Department for
Business, Energy
& Industrial Strategy

Offshore Carbon Dioxide Storage Licensing Round

Habitats Regulations Assessment Stage 1 – Site Screening

November 2022

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Contents

1 Introduction

1.1 Background and overview of plan

The North Sea Transition Authority (NSTA) launched a carbon storage licensing round (also termed the 1st carbon dioxide storage licensing round) on 14th June 2022 and invited applications for a number of offshore areas in the northern North Sea, central North Sea, southern North Sea and east Irish Sea. The licensing round closed on 13th September 2022.

The plan/programme covering this carbon storage licensing round has been subject to a Strategic Environmental Assessment (OESEA3), completed in July 2016. The SEA Environmental Report includes detailed consideration of the status of the natural environment and potential effects of the range of activities which could follow licensing, including potential effects on conservation sites. The SEA Environmental Report was subject to public consultation following which a post-consultation report was produced which summarised the comments received and provided further clarifications which has enabled the decision to adopt the plan/programme. BEIS (2018) documents a review of the OESEA3 Environmental Report undertaken to assess the continued currency of the SEA information base, its conclusions and recommendations and suitability to underpin continued leasing and licensing in relevant UK waters. The most recent SEA (OESEA4) undertaken in 2022 also covered future licensing for offshore carbon dioxide storage. Public consultation on OESEA4 concluded on 27th May 2022 and the Government Response was published in September 2022.

The *Energy Act 2008* (the Act) established a licensing regime for the storage of carbon dioxide in a controlled place including areas within UK territorial seas, and in areas beyond those waters which have been designated as the Exclusive Economic Zone (EEZ), formerly the Gas Importation and Storage Zone (GISZ). The Act prohibits the storage of carbon dioxide (with a view to its permanent disposal) except in accordance with a licence granted under the Act. The NSTA is the licensing authority responsible for granting licences and storage permits. In addition to a licence, a lease from The Crown Estate is required for carbon dioxide storage related activities. Following the grant of any lease/licence, offshore activities are subject to a range of statutory permitting and consenting requirements.

The *Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001* (as amended) implement the requirements of Articles 6(3) and 6(4) of the Habitats Directive with respect to carbon dioxide storage activities in UK territorial waters and on the UK Continental Shelf[1]. The *Conservation of Offshore Marine Habitats and Species Regulations 2017* cover other relevant activities in offshore waters (i.e. excluding territorial waters). Within territorial waters, the Habitats Directive was transposed into UK law via the *Conservation of Habitats and Species Regulations 2017* in England and Wales, the *Conservation (Natural Habitats, &c.) Regulations 1994* in Scotland (for non-reserved matters), and the *Conservation (Natural Habitats, &c) Regulations (Northern Ireland) 1995* (as amended) in Northern Ireland.

[1] A range of environmental legislation applicable for offshore oil and gas has been extended to carbon dioxide storage under the *Energy Act 2008 (Consequential Modifications) (Offshore Environmental Protection) Order 2010*, which includes the *Offshore Petroleum Activities (Conservation of Habitat) Regulations 2001.*

1.2 Purpose

As the carbon storage licensing aspects of the plan/programme are not directly connected with or necessary for nature conservation management of Special Protected Areas (SPAs) and Special areas of Conservation (SACs), to comply with its obligations under the relevant regulations, the Department for Business, Energy and Industrial Strategy[2] (the Department) is undertaking a Habitats Regulations Assessment (HRA).

In this HRA, the Department has applied the Habitats Directive test[3] (elucidated by the European Court of Justice in the case of Waddenzee (Case C-127/02)[4]) which is:

> *…any plan or project not directly connected with or necessary to the management of the site is to be subject to an appropriate assessment of its implications for the site in view of the site's conservation objectives if it cannot be excluded, on the basis of objective information, that it will have a significant effect on that site, either individually or in combination with other plans or projects.*
>
> *…where a plan or project not directly connected with or necessary to the management of a site is likely to undermine the site's conservation objectives, it must be considered likely to have a significant effect on that site. The assessment of that risk must be made in the light inter alia of the characteristics and specific environmental conditions of the site concerned by such a plan or project.*

1.3 Approach to screening

This screening assessment is the first stage of the HRA to determine whether licensing of any of the areas offered for carbon dioxide storage may have a significant effect on a relevant site, either individually or in combination[5] with other plans or projects. The screening assessment has been undertaken in accordance with European Commission Guidance (EC 2019) and with reference to other guidance and reports, including the Habitats Regulations Guidance Notes (English Nature 1997, Defra 2012, SEERAD 2000), SNH (2015), the National Planning Policy Framework (MHCLG 2021[6]), the Marine Policy Statement (HM Government 2011), English Nature report, No. 704 (Hoskin & Tyldesley 2006) and Natural England report NECR205 (Chapman & Tyldesley 2016).

The approach taken to screening has been to identify all relevant sites with the potential to be affected by activities that could follow licensing (i.e. those sites with marine qualifying features

[2] Note that while certain licensing and related regulatory functions were passed to the NSTA (a government company wholly owned by the Secretary of State for BEIS) on 1 October 2016, environmental regulatory functions are retained by the Department, and are administered by the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED).
[3] See Article 6(3) of the Habitats Directive.
[4] Also see the Advocate General's Opinion in the recent 'Sweetman' case (Case C-258/11), which confirms those principles set out in the Waddenzee judgement.
[5] Note that "in-combination" and "cumulative" effects have similar meanings, but for the purposes of HRA, and in keeping with the wording of Article 6(3) of the Habitats Directive, "in-combination" is used to describe the potential for such effects throughout. More information on the definitions of "cumulative" and "in-combination" effects are available in MMO (2014a) and Judd *et al.* (2015).
[6] Which states that "listed or proposed Ramsar sites", should receive the same protection as national network sites.

or with a marine ecological linkage such as anadromous and catadromous fish) (see Section 3). These sites are screened for the likelihood of significant effects based on the nature and scale of potential activities (as outlined in Section 2). Consideration is also given as appropriate to the site-specific advice on operations. For the purposes of assessment, the screening assumes that any activity which could follow licensing is undertaken in the absence of mitigation. This approach is consistent with recent judgements of the European Court of Justice[7] and the UK High Court[8], on where within the HRA process mitigation can be taken into account.

Those carbon dioxide storage licence areas on offer which are screened in will be subject to a second stage of HRA, Appropriate Assessment (AA), if applied for and before licence award decisions are taken. The areas applied for may be smaller than those offered such that the conclusions of this screening will be subject to review following the close of the round. It should be noted that should a licence award be made, any activities that may follow licensing will be subject to activity-specific assessment and where necessary, an HRA.

This screening assessment report is organised as follows:

- Overview of the plan, including a list and map of the areas offered, summary of the licensing process and nature of the activities that could follow (see Section 2)

- Identification of all sites potentially affected, together with their various interest features (Section 3 and Appendix A)

- Description of the screening assessment process used to identify likely significant effects on relevant sites (Section 4)

- The screening assessment including a consideration of in-combination effects (Section 5)

- Summary of conclusions including a list of areas from which likely significant effects on relevant national site network could not be discounted at the screening stage and for which further assessment (AA) is required before a licence award decision can be made (Section 6 and Appendix B)

A draft of this HRA screening assessment was subject to consultation with the SNCBs and has been amended as appropriate in light of comments received.

[7] People Over Wind and Sweetman vs. Coillte Teoranta C-323/17 (http://curia.europa.eu/juris/document/document.jsf?docid=200970&doclang=EN), clarified in Grace and Sweetman vs. An Bord Pleanala C-164/17 (http://curia.europa.eu/juris/document/document.jsf;jsessionid=F3195E5E6EE57FFD1D414A11FDD5E35E?text=&docid=204392&pageIndex=0&doclang=EN&mode=lst&dir=&occ=first&part=1&cid=4768745)
[8] Gladman Developments Ltd. vs. Secretary of State for Housing, Communities and Local Government and Medway Council (https://www.bailii.org/ew/cases/EWHC/Admin/2019/2001.html)

2 Areas offered and potential activities

2.1 Areas offered

Areas offered in the 1st carbon storage licensing round and considered in this screening assessment are shown on Figure 2.1. The areas are located in the central and northern North Sea, the southern North Sea and east Irish Sea.

2.2 Licensing

Chapter 3 of the *Energy Act 2008* (as amended) makes provision for a licensing and enforcement regime for the storage of carbon dioxide in a controlled place. Licensing regulations made under the Act include *The Storage of Carbon Dioxide (Licensing etc.) Regulations 2010 (as amended)* which sets out requirements for making licence applications. A carbon dioxide storage licence grants exclusive rights for the exploration and appraisal of potential storage sites in the territorial sea adjacent to the United Kingdom (with the exception of Scottish Territorial Seas) and on the UK Exclusive Economic Zone (EEZ), before making an application for a storage permit. The area of a Carbon Dioxide Storage Licence reflects the potential size of the storage site that is being subject to appraisal, however, as part of this licensing round, applications for licences may cover all or part of the areas offered, but not extent beyond these, and more than one licence application may be received for the areas offered. A Licence grants exclusive rights to the holders to undertaken exploration and appraisal activities with a view to evaluate the potential for carbon dioxide storage, but it does not constitute any form of approval for activities to take place in the licence area, nor does it confer any exemption from other legal or regulatory requirements. Offshore activities are subject to a range of statutory permitting and consenting requirements, including, where relevant, activity-specific AA under the Habitats Regulations.

Carbon dioxide storage licences contain three terms covering exploration and appraisal (Appraisal or Initial Term[9]), operation, and post-closure. The appraisal term (see overleaf for summary of the four stages) includes a work programme which may cover the drilling of appraisal wells, seismic survey, and other work such as geotechnical and geophysical studies. Where applicants do not wish to undertake appraisal and proceed to applying for a storage permit, reasons why exploration or appraisal is not required must be provided by the applicant; in this circumstance this phase of the licence is called the Initial term. Due to the early nature of the industry it is expected that all licences will have an appraisal term.

The length of the initial/appraisal term is not defined in regulations other than it is not to exceed "*…the period necessary to (a) generate the information necessary to select a storage site, and (b) prepare the documents required for an application under regulation 6*" (storage permit); recent applications have had appraisal terms of between four and eight years. The initial/appraisal term may be extended under conditions laid down in the licence[10], but will

[9] The name 'appraisal term' applies where there is a work programme in place, when there is no such work programme it is termed the 'initial term'. This HRA screening covers both appraisal or initial terms.
[10]

expire if no permit application is made to NSTA by the date of its expiry or if a permit application is refused.

The NSTA will generally divide the Appraisal term into four stages with associated work programme activities and a formal stewardship engagement process. These are:

- Early Risk Assessment (identification of the critical risks, project and engagement plan)
- Site Characterisation (definition of the proposed Storage Site and Complex, geophysical surveys)
- Assess (initial storage development planning, including of the development drilling, construction & commissioning, where applicable)
- Define (Storage Permit Application submission)

Financial viability is considered prior to licence award. The applicant must demonstrate that it has the technical competence to carry out the activities that could be permitted under the licence, and the financial capacity to complete the work programme, before the licence is granted.

2.3 Activity

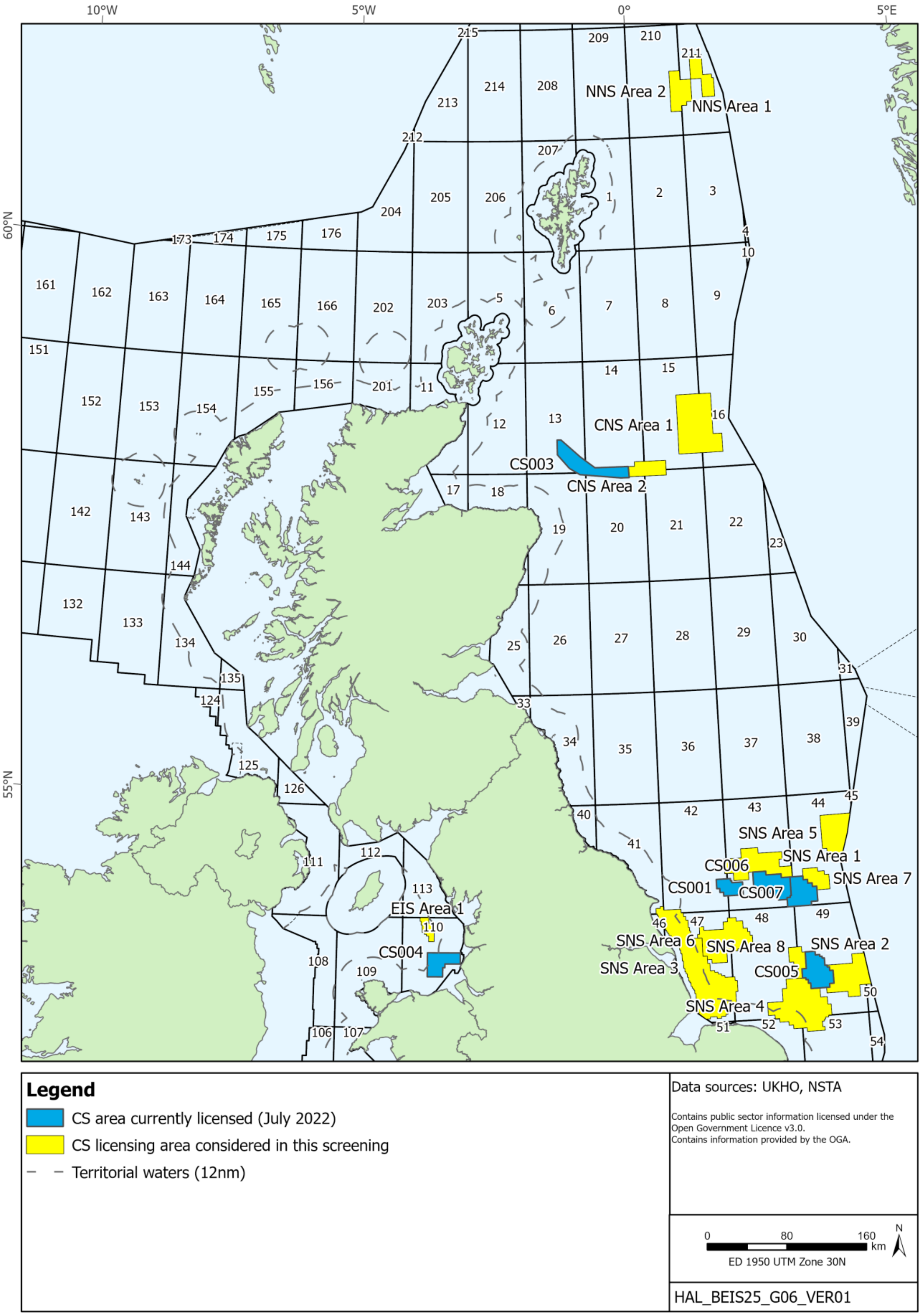
As part of the licence application process, applicants provide the NSTA with details of work programmes they propose in the Appraisal/Initial Term. These work programmes are considered along with a range of other factors by the NSTA before arriving at a decision on whether to license the area. There are two levels commitment in the work programme, though elements of the work programme would usually be firm commitments:

- A Firm Commitment is a commitment to the NSTA to perform an element of the work programme. The fact that a licensee has been awarded a licence on the basis of a “firm commitment” to undertake a specific activity should not be taken as meaning that the licensee will actually be able to carry out that activity. This will depend upon the outcome of all relevant activity-specific environmental assessments. Failure to carry out firm commitments may result on the licence being revoked.
- A Contingent Commitment is also a commitment to the NSTA to perform an element of the work programme, but a licensee may seek NSTA’s agreement no later than three months before the deadline, that the commitment is no longer required by setting out the rationale in writing.

Offshore activities (see Table 2.1) such as seismic survey or drilling are subject to relevant activity-specific environmental assessments by the Department, and there are other regulatory provisions exercised by other Regulatory bodies such as the Health and Safety Executive. It is the licensee’s responsibility to be aware of, and comply with, all regulatory controls and legal requirements, and work offshore cannot proceed until the relevant consents/approvals are in place.

The proposed work programmes for the appraisal term are detailed in the licence applications. For some activities, such as seismic survey, the potential impacts associated with noise could occur some distance from the areas applied for and the degree of activity is not necessarily proportional to the size of the area. In the case of direct physical disturbance, the area being applied for is relevant.

Figure 2.1: Location of areas offered in the context of existing carbon storage licences



2.3.1 Likely scale of activity

This assessment has been undertaken at the stage at which areas are offered for licensing. This is the first carbon dioxide storage licensing round and it is therefore not possible to gauge the potential level of interest in the areas offered or the potential of any of the areas to proceed to the permit application stage.

Licensees that fulfil the Appraisal/Initial Terms and progress to applying for storage permit may require further drilling, installation of infrastructure such as wellheads, pipelines and possibly fixed platform injection facilities. The nature and scale of potential environmental impacts from the drilling of injection wells are similar to those of exploration and appraisal wells and thus the screening criteria described in Section 4 are applicable to the potential effects of development well drilling within any of the areas offered.

2.3.2 Carbon storage appraisal activities considered by the HRA

The nature, extent and timescale of development, if any, which may ultimately result from the licensing of the areas is uncertain, and therefore it is regarded that at this stage a meaningful assessment of development level activity (e.g. pipelay, placement of jackets, subsea templates) cannot be made. Once project plans are in place, subsequent permitting processes relating to appraisal, operation and decommissioning/post-closure, would require assessment including HRA where appropriate, allowing the opportunity for further mitigation measures to be identified as necessary, and for permits to be refused if necessary. In this way the opinion of the Advocate General in ECJ (European Court of Justice) case C-6/04, on the effects on Natura sites, "*must be assessed at every relevant stage of the procedure to the extent possible on the basis of the precision of the plan. This assessment is to be updated with increasing specificity in subsequent stages of the procedure*" is addressed. Therefore, only activities as part of the work programmes associated with the appraisal term will be considered in this HRA (see Table 2.1).

For the purposes of this screening assessment, the implications of geophysical survey and drilling are considered in a generic way for all the areas offered; a generic description of the nature and scale of these activities is given in Table 2.1 below. As there are very few offshore carbon dioxide appraisal examples, Table 2.1 draws heavily on experience from oil & gas activities which are considered useful proxies for the potential activities that could take place during the appraisal term. The screening assessment considers:

- The potential physical disturbance and drilling effects associated with the drilling of an exploration or appraisal well within the areas offered.

- The potential underwater noise effects associated with undertaking a seismic survey within each of the areas offered (as well as undertaking site-specific seismic operations including rig site survey and Vertical Seismic Profiling).

- The potential for in-combination effects.

Subsequent AA of carbon dioxide storage licence areas applied for, for which a likely significant effect cannot currently be excluded, will consider an approach based on the maximum likely work programme associated with the appraisal term.

Table 2.1: Indicative overview of potential activities that could arise from the appraisal term

Potential activity	Description	Assumptions used for assessment
Geophysical survey		
Seismic (2D and 3D) survey	2D seismic involves a survey vessel with an airgun array and a towed hydrophone streamer (up to 12 km long), containing several hydrophones along its length. The reflections from the subsurface strata provide an image in two dimensions (horizontal and vertical). Repeated parallel lines are typically run at intervals of several kilometres (minimum *ca*. 0.5km) and a second set of lines at right angles to the first to form a grid pattern. This allows imaging and interpretation of geological structures and identification of potential geological structures suitable for carbon dioxide storage. 3D seismic survey is similar but uses several hydrophone streamers towed by the survey vessel. Thus closely spaced 2D lines (typically between 25 and 75m apart) can be achieved by a single sail line.	These deep-geological surveys tend to cover large areas (300-3,000km^2) and may take from several days up to several weeks to complete. Typically, large airgun arrays are employed with 12-48 airguns and a total array volume of 3,000-8,000 in^3. From available information across the UKCS, arrays used on 2D and 3D seismic surveys produce most energy at frequencies below 200Hz, typically peaking at 100Hz, and with a peak broadband source level of around 256dB re 1μPa @ 1m (Stone 2015). While higher frequency noise will also be produced which is considerably higher than background levels, these elements will rapidly attenuate with distance from source; it is the components <1,000Hz which propagate most widely.
Rig site survey	Rig site surveys are undertaken to identify seabed and subsurface hazards to drilling, such as wrecks and the presence of shallow gas. The surveys use a range of techniques, including multibeam and side scan sonar, sub-bottom profiler, magnetometer and high-resolution seismic involving a much smaller source (mini-gun or four airgun cluster of 160 in^3) and a much shorter hydrophone streamer. Arrays used on site surveys and some Vertical Seismic Profiling (VSP) operations (see below) typically produce frequencies predominantly up to around 250Hz, with a peak source level of around 235dB re 1μPa @ 1m (Stone 2015).	A rig site survey typically covers 2-3km^2. The rig site survey vessel may also be used to characterise seabed habitats, biota and background contamination. Survey durations are usually of the order of four or five days.
Drilling and well evaluation		
Rig tow out & de-mobilisation	Mobile rigs are towed to and from the well site typically by 2-3 anchor handling vessels.	The physical presence of a rig and related tugs during tow in/out is both short (a number of days depending on initial location of rig) and transient.
Rig placement/ anchoring	Semi-submersible rigs are used in deeper waters (normally >120m). Mooring is achieved using either anchors (deployed and recovered by anchor handler vessels) or dynamic positioning (DP) to manoeuvre into and stay in position over the well location. Eight to 12 anchors attached to the rig by cable or chain are deployed radially from the rig; part of the anchoring hold is provided by a proportion of the cables or chains lying on the seabed (catenary).	Semi-submersible rig anchors (if used) may extend out to a radius of 1.5-1.8km in North Sea waters of the UK. An ES for an exploration well in Block 18/05 in *ca*. 90m water depth estimated that the area of seabed affected by anchoring was *ca*. 0.01km^2 (Apache North Sea Limited 2006), and in deeper waters the seabed footprint may be in the order of 0.06km^2.

Potential activity	Description	Assumptions used for assessment
	Jack-up rigs are used in shallower waters (normally <120m) and jacking the rig legs to the seabed supports the drilling deck. Each of the rig legs terminates in a spud-can (base plate) to prevent excessive sinking into the seabed. Unlike semi-submersible rigs, jack-up rigs do not require anchors to maintain station, and these are not typically deployed for exploration activities, with positioning achieved using several tugs, with station being maintained by contact of the rig spudcans with the seabed. Anchors may be deployed to achieve precision siting over fixed installations or manifolds at injection facilities, which are not considered in this assessment.	It is assumed that jack-up rigs will be three or four-legged rigs with 20m diameter spudcans with an approximate seabed footprint of 0.001km^2 within a radius of *ca*. 50m of the rig centre. For the assessment it is assumed that effects may occur within 500m of a jack-up rig which would take account of any additional rig stabilisation (rock placement) footprint. A short review of 18 Environmental Statements[11], which included drilling operations in the southern North Sea since 2007 (specifically in quadrants 42, 43, 44, 47, 48, 49 and 53) indicated that rig stabilisation was either not considered necessary and/or assessed as a worst-case contingency option. Where figures were presented, the spatial scale of potential rock placement operations was estimated at between 0.001-0.004km^2 per rig siting.
Marine discharges	Typically around 1,000 tonnes of cuttings (primarily rock chippings) result from drilling an exploration well. Water-based mud cuttings are typically discharged at, or relatively close to sea surface during "closed drilling" (i.e. when steel casing in the well bore and a riser to the rig are in place), whereas surface hole cuttings are normally discharged at seabed during "open-hole" drilling. Use of oil based mud systems, for example in highly deviated sections or in drilling water reactive shales, would require onshore disposal or treatment offshore to the required standards prior to discharge.	The distance from source within which smothering or other effects may be considered possible is generally a few hundred metres. For the assessment it is assumed that effects may occur within 500m of the well location covering an area in the order of 0.8km^2 (refer to Section 4.2 for supporting information).
Conductor piling	Well surface holes are usually drilled "open-hole" with the conductor subsequently inserted and cemented in place to provide a stable hole through which the lower well sections are drilled. Where the nature of the seabed sediment and shallow geological formations are such that they would not support a stable open-hole (i.e. risking collapse), the conductor may be driven into the sediments. In North Sea exploration wells, the diameter of the conductor pipe is usually 26" or 30" (<1m), which is considerably smaller than the monopiles used for offshore wind farm foundations (>3.5m diameter), and therefore require less hammer energy and generate noise of a considerably lower amplitude. For example, hammer energies to set conductor pipes are in the order of 90-270kJ (see: Matthews 2014, Intermoor website), compared to energies of up to 3,000kJ in the installation of piles at some southern North Sea offshore wind farm sites.	The need to pile conductors is well-specific and is not routine. It is anticipated that a conductor piling event would last between 4-6 hours, during which time impulses sound would be generated primarily in the range of 100-1,000Hz, with each impulse of a sound pressure level of approximately 150dB re 1μPa at 500m from the source.

[11] Note that this review was of oil and gas wells. Approaches to rig placement for carbon dioxide appraisal would be the same.

Potential activity	Description	Assumptions used for assessment
	Direct measurements of underwater sound generated during conductor piling are limited. Jiang *et al.* (2015) monitored conductor piling operations at a jack-up rig in the central North Sea in 48m water depth and found peak sound pressure levels (L_{pk}) not to exceed 156dB re 1 µPa at 750m (the closest measurement to source) and declining with distance. Peak frequency was around 200Hz, dropping off rapidly above 1kHz; hammering was undertaken at a stable power level of 85 ±5 kJ but the pile diameter was not specified (Jiang *et al.* 2015). MacGillivray (2018) reported underwater noise measurements during the piling of six 26" conductors at a platform, six miles offshore of southern California in 365m water depth. After initially penetrating the seabed under its own weight, each conductor was driven approximately 40m further into the seabed (silty-clay and clayey-silt) with hammer energies that increased from 31 ±7 kJ per strike at the start of driving to 59 ±7 kJ per strike. Between 2.5-3 hours of active piling was required per conductor. Sound levels were recorded by fixed hydrophones positioned at distances of 10-1,475m from the source and in water depths of 20-370m, and by a vessel-towed hydrophone. The majority of sound energy was between 100-1,000Hz, with peak sound levels around 400Hz. Broadband sound pressure levels recorded at 10m from source and 25m water depth were between 180-190dB re 1µPa (SEL = 173-176dB re 1µPa·s), reducing to 149-155dB re 1µPa at 400m from source and 20m water depth (SEL = 143-147dB re 1µPa·s).	
Rig/vessel presence and movement	On site, the rig is supported by supply and standby vessels, and helicopters are used for personnel transfer.	Supply vessels typically make 2-3 supply trips per week between rig and shore. Helicopter trips to transfer personnel to and from the rig are typically made several times a week. A review of Environmental Statements for exploratory drilling suggests that the rig could be on location for, on average, up to 10 weeks. Support and supply vessels (50-100m in length) are expected to have broadband source levels in the range 165-180dB re 1µPa@1m, with the majority of energy below 1kHz (OSPAR 2009). Additionally, the use of thrusters for dynamic positioning has been reported to result in increased sound generation (>10dB) when compared to the same vessel in transit (Rutenko & Ushchipovskii 2015).

Potential activity	Description	Assumptions used for assessment
Well evaluation (e.g. Vertical Seismic Profiling)	Sometimes conducted to assist with well evaluation by linking rock strata encountered in drilling to seismic survey data. A seismic source (airgun array, typically with a source size around 500 in^3 and with a maximum of 1,200 in^3, Stone 2015) is deployed from the rig, and measurements are made using a series of geophones deployed inside the wellbore.	VSP surveys are of short duration (one or two days at most).

