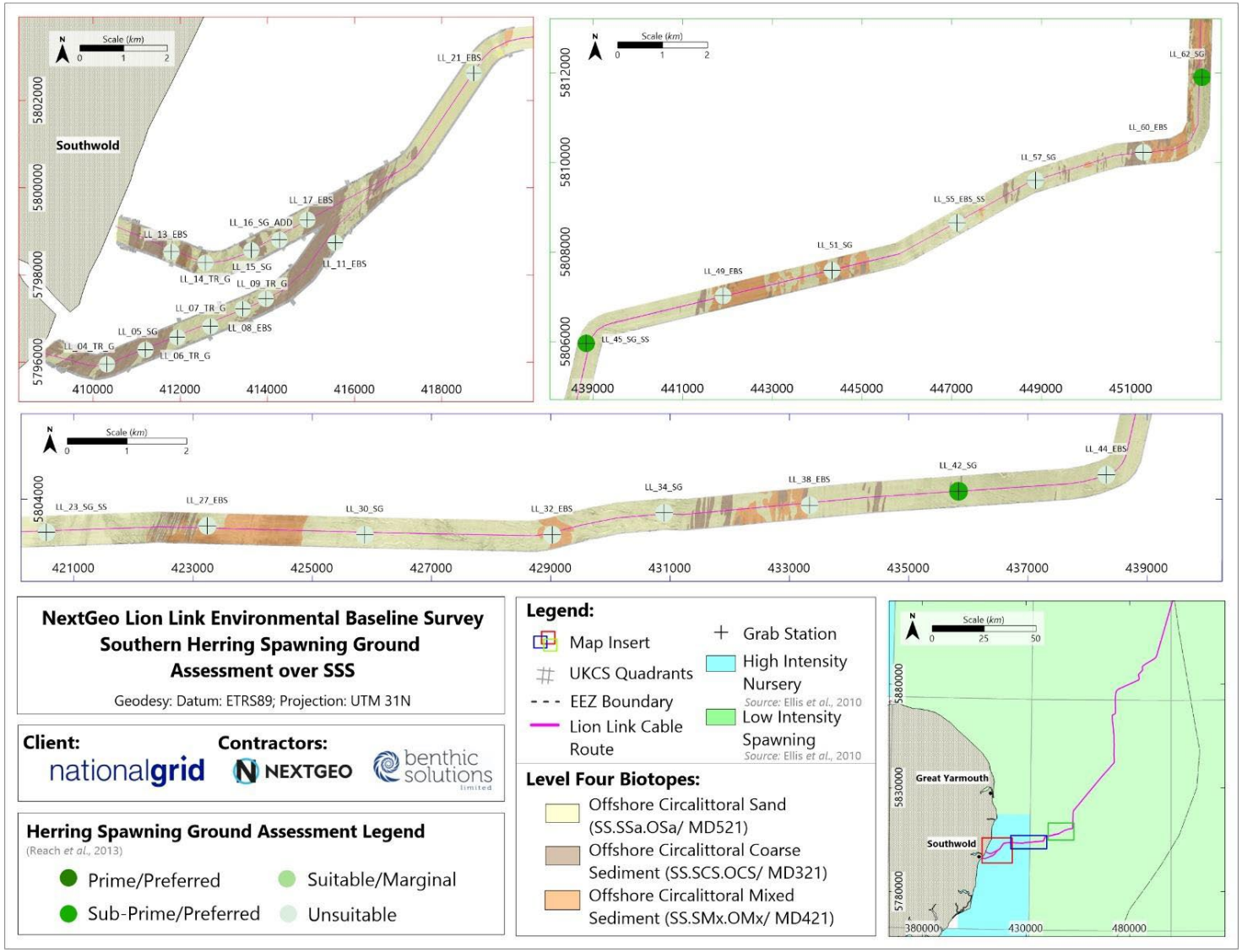
Inset 4.9: Herring spawning and nursery grounds per Reach et al. (Ref 39) within survey block 14 to block 11



Inset 4.10: Herring spawning and nursery grounds per Reach et al. (Ref 39) within survey block 11 to block 9



Inset 4.11 Herring spawning and nursery grounds per Reach et al. (Ref 39) within survey block 9 to block 3



