Strategic Compensation Studies

Auk ANS Site Selection Report

Offshore Wind Evidence + Change Programme | THE CROWN ESTATE · SCS Strategic Compensation Studies · OffshoreWind IndustryCouncil

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About the OWEC Programme: This project forms part of the Offshore Wind Evidence and Change (OWEC) programme, led by The Crown Estate in partnership with the Department for Energy Security and Net Zero and Department for Environment, Food & Rural Affairs. The Offshore Wind Evidence and Change programme is an ambitious strategic research and data-led programme. Its aim is to facilitate the sustainable and coordinated expansion of offshore wind to help meet the UK's commitments to low carbon energy transition whilst supporting clean, healthy, productive, and biologically diverse seas.

About the OWEC SCS Project: The Strategic Compensation Studies (SCS) is a £3.5 million project running until the end of 2027 which forms part of the OWEC programme. Alongside OWEC funding, the SCS project is supported through financial and in-kind contributions from participating Offshore Wind Industry Council (OWIC) members.

Further information can be found via the Strategic Compensation Studies webpage.

Purpose of this Report: This report forms part of the SCS artificial nesting structure (ANS) work package and aims to identify potential search areas for auk offshore Artificial Nesting Structures based on species/group specific suitability criteria. This follows from previous studies and offers further insight into optionality for suitable compensation measures for auk species.

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Acronyms

Acronym	Term
Anatec	Anatec Ltd
ANS	Artificial Nesting Structure
AoS	Areas of Search
BGS	British Geological Survey
BTO	British Trust for Ornithology
CCS	Carbon Capture and Storage
CEA	Collaborative Environmental Advisors
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CES	Crown Estate Scotland
CTV	Crew Transfer Vessel
DBSE	Dogger Bank South (East)
DBSW	Dogger Bank South (West)
DCO	Development Consent Order
Defra	Department of Environment, Food and Rural Affairs
DESNZ	Department for Energy Security and Net Zero
DtF	Department for Transport
EEZ	Exclusive Economic Zone
EMODnet	European Marine Observation and Data Network
ERM	Environmental Resources Management Ltd.
FEED	Front-End Engineering Design
GIS	Geographical Information System
HE	Historic England
HPAI	Highly Pathogenic Avian Influenza
HRA	Habitats Regulations Assessment
IMO	International Maritime Organisation
JNCC	Joint Nature Conservation Committee
KCIMP	Kittiwake Compensation Implementation and Monitoring Plan
KSCP	Kittiwake Strategic Compensation Plan
MCA	Maritime and Coastguard Agency
MCZ	Marine Conservation Zone
MMO	Marine Management Organisation
MoD	Ministry of Defence
MPA	Marine Protected Area
NM	Nautical Mile
NS	Nature Scot

Acronym	Term
NSIP	Nationally Significant Infrastructure Project
NSN	National Site Network
NSTA	North Sea Transition Authority
O&G	Oil and Gas
offANS	Offshore Artificial Nesting Structure
OWF	Offshore Wind Farm
OWIC	Offshore Wind Industry Council
PEXA	Practice and Exercise Areas
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SBP	Sub-bottom Profiler
SME	Subject Matter Experts
SMP	Seabird Monitoring Programme
SNCB	Statutory Nature Conservation Body
SOV	Service Operation Vessel
SPA	Special Protection Area
TCE	The Crown Estate
Ternan	Ternan Energy
TSS	Traffic Separation Scheme
UHRS	Ultra-high-Resolution Seismic
UUHRS	Ultra-Ultra High-Resolution Seismic

Glossary

Term	Definition
Additionality	Best practice principle relevant to (inter alia) compensation delivered in compliance with legislative requirements applicable to MPAs. A real increase in social value that would not have occurred in the absence of the intervention being appraised.
Co-location	The presence of two or more different species, populations, or biological communities in the same geographic area or habitat at the same time. In this instance, co-location is referring to the use of offANS to support both auks (razorbill and guillemot) and kittiwake species.
Habitat	A place where an organism or community of organisms normally live.
Habitat Creation	The process of establishing new habitats by closely matching the abiotic environment to desired ecological outcomes, considering factors such as geology, hydrology, vegetation structure, and regional climatic variations.
Library Of Strategic Compensation Measures	A list of strategic compensation measures for offshore wind projects that have been approved by the Secretary of State for the Department for Environment, Food and Rural Affairs.
Like-For-Like	In the context of biodiversity offsets, this term is synonymous with the concept of like for like and refers to areas with highly comparable biodiversity components. This similarity can be observed in terms of species diversity, functional diversity and composition, ecological integrity or condition, landscape context (e.g., connectivity, landscape position, adjacent land uses or condition, patch size, etc.), and ecosystem services (including people's use and cultural values). Also used as Ecological equivalence.
Marine Recovery Fund	The MRF is intended to facilitate the delivery of strategic compensatory measures to compensate for unavoidable damage to Marine Protected Areas (MPAs) from offshore wind developments.
Mitigation Hierarchy	Defines a sequential process that should be adopted to avoid, mitigate and compensate negative ecological impacts, with compensation very much interpreted as a measure of last resort.
Mitigation Measures	Measures taken to avoid, reduce and, if possible, offset the principal adverse effects of the licensed activity.

Executive Summary

This study was undertaken with the primary purpose of identifying suitable locations for siting artificial nesting structures (ANS) for common guillemot (*Uria aalge*), hereafter referred to as 'guillemot', and razorbill (*Alca torda*). Previously, ANS have been promoted as compensation for black-legged kittiwake (*Rissa tridactyla*), hereafter referred to as 'kittiwake', so this study was commissioned by the Offshore Wind Industry Council (OWIC) to further the understanding of whether ANS may also be suitable for Auk compensatory measures.

Collaborative Environmental Advisers Ltd (CEA) were contracted to deliver the study, alongside Anatec Ltd (Anatec), Environmental Resources Management Ltd (ERM) and Ternan Energy for specialist input. This study follows a similar process to the existing study commissioned by The Crown Estate, which focused on ecologically suitable areas for kittiwake ANS to enable consideration of co-locating ANS for multiple species as part of Round 4 Kittiwake Strategic Compensation Plan (KSCP). This study also has regard to consenting constraints and engineering feasibility of the potential ANS sites. This allows for increased confidence in the robustness and deliverability of the measure.

Heatmaps were created using ecological, technical and engineering, consenting, and shipping and navigation suitability criteria to identify potentially suitable locations to site an offANS and hard constraints. The relevant constraints and scoring of the criteria were agreed at workshops with relevant interested parties.

The heatmaps developed were presented to stakeholders and it was agreed that two refined Study Areas should be taken forward for further assessment. Full details of the data used to create the heatmaps is provided in Table 4-1. The Study Areas identified were located in the northeast and southwest of England. A more in-depth review of the refined Study Areas was undertaken, looking at additional shipping and navigation, and consenting and engineering considerations of the highest scoring area(s) within each Study Area.

The Northeast Study Area offers three large areas with high suitability scores, whereas the Southwest Study Area has one larger area and a couple of smaller sites. Both sites have different regionally specific constraints limiting their suitability. The Northeast Study Area has a higher amount of existing infrastructure present and shipping and navigation restrictions. Whereas the Southwest Study Area is limited by engineering feasibility for a fixed bottom offANS driven primarily by water depth. In the Southwest, geology may also require consideration of alternative foundation solutions to monopiles. The Southwest Study Area also has limited optionality of ports and construction transportation, opposed to the Northeast Study Area which has several large ports. These are all factors to consider for the deliverability of the offANS and cost implications to the Developer (or relevant delivery body).

Ecological suitability was the primary focus of the study, and both the Northeast and Southwest Study Areas offer viable locations with colonies of both seabird species present. Prey availability is well-evidenced within the Northeast Study Area, with sandeel stocks partially protected by fishing restrictions. Whilst there are limited spatial data showing sandeel presence within the Southwest Study Area, evidence from other industries (e.g. marine aggregates) and the presence of established auk colonies suggest that there is sufficient prey availability.

Co-location potential of an offANS for kittiwake and auks was also considered within the study. Kittiwake offANS Areas of Search (AoS) were identified in a study undertaken by NIRAS, focussing on the North Sea and the northeast of England. The areas identified as having high suitability scores for auk in the Northeast Study Area was overlayed with the Niras kittiwake AoS. There was some similarity of areas, with the biggest overlap within the areas off the coast of the Flamborough and Filey Coast SPA. This exercise confirmed that there are likely to be locations for siting an offANS which would be suitable for both auks and kittiwakes.

In summary, this study identified locations that are ecologically suitable for Auk offANS within both of the Study Areas. The ecological considerations ensure that there are suitable colonies and prey availability so an offANS is likely to be both successful and a benefit to the species. The sites are also feasible from an engineering and consenting perspective, meaning that developers, or the relevant delivery body, can have confidence in being able to deliver the measures within these locations.

1 Introduction

Artificial nesting structures (ANS) are being promoted as compensatory measures for various seabird species to offset the impact from the construction and operation of offshore wind farms (OWFs). However, the primary focus to date has been in regard to impacts on kittiwake (*Rissa tridactyla*), in English waters. Work undertaken by NIRAS (2023), on behalf of The Crown Estate as part of the Round 4 KSCP, identified areas of ecological suitability for kittiwake ANS.

The Collaboration on Offshore Wind Strategic Compensation (COWSC) ANS Expert Group's recommendation in October 2023 to provisionally include onshore and offshore ANS for guillemot and razorbill, as well as multispecies ANS, in the Library of Strategic Compensatory Measures (LoSCM) for England, Scotland, and Wales, was made with important caveats. Primarily, there was recognition of a lack of robust evidence demonstrating auks' utilisation of ANS, and an explicit need for further research, such as offshore surveys and trials of nesting spaces purpose-built for these species. Moreover, it was highlighted that viable onshore nesting sites are likely to be rare and highly location-dependent, for example, restricted to cliff edges. Consequently, the Secretary of State for Defra determined that neither onshore nor offshore ANS for guillemot and razorbill would be approved until more substantial evidence regarding their effectiveness, practicality, and strategic scalability was presented.

The Offshore Wind Industry Council (OWIC) led Strategic Compensation Studies project has contracted Collaborative Environmental Advisers Ltd (CEA) to undertake a study to identify potential search areas for auk offshore ANS (hereafter offANS) specifically, based on species/ group specific suitability criteria. Whilst the auks group covers a range of species, those which have been identified as possibly requiring compensation in current Offshore Wind Farm (OWF) applications (and consequently the focus of this workstream) are:

- Guillemot (*Uria aalge*); and
- Razorbill (*Alca torda*).

CEA have been supported by Anatec Ltd (Anatec), Environmental Resources Management Ltd (ERM) and Ternan Energy (Ternan). Anatec has provided analysis and evaluation of shipping and navigation constraints, Ternan has provided additional engineering and operational feasibility considerations, and ERM provided additional ornithological support.

This report includes:

- The approach taken to identifying and agreeing site selection criteria, their weighting, and the data used;
- The technical methodology used to produce heatmaps;
- The outputs of the heatmapping exercise;
- Identification of refined Study Areas for offANS based on the heatmaps; and
- A more in-depth review of the refined Study Areas.

Whilst some OWFs have proposed to co-locate nesting sites for auk species alongside ledges for kittiwake on offANS, the site selection criteria for the location of these offANS has primarily relied on suitability for kittiwake (as the primary target for the compensation measure). As such, the current locations being proposed for offANS may not fully align with the most advantageous locations for auk species, potentially reducing the efficacy of this measure for compensation of impacts to these species.

Whilst the primary aim of this study is to identify suitable areas for offANS for auk species, the study also aims to identify if there is the potential for co-location of offANS for both auks and kittiwake.

1.1 Lessons Learnt

Previously, Geographical Information System (GIS) site selection processes have been used to identify Areas of Search (AoS) for a range of applications, from offANS to siting for Nationally Significant Infrastructure Projects (NSIPs).

Following review of work undertaken by The Crown Estate (TCE) - and taking into account feedback from industry around additional criteria that have resulted in a number of the AoS initially identified not being practicable from a delivery perspective - it was considered that a further step to investigate technical feasibility and consenting suitability in-combination with the ecological suitability should be undertaken within this study. This would allow for more robust conclusions and confidence in the suitability of sites. This study therefore considers a wider range of consenting and installation feasibility constraints (Section 4.3) to ensure that any identified areas are expected to be not only ecologically suitable but also consentable, constructable and cost effective.

As well as incorporating additional datasets to support conclusions relating to non-ecological factors, a further step of a qualitative review of the suitability heatmaps has been undertaken by shipping and navigation and offshore engineering specialists. This review of installation and maintenance feasibility, and shipping and navigational constraints at a finer scale provides further confidence in the deliverability of an offANS in the locations identified through this study. This qualitative review, which was recommended by industry as a useful addition given the challenges for progressing offANS identified at the project level, allowed factors that are neither related to ecological suitability nor identified as a hard constraint to be considered in the interpretation of the suitability heatmap. For example, from an engineering perspective, there are always trade-offs to be made (such as cost or foundation type), which are difficult to categorise as a particular hard or soft constraint in initial mapping. This analysis allows confidence in the ecological suitability, alongside the feasibility and deliverability of the offANS for Developers, and takes previous ANS studies (e.g., NIRAS, 2023) to the next step, considering additional important factors.

As such, in addition to ecological factors, this review also considered the following:

- Engineering considerations such as ground conditions, potential foundation solutions (and associated cost implications);
- Other sea users and potential future developments which may result in consent risks for an offANS; and
- Existing (and predicted) shipping traffic patterns outside of hard constraints.

2 Scoring Criteria and Constraints

Annex I presents the full details of the scoring criteria and constraints used in the production of the heatmaps.

2.1 Study Area

The initial geographical scope for the site selection exercise for auk offANS was UK-wide. As such, the first stage of the assessment was to consider criteria to define an appropriate Study Area, or areas, within this. The logic driving the definition of the Study Area was based on providing a sufficiently wide area to support a robust numerical-based appraisal (i.e., capturing a wide range of other criteria), whilst only including those areas of the seas around the UK which have connectivity to existing auk colonies.

A number of options were considered for delineating the Study Area:

- Fixed distance (e.g., 200 km from the coastline);
- Foraging range; or
- Natal dispersal range.

Data-led foraging ranges (Woodward *et al.*, 2019) and natal dispersal ranges (e.g., Lyngs, 1993; Lavers, Jones and Diamond, 2007) were considered more scientifically robust than a simple fixed distance approach. Therefore, the fixed distance approach was discarded as an option through agreement with stakeholders.

Of the remaining options, it was agreed that natal dispersal was a more appropriate metric to define the Study Area, with this being more representative of connectivity to existing colonies, and consequently, the UK National Site Network (NSN). Foraging ranges (Woodward *et al.*, 2019) from prey resources and as indicators of competition with existing colonies were incorporated into the heatmap scores instead, as described in Section 2.2.1.

Whilst guillemot and razorbill have been recorded as dispersing up to 780 km and 3,200 km, respectively, from natal sites, average dispersal ranges (excluding the top 5% outliers) are 246 km (guillemot) and 315 km (razorbill) (Lyngs, 1993; Lavers, Jones and Diamond, 2007). Therefore, for the purposes of this work, the Study Area has been specified as 315 km from known colonies (using the Seabird Monitoring Programme (SMP[1]) records) for guillemot and

[1] https://jncc.gov.uk/our-work/seabird-monitoring-programme/

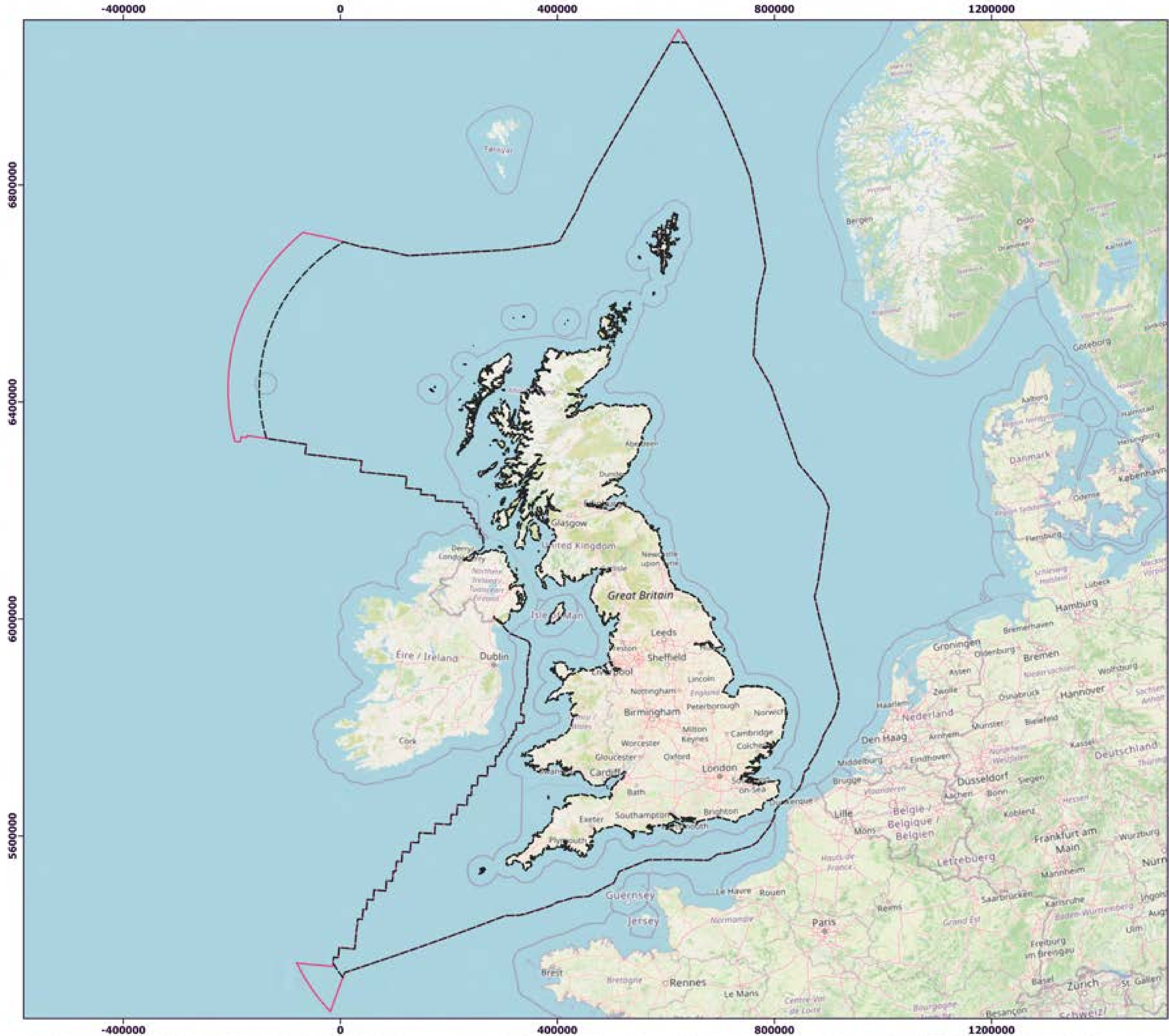
razorbill. Noting that co-location of breeding colonies of the two species is frequently recorded, due to similar habitat and prey requirements (Harris *et al.*, 2026). The Study Area was subsequently clipped to the extent of the UK Exclusive Economic Zone (EEZ), therefore, any areas within the 351 km dispersal range but outside of the UK EEZ are not considered as part of this study.

The final Study Area, based on the aforementioned criteria, is presented in Figure 2-1. The average dispersal ranges for guillemot and razorbill are presented in Figure 5-1.

Collaborative Environmental Advisers

Figure 2-1
Study Area

C01608-RUK-LOC-003-E



Legend

Study Area

EEZ

0 100 200 300 KM

0 40 80 120 NM

N

Date	12/06/2026
CRS	ETRS89 / UTM zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	meters
Scale at A3	1:6,825,000
Created	MW
Reviewed	AN
Authorised	SS

Document Path: X:\GIS\GIS_PROJECTS\C01608_OWIC_Auks\Projects\QGS\01_LOC\C01608_RUK_LOC_003.qgz

2.2 Suitability Criteria

The suitability criteria were derived from consideration of ecological, consenting, technical feasibility and shipping and navigation datasets. Within each topic, each factor was assessed individually and assigned a level of constraint (hard or soft), with appropriate scoring assigned. The criteria were scored between 0 and 2. Any scores above 1 indicate a highly positive factor, whilst scores of 1 are neutral, and those below 1 indicate a soft constraint. A score of 0 represents a complete hard constraint for an offANS.

Full details of the scoring criteria applied, and the datasets used are presented in Annex I. The most recent (at the time of writing) publicly available version of each dataset has been incorporated into the GIS heatmapping.

2.2.1 Ecological Suitability

To identify the most ecologically suitable locations for auk offANS siting, consideration has been given to habitat preferences, behaviour, and prey availability for each species to determine appropriate criteria and scoring bands. The parameters considered in this study included-

- Herring and Sandeel spawning and nursery grounds;
- Proximity to avian predator colonies; and
- Distance from auk colonies.

Where each of these criteria are present in the mapping exercise, the total multiplied score has been used to create the ecological suitability heatmap. Section 4 details the methodology applied, with an outlined and flow chart of the process provided in Section 4.1.

The ecological criteria incorporated into the mapping include distance to prey preferred habitat, proximity to avian predator breeding colonies, distance from existing guillemot and razorbill colonies, and displacement from existing OWF developments. Prey habitat suitability was considered a beneficial criterion, with positive scoring (>1) applied, with the remaining criteria being hard or soft constraints, as discussed below. The full list of criteria and scores applied are presented in Annex I.

Auk foraging ranges[2] (Woodward *et al.*, 2019) were an important factor in defining the scoring to the heatmap. Score bands accounting for access to foraging areas and prey resources, connectivity to existing colonies, and intra-specific competition were all based on foraging distances. Average foraging ranges were assumed to represent the key foraging area, thus, were used as a proxy for the core range, within which competition with existing colonies would be expected to be greatest.

Locations that were nearer to or within areas of prey resource (Coull, Johnstone and Rogers, 1998) were given a higher score, with the score decreasing with increasing distance. Limitations and inconsistencies with known distributions of sandeel *Ammodytes* spp were identified during the initial heatmapping exercise, thus, the scoring used in the prey resource criteria were reclassified (refer to Section 2.3 for details). Auks feed on a variety of prey species (Heubeck, 2009; Anderson *et al.*, 2013; Barret, 2015; Engvall, Waldenström and Hentati-Sundberg, 2023), depending on location and season (Buckingham *et al.*, 2023), with diets varying as prey availability changes. Two key prey species for guillemot and razorbill around the UK are Atlantic herring *Clupea harengus* and sandeel, with some northern and Scottish colonies feeding on gadoids (Anderson *et al.*, 2013) or switching diet with shifting prey distributions (Riordan and Birkhead, 2017). As such, spawning and nursery grounds of all these species (Coull, Johnstone and Rogers, 1998; Ellis *et al.*, 2012) were used to inform the heatmapping. The highest score (1.5) for this criterion was assigned to locations within spawning or nursery grounds, with scores decreasing with increasing distance (1.3-1.4 within mean foraging range (core range), 1.1-1.2 within maximum foraging range, and 1.0 for areas outside of the foraging range of both auk species).

Guillemot and razorbill dispersal rates are low compared to other seabird species such as kittiwake, with over 80% of individuals returning to the same natal colony to breed, and over 90% of adults returning to the same breeding colony the following year (Swann and Ramsay, 1983; Harris, Wanless and Barton, 1996; Lavers, Jones and Diamond, 2007). Maximum natal dispersal distances (>780 km) can exceed the extent of the Study Area, which is based

[2] Foraging ranges used (derived from the Woodward *et al.* (2019) meta-analysis): 'average' refers to the mean foraging range of all studies; 'mean-max' refers to the average of the maximum foraging range from each study included; and 'maximum' refers to the single maximum foraging range in all studies included.

on average dispersal distances (Lyngs, 1993; Lavers, Jones and Diamond, 2007). Therefore, to allow meaningful consideration of natal dispersal in the heatmap, areas within the mean maximum foraging range (Woodward *et al.*, 2019) of existing colonies were given a score of 2.0, with areas outside this given a neutral score (1.0). This means that areas within natal dispersal distances are not negatively affected, while giving preference to areas within reasonable distance of existing colonies.

In addition to these ranking criteria, a number of “hard” and “soft” constraints have been identified, to minimise competition between existing colonies and any offANS, ensure prey accessibility, and to maximise the likelihood of offANS colonisation.

Hard Constraints

Connectivity to existing colonies was deemed an important factor in offANS siting, allowing dispersal from breeding colonies and increasing likelihood of offANS becoming colonised. However, areas within the immediate vicinity of existing auk breeding colonies, where siting of an offANS may increase competition with existing colonies, were considered to be a hard constraint in the study.

These areas, based on seabird breeding season foraging ranges, represent the core range of each species. Data from Fair Isle were excluded, as these were collected in a period with limited prey resources, resulting in greater foraging ranges (Woodward *et al.*, 2019). The average foraging range, excluding Fair Isle, was used to identify constrained areas. Areas within 23.9 km of SMP sites which support breeding guillemot and areas within 31.2 km SMP sites which support breeding razorbill were considered a hard constraint to offANS siting and given a score of zero (0).

It should be recognised that installation and subsequent colonisation of an ANS would result in establishment of a ‘core’ range associated with the colony on the ANS. This has not been considered as a constraint to ANS siting in this study but instead should be looked at during the next steps of auk ANS development (Section 7).

A 2 km buffer has been applied to OWF array areas, aligning with the recommended buffer used for assessing displacement effects on auk species (SNCBs, 2022). This 2 km buffer is also considered a hard constraint to offANS siting.

Soft Constraints

Soft constraints are not entirely removed from potential offANS siting, but are given lower scoring to reflect the reduced suitability of a given location to enable site selection and optimisation. Ornithological criteria with scores below 1.0 are a soft constraint (i.e., they reduce the overall heatmap score).

Areas within the 43.3 km mean foraging range (core range) of lesser black-backed gull (*Larus fuscus*) (Woodward *et al.*, 2019) (shown in Figure 5-1) are considered to be at greater risk of predation. Therefore, these locations were scored at 0.5. Predation foraging ranges were not considered to be a hard constraint to offANS siting, as many successful and established auk colonies are within the core foraging range of avian predators, with auks and large gulls (as potential predators) recorded at the same locations in many instances. These locations were considered a soft constraint, where offANS suitability is lower, as it is possible to incorporate protection from avian predation into the design of the offANS structure.

Areas within 10 km of OWF developments were considered as a soft constraint. These were split into areas within 2-5 km and 5-10 km of OWFs, with respective scores of 0.2 and 0.5 in the heatmapping. This reflects the reduced suitability of an area to support breeding auk colonies due to the possibility of an OWF displacing birds from areas of prey resource (SNCBs, 2022). These locations are also more likely to result in increased competition with existing colonies as displaced individuals must find alternative foraging grounds.

2.2.2 Technical and Engineering Suitability

Whilst ecological suitability is the primary driver for the location of an ANS, any potential locations proposed are required to be technically feasible with respect to engineering constraints. The optimal location for the ANS will be influenced by numerous factors, including the ground conditions and how these can impact the installation of the structure (shown in Figure 4-5).

This avoids the risk of a delivery organisation or stakeholders identifying a location which it turns out is unfeasible to deliver and so cannot be taken forward by OWF developers or a strategic delivery partner. As such, a number of engineering related parameters were identified as hard constraints to refine potential search areas for an offANS. Principally these included-

- Water depth;
- Presence of seabed features;
- Notable rock outcroppings;
- Sub-surface geology type and depth; and
- Distance to ports as a proxy for the feasibility of operation and maintenance.

Some engineering considerations (e.g., seabed slope, current speeds, etc.) have not been used for scoring within this appraisal, as they are either too localised to be meaningfully mapped at the relevant scale for this study and may be mitigated through micrositing of a structure, or are pure design/ installation aspects (e.g., current speeds). Full details of the engineering consideration and the scoring criteria are presented in Annex I.

Annex III – Foundation considerations provides an overview of the fixed foundation types considered for the installation on an offANS. Whilst the foundation types have not been directly considered in the production of the heatmaps, a discussion around the suitability of foundation types within the potentially suitable areas has been presented in Sections 5 and 6.

Offshore Artificial Nesting Structure Design

Whilst fixed foundations can be installed at ever increasing water depths, the offANS foundation is likely to be the key capital expenditure component. This is particularly relevant to offANS which are likely to be a single one-off structure which does not benefit from efficiencies of scale associated with OWFs. Therefore, water depth provides a reasonable proxy for cost. A hard constraint of 60m was used, with higher scores allocated for shallower water depths (Figure 4-7).

In addition to water depth, the expected ground conditions have a major influence over the proposed foundation type. As ground conditions are often highly variable across large distances, it is not appropriate for them to form part of the main criteria to define the heatmap. The following section discusses the general geotechnical considerations for different foundation types and their relevance to offANS. Whilst the foundation types have not been directly considered in the production of the heatmaps, a discussion around the suitability of foundation types within the potentially suitable areas has been presented in Sections 5 and 6. The foundation types considered to be most appropriate for each Study Area are detailed in Sections 5.3.2 and 5.4.2.

Floating ANS structures have not been considered as part of this study. Floating structures are in general more costly than fixed bottom structures and are not justified where bottom fixed sites are identified.

The foundation types considered are:

- Monopile;
- Piled Jacket Structure;
- 'Monobucket' Suction Caissons and Suction Cassion Jackets;
- Gravity-Base Structure.

Further information on the foundation types outlined above is provided in Annex III.

2.2.3 Consenting Suitability

A number of parameters were identified as consenting constraints to refine potential search areas for an offANS. These included:

- Designated sites for benthic features;
- Ministry of Defence (MoD) practice and Exercise Areas (PEXAs);
- Renewable energy installations;
- Oil and gas facilities;
- Carbon Capture and Storage (CCS);
- Aggregate extraction licence areas; and
- Linear infrastructure.

Designated sites within English, Welsh and Scottish waters (including Special Areas of Conservation (SACs) and Marine Conservation Zones (MCZ) and

Marine Protected Areas (MPA)) for benthic habitats or seabed features were represented as a hard constraint in the heatmapping due to the consenting challenges and potential need for Measures of Equivalent Environmental Benefit (MEEB) and Habitats Regulations Assessment (HRA) compensation which would be disproportionate for an offANS (Figure 4-4).

Whilst SPAs have not been represented as a hard constraint, it is noted that locating an offANS within a SPAs may pose consenting challenges depending on the final design and designated features of the site. Whilst, Ramsar sites were not explicitly considered due to their proximity to the coast, the water depths of the sites would anyway render them unsuitable from a feasibility perspective as would their proximity to existing nesting sites on the coastline.

Zones classed as MoD PEXAs were considered to be a hard constraint; no buffers were applied to this dataset (Figure 4-4). However, this excluded any PEXAs classed as 'air' or 'aerospace', due to the offANS being a low structure and the fact that any design can include suitable lighting, and safety and navigational markings in accordance with the requirements of the Civil Aviation Authority, Health and Safety Executive and any other relevant design standards.

Other sea users were a further consenting consideration. The Study Area is used by a wide range of other users and industries, and, therefore, has infrastructure and activities throughout that needs taking into account (as shown in Figure 4-2 and Figure 4-3). The infrastructure considered herein includes renewable energy installations (OWFs, tidal turbines), oil and gas (O&G) facilities (platforms, well heads, manifolds), CCS areas, marine aggregate extraction licence areas, and linear infrastructure, such as cables and pipelines. Standard maritime safety buffer areas have also been applied to these features (e.g., 500m for O&G platforms).

Consenting offANS within areas of existing infrastructure or activity poses challenges, with potential conflict with the existing users. For the purposes of this study, a direct overlap/ co-existence is considered to provide a consent risk and have been considered as a hard constrained within a defined buffer of the asset or activity (Annex I).

2.2.4 Shipping and Navigation Suitability

The shipping and navigation constraints layer was primarily developed based on qualitative review of information available on Admiralty Charts within the Study Area, with rankings subsequently assigned by Anatec based upon its technical expert opinion. The review was proportionate to the scope of this initial assessment and the scale of the Study Area being considered, which comprises a large area, and as such the review focused on larger, less detailed charts. Further and more detailed assessment will be required to ascertain acceptability once more localised areas have been defined, and a lack of hard constraint identified at the initial heatmapping stage should not be taken to mean that any given area is necessarily developable for offANS from a shipping and navigation perspective.

The following constraints have been considered within this initial review:

- **International Maritime Organisation (IMO) Routeing Measures**- Anatec's experience and the principles of Maritime and Coastguard Agency (MCA) guidance within Marine Guidance Note 654 (Safety of Navigation- Offshore Renewable Energy Installations) was applied to ascertain rankings and buffer zones. Any interference with an IMO Routeing Measure including the approach to entry/ exit points is very unlikely to be acceptable.
- **Pilotage**- Where charted Pilot boarding diamonds[3] have been identified, it was assumed that development is unlikely to be acceptable in direct proximity, noting that the associated pilotage operations are sensitive. Any proposal to install an offANS near an identified pilotage area would require consultation with the relevant harbour authority, noting consultation would be required should development within or near any harbour authority limits be proposed. Level of concern is likely to be linked to the size of the port, frequency of usage, and the size of the vessels being boarded.
- **Anchorages**- Where charted anchorages were identified, it was assumed that development in or in direct proximity to these areas is unlikely to be acceptable, however based on Anatec's experience there may be scope to build a suitable distance away, subject to consultation. Only designated charted Anchorage Areas have been

[3] Pilot boarding diamonds are symbols on maritime admiralty charts that indicate the designated general area where a maritime pilot embarks or disembarks a vessel, usually via a small pilot boat.

included, consideration of preferred or recommended anchorages would need to be subject to further detailed assessment.

- **Preliminary Considerations of Important Routeing**- For the initial review, areas between aligning routeing measures were identified. High level consideration was also given to areas of known important routeing (based on Anatec's experience) constrained by hazards (e.g., existing wind farms, shallow banks).
- **Port Approaches**- The initial review included a preliminary assessment of approaches to ports and harbours, noting prevention of port access was not acceptable. This is not a comprehensive review of all UK ports, with only ports classed as 'major' within Department for Transport (DfT) port arrival statistics captured at this stage. Consultation would be required should development within or near any harbour authority limits be proposed.

Some of the shipping and navigation key navigational features, which form hard constraints, overlap with the infrastructure identified above. Buffer zones around the navigational features need to be respected and structures must not be located within these buffers to preserve safety of vessel operations.

2.3 Refinement of Criteria

Following discussions in Workshop 2 (Table 3-1), the weighting assigned to the herring and sandeel distribution was amended to create a more marginal difference between the ecological suitability inside versus outside of the spawning and nursery grounds and associated guillemot and razorbill foraging range buffers (Table 2-1). This ensured that areas outside of the spawning and nursery grounds, but still within the foraging ranges of auk species, were better represented and shown as a viable option for an auk offANS. Equally, areas that sat outside both the foraging ranges and the spawning and nursery grounds themselves, were scored more neutrally as it is still possible that an auk offANS can be built. The refinement of the scoring accounted for the limitations (data vintage and accuracy; refer also to Section 4.6) of the available herring and sandeel data (Coull, Johnstone and Rogers, 1998) used to create the heatmap. The refined scoring also considers that there are established auk colonies in areas where the data (Coull, Johnstone and Rogers, 1998) show no prey availability, such as at Skomer and Lundy. The presence of well-established colonies indicates that there must be prey available within foraging range, with studies showing that these colonies primarily feed on sandeel and herring (Anderson *et al.*, 2013; Riordan and Birkhead, 2017).

Table 2-1: Refinement of prey availability score weighting

Criteria	Score pre-criteria refinement	Updated score
Within spawning/ nursery (sp/ nurs) grounds	2	1.5
Within mean foraging range of guillemot (23.9 km) from sp/ nurs grounds	1.75	1.4
Within mean foraging range of razorbill (31.2 km) from sp/ nurs grounds	1.5	1.3
Within maximum foraging range of guillemot (135 km) from sp/ nurs grounds	1.25	1.2
Within the maximum foraging range of razorbill (191 km) from sp/ nurs grounds	1	1.1
Outside of both max foraging ranges	0.1	1

3 Consultation

Consultation has been undertaken with key stakeholders in the development of this study and is summarised below. The engagement with stakeholders was undertaken from the initial stages of the project, to ensure a robust and agreed approach to the study.

Two workshops were held, one on 12 December 2025 and a second on 26 February 2026. Invitations to the workshop were managed by OWIC to ensure a wide spread of stakeholders across jurisdictions and to secure technical input on ecological feasibility, engineering, and consenting considerations. The workshops included OWIC, relevant Statutory Nature Conservation Bodies (SNCBs), government body representatives, and offshore wind developers (Table 3-1).

A briefing note was issued prior to the first workshop (Annex II – Consultation Briefing Note), outlining the proposed approach and site selection criteria. It was considered crucial to involve stakeholders and Subject Matter Experts (SMEs) with different interests at the early stages of the project to input expert opinion on the weighting and scoring for each constraint. Discussions were focused on methodology, study area, and criteria for ecological, feasibility and consenting constraints. A second workshop was held to present the initial findings of the initial suitability heatmaps, to discuss adjustments to the constraints scoring and to inform selection of refined Study Areas.

Within the workshops, discussions were held to agree key areas such as appropriate constraints, scoring criteria, study area and the assessment approach ,and ensure there were no outstanding areas of disagreement. The areas of agreement from these meetings and where they have been adhered to are outlined in Table 3-1.

Table 3-1: Summary of attendance and areas of agreement at Workshops 1 and 2

Meeting/ Date	Attending Parties[4]	Area of Agreement	Section Where this is Addressed
Workshop 1: 12/12/2025	• OWIC • TCE • CEA • ERM • Natural England • Joint Nature and Conservation Committee (JNCC) • DESNZ	The dispersal distance from colonies will be used to define the Study Area.	Dispersal distances from colonies were utilised, as presented in Section 2.1 of this report.
		Auk heatmapping will be combined with the kittiwake layer to identify potential areas for co-location.	Co-location mapping has been undertaken and presented for auks and kittiwakes in Section 6.4.
		Concerns regarding Highly Pathogenic Avian Influenza (HPAI) are more appropriately considered within the design of the ANS and so will not be included explicitly in the heatmapping.	It was agreed that consideration of HPAI is beyond the remit of this study.

[4] Attending party acronyms: OWIC (Offshore Wind Industry Council); TCE (The Crown Estate); CEA (Collaborative Environmental Advisers Ltd); ERM (Environmental Resources Management Ltd); JNCC (Joint Nature Conservation Committee); DESNZ (Department for Energy Security and Net Zero); Defra (Department of Environment, Food and Rural Affairs); RWE (RWE AG); ODOW (Outer Dowsing Offshore Wind).