3 Relevant sites

Sites were considered for inclusion/exclusion in the screening process with respect to whether there was an impact pathway[12] between the marine features for which they are designated and potential exploration/appraisal activities which could arise following licensing (see Table 2.1). Sites considered include relevant designated SACs and SPAs and potential sites for which there is adequate information on which to base an assessment.

In accordance with the National Planning Policy Framework (MHCLG 2019), devolved policy (e.g. Scottish Planning Policy) and Marine Policy Statement (HM Government 2011), the relevant sites considered here include classified and potential SPAs[13], designated and candidate SACs, and any proposed site extensions. The full details of all sites including their type, status and qualifying features are provided in Appendix A. If further sites are established during this HRA process, they will be subject to screening and if necessary, included in subsequent AA stages. The sources of site data include the JNCC SAC and SPA summary spreadsheet (version as of 18th December 2020[14]), the NatureScot SiteLink[15] and Natural England Designated Sites View[16]. Interest features and site characteristics were filtered for their coastal and marine relevance. Any sites designated in the future would also be considered as necessary in subsequent project-specific assessments.

The sites included in the screening process cover:

- Coastal and marine sites along the coasts of the United Kingdom and in territorial waters
- Offshore sites (i.e. those largely or entirely beyond 12nm from the coast)
- Riverine sites designated for migratory fish and/or the freshwater pearl mussel
- Relevant sites in adjacent states
- Coastal Ramsar sites

A number of sites are designated for mobile species (seabirds, marine mammals and fish) which may be present beyond site boundaries. These are considered in Section 4.6. Natura 2000 sites in the waters of other states at or adjacent to the UK median line have been considered. All relevant sites are shown in Figures 3.1 to 3.6 with further site details in Appendix A.

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[12] Based on knowledge of potential sources of effect resulting from the activities (from previous BEIS AAs and SEAs), and pathways by which these effects may impact receptors present on the site (from previous BEIS AAs and SEAs, SNCB advice on operations and literature sources etc). Also refer to Section 4.2.

[13] Further consultation on proposed Special Protection Areas in Scotland is underway: https://consult.gov.scot/marine-scotland/sea-and-site-classification/. It has been recommended that the Pentland Firth pSPA be removed from the network. This site is still listed in this document while the consultation is ongoing, and any further consideration will depend on the whether or not the site is taken forward for classification by Scottish Ministers.

[14] https://hub.jncc.gov.uk/assets/a3d9da1e-dedc-4539-a574-84287636c898

[15] https://sitelink.nature.scot/home

[16] https://designatedsites.naturalengland.org.uk/

Figure 3.1: SPAs included in the screening process: northern and central North Sea

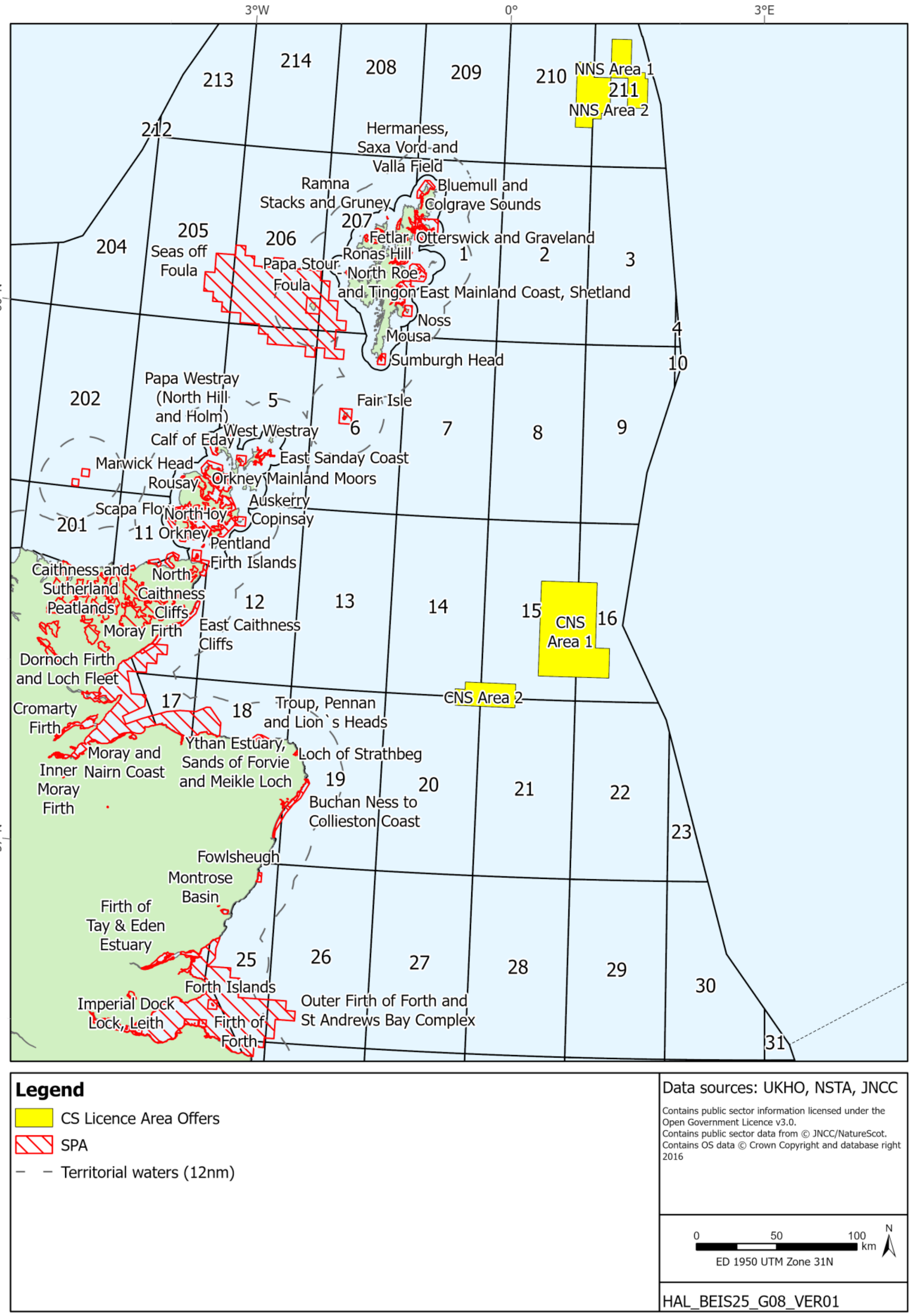


Figure 3.2: SPAs included in the screening process: southern North Sea

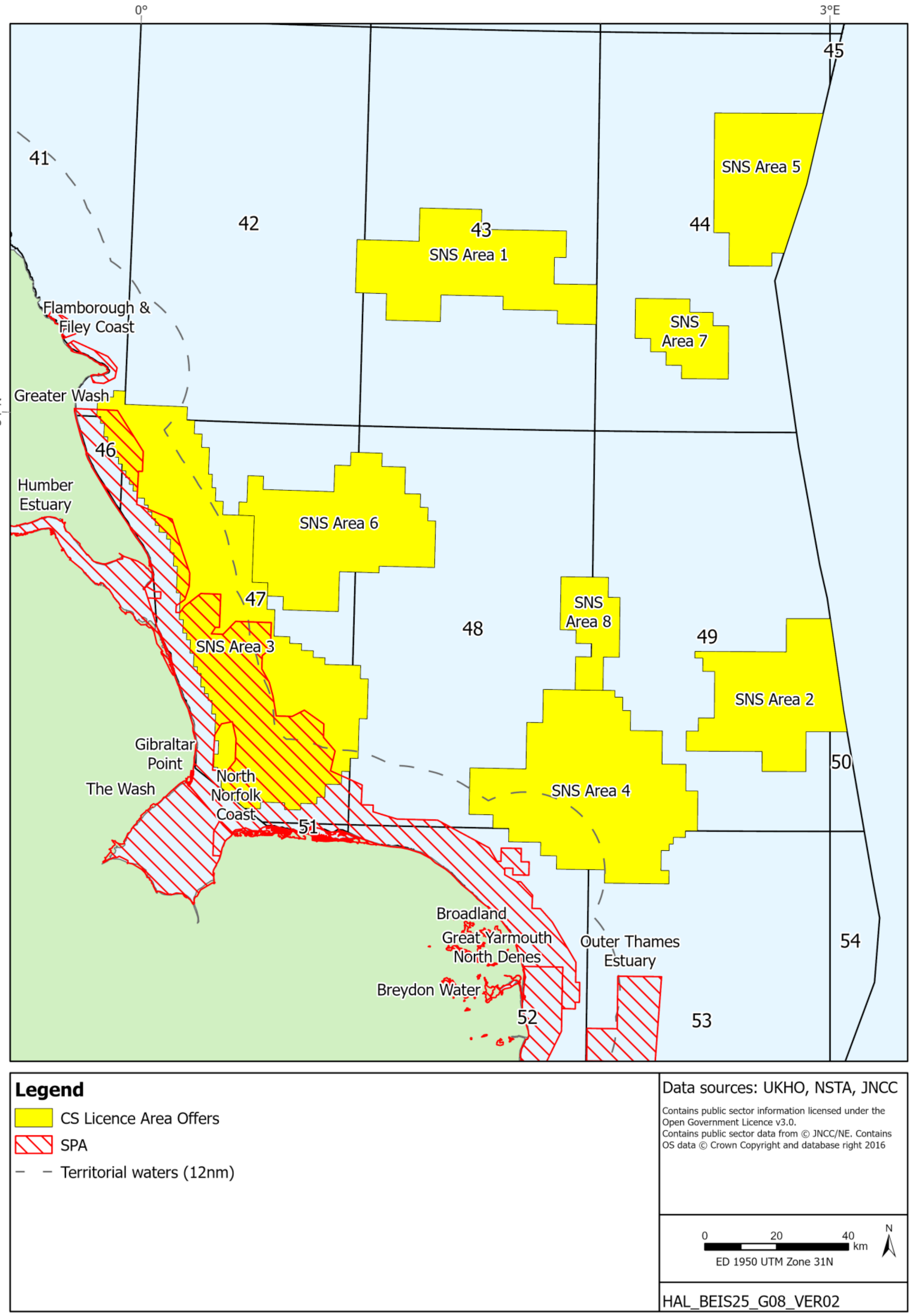


Figure 3.3: SPAs included in the screening process: east Irish Sea

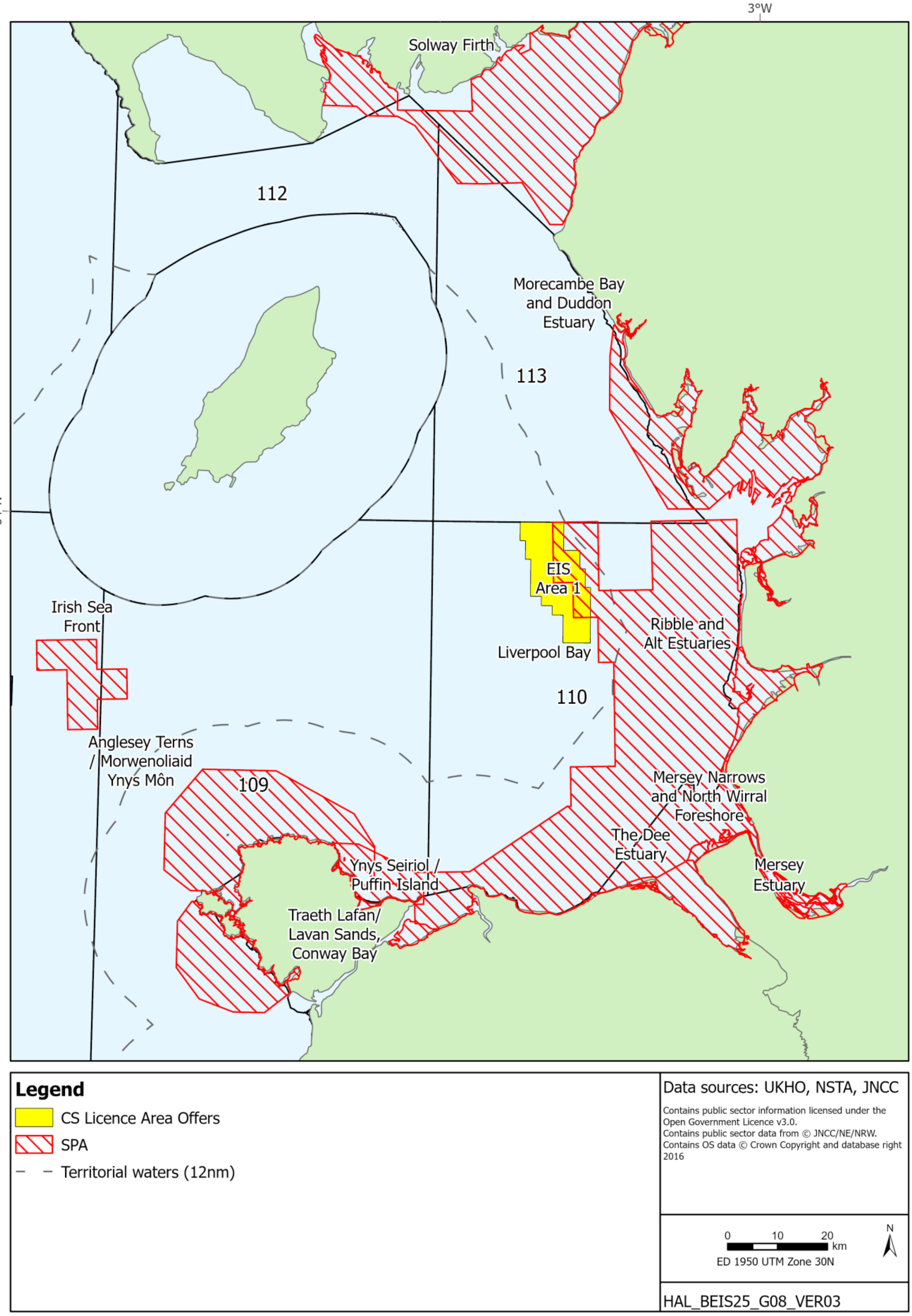


Figure 3.4: SACs included in the screening process: northern and central North Sea

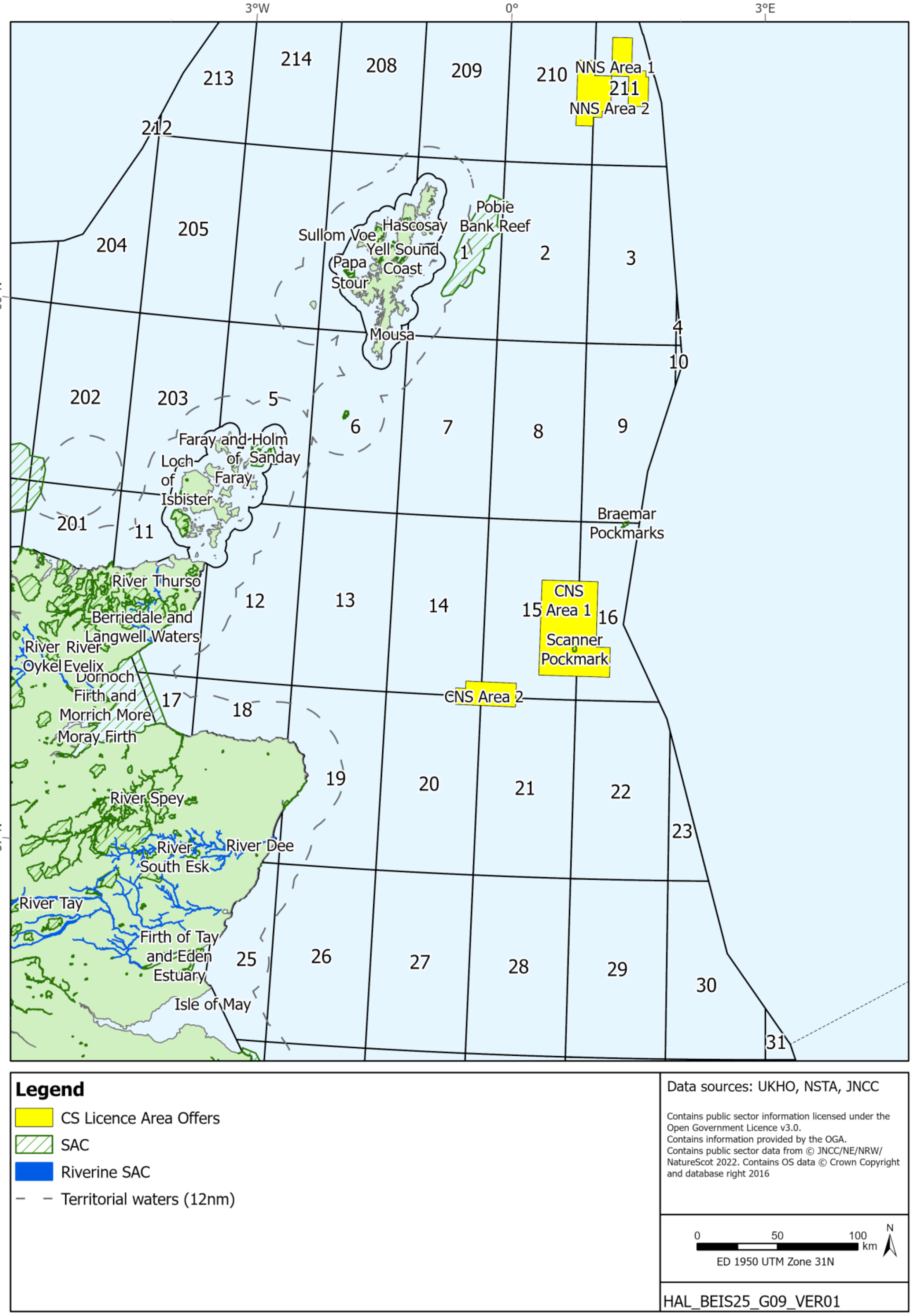


Figure 3.5: SACs included in the screening process: southern North Sea

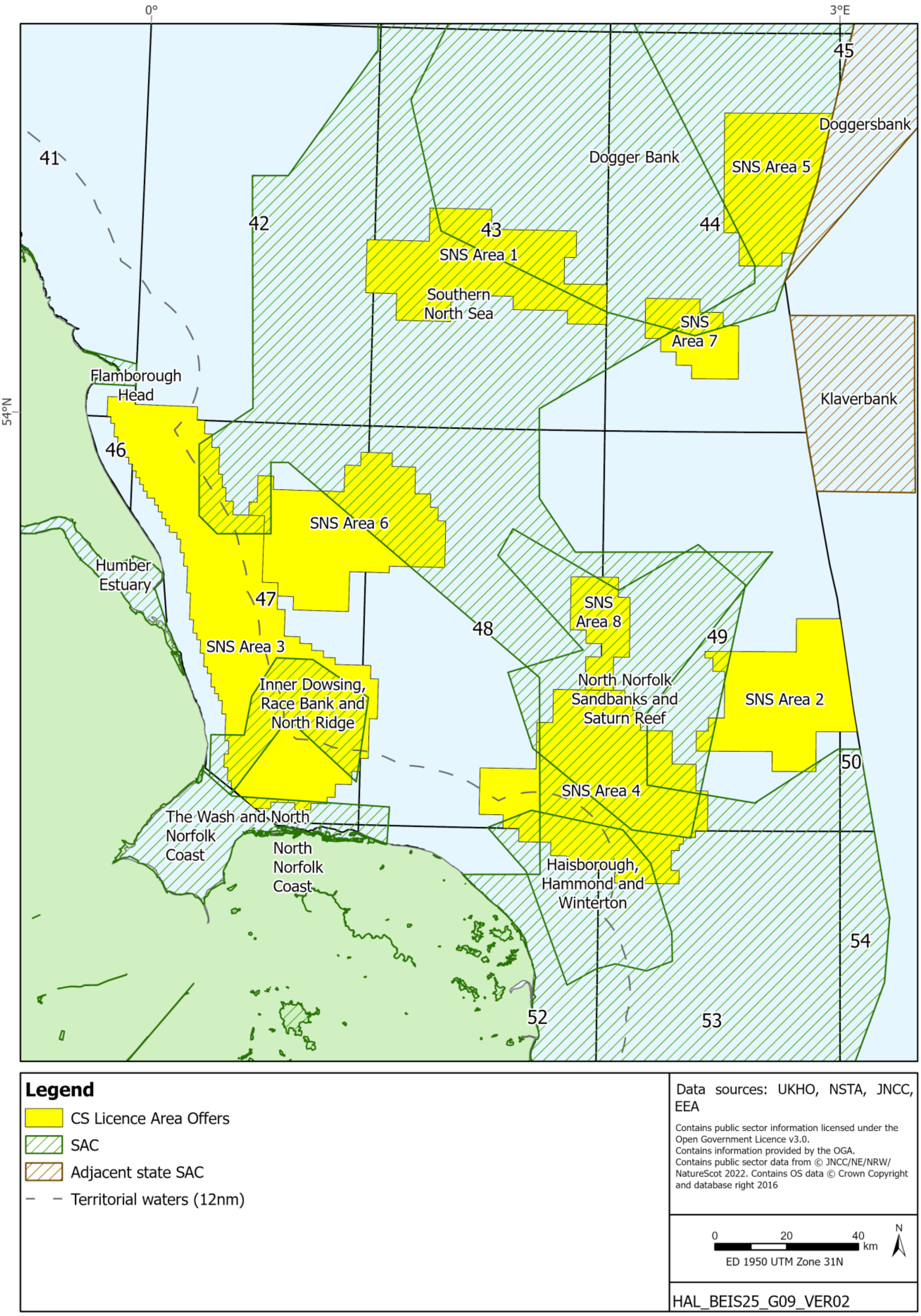
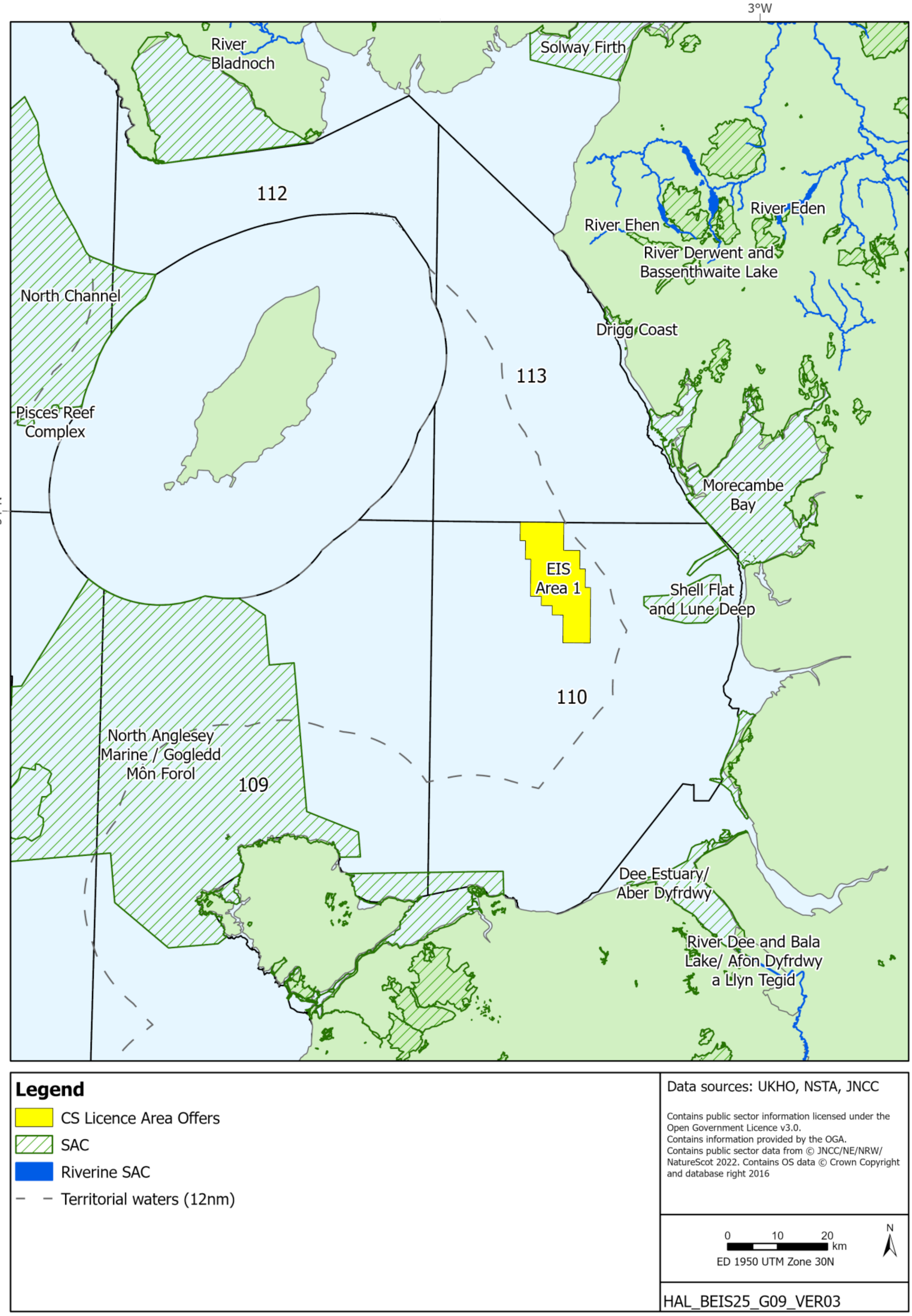


Figure 3.6: SACs included in the screening process: East Irish Sea



4 Screening Assessment Process

4.1 Introduction

This screening assessment is the first stage of an HRA to determine whether licensing of any of the areas offered in the 1st carbon storage licensing round is likely to have a significant effect on a relevant conservation sites in national site network, either individually or in combination with other plans or projects. The approach to the screening assessment has been undertaken in accordance with the European Commission Guidance (EC 2019) augmented by reference to a range of other guidance and reports (see list in Section 1.3).

The approach taken to screening has been to:

- Define the likely location and nature of exploration/appraisal activities that could follow licensing, together with their potential to result in likely significant effects on relevant conservation sites in national site network – see Section 2.

- Identify all relevant conservation sites in national site network and their qualifying primary and non-primary features with the potential to be affected by exploration/appraisal activities (i.e. those sites with marine features or with a marine ecological linkage) – see Section 3 and Appendix A.

- Screen the relevant sites for the likelihood of significant effects that could result from the licensing of the areas offered, based on the nature and scale of potential effects from exploration and appraisal activities and mapping in a geographic information system (GIS) – see Section 5. Consideration is also given as appropriate to the potential for mobile qualifying species (e.g. seabirds, marine mammals and fish) to be present beyond relevant site boundaries – see Section 4.6.

- Screen the relevant sites for likely significant effects that could result from the licensing of individual areas offered, in combination with other marine activities and plans – see Sections 4.7 and 5.

- Those areas which are screened in (i.e. for which likely significant effects on relevant conservation sites in national site network could not be discounted at the screening stage) will be subject to a second stage of HRA, AA, if applied for and before licence award decisions are taken – see Section 6 and Appendix B.

- Applications may be received covering all or part of an area offered. Where the areas applied for result in a change to the conclusion of the screening, this will be accounted for prior to AA being undertaken.

4.2 Sources of effect considered in this screening

As outlined in Section 2.3, activities which may be undertaken during the appraisal term will comprise exploration activities in the form of seismic survey, exploration or appraisal drilling, or other site investigation work including geophysical or geotechnical investigations. The foreseeable interactions from these activities with the potential to result in likely significant effects on relevant sites are therefore assessed in this report. These activities, their environmental effects, and relevant legal and other controls are extensively described in the previous SEA Environmental and Technical Reports[17] and are not duplicated in detail here.