5 Conclusions

5.1.1 The datasets on herring and sandeel habitats, sediment types and abundances reviewed and discussed in this study, indicate that sandeel habitat, and potential spawning grounds are likely to be present within the Proposed Offshore Scheme. Data collected from seabed surveys has shown that sediments and environmental conditions are unlikely to be suitable for herring spawning although this is further discussed in **Section 5.3.**

5.1.2 The recruitment success of pelagic and semi-pelagic fish such as herring and sandeel is driven by a range of environmental and biological factors, including but not limited to prey availability, water temperature and oxygenation, predation and spawning substrate and availability (Ref 1). Both herring and sandeel have specific requirements for suitable habitats for spawning and nursery grounds, and as such are highly vulnerable to disturbance or removal of such habitat. Both species require substrates which contain specific quantities of sand and gravel: for herring to lay their eggs and for sandeel to bury themselves within during night-time hours and for spawning. Both species require highly oxygenated water in relatively dynamic environments of a suitable depth (15 – 40m for herring spawning and between 30m and 50 - 70m for sandeel).

5.1.3 This habitat study has made use of publicly available GIS data and literature to identify areas of potential habitat for herring and sandeel. The initial desk-based review was used to inform the sampling strategy for a marine route characterisation survey undertaken in 2024/2025. The sampling strategy was discussed and agreed with Cefas, NE and the JNCC. The intention was to ensure that sufficient stations were selected to ground truth the publicly available assessment and inform the site-specific identification of sandeel and herring habitat. PSD data has now been collated and analysed from the Lionlink benthic survey report to further support the identification of sandeel and herring habitats.

5.2 Sandeel

5.2.1 Based on the evidence presented within **Section 3** of this report, it has been determined that discrete sections along the Proposed Offshore Scheme are preferred potential supporting habitat for sandeel.

5.2.2 Several locations along the Proposed Offshore Scheme have been identified as ‘Preferred’ habitat based on PSD data. **Table 5.1** summarises the KP locations between which ‘Prime’ or ‘Sub-Prime’ habitat was identified. Where multiple samples were acquired along a stretch of the Proposed Offshore Scheme recording ‘prime’ and ‘sub-prime’, that section of the Proposed Offshore Scheme has been classified based on the station that recorded the most suitable conditions for sandeel spawning according to Greenstreet et al (Ref 35).

5.2.3 It has been concluded that approximately 47% (85km) of the Proposed Offshore Scheme consists of "Prime" sandeel habitat and approximately 7% (14km) as "Sub-Prime" habitat, totaling approximately 99km. The majority of the 'Prime' and 'Sub-Prime' locations within the Proposed Offshore Scheme lie within the Norfolk and Suffolk spawning grounds, as defined by Coull *et al*. (Ref 5). The Proposed Offshore Scheme overlaps with the Norfolk and Suffolk spawning ground for approximately 76km; of this 53km has been classified as 'Prime' and/or 'Sub-Prime' sandeel habitat from acquired PSD data.

5.2.4 Temperature analyses over the typical sandeel spawning period (November – March inclusive) (Coull et al., Ref 4), has been conducted to further assess habitat suitability. Predicted seabed temperature within the Proposed Offshore Scheme during the spawning period ranges from 8.9°C to 9.3°C, which broadly falls within the optimum water temperature range for sandeel spawning (8.3°C to 9.0°C). Depth was also deemed suitable for sandeel in all areas of the Proposed Offshore Scheme classified as 'Prime' or 'Sub-Prime'.

5.2.5 The presence of sandeel was noted from 19 of the 104 transect locations where seabed imagery was acquired. Sandeel were also noted at a single grab location LL_108_EBS, a station which was considered unsuitable for sandeel spawning from the PSD data. However, caution is necessary when interpreting sampling areas lacking sandeel presence due to limitations in sandeel sampling techniques (Ref 40; Ref 39). As such, evidence suggests that sandeel are considered present within the Proposed Offshore Scheme.

5.2.6 All of the of the locations listed in **Table 5.1** align with the EMODnet Folk 16 seabed sediment data categorised into Preferred and Marginal habitat for sandeel. However, there are also many sampling stations that overlap with the Preferred and Marginal sandeel habitat, as defined by the EMODnet sediment data, which are classified as Unsuitable when using PSD. This analysis demonstrates that areas predicted as suitable for spawning are often unsuitable when validated by sediment sampling.