Meeting/ Date	Attending Parties[4]	Area of Agreement	Section Where this is Addressed
	• Defra • RWE • ODOW • Ørsted	Uncertainties surrounding possible impacts to auks, and changes in auk behaviour in response to climate change are too great to allow for inclusion of any criteria in relation to such within the heatmapping.	Climate change has been considered qualitatively within Section 6.3 of this report.
		Port proximity should be included (based on typical Service Operation Vessel (SOV) and Crew Transfer Vessels (CTV) ranges) as an indication of the feasibility of undertaking operation and maintenance activities.	Operational feasibility has been considered within Section 5.5 of this report, including port proximity and vessel types. A range of 70 km for CTV and 200 km for SOV has been used.
		Aggregate exploration and option areas will be a hard constraint.	Aggregate exploration and option areas have been considered a hard constraint as detailed within Section 2.2.3 of this report.
Workshop 2: 26/02/2026	OWIC CEA Natural England JNCC	Ministry of Defence (MoD) Practice and Exercise Areas (PEXA) data should be included in the heatmap.	PEXA data has been included within the consenting constraints as detailed in Section 2.2.3 of this report and

Meeting/ Date	Attending Parties[4]	Area of Agreement	Section Where this is Addressed
	RWE		included in heatmaps (Figure 5-2).
		CEA proposed a new approach to prey availability scoring, and it was agreed it was appropriate considering the data limitations of the available data and knowledge of existing auk colonies and prey populations in the southwest.	This has been updated and reflected in the ecological heatmap (Figure 5-1) and outlined within Section 2.3 within this report.
		Auk colony Seabird Monitoring Programme (SMP) and census data would be looked at more closely when analysing the refined Study Areas chosen.	Colony trends in the Southwest Study Area have been discussed in Section 6.
		The impact of climate change will be considered in the reporting.	Climate change has been a considered within Section 6.3 of this report.
		Further engineering input and advice is required to move forward with a depth constraint increase to the 80m contour.	Based on specialist advice and CEA's experience of offANS site development it was considered that increasing the depth beyond 60m would not be feasible owing to the cost implications. This is primarily

Meeting/ Date	Attending Parties[4]	Area of Agreement	Section Where this is Addressed
			owing to the potential need for a jacket foundation design.
		Southwest and northeast will be included as focus Study Areas, but Scotland will not be due to an abundance of natural nesting availability.	The Northeast and Southwest Study Areas are discussed in Section 5.3 and 5.4 respectively of this report.
		The symbology should be adjusted to each Study Area to show a higher resolution of data.	Figure 5-6 and Figure 5-23 (respectively) have had the symbology adjusted to the reflect the highest constraint scoring as green, to identify the most favourable areas.

A draft version of the report was shared with the Project Advisory Group (PAG) on the 13th May 2026 for their review. The members of the PAG are stakeholders within the offshore wind industry such as SNCBs, developers and advisory organisations. The overarching comments were that the report is fit for purpose and provides a useful screening for the location of an offANS for auks and co-location an offANS for auks and kittiwakes. These were all addressed and have been included within this final report.

In addition, comments were received regarding the inclusion of Round 5 'Project Development Areas' in the Celtic Sea, and the Leasing Round 6 Refine Areas of Search in the study. Considerations of the impacts of these areas have been addressed within Section 5.3 and 5.4 and these have also been included in the discussion and next steps.

The next steps have also been developed following PAG comments to expand this section and include details on what is required for offANS to be added in the LoSCM (Library of Strategic Compensation Measures).

Comments also highlighted limitations of the studies and areas that require further ecological considerations. These have been included within the next steps section, identifying where further studies would further understanding and would benefit investigation at a finer scale.

4 Heatmap Methodology

4.1 Process Overview

The heatmapping process for offANS has been undertaken via a GIS exercise taking into consideration ecological, technical and engineering, consenting, and shipping and navigational constraints. An overview of the process is shown in Figure 4-1. Full details of the data used to create the heatmaps is provided in Table 4-1.

Figure 4-1: Overview of the heatmap methodology

To enable any compensation measure to be successful, it is critical to ensure that the primary scoring values for any search areas are dictated by robust ecological suitability criteria. In addition, it must be demonstrated that there is connectivity to the NSN. Notwithstanding, it is equally important that any measure will not inadvertently conflict with the conservation objectives of any NSN site or risk negatively impacting (directly or indirectly) the population at any site (e.g., through excessive attraction of individuals away from an established colony).

To this end, a combination of ecological hard constraints (Section 2.2.1) are the primary aspects on which the scoring values have be determined. However, in practise it is likely that many of the areas identified as being ecologically suitable would be undeliverable, or pose challenging engineering or consenting hurdles. Therefore, feasibility, consenting, and shipping and navigation constraints (detailed in Sections 2.2.2, 2.2.3, and 2.2.4, respectively) have been evaluated, focusing on those which are classified as "hard" constraints to offANS siting. Full details of the scoring criteria are provided in Annex I.

Following initial heatmaps being shared with stakeholders at Workshop 2, it was agreed that two refined Study Areas (Southwest and Northeast England) would be taken forward, the rationale for this refinement is provided in Section 4.5. These two Study Areas contain potential locations that showed suitability for siting an offANS and allowed for a more detailed review of these sites and additional constraints, such as operational feasibility, to be considered. Ternan investigated the geology and engineering feasibility, whilst Anatec provided an additional shipping and navigation qualitative analysis of the refined Study Areas. This additional qualitative review is provided in Section 5.3 and 5.4 for the Northeast and Southwest Study Areas, respectively.

4.2 Heatmap Method Outline

The site selection process follows a similar multilayer GIS heatmap methodology as used by NIRAS (TCE, 2023) for the Round 4 ANS site selection for kittiwake. The kittiwake ANS site selection study focused on ecological criteria to identify a suite of AoSs, and recommended that engineering and other users criteria be further considered in the next steps (refinement to a site within an AoS). Based on these recommendations, and feedback from industry on additional key criteria with regard practical delivery, this study includes additional site refinement within the selection process. As such the analysis undertaken to identify potential auk offANS siting has additionally considered engineering suitability and constraints to delivery (such as other sea users, engineering feasibility, and risk associated with shipping and navigation). This approach should mean the AoS identified are suitable for an offANS for auk species in terms of both engineering opportunity and ecological suitability.

Using the heatmap methodology outlined at Figure 4-1, four initial heatmaps were produced-

1. A heatmap displaying ecological suitability to identify areas of potential success for auk offANS siting;
2. A heatmap displaying shipping and navigation constraints;
3. A heatmap displaying engineering feasibility to identify areas of potential success for physical installation and consenting constraints; and
4. A heatmap multiplying all constraint scores to identify areas which may be both ecological suitable for offANS siting whilst maintaining feasibility and consentability.

The heatmaps created display hotspots for suitability to allow finalisation of a number of AoS in the UK Study Area. Two refined Study Areas in the northeast and southwest of England were subsequently identified and subject to more in-depth review and discussion.

4.3 Dataset Identification and collation

A significant number of datasets were identified as holding particular relevance to the scope of this project. A list of these datasets is provided in Table 4-1. Key data repositories included TCE, Crown Estate Scotland (CES), the North Sea Transition Authority (NSTA), British Geological Survey (BGS), and European Marine Observation and Data Network (EMODnet). At the time of data processing, the most recent version of publicly available data were used.

Table 4-1: Underlying datasets and their sources

Data	Source	Date of Download
Renewable Energy Infrastructure		
Offshore wind farms[5]	TCE, CES	26/06/2025 (TCE) 19/09/2025 (CES)
Offshore wind export cables	TCE	26/06/2025
Tidal sites	TCE, CES	03/10/2025 (TCE) 20/10/2025 (CES)
Tidal export cables	TCE	12/09/2025
Wave sites	TCE, CES	03/10/2025 (TCE) 22/09/2025 (CES)
Linear Infrastructure		
Cables	CES, KIS-ORCA, EMODnet	19/09/2025 (CES) 20/05/2025 (KIS-ORCA) 15/01/2015 (EMODnet)
Pipelines	CES, NSTA	19/09/2025 (CES) 15/08/2025 (NSTA)
Oil and Gas Facilities		
Surface infrastructure	NSTA	04/03/2024
Subsea infrastructure	NSTA	30/09/2025
Wells	NSTA	30/09/2025
Licensed blocks	NSTA	30/09/2025
Oil and gas fields	NSTA	30/09/2025
Designated Sites		
Marine Conservation Zones (MCZs)	NE	29/09/2025
Nature Conservation Marine Protected Areas (NCMPAs)	NS	06/11/2025
Special Areas of Conservation (SAC)	NE, Nature Scot (NS)	20/03/2024 (NE) 02/04/2024 (NS)
World heritage sites	Historic England (HE)	16/09/2024
Seabed Features		

[5] Round 6 (R6) Refined Areas of Search were not available at the time of data processing. The R6 areas are discussed in sections 4.6, 5.1.1, 5.3.3, 6.1 and 7.

Data	Source	Date of Download
Bathymetry	EMODnet	2024
Seabed sediment (Rock outcroppings)	BGS	19/04/2024
Quaternary thickness	BGS	18/11/2023
Ecological		
Herring and sandeel spawning and nursery grounds	CEFAS	25/04/2023
Avian predator colonies	British Trust for Ornithology (BTO) SMP	2025
Auk colonies	BTO SMP	2025
Other		
MoD PEXAs	EMapSite/ OceanWise	2026
Shipping and navigation	This layer was provided by Anatec (Section 5.4.2).	-
Aggregate sites	TCE	03/10/2025
Wrecks	EMODnet	26/09/2025

Figure 4-2 to Figure 4-6 presents some of the key data which were collated to develop the heatmaps. Once collated, the data layers were processed to extract relevant features and integrate spatial buffers where necessary. The data were then scored across classification bands (Annex I) indicating the level of suitability for auk offANS.

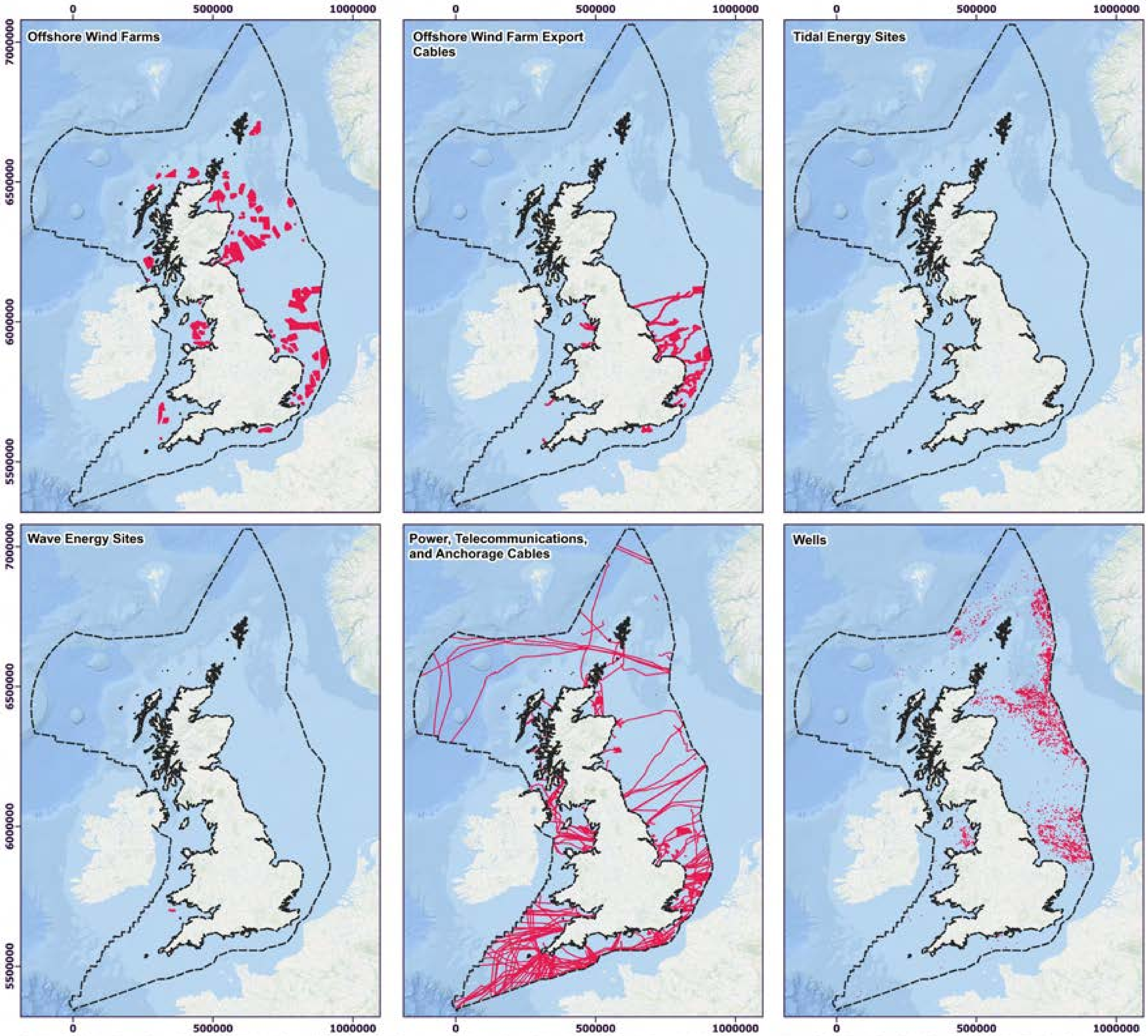


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Figure 4-2
Consenting Constraints - Power Infrastructure

C01608-RUK-LOC-005-C

Legend

Study Area
Consent Constraint

Date	12/06/2026
CRS	ETRS89 / UTM zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	meters
Scale at A3	1:13,220,000
Created	MW
Reviewed	AN
Authorised	LV

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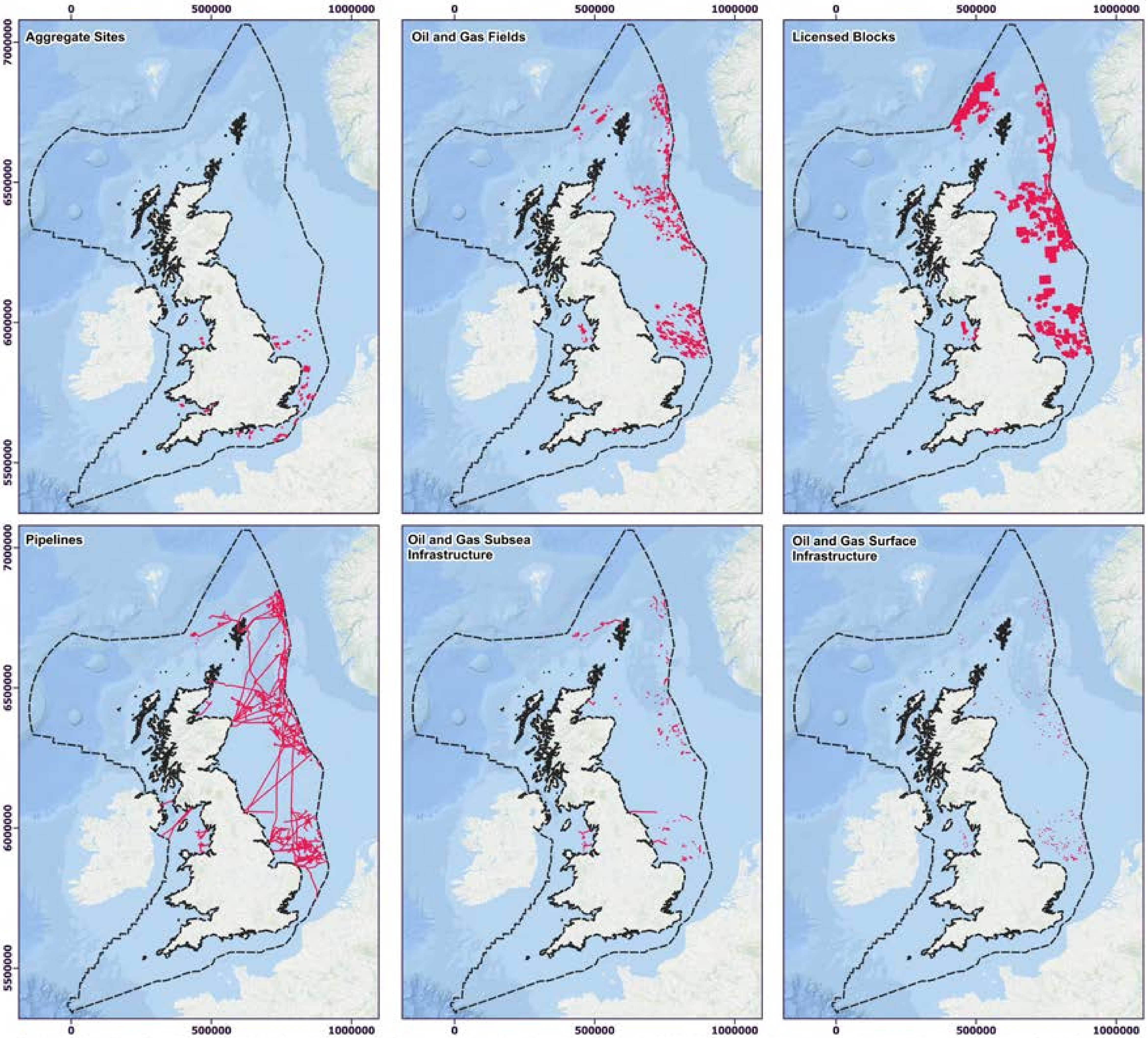

Collaborative Environmental Advisers

Figure 4-3
Consenting Constraints - Oil and Gas Infrastructure

C01608-RUK-LOC-006-C

Legend

Study Area

Consent Constraint

Date	12/06/2026
CRS	ETRS89 / UTM zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	meters
Scale at A3	1:13,220,000
Created	MW
Reviewed	AN
Authorised	LV

Document Path: X:\GIS\GIS_PROJECTS\C01608_OWIC_Auks\Projects\QGS\01_LOC\C01608_RUK_LOC_006.qgz

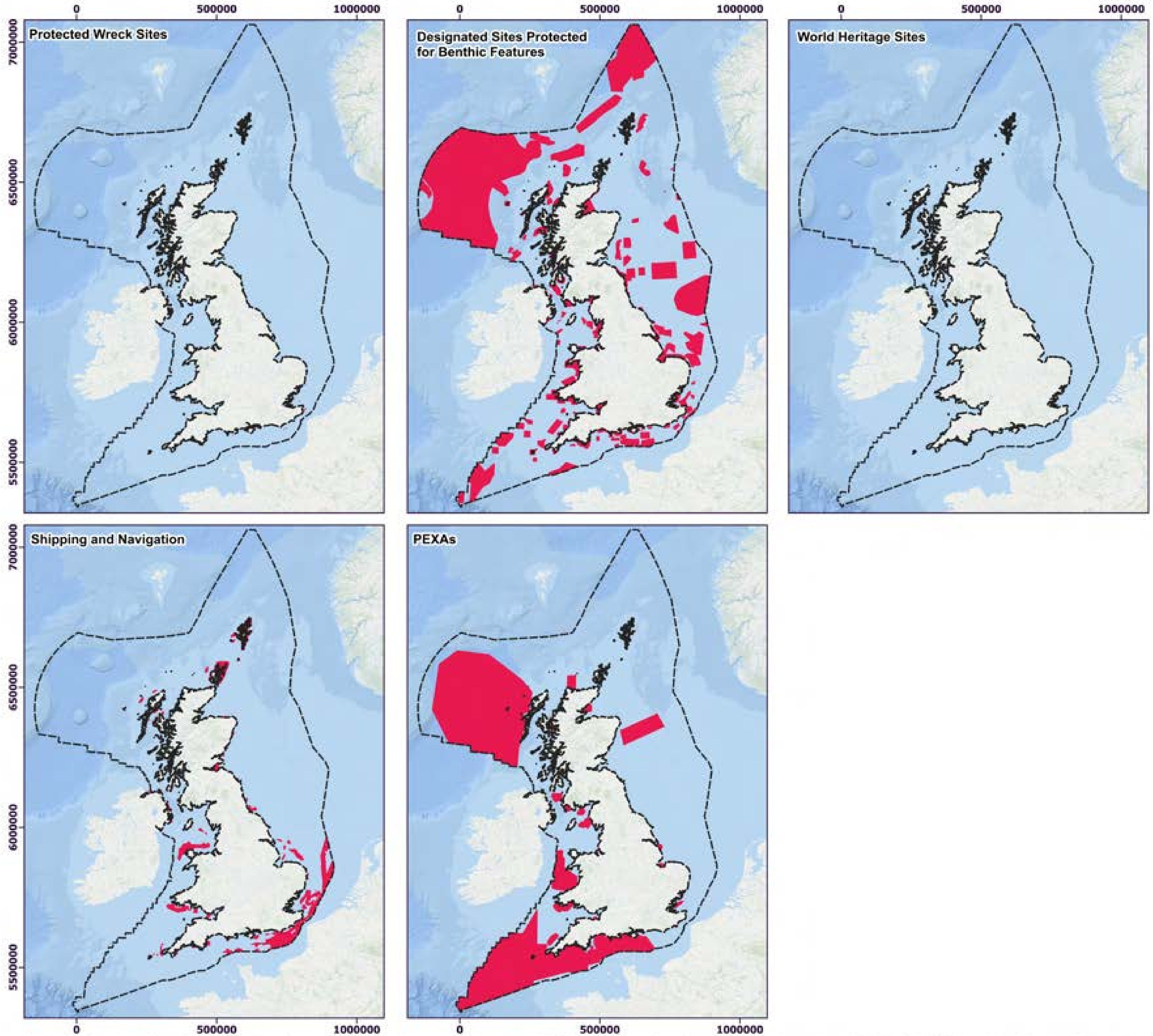

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Figure 4-4
Consenting Constraints - Non-Infrastructure

C01608-RUK-LOC-007-C

Legend

Study Area

Consent Constraint

0 400 800 KM

0 120 240 360 NM

Date	12/06/2026
CRS	ETRS89 / UTM zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	meters
Scale at A3	1:13,220,000
Created	MW
Reviewed	AN
Authorised	LV

Document Path: X:\GIS\GIS_PROJECTS\C01608_OWIC_Auks\Projects\QGS\01_LOC\C01608_RUK_LOC_007.qgz

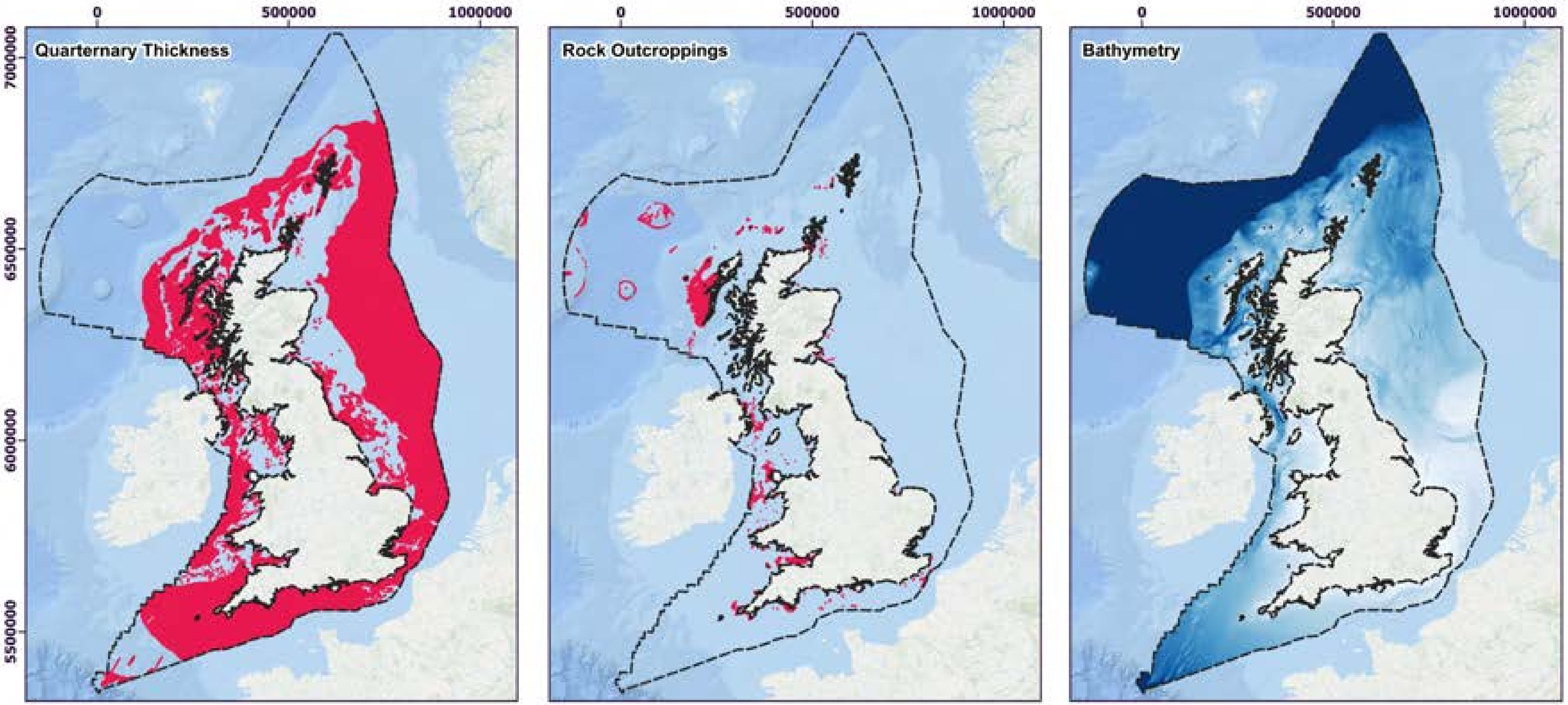

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Figure 4-5
Installation Feasibility Constraints

C01608-RUK-LOC-008-B

Legend

Study Area

Feasibility Constraint

Bathymetry (m)

0

-200

0 400 800 KM

0 120 240 360 NM

N

Date	12/06/2026
CRS	ETRS89 / UTM zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	meters
Scale at A3	1:13,220,000
Created	MW
Reviewed	AN
Authorised	LV

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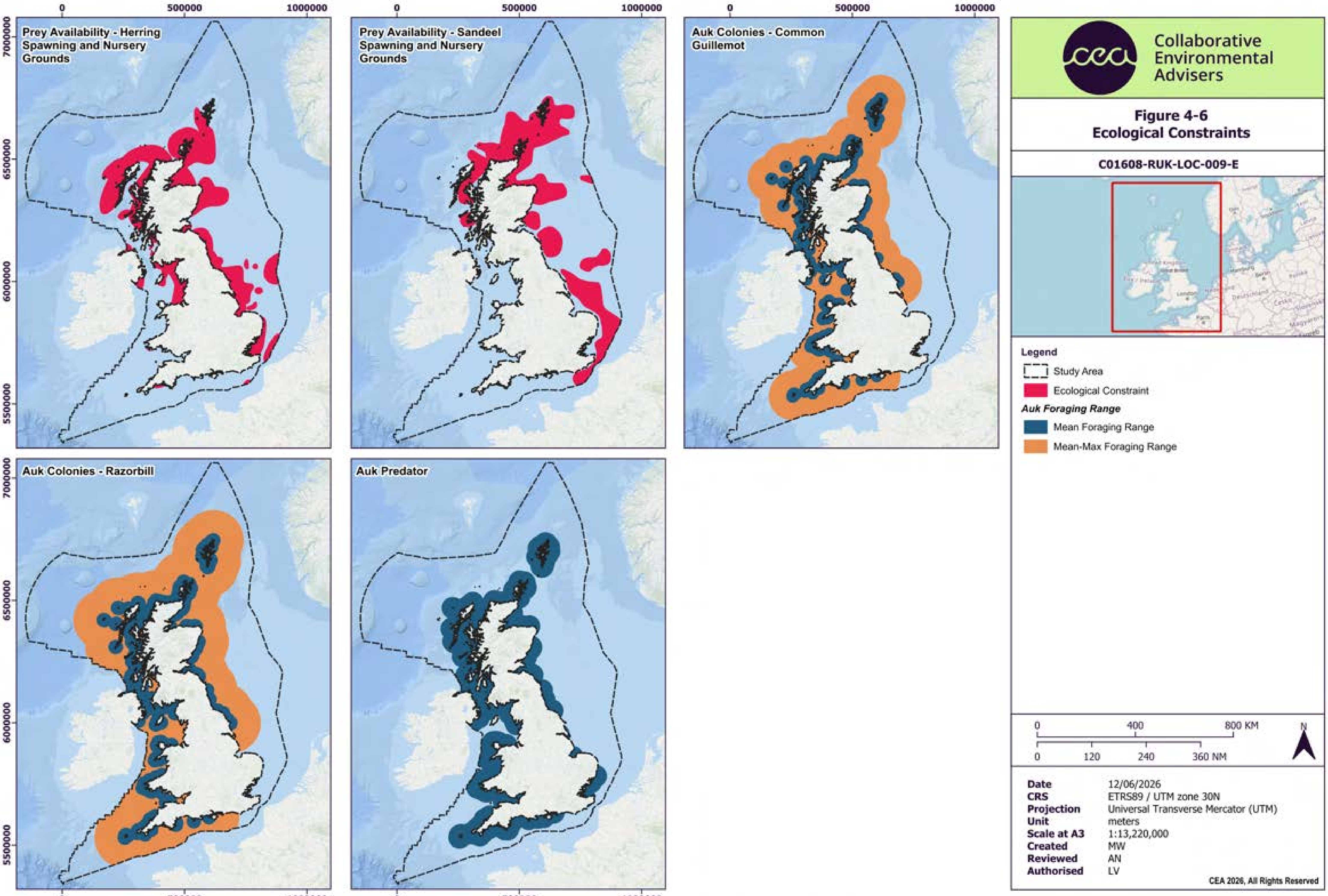

Figure 4-6
Ecological Constraints

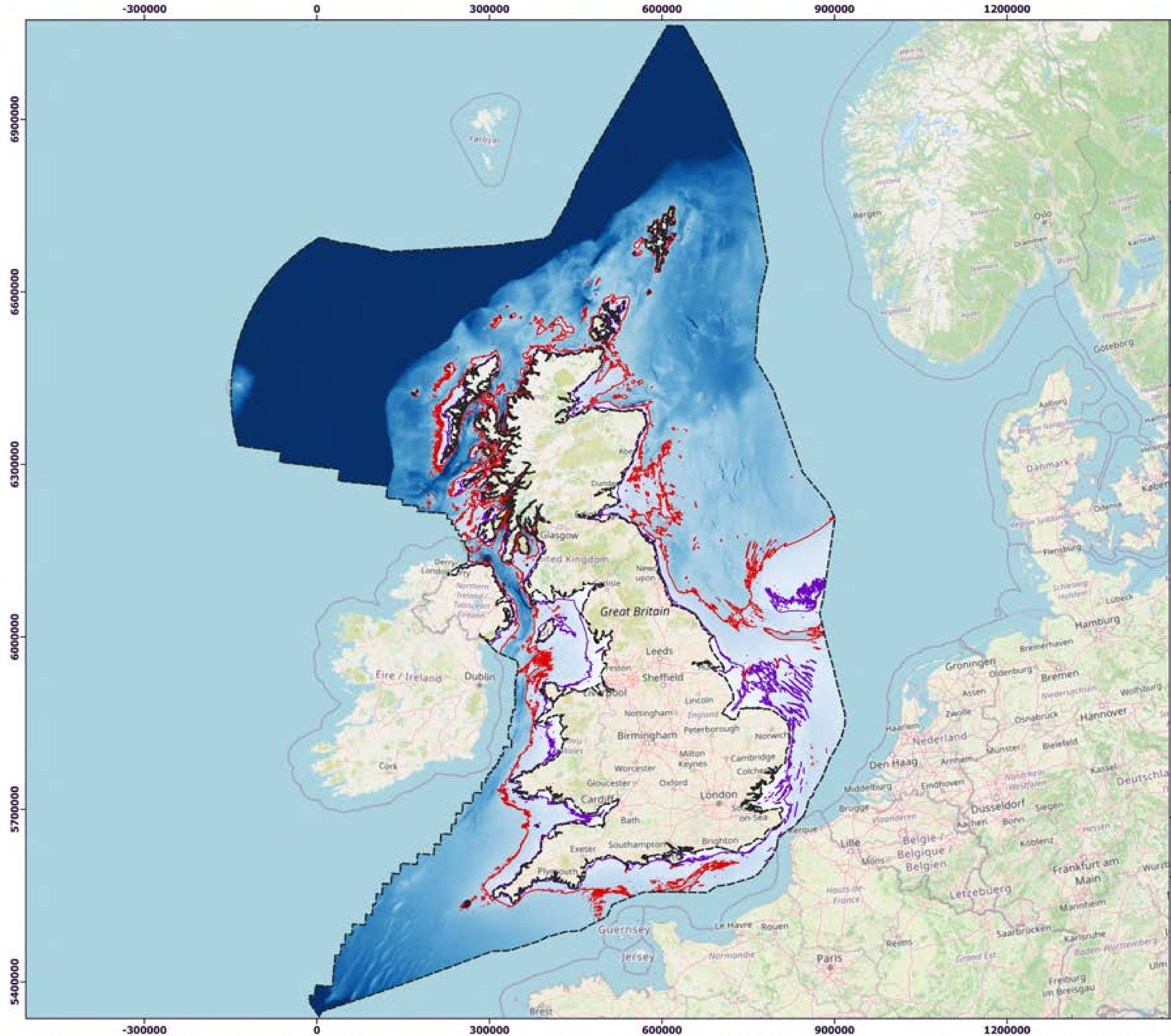

Figure 4-7
Bathymetry Contours of the Study Area

C01608-RUK-BATH-003-C

Legend

- Study Area
- 20 m Contour
- 60 m Contour

Bathymetry (m)

0

-200

0 100 200 300 KM

0 50 100 150 NM

N

Date	12/06/2026
CRS	WGS 84 / UTM zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	meters
Scale at A3	1:6,440,000
Created	MW
Reviewed	AN
Authorised	SS

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4.4 Heatmap Creation

In order to produce the desired visual representation of the data layers, a multilayer multiplication method was used which resulted in hard constraints being consistently scored as 0. This allowed for singular symbolisation of hard constraints within the final heatmap.

For data layers that represented ecological opportunity, a scoring range of 1 to 2 was used, where 1 represented an area of no real ecological benefit, and 2 weighting as the highest ecologically suitable locations. This ensured that highly preferential areas of ecological value were prioritised over feasibility and consenting constraints.

The finalised constraint and suitability values were utilised to determine the final heatmap symbology, applying a purple (highly constrained) to yellow (area of opportunity) colour ramp. This scale was chosen as it is colour-blind accessible and provides suitable colour variations to identify different rankings. Any area of hard constraint (attributed with a score of 0) was symbolised separately in dark grey, to help better identify areas excluded from this study as per the criteria described in Section 3.2.

Figure 4-7 presents the bathymetry utilised in the generation of the heatmaps and the areas within a suitable water depth (20-60 m) within which an offANS could be installed and maintained.

4.5 Study Area Refinement

Following GIS heatmapping, the outputs were reviewed to identify refined Study Areas where auk offANS siting was identified to be most suitable within the overall Study Area. The review considered all ecological, feasibility, consenting, and shipping and navigation criteria included in the heatmapping.

It is recognised that Scotland supports several key auk breeding colonies on its mainland and islands. Through the consultation workshop it was noted that there is likely to be sufficient breeding habitat available for auks within the existing colonies (Table 3-1). Review of seabird census and SMP data (Burnell *et al.*, 2023; Harris *et al.*, 2026) supported this, with evidence suggesting that the availability of natural habitat is not a limiting factor at Scottish auk colonies, as the majority of colonies historically supported greater populations than present. It is anticipated that such colonies would be unlikely to benefit from offANS, and, therefore, it was agreed with stakeholders that Scotland would be excluded at this stage, and no specific Study Areas would be located there. It is noted that the some potentially preferable areas in Scotland were identified in the UK wide heatmaps, therefore there may be benefit in revisiting this in the future.

4.6 Limitations

The limitations of the raw data used to produce the heatmaps are considered in this section. Throughout the study, decisions on how best to proceed with encountered limitations were discussed within the project team and SMEs where appropriate.

Variation in ecological parameters, such as foraging ranges or prey distribution, has not been considered in the mapping exercise. Seabird foraging ranges show high levels of variation, with standard deviations often exceeding the average (Woodward *et al.*, 2019), depending on a range of factors, including the distribution and availability of prey species.

Whilst dispersal range has been considered in the study area refinement (Section 2.1) and in the scoring criteria (Section 2.2.1), it was not reasonably possible to incorporate dispersal rates or to imply likelihood of colonisation as a quantitative factor. It is recognised that auk natal dispersal rates are substantially lower than some other seabird species, such as kittiwake. Some studies suggest that over 80% of individuals of both species return to their natal colony for first breeding, and over 90% of breeding birds return to the same colony in subsequent years (Swann and Ramsay, 1983; Harris, Wanless and Barton, 1996; Lavers, Jones and Diamond, 2007). However, other studies indicate that guillemot dispersal is greater, with up to 58% of birds breeding at locations other than their natal colony (Horswill and Robinson, 2015). Additionally, there is a smaller evidence base for auks colonising anthropogenic offshore structures compared with kittiwakes, with most evidence being observational and a limited number of individuals.

To represent prey availability in the heatmap, data from Coull, Johnstone and Rogers (1998) were used. These data are dated (>25 years old) and are unrepresentative of known populations of herring and sandeel in the southwest. However, these data are considered to be the best available indicator of prey species for use in this study. It was not reasonably possible to revise the scoring or treatment of individual data layers on a regional basis, therefore, the scoring for connectivity to prey resources was reclassified (Table 2-1; Section 2.3).

To consider whether any areas are preferential for the co-location of both Kittiwake and Auk ANSs, The Crown Estate (2023) outputs were used. The heatmap created in the TCE study does not cover the full extent of the Northeast Study Area identified in the auk offANS assessment. As a result, a proportion of the area considered as 'preferential' for auk offANS in this study has not been considered for potential co-location due to the data limitations.

The Crown Estate's Offshore Wind Leasing Round 6 was announced with Round 6 Refined Areas of Search publicised in late March 2026. Therefore, it has not been possible to incorporate these locations into the scoring criteria as they were published following the heatmap creation.

5 Results

5.1 UK Wide Heatmaps

5.1.1 Ecological Suitability Heatmap

The key hard constraint for ecological criteria was exclusion of areas within the core foraging range of existing auk colonies, based on SMP data (shown in Figure 4-6). This is evident in the ecological constraints heatmap (Figure 5-1), shown as a 'buffer' around auk colonies in UK waters, primarily in Scotland and Wales, but also the northeast and southwest coasts of England.

Outside of these hard constraints, ecological suitability is typically greater further inshore, where there is evidence of suitable foraging grounds and connectivity to existing colonies, for natal dispersal opportunities. The coasts of Scotland and northeast England are shown to be of highest suitability based on the ecological scoring criteria. Whilst the southwest of England is of moderate suitability (scores of four to five; Figure 5-1), this area may nonetheless represent a suitable location for auk offANS due to it being within the maximum natal dispersal range of both species, within the maximum foraging range of existing colonies, and within foraging range of prey resources (refer to Section 5.4 for further discussion).

Offshore locations in the outer extent of the Study Area were of lowest suitability (excluding hard constraints). These areas, whilst technically within natal dispersal range, have lower levels of connectivity to established breeding colonies and lower prey availability.

Inshore areas with low suitability include East Anglia and Southeast England. The data used to inform the study suggest that prey are present and available in these areas (Coull, Johnstone and Rogers, 1998). However, there is limited connectivity to existing auk colonies, meaning colonisation and successful establishment of offANS in East Anglia and southeast England is less likely.

The core range of existing guillemot and razorbill colonies eliminated the majority of Welsh waters (Figure 5-1). Similar results can be seen for the southwest of Scotland, Northern Ireland, and the Isle of Man, where hard constraints (buffers around existing colonies and the coast) occupy most of these areas.