Subsequent storage site development activity is contingent on successful exploration and appraisal and may or may not result in the eventual installation of infrastructure. Where relevant, such future activities will themselves be subject to a screening procedure and tests under the Habitats Regulations.

In recent years, much work has been undertaken in the area of sensitivity assessments and activity/pressure (i.e. mechanisms of effect) matrices (e.g. Tillin *et al*. 2010, JNCC 2013, Tillin & Tyler-Walters 2014, Defra 2015, Robson *et al.* 2018, the Scottish Government Feature Activity Sensitivity Tool, FeAST, the MarESA tool, Tyler-Walters *et al*. 2018). These matrices are intended to describe the types of pressures that act on marine species and habitats from a defined set of activities and are related to benchmarks where the magnitude, extent or duration is qualified or quantified in some way and against which sensitivity may be measured – note that benchmarks have not been set for all pressures. The sensitivity of features to any pressure is based on tolerance and resilience, and can be challenging to determine (e.g. see Tillin & Tyler-Walters 2014, Pérez-Domínguez *et al.* 2016, Maher *et al.* 2016), for example due to data limitations for effect responses of species making up functional groups and/or lack of consensus on expert judgements. Outputs from such sensitivity exercises can therefore be taken as indicative.

This activity/pressure approach now underpins advice on operations (e.g. as required under Regulation 37 of the *Conservation of Habitats and Species Regulations 2017*[18], Regulation 21 of the *Conservation of Offshore Marine Habitats and Species Regulations 2017* and those relevant to Regulations of the devolved administrations) for many of the sites included in this assessment. Where available, the advice on operations identifies a range of pressures for site features in relation to exploration and appraisal activity which is relevant to carbon dioxide storage[19], along with a standard description of the activity, pressure benchmarks, and justification text for the activity-pressure interaction (including with reference to source information). The relevance of the pressures to site-specific features are identified; however, in many instances assessment of the sensitivity of a feature to a given pressure has not been made, or it has been concluded that there is insufficient evidence for a sensitivity assessment to be made at the pressure benchmark[20]. Whilst the matrices provided as part of the advice

[17] https://www.gov.uk/guidance/offshore-energy-strategic-environmental-assessment-sea-an-overview-of-the-sea-process

[18] Under this Regulation, advice must be provided by the appropriate nature conservation body to other relevant authorities as to: a national network site's conservation objectives and any operations which may cause deterioration of natural habitats or the habitats of species, or disturbance of species, for which the site has been designated.

[19] E.g. under the activity exploratory drilling in the latest JNCC PAD pressures include: above water noise, abrasion/disturbance of the substrate on the surface of the seabed, penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion, habitat structure changes - removal of substratum (extraction), smothering and siltation rate changes, hydrocarbon & PAH contamination, introduction of other substances (solid, liquid or gas), synthetic compound contamination, transition elements & organo-metal (e.g. TBT) contamination, introduction or spread of non-indigenous species, litter, collision above/below water with static or moving objects not naturally found in the marine environment (e.g., boats, machinery, and structures), introduction of light, visual disturbance, underwater noise changes and vibration. For example, see: https://designatedsites.naturalengland.org.uk/

[20] Note that pressure benchmarks are used as reference points to assess sensitivity and are not thresholds that identify a likely significant effect within the meaning of the Habitats Regulations.

are informative and identify relevant pressures associated with exploratory drilling, resultant impacts at a scale likely to give rise to significant effects are not inevitable consequences of activity, and they can often be mitigated through timing, siting or technology (or a combination of these). The Department expects that these options would be evaluated by the licensees and documented in the environmental assessments required as part of the activity-specific consenting regime.

A review of the range of pressures identified in SNCB advice for the relevant sites was undertaken for the purpose of this assessment. The review concluded that the evidence base for potential effects of carbon dioxide storage site appraisal from Offshore Energy SEAs (DECC 2016, BEIS 2018, BEIS 2022) covers the range of pressures identified in the advice for the relevant sites (as summarised in Sections 4.4-4.6) and has therefore been used to underpin the assessment against site-specific information. It is noted that existing controls are in place for many relevant pressures (e.g. introduction of other substances (solid, liquid or gas), synthetic compound contamination (including antifoulants), transition elements & organo-metal contamination, introduction or spread of non-indigenous species, and litter), either directly in relation to exploratory/appraisal activities (as outlined in Section 4.3) or generally in relation to shipping controls (e.g. MARPOL Annex I and V controls on oil and garbage respectively, and the Ballast Water Management Convention). In addition to site advice on operations, the conservation objectives have been taken into account during the screening process.

Consideration of the potential for activities to result in likely significant effects was made, informed by the evidence base in the scientific literature and the Department's BEIS Strategic Environmental Assessments. Based on this consideration, this screening assessment addresses those sources of impact generally considered to have the potential to affect relevant sites, specifically:

- Physical disturbance and drilling effects (e.g. from rig siting, marine discharges, rig/vessel presence and movement)
- Underwater noise effects
- In-combination effects

Potential accidental events, including spills or releases, are not considered in this HRA screening as they are not part of the work plan. Measures to prevent accidental events, response plans and potential impacts in the receiving environment would be considered as part of the environmental impact assessment (EIA) process for specific projects that could follow licensing when the location, nature and timing of the proposed activities are available to inform a meaningful assessment of such risks.

4.3 Existing regulatory requirements and controls

The HRA screening assumes that the high level controls described below are applied as standard to activities since they are legislative requirements which if not adhered to would constitute an offence. These are distinct from mitigation measures which may be identified and employed at a project-specific level to avoid adverse effects on site integrity.

4.3.1 Physical disturbance and drilling effects

There is a mandatory requirement to have sufficient recent and relevant data to characterise the seabed in areas where activities are due to take place (e.g. rig placement)[21]. If required, survey reports must be made available to the relevant statutory bodies on submission of a relevant permit application or Environmental Statement for the proposed activity, and the identification of any potential sensitive habitats by such survey (including those under Annex I of the Habitats Directive) may influence BEIS's decision on a project level consent.

Drilling chemical use and discharge is subject to strict regulatory control through permitting, monitoring and reporting (e.g. the mandatory Environmental Emissions Monitoring System (EEMS) and annual environmental performance reports). The use and discharge of chemicals must be risk assessed as part of the permitting process (e.g. Drilling Operations Application) under the *Offshore Chemicals Regulations 2002* (as amended), and the discharge of chemicals expected to have a significant negative impact would not be permitted.

At the project level, discharges would be considered in detail in project-specific EIAs (and where necessary through HRAs) and chemical risk assessments under existing permitting procedures.

4.3.2 Underwater noise effects

Controls are in place to cover all significant noise generating activities on the UKCS, including geophysical surveying. Seismic surveys (including VSP and high-resolution site surveys), sub-bottom profile surveys and shallow drilling activities require an application for consent under the *Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001* (as amended) and cannot proceed without consent. These applications are supported by an EIA, which includes a noise assessment. Regarding noise thresholds to be used as part of any assessment, applicants are encouraged to seek the advice of relevant SNCB(s) (JNCC 2017) in addition to referring to European Protected Species (EPS) guidance (JNCC 2010). Applicants should be aware of recent research development in the field of marine mammal acoustics, including the development of a new set of criteria for injury (Southall *et al*. 2019).

The Department consults the relevant statutory consultees on the consent applications for advice and a decision on whether to grant consent is only made after careful consideration of their comments. Statutory consultees may request additional information or risk assessment, specific additional conditions to be attached to consent (such as specify timing or other specific control measures), or advise against consent.

It is a condition of consents issued under Regulation 4 of the *Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001* (as amended) for seismic and sub-bottom profile surveys that the JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys are followed. Where appropriate, EPS disturbance licences may also be required under the *Conservation of Offshore Marine Habitats and Species Regulations 2017*[22]. The JNCC guidelines (2017) reaffirm that adherence to these guidelines constitutes best practice and will, in most cases, reduce the risk of deliberate injury to marine mammals to negligible levels. Applicants are expected to make every effort to design a survey that

[21] See BEIS (2021). The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 – A Guide.
[22] Disturbance of European Protected Species (EPS) (i.e. those listed in Annex IV) is a separate consideration under Article 12 of the Habitats Directive, and is not considered in this assessment.

minimises sound generated and consequent likely impacts, and to implement best practice measures described in the guidelines.

In addition, potential disturbance of certain qualifying species (or their prey) may be avoided by the seasonal timing of offshore activities.

4.4 Physical disturbance and drilling effects

Exploration/appraisal activities may exert the following pressures[23] which have the potential to cause physical disturbance and drilling effects on relevant sites:

- Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion from jack-up drilling rig spud can placement, semi-submersible drilling rig anchor placement, dragging and the contact of anchor cables and chains with the seabed (see Section 4.4.1)
- Abrasion/disturbance of the substrate on the surface of the seabed and smothering/siltation rate change through the discharge of surface hole cuttings around the well, placement of wellhead assembly, and by settlement of drill cuttings onto the seabed following discharge near sea surface (see Section 4.4.2)
- Physical change to another seabed type through rock placement around jack-up legs for rig stabilisation (see Section 4.4.3)
- Contamination (see Section 4.4.4)
- Introduction or spread of non-indigenous species (see Section 4.4.5)
- Visual disturbance (and underwater noise, covered in Section 4.5), introduction of light and collision associated with the presence and movement of vessels causing displacement of sensitive receptors (see Section 4.4.6)
- Collisions above or below water with static or moving objects (see Section 4.4.7)

These are described briefly below and have informed the setting of screening criteria for physical disturbance and drilling effects (Section 4.4.8).

4.4.1 Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion

Semi-submersible rigs normally use anchors to hold position, typically between 8 and 12 in number at a radius related to water depth, seabed conditions and anticipated metocean conditions. The seabed footprint associated with semi-submersible rig anchoring results from a combination of anchor scars caused by anchors dragging before gaining a firm hold, and scraping by the cable and/or chain linking the anchor to the rig, where these contact the seabed (the catenary contact). In North Sea depths, rig anchors extend to a radius of up to *ca*. 1,500m (note that semi-submersible rigs are typically not used in water depths of less than 120m). In the deeper waters of the UK the use of anchors could be avoided through the use of

[23] Following those noted in Section 4.2.

dynamically positioned (DP) drill ships or DP semi-submersible rigs. These use a number of thrusters and accurate positioning information to maintain their station.

Jack-up rigs, normally used in shallower water (<120m), leave three or four seabed depressions from the feet of the rig (the spudcans) around 15-20m in diameter. The form of the footprint depends on factors such as the spudcan shape, the soil conditions, the footing penetration and methods of extraction, with the local sedimentary regime affecting the longevity of the footprint (HSE 2004). For example, side scan survey data from a 2011 pipeline route survey in Blocks 30/13c and 30/14 showed spudcan depressions from the drilling of a well in 2006 (no information on the depths of the depressions was provided). The well was located in a *ca*. 70m water depth, exposed to low tidal currents (0.1-0.26m/s) with sediments consisting of fine to medium silty sand with gravel, cobbles and coarse sand also present (Maersk 2011). By comparison, swathe bathymetry data collected as part of FEPA monitoring of the Kentish Flats wind farm off the Kent coast indicated a set of six regular depressions in the seabed at each of the turbine locations resulting from jack-up operations. Immediately post-construction, a January 2005 survey recorded these depressions as having depths of between 0.5 and 2.0m. By November 2007, these depths had reduced by an average of 0.6m indicating that the depressions were naturally infilling as a result of the mobile sandy sediments present across the area (Vattenfall 2009). In locations with an uneven or soft seabed, material such as grout bags or rocks may be placed on the seabed to stabilise the rig feet, and recoverable mud mats may be used in soft sediment (see below).

The drilling of the surface hole of a well and installation of the conductor will result in highly localised changes to the substrate below the surface of the seabed. Following drilling, exploration wells are typically plugged and abandoned with the casing being removed to approximately 3m below the seabed. As noted above in relation to depressions from jack-up rig spudcans, some natural infilling and recovery of the seabed would be expected following conductor removal.

4.4.2 Abrasion/disturbance of the substrate on the surface of the seabed and habitat structure changes – removal of substratum

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

The extent and potential impact of drilling discharges have been reviewed in successive SEAs, OESEA, OESEA2, OESEA3 and OESEA4 (DECC 2009, 2011, 2016 and BEIS 2022, respectively, also see BEIS 2018).

Relevant information on the recovery of benthic habitats to smothering mainly comes from studies of dredge disposal areas (see Newell *at al.* 1998). Recovery following disposal occurs through a mixture of vertical migration of buried fauna, together with sideways migration into the area from the edges, and settlement of new larvae from the plankton. The community recolonising a disturbed area is likely to differ from that which existed prior to construction. Opportunistic species will tend to dominate initially and on occasion, introduced and invasive species may then exploit the disturbed site (Bulleri & Chapman 2010). Harvey *et al.* (1998) suggest that it may take more than two years for a community to return to a closer resemblance of its original state (although if long lived species were present this could be much longer). Shallow water (<20m) habitats in wave or current exposed regimes, with unconsolidated fine grained sediments have a high rate of natural disturbance and the characteristic benthic species are adapted to this. Species tend to be short lived and rapid reproducers and it is generally accepted that they recover from disturbance within months. By contrast a stable sand and gravel habitat in deeper water is believed to take years to recover (see Newell *et al.* 1998, Foden *et al*. 2009). Changes in water quality from increased suspended sediment loads are noted as a pressure relevant to exploration drilling[24]. Drilling activities may result in enhanced turbidity, e.g. from discharge of cuttings or spent mud, but such discharges are made via a subsurface caisson, are episodic rather than continuous and are quickly dispersed and are not likely to impact shallow plunge diving birds such as terns.

4.4.3 Physical change to another seabed type

As noted, there may be a requirement for jack-up rig stabilisation (e.g. rock placement or use of mud mats) depending on local seabed conditions, but this is not typical. In soft sediments, rock deposits may cover existing sediments resulting in a physical change of seabed type. The introduction of rock into an area with a seabed of sand and/or gravel can in theory provide “stepping stones” which might facilitate biological colonisation including by non-indigenous species by allowing species with short lived larvae to spread to areas where previously they were effectively excluded. On the UK Continental Shelf, natural “stepping stones” are widespread and numerous for example in the form of rock outcrops, glacial dropstones and moraines, relicts of periglacial water flows, accumulations of large mollusc shells, carbonate cemented rock etc., and these are often revealed in rig site and other (e.g. pipeline route) surveys. The potential for man-made structures to act as stepping stones in the North Sea and the impact of their removal during decommissioning is being investigated as part of the INSITE[25] programme. Phase 1 projects (2015-2017) are now complete; those of relevance suggest that man-made structures may influence benthic community structure and function but only on a limited spatial scale. Modelling indicates the potential for biological connectivity between structures in the North Sea, but this has not been validated by empirical data (ISAB 2018). Phase 2 of the INSITE research aims to tackle gaps in understanding of the role of man-made structures in marine ecosystems and is due to be complete in early 2023. An additional project has been commissioned to provide a synthesis of evidence relating to manmade structures in the marine environment, building on phases 1 and 2 of the INSITE programme.

[24] https://hub.jncc.gov.uk/assets/97447f16-9f38-49ff-a3af-56d437fd1951, also see Advice on Operations for SACs SPAs: https://designatedsites.naturalengland.org.uk/; note that changes in suspended solids (water clarity) is generally not noted as a pressure against exploration drilling for SPAs relevant to this assessment.
[25] https://www.insitenorthsea.org/

4.4.4 Contamination[26]

In contrast to historic oil based mud discharges[27], effects on seabed fauna resulting from the discharge of cuttings drilled with water based muds (WBM) and of the excess and spent mud itself are usually subtle or undetectable. Although the presence of drilling material at the seabed close to the drilling location (<500m) is often detectable chemically (e.g. Cranmer 1988, Neff *et al.* 1989, Hyland *et al.* 1994, Daan & Mulder 1996, Currie & Isaacs 2005, OSPAR 2009b, Bakke *et al.* 2013). Recent studies (e.g. Nguyen *et al.* 2021, Gillett *et al.* 2020, Dijkstra *et al.* 2020, Aagaard-Sørensen *et al.* 2018, Junttila *et al.* 2018) have investigated the spread and effects of WBM discharges on various aspects of seabed ecology including those not typically included in benthic monitoring programmes; the results indicate that, where effects were detected, they were of small spatial scale and relatively short duration.

Considerable data from oil and gas activities has been gathered from the North Sea and other production areas, indicating that localised physical effects are the dominant mechanism of ecological disturbance where water-based mud and cuttings are discharged. Modelling of WBM cutting discharges has indicated that deposition of material is generally thin and quickly reduces away from the well. Jones *et al.* (2006, 2012) compared pre- and post-drilling ROV surveys of a West of Shetland exploration well in Block 206/1a in *ca*. 600m water depth and documented physical smothering effects within 100m of the well (note that this is over 400m deeper than any of the areas on offer in this round). Outside the area of smothering, fine sediment was visible on the seafloor up to at least 250m from the well. After three years, there was significant reduction of cuttings material visible particularly in the areas with relatively low initial deposition (Jones *et al*. 2012). The area with complete cuttings cover had reduced from 90m to 40m from the drilling location, and faunal density within 100m of the well had increased considerably and was no longer significantly different from conditions further away. The use of a ROV has also allowed the detection of small scale changes in benthic fauna in the immediate vicinity of a wellbore in the Norwegian sector of the North Sea, for example Hughes *et al.* (2010) found declines of the density of sea urchin *Gracilechinus acutus* within 50m of a well; such effects are considered temporary and negligible.

OSPAR (2009) concluded that the discharge of water-based muds and drill cuttings may cause some smothering in the near vicinity of the well location. The impacts from such discharges are localised and transient, but may be of concern in areas with sensitive benthic fauna, for example corals and sponges. Field experiments on the effects of water-based drill cuttings on benthos by Trannum *et al*. (2011) found after six months only minor differences in faunal composition between the controls and those treated with drill cuttings. This corresponds with the results of field studies where complete recovery was recorded within 1-2 years after deposition of water-based drill cuttings (Daan & Mulder 1996, Currie & Isaacs 2005).

Finer particles may be dispersed over greater distances than coarser particles although exposure to WBM cuttings in suspension will in most cases be short-term (Bakke *et al.* 2013). Chemically inert, suspended barite has been shown under laboratory conditions to potentially have a detrimental effect on suspension feeding bivalves. Standard grade barite, the most commonly used weighting agent in WBMs, was found to alter the filtration rates of four bivalve species (*Modiolus modiolus, Dosinia exoleta, Venerupis senegalensis* and *Chlamys varia*) and to damage the gill structure when exposed to 0.5mm, 1.0mm and 2.0mm daily depth

[26] Including contamination from transition elements and organo-metals, hydrocarbons and PAHs, synthetic compounds and the introduction of other substances (solid, liquid or gas).
[27] OSPAR Decision 2000/3 on the Use of Organic-Phase Drilling Fluids (OPF) and the Discharge of OPF-Contaminated Cuttings came into effect in January 2001 and effectively eliminated the discharge of cuttings contaminated with oil based fluids (OBF) greater than 1% by weight on dry cuttings.

equivalent doses (Strachan 2010, Strachan & Kingston 2012). All three barite treatments altered the filtration rates leading to 100% mortality. The horse mussel (*M. modiolus*) was the most tolerant to standard barite with the scallop (*C. varia*) the least tolerant. Fine barite, at a 2mm daily depth equivalent, also altered the filtration rates of all species, but only affected the mortality of *V. senegalensis*, with 60% survival at 28 days. The bulk of WBM constituents (by weight and volume) are on the OSPAR list of substances used and discharged offshore which are considered to Pose Little or No Risk to the Environment (PLONOR). Barite and bentonite are the materials typically used in the greatest quantities in WBMs and are of negligible toxicity. Field studies undertaken by Strachan (2010) showed that the presence of standard grade barite was not acutely toxic to seabed fauna but did alter benthic community structure. When the suspended barite levels used in laboratory studies are translated to field conditions (i.e. distances from the point of discharge) it is clear that any effects will be very local to a particular installation (in the case of oil and gas facilities, well within 500m).

Most studies of ecological effects of drilling discharges have involved soft-sediment species and habitats. Studies of the effects of water based mud discharges from three production platforms in 130-210m water depth off California found significant reductions at some stations in the mean abundance of four of 22 hard bottom taxa investigated using photographic quadrats (Hyland *et al.* 1994). These effects were attributed to the physical effects of particulate loading, namely disruption of feeding or respiration, or the burial of settled larvae. The impacts from WBM discharges may be of more concern in areas with sensitive benthic fauna, for example corals and sponges. Laboratory experiments by Allers *et al.* (2013) indicated that cold water coral (*Lophelia pertusa*) fragments were resilient to sedimentation-induced oxygen stress, but if coverage by sediment was complete and lasted long enough, the coral could not recover and died. Such effects can be mitigated in areas of sensitive species presence through site specific controls on whether, and where, drilling discharges are made. Järnegren *et al.* (2017) noted that natural high turbidity events lasting hours or days can occur in areas with adult corals, but based on their experiments suggested that the planktonic larvae of *L. pertusa* were susceptible to damage or mortality from suspensions of drill cuttings which included bentonite.

4.4.5 Introduction or spread of non-indigenous species

Through the transport and discharge of vessel ballast waters (and associated sediment), and to a lesser extent fouling organisms on vessel/rig hulls, non-native species may be introduced to the marine environment. Should these introduced species survive and form established breeding populations, they can result in negative effects on the environment. These include: displacing native species by preying on them or out-competing them for resources; irreversible genetic pollution through hybridisation with native species, and increased occurrence of harmful algal blooms (as reviewed in Nentwig 2006). The economic repercussions of these ecological effects can also be significant (see IPIECA & OGP 2010, Lush *et al*. 2015, Nentwig 2007). In response to these risks, a number of technical measures have been proposed such as the use of ultraviolet radiation to treat ballast water or procedural measures such as a mid-ocean exchange of ballast water (the most common mitigation against introductions of non-native species). Management of ballast waters is addressed by the International Maritime Organisation (IMO) through the International Convention for the Control and Management of Ships Ballast Water & Sediments, which entered into force in 2017[28]. The Convention includes Regulations with specified technical standards and requirements (IMO Globallast website[29]). Further, carbon dioxide exploration and appraisal activity is unlikely to change the risk of the

[28] http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Control-and-Management-of-Ships%27-Ballast-Water-and-Sediments-(BWM).aspx
[29] http://archive.iwlearn.net/globallast.imo.org/the-bwmc-and-its-guidelines/index.html

introduction of non-native species as the vessels typically operate in a geographically localised area (e.g. rigs may move between the Irish Sea and North Sea), and the risk from hull fouling is low, given the geographical working region and scraping of hulls for regular inspection.

4.4.6 Visual disturbance

The areas offered may support important numbers of birds at certain times of the year including overwintering birds and those foraging from coastal SPAs. Therefore, the presence and/or movement of vessels and aircraft from and within carbon storage licence areas during exploration and appraisal activities could temporarily disturb birds from relevant SPA sites. In areas where helicopter transits are regular, a degree of habituation to disturbance amongst some birds has been reported (see Smit & Visser 1993). The anticipated level of helicopter traffic associated with exploration/appraisal drilling activity (2-3 trips per week, see Table 2.1) is likely to be insignificant in the context of existing helicopter, military and civilian aircraft activity levels.

Physical disturbance of seaduck and other waterbird flocks by vessel and aircraft traffic associated with carbon dioxide exploration and appraisal is possible, particularly in SPAs established for shy species (e.g. common scoter). Such disturbance can result in repeated disruption of bird feeding, loafing and roosting. Divers and sea ducks have been assessed as being the most sensitive species groups to offshore development and associated boat and helicopter traffic. For example, large flocks of common scoter were observed being put to flight at a distance of 2km from a 35m vessel, though smaller flocks were less sensitive and put to flight at a distance of 1km (Kaiser 2002, also see Schwemmer *et al.* 2011). Larger vessels would be expected to have an even greater disturbance distance (Kaiser *et al.* 2006). Mendel *et al.* (2019) further note behavioural response in red-throated diver within 5km of ships.

With respect to the disturbance and subsequent displacement of seabirds in relation to offshore wind farm (OWF) developments, the Joint SNCB interim displacement advice[30] recommends for most species a standard displacement buffer of 2km with the exception of the species groups of divers and sea ducks for which JNCC (2022) recommend a 4km displacement buffer. Whilst displacement effects for divers have been detected at greater distances (e.g. 5-7km, Webb 2016; 8km, HiDef 2017; 10-16.5km, Mendel *et al.* 2019, Heinänen *et al.* 2020, APEM 2021; 10km, MacArthur Green 2019; 10-15km, Dorsch *et al.* 2019), and a buffer of 10km is recommended by JNCC (2022), this relates to the construction and operation of offshore wind farms which have a much larger spatial and temporal footprint than carbon dioxide storage exploration appraisal activities.

A significant number of various bird species migrate across the North Sea region twice a year or use the area as a feeding and resting area (OSPAR 2015). Some species crossing or using the area may become attracted to offshore light sources, especially in poor weather conditions with restricted visibility (e.g. low clouds, mist, drizzle, Wiese *et al*. 2001), and this attraction can potentially result in mortality through collision (OSPAR 2015). As part of navigation and worker safety, and in accordance with international requirements, drilling rigs and associated vessels are lit at night and the lights will be visible at distance (some 10-12nm in good visibility). Guidelines (applicable to both existing and new offshore installations) aimed at reducing the impact of offshore installations lighting on birds in the OSPAR maritime area are available (OSPAR 2015). Exploration/appraisal drilling activities are temporary so a drilling rig will be present at a location for a relatively short period (e.g. on average up to 10 weeks), limiting the potential for significant interaction with migratory bird populations. Given the seasonal nature

[30] https://hub.jncc.gov.uk/assets/9aecb87c-80c5-4cfb-9102-39f0228dcc9a

of the sensitivity, where relevant it is more appropriate to consider this in project level assessment (e.g. EIA and HRA where necessary), when the location and timing of activities are known.

The presence and/or movement of vessels from and within areas offered during exploration and appraisal activities could also potentially disturb marine mammals foraging within or close to sites for which they are a qualifying feature. Reported responses include avoidance, changes in swimming speed, direction and surfacing patterns, alteration of the intensity and frequency of calls and increases in stress-related hormones (Rolland *et al.* 2012, Dyndo *et al.* 2015, Veirs *et al.* 2016). Harbour porpoises, white-sided dolphins and minke whales have been shown to respond to survey vessels by moving away from them, while white-beaked dolphins have shown attraction (Palka & Hammond 2001). A study on captive harbour porpoises in a semi-natural net-pen complex in a Danish canal, recorded their behaviour while simultaneously measuring underwater noise of vessels passing the enclosure; reaction to noise was defined to occur when a highly stereotyped ‘porpoising’ behaviour was observed. Porpoising occurred in response to almost 30% of vessel passages; the most likely behavioural trigger were medium- to high- frequency components (0.25–63 kHz octave bands) of vessel noise, while low- frequency components of vessel noise and additional pulses from echo-sounders could not explain the results (Dyndo *et al*. 2015). A tagging study of a small number of free-ranging porpoises in Danish coastal waters estimated that porpoises encountered vessel noise 17–89% of the time (from evaluation of the wideband sound and movement tag recordings). Occasional high-noise levels (coinciding with a fast ferry) were associated with vigorous fluking, bottom diving, interrupted foraging and even cessation of echolocation, leading to significantly fewer prey capture attempts at received levels greater than 96 dB re 1 mPa (16 kHz third-octave, Wisniewska *et al.* 2018).