Table 5.1: Summary of data analysed for the 'Prime' and 'Sub-Prime' locations overlapping a spawning ground defined by Coull et al (Ref 4)

Locations (KPs)	Length of section (km)	PSA Data (Greenstreet et al (Ref 35))	Modified Folk (Latto et al (Ref 34))	Spawning Ground (Coull et al. Ref 5)	Suitable Depth (approx. 30m to 70m)
KP22 to K23	1	Prime	Preferred	No	Yes
KP27 to KP33	6	Prime	Preferred	Norfolk/Suffolk	Yes
KP40 to KP56	16	Prime	Preferred	Norfolk/Suffolk	Yes

Locations (KPs)	Length of section (km)	PSA Data (Greenstreet et al (Ref 35))	Modified Folk (Latto et al (Ref 34))	Spawning Ground (Coull et al. Ref 5)	Suitable Depth (approx. 30m to 70m)
KP57 to KP58	1	Sub-Prime	Unsuitable	Norfolk/Suffolk	Yes
KP59 to KP64	5	Prime	Preferred	Norfolk/Suffolk	Yes
KP67 to KP71	4	Prime	Preferred	Norfolk/Suffolk	Yes
KP74 to KP76	2	Sub-Prime	Preferred	Norfolk/Suffolk	Yes
KP79 to KP86	7	Prime	Preferred	Norfolk/Suffolk	Yes
KP89 to KP91	2	Prime	Preferred	Norfolk/Suffolk	Yes
KP92 to 108	16	Prime	Preferred	Norfolk/Suffolk	Yes
KP112 to KP123	13	Prime	Preferred	No	Yes
KP129 to KP133	4	Prime	Preferred	No	Yes
KP140 to KP151	11	Sub-Prime	Preferred	No	Yes

1 Coull et al. (Ref 5) data intersects the Proposed Offshore Scheme at KP101.

5.3 Herring

5.3.1 Based on the evidence presented within **Section 4** of this report, it has been determined that only discrete sections along the Proposed Offshore Scheme are located within the Preferred potential supporting habitat for herring.

5.3.2 An assessment using PSA of the sediments along the Proposed Offshore Scheme has identified occasional areas of 'Prime' and 'Sub-Prime' areas. Grab samples identifying suitable ‘Prime’ and ‘Sub-Prime’ habitat were isolated; a single grab station (LL_03-TR) was classified as 'Prime' herring habitat and three grab stations (LL_42_SG, LL_45_SG_SS and LL_62_SG) as 'Sub-Prime'. Each station was considered as representative of around 2km of the Proposed Offshore Scheme.

5.3.3 Predicted seabed temperature within the Proposed Offshore Scheme ranged from 11°C at closer to the coast an 8°C at the furthest point of the Proposed Offshore Scheme at the boundary of the EEZ. This broadly falls within the optimum water temperature range for herring spawning (between 5°C and 14°C).

5.3.4 Depth was deemed suitable for samples acquired at KP30 and KP34.5. Samples acquired at KP0.5 and KP1.5 were located in 5 and 6ms depth respectively.

5.3.5 Higher levels of seafloor dissolved oxygen nearer to shore from KP0 to KP15 (**Inset 4.7:**) likely as a result of dynamic physical conditions (e.g., currents and mixing) and photosynthesising plankton. Beyond KP15, the seafloor dissolved oxygen levels gradually reduce from 274.75 µmol/l to 273.94 µmol/l. Of the sediment samples that were considered 'Prime' or 'Sub-Prime', this correlates with a single sample acquired at KP1.5

5.3.6 The locations noted in **Table 5.2** are representative of a small number of isolated grab samples acquired within the boundaries of the Proposed Offshore Scheme. The locations noted in **Table 5.2** are representative of a small number of isolated grab samples acquired within the boundaries of the Proposed Offshore Scheme. Of the stations identified as 'Prime' and 'Sub-Prime' locations, only Station LL_03-TR was situated within the spawning grounds off the Suffolk coast, as defined by Coull et al. (Ref 5). The Proposed Offshore Scheme overlaps with the Suffolk spawning ground for approximately 17.5km, of which approximately 2km has been classified as 'Prime' and/or 'Sub-Prime' herring habitat in the suitable water depth for herring spawning.