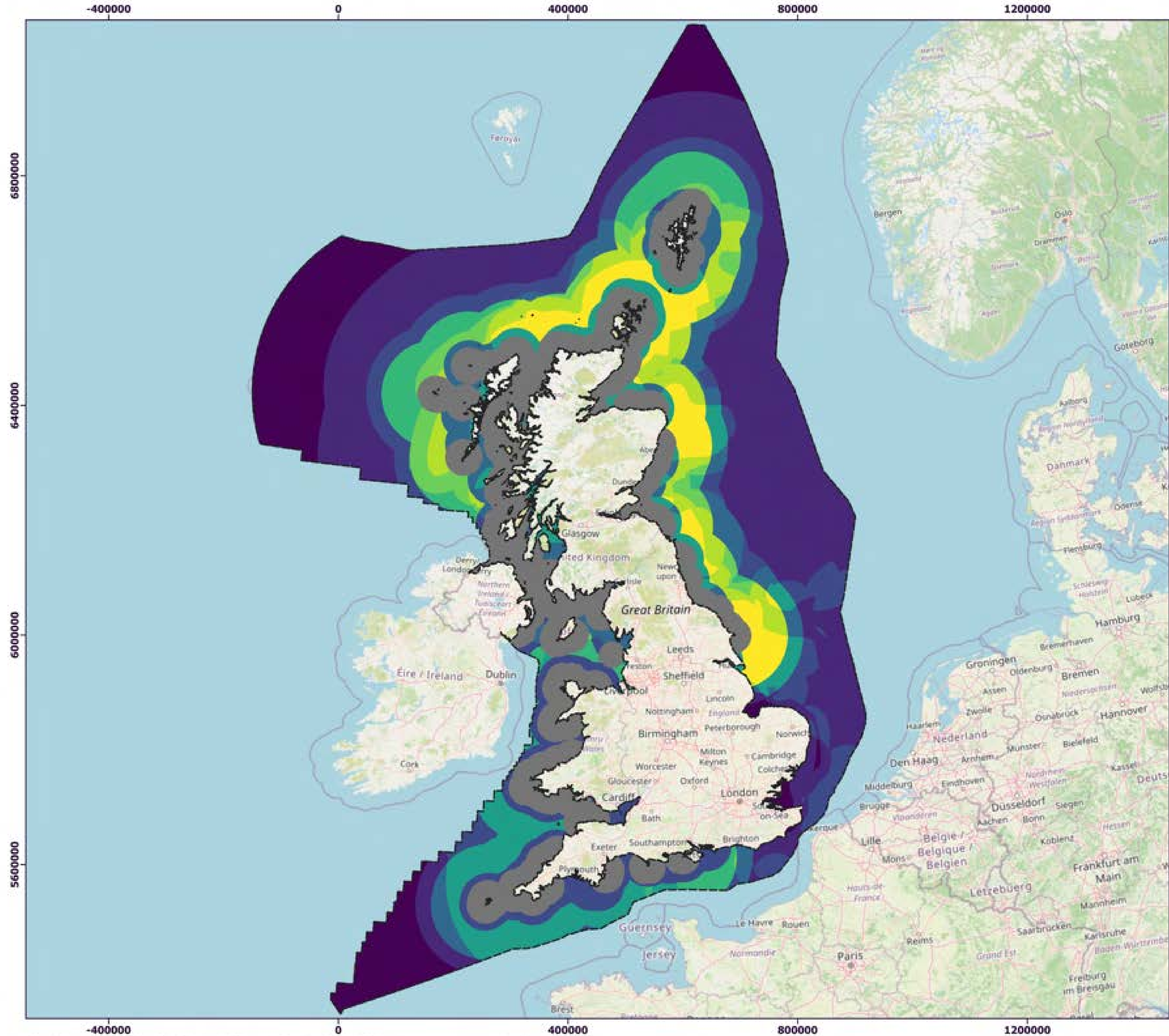

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Figure 5-1
Ecological Suitability Heatmap

C01608-RUK-BIRD-003-D

Legend

Study Area

Ecological Suitability Score

- 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9

0 100 200 300 KM
0 40 80 120 NM
N

Date	12/06/2026
CRS	ETRS89 / UTM zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	meters
Scale at A3	1:6,450,000
Created	MW
Reviewed	AN
Authorised	SS

Document Path: X:\GIS\GIS_PROJECTS\C01608_OWIC_Auks\Projects\QGIS\09_BIRD\C01608_RUK_BIRD_003.qgz

5.1.2 Consenting and Installation Feasibility Suitability Heatmap

The consenting and installation feasibility suitability heatmap was generated from the amalgamation of the consent constraints and the engineering feasibility scoring. The need to constrain a suitable water depth range (20-60m), reduced the majority of the Study Area as a suitable location for the installation of an offANS (i.e., a hard constraint) (Figure 5-2). Generally, near to the coast and further offshore were out of suitable depth ranges around the UK, with the Southeast having large areas offshore that are too shallow and the southwest coast and Scotland being limited by the deep waters close to the coast. Within the feasible depth range the sub-surface geology (quaternary thickness) was considered which further reduced feasible areas. Where the quaternary thickness was less desirable from an installation perspective, defined in this study as below 5m or above 50m, a score of 0.5 has been applied (Annex I). This ensures that the remaining areas were feasible for pile driving and therefore offANS installation.

The east coast has a high quantity of marine infrastructure from other sea users. There are a high number of oil and gas installations and licensing blocks in comparison to the rest of UK waters (Figure 4-3). This region also contains the highest density of pipelines, subsea infrastructure and surface infrastructure. OWFs are found predominantly off the east coast along with their associated infrastructure such as subsea cables (Figure 4-2). The majority of marine aggregate extraction sites are also located off the east coast, with a small number located in the English Channel, south Welsh coast, Bristol Channel and Southwest Approaches. For safety and engineering feasibility all infrastructure, and suitable buffers (e.g., 500 m safety zones around O&G Platforms), were considered a hard constraint.

Designated sites with benthic features were considered a hard constraint due to consenting risks and potential impacts to the protected features (Figure 4-4). This removed areas throughout UK waters, both inshore and offshore. The south, southwest, Welsh and Scottish coasts have a high number of designated sites for benthic features and habitats off the coast.

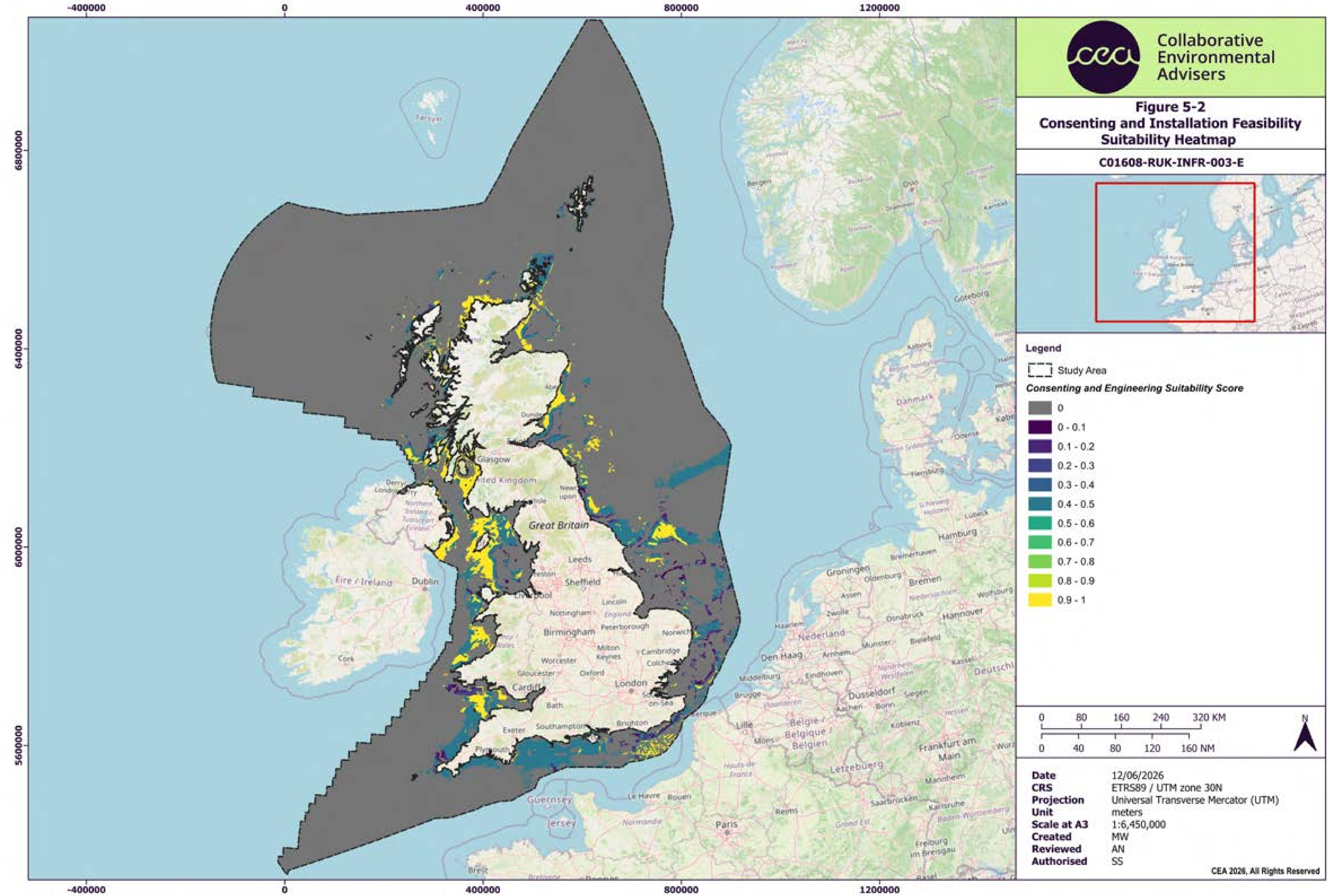

Figure 5-2 Consenting and Installation Feasibility Suitability Heatmap

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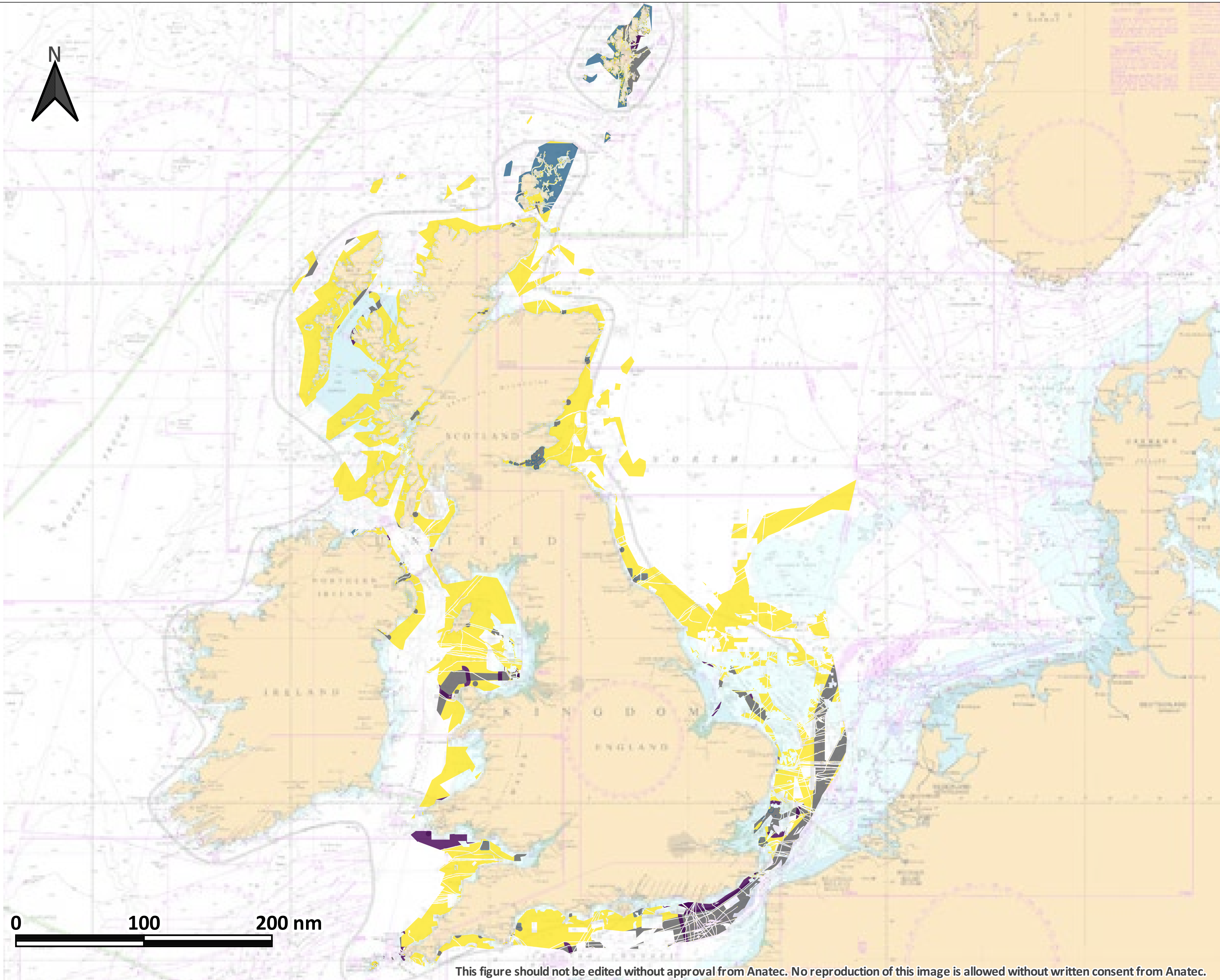
5.1.3 Shipping and Navigation Constraints

Using the methodology outlined in Section 4, Anatec preliminarily identified and ranked shipping and navigation constraints via information available on nautical charts and their experience. Key identified constraints included IMO routeing measures, anchorages, and pilot boarding areas. The suitability heatmap for shipping and navigation constraints is provided in Figure 5-3.

The suitability heatmap showed large areas where no constraints were identified; however, it should be noted that this is likely a reflection of the high-level nature of the assessment and the lack of identified constraints within these large areas does not mean the absence of constraints. Further assessment is required to ascertain the nature of constraints within these areas in more detail, in particular to characterise vessel routeing via vessel traffic data. This stage should be undertaken when an ANS location is being selected within a Study Area and would be informed by detailed assessment of Automatic Identification System data.



Legend

Shipping and Navigation Constraints
- Hard Constraint
- Medium-Hard Constraint
- Medium Constraint
- No Constraint Identified

Anatec Limited
Risk based decision making
An Employee Owned Company

Project

A5522 CEA Auk ANS Site Selection

Figure Title

Figure 5-3: Shipping and Navigation Constraints

Date: 12/06/2026	Drawn: LA	Checked: AF

Coordinate System: WGS 84 / World Mercator (EPSG:3395)

5.1.4 Combined Suitability Heatmap

Figure 5-4 presents the final UK wide heatmap of areas suitable for the installation of an offANS for auk species.

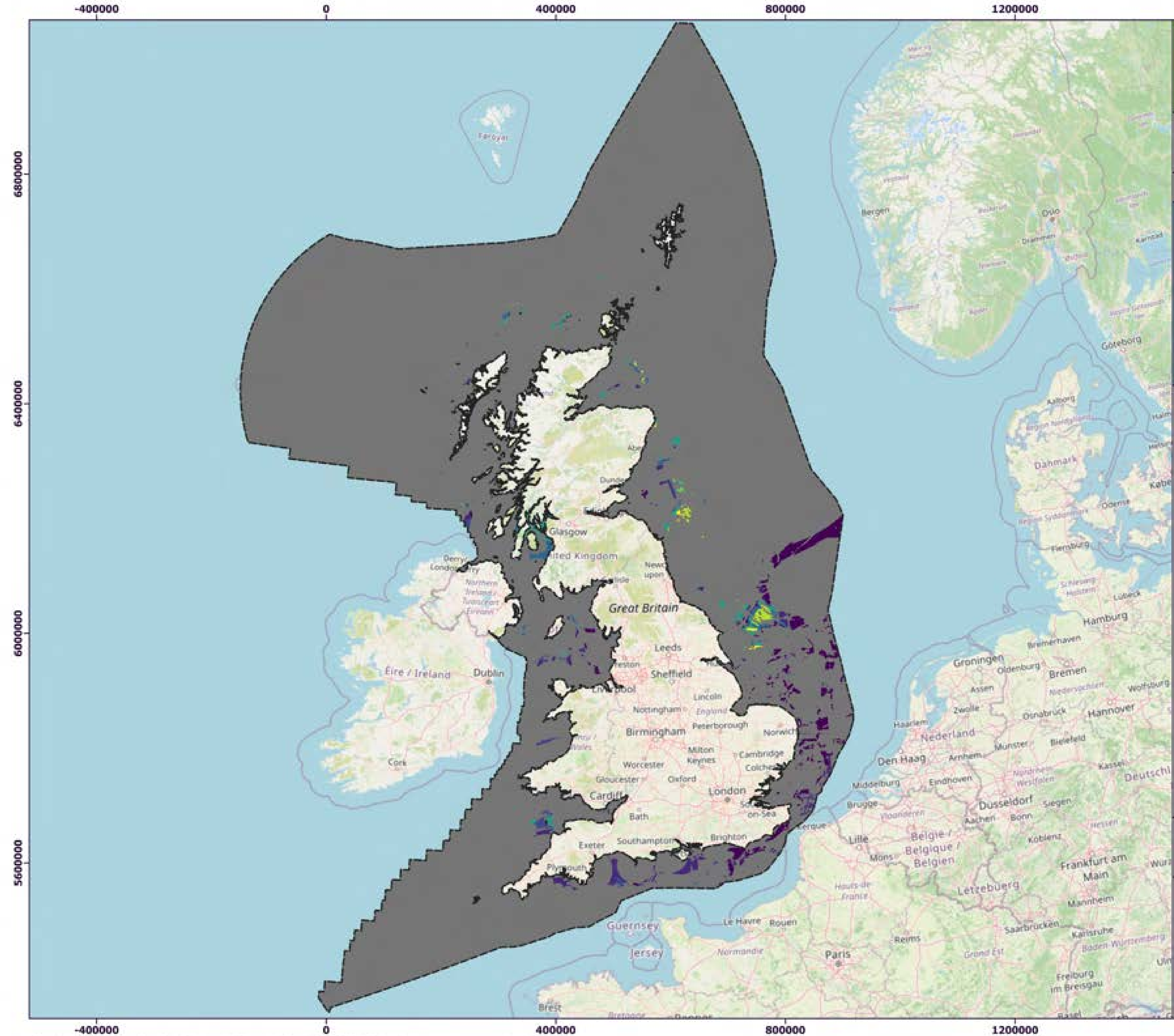
As discussed in the previous sections, much of the inshore areas are restricted in relation to ecological criteria as they are within the core foraging range of existing auk colonies. Water depth constraints reduce available search areas both inshore (<20 m) and further offshore (>60 m). When the other consenting considerations are combined into the heatmap, the majority of the Study Area, approximately three quarters, is unsuitable for offANS siting for auk species (Figure 5-4). As presented in Figure 5-4, the areas which are most suitable are represented as yellow (and with a high numerical score) and the less desirable areas represented as purple. Areas which have hard constraints are represented as grey.

There are, however, some discrete locations where offANS may be suitable and could result in colonisation and establishment of breeding auk colonies. These locations are off the east coast of England and the Southeast coast of Scotland, with overall suitability scores of six to nine. The southwest of England had moderate suitability, particularly in the Bristol Channel, with a sizeable area scoring up to five. The Southeast coast of England and within the English Channel had low to moderate suitability, with dispersed areas of scores ranging from one to four. The Irish Sea and west of Scotland was mostly constrained with some limited areas of low suitability.

Collaborative Environmental Advisers

Figure 5-4
Suitability Heatmap

C01608-RUK-INFR-004-D



Legend

Study Area

Suitability Score

- 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9

0 80 160 240 320 KM
0 40 80 120 160 NM

N

Date	12/06/2026
CRS	ETRS89 / UTM zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	meters
Scale at A3	1:6,450,000
Created	MW
Reviewed	AN
Authorised	SS

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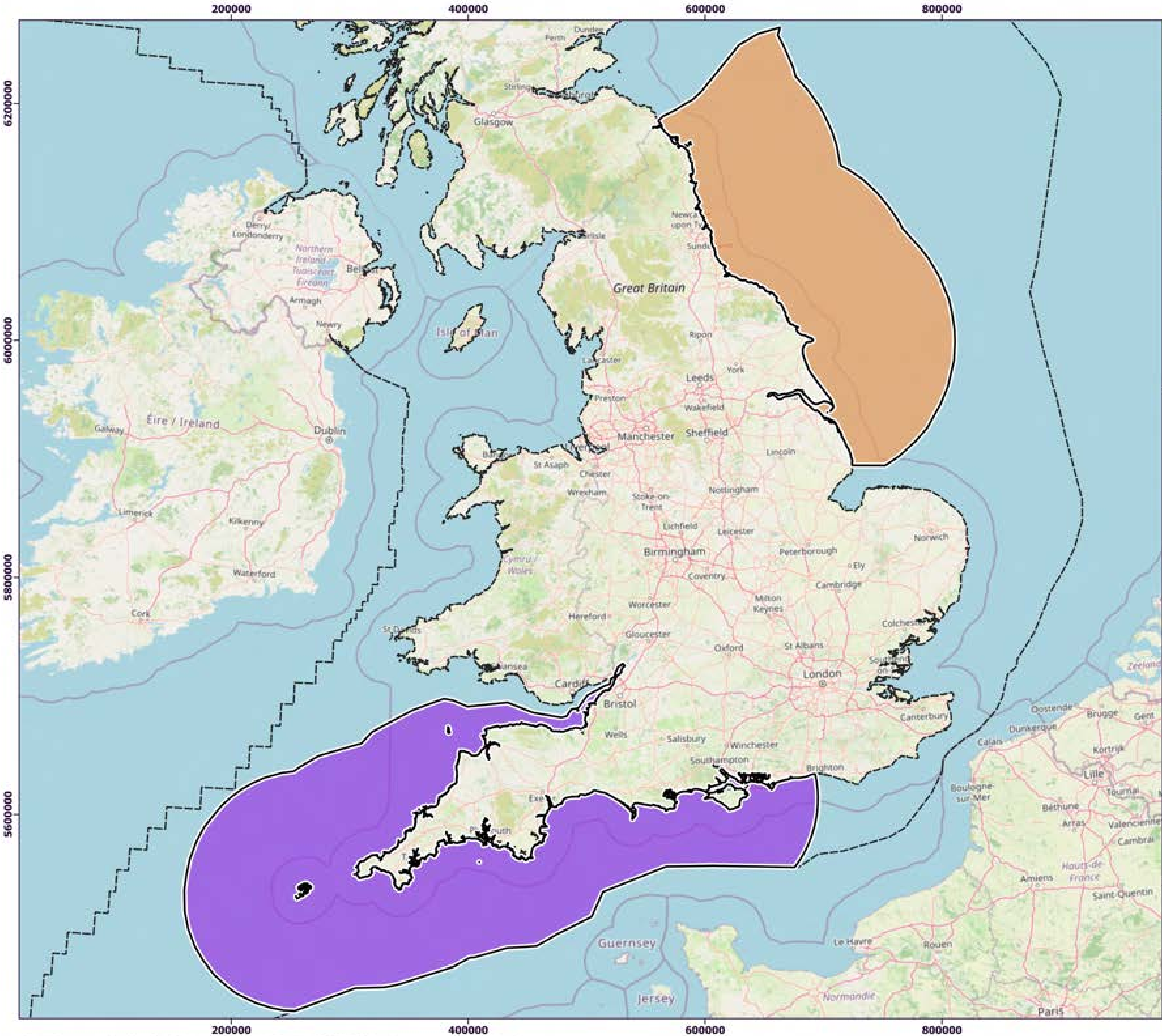
5.2 Refined Study Areas

Following Workshop 2 on 26 February 2026, it was agreed that two refined Study Areas would be taken forward, focused on the northeast and southwest of England (Table 3-1)(Figure 5-5). These Study Areas were selected on the basis that the UK heatmaps showed potentially suitable areas within these regions which would benefit from more detailed analysis. Additionally, there are large auk populations present in the northeast which are established colonies, so it was agreed with stakeholders that offering some alternative habitat may be beneficial to these populations. Within the southwest, the constraint mapping provided areas that may be suitable, and stakeholders agreed that further investigation into this area would be beneficial.

It was agreed that Scotland would not be considered for more detailed analysis at this time due to an abundance of natural nesting habitat availability for auk species, and therefore limited benefits of the introduction of offANS. While Scotland should not be excluded from future ANS siting considerations, it has not been evaluated at a detailed study-area level in this analysis. Similarly, Wales was also considered initially and discussed in consultation workshops; however, nesting availability is not deemed to be a limiting factor for auk populations at present.

An area-specific and refined symbology was chosen for each refined Study Area, which better highlighted areas of constraint or suitability within each Study Area. This symbology highlights the distribution and granularity of scoring based off area specific scoring ranges. It should be noted that the heatmaps created for the two areas are not directly comparable in terms of symbology.



Collaborative Environmental Advisers

Figure 5-5
Refined Study Areas

C01608-RUK-LOC-004-B

Legend

- Study Area (UK Wide)
- South West Study Area
- North East Study Area

0 50 100 150 KM
0 25 50 75 NM

N

Date	12/06/2026
CRS	ETRS89 / UTM zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	meters
Scale at A3	1:3,125,000
Created	MW
Reviewed	AN
Authorised	SS

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5.3 Northeast Study Area

The Northeast Study Area is shown on Figure 5-6, and presents a heatmap of the combined constraints. The scoring symbology has been reclassified to show suitability in the context of the Northeast Study Area alone.

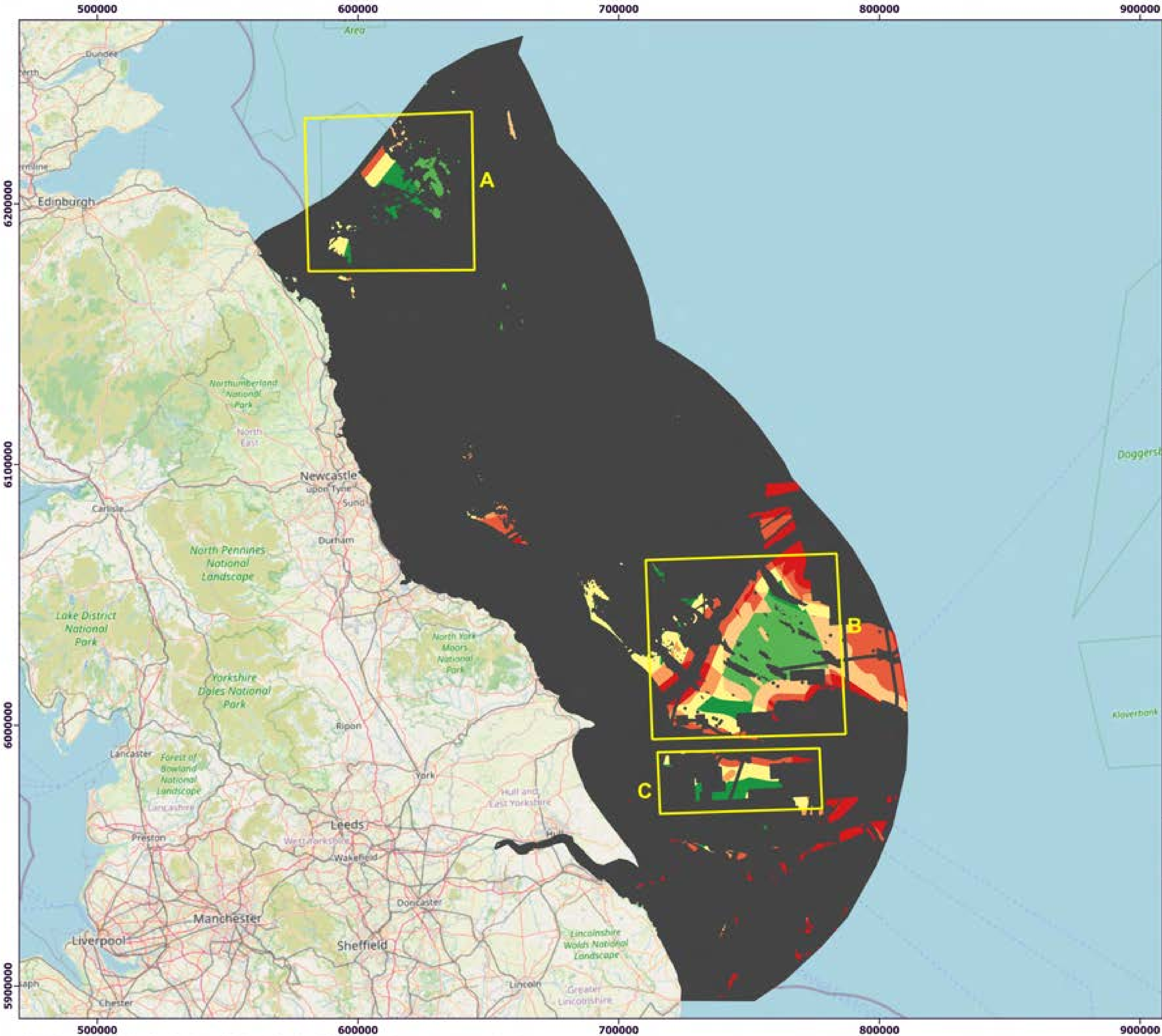
Within the Northeast Study Area, there are three discrete locations which are shown to be of high suitability for auk offANS siting (shown as A, B and C in Figure 5-6). These locations have connectivity to existing auk colonies on the east coast of England and in southern Scotland, are within foraging range of key prey resources (Coull, Johnstone and Rogers, 1998), and are potentially feasible for development from a consenting and engineering perspective.

The heatmap outlines a large variety of optionality within the Northeast Study Area. The total area with a constraint score of 7 or above (considered to have high suitability) is 1,250 km^2. The greatest scoring areas are associated with lower water depths within the surrounding areas of Dogger Bank, to the southwest of the Dogger Bank OWF projects (Figure 5-20).

Collaborative Environmental Advisers

Figure 5-6
North East Study Area Suitability Heatmap

C01608-RUK-INFR-005-E



Legend

Suitable Area

Suitability Score

- 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9

0 30 60 90 KM
0 15 30 45 NM
N

Date	12/06/2026
CRS	ETRS89 / UTM zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	meters
Scale at A3	1:1,420,000
Created	MW
Reviewed	AN
Authorised	LV

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5.3.1 Ecological Suitability

The Northeast Study Area provides multiple large areas of ecological suitability. The coast supports both guillemot and razorbill colonies, and is in proximity to the significant colony at Bempton Cliffs, within the Flamborough and Filey Coast SPA. If colonised, offANS within the Northeast Study Area has the potential to support and feed into the UK NSN with little risk of increasing competition for resources due to criteria applied, such as distance from existing colonies. The Study Area also has spawning and nursery grounds of both herring and sandeel (Coull, Johnstone and Rogers, 1998), indicating high prey availability, which is supported by the presence of long-established, successful seabird colonies.

Ecological constraints within the Northeast Study Area are primarily those associated with competition with existing colonies and areas falling outside foraging range with sufficient prey resource availability. Much of the inshore areas are represented as a hard constraint due to the presence of existing auk colonies, most notably at the Flamborough and Filey Coast SPA.

The majority of the Northeast Study Area is within foraging range of key prey spawning or nursery grounds.

5.3.2 Technical and Engineering Suitability

To assess the engineering constraints within the Northeast Study Area it is important to understand the ground conditions and geology which is presented in the following section.

Ground conditions

In the absence of site-specific geological and geotechnical data for the Northeast Study Area data from Ternan's internal database, publicly available data from nearby OWFs and regional geological publicly available data (e.g., BGS geological maps) have been used to provide a sufficient understanding of the ground conditions that are expected at each of the study areas. The Study Area has been divided into three areas which are presented in Figure 5-7 and details of the ground conditions within each area are detailed below.

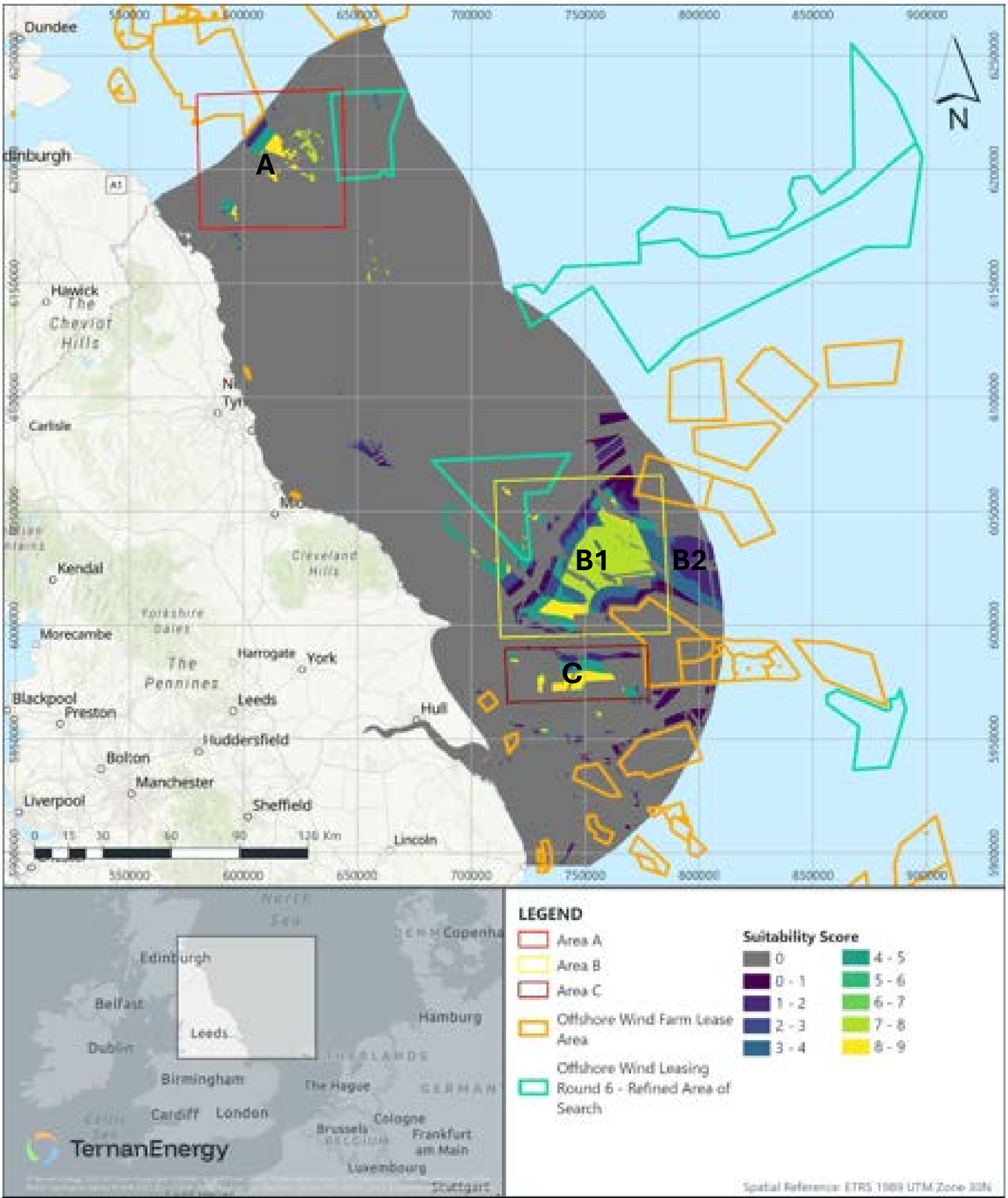


Figure 5 7: Offshore windfarms relative to Ground Condition Locations A, B1, B2 and C.

Location A

This area has not been part of any offshore wind development yet, and therefore there are limited data within the area to draw from. The nearest offshore wind farms are Ossian and Morven, but as these are currently under development there are no data releases available on public databases. Ternan has some inhouse data from the vicinity (source anonymised) which are used together with BGS information to provide an indicative stratigraphic column (Table 5-1).

Table 5-1 Anticipated stratigraphy at Location A

Age	Formation	Lithology
Quaternary	Surface Sediments	Very loose to loose SAND
	Forth	SAND and GRAVEL
	St Abbs	Interbedded, soft to firm, mud to silty mud and SILT, with rare small pebbles
	Wee Bankie	Overconsolidated sandy and gravelly TILL with interbeds of SAND and pebbly SAND and possibly gravel
	Marr Bank	Medium dense to very dense SAND interlaminated with high strength CLAY with gravel, cobbles and boulders
	Coal Pit	Sandy silty CLAY and interlaminated CLAY and fine-grained silty SAND; CLAY generally stiff and overconsolidated with some pebbles. Shell fragments and complete valves abundant in places
	Fisher	Very stiff overconsolidated CLAY with silt and shelly sand with pebbles of varying origin including chalk
	Ling Bank	Greenish grey micaceous SILT with SAND and CLAY interbeds.
	Aberdeen Ground	Heavily overconsolidated, commonly fissured, grey CLAY with lenses and laminae of SILT and SAND
Palaeogene		MUDSTONE with possible interbeds of SANDSTONE/SILTSTONE and/or LIMESTONE. Possible lignite present
Cretaceous	Chalk Group	CHALK with possible flint and chert bands, hard ground CLAY and fossil-rich beds
	Cromer Knoll Group	Calcareous MUDSTONE and shale with marl and limestone. Also possible thin beds of SANDSTONE
Triassic	Smith Bank	MUDSTONE with minor siltstone, thin beds of SANDSTONE and possible thin carbonate or anhydrite bands

Seabed Sediments

According to the BGS Sea Bed Sediments Map (1:250,000) over much of the area the Holocene sediments occur as a thin veneer less than 1m thick overlying a generally smooth, locally irregular surface of Quaternary till over bedrock or directly on bedrock. Thicker accumulations of mainly early Holocene age are present particularly in the NE, adjacent to the Swallow Pit, where they may reach 25m in thickness.

Sand, slightly gravelly, gravelly sand and sandy gravel dominate the seabed sediments over the northern and eastern parts of the area (Figure 5-8).