More evidence is available on bottlenose dolphins, especially for coastal populations. Shore-based monitoring of the effects of boat activity on the behaviour of bottlenose dolphins off the US South Carolina coast, indicated that slow moving, large vessels, like ships or ferries, appeared to cause little to no obvious response in bottlenose dolphin groups (Mattson *et al*. 2005). Pirotta *et al*. (2015) used passive acoustic techniques to quantify how boat disturbance affected bottlenose dolphin foraging activity in the inner Moray Firth. The presence of moving motorised boats appeared to affect bottlenose dolphin buzzing activity (foraging vocalisations), with boat passages corresponding to a reduction by almost half in the probability of recording a buzz. The boat effect was limited to the time where a boat was physically present in the sampled area and visual observations indicated that the effect increased for increasing numbers of boats in the area (Pirotta *et al.* 2013). Dolphins appeared to temporarily interrupt their activity when disturbed, staying in the area and quickly resuming foraging as the boat moved away.

Of primary concern for this HRA, is whether vessels linked to potential operations result in a significant increase to overall local traffic. New *et al*. (2013) developed a mathematical model simulating the complex social, spatial, behavioural and motivational interactions of coastal bottlenose dolphins in the Moray Firth to assess the biological significance of increased rate of behavioural disruptions caused by vessel traffic. A scenario was explored in which vessel traffic increased from 70 to 470 vessels a year but despite the more than six-fold increase traffic, the dolphins’ behavioural time budget, spatial distribution, motivations and social structure remained unchanged. While harbour porpoises appear to be more sensitive to potential disturbance than bottlenose dolphins, the increase in vessel traffic linked to the proposed plan is expected to be negligible (see Table 2.1). In UK waters, a modelling study indicated a negative relationship between the number of ships and the presence and abundance of harbour porpoises within relevant management units when shipping intensity exceeded a suggested threshold of approximately 50 ships per day (within any of the model's 5km grid cells) in the Celtic Sea/Irish Sea and 80 ships per day in the North Sea (Heinänen & Skov 2015). The Marine Management Organisation project "Mapping UK shipping density and routes from AIS" (MMO 2014b) and the 2015 national dataset of marine vessel traffic[31] provides relevant shipping density information[32]. From 2015 AIS-derived ship density data, the approaches to major ports such as in the Humber and Thames regions had estimated shipping densities of up to 500 vessels per week, with the majority of coastal waters (10-25 vessels per week) and offshore waters (<5 vessels per week) supporting much lower densities. Jones *et al.* (2017) used the MMO (2014b) data to highlight areas where high rates of co-occurrence between seals at-sea and shipping coincided with SACs. They predicted exposure to shipping (and associated shipping noise) was likely to be high in areas where very high intensities of spatial overlap occurred for one or both species of seals such as Orkney (e.g. Faray and Holm of Faray SAC), Shetland (e.g. Yell Sound Coast SAC), east coast of Scotland and England (e.g. Berwickshire and North Northumberland Coast SAC, Humber Estuary SAC, the Wash and North Norfolk Coast SAC), west Scotland (South East Islay Skerries SAC) and north Wales (no adjacent SAC with seals as a feature).

4.4.7 Collisions above or below water with static or moving objects

Worldwide, collisions with vessels are a potential source of mortality to marine mammals, primarily cetaceans. Whales are occasionally reported to be struck and killed, especially by fast-moving ferries but smaller cetacean species and seals can also be impacted by propeller strikes from smaller vessels. In the UK certain areas experience very high densities of commercial and recreational shipping traffic, some of which may also be frequented by large numbers of marine mammals; despite this, relatively few deaths are recorded as results of collisions (Hammond *et al.* 2008). Between 2000 and 2009, only 11 out of 1,100 post-mortems on harbour porpoises and common dolphins identified collision as the cause of death (UKMMAS 2010). Advice on operations for the Southern North Sea SAC[33] indicates that post mortem investigations of harbour porpoise deaths have revealed death caused by trauma (potentially linked with vessel strikes) is not currently considered a significant risk (e.g. see Deaville & Jepson 2011).

4.4.8 Screening criteria for physical and drilling effects

With respect to **physical and drilling effects**, any area should be screened in that is within or overlaps with a site, together with any area within a buffer of 10km from a site where there is a potential interaction between site features and exploration/appraisal activities in the area.

The areas and relevant sites screened in on the basis of physical and drilling effects are shown in Figures 5.1 (SPAs) and 5.2 (SACs), and listed in Appendix B2. The relevant impact pathways to be considered at the AA stage will depend on the location of the licence areas applied for and the qualifying features of the relevant sites. The potential for interactions of mobile qualifying species (primarily seabirds, marine mammals and fish) with exploration and

[31] https://data.gov.uk/dataset/vessel-density-grid-2015
[32] Note that shipping densities are low over the majority of Blocks with higher densities primarily in coastal waters close to major ports.
[33] https://hub.jncc.gov.uk/assets/206f2222-5c2b-4312-99ba-d59dfd1dec1d#SouthernNorthSea-conservation-advice.pdf

appraisal activities when outside of relevant site boundaries is considered in Section 4.6. Where appropriate, areas >10km from relevant site boundaries may be screened in.

4.5 Underwater noise effects[34]

The current level of understanding of sources, measurement, propagation, ecological effects and potential mitigation of underwater noise associated with hydrocarbon exploration and production have been extensively reviewed, assessed and updated in each of the successive offshore energy SEAs (see DECC 2009, 2011, 2016, BEIS 2022). The following description of noise sources and potential effects builds on these previous publications, augmented with more recent literature sources.

4.5.1 Noise sources and propagation

For all sources of anthropogenic underwater noise, there is now a reasonable body of evidence to quantify sound levels associated with these activities and to understand the likely propagation of these sounds within the marine environment, even in more complex coastal locations (DECC 2016, 2018, BEIS 2022).

Of those activities that generate underwater sound, deep geological seismic survey (2D and 3D) is of primary concern due to the high amplitude, low frequency and impulsive nature of the sound generated over a relatively wide area. Typical 2D and 3D seismic surveys consist of a vessel towing a large airgun array, made up of sub-arrays or single strings of multiple airguns, along with towed hydrophone streamers. Total energy source volumes vary between surveys, most commonly between 1,000 and 8,000 cubic inches, with typical broadband source levels of 248-259 dB re 1μPa (OGP 2011). Most of the energy produced by airguns is low frequency: below 200Hz and typically peaking around 100Hz; source levels at higher frequencies are low relative to that at the peak frequency but are still loud in absolute terms and relative to background levels.

In addition to seismic surveys, relevant sources of impulsive sound are restricted to the smaller volume air-guns and sub-bottom profilers (SBPs) used in site surveys and well evaluation (i.e. Vertical Seismic Profiling, VSP), and also from occasional pile-driving of conductors during drilling (see Table 2.1). Compared to deep geological survey, these smaller volume seismic sources tend to generate sound of lower amplitude, are typically complete within several hours on a single day, are conducted from either a fixed point (VSP) or cover a small area (site surveys). Consequently, the overall magnitude and area of risk from sound effects is considerably smaller than in the case of deep geological seismic surveys.

Electromechanical sources such as ‘pinger’ or ‘chirper’ SBPs, side-scan sonar and multi-beam echosounders (MBES) have narrower beam widths and dominant frequencies much higher than those of air guns[35] such that, even at high amplitudes, the generated sound would be expected to rapidly attenuate and likely not propagate far enough for marine species to be negatively affected by received sound levels. For example, the absorption coefficient alone in seawater is approximately -36dB/km at 100kHz, rising to -61dB at 200kHz (Lurton 2016).

[34] Note that all underwater noise effects fall within the “underwater noise change” and “vibration” pressure definitions.

[35] It should be noted that airgun (including VSP) and sub-bottom profiling site surveys undertaken in relation to licences issued under the *Petroleum Act 1998* require consent under the *Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001* (as amended), but side-scan sonar and multibeam echosounder surveys only require to be notified to the Regulator (JNCC 2017).

SBPs of the 'boomer' and 'sparker' type do generate a true broadband seismic pulse of low frequency, although the peak pressures produced by these small devices are considerably lower than those generated by airguns. Two studies commissioned by the US Bureau of Ocean Energy Management investigated sound generated by equipment commonly used in high-resolution geophysical surveys, including electromagnetic sources. Calibrated source levels were measured under controlled conditions in a test tank (Crocker & Fratantonio 2016); acoustic characteristics of several example equipment types tested are provided in Table 4.1.

Table 4.1: Measured acoustic characteristics for example sources used in high-resolution geophysical surveys

Source tested	Category; signal type	Source levels at maximum power tested (dB re 1µPa@1m)[1]		Approximate frequency of dominant energy (kHz)	-3dB beam width (degrees); across track
		SPLpeak-peak	SEL		
Delta Sparker	SBP 'sparker'; impulse	206-225	163-185	< 1	n/a
Applied Acoustics 251	SBP 'boomer' (single plate); impulse	208-216	166-174	< 4	49-76
EdgeTech 512i	SBP 'chirper'; chirp	176-191	145-160	3-5	51-80
Reson Seabat 7111	MBES; tone burst	197-233	152-197	100	~160
EdgeTech 4200	Side-scan sonar; tone burst	206-216	165-205	100 or 400	~50 (1.6-2.6 along track)

Notes: 1. Values represent minimum and maximum according to different source configurations (e.g. power level, pulse width or centre frequency); maximum values typically correspond to the highest power level tested. SBP = sub-bottom profiler; MBES = multibeam echosounder. Source: Crocker & Fratantonio (2016).

The test tank experiments were followed by measurements in shallow (≤ 100m depth) open-water environments to investigate sound propagation (Halvorsen & Heaney 2018). Problems were encountered during the open-water testing resulting in a lack of calibration in the reported sound source levels (Labak 2019). The accompanying advice note (Labak 2019) emphasises that these uncalibrated data should not be used to provide source level measurements, and consequently the reported isopleths (summarising sound propagation) should not replace project-specific sound source verifications.

Despite the caveats on the current open-water test results, it is worth noting some general patterns observed. In all test environments, broadband received levels from all MBES, side-scan sonar and SBP 'chirper' or 'boomer' devices tested were rapidly attenuated with distance from source, with particularly pronounced fall-off for directional sources when the receiver was outside of the source's main beam. Acoustic signals from the SBP 'sparkers' tested showed slightly greater propagation, as would be expected from the lower-frequency impulsive signals these devices produce. The greatest propagation was generally observed at the deepest test site (100m water depth) from sources generating low frequencies (<10kHz) whilst some of the highest frequency sources (>50kHz) experienced such attenuation that they were only weakly detectable or undetected by recording equipment. While acknowledging that these results require refinement, for all the aforementioned devices broadband sound levels recorded a few hundred metres from the source were approximately an order of magnitude lower than the criteria for permanent or temporary hearing loss (Southall *et al*. 2019). These preliminary results, combined with the calibrated source measurements in test tanks, suggest that SBPs and other electromechanical sources used in high-resolution geophysical surveys have a very low potential for significant disturbance of sensitive marine fauna.

Drilling operations and support vessel traffic are sources of continuous noise (non-impulsive), of a comparable amplitude, dominated by low frequencies and of a lower amplitude than deep geological seismic survey. Sound pressure levels of between 120dB re 1μPa in the frequency range 2-1,400Hz (Todd & White 2012) are probably typical of drilling from a jack-up rig, with slightly higher source levels likely from semi-submersible rigs due to greater rig surface area contact with the water column. In general, support and supply vessels (50-100m) are expected to have broadband source levels in the range 165-180dB re 1μPa@1m, with the majority of energy below 1kHz (OSPAR 2009). Additionally, the use of thrusters for dynamic positioning has been reported to result in increased sound generation (>10dB) when compared to the same vessel in transit (Rutenko & Ushchipovskii 2015).

Encounters with unexploded ordnance (UXO) from past military conflicts or training are possible almost anywhere across the UKCS, however, they are most frequent in the southern North Sea and eastern Irish Sea. If UXO are encountered during exploration activities, there is considerable scope to avoid interaction and the need for disposal by adjusting the well location. To date, clearance of UXO has generally been undertaken by high-order detonation, but this is a source of loud impulsive underwater sound with the potential to cause significant effects on noise sensitive receptors. Alternative "low-order" approaches (e.g. deflagration) which render the UXO safe but without causing it to explode are available, and their use is being encouraged (e.g. see BEIS, 2022 and the unexploded ordnance clearance joint interim position statement[36]).

4.5.2 Potential ecological effects

Potential effects of anthropogenic noise on receptor organisms range widely, from masking of biological communication and small behavioural reactions, to chronic disturbance, physiological injury and mortality. While generally the severity of effects tends to increase with increasing exposure to noise, it is important to draw a distinction between effects from physical (including auditory) injury and those from behavioural disturbance. In addition to direct effects, indirect effects may also occur, for example via effects on prey species, complicating the overall assessment of significant effects. Marine mammals, and in particular the harbour porpoise, are regarded as the most sensitive to underwater noise effects therefore it is considered appropriate to focus on marine mammals when assessing risk from underwater noise; however, high amplitude impulsive noise also potentially presents a risk to fish and diving birds.

Marine mammals

The risk of physical injury (hearing loss) from an activity can be assessed by modelling the propagation of sound from an activity and using threshold criteria corresponding to the sound levels at which permanent hearing loss (permanent threshold shift, PTS) would be expected to occur. For marine mammals, the applicable SEA (DECC 2016) reflects the injury thresholds criteria developed by Southall *et al.* (2007), including the subsequent update for harbour porpoises in Lepper *et al*. (2014), based on the work by Lucke *et al.* (2009). Since then, NOAA has further updated the acoustic thresholds, including alternative frequency-weighting functions (NMFS 2016, 2018) which were adopted as updated criteria thresholds in the peer-reviewed literature (Southall *et al.* 2019). It is recognised that geophysical surveys (primarily 2D and 3D seismic) have the potential to generate sound that exceeds thresholds of injury, but only within a limited range from source (tens to hundreds of metres); for site surveys and VSP, the range from source over which injury may occur will be even smaller. Within this zone,

[36] https://www.gov.uk/government/publications/marine-environment-unexploded-ordnance-clearance-joint-interim-position-statement/marine-environment-unexploded-ordnance-clearance-joint-interim-position-statement

JNCC (2017) guidelines are considered to be sufficient in minimising the risk of injury to marine mammals to negligible levels.

With respect to behavioural disturbance of marine mammals, it is more difficult to establish broadly applicable threshold criteria based on exposure alone. This is due, in part, to the challenges encountered in studies of wide-ranging species with complex behaviour, but is largely because many behavioural responses are context-specific (e.g. Gomez *et al*. 2016, Harding *et al*. 2019). For compliance with the Habitat Directive, the guidance for the protection of marine European Protected Species from injury and disturbance (JNCC 2010) recommends that 'disturbance' is interpreted as sustained or chronic disruption of behaviour scoring five or more in the Southall *et al*. (2007) behavioural response severity scale[37]. This is to highlight that a disturbance offence is unlikely to occur from sporadic changes in behaviour with negligible consequences on vital rates and population effects (i.e. trivial disturbance). While it is possible to envisage how some behavioural effects may ultimately influence vital rates, evidence is currently limited. The focus of field studies has been on measuring displacement and changes in vocalisation with the assumption that these may influence vital rates mainly via a reduction in foraging opportunities.

Evidence of the effects of seismic surveys on odontocetes and pinnipeds is limited but of note are studies in the Moray Firth observing responses to a 10 day 2D seismic survey in September 2011 (Thompson *et al.* 2013a). The survey exposed a $200km^2$ area to noise throughout that period; peak-to-peak source levels generated by the 470 cubic inch airgun array were estimated to be 242-253 dB re 1 μPa at 1m and are therefore representative of the volume of a typical array used in VSP, and larger than that used in rig-site survey. Within 5-10km from the source, received peak-to-peak SPLs were estimated to be between 165 and 172 dB re 1 μPa, with SELs for a single pulse between 145 and 151 dB re 1 μPa^2s. A relative decrease in the density of harbour porpoises within 10km of the survey vessel and a relative increase in numbers at distances greater than 10km was reported; however, these effects were short-lived, with porpoise returning to affected areas within 19 hours after cessation of activities. Overall, it was concluded that while short-term disturbance was induced, the survey did not lead to long-term or broad-scale displacement (Thompson *et al*. 2013a). Further acoustic analyses revealed that for those animals which stayed in proximity to the survey, there was a 15% reduction in buzzing activity associated with foraging or social activity; however, a high level of natural variability in the detection of buzzes was noted prior to survey (Pirotta *et al*. 2014). Passive acoustic monitoring provided evidence of short-term behavioural responses also for bottlenose dolphins, but no measurable effect on the number of dolphins using the Moray Forth SAC could be revealed (Thompson *et al*. 2013b).

High frequency sources with central operating frequencies at the upper end of marine mammal hearing ranges or above (e.g. echosounders, side-scan sonar) have been shown to emit energy at lower frequencies audible to most marine mammals (e.g. Risch *et al.* 2017), although at reduced amplitudes and with a small, emitted sound field which is unlikely to cause behavioural effects (Cotter *et al.* 2019). Consideration of the higher frequency signals, typically lower source levels and higher directionality of these and other similar sources has led to the assumption that these would not propagate far enough for marine species to be negatively affected by received levels (Halvorsen & Heaney 2018). However, a precautionary approach has been adopted where it is acknowledged that such sources are within the hearing range of marine mammals and therefore could, in a few cases, cause localised short-term impacts on behaviour or temporary displacement of a small number of individuals (Boebel *et al.* 2005).

[37] See Table 4 (p450) of Southall *et al.* (2007) for a full description of response scores.

A conservative assessment of the potential for marine mammal disturbance from seismic surveys will assume that firing of airguns will affect individuals within 10km of the source (in keeping with the Effective Deterrence Radius (EDR) suggested by SNCBs), resulting in changes in distribution and a reduction of foraging activity, but the effect is short-lived. A 5km Effective Deterrence Radius (EDR) has also been suggested by UK SNCBs as appropriate in assessing geophysical survey disturbance. The precautionary criterion applied during initial screening (15km from relevant sites) is maintained here to identify the areas applied for to be considered with respect to likely significant effects in this assessment (see Section 5.2); this is to reflect the degree of uncertainty and the limited direct evidence available and to allow for a greater potential for disturbance when large array sizes are used.

Evidence on harbour porpoise responses to impact piling during wind-farm construction is also relevant since the impulsive character of the sound generated during piling is comparable with that from seismic airguns and for assessing in-combination effects with wind farms currently planned or under construction across the North Sea. Empirical studies during the construction of OWFs in the North and Baltic Seas (Carstensen *et al*. 2006, Tougaard *et al*. 2009, Brandt *et al*. 2011, 2018, Dähne *et al.* 2013) have all observed displacement of harbour porpoises in response to pile-driving. The magnitude of the effect (spatial extent and duration) varied between studies as a function of the many factors including exposure level, duration of piling, use of technical mitigation measures and ecological importance of the area. Nonetheless, from the available evidence it has been concluded that impact piling will displace individual harbour porpoises within an area of approximately 20km radius (BEIS 2022).

Graham *et al.* (2019) investigated harbour porpoise behavioural responses to piling noise using echolocation detectors (C-PODs) and noise recorders during the 10-month foundation installation of a wind farm in the Moray Firth. Each turbine base was secured using four 2.2m diameter steel piles, installed with a typical hammer energy of 600-700kJ. Using an array of acoustic loggers moored between 0.4 and 76.5km from piling locations, acoustic detections of porpoise in the 24 hours following the end of piling events (lasting *ca.* 5 hours) were examined relative to detections during a baseline period 24-48 hours prior to the onset of piling. Harbour porpoise were present within the windfarm construction site throughout the construction period. The probability of response (significantly reduced detections) reduced with increasing distance to piling and as the number of locations piled increased: there was a ≥50% probability of a behavioural response at a distance of 7.4km from piling at the start of construction, reducing to 4.0km midway through construction, and 1.3km at the final piling event. Acoustic Deterrent Devices (ADDs) were used prior to almost all piling events examined. While data for piling without ADD use was limited, thereby reducing the ability to distinguish the effects of different sound sources, the study results suggest that response levels were increased with ADD use.

SNCB advice (e.g. JNCC 2020) assumes a distance of 15km as the zone of disturbance for pile-driving. This EDR is particularly precautionary for smaller piles, as no differentiation is made between these (e.g. as used in the oil and gas industry for subsea developments or to set conductors) and monopiles which are typically used for offshore wind. The scale of pin-pile installation for the Beatrice OWF is intermediate between OWF monopile foundations and the piling of conductors/subsea infrastructure, being approximately twice the pile diameter and hammer energy typical of the latter. Graham *et al*. (2019) provided evidence that the probability of harbour porpoise behavioural responses to piling was low at distances >10km and unlikely to exceed 20km, and diminished over time. Considering these results relative to the typical pile diameters and hammer energies used in conductor piling, the 15km noise effects criterion applied in this screening is considered to be suitably precautionary for harbour porpoise.

At the Danish Horns Rev wind farm, satellite telemetry showed that harbour seals were still transiting the site during periods of piling, but no conclusive results could be obtained from analysis of habitat use with regard to a change in response to piling (Tougaard *et al*. 2006). Evidence of a response was obtained by Edrén *et al.* (2010) at a haul-out site 4km away from the Danish Nysted windfarm; during piling, numbers hauling out were reduced by 10-60% but the effect was only of short duration since the overall number of seals increased slightly during the whole construction phase. Russell *et al*. (2016) used telemetry data from 23 harbour seals to investigate potential avoidance of seals to the construction of the Lincs wind farm in The Wash off the east coast of England, including pile-driving of mono-pile foundations. While there was no significant displacement during construction as a whole, seal abundance during piling was significantly reduced up to 25km from the piling activity, with a 19-83% (95% confidence intervals) reduction in usage compared to breaks in piling activity. This displacement was shown to be temporary, with seals returning to their non-piling distribution within two hours of the cessation of piling.

Information on the potential effects of other geophysical surveys (e.g. sub-bottom profilers) is limited, with empirical studies of animal responses to such surveys lacking. Recent laboratory and field studies of the source levels and propagation of a variety of high-resolution geophysical survey sources (see Section 4.5.1) provided evidence to support the conclusion of negligible risk of significant effects from electromagnetic sources, with received levels dropping to below that which might be expected to cause behavioural disturbance within a few hundred metres of the source (Halvorsen & Heaney 2018).

With regard to conductor piling, the low hammer energy, narrow diameter of pipes and short duration of piling, combined with field measurements of sound propagation from this activity (Jiang *et al*. 2015, MacGillivray 2018), and the behavioural responses reported in Graham *et al*. (2019), suggest a very low potential for significant disturbance of marine mammals.

Noise from vessels and drilling activity is audible to marine mammals but are not of the characteristics sufficient to cause injury. Vessel noise may elicit low-level disturbance effects in marine mammals (e.g. changes in vocalisation rates and dive behaviour)[38]; however, such effects are temporary, of limited spatial extent.

Fish

Many species of fish are highly sensitive to sound and vibration and broadly applicable sound exposure criteria have recently been published (Popper *et al.* 2014). Studies investigating fish mortality and organ damage from noise generated during seismic surveys are very limited and results are highly variable, from no effect to long-term auditory damage (reviewed in Popper *et al.* 2014). Slabbekoorn *et al*. (2019) note that there are few good case-studies in the peer-reviewed literature that report on the impact of a seismic survey on the behavioural response of free-ranging fish or the direct impact on local fisheries. Behavioural responses and effects on fishing success ("catchability") have been reported following seismic surveys (Pearson *et al.* 1992, Skalski *et al.* 1992, Engås *et al.* 1996, Wardle *et al*. 2001, Bruce *et al.* 2018). Potential effects on migratory diadromous fish is an area of significant interest for which empirical evidence is still limited, especially as salmonids and eels are sensitive to particle motion (not sound pressure) (Gill & Bartlett 2010). Atlantic salmon *Salmo salar* have been shown through physiological studies to respond to low frequency sounds (below 380Hz), with best hearing at 160Hz (threshold 95 dB re 1 μPa). Harding *et al.* (2016) note a lower sensitivity at 100Hz than

[38] Note that in studies of animals in the wild it is difficult to determine the relative contribution of noise and physical presence of vessels in the observed responses, with the latter discussed in Section 4.4.6.

previously reported (Hawkins & Johnstone 1978), and greater sensitivity at frequencies of >200Hz, with evidence of some response at 400-800Hz. However, the authors qualify their results with differences in methodological approach, and the use of fish maintained in tanks receiving low frequency ambient sound within the greatest range of sensitivity (<300Hz) for some time in advance of the experiments taking place. The ability of salmon to respond to sound pressure is regarded as relatively poor with a narrow frequency span, a limited ability to discriminate between sounds, and a low overall sensitivity relative to other fish species (Hawkins & Johnstone 1978, cited by Gill & Bartlett 2010, Harding *et al.* 2016). The Mickle *et al*. (2018) study of the hearing ability of sea lamprey (*Petromyzon marinus*) reported that, consistent with fish lacking a swim bladder, sea lamprey showed a limited sensitivity to sound, with juveniles detecting tones of 50-300Hz, but not higher frequencies

In addition to considering direct effects on fish as qualifying features of national network sites, fish also form important prey items of seabird, marine mammal and fish qualifying features. Fish species of known importance to both diving seabirds and marine mammals in the North Sea include sandeels, pelagic species such as herring and sprat, and young gadoids. Sandeels lack a swim bladder, which is considered to be responsible for their observed low sensitivity to underwater noise (Suga *et al*. 2005) and minor, short-term responses to exposure to seismic survey noise (Hassel *et al*. 2004), although data are limited. By contrast, herring are considered hearing specialists, detecting a broader frequency range than many species. Sprat are assumed to have similar sensitivities to herring due to their comparable morphology, although studies on this species are lacking. Observed responses of herring to underwater noise vary. For example, Peña *et al*. (2013) did not observe any changes in swimming speed, direction, or school size as a 3D seismic vessel slowly approached schools of feeding herring from a distance of 27km to 2km; conversely, Slotte *et al*. (2004) observed herring and other mesopelagic fish to be distributed at greater depth during periods of seismic shooting than non-shooting, and a reduced density within the survey area. Evidence for and against avoidance of approaching vessels by herring has been reported (e.g. Skaret *et al*. 2005, Vabø *et al*. 2002), with the nature of responses believed to be related to the activity of the school at the time.

Following a review of relevant studies, MMS (2004) consider that the “consensus is that seismic airgun shooting can result in reduced trawl and longline catch of several species when the animals receive levels as low as 160dB”. These reduced catches are temporary in nature and likely reflect temporary displacement and/or altered feeding behaviour. No associations of lower-intensity, continuous drilling noise and fishing success have been demonstrated, and large numbers of fish are typically observed around producing installations in the North Sea (e.g. Løkkeborg *et al*. 2002, Fujii 2015) and elsewhere (e.g. Stanley & Wilson 1991).