5.3.7 All remaining stations were characterised as 'Unsuitable' for herring spawning grounds due to the predominant proportions of sand and fine sediments. Very few stations were classified as a preferred sediment type for herring spawning and no consecutive stations were recorded suggesting that any sediment potentially suitable for herring spawning is infrequent and patchy along the Proposed Offshore Scheme.

Table 5.2: Summary of data analysed for the 'Prime' and 'Sub-Prime' locations overlapping a spawning ground defined by Reach et al (Ref 39)

Station	KP	Within known herring spawning ground area (Ref 5).	Habitat Sediment Preferenc e	Habitat Sediment Classi	Suitable Depth (approx. 15m to 40m)	Within ICES Rectangle 33F2 (Approx between KP23 and KP52)
LL_01_E BS	0.5	Yes	Suitable	Marginal	No	No
LL_03-TR	1.5	Yes	Prime	Preferred	No	No
LL_42_S G	30	No	Sub-prime	Preferred	Yes	Yes
LL_45_S G_SS	34.5	No	Sub-prime	Preferred	Yes	Yes

Station	KP	Within known herring spawning ground area (Ref 5).	Habitat Sediment Preferenc e	Habitat Sediment Classi	Suitable Depth (approx. 15m to 40m)	Within ICES Rectangle 33F2 (Approx between KP23 and KP52)
LL_62_S G	50	No	Sub-prime	Preferred	No	Yes

Topic Glossary

Acronym/ Phrase/ Abbreviation	Definition
BAP	Biodiversity Action Plan
BGS	British Geological Survey
CEA	Collaborative Environmental Advisers
Cefas	Centre for Environment, Fisheries and Aquaculture Science
DATRAS	Database of Trawl Surveys
DMR	Dedicated Metallic Return
eDNA	Environmental deoxyribonucleic acid
EEZ	Exclusive Economic Zone
G	Gravel
GB	Great Britain
GIS	Geographic Information Systems
(g)S	slightly gravelly Sand
gS	gravelly Sand
GW	Gigawatts
HVDC	High Voltage Direct Current
ICES	International Council for the Exploration of the Sea
IBTS	International Bottom Trawl Survey
IHLS	International Herring Larval Survey
KP	Kilometre Point
MHWS	Mean High-Water Springs
MMO	Marine Management Organisation
NETS	National Electricity Transmission System
NGV	National Grid Ventures
PINS	Planning Inspectorate
PSA	Particle Size Analysis
PSD	Particle Size Distribution
S	Sand
SA	Sandeel Area
Semi-Pelagic	Organisms that occupy a position in the water column between the pelagic (open water) and benthic (seafloor) zones. These organisms typically live and feed just above the seafloor but do not remain exclusively on the bottom or in the upper water column

Acronym/ Phrase/ Abbreviation	Definition
sG	sandy Gravel
SNCB	Statutory Nature Conservation Body

References

Ref 1 Reach, I., Kyle-Henney, M., Barr, N., Warner, I., Lowe, S., and Lloyd Jones, D. (2024). Identifying and Mapping Sandeel Potential Supporting Habitat: An Updated Method Statement.

Ref 2 Defra (2024). Consultation outcome. Government response. (Online) Available at: Government response - GOV.UK (www.gov.uk) [Accessed May 2024]

Ref 3 ICES (2023a). Eggs and Larvae database. Available at: Eggs and Larvae, Download dataset (ices.dk) [Accessed May 2024].

Ref 4 Coull, K.A., Johnstone, R. and Rogers, S.I. (1998). Fisheries Sensitivity Maps in British Waters. Published and distributed by UKOOA Ltd. (Online) Available at: Fisheries Sensitivity maps in British waters (cefas.co.uk) [Accessed May 2024].

Ref 5 Langton, R., Boulcott, P. and Wright, P.J. (2021). A verified distribution model for the lesser sandeel *Ammodytes marinus.* Marine Ecology Progress Series **667:** 145-159.