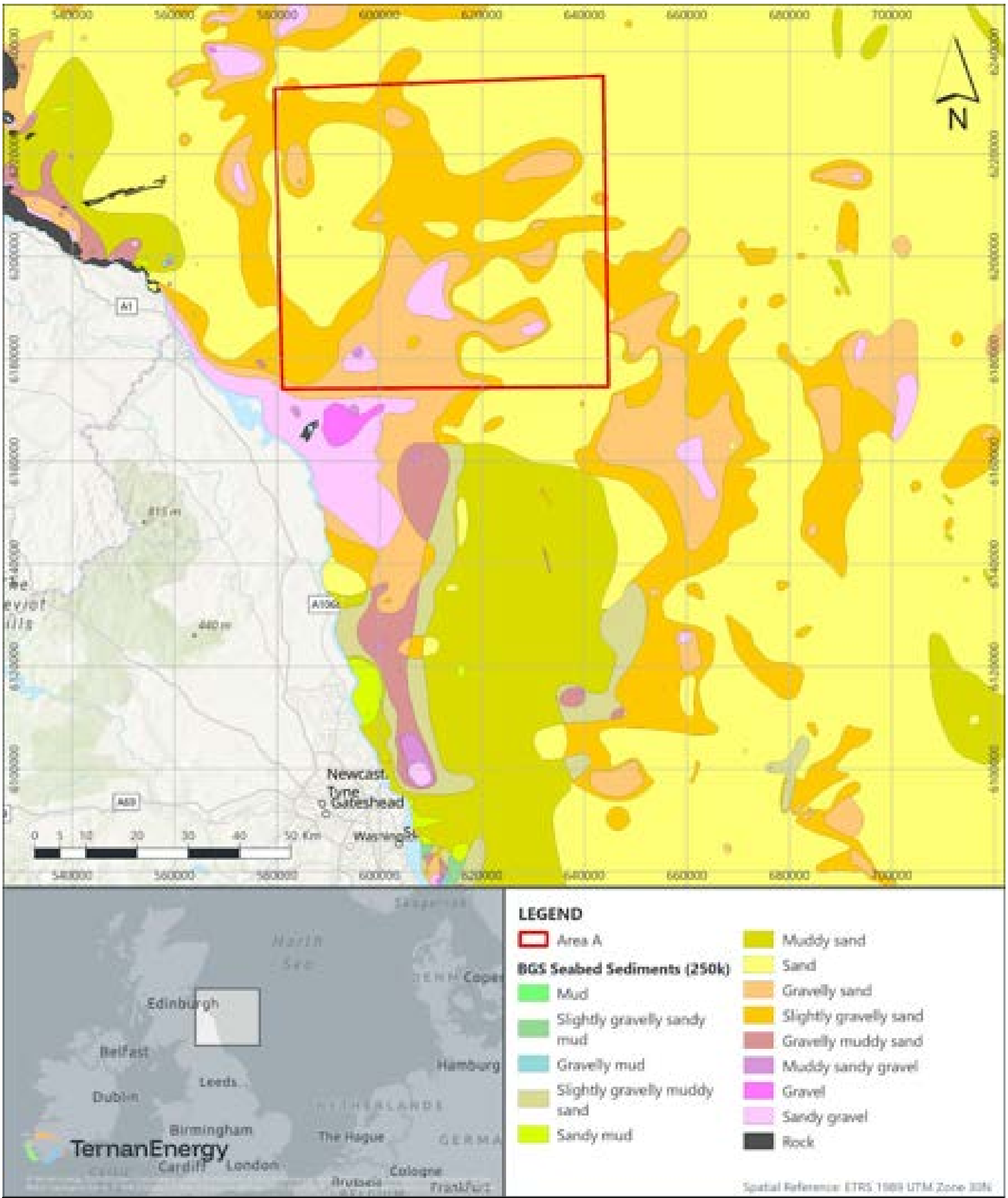


Figure 5-8: Seabed sediment type distribution within Location A (from BGS 1:250000)

Quaternary

According to the BGS the thickness of the Quaternary across most of the site ranges from 5-20m. In localised areas in the southwest the thickness can be less than 5m while in the central area and northeast it can be as thick as 30-50m, likely associated with channel infill (Figure 5-9).

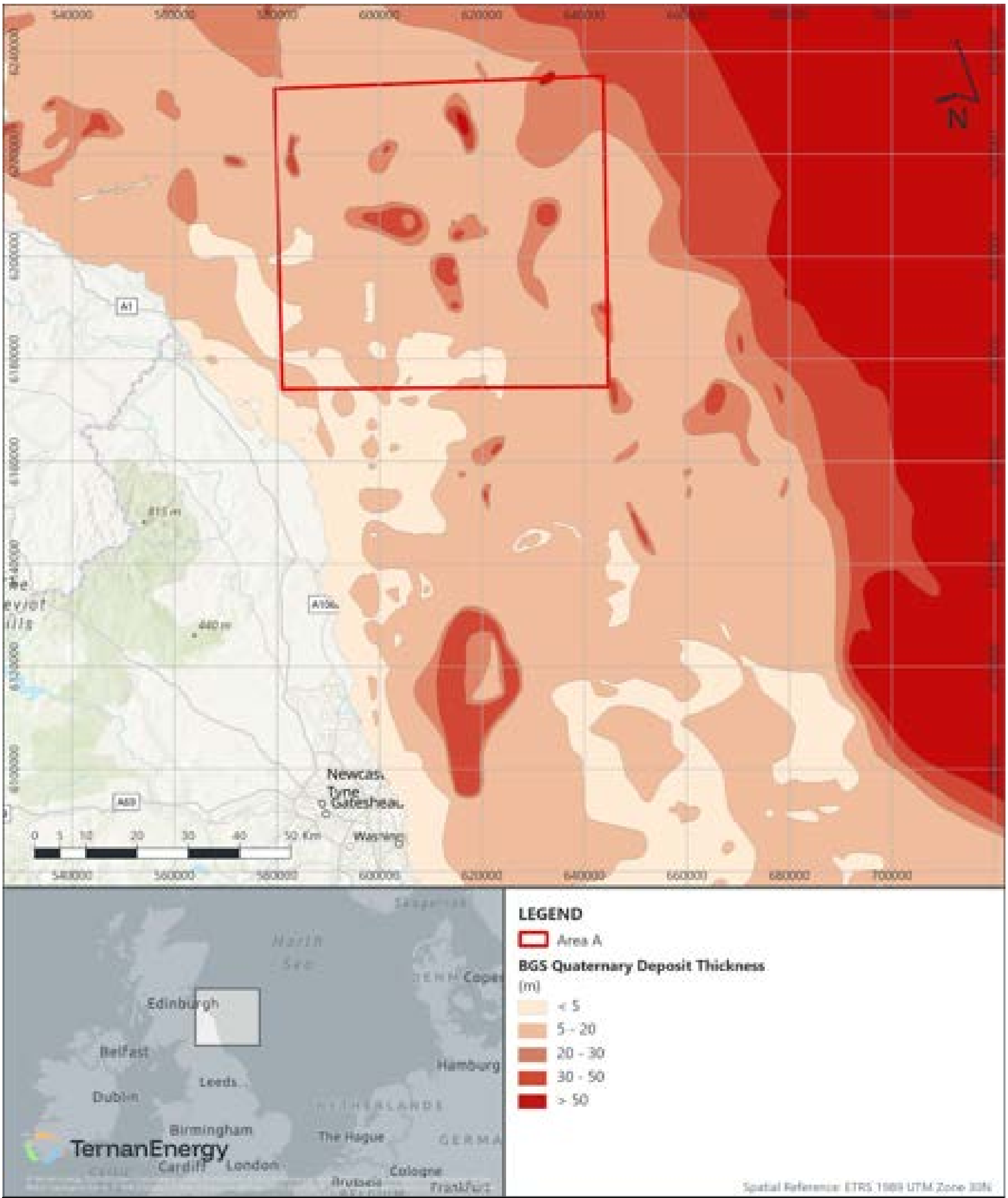


Figure 5-9: Quaternary sediments thickness within Location A (from BGS 1:250000)

Location A straddles two BGS Quaternary sheets, the Marr Bank and Farne sheets (Figure 5-10). According to the BGS Quaternary sheets the formations that may be present in Area A are the Forth, St Abbs, Wee Bankie, and Marr Bank Formations (Table 5-1). At depth, where the Quaternary is thicker, the Coal Pit and the Aberdeen Ground Formations may be found (Figure 5-11 and Figure 5-12).

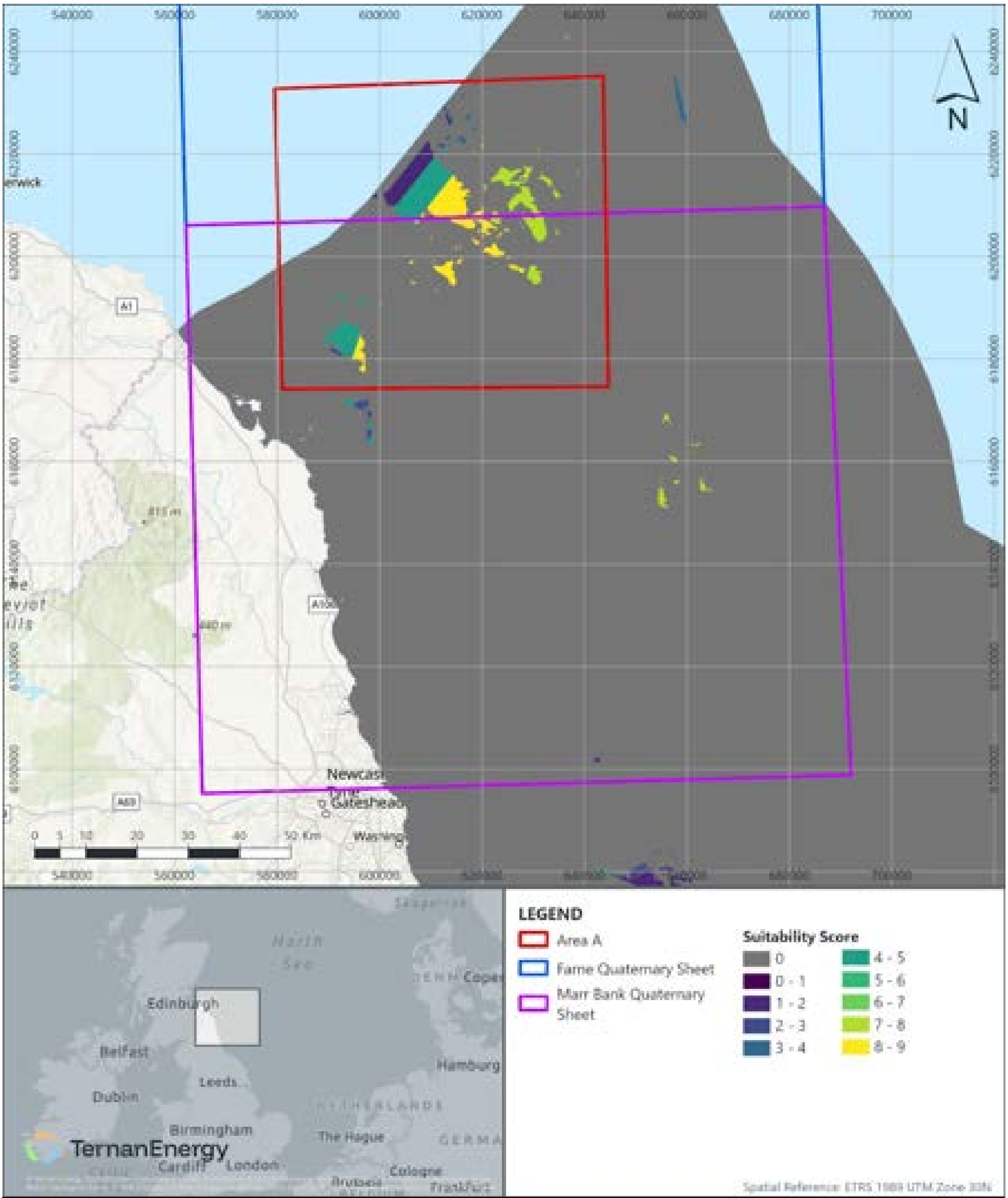


Figure 5-10: Location A straddling Marr Bank and Farne BGS Quaternary sheets

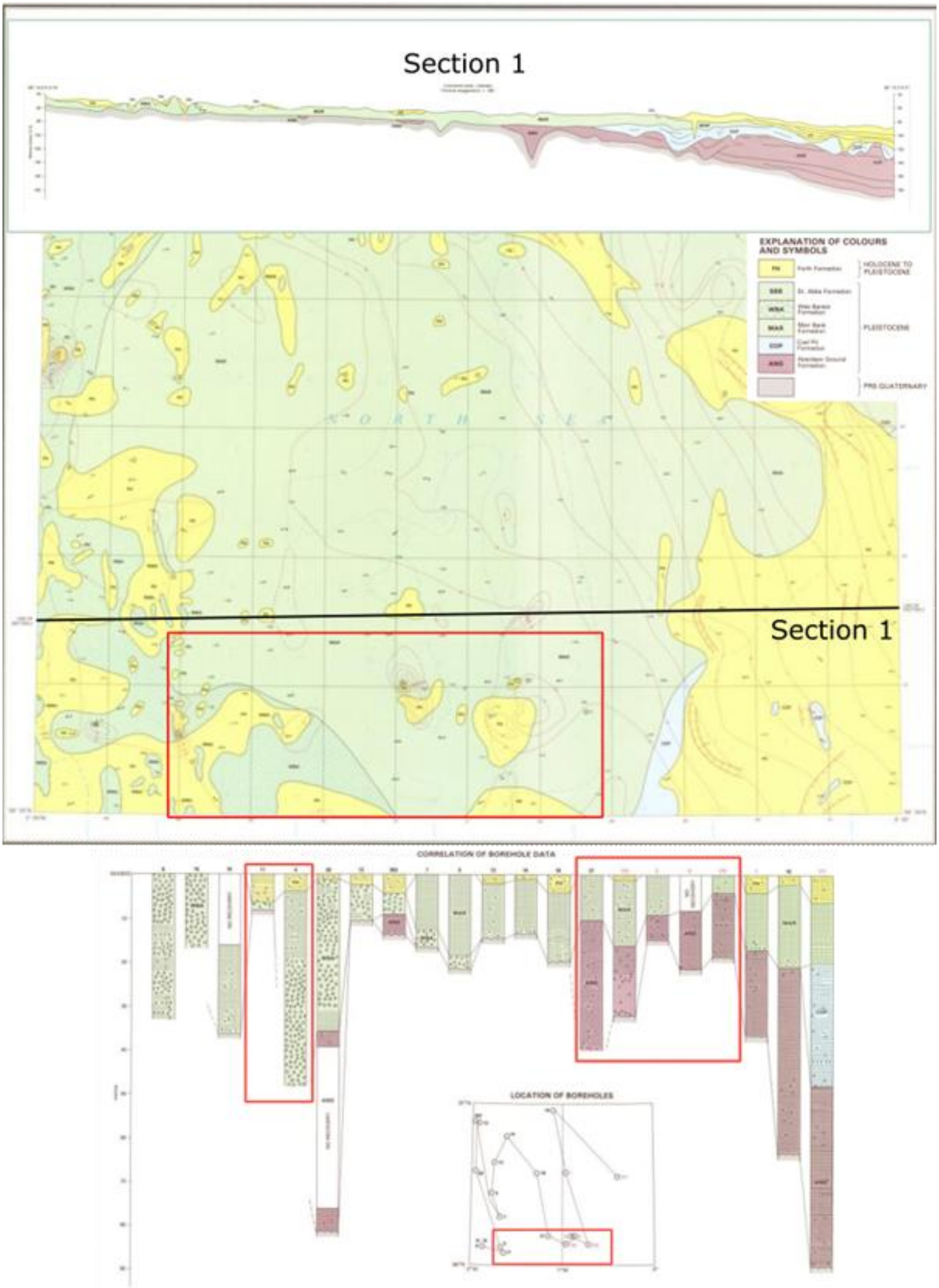


Figure 5-11 North half of Location A (red rectangle) over the Marr Bank BGS Quaternary sheet

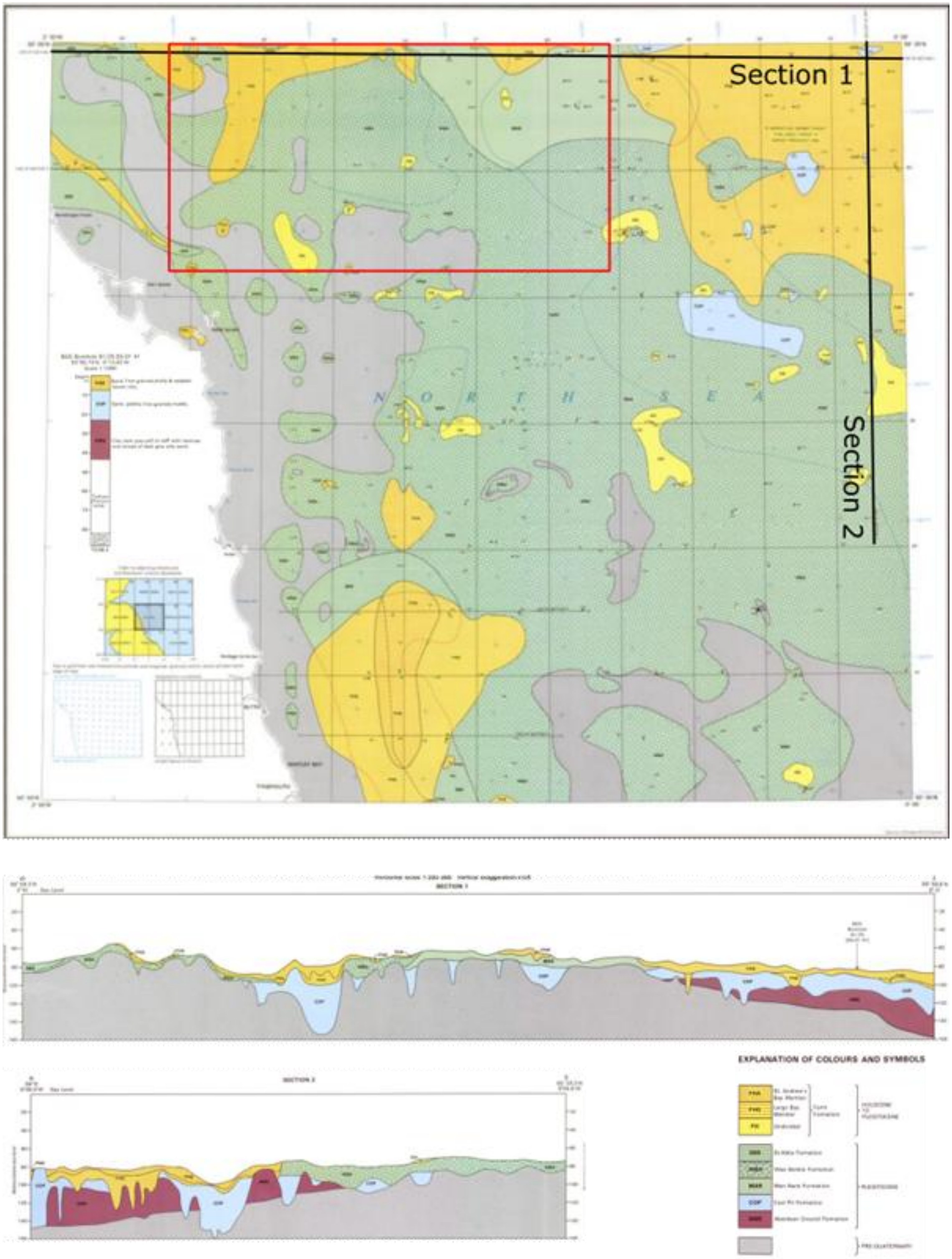


Figure 5-12 South half of Location A (red rectangle) over the Farne BGS Quaternary sheet

Bedrock

The bedrock in the central part of Area A is mostly Triassic, possibly the Smith Bank Formation (Table 5-1)(Figure 5-12). On the eastern edge, the Cromer Knoll Formation of the Cretaceous bedrock will likely be encountered and in the southwest the bedrock is likely Permian mudstone with gypsum. Limited in the southwesternmost corner of Area A are Carboniferous rocks comprising sandstone with limestone. Igneous intrusions may be encountered in the Carboniferous rocks.

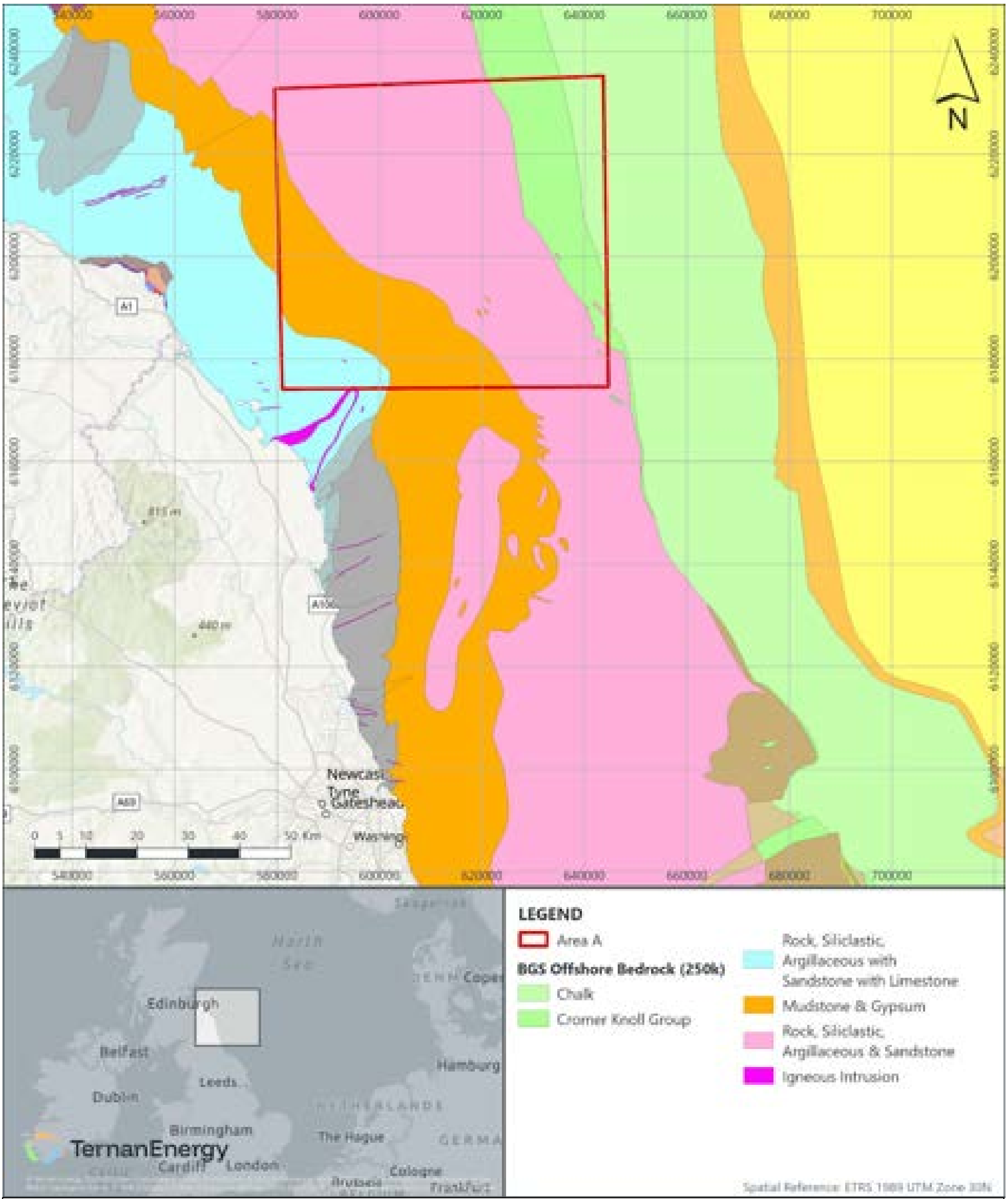


Figure 5-13: Bedrock lithology types within Location A (from BGS 1:250000)

Location B1

Dogger Bank South (West) (DBSW) OWF is situated about 13 km northeast of Location B1 (Figure 5-7). The export cable route for Dogger Bank South OWF passes through this area. Ternan has developed a conceptual understanding of the site through published reports on site investigation in Dogger Bank South using BGS geological profiles. In addition, the BGS Quaternary Geology sheets, BGS bedrock geology and BGS sediments maps have been consulted.

Bathymetry and Morphology

Based on the EMODNet bathymetric data the range of water depths in this area is 30-62m. The shallower water areas are associated with the crests of sand banks. The thickness of sand present is expected to correspond to the amplitude of these banks.

The majority of the seabed sediments is predominantly sand and gravelly sand (Fugro, 2023a). Muddy sand with gravelly till deposits is expected to subcrop below seabed due to erosion of sands by near-floor currents (Figure 5-14). This is evident in the export cable route corridors where the subcropping till is patchy. There are likely to be very large bedforms up to 15m superimposed by small bedforms in the area (Fugro, 2023b) of the Dogger Bank South export cable corridor (Figure 5-14). These bedforms trend northeast to southwest directions. Rippled scour depressions are likely to be present which will likely be mobile. These features will form and dissipate over time, driven by the variable sea-states at different times across the site. The large-scale features, like sand banks, are expected to be non-mobile. Hence, it is likely that the site is mostly stable on both an annual and decadal timescale (Fugro, 2023b).

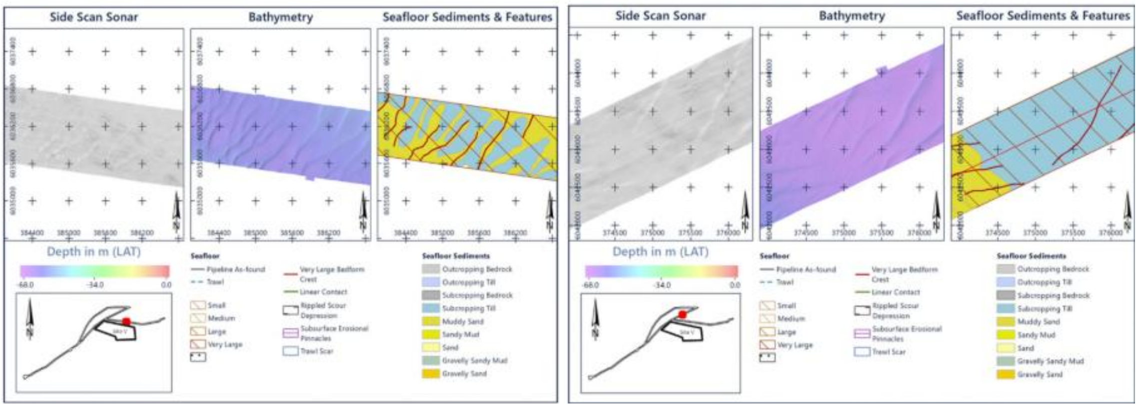


Figure 5-14: Bathymetry and seabed morphology near Location B1 (Fugro, 2023b)

Stratigraphy

Table 5-2 provides the conceptual stratigraphic framework for this location. The Holocene sediments are likely to be present everywhere with sand and shell fragments. The Holocene layer is underlain by the channels of the Botney Cut Formation and may comprise of sand and gravels. Glacial tills of the Bolder Bank Formation are likely to be present across the area. The Dogger Bank Formation is likely to be present and likely with deformed glacio-tectonic deposits with beds of sand. It is followed by the Eem - Egmond ground Formation with likely sand with shells and beds of mud. The Swarte Bank Formation may feature large, deep channel valleys with variable sand and clay. It is underlain by Yarmouth Roads Formation with clayey to silty sand with deltaic to fluvial deposits (Fugro, 2023b).

Glaciotectonic deformation has affected the sequence between and including Dogger Bank Formation and Yarmouth Roads Formation, due to the repeated ice sheet advances and retreats. This tectonic deformation is widespread in the Dogger Bank Formation which comprises of thrust faults (shown in Figure 5-15 by the blue and red triangles) and folding while it is quite local in other underlying units. It is predominantly found in the west of Dogger Bank South OWF. The distribution of deformation is shown in Figure 5-15. It is mapped as area of deeper deformation shown by the red colour hatching and area of shallow deformation shown by the green colour hatching. The arrows point to the direction of ice-push during repeated advances or retreats. Such complex tectonism can lead to greater heterogeneity and, hence uncertainty, in spatial soil properties (Fugro, 2023a). Since Location B1 is close to DBSW, such local glaciotectonic processes may be anticipated.

Table 5-2: Anticipated stratigraphy in Location B1

Formation	Occurrence	External form	Interpretation	Seismic facies	Depositional period
Holocene	Broad	Sheet	Marine sands and gravel	Acoustically transparent to locally high amplitude	Holocene
Botney Cut Fm	Localised	Localised channel fills	Gravelly sands and clay	Stratified, crossbedded, low to high amplitude, locally transparent	Late Weichselian
Bolders Bank and/or Dogger Bank Fm	Broad	Deformed, channels	Clay, locally with beds of sands	Chaotic, locally high amplitude reflectors	Late Weichselian
Egmond Ground, Kettle Hole, Cleaver Bank and/or Eem Fm	Broad	Stratified	Sands with shell fragments, beds of clay	Stratified, low amplitude, low frequency reflectors	Holstenian
Swarte Bank Fm	Broad	Tunnel valleys	Sand and/or clay	Acoustically transparent to chaotic	Elsterian
Yarmouth Roads and/or Markham's Hole Fm	Broad	Stratified	Clayey and silty sands	Complex at top, stratified at base	Lower to middle Pleistocene

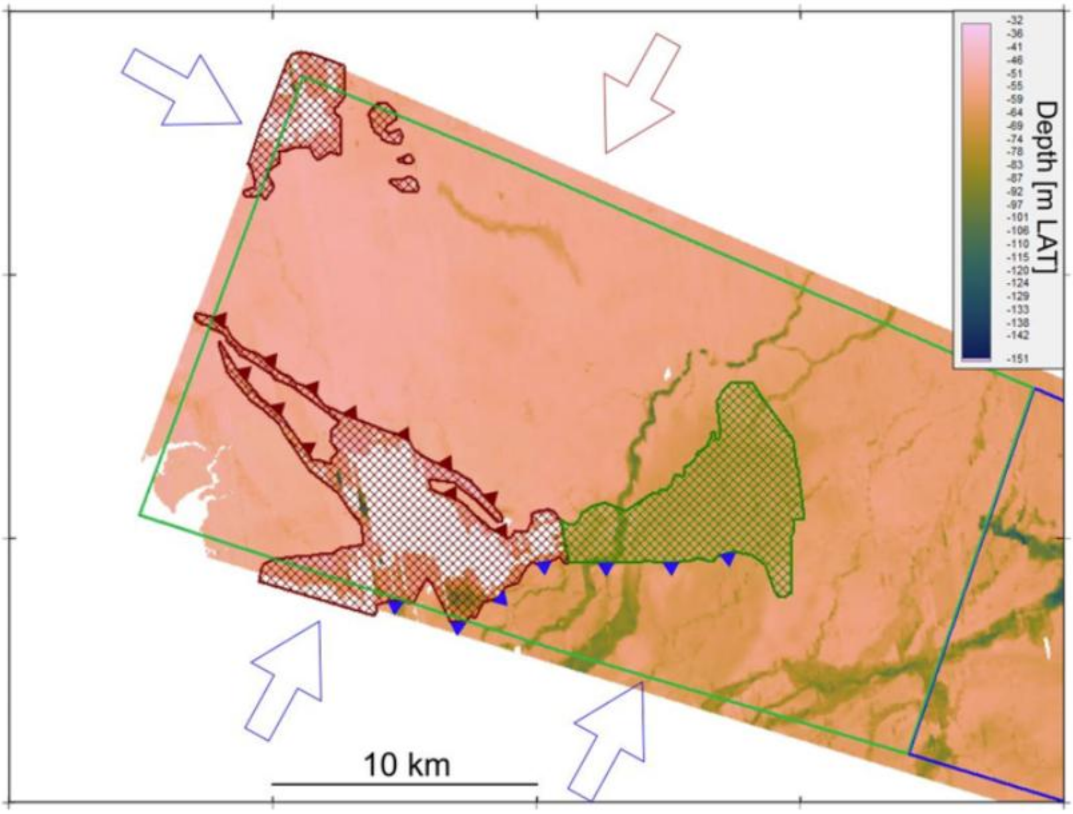


Figure 5-15: Distribution of glaciotectonic deformation in Dogger Bank South West (From Fugro, 2023a). Deeper deformation shown by the red colour hatching and area of shallow deformation shown by the green colour hatching

Location B2

At Location B2 information can be drawn from Dogger Bank South East (DBSE) (to the northeast) and Hornsea 1 OWFs (to the southwest)(Figure 5-7). Ternan has utilised published reports and papers to develop a comprehensive understanding of the anticipated site conditions at this location by interpolating the site characterisation at these OWFs through integration of geological, geophysical and geotechnical information. In addition, the BGS Quaternary Geology sheets, BGS bedrock geology and BGS sediments maps have been consulted.

Bathymetry and Morphology

The range of bathymetry around Location B2 is 19-46m. The shallower parts are associated with the upper parts of large sand banks. There may be smaller scale bedforms present, 1-2m heights superimposed on the sand banks formed by near-seafloor currents. These include rippled scour depressions, natural seafloor trenches and seafloor depressions. At DBSE OWF the seabed morphology is smooth where Holocene sands are thicker than 2m, which is what is anticipated at Location B2 considering the composition of the sand banks.

The DBSE area shows a range of sediment types, sand being the dominant sediment covering the seafloor followed by muddy sand and slightly gravelly sand (Figure 5-16). Presence of slightly gravelly sands at the seabed occurs where the sand is thin and periglacial deposits (gravel and boulders) are present near the seafloor (Fugro, 2023c).

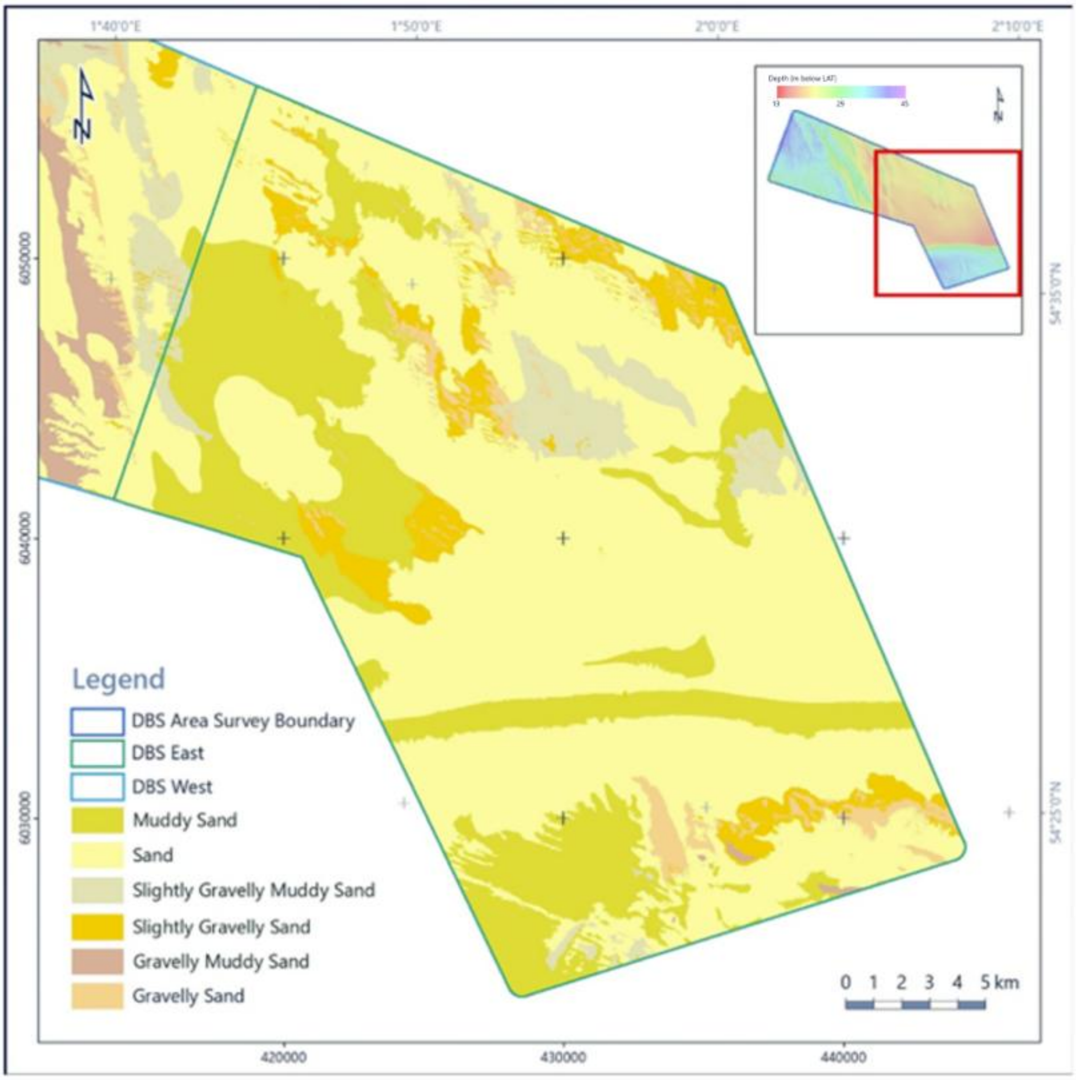


Figure 5-16: Seabed sediments and water depth (below LAT) at DBSE (From Fugro, 2023c)

Stratigraphy

Table 5-3 lists a likely stratigraphic framework at Location B2. It is based on detailed seismo-stratigraphic interpretation of high-resolution geophysical data (Sub-bottom Profiler (SBP), Ultra-High-Resolution Seismic (UHRS) and Ultra-Ultra High-Resolution Seismic (UUHRS)) acquired in Dogger Bank South and Hornsea 1 OWFs.

The Quaternary sequence may range between 30 and 60m in thickness across the whole area as shown in Figure 5-17. The Holocene sediments cover the majority of the area and thin at the flanks of the underlying localised channels of Botney Cut Formation. These interglacial channels comprise gravelly clay with a complex sequence of glacial infills across the Dogger Bank South and Hornsea 1 OWF as shown in Figure 5-17.

Table 5-3: Anticipated stratigraphic units at Location B2

Formation	Occurrence	External form	Interpretation	Seismic facies	Depositional period
Holocene	Broad	Sheet with bedforms	Marine sands and gravel	Medium to high amplitude	Holocene
Botney Cut Fm	Localised	Inter-glacial channels	Gravelly and sandy clay	Channelised unit with a stratified to acoustically chaotic	Late Weichselian to early Holocene
Bolders Bank Fm/Dogger Bank Fm	Broad	Channels	Sub-glacial till, clays with beds of sand	Chaotic, to seismically transparent (medium to high amplitudes)	Late Weichselian
Eem/Egmond Ground Fm	Broad	Stratified	Sand with shell fragments and beds of clay	Low frequency, low amplitude stratification	Holstenian
Swarte Bank Fm	Broad	Tunnel valleys	Gravelly coarse sands	Valleys with an acoustically transparent to chaotic seismic character	Elsterian to early Holstenian
Yarmouth Roads Fm	Broad	Stratified	Clayey and silty sands	Stratified, low amplitude and frequency	Waalian to early Elsterian
Winterton Shoal	Broad	Stratified	Clayey and silty sands	Stratified, low amplitude and frequency	Eburonian to Waalian

Formation	Occurrence	External form	Interpretation	Seismic facies	Depositional period
and Markham's Hole Fm					
London Clay, Chalk and Mesozoic strata	Broad	Stratified and folded	Clay, chalk, siliciclastic rocks	Stratified and folded	Tertiary and pre-Tertiary

It is underlain by Bolders Bank Formation in Hornsea 1 and Dogger Bank Formation in Dogger Bank South OWFs. The Bolders Bank Formation is divided into two sub-facies in Hornsea 1 OWF, an upper Unit of slightly sandy gravelly clay (till) and a lower unit that consists of dark grey clay with laminations of silty fine sands. Hence, it is anticipated that both these formations are likely present at Location B2 with Bolders Bank Formation to the south and Dogger Bank Formation to the north of the area. Both units may exhibit similar seismic facies with lodgement and ablation tills. These formations may be interfingered or transitional at Location B2 (Cameron *et al*, 1992). Bolders Bank is a subglacial till and most likely to be found in western and southern parts of Location B2 (Terente *et al.*, 2016). On the other hand, Dogger Bank Formation comprises glacio-lacustrine and glacio-fluvial deposits and is likely to be deformed by glaciotectonism in the east. It is likely that this area may form a transition zone of deformed sediments influenced by the BIIS and FIS.