Diving birds

Direct effects from seismic exploration noise on diving birds could potentially occur through physical damage, or through disturbance of normal behaviour, although evidence for such effects is very limited. Unlike other receptor groups, no dedicated reviews on the effects of noise on diving birds have been undertaken; distillations of available evidence can be found in Hartley Anderson Limited (2020), U.S. Department of the Navy (2020) and the DOSITS website[39]. The exposure of shallow plunge-diving or surface-dipping aquatic birds to underwater noise is likely to be negligible due to the very short period of time they spend underwater (U.S. Department of the Navy 2020). Deeper-diving species which spend longer periods of time underwater (e.g. auks) may be most at risk of exposure to high-intensity noise

[39] https://dosits.org/animals/sound-reception/how-do-aquatic-birds-hear/

from seismic survey and consequent injury or disturbance, but all species which routinely submerge in pursuit of prey and benthic feeding opportunities (i.e. excluding shallow plunge feeders) may be exposed to anthropogenic noise. A full list of relevant species occurring in the UK is provided in Box 4.1, all of which are qualifying species of one or more relevant sites considered in this HRA (see Appendix A).

Very high amplitude low frequency underwater noise may result in acute trauma to diving seabirds, with several studies reporting mortality of diving birds in close proximity (i.e. tens of metres) to underwater explosions (Yelverton *et al*. 1973, Cooper 1982, Stemp 1985, Danil & St Leger 2011). However, mortality of seabirds has not been observed during extensive seismic operations in the North Sea and elsewhere. While seabird responses to approaching vessels are highly variable, flushing disturbance would be expected to displace most diving seabirds from close proximity to seismic airgun arrays, particularly among species more sensitive to visual disturbance such as scoter, divers and cormorant (Garthe & Hüppop 2004, Fliessbach *et al*. 2019). Therefore, the potential for acute trauma to diving birds from seismic survey is considered to be very low.

Data relating to the potential behavioural disturbance of diving birds due to underwater noise are very limited. The reported in-air hearing sensitivity for a range of diving duck species, red-throated diver and gannet have been tested for tone bursts between frequencies of 0.5-5.7kHz; results revealed a common region of greatest sensitivity from 1-3kHz, with a sharp reduction in sensitivity >4kHz (Crowell e*t al.* 2015). Similar results were observed for African penguin; tests of in-air hearing showed a region of best sensitivity of 0.6-4kHz, consistent with the vocalisations of this species (Wever *et al*. 1969). Testing on the long-tailed duck underwater showed reliable responses to high intensity stimuli (> 117 dB re 1µPa) from 0.5-2.9kHz (Crowell 2014). An underwater hearing threshold for cormorant of 70-75 dB re 1µPa rms for tones at tested frequencies of 1-4kHz has been suggested (Hansen *et al*. 2017). The authors argue that this underwater hearing sensitivity, which is broadly comparable to that of seals and small odontocetes at 1-4kHz, is suggestive of the use of auditory cues for foraging and/or orientation and that cormorant, and possibly other species which perform long dives, are sensitive to underwater sound. The use of acoustic pingers mounted on the corkline of a gillnet in a salmon fishery, emitting regular impulses of sound at *ca.* 2kHz, was associated with a significant reduction in entanglements of guillemot, but not rhinoceros auklet (Melvin *et al*. 1999). In a playback experiment on wild African penguins, birds showed strong avoidance behaviour (interpreted as an antipredator response) when exposed to killer whale vocalisations and sweep frequency pulses, both focussed between 0.5-3kHz (Frost *et al*. 1975).

McCauley (1994) inferred from vocalisation ranges that the threshold of perception for low frequency seismic noise in some species (e.g. penguins, considered as a possible proxy for auk species) would be high, hence individuals might be adversely affected only in close proximity to the source. A study investigated seabird abundance in Hudson Strait (Atlantic seaboard of Canada) during seismic surveys over three years (Stemp 1985). Comparing periods of shooting and non-shooting, no significant difference was observed in abundance of fulmar, kittiwake and thick-billed murre (Brünnich's guillemot). More recently, Pichegru *et al*. (2017) used telemetry data from breeding African penguins to document a shift in foraging distribution concurrent with a 2D seismic survey off South Africa. Pre/post shooting, areas of highest use (indicated by the 50% kernel density distribution) bordered the closest boundary of the seismic survey; during shooting, their distribution shifted away from the survey area, with areas of higher use at least 15km distant to the closest survey line. However, insufficient information was provided on the spatio-temporal distribution of seismic shooting or penguin distribution to determine an accurate displacement distance. It was reported that penguins quickly reverted to normal foraging behaviour after cessation of seismic activities, suggesting a relatively short-term influence of seismic activity on these birds' behaviour and/or that of their prey (Pichegru *et al*. 2017).

These data are limited, but the observed regions of greatest hearing sensitivity for cormorants in water and other diving birds in air are above those low frequencies (i.e. <500Hz) which dominate and propagate most widely from geological survey. While there is some evidence of noise-induced changes in the distribution and behaviour of diving birds in response to impulsive underwater noise, these have been temporary and may be a direct disturbance or reflect a change in prey distribution during that period (possibly as a result of seismic activities).

Box 4.1: Migratory and/or Annex I diving bird species occurring in the UK considered potentially vulnerable to underwater noise effects

Divers and grebes	**Diving ducks**
Great northern diver *Gavia immer* Red-throated diver *Gavia stellata* Black-throated diver *Gavia arctica* Little grebe *Tachybaptus ruficollis* Great crested grebe *Podiceps cristatus* Slavonian grebe *Podiceps auritus* **Seabirds** Manx shearwater *Puffinus puffinus* Gannet *Morus bassanus* Cormorant *Phalacrocorax carbo carbo* Shag *Phalacrocorax aristotelis* Guillemot *Uria aalge* Razorbill *Alca torda* Puffin *Fratercula arctica*	Pochard *Aythya ferina* Tufted duck *Aythya fuligula* Scaup *Aythya marila* Eider *Somateria mollissima* Long-tailed duck *Clangula hyemalis* Common scoter *Melanitta nigra* Velvet scoter *Melanitta fusca* Goldeneye *Bucephala clangula* Red-breasted merganser *Mergus serrator* Goosander *Mergus merganser*

Note: Includes species which are known to engage in pursuit diving or benthic feeding in marine, coastal and estuarine waters at least during part of the year.

4.5.3 Screening criteria for underwater noise effects

With respect to **underwater noise effects**, any area offered that is within 15km of a SAC with qualifying features regarded as sensitive to underwater noise (e.g. marine mammals and migratory fish) should be screened in. In the context of measurements and modelling for the different sound sources, established injury threshold criteria and, relevant studies of observed effects, including those in the UKCS, 15km is considered to be a conservative estimate of a maximum distance within which likely significant effects could be expected from the loudest noise sources associated with seismic survey activities. Areas within 15km of an SPA designated for diving birds (see Box 4.1) should also be screened in.

Relevant sites and carbon storage licence areas offered which have been screened in on the basis of underwater noise effects are shown in Figures 5.3 (SPAs) and 5.4 (SACs) and are listed in Appendix B3. The potential for interactions of mobile qualifying species (primarily seabirds, marine mammals and fish) with exploration and appraisal activities when outside of relevant site boundaries is considered in Section 4.6. Where appropriate, areas >15km from relevant site boundaries may be screened in.

4.6 Consideration of mobile species

There is the potential for mobile qualifying species (primarily seabirds, marine mammals and fish) to interact with exploration and appraisal activities which could occur in the areas offered while those species are outside of their related relevant sites. An overview of the current understanding of the foraging ranges of relevant species is given below, including a discussion of their potential interaction with work programme activities at distance from relevant sites. An important distinction is made in this section between a potential interaction with site features and those exploration and appraisal activities which may follow licensing, and the potential for likely significant effects (i.e. those which undermine the site's conservation objectives).

4.6.1 Seabirds

Marine SPAs designated for foraging aggregations of seabirds and their 'source' SPAs

Efforts over the past decade to identify important foraging aggregations of seabirds for the purpose of SPA designation (e.g. Kober *et al*. 2010, 2012, Lawson *et al*. 2018) have resulted in a number of designated marine SPAs. It is recognised that bird aggregations within these marine SPAs may originate from separately designated breeding colony SPAs. In many cases colony SPAs are adjacent to a related marine SPA (e.g. terns breeding at Lindisfarne SPA or Northumbria Coast SPA and foraging within the Northumberland Marine SPA) but the seabirds from the colony may also be located some distance away (e.g. seabirds breeding at the Flannan Islands SPA and foraging at the Seas off St Kilda SPA, ~16km distant). Consequently, the marine SPA site documentation and additional tagging data (where available) have been examined to identify their known 'source' colony SPAs; where areas have been screened in for these marine SPAs based on the screening criteria, they have also been screened in for their linked 'source' SPAs (see Table 4.2). While it is acknowledged that the mean maximum foraging ranges of many seabird species are large, and that there is the theoretical potential for marine SPAs to be used by birds from a large number of colony SPAs, the focus here is on source SPAs from which the majority of birds within the marine SPA are likely to originate, as discussed in the relevant site documentation, or have been shown to be linked through tagging data.

Table 4.2: Marine SPAs initially screened in which are designated for foraging aggregations of seabirds during the breeding season and their 'source' breeding colony SPAs

Marine SPA/pSPA	'Source' breeding colony SPAs (relevant species; distance)
Southern North Sea	
Greater Wash SPA	North Norfolk Coast SPA (breeding sandwich tern, little tern and common tern; contiguous)
	Humber Estuary SPA (breeding little tern, contiguous)
	Gibraltar Point SPA (breeding little tern, contiguous)
	Great Yarmouth North Denes SPA (breeding little tern; contiguous)
	Breydon Water SPA (breeding common tern; contiguous)
	Outer Thames Estuary SPA (breeding little tern; contiguous, breeding common tern; contiguous, non-breeding red-throated diver; contiguous)
	The Wash SPA (breeding little tern; contiguous, non-breeding common scoter; contiguous)
East Irish Sea	
Liverpool Bay SPA	Morecambe Bay & Duddon Estuary SPA (breeding common tern and little tern, adjacent)

Marine SPA/pSPA	'Source' breeding colony SPAs (relevant species; distance)
	Ribble and Alt Estuaries SPA (breeding common tern, contiguous)
	Mersey Narrows and North Wirral Foreshore SPA (breeding common tern, contiguous)
	The Dee Estuary SPA (breeding common tern and little tern, contiguous)

Notes: includes sites designated for wintering waterbird features which are common with the overlapping/adjoining marine SPA.

Data on movements and foraging ranges

Information on the foraging movements of a number of seabird species has increased in recent years, mainly due to advances in satellite and other tracking technologies (e.g. Langston *et al*. 2013, Wakefield *et al*. 2015, 2017, Thaxter *et al*. 2014, 2018, Cleasby *et al*. 2015, Bogdanova *et al*. 2017, Carter *et al*. 2016, Edwards *et al*. 2016, Votier *et al*. 2017, Lane *et al.* 2021). Woodward *et al*. (2019) reported on representative breeding season foraging ranges for a range of species. While some colony specific data are referred to by Woodward *et al.* (2019), there generally remains limited information on foraging areas used by species from these colonies.

Table 4.3 provides indicative foraging ranges (mean and mean maximum) travelled for a range of seabird species from a breeding colony to a foraging area. The mean maximum foraging range value has been used here to show possible connectivity to breeding colony SPAs, but bird density will not be continuous throughout this range. Other ways of representing foraging ranges (e.g. the mean, or percentage foraging area derived from kernel analyses) may therefore provide more useful information, where available. Whilst applying mean maximum foraging radius would encompass the majority of a population's home-range area, the overall size of the predicted foraging areas around the colony would potentially make it too large to be a useful management tool, without further refinement using habitat and bathymetric data (Soanes *et al.* 2016). Similarly, the assumption that seabirds are uniformly distributed out to some threshold distance from their colonies, such as their putative maximum foraging range, is unrealistic. Seabird density declines with distance from the colony with density-dependent competition, coastal morphology and habitat preferences (Wakefield *et al*. 2017), for example oceanographic features at which seabirds preferentially forage including shelf-edge fronts, upwelling and tidal-mixing fronts, offshore banks and internal waves, regions of stratification, and topographically complex coastal areas subject to strong tidal flow (Cox *et al.* 2018), resulting in highly non-uniform distributions. While Critchley *et al*. (2018) used a distance-weighted foraging radius approach to project distributions at sea for a wide range of seabird species during the breeding season, the authors recognised the limitations of not considering environmental variables that contribute to such non-uniform distributions noted above.

More recently, Waggitt *et al.* (2020) produced monthly maps of modelled seabird distributions for UK seas for 12 seabird species. The model used collated and standardised North-East Atlantic survey data covering the years 1980-2018, with maps covering a broad area of North West European waters. The mapped outputs are instructive in showing a general illustration of relative seabird density and broad-scale distribution, but at this time, lack the precision that would be required to make any interpretation of absolute densities (Waggitt *et al.* 2020). They do, however, represent an alternative approach to understanding the distribution of seabirds throughout the year in the absence of basin-scale seasonal data.

Table 4.3: Indicative breeding season foraging ranges

Species	Mean maximum[1] (km)	Mean[2] (km)	Confidence level[3]
Eider	21.5	3.2±4.2	Poor
Red-throated diver	9	4.5	Low
Fulmar	542.3±657.9	134.6±90.1	Good
Manx shearwater	1346.8±1018.7	136.1±88.7	Moderate
Leach's storm petrel	n/a	657	Moderate
Gannet	315.2±194.2	120.4±50	Highest
Cormorant	25.6±8.3	7.1±3.8	Moderate
Shag	13.2±10.5	9.2±4.9	Highest
Arctic skua	n/a	2±0.7	Poor
Great skua	443.3±487.9	67±31.5	Uncertain
Black-headed gull	18.5	7	Uncertain
Common gull	50	n/a	Poor
Mediterranean gull	20	11.5	Uncertain
Herring gull	58.8±26.8	14.9±7.5	Good
Lesser black-backed gull	127±109	43.3±18.4	Highest
Kittiwake	156.1±144.5	54.7±50.4	Good
Sandwich tern	34.3±23.3	9±9.2	Moderate
Roseate tern	12.6±10.6	4.1±2.6	Moderate
Common tern	18±8.9	6.4±4.5	Good
Arctic tern	25.7±14.8	6.1±4.4	Good
Little tern	5	3.5	Moderate
Guillemot	55.5±39.7[4]	23.9±21.1[4]	Highest
Razorbill	73.8±48.4[4]	31.2±17.3[4]	Good
Puffin	137.1±128.3	62.4±34.4	Good

Notes:

1. The maximum range reported in each study averaged across studies.

2. The mean foraging range reported for each colony averaged across all colonies. For tracking studies, this was typically the mean foraging range from all central place foraging trips assessed at the colony.

3. Confidence levels were assigned as follows: highest (based on >5 direct studies where data suggests low variability between sites making the ranges more likely to be representative for unsampled sites); good (based >5 direct studies with greater variability in data and a lower confidence that the ranges will be representative for unsampled sites); moderate (between 2-5 direct studies); low (indirect measures or only one direct study); uncertain (survey-based estimates); poor (few survey estimates or speculative data only).

4. Excludes data for Fair Isle where foraging range may have been unusually high as a result of reduced prey availability during the study year.

Source: Woodward *et al.* (2019)

The distribution at sea throughout the year of many of the species in Table 4.3 is summarised in Appendix A1a.6 of the OESEA4 Environmental Report (BEIS 2022); in general, they are widely distributed at low densities with areas of moderate or higher density. Within the North Sea, these areas include: the shelf edge for gannet and lesser black-backed gulls; the Dogger Bank for guillemot; the Dutch Bank for herring gull; Fladen Ground for kittiwake; and, the Moray Firth and Aberdeen bank for razorbill (Stone *et al*. 1995), and in the Irish Sea, the Irish Sea Front is important for Manx shearwater, common guillemots, razorbills and gannets.

Wakefield *et al.* (2017) used extensive tracking data and environmental covariates to model the predicted at-sea distribution of four seabird species during the breeding season (shag, guillemot, razorbill and kittiwake), including extrapolations for Seabird 2000 census counts at some 5,500 breeding sites in Britain and Ireland. Seabird density was shown to decline with distance from the colony, with kittiwake distribution being the most diffuse (albeit with discrete high-density areas) and shag the most confined to near-shore waters. While density-dependent competition, coastal morphology and habitat preferences resulted in highly non-uniform distributions, the core areas of use of all four study species overlapped within most of the coastal waters in Scotland, highlighting the importance of this area to these species (Wakefield *et al*. 2017). The data underpinning the modelling exercise were collected during the incubation and the early chick rearing period and therefore may only be representative of this period, and also not reflect non-breeding or immature behaviours (Cleasby *et al.* 2018).

A BEIS-funded three-year telemetry study of gannets from Bempton Cliffs indicated a marked decline in the density of foraging locations with distance from colony, which was the overriding influence on gannet distribution at-sea during the breeding season (Langston *et al*. 2013). Similarly, Votier *et al*. (2010, 2011) reported that breeding gannets, constrained by the need to regularly return to the nest, foraged less widely than immature birds. Other studies using GPS tracking of breeding gannets have indicated some consistency in the use of foraging areas by individual adults (e.g. Hamer *et al*. 2007, Patrick *et al*. 2015, Wakefield *et al*. 2015). Votier *et al*. (2017) showed that breeding gannets (aged 5+) displayed strong site fidelity, followed similar routes and were faithful to distal points during successive trips. Conversely, immature gannets (aged 2-3) were far more exploratory and lacked route or foraging site fidelity, and failed breeders showed intermediate behaviours. The authors proposed that foraging sites may be learned during exploratory behaviours early in life, which become established with age and experience (see also Grecian *et al*. 2018, Phillips *et al.* 2017). A tagging study at Bass Rock indicated that females made longer foraging trips than males both prior to chick hatching and during chick rearing, though both sexes show a more restricted foraging distribution during the rearing stage (Lane *et al.* 2020).

Aggregations of birds could be present in some of the areas on offer while foraging and in the post-breeding period, which for some birds (e.g. auks) includes post-breeding moult when the birds are flightless. These birds are likely to comprise individuals from several colony SPAs in the UK and further afield, spanning several hundred kilometres of coastline. As part of the process of identifying potential Marine Protected Areas, seabird aggregations have been delineated through analysis of the European Seabirds at Sea (ESAS) database (Kober *et al.* 2010, 2012). Forty-two areas were identified for eleven seabird species, covering many of the species highlighted in Table 4.3 (fulmar, Manx shearwater, gannet, shag, great skua, kittiwake, common gull, herring gull, Arctic tern, guillemot and puffin) in both the breeding and the non-breeding seasons. A review of 25 of these areas in light of other independent information was carried out to provide a more robust and complete evidence-base on which to base any future decisions about these areas (note that a number are currently proposed SPAs) (Cook *et al.* 2015). The review also considered whether there was a sound ecological rationale behind each aggregation such as the presence of suitable habitat, proximity to known breeding colonies, or high abundance of prey species in the area. In addition to offshore seabird aggregations, work on inshore wintering waterbird aggregations (e.g. Lawson *et al.* 2015a, b, c, Lawson *et al.* 2018, O'Brien *et al.* 2015), foraging areas for terns (Wilson *et al.* 2014, Parsons *et al.* 2015), foraging areas for red-throated divers (Black *et al.* 2015) and aggregations of shags (Daunt *et al.* 2015) has also contributed to the identification of SPAs.

Physical, visual or acoustic disturbance from exploration drilling and seismic survey is not regarded to result in significant effects for SPA features in relation to any of the areas on offer beyond those already screened in, as outlined in Sections 4.4 and 4.5. This is due to: the relatively small seabed footprint and transitory nature of rig placement/installation and drilling discharges coupled with the relatively low densities of seabirds in offshore waters; that none of the species that are likely to be present offshore (outside areas screened in by the 10km physical disturbance criterion) are particularly vulnerable to disturbance by shipping (Garthe & Hüppop 2004) and are therefore unlikely to be significantly disturbed by the presence and movement of vessels associated with exploration activities. The typically low density of diving birds in offshore areas, and their limited exposure time and likely low sensitivity to underwater noise (see Section 4.5) would indicate that significant disturbance from seismic surveys in the areas offered beyond those already screened in by the 15km noise criterion, is unlikely.

4.6.2 Marine mammals

Applicable Annex II species include the two species of seal which breed in the UK, the harbour (*Phoca vitulina*) and grey seal (*Halichoerus grypus*) and two cetaceans, the harbour porpoise (*Phocoena phocoena*) and bottlenose dolphin (*Tursiops truncatus*). These species are highly mobile and wide-ranging and will spend time away at considerable distances beyond the boundaries of designated sites. Therefore, there is a need to consider the potential for activities which may follow licensing to have effects on site features outside of site boundaries. Such effects are considered for these four marine mammal species in the sections below, distinguishing between short-term disturbance (which is managed under EPS disturbance licences) and likely significant effects in the context of the site conservation objectives.

Seals

There are 14 seal management units (SMUs) currently in use around the UK (see Figures 5.5 and 5.6) which were delineated based on a number of factors including the practicalities of surveying the areas, respecting national boundaries and the minimisation of movements between SMUs in the foraging season and between foraging and breeding season (SCOS 2020). Given the movement of animals between MUs (Russell *et al*. 2013), especially by grey seals, impacts on animals may have effects at the population level outside the particular MU with which the ‘population’ is associated (SCOS 2020). SCOS (2020) notes that harbour seals can likely be split into two metapopulations; Scotland and Northern Ireland, east England, with the latter being part of a wider continental Europe population. Grey seals are much further ranging (see below) suggesting they are part of a bigger European metapopulation.

Major breeding colonies of grey and harbour seals are protected around the UK as a series of coastal SACs, several of which extend, to varying degrees, into adjacent waters. As central-place foragers, seal colonies and haul-out sites are important not only in the breeding season, but throughout the year through provision of habitat for resting and during moulting periods. Nonetheless, grey and harbour seals are highly mobile marine species which spend extensive periods of time foraging beyond the boundaries of colony SACs (Matthiopoulos *et al*. 2004, Sharples *et al*. 2012, Jones *et al*. 2015). One study estimated that between 21-58% of female grey seals predominately foraged in a different region[40] to that within which they bred (Russell *et al*. 2013), while telemetry and individual recognition (photo-identification) data have revealed the movement of seals, particularly grey seals, between the UK and the waters of adjacent countries (Jones *et al*. 2015, Brasseur *et al*. 2015).

Models of the at-sea distribution of grey and harbour seals which breed and haul-out around the UK and Ireland have been developed from extensive tagging data combined with

[40] The regions investigated included: Hebrides; northern Scotland (*ca*. Cape Wrath to Rattray Head); east coast (*ca*. Rattray Head to River Tees); and, south-east coast (*ca*. River Tees to Deal) (Russell *et al*. 2013).

population estimates derived from aerial and land-based counts (e.g. Jones *et al*. 2015). The most recent model iterations (Carter *et al.* 2020, 2022) use a habitat modelling approach incorporating data from approximately 114 grey and 239 harbour seal individuals tagged between 2005 and 2019, counts of seals on land from aerial and ground survey platforms conducted during the annual harbour seal moult in August, and a range of environmental covariates. Figures 5.4 and 5.5 show the mean predicted relative density in UK waters of harbour and grey seals respectively on a 5x5km grid in relation to the relevant seal management units, the carbon storage licence areas offered and those already screened consistent with the screening criteria presented in Sections 4.4. and 4.5.

Grey seals use offshore areas (up to 100km from the coast) connected to their haul-out sites by prominent corridors, while harbour seals primarily stay within 50 km of the coastline (Jones *et al*. 2015). For both species, density is greatest in coastal waters adjacent to colonies. Some of the areas offered overlap offshore areas of relatively high seal usage in the southern North Sea which extend from the Humber Estuary SAC and The Wash and North Norfolk Coast SAC, and these are discussed below.

A large area of estimated high density (relative to the majority of UK and Irish waters) of grey seals radiates out from the Humber Estuary SAC (Figure 5.6). While the highest predicted densities of ≥100 seals per grid cell are within c. 12km of the site boundary, densities of 50-100 seals per grid cell extend up to almost 20km from the site boundary. Furthermore, there are several discrete areas of relatively high density (50-100 seals per grid cell) up to c. 60km offshore and over 80km from the site boundary, lying within a larger area of moderate-high relative density (10-50 seals per grid cell) extending from the site. While it is likely that some grey seals occurring in these offshore areas breed at colonies elsewhere on the UK east coast (e.g. Blakeney Point, Farne Islands), due to the area's proximity to the large colony at Donna Nook (at the mouth of the Humber Estuary), and the tracks of individuals seals tagged there connected with these areas, the majority of seals using these waters are likely to be associated with the Humber Estuary SAC. Furthermore, tracks from seals tagged at Donna Nook suggest that this area provides a route for seals in transit to/from foraging patches further offshore, over the Dogger Bank. Consequently, along with SNS Area 3 (which is within 15km of the site boundary), SNS Area 6 is screened in for further assessment with regard to potential physical and underwater noise effects on the grey seal feature of the Humber Estuary SAC. This area overlaps or is immediately adjacent to the area of higher relative density of seals extending from the Humber Estuary (defined as grid cells of ≥0.025% of the seal population per 5x5km).

At a British Isles-level, harbour seals primarily occur in coastal waters and spend only 3% of their time >50km from the coast; however, The Wash is one exception, where harbour seals spend more time farther offshore and have been observed travelling to sandbanks up to 150km offshore (Jones *et al*. 2015). The predicted at-sea usage map for harbour seal (Figure 5.5) show a large area of higher use (relative to the majority of UK and Irish waters) extending north-east from The Wash, with values of >0.1% of the British population per 5x5km grid cell in some areas, and of > 0.01% up to approximately 40km from the site boundary. From tracks of individual seals tagged at The Wash (e.g. see Carter *et al.* 2020), and consideration of the distribution of adjacent colonies, it can be assumed that the majority of harbour seals using this area are associated with The Wash and North Norfolk Coast SAC. The only area offered which is of relevance to this consideration is SNS Area 3, which has already been screened in based on the physical disturbance and noise criteria described in Sections 4.4 and 4.5 respectively, including for effects on the harbour seal feature of The Wash and North Norfolk Coast SAC.

Cetaceans

Bottlenose dolphins

Analyses of photo-identification data and some genetic studies have shown that within European waters there are coastal/inshore groups of bottlenose dolphins which are mobile and range over large areas but still show strong site fidelity along defined stretches of coast (see ICES 2013, Quick *et al*. 2014). Robinson *et al*. (2012) reported that some individual dolphins sighted off the east coast of Scotland were sighted in subsequent years off the west coast of Scotland and in Irish waters, although the population identity of these apparently wide-ranging individuals was unknown. Whilst ICES (2013) recognised that in some areas information is incomplete, that distribution may be ephemeral and the animals present likely comprise sympatric populations, they proposed a series of bottlenose dolphin MUs for UK waters; the boundaries of which were finalised by IAMMWG (2015). Within UK waters, the only SACs where bottlenose dolphin is a qualifying feature lie within the Irish Sea and coastal east Scotland MUs.

With regard to the MU for bottlenose dolphin in the coastal regions of east of Scotland and the Moray Firth SAC (the only site designated for this population), the range of this population extends well beyond the boundaries of the SAC as animals utilise waters off the southern Moray Firth, Grampian and Fife coasts (Cheney *et al*. 2013), with sightings also taking place off the coast of northeast England[41]. Quick *et al*. (2014) showed that individual dolphins range up and down the coast, with much spatial and temporal variability in individual movements. Outside of the Moray Firth SAC, dolphins were most frequently encountered in waters less than 20m deep and within 2km of the coast in and around the Tay Estuary as well as along the coast between Montrose and Aberdeen. Further studies of animals occurring between St Andrews Bay and the Tay Estuary have revealed the estimated number of dolphins using this area in summer to have increased from 2009-2019, and represent, on average, 53% of the total estimated east coast population (Arso Civil *et al*. 2019, 2021).