Ref 6 EMODnet (2019). EMODnet Seabed Substrates – Seabed substrate map of the European sea areas. (Online) Available at: EMODnet Product Catalogue (europa.eu) [Accessed May 2024]

Ref 7 EMODnet (2022). EMODnet Digital Bathymetry (DTM 2022). (Online) Available at: EMODnet Product Catalogue (europa.eu) [Accessed May 2024]

Ref 8 Lewis, H., Castillo Sanchez, J. M., Siddorn, J., King, R., Tonani, M., Saulter, A., Sykes, P., Péquignet, A.-C., Weedon, G., Palmer, T., Staneva, J., and Bricheno, L. (2019) Can wave coupling improve operational regional ocean forecasts for the North-West European Shelf in Ocean Science, '"15"', 669–690. (Online) Available at: https://doi.org/10.5194/os-15-669-2019 [Accessed May 2024]

Ref 9 Tonani, M., Sykes, P., King, R.R., McConnell, N., Péquignet A-C., O'Dea, E., Graham, J.A., Polton, J., Siddorn, J. (2019). The impact of a new high-resolution ocean model on the Met Office North-West European Shelf forecasting system in Ocean Science., '"15"', 1133–1158, 2019. (Online) Available at: https://doi.org/10.5194/os-15-1133-2019 [Accessed May 2024]

Ref 10 Crocker, R., Maksymczuk, J., Mittermaier, M., Tonani, M., and Péquignet A-C (2020). An approach to the verification of high-resolution ocean models using spatial methods in Ocean Science, '"16"', 831–845, 2020. (Online) Available at: https://doi.org/10.5194/os-16-831-2020 [Accessed May 2024]

Ref 11 Bruciaferri, D., Tonani, M., Lewis, H., Siddorn, J., Saulter, A., Castillo, J.M., Garcia Valiente, N., Conley, D., Sykes, P., Ascione, I., and McConnell, N. (2021). The impact of ocean-wave coupling on the upper ocean circulation during storm events in

Journal of Geophysical Research, Oceans, 2021, 126, 6. (Online) Available at: https://doi.org/10.1029/2021JC017343 [Accessed May 2024].

Ref 12 EMODnet (2023). European seas - DIVAnd 4D monthly analysis of Water body dissolved oxygen concentration 1960/2020 v2023. (Online) Available at: EMODnet Product Catalogue (europa.eu) [Accessed May 2024]

Ref 13 BRIG (2007). Report on the Species and Habitat Review: Report by the Biodiversity Reporting and Information Group (BRIG) to the UK Standing Committee. (Online) Available at: Report on the Species and Habitat Review 2007 (jncc.gov.uk) [Accessed May 2024].

Ref 14 Gov.UK (2006). Natural Environment and Rural Communities Act 2006. (Online) Available at: Natural Environment and Rural Communities Act 2006 (legislation.gov.uk) [Accessed May 2024]

Ref 15 Defra (2022). Habitats and species of principal importance in England. (Online) Available at: https://www.gov.uk/government/publications/habitats-and-species-of-principal-importance-in-england [Accessed May 2024].

Ref 16 Frederiksen, M., Edwards, M., Richardson, A.J., Halliday, N.C., Wanless, S. (2006). From plankton to top predators: bottom-up control of a marine food web across four trophic levels. Journal of Animal Ecology, 75 (6): 1259-1268. (Online) Available at: From plankton to top predators: bottom-up control of a marine food web across four trophic levels - FREDERIKSEN - 2006 - Journal of Animal Ecology - Wiley Online Library [Accessed May 2024]

Ref 17 Greenstreet, S.P.R., Holland, G.J., Guirey, E.J., Armstrong, E., Fraser H.M. and Gibb, I.M. (2010) Combining hydroacoustic seabed survey and grab sampling techniques to assess “local” sandeel population abundance. *ICES Journal of Marine Science* **67:** 971-984.

Ref 18 Defra (2023a). Press release: No sandeel fishing for 2023 in effort to protect marine ecosystem. (Online) Available at: No sandeel fishing for 2023 in effort to protect marine ecosystem - GOV.UK (www.gov.uk) [Accessed May 2024].

Ref 19 NatureScot (2023) Sandeels. (Online) Available at: Sandeel | NatureScot [Accessed May 2024]

Ref 20 Engelhard, G.H., Peck, M.A., Rindorf, A., Smout, S.C., van DeursS., Lauerberg, R.A.M., Scott, F., Brunel, T., Aarts, G., van Kooten, T. and Dickey-Collas, M. (2014). Forage fish, their fisheries, and their predators: who drives whom? *ICES Journal of Marine Science,* **71(1):** 90-104. (Online) Available at: Forage fish, their fisheries, and their predators: who drives whom? | ICES Journal of Marine Science | Oxford Academic (oup.com) [Accessed May 2024].