The Eem Formation is present below Dogger Bank Formation while Egmond Ground Formation has been interpreted below Bolders Bank Formation. Both these units are predominantly marine sands and gravels. These formations are underlain by Swarte Bank formations in both OWFs, hence, the likelihood of sub-glacial tunnel valleys is greater at Location B2 (Fugro 2023a; Terente *et al.*, 2026). It may be present in a sequence of channel valleys cutting deep into the pre-Quaternary sediments. These channels are formed by sub-glacial meltwater and thicken to the south of the Hornsea zone (Fugro, 2023b). These channels feature chaotic seismic infills with a stratified top shown in Figure 5-17. Yarmouth Roads Formation is anticipated to be present at Location B2 throughout, except where it might be locally eroded. It may consist of clayey sand and siltysand indicating shallow marine to fluvial depositional environments.

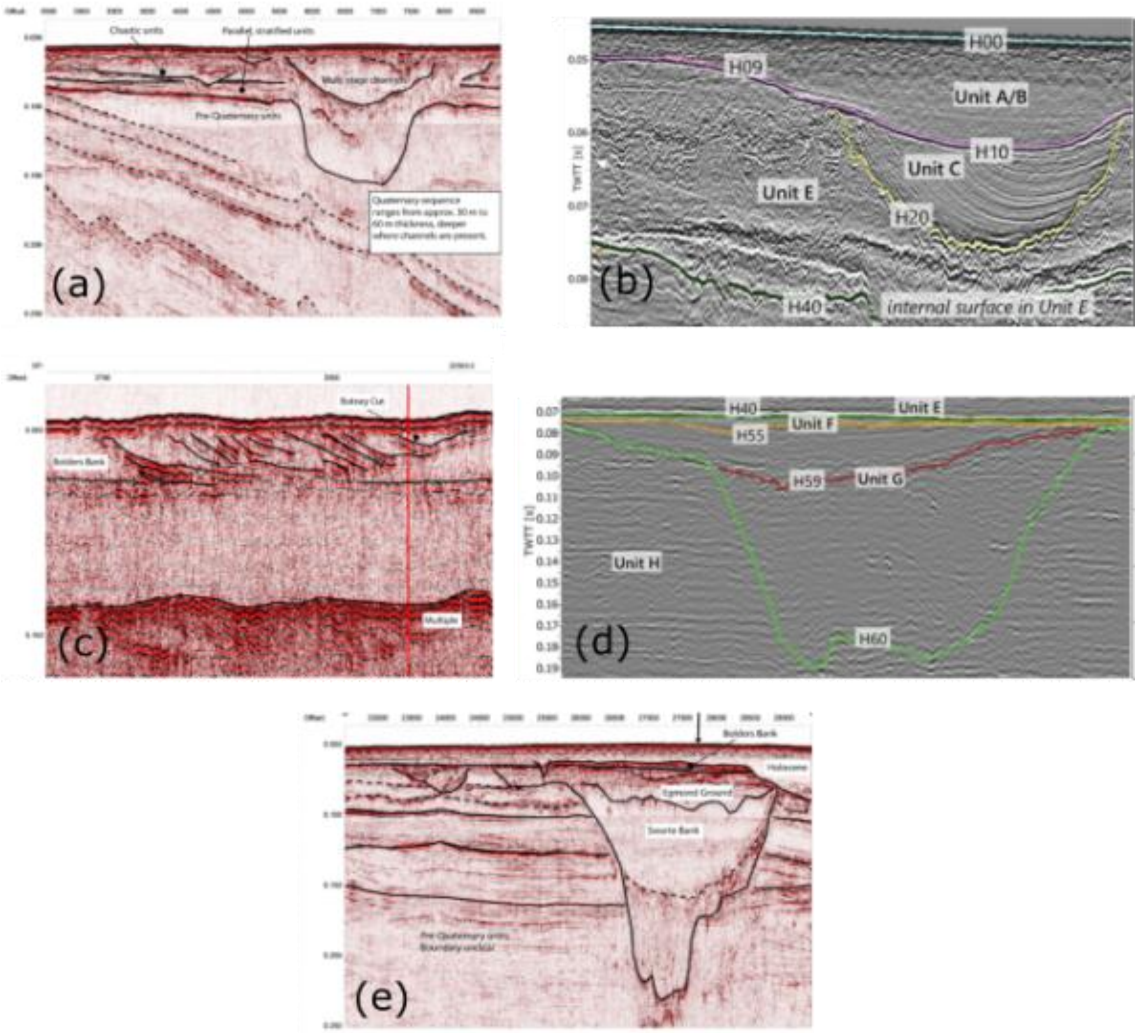


Figure 5-17: (a) Thickness of Quaternary sediments in Hornsea 1 (From Terente., et al, 2016); (b) Botney Cut Fm channels in Dogger Bank South (From Fugro, 2023a); (c) Botney Cut Fm channels in Hornsea 1 (From Terente., et al, 2016); (d) Swarte Bank Fm valleys in Dogger bank South (From Fugro, 2023a); (e) Swarte Bank Fm valleys in Hornsea 1 (From Terente., et al, 2016)

Location C

Humber Gateway and Westermost Rough OWFs are near Location C (Figure 5-7). A conceptual understanding of Location C is developed based on integration of bathymetry, geophysical and geotechnical information published in reports from these OWFs. In addition, the BGS Quaternary Geology sheets, BGS bedrock geology and BGS sediments maps have been consulted.

Bathymetry and Morphology

Water depth at Location C ranges 26-43m. Small and large bedforms between 5-10m height are observed across the area in EMODNET bathymetric data. Published reports from Westermost Rough OWF have been reviewed to understand the seabed morphological features. Three distinct seabed glacial landforms have been identified in Westermost Rough OWF- Glaciofluvial channel fill, subaqueous fans, and push moraines. These features either developed during deglaciation or through Last Glacial Maximum (Devensian/Weichselian) ice-sheet fluctuations (Patton *et al*, 2009). Up to thirty sinuous ridges and hummocks ranging from 100 to 2400m long and 6m high have been identified as shown in Figure 5-18 (Patton *et al.*, 2009). These ridges are trending in northwest-southeast direction with steeper side towards the west. They comprise of slightly silty gravelly sand which suggest either glacio-fluvial channel fill or subaqueous fans or push moraines. Since these features are regional and linked to the ice-sheet movement, we expect a similar seafloor morphology at Location C. Large bedforms (larger than those observed in Westermost Rough) are likely to be present at Location C which is 25 km south of Dogger Bank South export cable route (Fugro, 2023b).

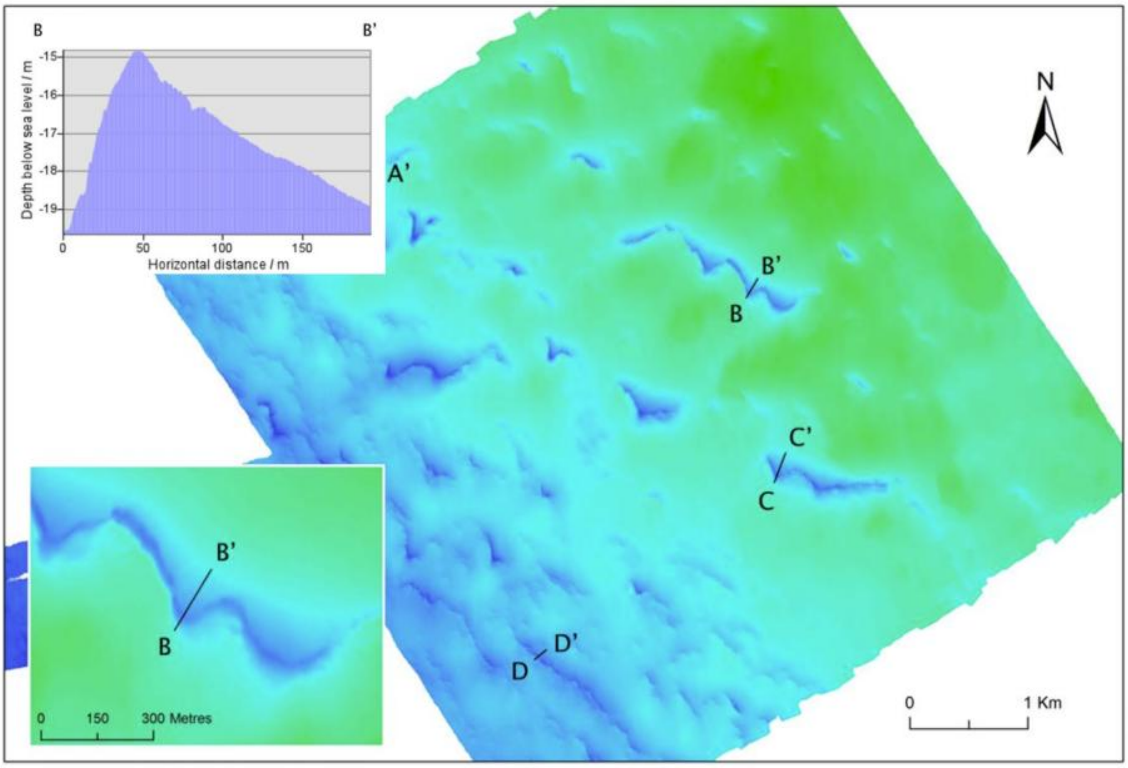


Figure 5-18: Seabed morphology in Westermost Rough OWF (From Patton et al, 2009)

Stratigraphy

The stratigraphic profile at Westermost Rough OWF has been interpreted in sub-bottom profiler (pinger) and boomer data with maximum depth of penetration up to 15 and 45 m, respectively. At the base of the Holocene sediments a sandy gravel layer with cobbles and boulders has been observed in SBP and UHR seismic data which covers most of the area but thins westward (Figure 5-19; Patton *et al*, 2009). These are most likely reworked glacial deposits during Holocene transgression.

The Botney Cut Formation, interpreted as laminated clay and fine sands, consists of parallel low-amplitude reflectors with steep channels incising the underlying formations as shown in Figure 5-19. Channels trend northeast to southwest, incising up to 38 m in the southwest. The underlying Bolders Bank Formation is absent where Botney Cut Formation channels are present. It has two subfacies, the upper one is lodgement till and while the lower one consists of uneven deposit of ablation till. The chalk formation lies 6 to 18 m below seabed and reaches up to 6 m below the seabed at the flanks of the channels where the overlying units are either thin or absent.

Table 5-4: Anticipated stratigraphic units at Location C based on data from Westermost Rough (Patton et al, 2009)

Formation	Occurrence	External form	Interpretation	Seismic facies	Depositional period
Holocene	Broad	Veneer	Sandy gravel with cobbles and boulders	Low amplitude	Holocene
Botney Cut Fm	Broad	Steep Channels	Laminated clay and fine sands	Chaotic to locally parallel low amplitude	Late Weichselian
Bolders Bank Fm	Absent where Botney Cut Fm channels present	Channel fill	Gravelly sandy clay with chalk, red-brown sandstone. And grey mudstone.	Uniform low amplitude	Late Weichselian
				Non-uniform, base eroded	Late Weichselian
Flamborough Bank Fm	Broad	Sheet	Chalk	Parallel, low amplitude	Cretaceous
Speeton Clay Fm	Not observed on seismic data near the area of interest		Clay with mudstones	Not available	Not available
Kimmeridge Clay Fm	Not observed on seismic data near the area of interest		Clay with mudstones	Not available	Not available

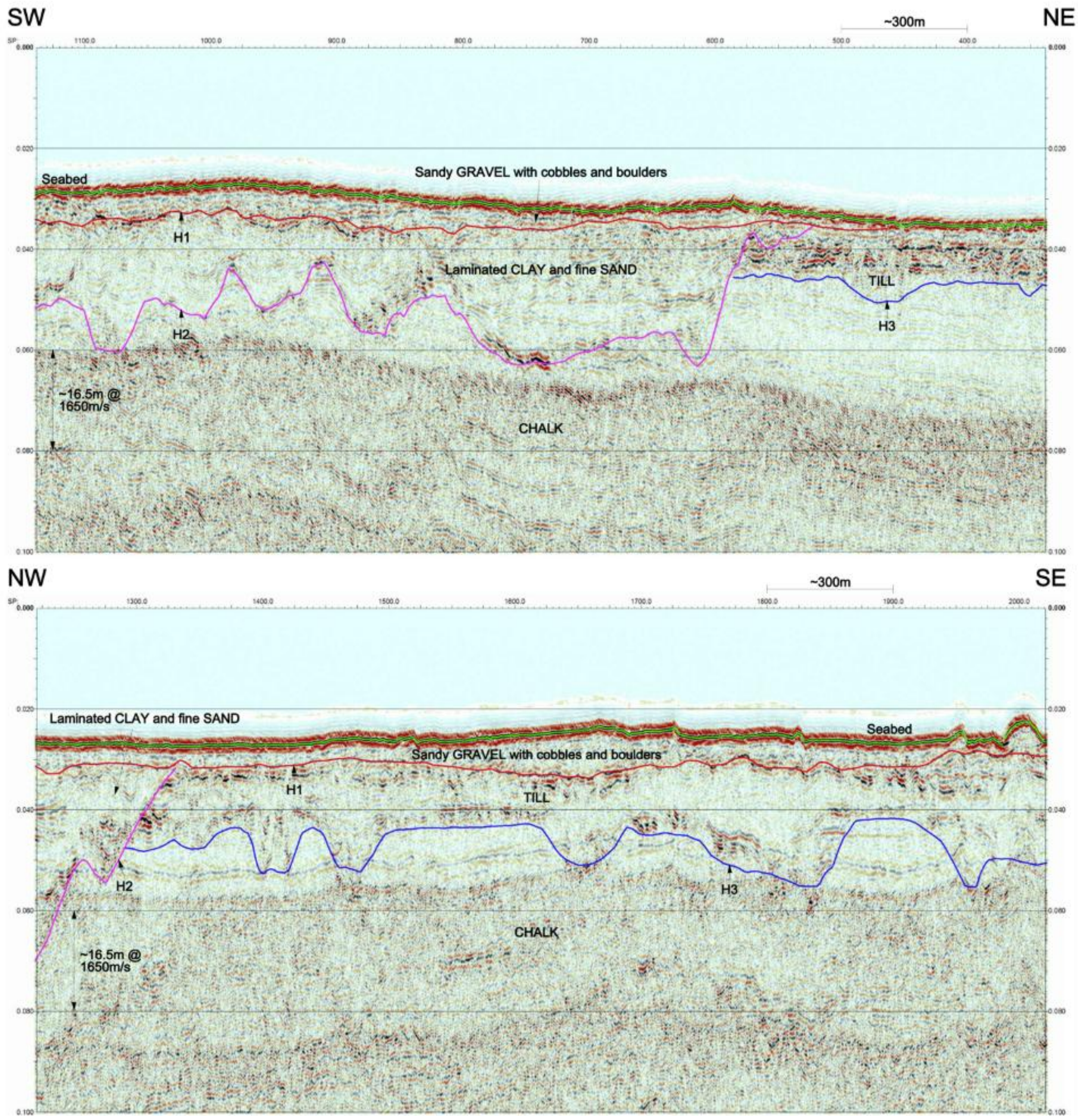


Figure 5-19: Interpreted seismo-stratigraphy in Westermost Rough. Exact location of seismic section not shown on original source (From Patton et al, 2009)

Engineering Considerations

Table 5-5 below discusses the feasibility and suitability of each of the four foundation types, discussed in Annex III, within the Northeast Study Area.

Table 5-5: Foundation Type Suitability Summary

Proposed Foundation type	Foundation Type Pros / Cons
Monopile	A driven monopile is the most suitable foundation type for the ground conditions expected to be encountered across the Area Location B and C. In Location A the ground conditions are more variable with shallow bedrock in places, this will limit where a monopile could be used within this area. However, as the water depth approaches and exceeds 50m, a monopile may not be the most economical solution and this should be considered during pre-Front-End Engineering Design (FEED)/FEED.
Jacket Structures – Piled	Driven piled jackets would also be suitable for the ground conditions expected within this Location B and C. Within Location A driven piled jackets will also be suitable but due to the more variable ground conditions the location of such foundation will need to be carefully considered to prevent early refusal on bedrock. However, a jacket structure is more complex and costly to fabricate than a monopile which in shallower water depths would make jacket structures a less favourable foundation option to monopiles. Piled foundation types are less sensitive to variable ground conditions.
Suction Caissons	Suction Caisson jackets or Monobuckets would be feasible given the ground conditions expected in the Study Area but would not be the most suitable. The ground conditions within the Study Area are expected to be vertically and horizontally variable with buried channels known to be present, which increases the horizontal variability of the ground

Proposed Foundation type	Foundation Type Pros / Cons
	conditions. As suction caissons require more uniform vertical soil profiles micro siting of a suction caisson foundation may be harder. The presence of coarser material (gravels, cobbles and boulders) may increase the risk of early refusal and prevention of achieving full caisson embedment. Additional and more complex site investigation and advanced laboratory testing are often required for detailed design of suction caisson foundations which increases the complexity and costs of design and installation.
Gravity base	Gravity base foundations are feasible for this Study Area given the ground conditions. However, the presence of sand waves and ripples across much of the Study Area is likely to increase the extent of seabed preparation required. Combined with limited nearby fabrication facilities and more extensive site investigation requirements, this makes gravity base foundations the least economical option for this Study Area. In Area A where there is shallow or outcropping bedrock, gravity base foundations may be a more suited option if a jacket or monopile foundation cannot be sited where the sediment cover is thicker.

5.3.3 Consenting Suitability

With regard to consenting suitability, the south and mid-region of the Study Area has a number of hard constraints, closest to Locations B2 and C. There is infrastructure including OWFs (Figure 5-20), surface and sub-surface infrastructure, pipelines, aggregate sites and oil fields (Figure 5-20) present.

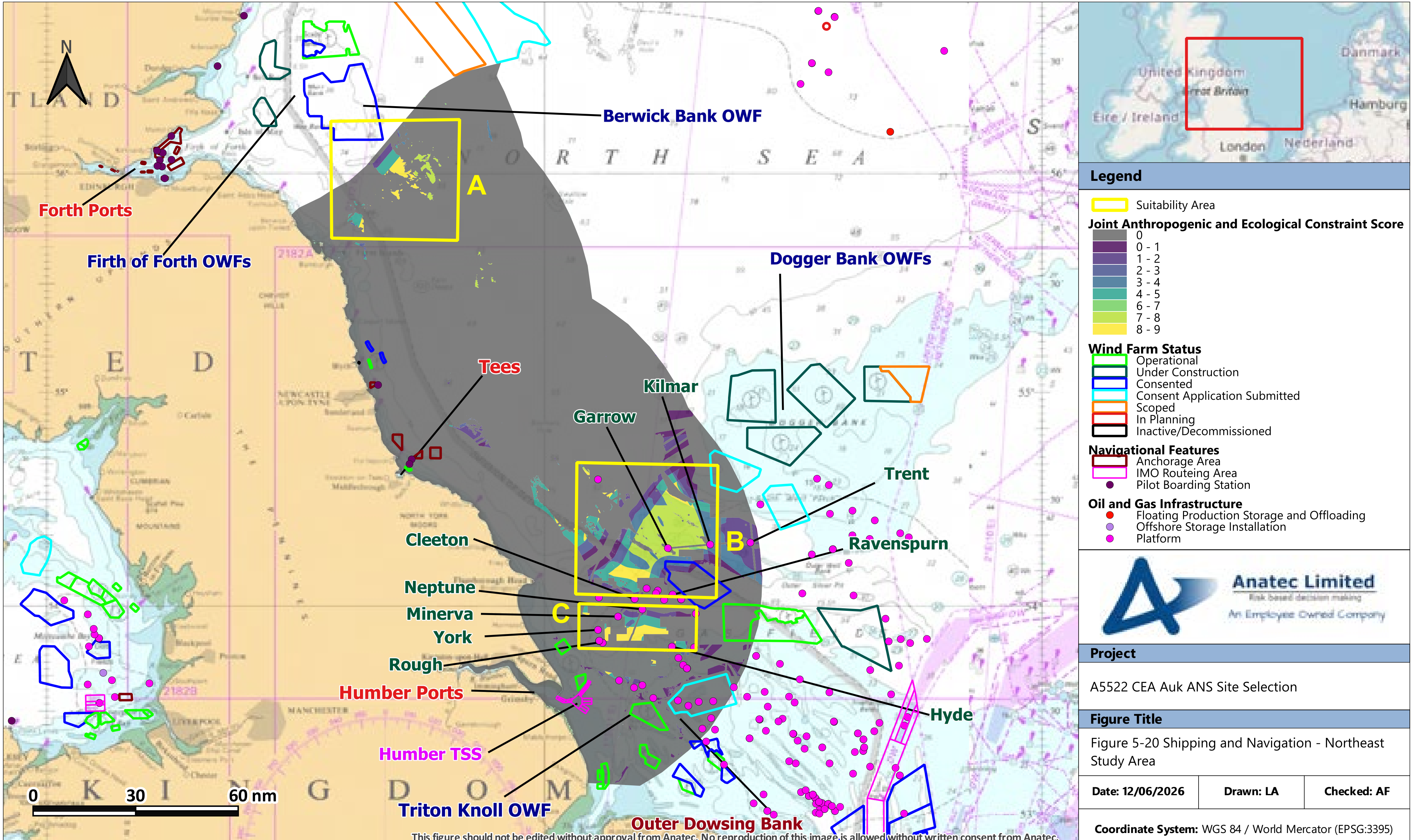
Sites designated for benthic features are located towards the north and the south of the Study Area which have been excluded from the study as hard constraints. These sites include; Swallow Sand MCZ; Holderness Offshore MCZ; Holderness Inshore MCZ; Inner Dowsing, Race Bank and North Ridge SAC; Dogger Bank SAC; The Wash and North Norfolk Coast SAC; Flamborough Head SAC; and Farnes East MCZ.

It should be noted that following the announcement by The Crown Estate on 26th March 2026, the Offshore Wind Leasing Round 6 refined areas of search includes sites that are within the Northeast Study Area, although they have no overlap with the areas of high suitability. The timing of The Crown Estate announcement means that this study has not been able to consider any additional constraints posed by proximity to the Round 6 areas of search (other than confirming there is no direct overlap) and this would need to be considered further should any of the offANS locations in this region be progressed.

Therefore, whilst there are limitations within the Study Area when considering consenting suitability, there is confidence that an offANS would be both consentable and feasible.

5.3.4 Shipping and Navigation Suitability

This section provides a summary of shipping and navigation considerations for the Northeast Study Area, in particular the areas that have been identified as having higher suitability scores i.e., greater feasibility. Figure 5-20 presents key navigational features deemed of relevance for shipping and navigation within the Northeast Study Area, and for clarity labels the three areas of higher constraint scores i.e., greater feasibility as A, B and C.



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Risk based decision making

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A5522 CEA Auk ANS Site Selection

Figure Title

Figure 5-20 Shipping and Navigation - Northeast Study Area

Date: 12/06/2026	**Drawn:** LA	**Checked:** AF

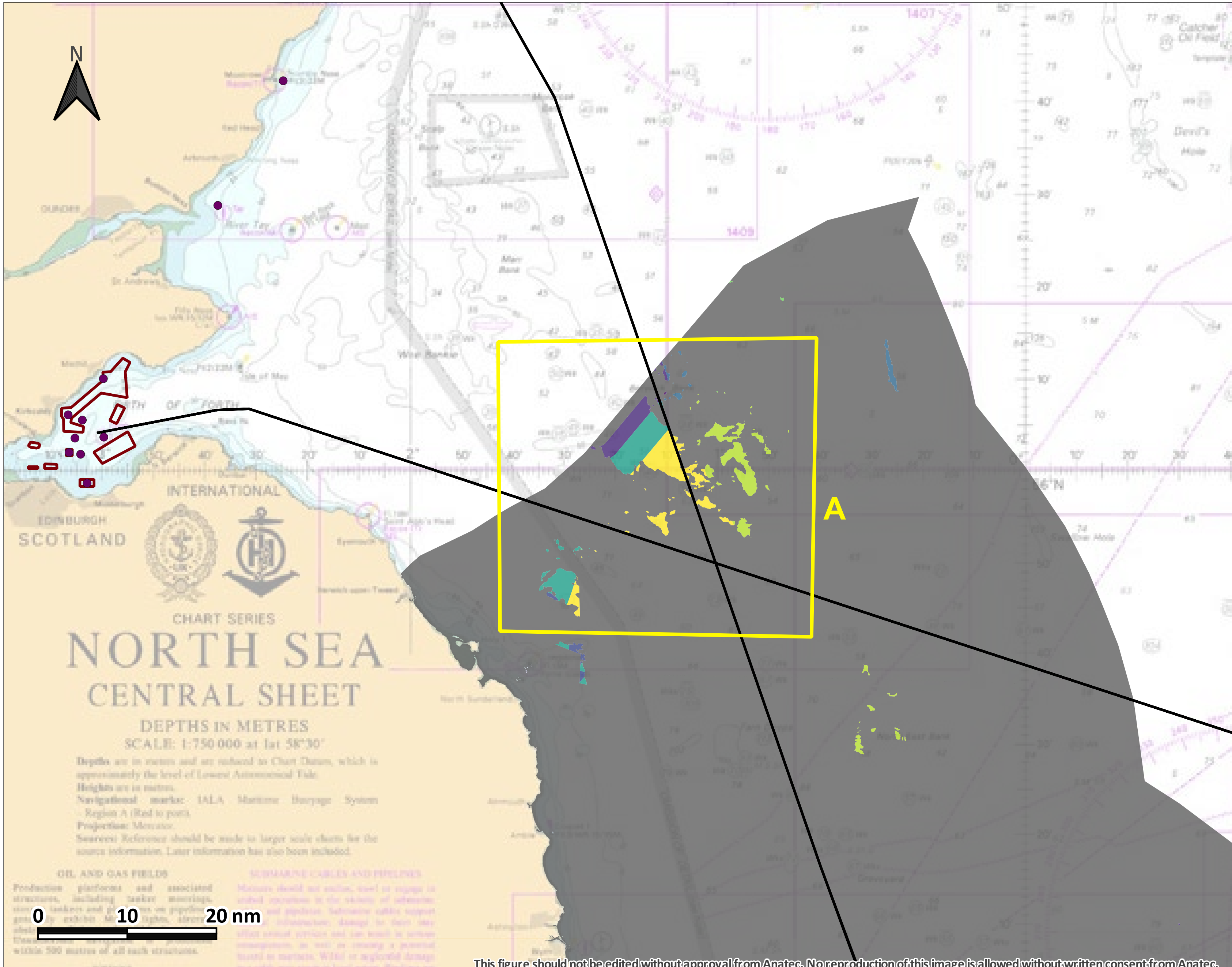
Coordinate System: WGS 84 / World Mercator (EPSG:3395)

Location A

The area of higher feasibility to the south of the Scottish border is located approximately 30 nautical miles (NM) south of the OWF projects located off the Firth of Forth (Seagreen, Neart na Gaoithe, and Inch Cape). Vessels intersecting this area are likely to include the following, noting that there are no IMO routeing measures in direct proximity and therefore vessels will generally choose an optimal passage based upon their terminus ports and route waypoints:

- East/ west traffic to/ from the Forth ports; and
- North/ south traffic running along the east UK coast.

A general indicative position for these two routes in the context of Location A is presented in Figure 5-21.



Legend

Suitability Area
General Main Commercial Route

Joint Anthropogenic and Ecological Constraint Score

- 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 6 - 7
- 7 - 8
- 8 - 9

Navigational Features

Anchorage Area
Pilot Boarding Station

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Figure Title

Figure 5-21 Shipping and Navigation - North East Study Area Commercial Routes (Location A)

Date: 12/06/2026	Drawn: LA	Checked: AF

Coordinate System: WGS 84 / World Mercator (EPSG:3395)

Given the relatively open sea, it is likely that any displacement impact could be managed via suitable passage by the vessels planning noting that any deviations from a single offANS in this area would be minor.

It should be considered that in the future, development of other offshore wind projects (notably Berwick Bank directly to the north) may lead to notable changes in routeing patterns. This includes a potential narrowing of north/ south traffic which would choose to pass either inshore or offshore of Berwick leading to narrower routes either side of the array. Vessels choosing to pass offshore may be more likely to pass an offANS in this area however precise routeing patterns are complex to predict given the various possible scenarios that may develop depending on how the relevant offshore wind projects progress.

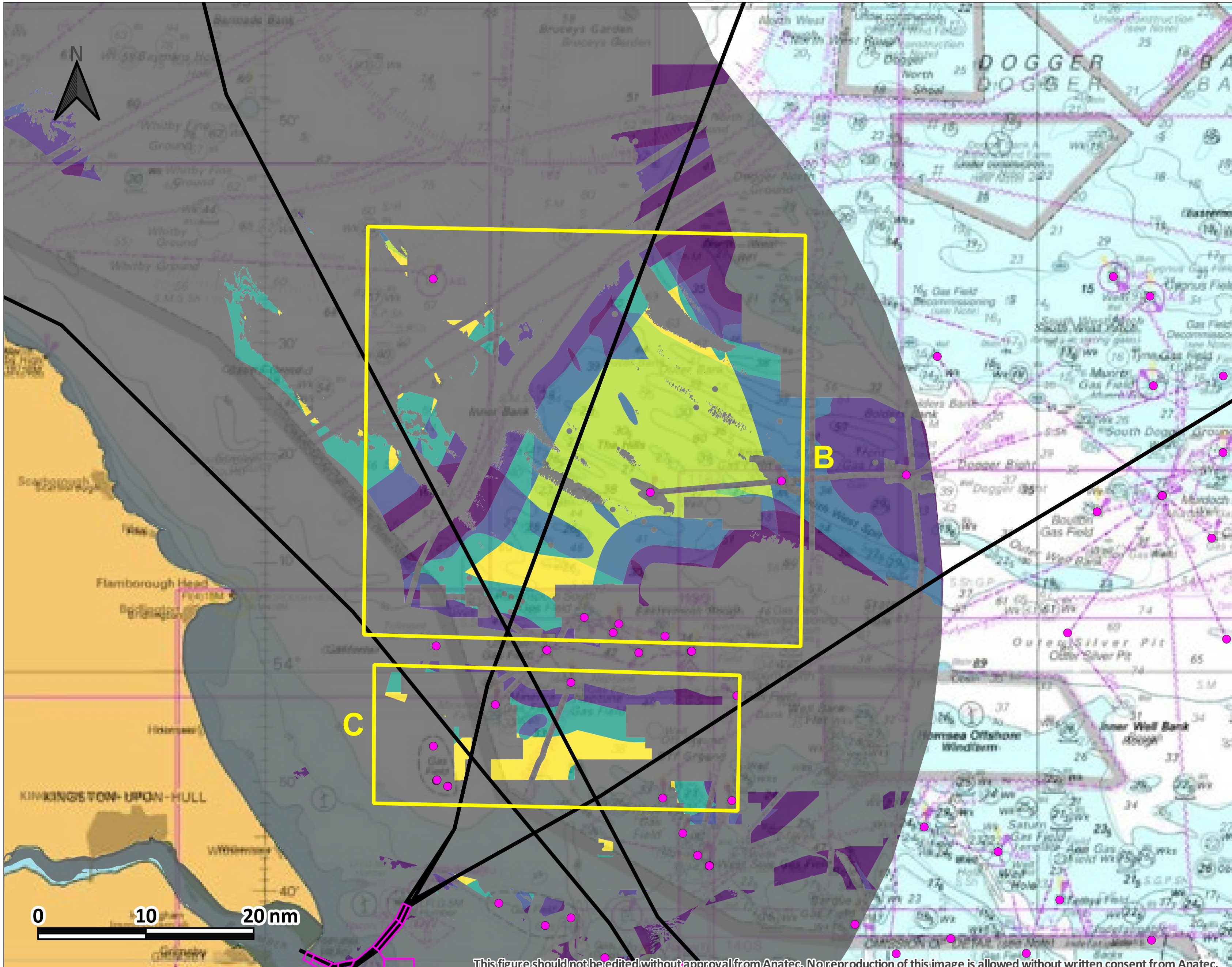
Location B

The area of higher feasibility at point 'B' lies to the east of Flamborough Head on the Yorkshire coast. It is approximately 22 NM southwest of the under-construction Dogger Bank projects, consisting of Dogger Bank A, Dogger Bank B, Dogger Bank C, and Sofia.

This general area includes vessels undertaking the following transits:

- Northeast/ southwest traffic between Humber ports and northern Europe;
- Broadly southeast/ northwest traffic to/ from Tees and Europe noting this includes regularly scheduled commercial ferry routeing from various operators. This routeing is restricted to the south as it passes between the Outer Dowsing bank and Triton Knoll offshore wind farm; and
- North/ south traffic running along the east UK coast.

A general indicative position for these routes in the context of Location B is presented in Figure 5-22.



Legend

- Suitability Area
- General Main Commercial Route

Joint Anthropogenic and Ecological Constraint Score

- 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 6 - 7
- 7 - 8
- 8 - 9

Navigational Features

- IMO Routeing Area
- Platform

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A5522 CEA Auk ANS Site Selection

Figure Title

Figure 5-22 Shipping and Navigation - North East Study Area Commercial Routes (Locations B & C)

Date: 12/06/2026	Drawn: LA	Checked: AF

Coordinate System: WGS 84 / World Mercator (EPSG:3395)

The key routeing restriction in immediate proximity is the local surface-piercing oil and gas infrastructure. This includes the Kilmar and Garrow platforms, in addition to the Trent gas field to the east, and the Ravenspurn, Cleeton, and Neptune gas fields to the south. The locations of these platforms relative to local vessel routeing will need to be considered in any offANS siting, noting that placement of an offANS in an interim position between platforms may lead to a larger overall displacement effect. Location B is far enough offshore that much of the busiest routeing (particularly vessels restricted by transit between the Outer Dowsing bank and Triton Knoll offshore wind farm to the south) is likely to pass further inshore.

Regularly scheduled commercial ferry routeing would be the most sensitive user to any deviations, given timetabled schedules could be impacted.

The size of the overall area is such that there is likely to be locations for an individual offANS that would lead to only very minor deviations manageable by passage planning, however this is subject to more detailed vessel traffic analysis to fully identify and characterise vessel routeing notably any commercial ferry routes.

Deviations will potentially be further influenced by the development of future OWFs in the area, noting that the oil and gas infrastructure and local shallow banks mean that much of the busier routeing is already well established and already avoiding potential future development.

Location C

Vessel patterns in proximity to location C are likely to be broadly similar to those estimated for area B, notably potential for commercial ferry routeing passing through or in proximity. However, given Location C is further inshore than Area B, it may be more likely to be intersected by the busy traffic that goes on to pass between the Outer Dowsing bank and Triton Knoll offshore wind farm (which is an important route).

The northernmost Humber TSS aligns with Area C, and therefore vessels either exiting or departing the Humber via this Traffic Separation Scheme (TSS) may also intersect Area C. The distance from the TSS (approximately 15 NM) is such that any required deviations are likely to be able to be managed via passage planning.

A general indicative position for these routes in the context of Location C is presented in Figure 5-22.

Similar to Area B, local gas infrastructure already influences navigation in and near Area C, with local surface-piercing infrastructure including platforms associated with the Minerva, Cleeton, Neptune, Rough, Hyde and York fields. Similar assumptions apply i.e., the locations of these platforms relative to local vessel routeing will need to be considered in any offANS siting. The same also applies in terms of any impacts on commercial ferry routes i.e., such users are the most sensitive to deviations and the associated routeing requires more detailed characterisation.

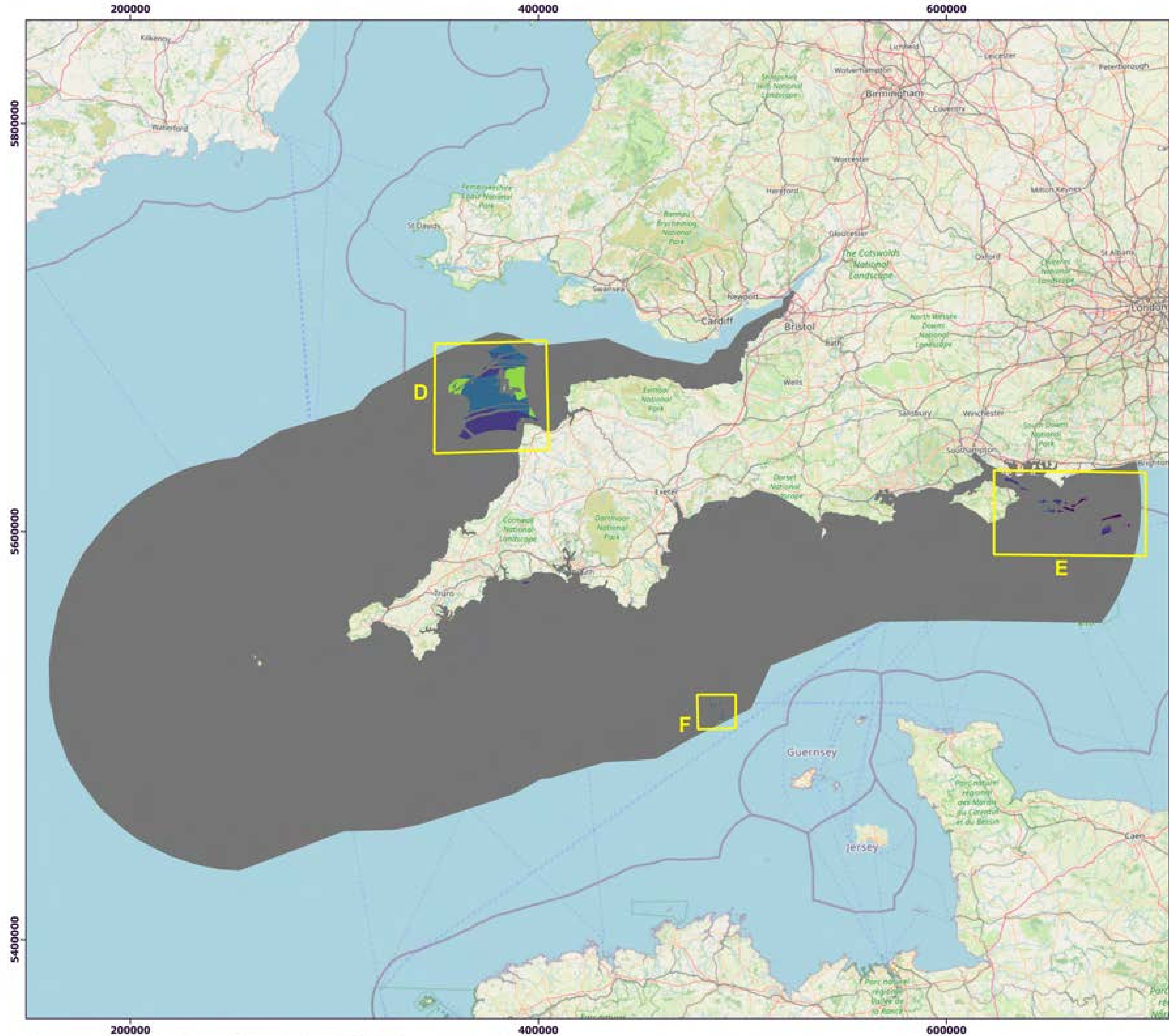
As for Area C the prospect of future OWF development should also be considered, noting that the oil and gas infrastructure and local shallow banks mean that much of the busier routeing is already well established and already avoiding potential future development.

As with Location B, given adequate passage planning Area B is likely to include some specific locations which are suitable. However, there are multiple constraints present and there would be a need to consult key stakeholders early in the site refinement process, including commercial ferry operators and regular operators navigating between the Outer Dowsing Bank and Triton Knoll offshore wind farm or out of the Humber.

5.4 Southwest Study Area

The suitability heatmap of the Southwest Study Area is provided in Figure 5-23.