Sightings of several distinctive individuals from the coastal east Scotland population have also been reported in non-UK waters[42]: one individual was observed of the east coast of Ireland in May 2019 and off southwest Ireland in July 2019 along with another individual from the Scottish east coast population; further, images from a sighting of bottlenose dolphins off the Netherlands coast in July 2019 confirmed the presence of at least four individuals from the Scottish east coast population. All of these individuals were observed in the Moray Firth in summer 2018.

The carbon storage licence areas offered are too distant from the East Coast bottlenose dolphin management unit, the Firth of Tay or north east England for there to be a foreseeable interaction with the bottlenose dolphin population of the Moray Firth SAC.

Bottlenose dolphins are the second most frequently recorded species in the Irish Sea, with a predominantly coastal distribution and particularly high concentrations off west Wales and off the coast of Co. Wexford in southeast Ireland. While effort-related sightings are few in the northern Irish Sea, the species is regularly sighted in summer off the Galloway coast of south-west Scotland and around the Isle of Man (Hammond *et al.* 2005, Baines & Evans 2012). Relevant SACs for the Irish Sea MU for bottlenose dolphins, which includes the entire Irish

[41] https://www.seawatchfoundation.org.uk/recentsightings/, also see citizenfins, a project combining research and citizen science to improve the understanding of the movements of bottlenose dolphin along the east coasts of Scotland England: https://citizenfins.wp.st-andrews.ac.uk/
[42] https://www.abdn.ac.uk/lighthouse/blog/international-sightings/

Sea, includes the Lleyn Peninsula and Sarnau SAC and Cardigan Bay SAC to the south of the EIS Area 1. The wider movements of dolphins associated with these two sites are not well known, and occasional sightings throughout much of the Irish Sea coast suggest that some animals may range widely throughout the region (Baines & Evans 2012). However, regular sightings at rates comparable to those from land- and vessel-based surveys in Cardigan Bay, combined with extensive matches of individuals with those observed in Cardigan Bay indicate that coastal waters around the north and east coast of Anglesey are important for animals associated with these two SACs (Pesante *et al.* 2008, Baines & Evans 2012, Evans *et al.* 2015). It is apparent that a large proportion of this population spend the winter in waters off north Wales, whilst smaller numbers can be seen in this area throughout the year (Pesante *et al.* 2008). Photo ID has confirmed the waters around the Isle of Man to represent the northern range limit of the Cardigan Bay population (Feingold & Evans 2014), but is likely to extend further (Lohrengel *et al.* 2018)

Harbour porpoise

The harbour porpoise is the most common cetacean in UK waters; it is wide-ranging and abundant throughout the UK shelf seas, both coastally and offshore (Reid *et al*. 2003). It is seen throughout the year, although peak numbers are generally recorded in summer months from June to October. Since the early 1990s it appears to have become much less common around the Northern Isles, while increasing in numbers in the English Channel, southern North Sea and in the Celtic Sea, where few individuals had been previously observed (i.e. SCANS-I 1994) (Hammond *et al*. 2013, 2017; also see Evans *et al.* 2015). In coastal waters they are often encountered close to islands and headlands with strong tidal currents (e.g. Pierpoint 2008); sightings becoming increasingly rare close to the continental shelf edge, with relatively few records in deeper waters beyond the shelf edge (Reid *et al*. 2003). Individuals across the UKCS are part of the north east Atlantic population which is mainly considered to be a single 'continuous' population, even though some degree of genetic differentiation has been observed (Andersen *et al.* 1997, 2001, Tolley *et al.* 2001, Fontaine *et al.* 2007). However, for management and conservation purposes, three distinct UK Management Units have been proposed (IAMMWG 2015, 2021); the North Sea, West Scotland and the Celtic & Irish Seas.

Heinänen & Skov (2015) identified discrete and persistent areas of relatively high porpoise density, which were mainly within the Irish Sea and Welsh coastal waters, shelf waters of the North Sea and along the north-west Scottish coast. Six Special Areas of Conservation (in both inshore and offshore waters) for harbour porpoise were identified, all of which have now been designated. For one of the harbour porpoise SACs (Southern North Sea), multiple relevant licence area offers have been screened-in through the criteria for potential physical and drilling or acoustic effects, as have areas relevant to the Doggersbank SAC and Klaverbank SAC in neighbouring Dutch waters.

While harbour porpoise are a wide-ranging species and are likely to frequently occur beyond site boundaries, these sites encompass large areas of favourable habitat supporting higher densities of the species than other areas of the UKCS. Considering this, in addition to the buffer provided by the screening criteria, and maintaining a distinction between the potential for interaction between activities following the licensing of any area and site features outside of site boundaries (e.g. short-term disturbance, which is managed under EPS disturbance licences) and likely significant effects in the context of the site conservation objectives, it is not considered necessary to screen in any additional carbon storage licence area-site combinations for harbour porpoise.

4.6.3 Fish

Of those fish listed under Annex II of the EC Habitats Directive, only Atlantic salmon, sea lamprey and river lamprey are qualifying species of sites relevant to the carbon dioxide licence area offers.

Given their widespread and transient presence offshore, potential temporary exploration/appraisal activity away from the coast is unlikely to have a significant effect on relevant sites. Of the relevant sites with qualifying Annex II fish species, the Humber Estuary SAC (sea lamprey, river lamprey) has already been screened in on the basis of its proximity to SNS Area 3. The closest relevant site to any other area offered (EIS Area 1) is some 45km (Dee Estuary SAC, sea lamprey, river lamprey) and significant effects are not considered to be likely.

4.6.4 Conclusion

Whilst individuals of the mobile species discussed above could potentially interact with work programme activities associated with the appraisal term (see Section 2.2) for area other than those already screened in using the criteria set out in Sections 4.4 and 4.5, and those additional areas identified in the southern North Sea above, significant effects on the populations of sites relating to such species, and therefore the conservation status of such sites, are not considered likely. This is due to the combination of:

- The small physical footprint of activities and their transitory nature.
- The likely scale of potential activity duration of the appraisal term (likely between 4 and 8 years) within which activity could take place.
- The likely relative density of relevant features in relation to activities which could take place.

4.7 In-combination effects

This screening assessment includes the potential for in-combination effects resulting from the interaction of exploration/appraisal activities in the carbon dioxide storage licence areas with activities resulting from other marine plans, programmes and activities to lead to likely significant effects on relevant sites.

Marine planning has a key role in informing strategic and project level spatial considerations, with the Marine Policy Statement indicating, *"Marine Plans should reflect and address, so far as possible, the range of activities occurring in, and placing demands on, the plan area. The Marine Plan should identify areas of constraint and locations where a range of activities may be accommodated. This will reduce real and potential conflict, maximise compatibility between marine activities and encourage co-existence of multiple uses."*

Marine plans have been adopted in England and Scotland which cover all of the carbon dioxide storage areas on offer. To date, whilst the marine plans acknowledge the potential interactions between activities and map these, indicate key resource areas and provide policy context and direction in relation to potential activity interactions, they are not spatially prescriptive and provide a limited indication of the location of possible future development, how co-location may be accommodated, or any form of activity prioritisation.

The uncertainty over the scale and timing of activities which could follow licensing of 1st carbon storage licensing round and the activities resulting from other plans and programmes is recognised. Using a GIS, the areas offered are considered in the context of areas of activity and proposals for a range of marine activities/potential activities including:

- Oil and gas licences (Figure 5.7)
- Leases/licences or Agreement for Leases for hydrocarbon gas storage (Figure 5.7)
- Oil and gas infrastructure (Figure 5.7)
- Marine renewable energy developments, zones and related cables/cable agreement areas, and offshore interconnectors (Figure 5.8)
- Telecommunications cables (Figure 5.8)
- Marine aggregate extraction (Figure 5.8)
- Shipping density (Figures 5.9 and 5.10)
- Fisheries

GIS outputs are included for each of the above showing the spatial relationship to SPAs and SACs and a text based consideration is made of the potential for in-combination effects leading to likely significant effects on national network sites (see Section 5).

5 Screening

5.1 Screening of potential effects of appraisal activities

The screening of the various sources of impact from exploration and appraisal activities which could follow licensing of all, or part of the areas offered (as described in Section 4) were applied to the relevant SPA and SAC sites and considered in the context of mobile species when not within site boundaries. This led to the identification of a number of site/area combinations for which likely significant effects could not be discounted at the screening stage. Figures 5.1-5.3 illustrate these initial screening results as paired maps showing the areas offered and sites which have been screened in.

The areas screened in at this stage are:

- Eastern Irish Sea: Area 1
- Central North Sea: Area 1
- Southern North Sea: Area 1, Area 2, Area 3, Area 4, Area 5, Area 6, Area 7, Area 8

5.2 Screening for potential in-combination effects

All areas offered as part of the 1st carbon storage licensing round, including those screened in (above), were considered further in terms of the potential for likely significant effects to arise from activities following licensing, in-combination with those from other marine activities. Relevant marine activities were identified based on those referred to in Appendix 1h of OESEA4 (BEIS 2022)[43] and where it was considered that a relevant pathway of in-combination effect was present. The sources of in-combination effect are regarded to be largely related to physical disturbance and underwater noise, and in the context of those areas being offered for licensing, any such effects are expected to be primarily from other offshore energy activity, specifically offshore wind in the east Irish Sea and southern North Sea.

Figure 5.7 illustrates the spatial relationship between existing oil and gas licences, agreements for lease (AfL) for gas storage and carbon dioxide storage, the relevant sites, as well as the carbon dioxide licensing areas on offer. Existing controls on exploration and appraisal operations which include those for oil and gas, and carbon dioxide storage are outlined in Section 4.3. These suggest that significant in-combination effects of existing licensed areas and those proposed for licensing in the 1st carbon storage licensing round on relevant sites are not likely. There is some overlap with existing seaward oil and gas licences and related infrastructure, with some infrastructure potentially relevant to re-use for carbon dioxide transport and storage[44]. Whilst some of the licensed oil and gas blocks which overlap the areas offered for carbon dioxide storage are mature, with some also relevant to fields subject to decommissioning, others were relatively recently acquired e.g. in the 30th or 32nd Rounds and exploration activity may still take place in these. In view of the typical licence and activity

[43] Relevant marine planning portals for England and Scotland were also referred to, in addition to other sources of the latest spatial data on marine activities including data.gov.uk and EMODnet

[44] e.g. see: https://www.gov.uk/government/consultations/carbon-capture-usage-and-storage-ccus-projects-re-use-of-oil-and-gas-assets

durations relevant to exploration and appraisal for oil and gas and carbon dioxide storage, the limited potential spatial overlap and the documented scale of effects together with existing controls on exploration and appraisal operations (see Section 4.3), significant in-combination effects on relevant sites are not likely to occur.

The oil and gas industry are planning for the decommissioning of a number of mature oil and gas fields that overlap with the areas offered for carbon dioxide storage, or are implementing decommissioning plans which involve offshore activities (e.g. for well plug and abandonment and infrastructure removal)[45]. This includes plans for fields and related infrastructure in the areas offered for carbon storage, which may be partially complete, including in the northern North Sea (Tern, Cormorant), central North Sea (e.g. MacCulloch and the Greater Balmoral Area), southern North Sea (Cavendish, Indefatigable, Vulcan, Hewitt) and east Irish Sea (south Morecambe). Some of these are adjacent to or coincide with relevant sites, including in the central and southern North Sea, and east Irish Sea. These include Liverpool Bay SPA, Southern North Sea SAC, Dogger Bank SAC, North Norfolk Sandbanks and Saturn Reef SAC and Haisborough, Hammond and Winterton SAC. All of these sites have already been screened in to the second stage of HRA where the potential for significant cumulative and in-combination effects from the above and any further decommissioning programmes would be assessed.

The Rough gas storage facility is located adjacent to SNS Area 3. Production from Rough continues, but storage has now ceased, however, a licence to store gas at the site was approved in July 2022[46]. When considered in the context of the nature and scale of potential activities associated with the appraisal term of carbon dioxide storage licensing, the limited offshore facilities and operations associated with Rough are unlikely to result in significant in-combination effects. Additionally, a gas storage application has also been made for the Bains field in the east Irish Sea, adjacent to EIS Area 1, but there are no current plans in place to take forward any project and no significant effects are therefore foreseeable.

A number of existing carbon dioxide appraisal and storage licence areas are immediately adjacent to those areas on offer. These include CS001, CS005, CS006 and CS007 in the southern North Sea and CS003 in the central North Sea. The latter licence relates to the Acorn project. There remains some uncertainty as the nature and timing of any storage projects relating to the current southern North Sea licences. In view of the likely scale of appraisal activity that could result from licensing and of the 1st carbon storage licensing round areas and a lack of firm project plans or timescales for most of the offshore storage projects, significant in-combination effects are not currently considered likely.

Figure 5.8 shows marine renewable energy development areas, relevant sites and the areas offered in the 1st carbon storage licensing round. A number of the areas overlap with renewable energy developments (either planned or operational), and with relevant sites. For example, EIS Area 1 partly overlaps with the Walney and Walney extension offshore wind farms, and a Round 4 project area. Similarly there is a small overlap between SNS Area 1 and the Round 4 project to the south of Dogger Bank, and SNS Area 3 and a number of wind farms off the Humber and Wash, including Westermost Rough, Humber Gateway, Lincs, Inner Dowsing, Lynn and Race Bank. Issues relating to co-location between carbon dioxide storage

[45] See: https://www.gov.uk/guidance/oil-and-gas-decommissioning-of-offshore-installations-and-pipelines and https://www.nstauthority.co.uk/supply-chain/energy-pathfinder/
[46] https://www.nstauthority.co.uk/licensing-consents/gas-storage-and-unloading/, https://www.nstauthority.co.uk/news-publications/news/2022/nsta-awards-rough-gas-storage-licence-to-centrica-offshore-uk-ltd-in-first-stage-of-potential-reopening/

and offshore wind are discussed in OESEA4 (BEIS 2022), with storage site monitoring being a key concern (e.g. see Robertson & McAreavey 2021). The Offshore Wind and CCUS Co-location Forum[47], led by The Crown Estate, was formed in 2021 and brings together the NSTA, the Carbon Capture and Storage Association (CCSA), RenewableUK, Government and Crown Estate Scotland to provide strategic coordination of co-location research and activity. There is significant overlap with some of the areas offered, wind farm lease areas across a range of stages of development, and relevant sites. This includes the Liverpool Bay SPA, Greater Wash SPA, Dogger Bank SAC, southern North Sea SAC, Inner Dowsing, Race Bank and North Ridge SAC.

A HRA has been published as part of a review of consents (RoC) for offshore wind farms identified to have a likely significant effect on the Southern North Sea SAC, the conclusions of which are that, with agreed mitigation measures, the construction of wind farms (including Dudgeon, Hornsea Project One and Two, East Anglia One, Triton Knoll, and Dogger Bank Creyke Beck A and B, Teesside A and B) will not result in an adverse effect on site integrity, including in-combination with oil and gas related activity, in particular seismic survey[48]. This will be considered as part of the in-combination effects assessment of the second stage of HRA where appropriate, and the Southern North Sea SAC has been screened in for a number of the areas offered (Figure 5.2 and Figure 5.3). Relevant wind farm development consent applications submitted following this RoC are expected to be subject to HRA in due course. A RoC process has also commenced for SPAs[49] which include sites and projects of relevance to this assessment (and in particular offshore wind) in the Irish Sea and southern North Sea, including Liverpool Bay SPA and the Greater Wash SPA. The screening stage of the HRA has been concluded and the AA process is ongoing.

In view of the likely terms of any licence offered as part of the round and the early stage of exploration and appraisal planning for those carbon dioxide storage licence areas offered, and status of project development for Round 4 areas which overlap these, in-combination effects are not likely to be significant. Should any areas of licensed in close proximity to existing operational wind farms, and in particular those associated with Liverpool Bay SPA and the Greater Wash SPA, likely significant effects cannot be discounted at this stage. These areas offered and related sites are already screened in (Section 5.1) and will be subject to AA.

Leasing rounds for further offshore wind are presently in planning in parts of Scottish waters[50] and are relevant to this HRA. The Scottish Government are in the process of progressing the Sectoral Marine Plan for Offshore Wind for Innovation and Targeted Oil and Gas Decarbonisation (INTOG). A number of areas of search have been identified and subject to consultation, with the plan targeting future offshore wind leasing specifically to help decarbonise offshore oil and gas production. Two of the INTOG areas overlap NNS Area 1 and NNS Area 2 and several lie close to CNS Areas 1 and 2 (Figure 5.8). For the purposes of this HRA, it is noted that projects are yet to be defined within the broad INTOG areas and that the plan is to be subject to Sustainability Appraisal (incorporating SEA) and HRA. The timing

[47] https://www.thecrownestate.co.uk/en-gb/what-we-do/on-the-seabed/energy/offshore-wind-and-ccus-co-location/
[48] https://www.gov.uk/government/consultations/southern-north-sea-review-of-consents-draft-habitats-regulations-assessment-hra
[49] https://www.gov.uk/government/consultations/review-of-consents-for-major-energy-infrastructure-projects-and-special-protection-areas, https://www.gov.uk/government/publications/review-of-consents-for-major-energy-infrastructure-projects
[50] https://www.gov.scot/publications/initial-plan-framework-sectoral-marine-plan-offshore-wind-innovation-targeted-oil-gas-decarbonisation-intog/

and nature of any subsequent developments are unknown but likely significant in-combination effects have not been identified at this stage.

Potential extensions to eight existing offshore wind farm projects were announced by The Crown Estate in October 2018, covering an additional 3.4GW of new capacity[51]. While none of these overlap any of the carbon storage licence areas offered, several are close to relevant sites which have been screened in, in particular Awel y Môr in relation to Liverpool Bay SPA, and Sheringham Shoal extension and the Greater Wash SPA (Figure 5.8). The extensions were subject to a plan level HRA undertaken by The Crown Estate, which concluded that seven of the eight projects, including those previously mentioned, could progress subject to further site investigation and assessment under the *Planning Act 2008*. Individual project-level HRAs are required to consider effects on, for example, red-throated diver, sandwich tern and lesser black-backed gull which could not be considered in detail at the plan level due to the uncertainty about wind farm design details and the scale of impacts.

The cable routes which may be used to take power to shore for future offshore wind farms are highly uncertain. The Offshore Transmission Network Review (OTNR) was initiated in 2020 and has the aim of coordinating offshore grid connections and having a more strategic approach to offshore transmission that is considered holistically with the onshore network to deliver greater coordination and reduce cumulative effects[52]. The review has three work streams covering Early Opportunities, the Pathway to 2030 and the Enduring Regime. The Holistic Network Design (HND) is part of the Pathway to 2030 work stream and was published in July 2022. The HND largely relates to projects which are at an early development stage, including those from Round 4 and ScotWind leasing, and some in the Celtic Sea. While the HND includes recommendations for the optimal transmission network, the detailed network design will provide more information on the specific routes for offshore cabling. There is insufficient detail at present to meaningfully consider the in-combination effects of potential future cable routes for projects at an early consenting stage.

This screening has already identified a number of sites which should be subject to AA for those areas offered which overlap a number of proposed or operating wind farms, including the Greater Wash SPA. Any further information relating to the proposed Round 4 windfarms or updates to any other wind farm in the planning process will be considered as part of the in-combination effects assessment of the second stage of HRA where appropriate. Plans for further leasing by The Crown Estate may come forward during the appraisal terms of any licences which could be granted as part of the round. Should any further information on further leasing in relevant UK waters become available, this will be considered as part of the in-combination effects assessment of the second stage of HRA.

A range of cables traverse carbon dioxide storage areas offered, which include renewables export cables, electricity interconnectors and telecommunications cables. The surface area of these is extremely small, and they are well-charted features which are readily avoided during exploration or appraisal activities. A range of interconnector projects are either in planning, or at an early stage of development or are under construction, which are of relevance. These include NorthConnect (close to CNS Areas 1 and 2), Eastern HVDC Link (SNS Area 3), Viking Link (SNS Area 4, Area, 6 and Area 7) and the Continental Link multi-purpose interconnector (the details of this project are not yet well defined but may interact with areas offered off the Yorkshire coast). While these project have proposed installation and commissioning dates

[51] https://www.thecrownestate.co.uk/en-gb/media-and-insights/news/2018-the-crown-estate-completes-initial-assessment-of-offshore-wind-extension-applications/
[52] https://www.gov.uk/government/groups/offshore-transmission-network-review

within the timeframe in which offshore activities associated with the appraisal term of any licences awarded could take place, some remain at a pre-planning or feasibility stage (e.g. Continental Link). It is not considered that any additional carbon dioxide licence areas on offer or sites should be screened in due to the potential for interaction with these proposals. Where appropriate these proposals will be considered in more detail in relation to those areas already screened into the second stage of HRA.

Marine aggregate extraction areas, relevant sites and areas offered are shown in Figure 5.8. SNS Areas 3 and 8 overlap licensed aggregate extraction production areas in the southern North Sea, which are also located partly or entirely within the Greater Wash SPA and North Norfolk Sandbanks and Saturn Reef SAC respectively. These areas on offer for carbon dioxide storage and relevant sites have already been screened in to the second stage of HRA, and should part or all of the areas be applied for, the potential for significant in-combination effects on the sites would be assessed.

Figures 5.9 and 5.10 illustrate the spatial relationship between the density of navigation in UK waters, relevant sites and the carbon storage licence areas offered. The only area which overlaps with elevated navigation density and is in proximity to relevant sites (where potential significant in-combination effects could occur) has already been screened in to the second stage of HRA where this consideration will be made (SNS Area 3 and the Greater Wash SPA).

Commercial fishing occurs throughout UK waters and effort data provides a strategic level proxy of fisheries activity across the UKCS. However, it is noted that activity is seasonally and annually variable, and collated publicly available data does not include all fishing activity. Fishing and particularly bottom trawling has historically contributed to seabed disturbance over extensive areas. The updated UK assessment as part of the UK Marine Strategy indicated that while there have been some improvements in commercial fish stocks, there remain issues such that Good Environmental Status (GES) will not be achieved by 2020[53]. Specific to the consideration of conservation sites, the initial assessment of 2012 noted that depending on the nature of future measures (e.g. in relation to MPA management in the wider environment and within MPAs[54], also see the proposed updated programme of measures for the UK's Marine Strategy[55]), the effects of fisheries are likely to be reduced and therefore some improvement in benthic habitats could be expected[56]. A number of byelaws have recently been imposed on conservation sites which effectively prohibit the use of certain gears in all or part of certain SACs, including the Dogger Bank SAC and The Inner Dowsing, Race Bank and North Ridge SAC[57]. Additionally, it is noted that the MMO are pursuing further fisheries restrictions through bylaws for certain conservation sites/features, which is subject to a call for evidence[58]; of most relevance to this assessment is the North Norfolk Sandbanks and Saturn Reef SAC. Similarly, a number of management measures incorporating the prohibition of demersal towed or static

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53 https://www.gov.uk/government/publications/marine-strategy-part-one-uk-updated-assessment-and-good-environmental-status

54 For example, see the MMO strategic management table for MPAs: https://www.gov.uk/government/publications/marine-protected-areas-strategic-management-table and measures proposed by the Scottish Government: https://www.gov.scot/Topics/marine/marine-environment/mpanetwork/SACmanagement

55 https://www.gov.uk/government/consultations/marine-strategy-part-three-programme-of-measures

56 https://www.gov.uk/government/publications/marine-strategy-part-three-uk-programme-of-measures

57 https://www.gov.uk/government/publications/the-inner-dowsing-race-bank-and-north-ridge-special-area-of-conservation-specified-areas-prohibited-fishing-gears-byelaw-2022, https://www.gov.uk/government/publications/the-dogger-bank-special-area-of-conservation-specified-area-bottom-towed-fishing-gear-byelaw-2022

58 https://www.gov.uk/guidance/marine-conservation-byelaws#new-mmo-byelaws https://consult.defra.gov.uk/mmo/call-for-evidence-stage-2/

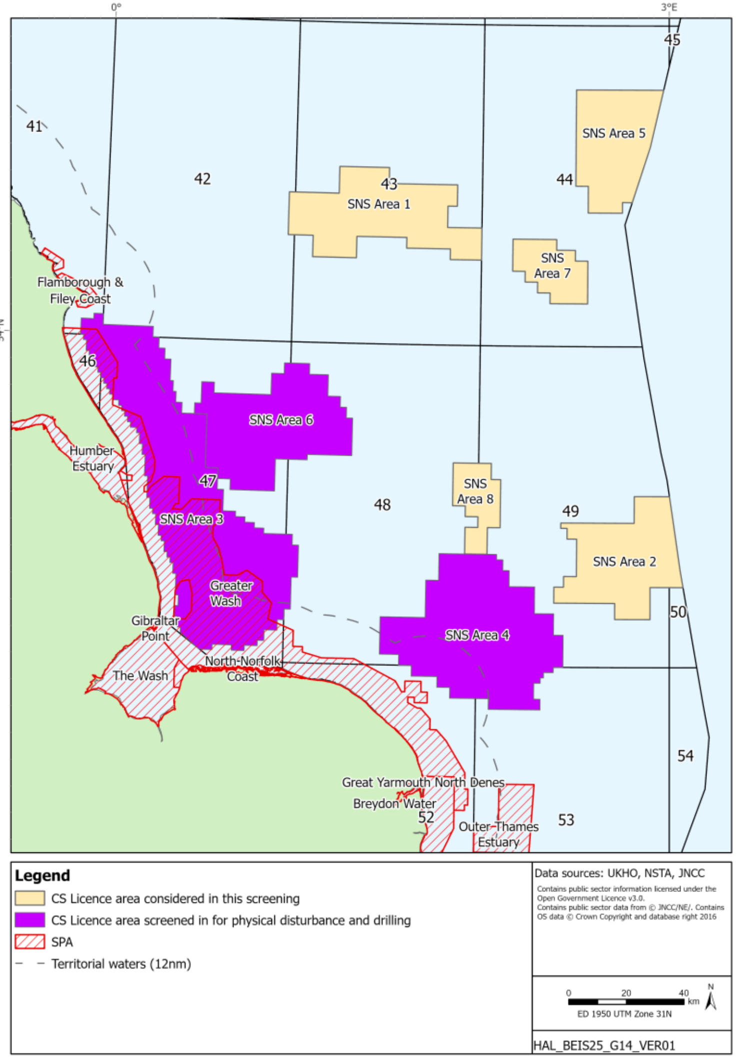
gears in areas of Annex I habitat have been previously proposed for sites in Scottish waters, including the Scanner Pockmark SAC.

Whilst fishing may be linked to historical disturbance to site features, and presents an ongoing risk to these, future management measures should limit the potential for in-combination effects with other activities, particularly when considered in the context of existing controls which are available to avoid effects on sites from exploration/appraisal activity (see Section 4.3), and other activities including offshore renewables which are subject to statutory environmental impact assessment and where appropriate, an HRA. All of the carbon dioxide storage licence areas offered in, or within 10km of sites designated for Annex I habitats, have been screened in to the second stage of HRA, when the potential for significant cumulative and in-combination effects on national network sites would be assessed.

For activity-specific assessments, it is the licensee's responsibility to identify potential in-combination effects and undertake early engagement with other stakeholders.