Ref 21 Defra (2023b). What are the ecosystem risks and benefits of full prohibition of industrial Sandeel fishing in the UK waters of the North Sea (ICES Area IV)? Defra

request for advice. (Online) Available at: What are the ecosystem risks and benefits of full prohibition of industrial Sandeel fishing in the UK waters of the North Sea (ICES Area IV)? (publishing.service.gov.uk) [Accessed May 2024].

Ref 22 RSPB (2024). The closure of sandeel fisheries: our legacy of campaigning. (Online) Available at: The closure of sandeel fisheries: our legacy of campaigning (rspb.org.uk) [Accessed May 2024]

Ref 23 MacDonald, A., Heath, M.R., Greenstreet, S.P.R. and Speirs, D.C. (2019) Timing of sandeel spawning and hatching off the east coast of Scotland. *Frontiers in Marine Science* **6** (Online) Available at: Frontiers | Timing of Sandeel Spawning and Hatching Off the East Coast of Scotland (frontiersin.org) [Accessed May 2024].

Ref 24 Brown & May Marine Ltd. (2014). Dogger Bank Teesside A & B: Environmental Statement Chapter 14 Appendix F: Sandeel survey report. (Online) Available at: DOGGER BANK [Accessed May 2024].

Ref 25 ICES (2023b). ICES advice on fishing opportunities, catch and effort: Greater North Sea ecoregion. Sandeel (*Ammodytes* spp.) in divisions 4.a-b, Sandeel Area 4 (northern and central North Sea). (Online) Available at: Sandeel (Ammodytes spp.) in divisions 4.a–b, Sandeel Area 4 (northern and central North Sea) (figshare.com) [Accessed May 2024].

Ref 26 Wright, P.J., Christensen, A., Regnier, T., Rindorf, A., van Deurs, M. (2019). Integrating the scale of population processes into fisheries management, as illustrated in the sandeel, Ammodytes marinus. ICES Journal of Marine Science. 76 (6): 1453-1463. (Online) Available at: Integrating the scale of population processes into fisheries management, as illustrated in the sandeel, Ammodytes marinus | ICES Journal of Marine Science | Oxford Academic (oup.com) [Accessed May 2024]

Ref 27 DECC (2004). Strategic Environmental Assessment (SEA) 5: Environmental Report. Appendix 4: Fish and shellfish ecology. (Online) Available at: Strategic Environmental Assessment 5: Environmental Report - GOV.UK (www.gov.uk) [Accessed May 2024].

Ref 28 Green, E. (2017). A literature review of the lesser (Raitt's) sandeel *Ammodytes marinus* in European waters. RSPB. (Online) Available at: Green 2017.pdf [Accessed May 2024].

Ref 29 Brown & May Marine Ltd. (2014). Dogger Bank Teesside A & B: Environmental Statement Chapter 14 Appendix F: Sandeel survey report. (Online) Available at: DOGGER BANK [Accessed May 2024].

Ref 30 Wright, P.J., Jensen, H. and Tuck, I. (2000) The influence of sediment type on the distribution of the lesser sandeel, *Ammodytes marinus.* Journal of Sea Research **44:** 243-256.

Ref 31 van der Kooij, J., Scott, B.E. and Mackinson, S. (2008) The effects of environmental factors on daytime sandeel distribution and abundance on the Dogger Bank. *Journal of Sea Research* **60:** 201-209.

Ref 32 Holland, G.J., Greenstreet, S.P.R., Gibb, I.M., Fraser, H.M. and Robertson, M.R. (2005) Identifying sandeel *Ammodytes marinus* sediment habitat preferences in the marine environment. *Marine Ecology Progress Series* **303:** 269-282. (Online) Available at: Microsoft Word - herring.doc (ices.dk) [Accessed May 2024].

Ref 33 Langton, R., Boulcott, P. and Wright, P.J. (2021). A verified distribution model for the lesser sandeel *Ammodytes marinus.* Marine Ecology Progress Series **667:** 145-159.

Ref 34 Latto, P.L, Reach, I.S., Alexander, D., Armstrong, S., Backstrom, J., Beagley, E., Murphy, K., Piper, R. and Seiderer, L.J. (2013) Screening Spatial Interactions between Marine Aggregate Application Areas and Sandeel Habitat, A Method Statement produced for BMAPA.