The heatmap (Figure 5-23) outlines offANS suitability within the Southwest Study Area. Whilst the majority of the area is hard constrained by installation feasibility, limited by suitable depth (detailed within Section 5.4.2), there are some areas where offANS may be sited. The peak suitability score is 5.8, and the cumulative area with a suitability score of 4 and above is 116 km^2.



Collaborative Environmental Advisers

Figure 5-23
South West Study Area Suitability Heatmap

C01608-RUK-INFR-006-J

Legend

Suitable Area

Suitability Score

- 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6

0 30 60 90 KM
0 15 30 45 NM

Date	12/06/2026
CRS	ETRS89 / UTM zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	meters
Scale at A3	1:1,815,000
Created	MW
Reviewed	AN
Authorised	SS

5.4.1 Ecological Suitability

From an ecological perspective, the areas identified across the Study Area as suitable have both guillemot and razorbill colonies present. Coull, Johnstone and Rogers (1998) suggest there is limited prey availability, with no sandeel spawning or nursery grounds, and limited herring spawning grounds off the south coast of England (between St Austell and Plymouth) and southwest Wales (Milford Haven), as detailed in Section 4.6. However, there is evidence showing prey availability, with established colonies (e.g., Lundy and Skomer) feeding primarily on sandeel and herring (Anderson *et al.*, 2013; Riordan and Birkhead, 2017).

Other evidence of sandeel presence in the region includes anecdotal evidence from fishing and aggregates industry, monitoring at marine aggregate extraction sites (e.g., Area 531), and the Severn Estuary/ Môr Hafren SAC supports sandeel as part of the fish assemblage feature. Sandeel habitat suitability mapping (MarineSpace *et al.*, 2013; Reach *et al.*, 2024) suggest that the Bristol Channel is largely of high suitability and with a high confidence for supporting sandeel (MarineSpace *et al.*, 2021). Additionally, there are established auk colonies in the area, suggesting there is sufficient prey availability in the region.

Auk colonies in the southwest UK have been a topic of interest recently, with Defra commissioning a study into colony trends and conservation interventions (Kirk *et al.*, in prep.). Developers, including Outer Dowsing, Rampion 2, Five Estuaries, North Falls and Doggerbank D; are also undertaking monitoring in these areas, building the understanding of populations and key threats. Hornsea 4 (Ørsted) undertook bycatch monitoring in the southwest UK as well (OWIC, 2025), highlighting the range of activities impacting these important colonies.

The area also supports breeding black-backed gulls (*Larus* spp.), however, the areas of highest suitability are outside the foraging range of large gulls (Woodward *et al.*, 2019), potentially reducing the risk of auk predation in the Southwest Study Area for an offANS. There is some evidence that anthropogenic disturbance from coastal activities, such as tourism and boating, are affecting the auk colonies along the coast. OffANS are unlikely to be affected by disturbance due to the distance from the coast, thus, may be preferential habitat for nesting auks.

5.4.2 Technical and Engineering Suitability

To assess the engineering constraints within the Southwest Study Area it is important to understand the ground conditions and geology which is presented in the following section.

Ground conditions

Ground conditions for the Southwest Study Area has been defined using data from Ternan's internal database, publicly available data from nearby offshore wind farms and regional geological publicly available data (e.g., BGS geological maps).

Bathymetry and Morphology

West of Lundy Island there is a large sandbank that extends westward approximately 13 km long. This sandbank is to the south of a large area of exposed bedrock. To the west of the bedrock following on from the sandbank is a sand wave field (Figure 5-24). The sandwaves are orientated roughly north-south, likely associated to ebbing flow out of the Bristol Channel around the island and sandbank. Seabed gradients across the area are found to reach locally 8°.

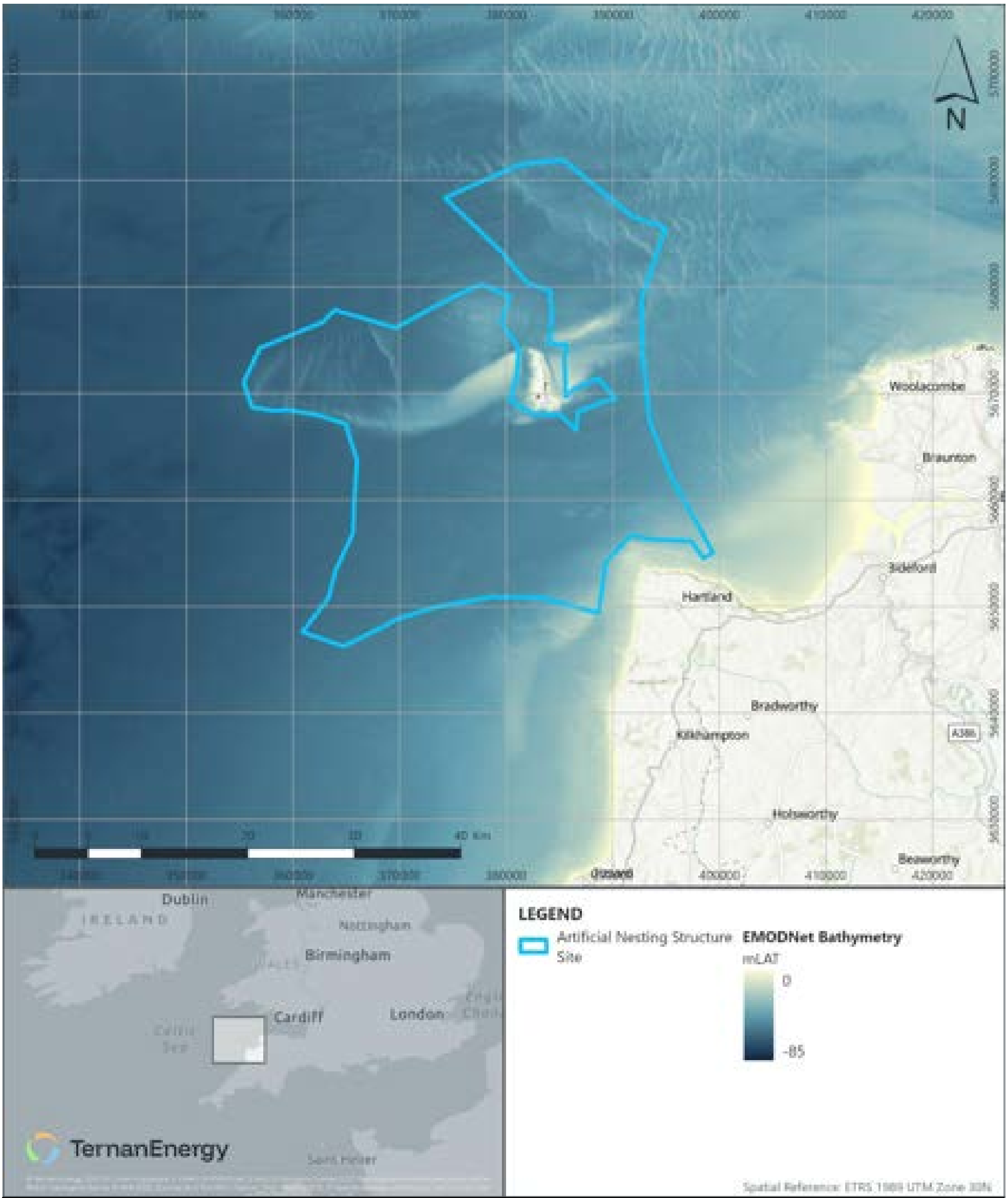


Figure 5-24: Shaded relief bathymetry

Bedrock outcrop and sub-crop are present. Across much of this area the bedrock is only covered by a thin veneer of surficial sediment, as the BGS notes that surficial sediment is often <1m thick, however a detailed map of outcropping bedrock is not available apart from near-shore exposures. Annex I Reef has been mapped by the JNCC and the distribution of the identified reef areas correlates well with the area of thin sediment and bedrock. In comparison with the available bathymetry data areas of reef indicate areas of bedrock.

The Quaternary succession is less than 5m thick in the majority of this area (Figure 5-25). It may be thicker and even encountering buried glacial valleys towards the northeast corner of the site. In the centre north there will likely be outcropping bedrock at seabed.

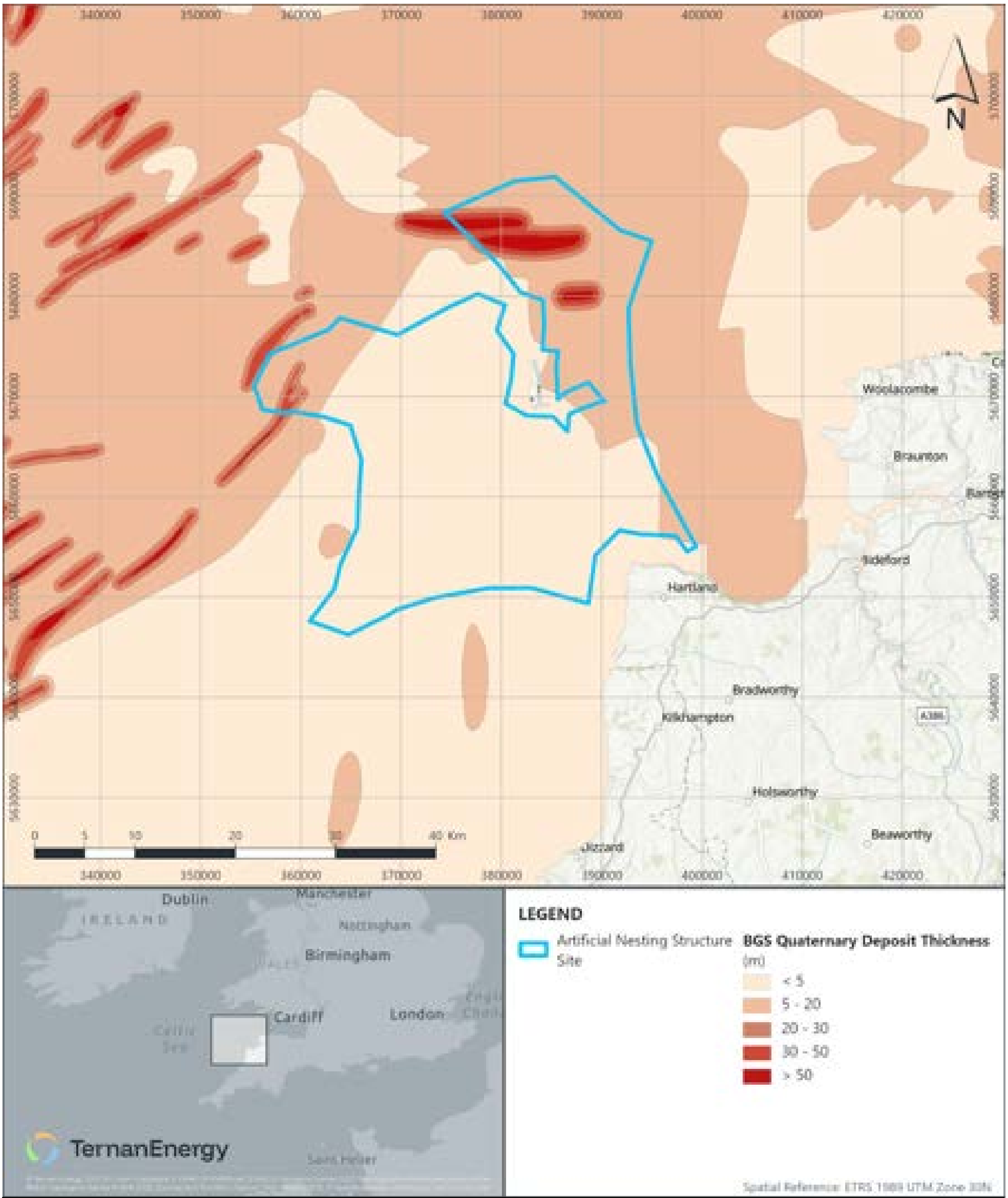


Figure 5-25: Quaternary sediments thickness across the Inner Shelf (from BGS 1-250000)

The seabed sediments comprise mainly gravelly sand or gravel with patches of sand and gravelly muddy sand (Figure 5-26)). Rock outcrop is also identified on the BGS seabed sediment map. Quaternary deposits here are thin.

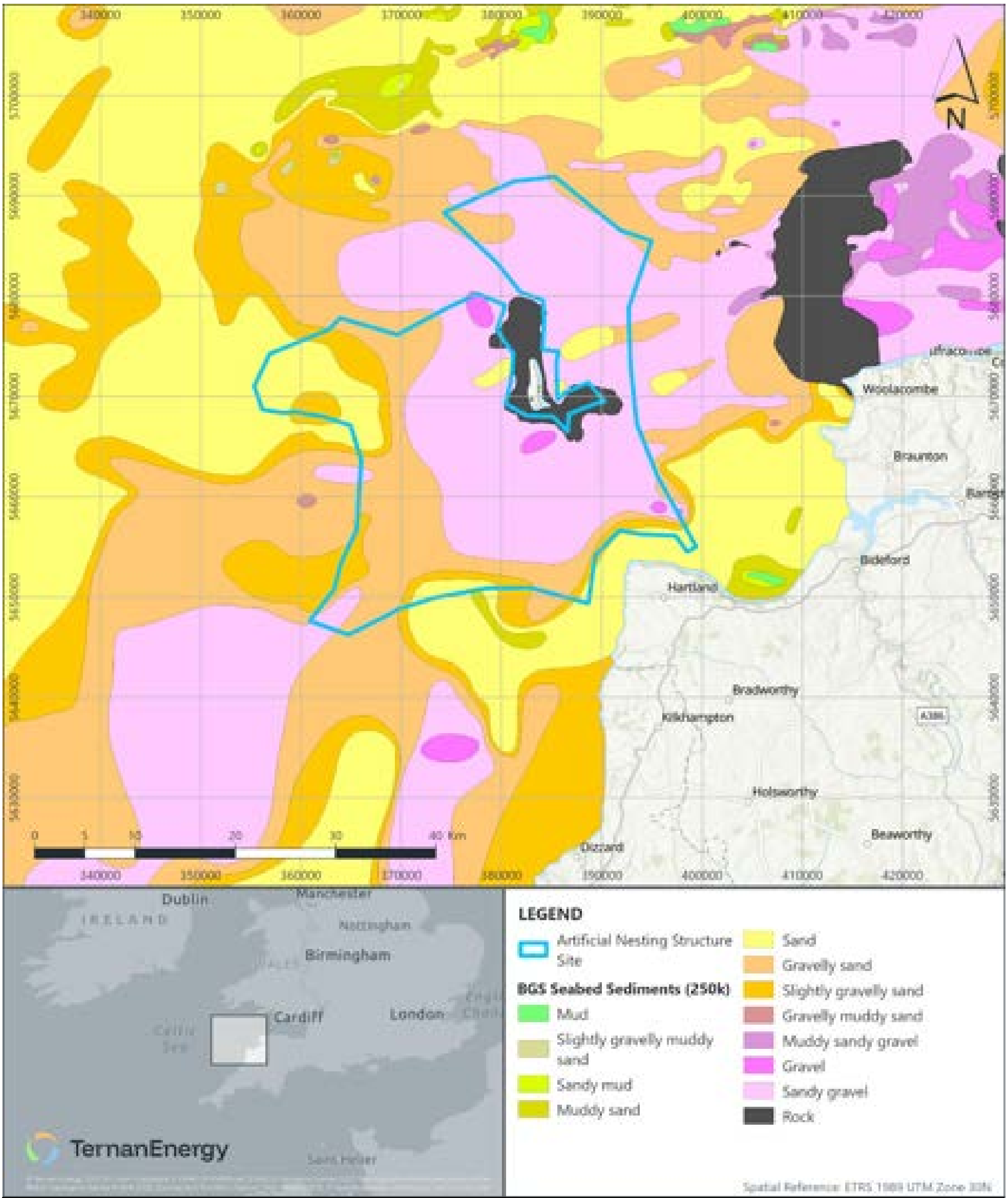


Figure 5-26: Seabed sediment type distribution in the Outer Bristol Channel (from BGS 1:250,000)

Stratigraphy

There is very little information available on the Quaternary deposits in the Southwest Study Area. A note provided on the BGS Lundy 'Seabed Sediments and Quaternary Geology' sheet map states that the Quaternary thickness is "*generally less than 1m overlying a comparatively smooth bedrock surface*". A cross section west - east through the Outer Bristol Channel and westwards (Figure 5-27), shows that the Quaternary sediments around the Lundy Island area have not been differentiated into the specific formations known in the Celtic Sea area (Table 5-6). Localised elongated patches of thicker deposits are present (Figure 5-25) which can exceed 50m thickness. These incisions are thought to be glacial in origin, potentially kettle holes, and are infilled with sediments from the Late Weischselian Base Western Irish Sea formation, Bedded and Infill Facies and Upper Till Facies of the Cardigan Bay Formation (Table 5-6).

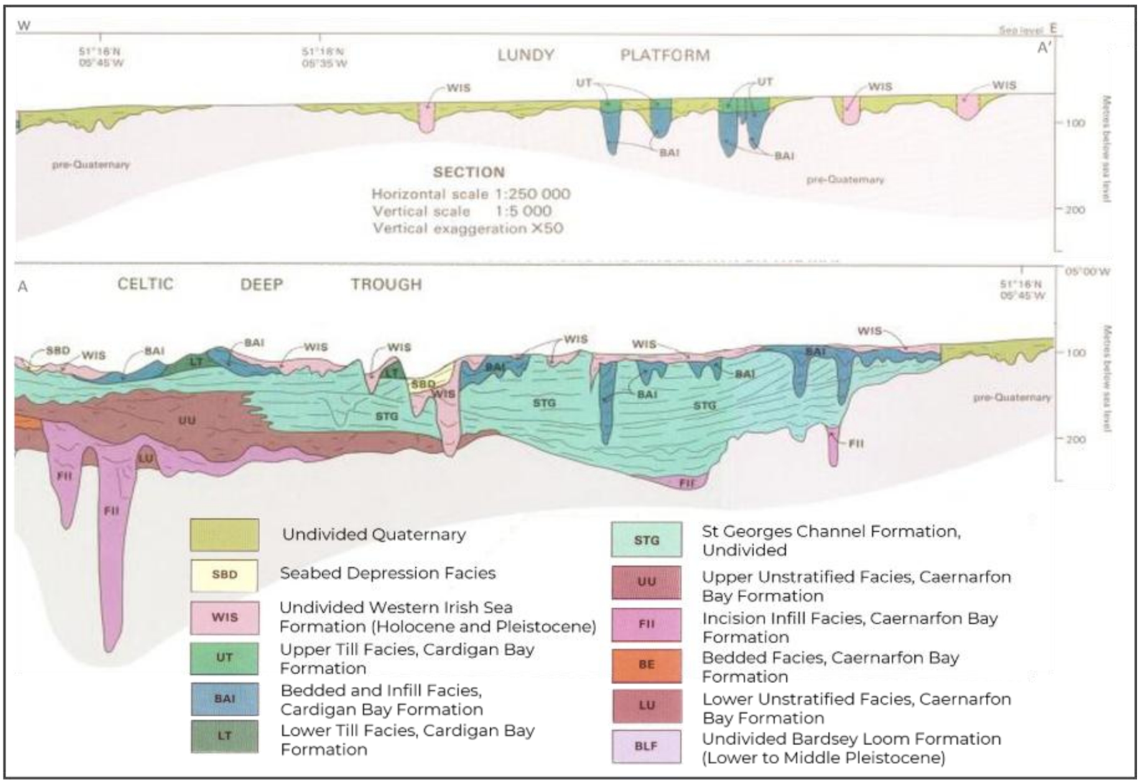


Figure 5-27: Cross section through Quaternary deposits in northern AOS (British Geological Survey, 1991)

Table 5-6: Quaternary Formations Description in the Celtic Sea (From BGS)

Group	Age	Formation Name (Chronostratigraphy)		BGS Description	Climate (Stage)
Brython Glacigenic Group	0.116Ma-11.8ka	Western Irish Sea Formation (Late Pleistocene to Holocene)		Glaciomarine/marine clay and silt with local concentrations of sand. The thickness is between 10m and 20m however can be up to 60m as localised channel infill	Glacial (Weichselian)
		Cardigan Bay Formation (Mid to Late Pleisto-cene)	Upper Till member	Glacial till (over-consolidated)	Glacial (Weichselian)
	0.362-0.116Ma		Bedded and Infill Facies	Proglacial silt overlying gravelly sand; Glacial channels infilled during deglaciation (lithology unknown)	Late Glacial to Interglacial (Saaliann to Eemian
			Lower Till member	Glacial to sub-glacial till (over-consolidated)	Glacial (Saalian)
		St Georges Channel Formation (Mid Pleistocene)		Highly variable formation – divided into 5 members, glaciomarine muds, deltaic	Glacial (Saalian)

Group	Age	Formation Name (Chronostratigraphy)	BGS Description	Climate (Stage)
			and ice contact sands and unstratified sub glacial tills	
	0.48-0.42Ma	Caernarfon Bay Formation (Mid Pleistocene)	Glacial till, sand, silt and clay (over-consolidated)	Glacial (Elsterian)
Demetae Group	>0.48Ma	Bardsey Loom Formation (Lower or Middle Pleistocene)	Fluvial or shallow marine deposits (interbedded clay, sand, gravel and peat)	Variable
Notes- Age based on Celtic Sea Stages (British Geological Survey, 1991) *and* (Mellett, *et al*, 2015) *and BGS Geochronology data* (https-//devdata.bgs.ac.uk/doc/Geochronology.html)				

The Pre-Quaternary geology around Lundy is made primarily of Devonian-Carboniferous sandstone, mudstone and limestone (grey area in Figure 5-28). Oligocene sandstone and mudstone and potentially lignite occupies the northeast area (light pink) and towards the southwest there are (fault-bound) patches of Palaeogene siltstone and Triassic mudstone and halite (yellow and bright pink areas, respectively). Lundy Island itself is an igneous intrusion (granite).

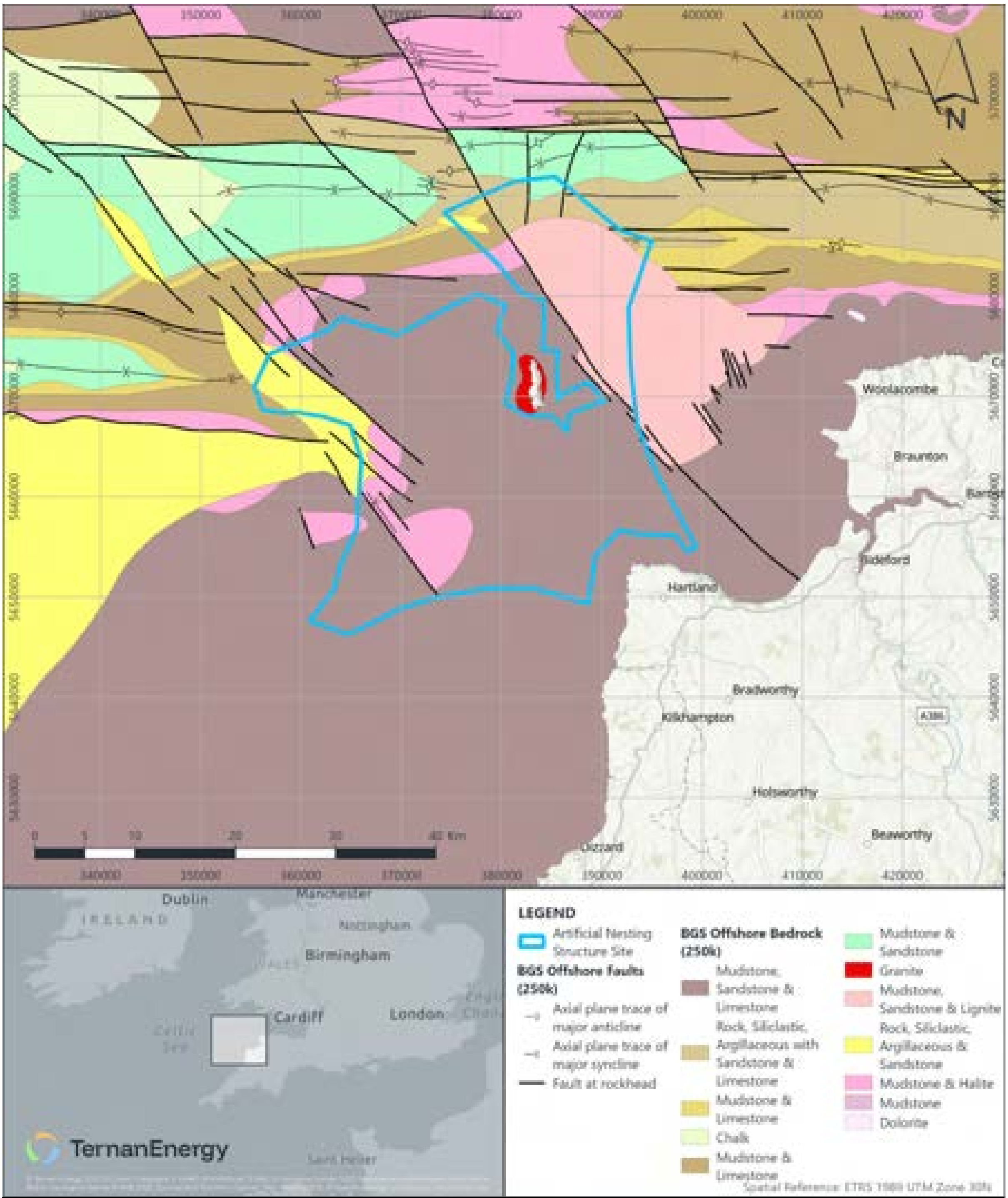


Figure 5-28: Pre-Quaternary geological map (from BGS 1:250,000 Offshore Bedrock map)

Table 5-7: Pre-Quaternary Geological units present in the Celtic Sea (from BGS 1-250000 Offshore Bedrock map)

Age		Lithology
Palaeogene and Neogene		siliciclastic, argillaceous and sandstone and conglomerate
Palaeogene	Eocene	limestone
		siliciclastic argillaceous and sandstone
Cretaceous	Upper	chalk
	Lower	mudstone and sandstone
		limestone and sandstone
Jurassic	Lower - Middle	mudstone and limestone
		siliciclastic argillaceous with sandstone and limestone
Triassic		mudstone and halite stone
Permian and Triassic		mudstone and halite stone
Devonian and Carboniferous		mudstone and sandstone and limestone
Lower Palaeozoic		mudstone and volcanoclastic igneous rock and siltstone and slate
		Slate

Engineering Considerations

Table 5-8 below discusses the feasibility and suitability of each of the four foundation types, discussed in Section 3.2.2, within the Southwest Study Area.

Table 5-8: Foundation Type Suitability Summary

Proposed Foundation type	Foundation Type Pros / Cons
Monopile	This foundation type is likely not feasible across the Southwest Study Area as a driven pile, due to the shallow depth of bedrock. If a monopile was to be selected, this would have to be a drill and grouted monopile which would require a large socket to be drilled for the monopile to be inserted into. This installation method would be costly and would not be an economical solution.
Jacket Structures – Piled	A driven piled jacket foundation type would likely not be feasible across the Southwest Study Area due to the presence of shallow bedrock, as with the monopile foundation type, a piled jacket foundation could be used but the piles would be required to be drill and grouted. The drilling of the pile sockets would be costly, in addition to the more complex and costly jacket structure this foundation type is not suitable for the Southwest Study Area.
Suction Caissons	Suction Caisson jackets or Monobuckets could be feasible across limited areas of the Southwest Study Area. Suction caissons typically require much shallower (up to 10m) penetration depths than piles and so in area of the Study Area there may be sufficient overburden for suction caissons. Suction caissons require more uniform vertical soil profiles and the presence of coarser material (gravels, cobbles and boulders) may increase the risk of early refusal and prevention of achieving full caisson embedment. Additional and more complex site investigation and advanced laboratory testing are often required for detailed design of suction caisson foundations which increases the complexity and costs of design and installation.

Proposed Foundation type	Foundation Type Pros / Cons
Gravity base	Gravity base foundations are feasible and suitable for the Study Area and are well suited to areas with shallow or outcropping bedrock. However, where gravity base foundations are placed on outcropping bedrock the seabed needs to be levelled, this is done by using gravel to create a gravel bed/platform for the gravity base to sit on. This adds additional cost and installation complexity and adds additional scour risk and protection requirements. .

5.4.3 Consenting Suitability

The primary location within the Southwest Study Area which may be suitable for auk offANS is located off the north Devon coast, at Hartland's Point, with a peak suitability score of 4.8. There are limited options on the south and southwest coasts and in the English Channel due to water depth and other user constraints (refer to Sections 5.4.2 and 5.4.4). There are some areas of potential offANS suitability to the east of the Isle of Wight, however, the maximum score there is 2.9.

The Study Area has a high number of subsea cables making landfall throughout the Cornish and Devon coasts, including interconnector cables going between the UK and Isles of Scilly, Guernsey, Jersey, Ireland, Portugal and the United States. These are predominantly off the north devon coast and Bristol channel, and are to the south and north of the highest suitability area off Hartland Point.

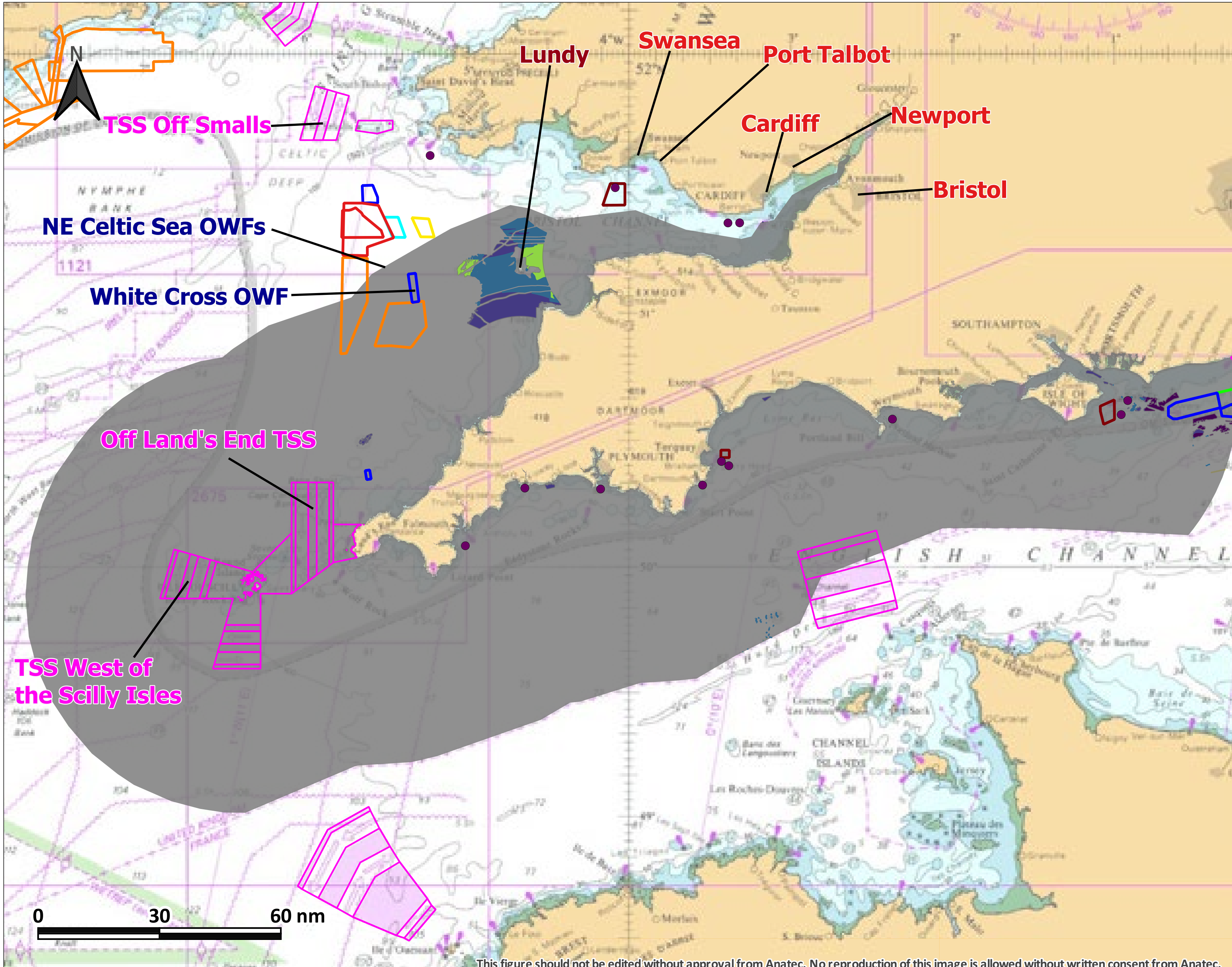
Offshore wind development Round 5 is within the Celtic Sea and these sites have been included within the hard constraints. These sites are to the northeast of the most suitable area. A review of the "Celtic Sea Floating Offshore Wind Leasing Round 5 - PDA Characterisation Report - PDA 1" (TCE, 2023) heatmaps of consenting constraint has been undertaken. This review concluded that the most suitable area for an offANS is within a medium intensity area for fisheries (based on the AIS Fisheries data). The area also intersects with the Primary Surveillance Radar and therefore further assessment and potentially mitigation for any proposed offANS would be required.

There is limited additional other infrastructure within the area. Oil and gas infrastructure, aggregate extraction sites and pipelines are not present within the Study Area.

There are a high number of designated sites for benthic features near the coast in the north and west offshore region that are presented as hard constraints. These include large MCZs such as Cape Bank MCZ and Southwest Approaches to the Bristol Channel MCZ, and smaller sites, including Lundy SAC, North West of Lundy MCZ, Padstow Bay and Surrounds MCZ, Hartland Point to Tintagel MCZ, and Morte Platform MCZ. Off the coast towards the Isle of Wight there is also multiple sites including Wight-Barfleur Reef SAC, Offshore Brighton MCZ, Offshore Overfalls MCZ, and Albert Field MCZ.

5.4.4 Shipping and Navigation Suitability

The Southwest Study Area is presented on Figure 5-29, with the suitability heatmap, as well as key navigational features, also shown Figure 5-29.



Legend

Joint Anthropogenic and Ecological Constraint Score
- 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6

Wind Farm Status
- Operational
- Consented
- Consent Application Submitted
- Scoped
- In Planning
- Area of Search

Navigational Features
- Anchorage Area
- IMO Routeing Area
- Pilot Boarding Station

Anatec Limited
Risk based decision making
An Employee Owned Company

Project

A5522 CEA Auk ANS Site Selection

Figure Title

Figure 5-29: Shipping and Navigation - Southwest Study Area

Date: 12/06/2026	Drawn: LA	Checked: AF

Coordinate System: WGS 84 / World Mercator (EPSG:3395)

The focus of the shipping and navigation assessment has been primarily on the area of higher feasibility at the entrance to the Bristol channel. This area surrounds Lundy (an island in the channel), and as such vessels intersecting the area could be passing either north or south of Lundy depending on their terminus ports. Relevant vessels are likely to be on transits to or from local ports including but not limited to Swansea, Port Talbot, Cardiff, Newport and Bristol. There are also a number of smaller harbours in closer proximity including Bideford, Barnstable, Appledore and Braunton.

Lundy is located approximately 10nm north of the coast (Hartland Point). As such, there is likely to be sufficient remaining sea room for vessels to transit south should an offANS be sited between Lundy and the coast to the south, however more detailed vessel traffic analysis is required to confirm this via full characterisation of the relevant routeing. There is in excess of 20 NM to the coast to the north from Lundy, and therefore again it is likely that hazards associated with a single offANS could be managed subject to full route characterisation.

The development of future offshore wind projects (such as White Cross) may lead to changes to vessel routeing, with potential for cumulative displacement impacts. This could reduce or increase traffic levels in proximity to an offANS location depending on how the cumulative scenario develops.

5.5 Operational Feasibility

The proximity of the offANS to a suitable port is of importance and should be considered when selecting the final location for an offANS as access will be required for operational reasons and maintenance tasks.

Suitable ports have been summarised in Table 5-9 for the Northeast Study Area and Table 5-10 for the Southwest Study Area. Figure 5-30 shows the CTV and SOV transit range from port. Transit ranges of 70 km and 200 km have been used for CTV's and SOV's, respectively. It should be noted that these distances are indicative and will vary depending on vessel size, speed, weather conditions, and availability of suitable sheltered waters for use during adverse weather. This analysis provided a suitable indication for both ease and viability of maintenance of the offANS.
As demonstrated in Figure 5-29, the Southwest Study Area and identified potentially suitable area for siting an offANS can be serviced by both SOVs and CTVs. A SOV solution can only service approximately half of the Southwest Study Area and a CTV solution is restricted to the Bristol channel. Whereas, only the western portion of Locations B and C in the Northeast Study Area are accessible by CTVs from Hull, Immingham and Grimbsy. Location A is not considered to be serviceable utilising a CTV solution (Figure 5-29). However, as shown in Figure 5-29 the entirety of the Northeast Study Area can be serviced by SOVs.

It is noted that should the offANS be developed and operated by a stand-alone delivery partner (as opposed to being associated with an OWF) the ability to access the site via a CTV or similar is likely to be critical, as it is unlikely to be cost-effective to mobilise an SOV for such activities.

Table 5-9: Northeast CTV and SOV O&M Ports

Vessel Type	Port Name	Comment
CTV	Port of Hull Grimsby Port of Tyne Great Yarmouth	These ports are well established as offshore wind support hubs with good access and infrastructure to support CTVs and O&M activities.
SOVs	Grimsby Port of Tyne Lowestoft Sunderland Newcastle	Many of these ports are established ports for SOV vessels and frequently accommodate survey vessels working on North Sea offshore wind farms.

Table 5-10: Southwest CTV and SOV O&M Ports

Vessel Type	Port Name	Comment
CTV	Bideford Quay Appledore Quay Ilfracombe Harbour Port Talbot Pembroke Port (Port of Milford Haven)	These ports are not established hubs to support offshore infrastructure O&M and some are tidal with access limitations depending on vessel draft and tide times.
SOVs	Port Talbot Pembroke Port (Port of Milford Haven) Swansea	These ports are not used for offshore wind O&M but have suitable facilities and can accommodate SOVs and their needs.