Figure 5.1: Physical and drilling effects – Areas offered and SPAs screened in

Southern North Sea



East Irish Sea

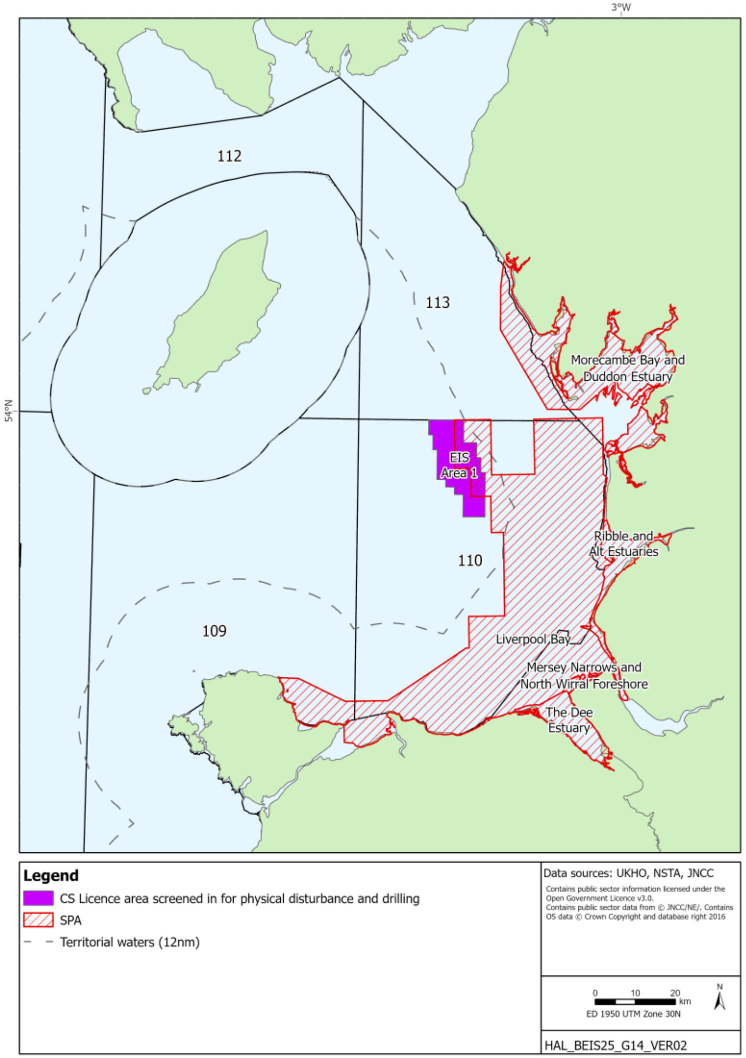
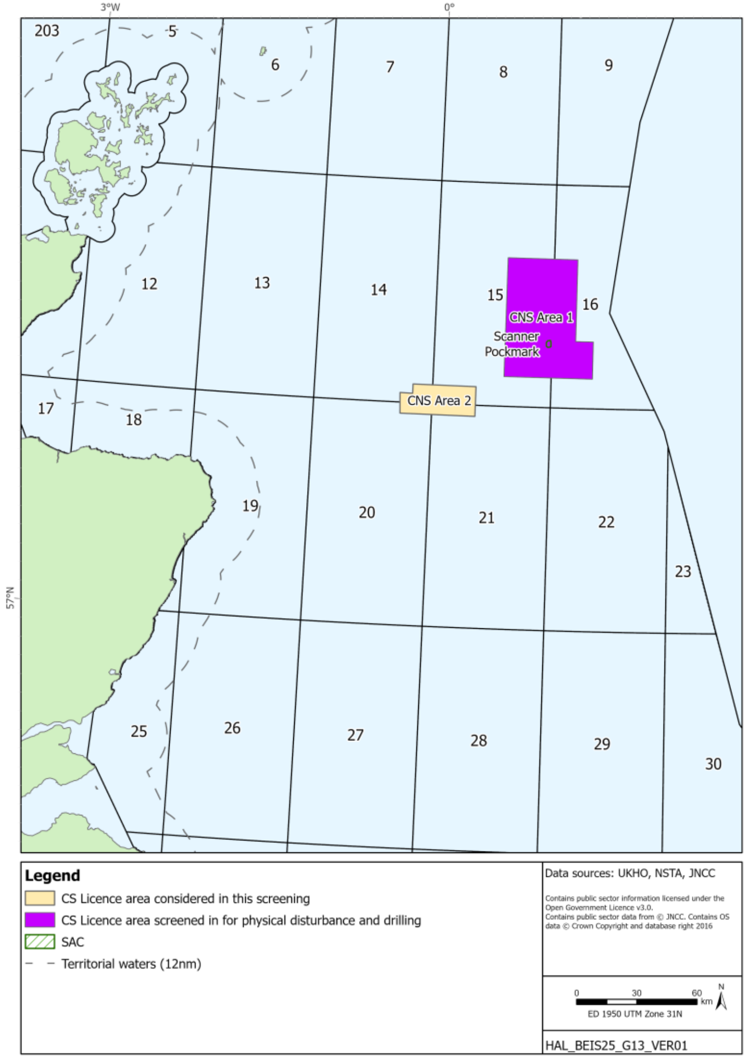


Figure 5.2: Physical and drilling effects – Areas offered and SACs screened in

Central North Sea



Southern North Sea

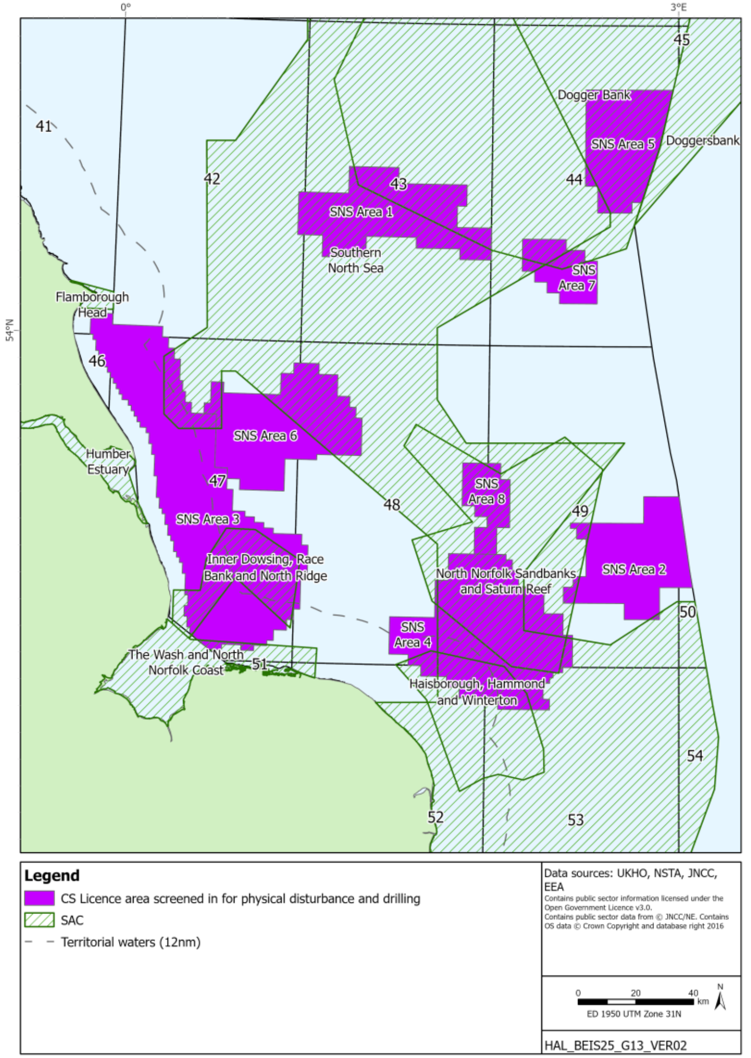
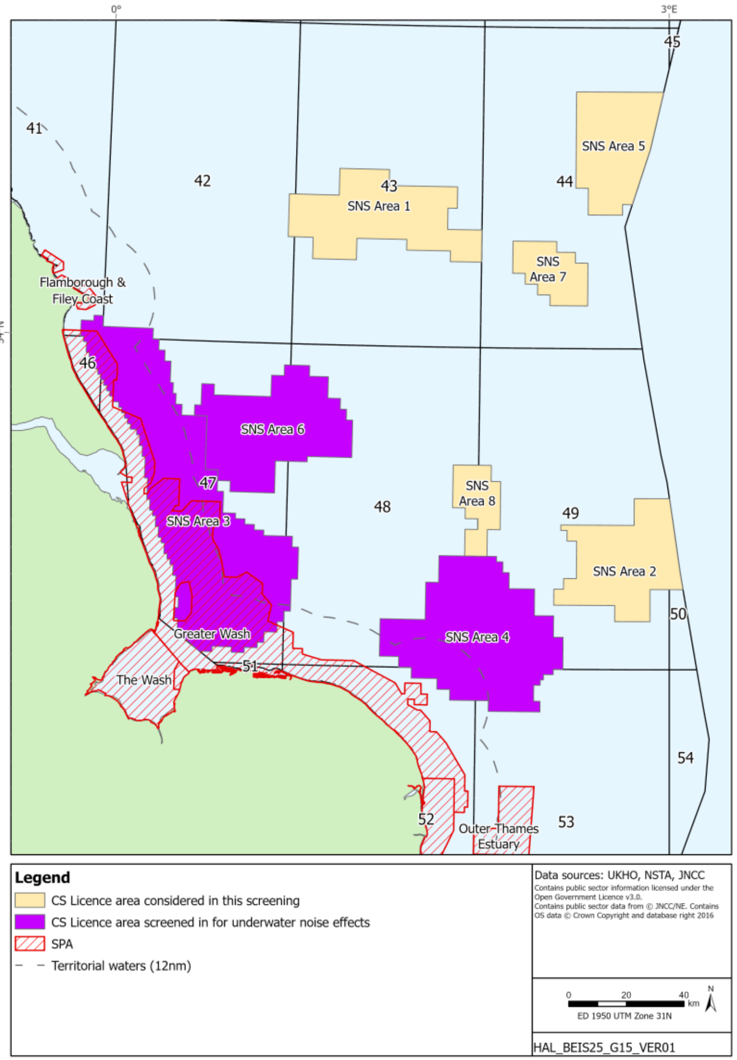


Figure 5.3: Underwater noise effects – Areas offered and SPAs screened in

Southern North Sea



East Irish Sea

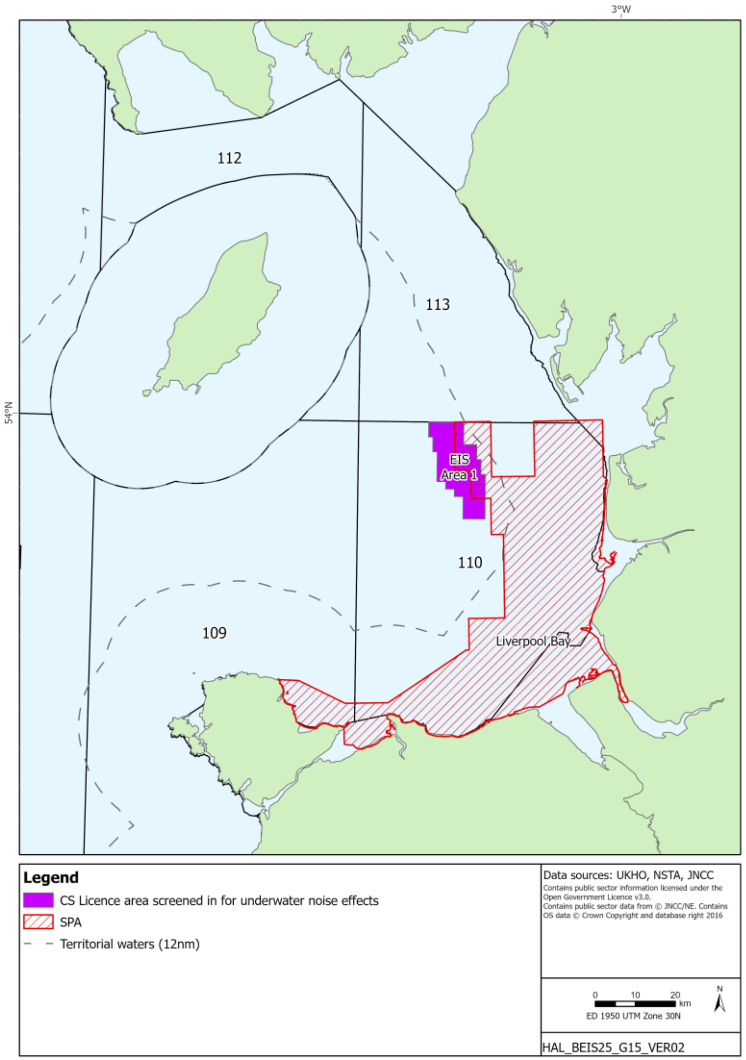


Figure 5.4: Underwater noise effects – Areas offered and SACs screened in Southern North Sea

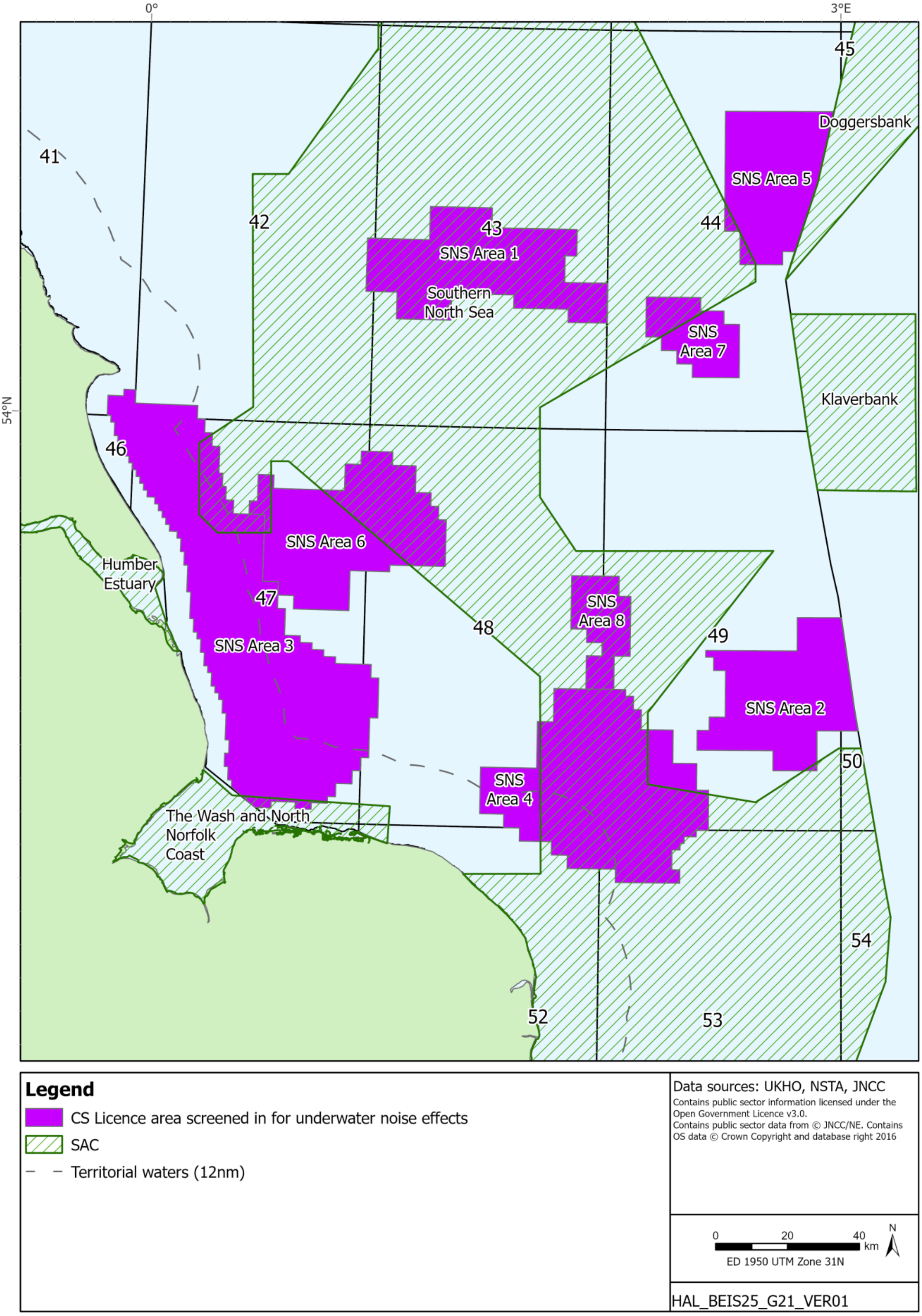


Figure 5.5: Estimated density of harbour seals in UK waters

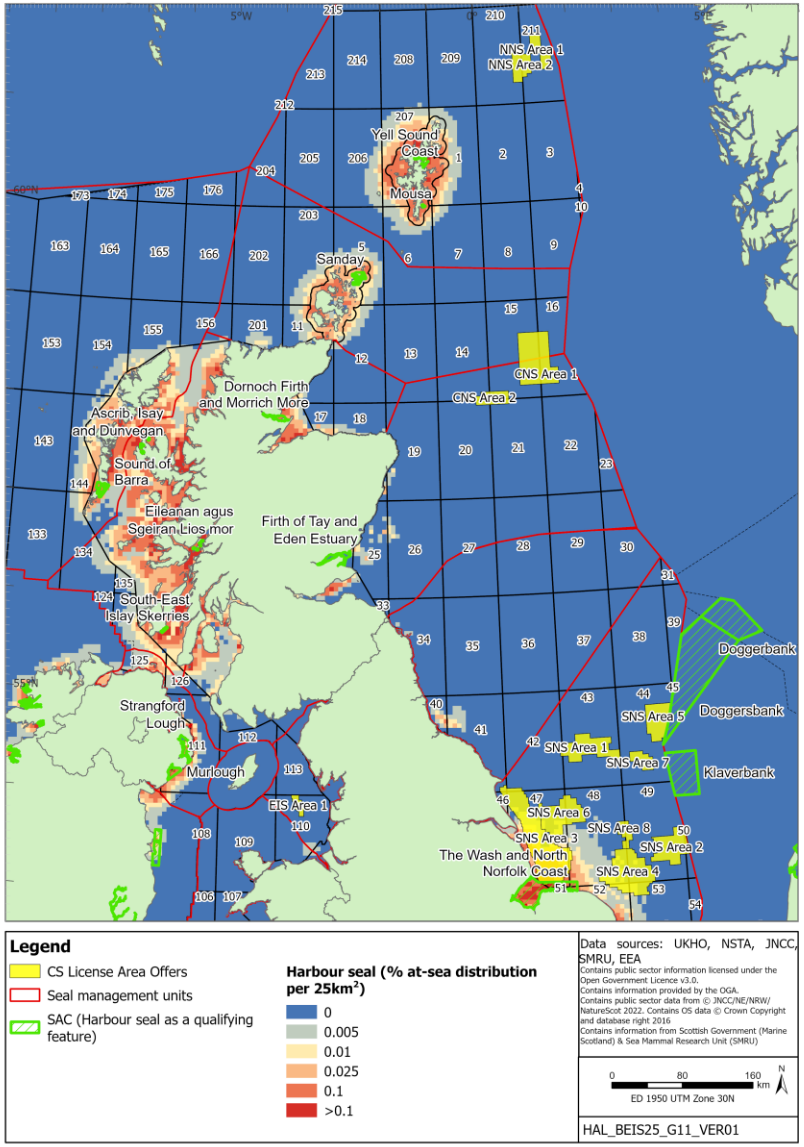


Figure 5.6: Estimated density of grey seals in UK waters

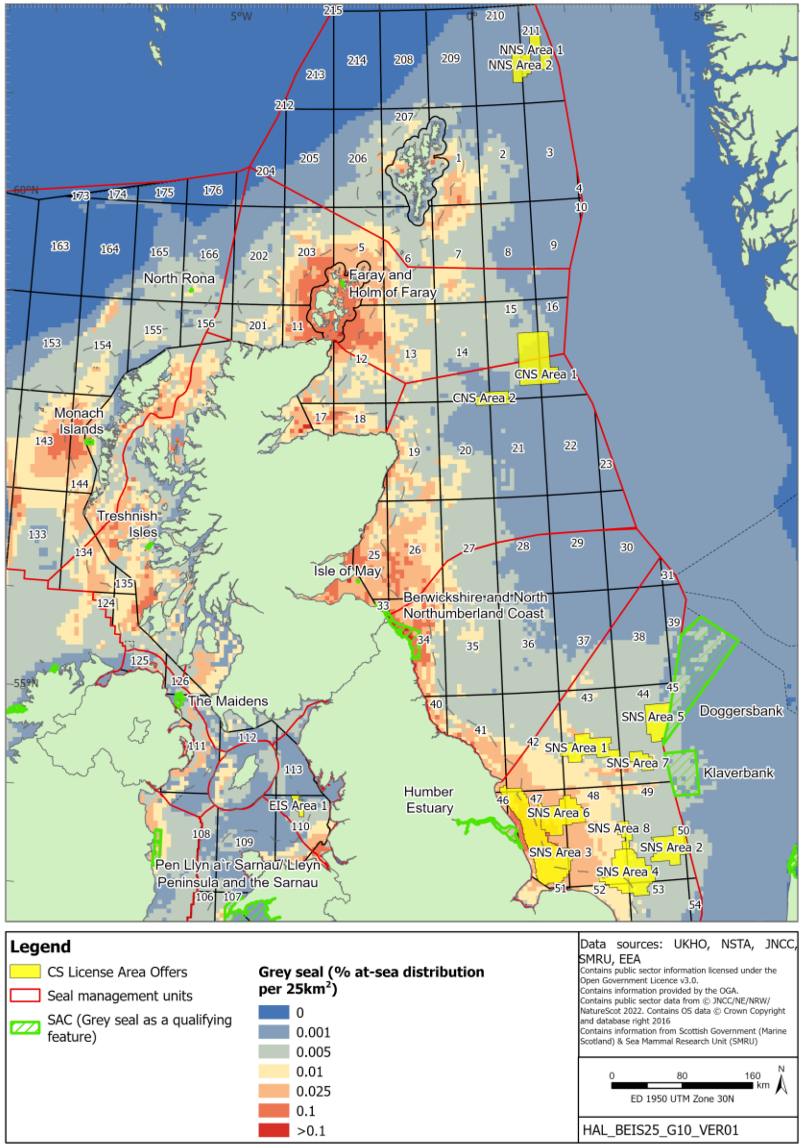
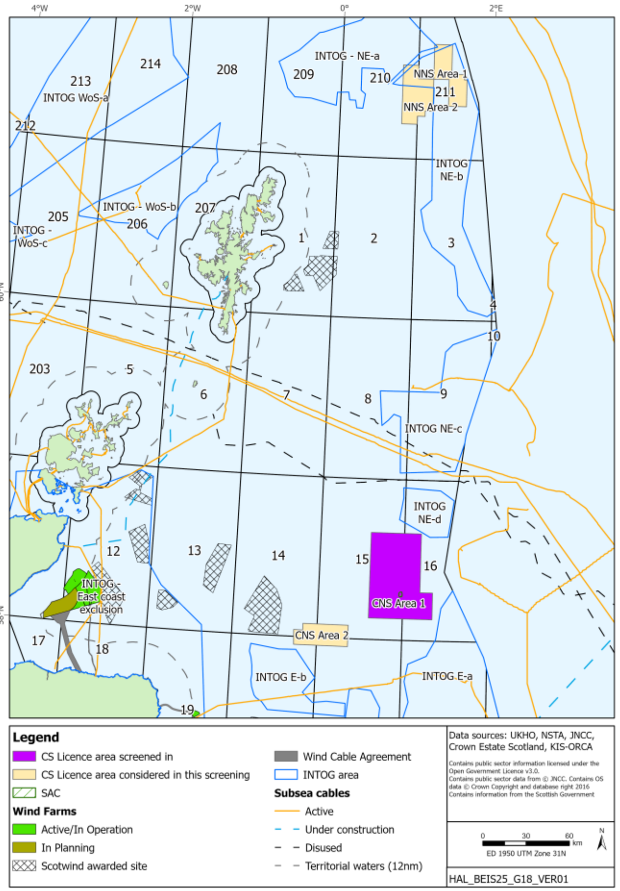
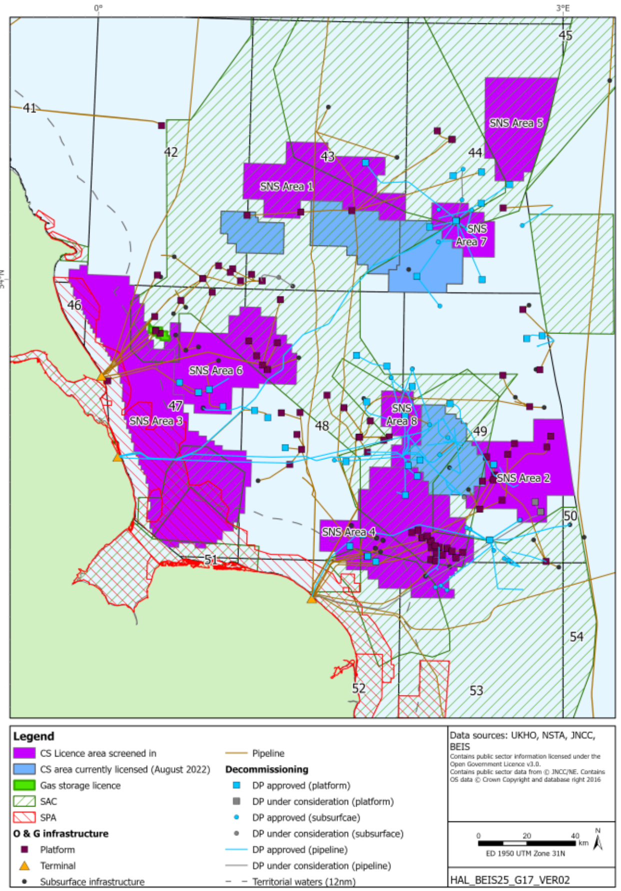


Figure 5.7: Existing oil and gas infrastructure, carbon and gas storage licences, SACs, SPAs and the Areas offered

Central and northern North Sea



Southern North Sea



East Irish Sea

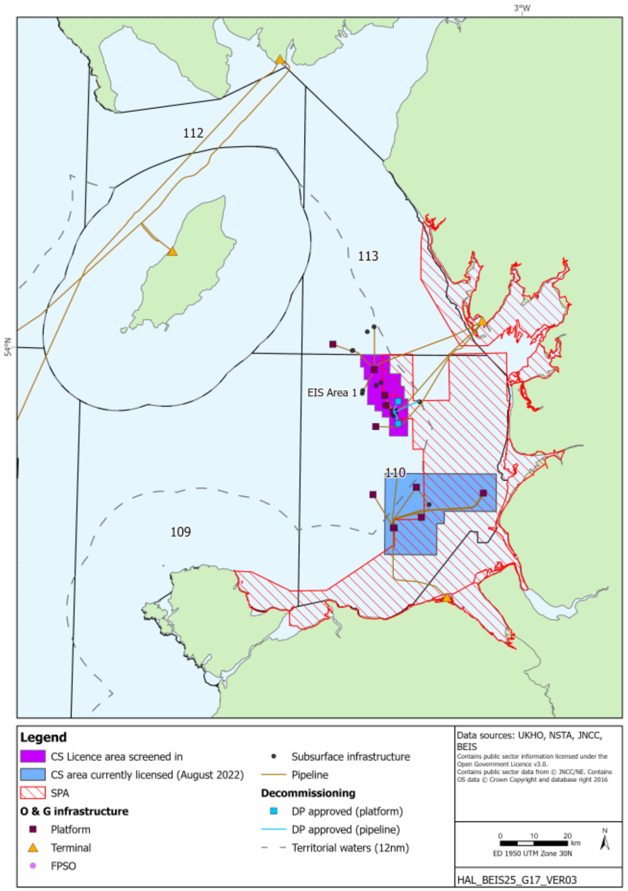


Figure 5.8: Marine renewable energy, aggregate extraction, SPAs, SACs and Areas Offered