Ref 35 Greenstreet, S.P.R., Holland, G.J., Guirey, E.J., Armstrong, E., Fraser H.M. and Gibb, I.M. (2010) Combining hydroacoustic seabed survey and grab sampling techniques to assess “local” sandeel population abundance. *ICES Journal of Marine Science* **67:** 971-984.

Ref 36 Folk, R.L. (1954). The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature. The Journal of Geology, 62, 344-359. (Online) Available at: Folk, R.L. (1954) The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature. The Journal of Geology, 62, 344-359. - References - Scientific Research Publishing (scirp.org) [Accessed May 2024]

Ref 37 Ellis, J.R., Milligan, S.P., Readdy, L., Taylor, N. and Brown, M.J. (2012). Spawning and nursery grounds of selected fish species in UK waters. Sci. Ser. Tech. Rep., Cefas Lowestoft, 147: 56 pp.

Ref 38 The Planning Inspectorate (2018) SCOPING OPINION:Proposed Hornsea Four Wind Farm. Case Reference: EN010098. (Online) Available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010098/EN010098-000584-F1.7%20AAI%20Volume%20F1.7%20Scoping%20Opinion.pdf [Accessed May 2024]

Ref 39 Reach I.S., Latto P., Alexander D., Armstrong S., Backstrom J., Beagley E., Murphy K., Piper R. and Seiderer L.J. (2013). Screening Spatial Interactions between Marine Aggregate Application Areas and Atlantic Herring Potential Spawning Areas. A Method Statement produced for BMAPA

Ref 40 Reach, I., Kyle-Henney, M., Barr, N., Warner, I., Lowe, S., and Lloyd Jones, D. (2024). Identifying and Mapping Sandeel Potential Supporting Habitat: An Updated Method Statement. (Online) Available at: https://www.erm.com/globalassets/insights/documents/Identifying_and_Mapping_

Sandeel_Potential_
Supporting_Habitat_An_Updated_Method_2024_w_Appendices.pdf

Ref 41 ICES Database on Trawl Surveys (DATRAS) (2023). ICES, Copenhagen, Denmark. (Online) Available at: https://datras.ices.dk [Accessed May 2024].

Ref 42 Marine Scotland (2021a). Lesser sandeel (*Ammodytes marinus*) - North Sea – Probability of presence of buried sandeel. (Online) Available at: Lesser Sandeel (Ammodytes marinus) – North Sea - Probability of presence of buried sandeel | Marine Scotland Information [Accessed May 2024]

Ref 43 MacDonald, A., Heath, M.R., Greenstreet, S.P.R. and Speirs, D.C. (2019) Timing of sandeel spawning and hatching off the east coast of Scotland. *Frontiers in Marine Science* **6** (Online) Available at: Frontiers | Timing of Sandeel Spawning and Hatching Off the East Coast of Scotland (frontiersin.org) [Accessed May 2024].

Ref 44 Gov.UK (2006). Natural Environment and Rural Communities Act 2006. (Online) Available at: Natural Environment and Rural Communities Act 2006 (legislation.gov.uk) [Accessed May 2024]

Ref 45 Barnes, M.K.S. (2008). Clupea harengus Atlantic herring. In Tyler-Walters H. and Hiscock K. Marine Life Information Network: Biology and Sensitivity Key Information Reviews. Plymouth: Marine Biological Association of the United Kingdom. (Online) Available at: https://www.marlin.ac.uk/species/detail/45 [Accessed May 2024].

Ref 46 Whitehead, P.J.P. (1986). Clupeidae. In Fishes of the North-eastern Atlantic and the Mediterranean Volume I (Whitehead, P.J.P., Bauchot, M.-L., Hureau, J.-C., Neilsen, J., and Tortonese, E., eds.) UNESCO, Paris, 268-281.

Ref 47 Atterbury, A., Canning, S., Dinwoodie, K., Hall, R., Piesinger, N., Stewart, D., Thorpe, E. and West, L. (2021). Natural England and JNCC guidance on key sensitivities of habitats and Marine Protected Areas in English waters to aggregate resource extraction. JNCC Report No. 694. JNCC, Peterborough, ISSN 0963-8091.