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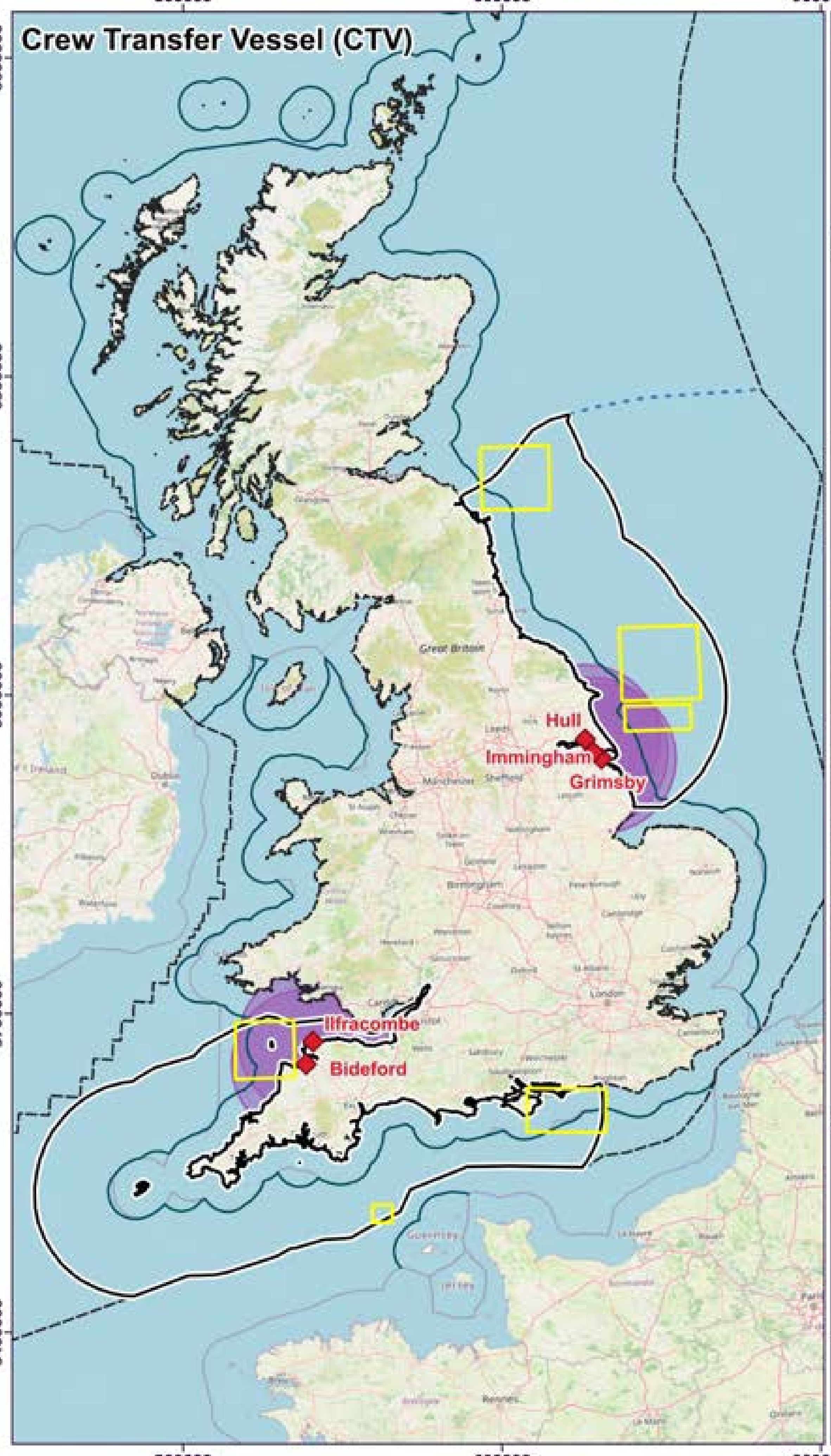
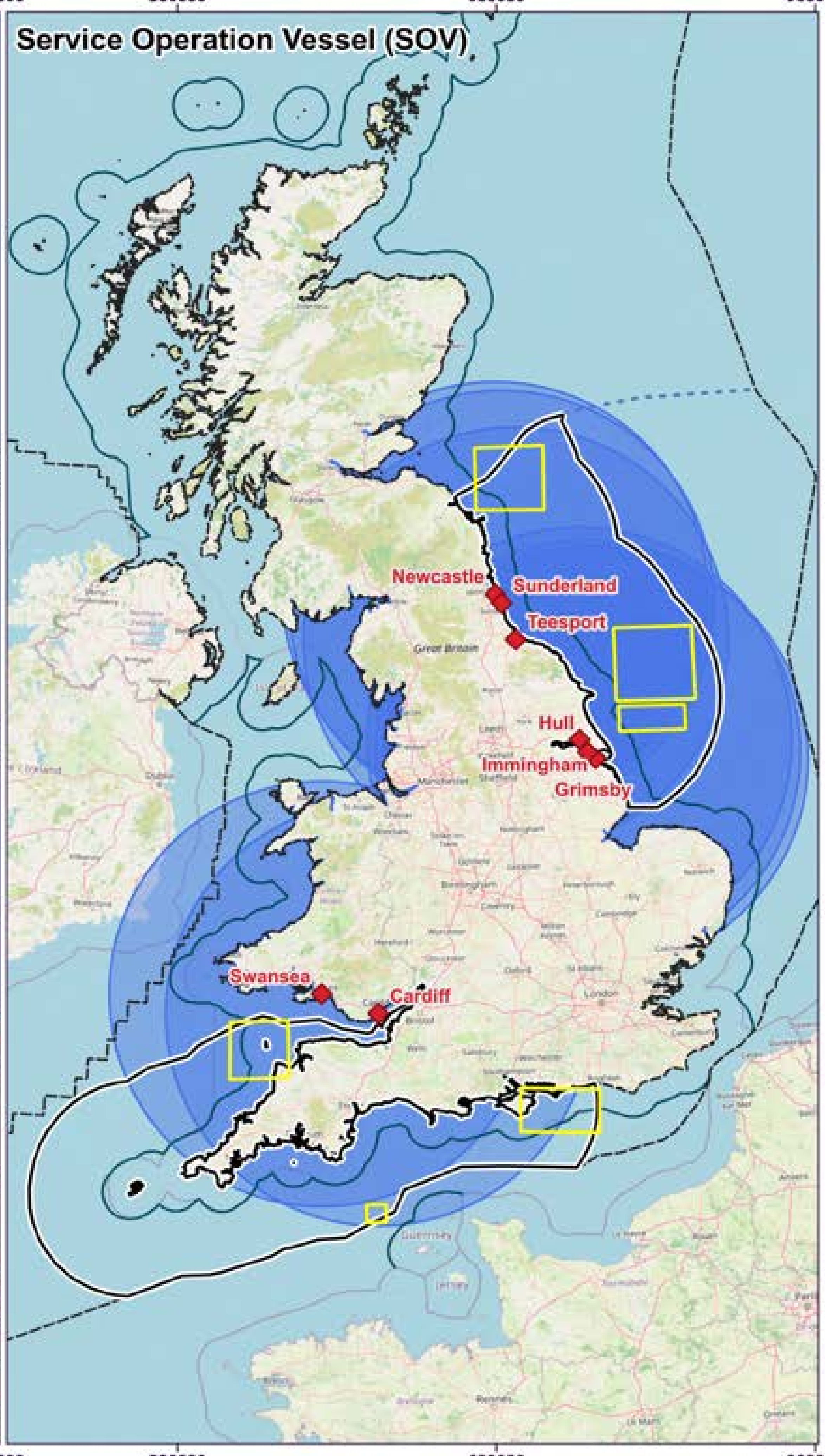
Figure 5-30
Shortlisted Sites Operational Feasibility

C01608-RUK-SHIP-001-F





Legend

- Study Area
- Refined Study Area
- Suitable Area
- 70km Buffer for CTV Access
- 200km Buffer for SOV Access
- Port
- Scottish Adjacent Waters
- 12NM Limit

0 100 200 300 KM
0 40 80 120 NM

Date	12/06/2026
CRS	ETRS89 / UTM zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	meters
Scale at A3	1:5,000,000
Created	MW
Reviewed	AN
Authorised	SS

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6 Discussion

6.1 Overview

Across the Northeast and Southwest Study Areas there is optionality and potentially suitable locations identified for the siting of an offANS for auk species. When comparing the two Study Areas, the constraint mapping shows that within the Northeast Study Area there is a larger number of suitable areas with higher suitability rankings (up to 9). Whilst the Southwest Study Area has one area of the highest suitability (up to 6) off Hartland Point and smaller areas located off the coast between Southampton and Brighton, and Plymouth. Both have optionality and multiple sites that are suitable from ecological, feasibility, consenting, and shipping and navigation considerations. It should be recognised that the spatial extent of offANS siting does not need to be substantial; it only needs to be able to contain the ANS itself and any supporting infrastructure. However, the surrounding areas must be able to support auk foraging in terms of prey availability and absence of impacts (e.g., sources of displacement).

An important factor in the success of an offANS is confidence from the OWF developer, or relevant delivery body as appropriate, in the deliverability. Both Study Areas offer locations that are likely to provide benefit to existing colonies, regional populations, and are sufficiently sized to offer optionality from an ecological perspective. Therefore, the technical and engineering considerations need to be suitable to ensure that the offANS can be delivered successfully in real life scenario.

Both of the highest suitability areas within the Northeast and Southwest Study Areas are located within proximity to potential OWF developments. This aligns with the detailed site selection processes which are undertaken to identify development areas and subsequent OWF project sites which includes similar considerations for consenting and engineering constraints (e.g. driveability of piles). The Southwest Study Area includes three Round 5 'Project Development Areas' in the Celtic Sea, and the Northeast Study Area encompasses the recent Leasing Round 6 Refine Areas of Search (as show in Figure 5-7). Whilst Round 5 is more advanced in the process, the projects are in the early stages of development and the consenting process. Therefore, there is uncertainty around potential interactions with both Round 5 and Round 6 areas.

In summary, across the UK suitability is limited by a combination of all factors. When considering ecological constraints, the southeast of England was the least suitable, along with the Welsh coast and northwest coast of England. The most suitable areas were the southwest of England, northeast of England and north and west Scottish coast. The technical and engineering suitability is a limitation for much of the UK coast, with depth removing large areas as not suitable. The consenting suitability varied across the UK. Offshore windfarms and oil and gas infrastructure limited areas, being found mostly within the Scottish coast and northeast and eastern coast of England. Shipping and Navigation on a UK wide scale showed most of the coast as suitable. Areas around the southeast of England, north Wales and the Bristol channel were the lowest suitability due to high volumes of shipping activity.

6.2 Study Areas

6.2.1 Northeast Study Area

A total 1,250 km^2 within the Northeast Study Area has been identified as potentially suitable for offANS siting with a suitability score of 7 or above. There is general agreement from the stakeholders engaged with as part of the development of this report that the existing colonies and regional populations in the Northeast Study Area are likely to benefit from offANS (

Table 3-1). Within the Northeast Study Area, there may be a benefit to the colonies, providing additional nesting habitat, and contributing to the NSN.

'Overspill' from successful recruitment at other colonies could provide nesting functionality that results in attracting some of those birds into the Flamborough and Filey Coast SPA population. OffANS with connectivity to SPAs, such as the Flamborough and Filey Coast SPA, may offer a level of resilience to impacts and threats to the NSN populations. Established colonies on the east coast are commonly identified as potentially being impacted by OWF developments due to displacement effects. For example, the Flamborough and Filey SPA populations have recently been required to be compensated by OWF development such as Outer Dowsing, Five Estuaries, and Rampion 2 for predicted impacts on the guillemot population. At the time of writing, no offshore wind projects have been required to compensate for razorbill. These projects are proposing measures such as habitat improvement and predator eradication for colonies across the UK and located away from the SPA. OffANS within proximity to the SPA may offer direct benefit to the colonies as an alternative to compensation at more distant colonies in the UK.

The Northeast Study Area has a high number of consenting constraints, with infrastructure associated with oil and gas, and offshore wind present and in planning within the area. These have been represented as hard constraints within the heatmapping as co-location is considered a consenting risk. The North Sea has a well-established supply chain, with numerous operational ports, supporting the maintenance both OWFs and oil and gas infrastructure. This existing supply chain represents an opportunity for the maintenance of any potential offANS. An analysis of the potentially suitable locations, relative to navigational routeing and traffic patterns indicates that any displacement impact could be managed via suitable passage by the vessels planning noting that any deviations from a single offANS in this area would be minor. However, consideration of future developments may lead to notable changes in routeing patterns and would need to be subject to a detailed assessment and consultation as part of any consent application for an offANS.

The Northeast Study Area also has a high volume of vessels and existing and potential future developments. Therefore, whilst the Northeast Study Area offers large areas to consider for an offANS, it also has high other sea user constraints and when selecting a potential location for an offANS at a smaller scale these would need to be considered.

Engineering feasibility of the Northeast Study Areas is less of a constraint, with the depth and quaternary thickness being suitable along most of the coast. Various foundation solutions are feasible across the potential locations including a monopile (Table 5-5).

Therefore, there is confidence that the area would be deliverable from an ecological, consenting and an engineering perspective.

In summary, the Study Area is limited by a combination of factors. The area is ecologically suitable, having prey availability and colonies of both guillemot and razorbill present. Engineering is also suitable for most of the area. Consentable areas are limited as the Study Area has a high number of other users. Vessels transit to the offshore windfarms and oil and gas infrastructure so there are shipping and navigation limitations. However, the existing infrastructure means that the Study Area has good port options, and supply chain, so operationally is feasible.

6.2.2 Southwest Study Area

The Southwest Study Area also offers areas of suitability, albeit lower than that of the Northeast Study Area, with a total area of 116 km^2 having a suitability score of 4 or above. The largest contingent area of potential offANS siting is located in the Bristol Channel, off the Devon coast, with smaller discrete locations in the English Channel, east of the Isle of Wight.

Whilst long-term (1974 onwards) site populations in the Southwest Study Area are generally stable or increasing, analysis of more recent SMP data (2010-2024) show a higher proportion of sites with declining populations for both guillemot and razorbill (Kirk *et al.*, in prep.). Through consultation with site managers, it is understood that key pressures of concern relate to anthropogenic disturbance. Stagnation in growth at smaller colonies could also indicate limitations in breeding habitat, as has been observed in some locations in Scotland, where colony growth slows once preferential nesting sites are occupied (Bennett *et al.*, 2022). Further, there is no clear evidence of prey-driven population declines in the Southwest Study Area, however, guillemot chick diet has shifted to less energy-efficient prey, such as gadids, in recent years (Riordan and Birkhead, 2017).

Auk colonies in the Southwest Study Area are subject to pressures from predation and anthropogenic disturbances on the coast, such as those associated with tourism and outdoor activities, such as climbing. Whilst installation of offANS and creating additional nesting spaces will not reduce such pressures, benefit could be seen through offering nesting sites away from sources of disturbance. Established colonies may also benefit through increased resilience and migration from offANS colonies.

Although suitability scores are lower in the Southwest Study Area compared to the Northeast Study Area, the ecological heatmap alone suggests the majority of the area is able to support auk colonies to some extent (Figure 5-1). Additionally, evidence and data which were unable to be incorporated into the heatmapping suggest the area may be of higher suitability due to the presence of sandeel (MarineSpace *et al.*, 2021; Reach *et al.*, 2024). Therefore, there may be limited specific locations for the structures themselves, but this is unlikely to affect colonisation potential.

The Southwest Study Area is predominantly constrained by engineering feasibility, especially the south coast, English Channel, and off the southwest coast. The depth within the south coast of Devon and Cornwall is a notable constraint. A monopile solution in the southwest is not considered feasible for an offANS (Table 5-8). Within the Bristol Channel and off the coast of Plymouth there are also rocky outcroppings limiting feasibility. However, the north coast of Devon and Cornwall, and areas around Dorset and Hampshire are suitable depths. In addition, there is very limited infrastructure and other sea users to consider within the area.

The further engineering considerations identified that across the Southwest Study area the ground conditions are unlikely to be suitable for monopile. The Southwest Study Area is limited in its port optionality but has options suitable for CTVs and SOVs. If the offANS were to be developed as a one-off strategic measure being within range of a CTV could be critical to the maintenance of the structure. Alternatively, if the offANS was associated with an OWF then a SOV may be feasible from a cost perspective.

The most suitable location within the Southwest Study Area has very few constraints or shipping and navigation considerations. This may equate to a lower consenting risk for an offANS sited in the Southwest Study Area relative to the northeast.

No locations have been identified in the Southwest Study Area with the potential to co-locate an offANS for kittiwake species (Section 6.4).

In summary, the area is ecologically suitable with both guillemot and razorbill colonies present. The area is also not limited by consenting risks, other users or shipping and navigation suitability. Engineering considerations is the most limiting with large areas outside of feasible depth.

6.2.3 Study Area Comparison

There are viable options for an offANS within the Southwest and the Northeast Study Areas. The Northeast Study Area offers areas of higher suitability scoring and potentially more optionality with multiple areas. Whilst the Southwest Study Area offers a large area and a few discrete smaller areas.

From an ecological perspective, both areas support well-established auk colonies (Burnell *et al.*, 2023; Harris *et al.*, 2025). Unlike in Scotland, there is not known to be an overabundance of available nesting habitat in either location. However, further investigation into colony trends and factors is required to fully understand the capacity of natural habitat in both study areas.

Comparison of the two Study Areas suggests that ecological suitability is greater in the Northeast Study Area (Figure 5-1). The data used to inform prey availability (Coull, Johnstone and Rogers, 1998) suggest that there is limited prey in the Southwest Study Area. However, auk colonies in the area feed primarily on herring and sandeel (Anderson *et al.*, 2013; Riordan and Birkhead, 2017) and the presence of established colonies indicate prey availability within the region. The Southwest Study Area also has habitat which supports herring and sandeel, albeit in lower spatial extents (Coull, Johnstone and Rogers, 1998; MarineSpace *et al.*, 2013; Kyle-Henney *et al.*, 2024; Reach *et al.*, 2024). The Northeast Study Area has a well-known sandeel population, with portions of the region closed to sandeel fisheries (Natural England, Cefas and JNCC, 2025).

When considering other users, the Northeast Study Area has a higher volume of vessels and existing and potential future developments. Whilst the Northeast Study Area offers larger areas to consider for an offANS, it also has higher other sea users, and shipping and navigation constraints. The most suitable location within the Southwest Study Area has very few constraints or shipping and navigation considerations. This may equate to a lower consenting risk for an offANS sited in the Southwest Study Area relative to the northeast.

The offANS must be feasible from engineering perspectives. The Southwest Study Area is limited by engineering feasibility, primarily water depth.

Additionally, in the Southwest Study Area, geology may require alternative foundations to monopiles. The Southwest Study Area also has limited optionality of ports and construction transportation, opposed to the Northeast Study Area which has several large ports. These are factors to be considered for the deliverability of the offANS and cost implications to the Developer, or other delivery body.

Table 6-1 Summary of the Study Area suitability

	Northeast Study Area	Southwest Study Area
Highest suitability score	9	5.7
Suitable area size and optionality	Area scoring 7 or above of 1,250 km^2 Three areas of potential suitability	Area scoring 4 or above 116 km^2 One large area and several smaller areas
Ecological suitability	Areas of high suitability with auk colonies present and prey available.	Areas of suitability with auk colonies present. There is limited evidence of herring and sandeel within the area, but colonies present suggest that prey is available.
Technical and Engineering suitability	The area is suitable from engineering considerations, the geology and depth in areas appropriate for monopiles.	The area is restricted by engineering considerations, with the geology not appropriate for monopiles and depths constraining large areas.
Consenting suitability	The area has a high number of other users to consider, with a number of OWFs and oil and gas infrastructure. There are also a number of designated sites.	The area has a low number of other users to consider. There are a number of designated sites.

	Northeast Study Area	Southwest Study Area
	The Leasing Round 6 Refine Areas of Search are within the Study Areas. However, there is a sufficiently large area, to provide optionality, that would be suitable.	Round 5 'Project Development Areas' are within the Study Area. Consenting suitability is not a high constraint for this Study Area.
Shipping and Navigation suitability	Due to the OWF and oil and gas infrastructure and existing shipping routes, there is a lot of vessel activity in the area. This would need to be a consideration in the location refinement.	The highest vessel traffic is within the Bristol channel, however there is sufficient sea room that the introduction of an offANS should not cause displacement.
Operational feasibility	A range of ports available for CTV and SOV.	Limited ports available but are suitable for CTV and SOV.

6.3 Climate Change

Climate change is not a constraint considered within the heatmaps, as agreed in the workshop on 12 December 2025 (Table 3-1). However, it is important to consider the impacts of climate change when considering offANS locations and the longevity of the offANS throughout the lifetime of the associated OWF projects. Climate change is a known contributor to changes in abundance guillemot and razorbill (BTO, 2024), and is considered to be one of the biggest threats to seabirds globally, alongside invasive species bycatch (Dias *et al.*, 2019).

Both guillemot and razorbill are susceptible to severe winter storms as they are forced to reduce foraging during storms, which has led to widespread mortality (Heubeck *et al.*, 2011). The frequency of such winter storm events is increasing due to climate change (Field *et al.*, 2012). Guillemots are also sensitive to heat, with increased heat stresses reducing breeding successes (Olin *et al.*, 2023).

Climate change has been evidenced to be shifting distributions of prey, and the timing of fish breeding and migration (Descamps *et al.*, 2019). Prey species such as sandeel are changing in abundance and distribution due to sea surface changes (Sandvik *et al.*, 2005; Wanless *et al.*, 2005; Heath *et al.*, 2009; Erikstad *et al.*, 2013; Régnier, Gibb and Wight, 2017). There has also been changes in the quality of prey. For example, sandeels have seen a reduction in growth rates, leading to smaller individuals as a result of climate change shifting their prey sources (Green, 2017). This means that auks are having to seek alternate prey and consuming less energy-rich prey items, as observed at the Skomer breeding colony (Riordan and Birkhead, 2017).

Therefore, climate change is causing changes throughout the trophic levels. As prey availability changes, it is important to consider this within the offANS locations to ensure that the structures are still within foraging ranges. This study has considered herring and sandeel as prey sources to add resilience and used the best available data to identify areas that are suitable. The design of the offANS will also need to provide shelter and suitable protection for storm and severe weather conditions to protect the auk colonies using the structures.

6.4 Co-location Opportunities

This study was designed to enable direct comparison to the results of the review of ANS AoS for kittiwake (NIRAS, 2023), with the aim to identify potential areas for co-location for kittiwake and auk species. This study has further developed the Niras methodology and allows for higher granularity of data, and further consideration of non-ecological constraints. The potential areas of co-location identified by comparing the findings of the two studies allows for the opportunity for offANS to be developed that offer benefits for multiple species. Co-location as a compensation option may be more cost effective than an offANS for one species.

Ecological factors affect the suitability of ANS siting for kittiwake and auks differently due to habitat requirements and foraging habits. For example, kittiwake forage near the surface, feeding primarily on lesser sandeel (Ruffino *et al.*, 2023), whereas auks can dive to depths in excess of 100 m for their prey (Dunn *et al.*, 2019). Therefore, surrounding water depth is likely to play a factor, being more limiting to kittiwake ANS siting than auks. Site fidelity is also an important consideration, with kittiwake having greater dispersal rates (Swann and Ramsay, 1983; Harris, Wanless and Barton, 1996; Horswill and Robinson, 2015) and distances (Lyngs, 1993; Lavers, Jones and Diamond, 2007; Coulson, 2011) auks than a factor that was considered in both studies.

No co-location opportunities have been identified in the Southwest Study Area as there are no existing ANS for other species and the region was not included the kittiwake study (NIRAS, 2023).

In the kittiwake study, nine refined AoSs (including onshore sites) were identified in the North Sea, labelled 'A' through 'I'. In these areas, suitability scores ranged from 1 (least suitable due onshore location) to 27 (most suitable due to proximity to food resources and existing colonies).

Comparison of the auk offANS Northeast Study Area and the kittiwake ANS AoS study has identified overlap with kittiwake AoSs B, C, and D (Figure 6-1; Table 6-2).

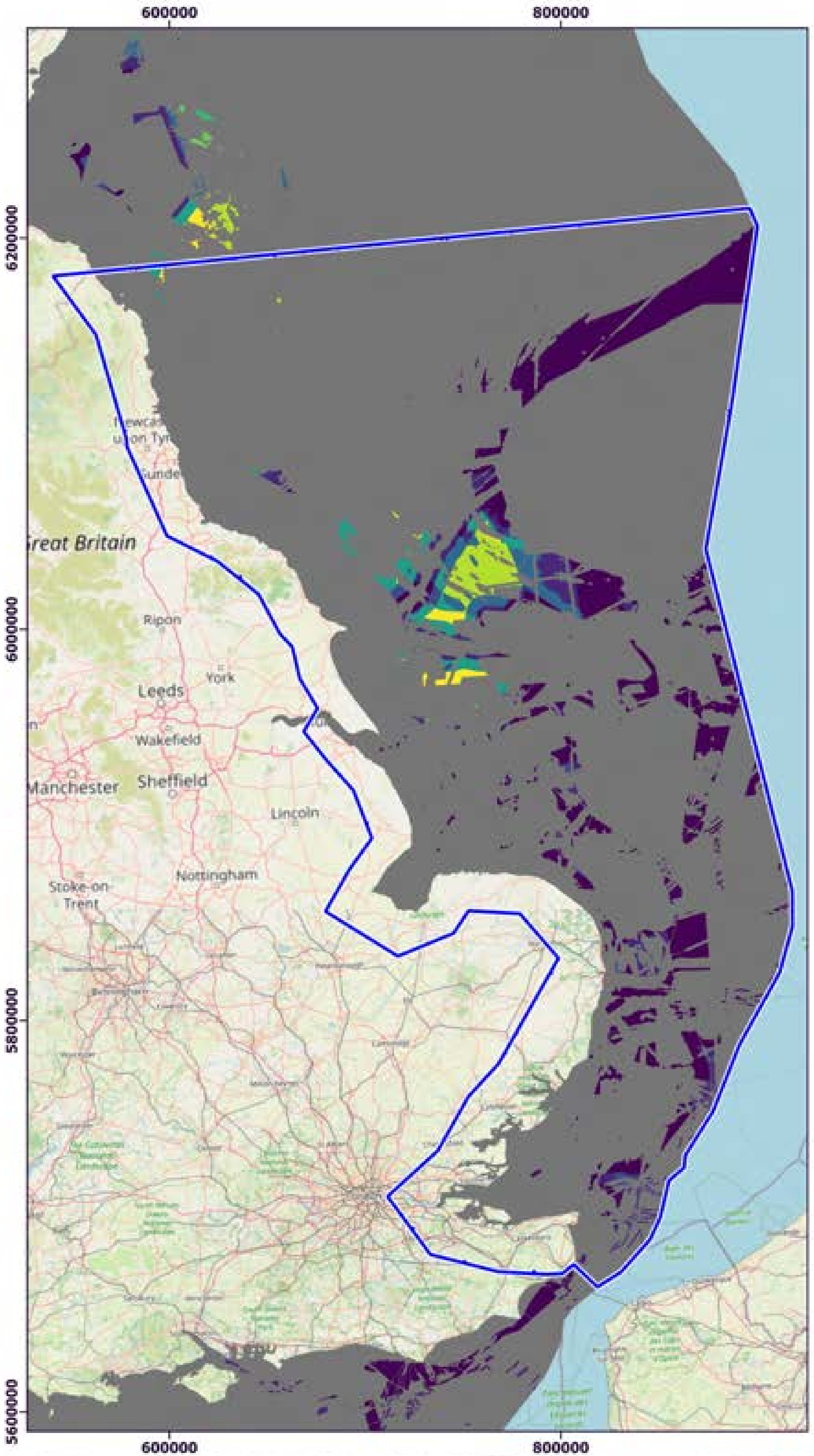
Table 6-2: Kittiwake AoS scoring and overlap with auk offANS suitability

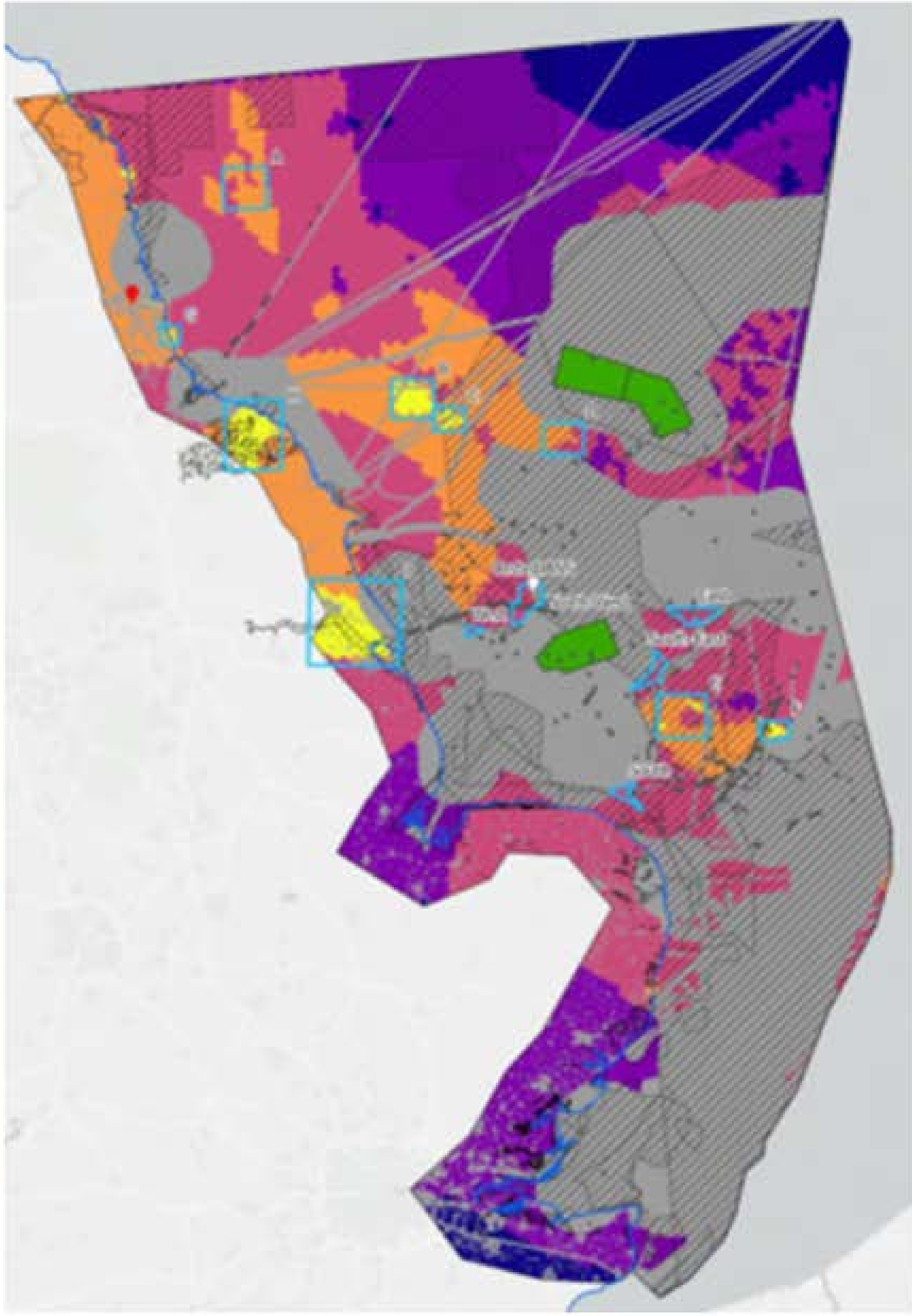
Kittiwake AoS	Area (km^2)	Score (kittiwake)	Hard Constraint (Auk) (km^2)	Score >7 (Auks) (km^2)	Suitable for Colocation (%)
B	308.2	27	302.5	5.7	1.8%
C	137.7	23	115.3	4.4	3.2%
D	239.7	25	24.6	106.0	44.2%

Kittiwake AoSs B, C, and D scored highly compared with other kittiwake areas, with scores of 27, 23, and 25 at B, C, and D, respectively which is outlined in Figure 6-2. The rationale for high scores are due to close proximity to prey resources associated with Dogger Bank. The Crown Estate (2023) identified risks associated with each of the kittiwake AoSs, which include proximity to unrecorded offshore populations, such as those on old marine infrastructure (e.g., O&G platforms), and proximity to existing OWF developments. Whilst unrecorded offshore populations may offer increased connectivity and colonisation potential, competition for resources may also increase. Areas in close proximity to OWF developments were excluded from the auk offANS heat mapping, reducing the likelihood of offANS colonies being affected by displacement.

In terms of co-location suitability, kittiwake AoS D has the most opportunity, with the western third of this search area scoring 7-8 for auk offANS, and the eastern portion scoring 4-5. There are limited areas of auk offANS hard constraint within kittiwake AoS D, represented by discrete locations of deeper water and subsurface infrastructure, such as cables or pipelines.

Kittiwake AoSs B and C are less suited to auk offANS siting (Figure 6-1; Table 6-2), with the vast majority (>95%) of AoS B comprising a hard constraint for an auk offANS. However, there is a small portion in the north of AoS B that scores highly (7-8) for an auk offANS. The remainder of this kittiwake AoS was a hard constraint for auk offANS for anthropogenic reasons, suggesting that it may have high ecological suitability. Kittiwake AoS C has moderate scoring for auk offANS, with a maximum score of 4-5 in the central north. Co-location here is less suited and would require further investigation; however, may still be feasible.





(The Crown Estate, 2023)

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Figure 6-1
Kittiwake and Auk Co-Location Potential

C01608-RUK-BIRD-004-B

Legend

Study Area (The Crown Estate, 2023)

Suitability Score

- 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9

Combined Score (The Crown Estate, 2023)

- -3 - 0
- 1 - 4
- 5 - 7
- 8 - 11
- 12 - 14

0 30 60 90 120 150 KM
0 15 30 45 60 75 NM
N

Date	12/06/2026
CRS	ETRS89 / UTM zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	meters
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Reviewed	AN
Authorised	SS

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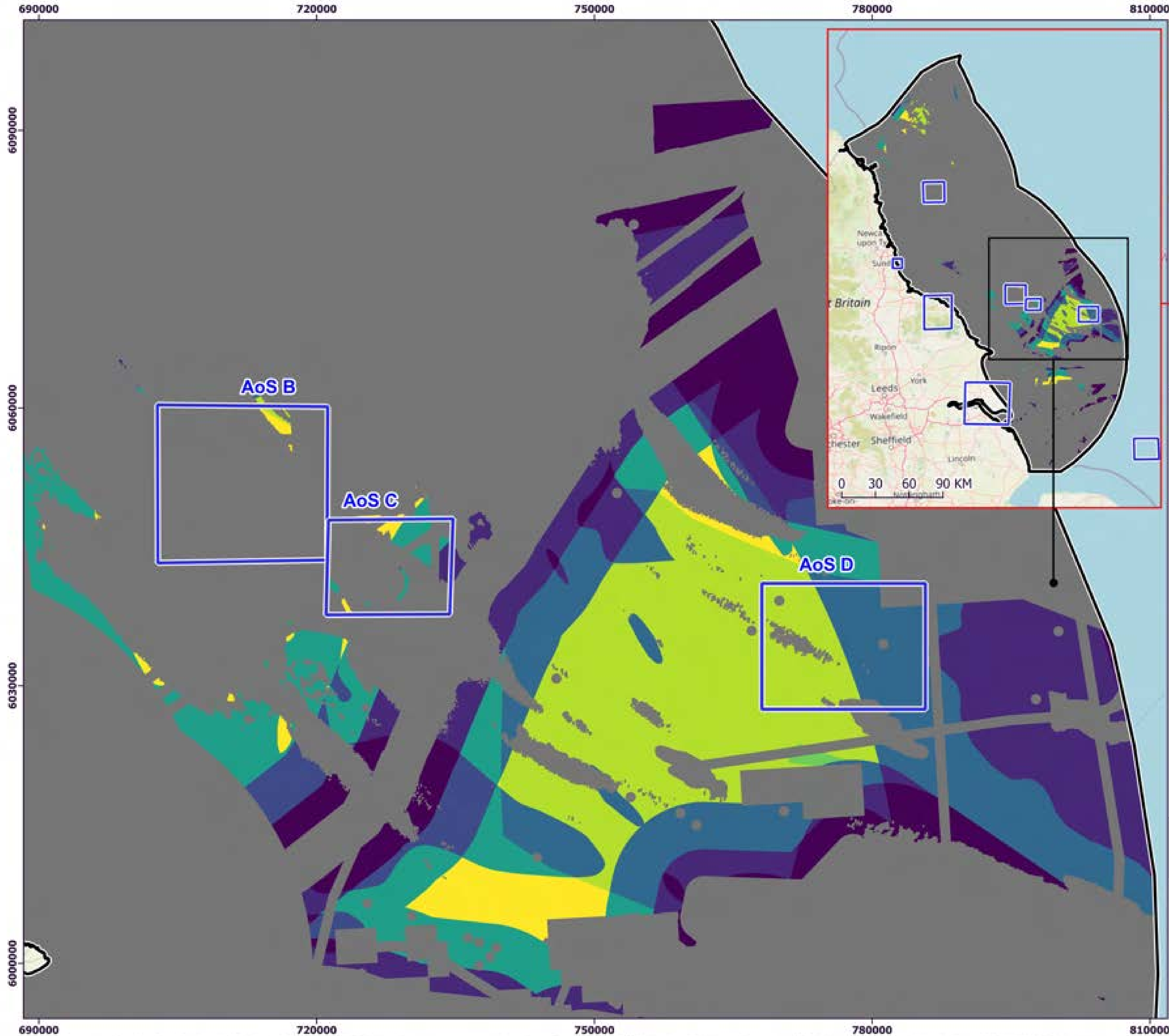
Figure 6-2
Comparison of Potential ANS Locations for Kittiwake and Auk Species

C01608-RUK-BIRD-005-E



Legend

Study Area

Kittiwake Area of Search (The Crown Estate, 2023)

Suitability Score

0
0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
6 - 7
7 - 8
8 - 9

0 7 14 21 KM

0 3 6 9 NM

N

Date	12/06/2026
CRS	ETRS89 / UTM zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	meters
Scale at A3	1:400,000
Created	MW
Reviewed	AN
Authorised	LV

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7 Next Steps

7.1 Further study opportunities

This section outlines some potential further analysis which could support the development of an offANS and to expand this study.

This study does not incorporate colonisation likelihood into the scoring (Section 4.6), rather, it presents the theoretical locations with the greatest feasibility from a range of criteria. When considering auk ANS installation and design, the likelihood of colonisation should be assessed, with respect to distance from and size of existing colonies, as well as a more in-depth review of previous instances of auks utilising offshore structures for breeding. Such information can feed into precise siting and the physical design of the ANS.

It is acknowledged that applying core foraging range to existing colonies may have underestimated the constraints to development. Likely foraging areas associated with an ANS and potential overlap with core foraging areas of existing colonies should also be considered in the future. This factor was not considered in the initial scoring, as it is believed that a more location-specific approach should be taken, rather than applying a further extent of hard constraint uniformly across the study area. Auk foraging ranges vary drastically (Woodward *et al.*, 2019) depending on location, colony size, and prey distribution and availability. Therefore, it is recommended that likely key foraging areas and prey resources are considered when identify specific ANS locations. Variation or colony-specific foraging ranges (Woodward *et al.*, 2019) should be incorporated when considering specific locations or ANS micro-siting.

Further analysis could include more technical and engineering suitability considerations including seabed slope and current speeds. The impact of these factors is localised and therefore could be appraised, in more detail, when potential ANS areas are refined further.

It has not been possible to include climate change considerations in a quantitative manner in this study due to unknowns and complex variables. Shifts in environmental suitability should be considered when reviewing specific areas for offANS siting. For offANS to be successful and a colony to become established long-term, predicted changes for the life cycle of the offANS should be taken into account including any potential changes in prey distribution. A review of climate projection and the trends of population of prey sources could ensure confidence that the offANS would be resilient to climate change.

Further consideration of the qualitive aspects presented in this study and wider consent considerations (such as military and commercial aviation routes and commercial fisheries) could be utilised to further refine the potential suitable areas to specific siting options for an offANS.

Further assessment of vessel traffic data, including sensitive routes and detailed routeing analysis, would be required to ascertain specific routeing patterns to support the consent of any proposed offANS.

The Crown Estate's Round 6 Refined Areas of Search should be considered when refining the auk ANS study areas further during site selection processes. This is particularly important for the Northeast Study Area, with the Round 6 locations being present in the North Sea. Further review will be required, however, a high-level visual comparison indicates that significant further constraint to auk ANS siting is unlikely to occur.