Ref 48 Weinstein, A (2021) More Food on the Table for New England's Puffins and Terns. Audubon. (Online) Available at: https://www.audubon.org/news/more-food-table-new-englands-puffins-and-terns [Accessed May 2024]

Ref 49 ICES (2006). ICES Herring Factsheet. (Online) Available at: https://www.ices.dk/about-ICES/projects/EU-RFP/EU%20Repository/ICES%20FIshMap/ICES%20FishMap%20species%20factsheet-herring.pdf [Accessed May 2024]

Ref 50 Payne M.R., (2010). Mind the gaps: a state-space model for analysing the dynamics of North Sea herring spawning components. *ICES Journal of Marine Science*, 67, pp. 1939–1947.

Ref 51 Gullestad, P., Sundby, S. and Kjesbu, O.S. (2020) Management of transboundary and straddling fish stocks in the Northeast Atlantic in view of climate-induced shifts

in spatial distribution. Fish Fish 21:1008–1026. (Online) Available at: https://doi.org/10. 1111/faf.12485 [Accessed May 2024]

Ref 52 Anon. (1998). COUNCIL REGULATION (EC) No 850/98 of 30 March 1998 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. EU, Brussels

Ref 53 Henderson and Somes. (2015). Identification Guide to the Inshore Fish of the British Isles. Pisces Conservation. RSPB, 2017.

Ref 54 Frost, M., and Diele, K. (2022). Essential spawning grounds of Scottish herring: current knowledge and future challenges. Reviews in Fish Biology and Fisheries 32(3): 721–744.

Ref 55 Burbank, J., DeJong, R.A., Turcotte, F. and Rolland, N. (2022). Understanding factors influencing Atlantic herring (*Clupea harengus*) recruitment: From egg deposition to juveniles. Fisheries Oceanography 32(2) pp 147-159. (Online) Available at: Fisheries Oceanography | Aquaculture Journal | Wiley Online Library [Accessed May 2024].

Ref 56 Harden-Jones, F.R. (1968). Fish migration. Edward Arnold, London. 325 pp

Ref 57 Reid, R.N., Cargnelli, L.M., Griesbach, S.J., Packer, D.B., Johnson, D.L., Zetlin, C.A., Morse, W.W., Berrien, P.L. (1999). Atlantic herring, Clupea harengus, Life History and Habitat Characteristics. Essential Fish Habitat Source Document. National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum NMFS-NE-126.48p.

Ref 58 ICES-Fish Map (n.d.) Herring *Clupea harangus.* (Online) Available at: Microsoft Word - herring.doc (ices.dk) [Accessed May 2024].

Ref 59 Stevenson, D.K. and Scott, M.L. (2005). Atlantic Herring, Clupea harengus, Life History and Habitat Characteristics. Second Edition. Essential Fish Habitat Source Document. National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum NMFS-NE-192. (Online) Available at: noaa_4034_DS1.pdf [Accessed June 2024].

Ref 60 von Nordheim, L., Kotterba, P., Moll, D., and Polte, P. (2018) Impact of Spawning Substrate Complexity on Egg Survival of Atlantic Herring (Clupea harengus, L.) in the Baltic Sea. Estuaries and Coasts 41: 549

Ref 61 RWE and Masadar. (2024). Environmental Statement Volume 7 Chapter 10 - Fish and Shellfish Ecology. RWE. (Online) Available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010125/EN010125-000436-7.10%20ES%20Chapter%2010%20-%20Fish%20and%20Shellfish%20Ecology.pdf

Ref 62 Davies, J., Baxter, J., Bradley, M., Connor, D., Kahn, J. Murray, E., Sanderson, W., Turnbull, C. and Vincent, M. (2001. Marine Monitoring Handbook. JNCC,

Peterbrorough. (Online) Available at: https://hub.jncc.gov.uk/assets/ed51e7cc-3ef2-4d4f-bd3c-3d82ba87ad95 [Accessed May 2025]

Ref 63 Turner, J., Hitchin, B., Verling. E and van Rein, H., (2016). Epibiota Remote Monitoring from Digital Imagery: Interpretation Guidelines. Available at: DOI 10.13140/RG.2.1.2442.2805 [Accessed: May 2025].

Ref 64 Coggan, R., Clements, A., White, J., and Golding, N. (2007). Recommended operating guidelines (ROG) for underwater video and photographic imaging techniques. (Online) Available at: DOI 10.13140/RG.2.1.1919.9206 [Accessed: May 2025]..

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