If a greater number of potential sites or a wider geographical distribution were desirable, then locations outside of the two refined Study Areas could also be investigated in further detail or areas outside of UK waters could be considered. Patterns in auk distribution throughout the year, including migration routes to and from breeding colonies, could be used to identify potential areas which were shown as low suitability in the mapping exercise of this study. For example, areas off the East Anglian coast were identified as low suitability due to limited connectivity, however, this is likely due to a lack of natural nesting habitat as prey availability appears high (Coull, Johnstone and Rogers, 1998). The non-ecological heatmap (Figure 5-1) suggests that areas off the coast of East Anglia have moderate to high suitability, whereas the ecological heatmap suggests low suitability (Figure 5-2), which is correlated with the locations of existing colonies.

7.2 Development of OffANS into a Library Measure

This study identifies suitable areas for an offANS, ensuring it is ecological suitable and deliverable. Further work is required to confidently add this measure into the library of strategic compensation measures.

There are multiple areas around the UK that are suitable from ecological, engineering, and other marine user perspectives for siting offANS. These areas are of a sufficient size that multiple offANS could be sited and could be developed as a potential strategic compensation measure. It is recognised that to date, the Secretary of State has not approved offANS for auk species as compensation for OWF projects. This study has demonstrated potential strategic scalability of an offANS for guillemot and razorbill.

This study has sought to demonstrate the practicality and scalability, particularly with co-location, of an offANS for auks. However, further evidence/investigation would be needed to address the Collaboration on Offshore Wind Strategic Compensation (COWSC) ANS Expert Group's recommendation in October 2023 with regard to effectiveness of offANS for auks species.

Although this current body of work does not directly resolve the evidence gap, there is a compelling case to be made for acknowledging the offshore survey efforts conducted by offshore wind developers, notably at sites such as Hornsea Four and Outer Dowsing. These surveys, as documented in the SCS Offshore Repurposing Report (OWIC, 2026), have contributed valuable insights into the frequency and extent to which seabird species, including auks, utilise offshore structures. Integrating these survey findings with the heatmap analysis undertaken for this report could provide a more comprehensive understanding of seabird behaviour in relation to offshore infrastructure. This synthesis of data has the potential to address some of the concerns previously raised and may support a renewed consideration by the Secretary of State for incorporating ANS as a strategic compensatory measure within the library. Such an approach would ensure that decisions are informed by the best available evidence, supporting both conservation objectives and the responsible development of offshore wind infrastructure.

8 References

Anderson, H.B., Evans, P.G.H., Potts, J.M., Harris, M.P. and Wanless, S. (2013). The diet of Common Guillemot *Uria aalge* chicks provides evidence of changing prey communities in the North Sea. *Ibis*, 156(1), pp.23-34. doi: https://doi.org/10.1111/ibi.12099

Barret, R.T. (2015). The diet, growth and survival of Razorbill *Alca torda* chicks in the southern Barents Sea. *Ornis Norvegica*, 38, pp.25-31. Doi: https://doi.org/10.15845/on.v38i0.891

Bennet, S., Wanless, S., Harris, M.P., Newell, M.A., Searle, K., Green, J.A. and Daunt, F. (2022). Site-dependent regulation of breeding success- Evidence for the buffer effect in the common guillemot, a colonially breeding seabird. *Journal of Animal Ecology*, 91(4), pp.752-765. Doi: https://doi.org/10.1111/1365-2656.13674

BTO (2024) *Seabird Population Trends and Causes of Change: 1986—2024*. [Online]. Thetford- British Trust for Ornithology. Available at: https://www.bto.org/sites/default/files/bto-jncc-rspb-seabird-montoring-programme-annual-report-2024.pdf [Accessed: 21 April 2026].

Buckingham, L., Daunt, F., Bogdanova, M.I., Furness, R.W., Bennett, S., Duckworth, J., Dunn, R.E., Wanless, S., Harris, M.P., Jardine, D.C., Newell, M.A., Ward, R.M., Weston, E.D. and Green, J.A. (2023). Energetic synchrony throughout the non-breeding season in common guillemots from four colonies. *Journal of Avian Ecology*, 1-2, e03018. Doi: https://doi.org/10.1111/jav.03018

Burnell, D., Perkins, A.J., Newton, S.E., Bolton, M., Tierney, T.D. and Dunn, T.E. (2023). *Seabirds Count A census of breeding seabirds in Britain and Ireland (2015-2021)*. Barcelona: Lynx Nature Books. ISBN: 978-84-16728-60-2.

Cameron, T.D.J., Crosby, A., Balson, P.S., Jeffery, D.H., Lott, G.K., Bulat, J., Harrison, D.J., 1992. The Geology of the Southern North Sea. United Kingdom Offshore Regional Report. British Geological Survey and HMSO, London.

Coull, K.A., Johnstone, R. and Rogers, S.I. (1998). *Fisheries Sensitivity Maps in British Waters*. Aberdeen: UKOOA Ltd.

Coulson, J.C. (2011). *The Kittiwake*. London: T. & A.D. Poyser.

Descamps, S., Ramírez, F., Benjaminsen, S., Anker-Nilssen, T., Barrett, R.T., Burr, Z., Christensen-Dalsgaard, S., Erikstad, K.E., Irons, D.B., Lorentsen, S.H. and Mallory, M.L., (2019) Diverging phenological responses of Arctic seabirds to an earlier spring. *Global Change Biology*, 25(12), pp.4081-4091.

Dias, M.P., Martin, R., Pearmain, E.J., Burfield, I.J., Small, C., Phillips, R.A., Yates, O., Lascelles, B., Borboroglu, P.G. and Croxall J.P. (2019). Threats to seabirds: A global assessment. *Biological Conservation*, pp.237, 525-537. Doi: https://doi.org/10.1016/j.biocon.2019.06.033

Dunn, R.E., Wanless, S., Green, J.A., Harris, M.P. and Daunt, F. (2019). Effects of body size, sex, parental care and moult strategies on auk diving behaviour outside the breeding season. *Journal of Avian Biology*, 50(7), e02012. Doi: https://doi.org/10.1111/jav.02012

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. *Science Series Technical Report*, 147, 56 pp. Lowestoft: Cefas.

Engvall, E., Waldenström, J. and Hentati-Sundberg, J. (2023). Diet and prey size preference in Razorbills *Alca torda* breeding at Stora Karlsö, Sweden. *Ornis Svecica*, 32, pp.87-98. Doi: https://doi.org/10.34080/os.v32.22615

Erikstad, K.E., Reiertsen, T.K., Barrett, R.T., Vikebø, F. and Sandvik, H. (2013). Seabird-fish interactions- the fall and rise of a common guillemot Uria aalge population. *Marine Ecology Progress Series*, 475, pp.267-276. Doi: http://dx.doi.org/10.3354/meps10084

Field, C.B. (2012). Managing the risks of extreme events and disasters to advance climate change adaptation- special report of the intergovernmental panel on climate change. [Online]. Cambridge- Cambridge University Press. Available at: https://www.osti.gov/biblio/1045512 [Accessed: 22 April 2026].

Fugro, 2023a. DBS WPM1 – Array Area Shallow Geological Results Report, Dogger Bank South Geophysical SI.

Fugro, 2023b. DBS WPM2 WPM3 – ECR Seafloor and Shallow Geological Results Report, Dogger Bank South Geophysical SI.

Fugro, 2023c. DBS WPM1 – Array Area Seafloor Results Report, Dogger Bank South Geophysical SI.

Green, E. (2017). Tern diet in the UK and Ireland- a review of key prey species and potential impacts of climate change. doi: http://doi.org/10.13140/RG.2.2.18688.74248

Harris, M.P., Wanless, S. and Barton, T.R. (1996). Site use and fidelity in Common Guillemot *Uria aalge*. *Ibis*, 138(3), pp.399-404. Doi: https://doi.org/10.1111/j.1474-919X.1996.tb08057.x

Harris, S.J., Baker, H., Balmer, D.E., Bolton, M., Burton, N.H.K., Clarke, J.A.E., Dunn, T.E., Evans, T.J., Hereward, H.F.R., Humphreys, E.M., Langlois Lopez, S., Money, S., Taylor, E.A. and O'Hanlon, N.J. (2026). *Seabird Population Trends and Causes of Change- 1986-2024, the annual report of the Seabird Monitoring Programme*. [Online]. BTO Research Report No. 795. Thetford: British Trust for Ornithology. ISBN: 978-1-912642-94-6. Available at: https://www.bto.org/our-work/science/publications/reports/smp-report [Accessed: 31 March 2026].

Heath, M., Edwards, M., Furness, R., Pinnegar, J. and Wanless, S. (2009). A view from above- changing seas, seabirds and food sources. In: Baxter, J.M., Buckley, P.J. & Frost, M.T. (eds). 2009. Ecosystem Linkages Report Card.

Heubeck, M. (2009). Common Guillemot *Uria aalge* chick diet and breeding performance at Sumburgh Head, Shetland in 2007-09, compared to 1990-91. *Seabird*, 22, pp.9-18. Doi: https://doi.org/10.61350/sbj.22.9

Heubeck, M., Aarvak, T., Isaksen, K., Johnsen, A., Petersen, I.K. and Anker-Nilssen, T. (2011). Mass mortality of adult Razorbills Alca torda in the Skagerrak and North Sea area, autumn 2007. *Seabird Journal*, 24, pp.11-32. Doi: https://doi.org/10.61350/sbj.24.11

Horswill, R. and Robinson, R.A. (2015). *Review of seabird demographic rates and density dependence*. JNCC Report No. 552. Peterborough: JNCC.

Kirk, A., Porter, L., Russell, A., Ward, S., Cross, K., Lloyd Jones, D. and Reach, I. (in press.). *Supporting Southwest Seabird Colonies- A review of the status and trends of common guillemot, razorbill, and great black-backed gull populations in the Southwest, current pressures, and opportunities for intervention for offshore wind development compensation.* Defra, in press.

Kyle-Henney, M., Reach, I., Barr, N., Warner, I., Lowe, S. and Lloyd Jones, D. (2024). *Identifying and Mapping Atlantic Herring Potential Spawning Habitat: An Updated Method Statement*.

Lavers, J.L., Jones, I.L. and Diamond, A.W. (2007). Natal and Breeding Dispersal of Razorbills (*Alca torda*) in Eastern North America. *Waterbirds*, 30(4), pp.588-594. Doi: https://doi.org/10.1675/1524-4695(2007)030%5b0588-NABDOR%5d2.0.CO;2

Lyngs, P. (1993). Colony interchange in Baltic Guillemots *Uria aalge*. *Dansk Orn. Foren. Tidsskr.*, 87, pp.247-250.

MarineSpace (2021). *Supplementary Report to Inform Appropriate Assessment- Severn Estuary/Môr Hafren Special Area of Conservation - Area 531 Sandeel.*

MarineSpace Ltd, ABPmer Ltd, ERM Ltd, Fugro EMU Ltd and Marine Ecological Surveys Ltd, 2013. *Environmental Effect Pathways between Marine Aggregate Application Areas and Sandeel Habitat: Regional Cumulative Impact Assessments.* A report for British Marine Aggregate Producers Association (BMAPA).

Natural England, Cefas and JNCC (2025). *Evidence update: North Sea sandeels*. [Online]. Defra. Available at: https://assets.publishing.service.gov.uk/media/685aba9f45eea7ef2e620778/Evidence_report_-_April_2025.pdf [Accessed: 07 May 2026].

NIRAS (2023). *Offshore Wind Leasing Round 4 Appendix D – Round 4 Strategic Compensation – Artificial Nesting Structure Site Selection*. [Online]. The Crown Estate. Available at: https://www.thecrownestate.co.uk/our-business/marine/round-4-document-library [Accessed: 10 April 2026].

Olin, A.B., Dück, L., Berglund, P.A., Karlsson, E., Bohm, M., Olsson, O. and Hentati-Sundberg, J. (2023). Breeding failures and reduced nest attendance in response to heat stress in a high-latitude seabird. *Marine Ecology Progress Series*, 737, pp.147-160. Doi: https://doi.org/10.3354/meps14244

OWIC (2025). *Offshore Bycatch Monitoring.* OWEC SCS Report No. 02. A report produced by OWIC for the OWEC Strategic Compensation Studies (SCS) project. Available at: https://www.owic.org.uk/resources/hornsea-project-four-offshore-bycatch-monitoring-executive-summary/ [Accessed: 06 May 2026].

OWIC (2026). *1d Offshore Structure Repurposing Roadmap.* OWEC SCS Report No. 08. A report produced by GoBe Consultants and Pinsent Masons LLP for the OWEC Strategic Compensation Studies (SCS) project. Available at: https://owic.org.uk/media/sgdjgcpk/18754_offshore-ans-repurposing_v4-1.pdf [Accessed: 06 May 2026].

Patton H., Yorke L., Habbard A., Glasser N., 2009. Seafloor glacial features in the southern North Sea, Westermost Rough OWF Report, Marine Data Exchange.

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*.

Régnier, T., Gibb, F.M. and Wright, P.J. (2017) Importance of trophic mismatch in a winter-hatching species: evidence from lesser sandeel. *Marine Ecology Progress Series*, 567, pp.185-197. Doi: https://doi.org/10.3354/meps

Riordan, J. and Birkhead, T. (2017). Changes in the diet composition of Common Guillemot *Uria aalge* chicks on Skomer Island, Wales, between 1973 and 2017. *Ibis*, 160(2), pp.470-474. Doi: https://doi.org/10.1111/ibi.12570

Ruffino, L., Arjona, Y., Clear, N. and Martin, E. (2023). *Towards better understanding black-legged kittiwake and fish prey interactions An assessment of scientific evidence to inform future research needs in the North Sea.* JNCC Report 733. Peterborough: JNCC. Available online at: https://data.jncc.gov.uk/data/ef7b01db-ca48-4469-b5ce-642efe0f7ed2/jncc-report-733-revised.pdf [Accessed: 29 May 2026].

Sandvik, H., Erikstad, K.E., Barrett, R.T. and Yoccoz, N.G. (2005) The effect of climate on adult survival in five species of North Atlantic seabirds. *Journal of Animal Ecology*, 74, pp.817-831. Doi: https://doi.org/10.1111/j.1365-2656.2005.00981.x

SNCBs (2022). *Joint SNCB Interim Displacement Advice Note*. [Online]. Available at: https://jncc.gov.uk/resources/9aecb87c-80c5-4cfb-9102-39f0228dcc9a [Accessed: 10 April 2026].

Swann, R.L. and Ramsay, A.D.K. (1983). Movements from and age of return to an expanding Scottish Guillemot colony. *Bird Study*, 30, pp.207-214. Doi: https://doi.org/10.1080/00063658309476798

Terente, V., Owen, M., Higgs, D., Ellery, G., 2016. Derivation of Ground Models and Characteristic Geotechnical Profiles in Offshore Wind Farms at pre-FID stage. International Journal of Offshore and Polar Engineering, 1, pp.135-143.

The Crown Estate (2023) Celtic Sea Floating Offshore Wind Leasing Round 5 PDA Characterisation Report - PDA 1, Available at: https://www.datocms-assets.com/136653/1720790217-pda-characterisation-report-pda-1.pdf [Accessed: 06 May 2026]

Wanless, S., Harris, M.P., Redman, P. and Speakman, J.R. (2005) Low energy values of fish as a probable cause of a major seabird breeding failure in the North Sea. *Marine Ecology Progress Series*, 294, pp.1-8. Doi: https://doi.org/10.3354/meps

Woodward, I., Thaxter, C.B., Owen, E. and Cook, A.S.C.P. (2019). *Desk-based revision of seabird foraging ranges used for HRA screening.* [Online]. BTO Research Report No. 724. Thetford: British Trust for Ornithology. ISBN: 978-1-912642-12-0. Available at: httpsL//www.bto.org/our-work/science/publications/reports/bto-research-reports/00724-woodward-seabird-foraging-ranges [Accessed: 30 March 2026].

Annex I – Scoring Criteria

Criteria	Layer Classification	Source	Score
Ecological Ornithology Criteria			
Overlap with prey preferred habitat - herring and sandeel spawning grounds	Within spawning grounds/ hotspots	Coull, Johnstone and Rogers (1998)	1.5
	Within mean foraging range of guillemot (23.9 km) from sp/ nurs ground		1.4
	Within mean foraging range of razorbill (31.2 km) from sp/ nurs ground		1.3
	Within maximum foraging range of guillemot (135 km) from sp/ nurs grounds		1.2
	Within the maximum foraging range of razorbill (191 km) from sp/ nurs grounds		1.1
	Outside of both max foraging ranges		1
Proximity to avian predator colonies	Within mean foraging range (43.3 km)	Woodward *et al* (2019)	0.5
	Outside mean foraging range		1
Distance from auk colonies (guillemot)	Within core/ mean foraging range (23.9 km)	JNCC	0
	Within mean-max foraging range (95.2 km)		2
	Outside mean-max foraging range		1
Distance from auk colonies (razorbill)	Within core/ mean foraging range (31.2 km)	JNCC	0
	Within mean-max foraging range (122.2 km)		2

Criteria	Layer Classification	Source	Score
	Outside mean-max foraging range		1
Displacement effect from offshore wind farms	2 km	TCE, CES	0
	5 km		0.2
	within 10 km		0.5
	outside 10 km		1
Engineering Criteria			
Water Depth	<-20 m	EMODnet	0
	-20 to -60 m		1
	>-60 m		0
Seabed sediments – presence of rock outcroppings	Outcroppings present	BGS	1
	Outcroppings absent		0
Sub-surface geology – quaternary thickness	0 to 5 m or >50 m	BGS	0.5
	>5 m		1
	No data/ Study Area		1
Other Sea Users			
Offshore wind export cables	2 km	TCE	0
	5 km		0.2
	within 10 km		0.5
	outside 10 km		1
Cables	within 500 m		0

Criteria	Layer Classification	Source	Score
	outside 500 m	KIS-ORCA, CES, EMODnet	1
Pipelines	within 500 m	NSTA, CES	0
	outside 500 m		1
Subsea Infrastructure	within 500 m	NSTA	0
	outside 500 m		1
Surface Infrastructure	within 500 m	NSTA	0
	outside 500 m		1
Wells	within 500 m	NSTA	0
	outside 500 m		1
Tidal Site Agreements	within 500 m	TCE, CES	0
	outside 500 m		1
Wave Site Agreements	within 500 m	TCE, CES	0
	outside 500 m		1
Aggregate Sites	Within boundary	EMODnet	0
	outside boundary		1
Wrecks	within 500 m	EMODnet	0
	outside 500 m		1
Licensed Blocks	Within boundary	EMODnet	0
	outside boundary		1

Criteria	Layer Classification	Source	Score
Oil/ Gas Fields	Within boundary	NSTA	0
	outside boundary		1
MCZ/ SAC Designated for benthic features	Within boundary	NE, NS	0
	outside boundary		1
Other Archaeological Sites/ Features – World Heritage Sites	Within boundary	Historic England	0
	outside boundary		1
Shipping Routes	Within Study Area	Anatec	1
	Medium constraint		0.5
	Medium Hard constraint		0.25
	Hard constraint		0

Annex II – Consultation Briefing Note

Strategic Compensation Studies

Auk ANS Site Selection: Criteria Briefing Note

Contents

List of Tables

Acronyms

Acronym	Term
AEoI	Adverse Effect on Integrity
ANS	Artificial Nesting Structure
CCS	Carbon Capture and Storage
GIS	Geographical Information System
NSN	National Site Network
O&G	Oil and Gas
OWF	Offshore Wind Farm
PAG	Project Advisory Group
SMP	Seabird Monitoring Programme
SPA	Special Protection Area

Glossary

Term	Definition
Artificial Nesting Structure	A structure which has been specifically designed to provide additional nesting capacity for a specific species of bird(s).
Compensation	A measure which a developer is required to undertake to offset unavoidable significant adverse effects on protected species and/or habitats.
Constraint	A restriction or limitation on the search area
Criteria	A desired feature which is needed to support the success of the measure
National Site Network	The protected sites already designated under the Nature Directives, and any further sites designated under the Habitats Regulations. Previously known as Natura 2000 sites.

1 Introduction

1.1 Overview

This Briefing Note has been prepared ahead of a planned workshop on 12th December 2025 to provide details of the proposed study area and specific criteria to be used for the identification of potential search areas for one or more artificial nesting structures (offANS) for auk species.

ANS are being promoted as compensatory measures for various seabird species to offset the impact from the construction and operation of offshore wind farms (OWFs); however, the primary focus to date has been in regard to impacts to kittiwake in English waters.

Where it has been proposed to co-locate nesting sites for auk species on these offANS, the site selection criteria for the location of any offANS has primarily relied on suitability for kittiwake (as the primary target for the compensation measure). As such, the current locations being proposed for offANSs may not fully align with the most advantageous locations for auk species, potentially reducing the efficacy of this measure for compensation of impacts to these species.

Therefore, OWIC have contracted Collaborative Environmental Advisors (CEA) to undertake a study to identify potential search areas for an auk offANS, based on species/group specific suitability criteria. Whilst the term "auks" can cover a range of species, those which have been identified as possibly requiring compensation in current OWF applications (and consequently the focus of this workstream) are:

- Guillemot (*Uria aalge*); and
- Razorbill (*Alca torda*).

1.2 Purpose of the Note and Workshop

The note is being shared with the Strategic Compensation Studies Project Advisory Group (PAG) and other relevant stakeholders ahead of the planned workshop on the 12th December 2025 to support early agreement on the criteria used.

The criteria described herein are those considered to be the key criteria which will be applied during the Geographical Information System (GIS) mapping exercise. Additional criteria may be identified and included within the final appraisal, either in response to consultation with the workshop stakeholders or through further discussions by the project team. The detail for scoring criteria is presented within Annex 1 of this document. The scoring values provided are subject to change following discussions with key stakeholders (to include the SCS PAG) and initial GIS evaluation.

The targeted outcomes of the workshop are:

- Agreement on the study area for the offANS site selection (and confirmation from NatureScot, Natural Resources Wales and DAERA of whether or not to include those organisations relevant jurisdictions);
- Agreement on the criteria to be used;
- Agreement on the scoring values (including on the relative weightings applied to the ornithological criteria); and
- Agreement on the approach to refinement of the search areas.

1.3 Holistic Site Selection Criteria

To enable any compensation measure to be successful, it is critical to ensure that the primary scoring values for any search areas are dictated by robust ecological suitability criteria. In addition, it must be demonstrated that there is connectivity to the National Site Network (NSN). Notwithstanding, it is equally important that any measure will not inadvertently conflict with the conservation objectives of any NSN site or risk negatively impacting (directly or indirectly) the population at any site (e.g. through excessive attraction of individuals away from an established colony).

To this end, a combination of hard constraints (to avoid impacts to designated sites) and other ecologically focused criteria are outlined in Section 2 below, with the ecological criteria being the primary aspects on which the scoring values will be determined. Full details of the scoring criteria are provided in Annex I.

However, there would be limited benefit to any study which simply identifies broad areas of potentially suitable locations, when in practise it is likely that many areas would be undeliverable, or pose excessively challenging engineering or consenting hurdles. Therefore, both engineering and other sea user constraints (primarily shipping, but also existing infrastructure) have been evaluated, focusing on those which should be classified as “hard” constraints.

2 Site Selection Criteria

2.1 Ornithology

2.1.1 Study Area Criteria

The scope for the site selection of an offANS for auks is UK-wide. As such, the first stage of the assessment was to consider criteria to define an appropriate study area. The logic driving the definition of the study area was based on providing a sufficiently wide area to support a robust numerical-based appraisal (i.e. capturing a wide range of other criteria), whilst only including those areas of the seas around the UK which have connectivity to existing auk colonies.

A number of options were considered for delineating the study area:

- Fixed distance (e.g. 200km from the coastline);
- Foraging range; or
- Natal dispersal range.

Of the three options above, the use of foraging ranges or dispersal ranges are more scientifically robust than a simple fixed distance as it is data-led; as such, a fixed distance was discarded as an option.

Of the remaining options, it was considered that natal dispersal was more appropriate for a study area definition, with this being better for demonstrating the extent of any connectivity to colonies (and consequently the NSN).

Whilst guillemot and razorbill have been recorded as dispersing up to 780km and 3,200km respectively from natal sites (Lyngs, 1993; Lavers *et al*., 2007), average dispersal ranges (excluding the top 5% outliers) for the two species are 246km and 315km, respectively.

Therefore, for the purposes of this work, the study area has been specified as 315km from known colonies (using the Seabird Monitoring Programme[1] records) for razorbill and guillemot (with co-location of breeding colonies being frequently recorded).

A key topic for discussion at the Workshop is to agree whether to only focus on English waters, or to include Scottish, Welsh and Northern Irish waters, noting that offANS have not been universally supported as a compensation measure due to differing availability of nesting space at key colonies.

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[1] https://jncc.gov.uk/our-work/seabird-monitoring-programme/

2.1.2 Ornithology Site Selection Criteria

To identify the most ecologically suitable location(s) for any offANS for auks, consideration has been given to habitat preferences, behaviour and prey availability for each species to determine appropriate criteria. The intention is that where each of these criteria are present in the mapping exercise, the total aggrated score will be used to create a "heatmap".

In addition to this ranking criteria, a number of "hard constraints" have been identified, to minimise competition between existing colonies and any offANS.

The key ornithology ranking criteria and constraints are detailed in Table 2.1.

Table 2.1: Ornithology Constraints Criteria

Criteria	Scoring method	Distance (if applicable)[2]
Within core foraging range (from existing colony)	Hard constraint	GU – 23.9km RA – 31.2km
Within maximum foraging range	Higher value applied within	GU – 135km RA – 191km
Overlap with prey preferred habitat	Higher value within, lower value with increased distance (using foraging ranges to categorise)	Graded buffer away from resource
Within displacement effect of existing/planned OWFs	Hard constraint within 2km, lower score closer to OWFs (out to 10km)	2km – 10km
At-sea utilisation distribution	Higher value for higher UD	Variable
Colony population	Higher score for proximity to larger populations Definition of "larger" colony to be defined regionally. Scoring may be applied as a multiplier to the foraging range parameter for the foraging range criteria	Variable
Proximity to avian predator colonies	Lower value closer to known colonies, higher value further away	Variable

[2] Note: all distances for foraging are from Woodward *et al.* (2019), excluding Fair Isle data. Where colony specific data is available, this may be appropriate to use instead, subject to agreement from the workshop attendees.

2.2 Engineering Constraints

As discussed in Section 1.3, whilst ecological suitability should drive the location of an ANS, any potential locations proposed should be deliverable. This avoids the risk of a delivery organisation or stakeholders identifying a preferred option which cannot be taken forward, or is discarded by OWF developers as impractical. As such, a number of engineering related parameters have been identified as hard constraints to refine potential search areas for an offANS. These hard constraints and other scoring constraints are set out in Table 2.2.

Table 2.2: Engineering Constraints Criteria

Criteria	Scoring method	Value
Depth	Hard constraint outside preferred range	20m – 60m
Presence of seabed features	Higher value where features absent	Sandwave fields, sandbanks, trenches
Seabed sediments	Hard constraint	Presence of rock outcroppings
Sub-surface geology	Higher value for deeper favourable sediments (e.g. deep Quaternary or Holocene sediments) Hard constraint for unfavourable geology (relevant layers too shallow) Precise scoring will be linked to water depth (due to the influence of this on foundation depth)	Variable depending on geology layers

Some engineering considerations (e.g. seabed slope, current speeds, etc.) have not used for scoring within this appraisal, as they are either too localised to be meaningfully mapped at the relevant scale for this study (e.g. slope, which can be mitigated through micrositing of a structure) or are pure design/installation aspects (e.g. current speeds).

2.3 Other Sea Users and Nature Conservation

“Other sea users” is a broad term, which for the purposes of this site selection work includes other infrastructure and shipping and navigation receptors.

The infrastructure considered herein are renewable energy installations (OWFs, tidal turbines), oil and gas (O&G) facilities (O&G platforms, well heads, manifolds), Carbon Capture and Storage (CCS) areas, aggregate licence areas and linear infrastructure including cables and pipelines. Standard buffer areas may also be applied to these features (e.g. 500m safety zones around O&G platforms).

Some of the shipping and navigation key navigational features, which form hard constraints, overlap with the infrastructure identified above. Buffer zones around the navigational features need to be respected and structures must not be located within these buffers to preserve safety of vessel operations.

Additionally, sites designated for benthic habitats or seabed features have been identified as a hard constraint which will be excluded from the study area. Other designated sites have been included in the search area, although it is noted that location of an offANS in these areas may pose consenting challenges depending on the final design and features of the site.

Scoring criteria have been proposed for activities and areas of seabed where co-existence is considered to be feasible and/or will not cause a safety hazard.

The criteria for the initial GIS exercise for other sea users are presented in Table 2.3

The datasets to be used for the study will include the most up to date publicly available versions. To future-proof the validity of this study, it would be advantageous if TCE could share any information on planned extents of future seabed leasing.

Table 2.3: Other Sea Users Constraints Criteria

Criteria	Scoring method	Value
Presence of other offshore infrastructure/ licence areas	Hard constraint	OWFs (operational and planned) O&G platforms O&G wells (active and abandoned) Licensed aggregate area (extraction) Cables (power and telecoms) Pipelines Aquaculture
Licence blocks	Higher score outside licenced blocks	O&G and CCS licence areas Aggregate Exploration and Option areas
Presence of key navigational features	Hard constraint	IMO routing measures Known routes between IMO routing measures navigational limitations (e.g. sandbanks)

Criteria	Scoring method	Value
		Pilotage areas Harbour approaches Anchorage areas
Overlap with a designated site for benthic features	Hard constraint	Sites designated for Annex I habitats
Presence of known archaeological features	Hard constraint	Known wrecks
High density commercial fishing activity	Higher score outside fishing grounds	AIS data for trawling activity
Ministry of Defence Practise and Exercise Areas	Hard constraint	Firing grounds

3 Site Selection Next Steps

Following the Workshop, meeting minutes will be circulated within one week. Attendees will be requested to provide comment on the minutes within two (2) weeks, excluding an expected close down period over the Christmas and New Year period. Comments on meeting minutes are anticipated to relate to minor clarifications, with clear agreement reached during the Workshop to enable mapping to commence immediately.

The initial heatmaps of ecological suitability and engineering constraints based on the agreed scoring criteria will be reviewed to ensure they are providing sufficient gradation of results to identify areas of high potential (i.e. not producing homogenous areas of search). This may require adjusting scoring to bring out important characteristics or rebalancing against other key factors including engineering constructions. Any subsequent amendment to the scoring criteria will be clearly set out in the final report.

Where required, the outputs of the heatmapping may also be reviewed qualitiatively to provide more nuanced identification of suitable areas of search. This may be particularly relevant to engineering criteria where a combination of factors need to be considered that may not be easily quanitified in the heatmapping process.

Once final areas of search for auks offANS are identified, these will be compared against the heatmap for kittiwake (Niras, 2023), to identify potential areas for co-location. It is noted that the study area for the kittiwake offANS was limited to the southern North Sea and data outside this area is not currently available for kittiwake suitability.

The final report will provide full details of the site selection methodology, study area, criteria and scoring, as well as providing a narrative description of the identified areas of search.

4 Summary

This document has been developed to set out the proposed initial criteria to be used for the auk offANS site selection work, for dissemination to workshop attendees ahead of the workshop planned for the 12th December. This document is intended to provide information to facilitate discussion and reach agreement on the criteria to be used for the apprisal.

The site selection will be driven by ecological criteria to ensure any search areas are positioned in the most favourable location to support auk colonisation. To support further development, a high-level consideration will also be given the feasibility of installation of a structure, using input from engineering and shipping and navigational experts. This will provide initial refinement to the search areas to focus on those which are developable.

Annex 1 – Proposed Scoring Criteria

Criteria	Layer classification	Source	Score
Ecological Ornithology Criteria			
Overlap with foraging ranges from known colonies	Within core (mean) foraging range	Woodward *et al.* 2019	0 (hard constraint)
	Within mean-max foraging range		1.5
	Within maximum foraging range		1
Overlap with prey preferred habitat - sandeel	Within sandeel spawning grounds or sandeel hotspots	Coull *et al.* (1998); Ellis *et al.* (2010); Jensen *et al.* (2011); Langton *et al.* (2021); Kyle-Henney *et al.* (2024)	2
	Within mean foraging range of sandeel spawning grounds/ hotspots		1.5
	Within mean-max foraging range of sandeel spawning grounds/ hotspots		1.25
	Within maximum foraging range of sandeel spawning grounds/ hotspots		1
Overlap with prey preferred habitat - clupeids	Within herring and sprat spawning grounds or hotspots	Coull *et al.* (1998); Ellis *et al.* (2010); Reach *et al.* (2024)	2
	Within mean foraging range of herring and sprat spawning grounds/hotspots		1.5
	Within mean-max foraging range of herring and sprat spawning grounds/hotspots		1.25

Criteria	Layer classification	Source	Score
	Within maximum foraging range of herring and sprat spawning grounds/hotspots		1
Within displacement effect of existing/planned OWFs	Within 2km of OWF	TCE	0 (hard constraint)
	Within 5km of OWF		0.2
	Within 10km of OWF		0.5
	Outside 10km of OWF		1
At-sea utilisation distribution	Within >50% UD contour	Cleasby *et al.* (2020)	2
	Within 10 – 50% UD contour		1
	Within <10% UD contour		0.8
Colony population - Multiplier to criteria "Overlap with foraging ranges from known colonies", based on the relative colony sizes for regions of the UK	Colony population >75% of regional maximum	SMP data (JNCC, 2025)	1.5
	Colony population 25 – 75% of regional maximum		1
	Colony population <25% of regional maximum		0.5
Proximity to avian predator colonies	Within core foraging range for avian predator	SMP data (JNCC, 2025), Woodward *et al.* (2019)	0.1
	Within mean-max foraging range for avian predator		0.5
	Outside mean-max foraging range for avian predator		1
Engineering Criteria			
Water depth	Less than 20m depth	EMODnet DTM bathymetry	0 (hard constraint)

Criteria	Layer classification	Source	Score
	20m – 40m depth		1
	40m – 60m depth		0.8
	Greater than 60m depth		0 (hard constraint)
Presence of seabed features (sandwaves, sandbanks, trenches)	Seabed features absent	JNCC, BGS	1
	Seabed features present		0.5
Seabed sediments – presence of rock outcroppings	Outcroppings absent	BGS	1
	Outcroppings present		0 (hard constraint)
Sub-surface geology	Depth of relevant geology layers, e.g. deep Quaternary or Holocene sediments	BGS	The precise scoring of this criteria will be subject to water depths, water currents and seabed surface sediments, all of which combine with sub-surface geology to influence the foundation options available. Final scoring will be applied through expert judgement.
Proximity to port facility for maintenance access	Relevance of inclusion of this criterion to be discussed, as distances to be used (based on possible vessel types which could be used) would be linked to responsible party for maintenance and possible coordination of maintenance activities with OWF (i.e. feasible distances would vary depending on whether the responsible party was an independent MRF operator, or if a developer with a proximal OWF was responsible).		
Other sea users			
Presence of other offshore infrastructure/licence areas	Within boundary of rights area for other sea users (and relevant buffer)	TCE, CES	0 (hard constraint)

Criteria	Layer classification	Source	Score
	Outside boundary of rights area for other sea users (and relevant buffer)		1
Licence blocks	Within boundary of a (non-exclusive) licence area	NSTA	0.5
	Outside boundary of a (non-exclusive) licence area		1
Presence of key navigational features (IMO routing measures, harbour approaches, pilotage, etc.)	Overlap with key navigational feature and buffer	UKHO	0 (hard constraint)
	Outside buffers around key navigational features		1
Overlap with a designated site for benthic features	Overlap with designated site for Annex I benthic habitats	JNCC, NE	0 (hard constraint)
	Outside designated site for Annex I benthic habitats		1
Presence of known archaeological features	Overlap with known archaeological features and buffer	UKHO, HE	0 (hard constraint)
	Outside buffer around known archaeolgical feature		1
High density commercial fishing activity	>75% of maximum fishing density	MMO, EMODnet	0.5
	25 – 75% of maximum fishing density		1
	<25% of maximum fishing density		1.5
Ministry of Defence Practise and Exercise Areas	Overlap with PEXA for live firing	Admiralty	0 (hard constraint)
	Outside PEXA for live firing		1

Annex III – Foundation considerations

Monopile

Monopiles are one of the best foundation solutions for offANS structures. This is because monopile foundations allow for simpler structures without the need for more expensive jackets and are often the foundation of choice for OWFs.

The widespread adoption of monopiles within the offshore wind industry for shallow water depths has provided extensive experience with their design, installation and in-service performance as foundations for marine structures. The largest monopile foundations considered feasible has increased in size since the advent of the offshore wind industry to keep up with increases in turbine size. Monopiles greater than 10m in diameter are now being proposed in water depths of approximately 50m, however towards this water depth monopiles are less likely to be the optimal foundation solution. As the water depth increases and results in increasing monopile foundation size, jacket structures and eventually floating structures as water depths further increase become the more economical options.

Monopile sizing can be more heavily influenced by surface soil layers than jacket piles might be even though the monopile penetration depth would usually be greater. Scour therefore requires careful consideration in the design of a monopile.

The most common installation method for monopiles is to drive them to the required penetration depth. Should premature pile refusal be highlighted as a concern during the driveability assessment, mitigation measures involving drilling can be used to ensure piles can be installed to depth.

Piling noise requires careful consideration for both monopile designs and driven pile supported jacket designs. Limitations on piling noise should be considered during the environmental impact assessment and consenting stages of the projects and limitations will likely vary from site to site. Note-consideration of piling noise has not been considered further in this study.

Piled Jacket Structure

Piled jacket structures are likely to be the most economical foundation type for sites with ground conditions suitable for installation of driven piles and water depths between 50 to 80m. Since the tubular members of the jacket and founding piles are of smaller diameter and wall thickness than monopiles there is a larger number of fabricators able to fabricate the structures and there will be a larger number of installation vessels with crane height and capacity to handle the jacket structures than a long monopile. This reduces the risk associated with over-reliance on a single contractor.

Where shallow rock exists, it is essential to ensure that the piles are dimensioned appropriately to reduce the amount of driving through rock to the minimum possible while still achieving the required pile capacity. There is also the option of having two piles at each leg to reduce the required pile penetration depth to shallower than the depth of rockhead. Jacket proportioning in particular base area can be used to reduce the demand on the foundations and associated pile length. The assessment of driving resistance in rock will also be of major importance for sites with shallow rock.

The options for mitigating the possibility for driven pile refusal are the same as those discussed above for monopiles. Consideration of the potential for drilling to reduce end bearing will be more critical for jacket piles than for monopiles. If driven piles cannot be installed, the jacket structure would need to be supported by another foundation type, most likely drilled and grouted piles. The installation process for drilled and grouted piles is however much slower than for driven piles and involves multiple stages and therefore results in a more expensive foundation solution.

'Monobucket' Suction Caissons and Suction Caisson Jackets

Suction caissons (both monobucket and jackets) have the advantage of not requiring a piling spread for installation and being a 'silent' foundation to install. Suction caissons are designed as large diameter steel tubes which are sealed at the top and open ended at the toe. Initial penetration of the suction caisson into the seabed is achieved by self-weight which is required to create a seal between the caisson and the seabed. This seal allows an under pressure to be developed by pumping out the water from within the suction caisson which drives the caisson to final penetration depth.

Gravity-Base Structure

There is potential to use gravity base foundations for the offANS structure in water depths up to 60m, but the size of the required footprint may become prohibitively large if scaled up versions of current technology are used.

Installation of gravity-based foundations can be a relatively slow and expensive process when compared to monopiles, jacket piles or suction caissons. The most appropriate use of gravity-based foundations is for locations where shallow rock of significant strength exists. This prevents other foundation types being practical with the exception of drilled and grouted piles which also involve a slow multistage installation process.

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