Northern and Central North Sea **Southern North Sea** **East Irish Sea**

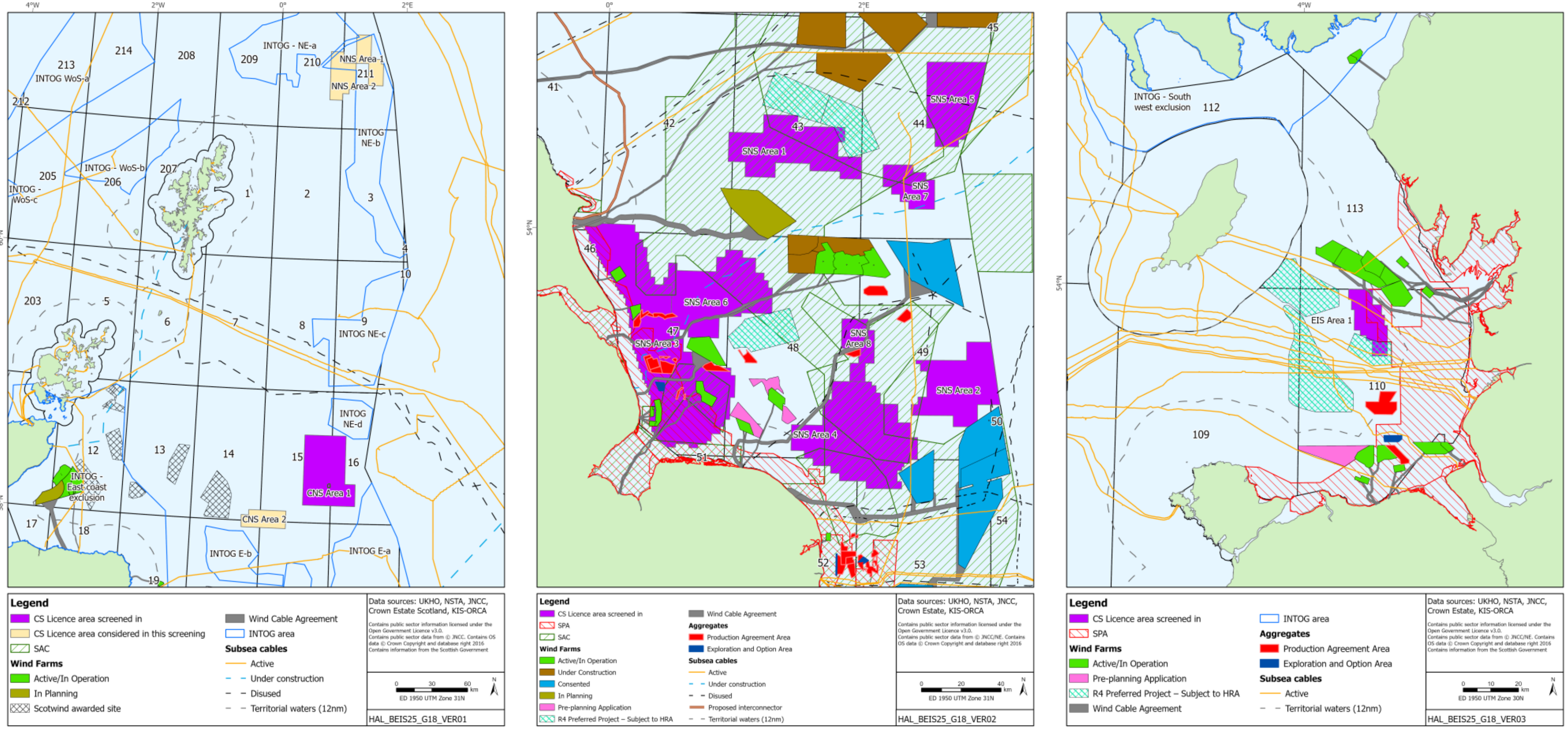


Figure 5.9: Navigation density, SPAs and Areas Offered

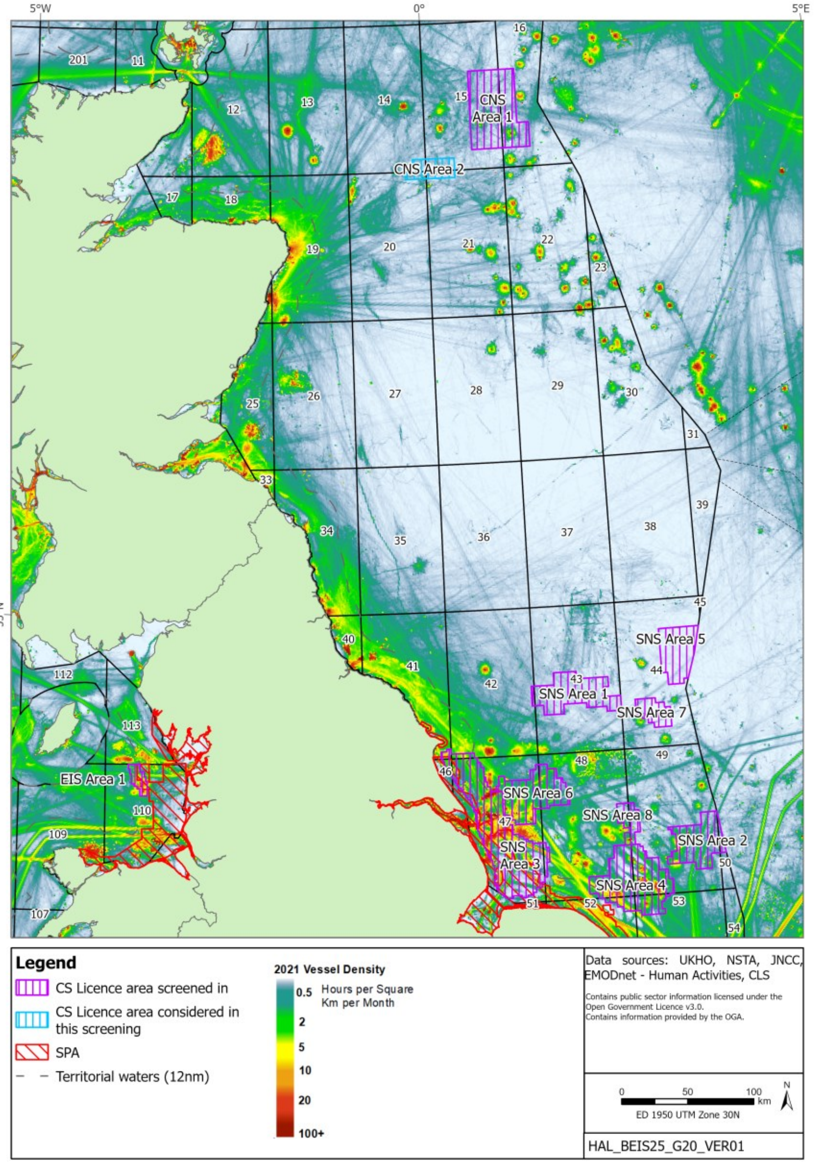
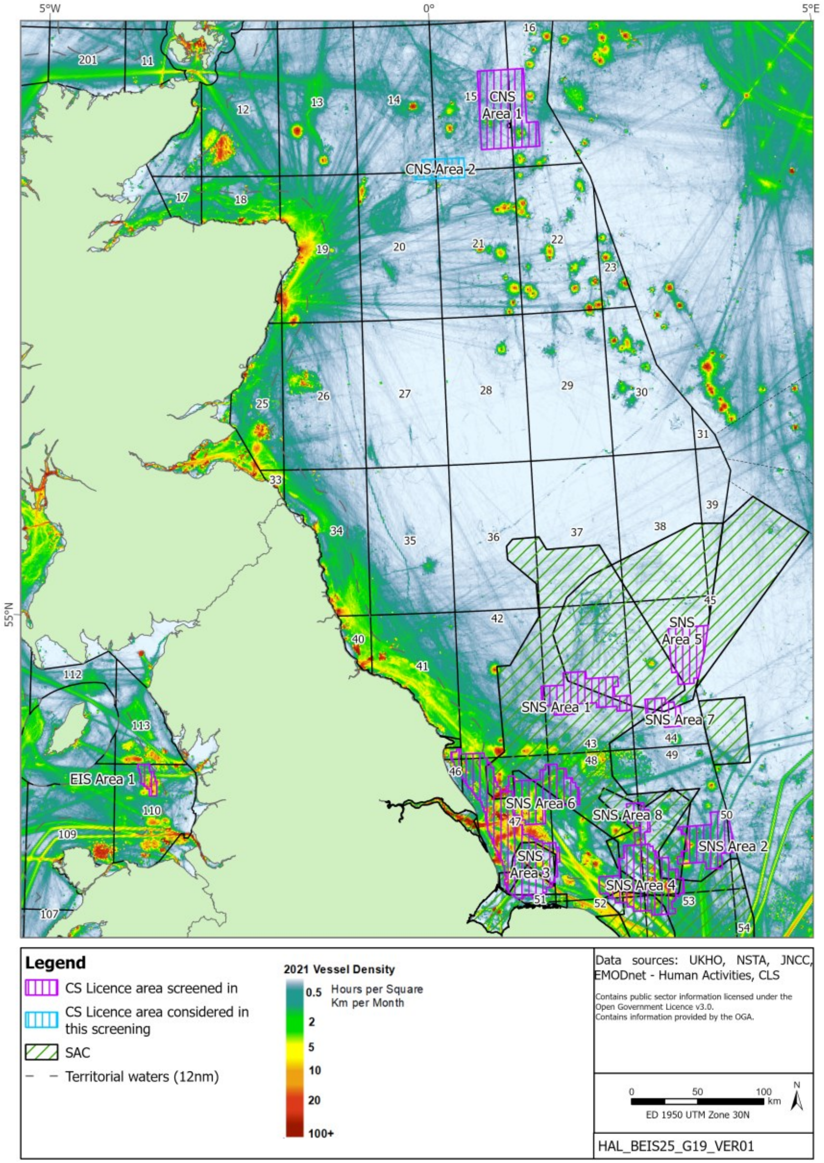


Figure 5.10: Navigation density, SACs and Areas Offered

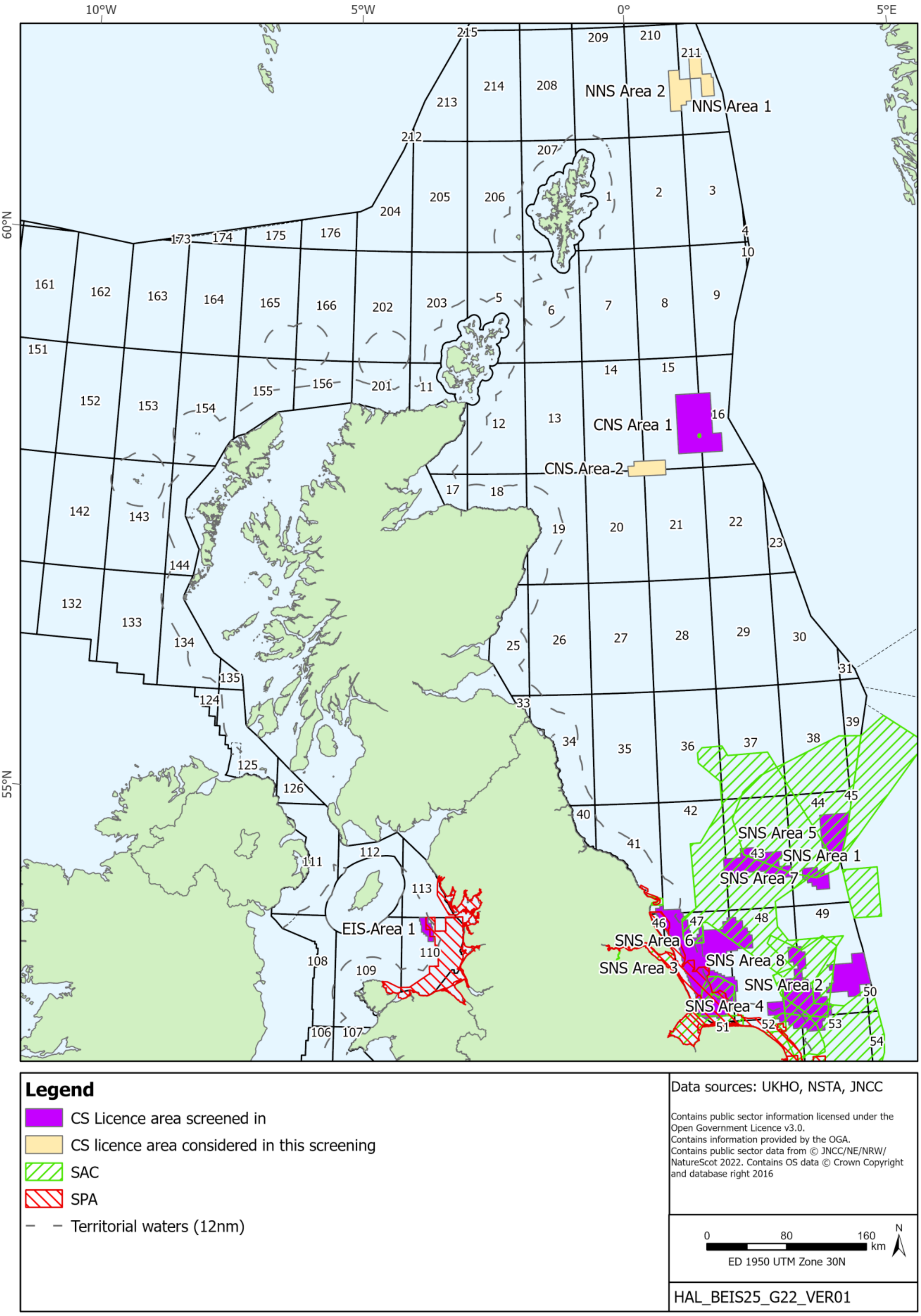


6 Conclusion

This screening assessment is based on the areas offered in the 1st carbon storage licensing round and has considered the likelihood for significant effects on relevant conservation sites in the national site network from exploration/appraisal activities that could follow licensing of these areas. The screening, which does not take account of mitigation, concluded that a number of areas on offer and relevant sites may be subject to a second stage of HRA, AA, if licences are applied for and prior to decisions on the grant of such licences. These areas are listed in Section 5.1 and Appendix B (which lists the areas and relevant sites according to the criteria by which they were screened in), and are shown in Figure 6.1. It should be noted that applicants may not apply for a licence equal to any of the areas on offer, but may apply for smaller areas within these. In view of the distance-based screening criteria used, and the spatially specific nature of some other data such as the higher areas of use by seals, there may be the need to review the combinations of licence applications and sites to be subject to AA once the licensing round has closed.

As described in Section 1.1, the award of a licence does not constitute any form of approval for activities to take place in the areas, nor does it confer any exemption from other legal or regulatory requirements. Offshore activities are subject to a range of statutory permitting and consenting requirements, including, where relevant, activity-specific AA. Even where a site/interest feature has been screened out at plan level, the potential for likely significant effects on any relevant site would need to be revisited at the project level, once project plans are known. New relevant site designations, new information on the nature and sensitivities of interest features within sites, and new information about effects including in-combination effects may be available to inform future project level HRA.

Figure 6.1: Areas Offered in the 1st carbon storage licensing round and sites for which a 2nd Stage of HRA may be undertaken



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Appendix A – The Designated Sites

A1 Introduction

The following maps and tables show the locations of potentially relevant sites and their qualifying features with respect to the areas offered as part of the 1st carbon storage licensing round.

The primary sources of site data were the latest JNCC SAC and SPA summary data[59] and interest features and site characteristics were filtered for their coastal and marine relevance. The websites of the relevant Statutory Nature Conservation Bodies (SNCBs) were also reviewed to verify and augment site information including NatureScot[60] and Natural England[61,62].

The sites in this Appendix are ordered thus:

A2 Coastal and marine Special Protection Areas

A3 Coastal and marine Special Areas of Conservation

A4 Sites in the adjacent waters of other member states

A5 Ramsar sites

[59] Version as of 18th December 2020 - https://hub.jncc.gov.uk/assets/a3d9da1e-dedc-4539-a574-84287636c898

[60] https://sitelink.nature.scot/home

[61] http://publications.naturalengland.org.uk/category/6490068894089216

[62] https://www.gov.uk/government/collections/conservation-advice-packages-for-marine-protected-areas

A2 Coastal and Marine Special Protection Areas

Special Protection Areas (SPAs) are protected sites classified for rare and vulnerable birds and for regularly occurring migratory birds. The SPAs included in this section are marine and coastal sites selected for the presence of one or more of the bird species listed in Box A.1 (below). Relevant SPAs in the adjacent waters of another Member State (Germany, Netherlands), see Maps A.3-A.5) are listed and described separately in Section A4. All relevant SPAs are included on Maps A.1 to A.5.

Box A.1: Migratory and/or Annex I bird species for which SPAs are selected in the UK

Divers and grebes

Great northern diver *Gavia immer*
Red-throated diver *Gavia stellata*
Black-throated diver *Gavia arctica*
Little grebe *Tachybaptus ruficollis*
Great crested grebe *Podiceps cristatus*
Slavonian grebe *Podiceps auritus*

Seabirds

Fulmar *Fulmarus glacialis*
Manx shearwater *Puffinus puffinus*
Storm petrel *Hydrobates pelagicus*
Leach's petrel *Oceanodroma leucorhoa*
Gannet *Morus bassanus*
Cormorant *Phalacrocorax carbo carbo*
Shag *Phalacrocorax aristotelis*
Guillemot *Uria aalge*
Razorbill *Alca torda*
Puffin *Fratercula arctica*

Gulls, terns and skuas

Arctic skua *Stercorarius parasiticus*
Great skua *Stercorarius skua*
Mediterranean gull *Larus melanocephalus*
Black-headed gull *Chroicocephalus ridibundus*
Common gull *Larus canus*
Lesser black-backed gull *Larus fuscus*
Herring gull *Larus argentatus*
Great black-backed gull *Larus marinus*
Kittiwake *Rissa tridactyla*
Sandwich tern *Thalasseus sandvicensis*
Roseate tern *Sterna dougallii*
Common tern *Sterna hirundo*
Arctic tern *Sterna paradisaea*
Little tern *Sternula albifrons*

Crakes and rails

Corncrake *Crex crex*

Birds of prey and owls

Waders

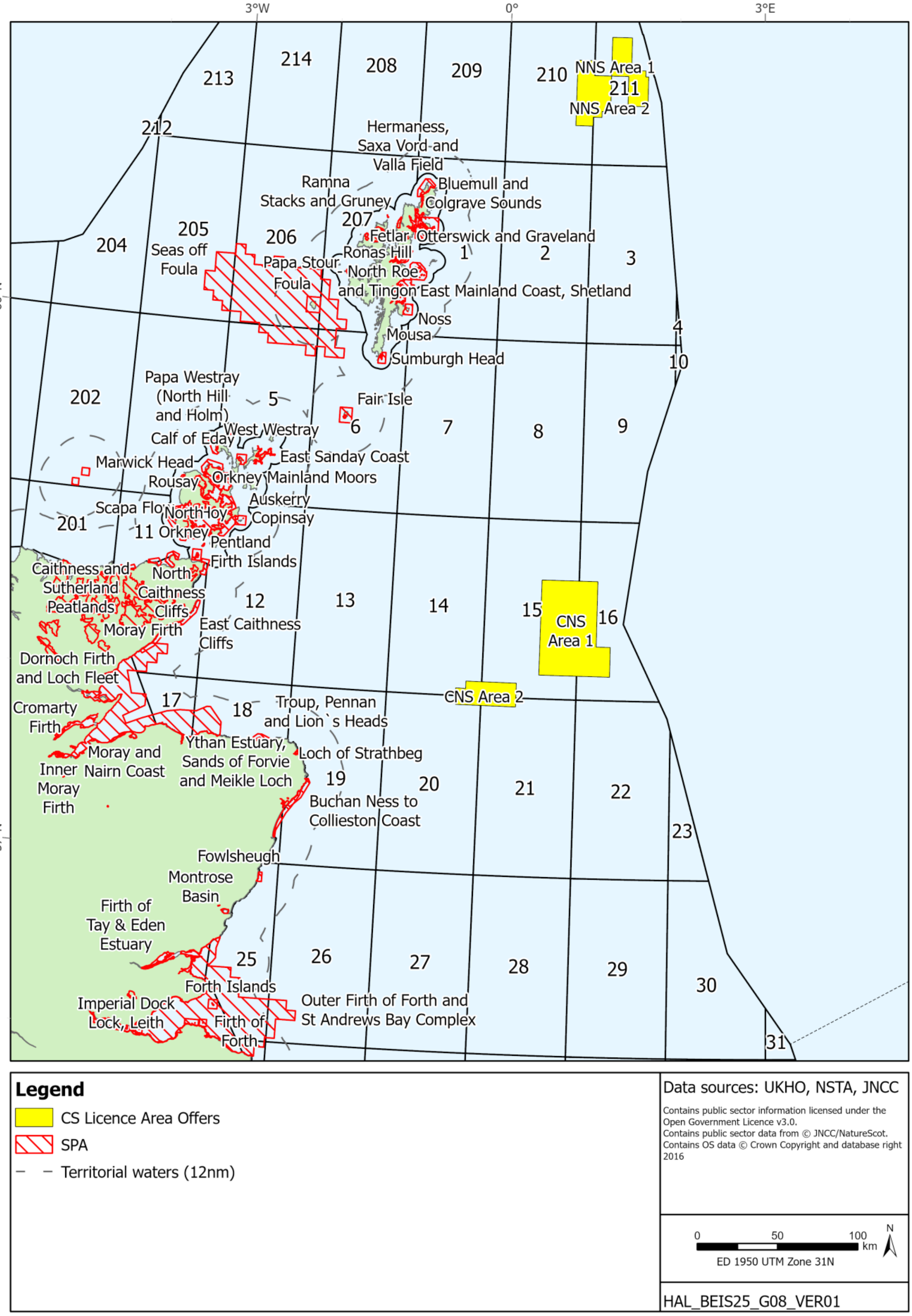
Oystercatcher *Haematopus ostralegus*
Avocet *Recurvirostra avosetta*
Stone curlew *Burhinus oedicnemus*
Ringed plover *Charadrius hiaticula*
Dotterel *Charadrius morinellus*
Golden plover *Pluvialis apricaria*
Grey plover *Pluvialis squatarola*
Lapwing *Vanellus vanellus*
Knot *Calidris canutus*
Sanderling *Calidris alba*
Purple sandpiper *Calidris maritima*
Dunlin *Calidris alpina alpina*
Ruff *Philomachus pugnax*
Snipe *Gallinago gallinago*
Black-tailed godwit *Limosa limosa* (breeding)
Black-tailed godwit *Limosa limosa islandica* (non-breeding)
Bar-tailed godwit *Limosa lapponica*
Whimbrel *Numenius phaeopus*
Curlew *Numenius arquata*
Redshank *Tringa totanus*
Greenshank *Tringa nebularia*
Wood sandpiper *Tringa glareola*
Turnstone *Arenaria interpres*
Red-necked phalarope *Phalaropus lobatus*

Waterfowl

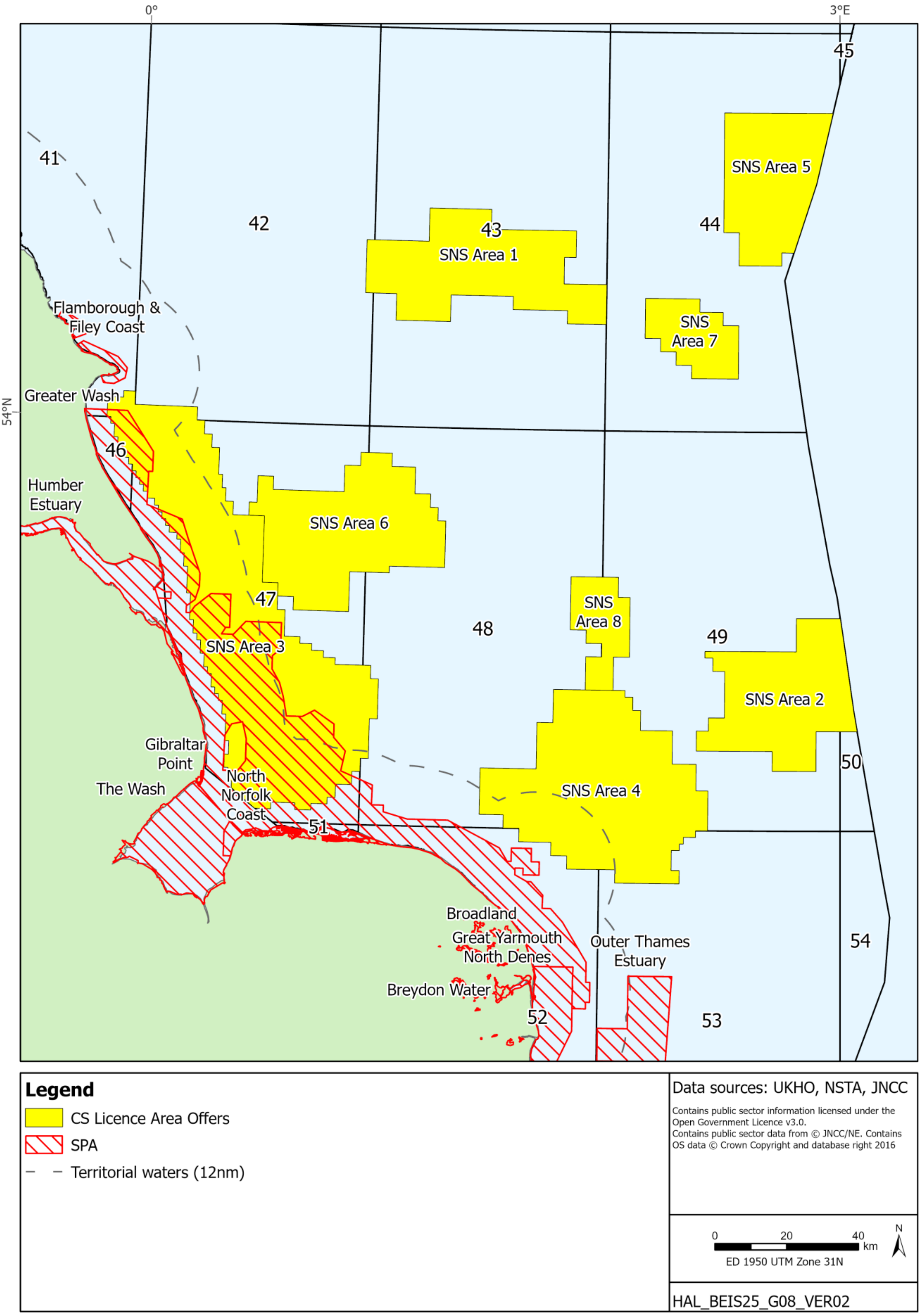
Bewick's swan *Cygnus columbianus bewickii*
Whooper swan *Cygnus*
Pink-footed goose *Anser brachyrhynchus*
Greenland white-fronted goose *Anser albifrons flavirostris*
Greater white-fronted goose *Anser albifrons albifrons*
Icelandic greylag goose *Anser anser*
Greenland barnacle goose *Branta leucopsis*
Svalbard barnacle goose *Branta leucopsis*
Dark-bellied brent goose *Branta bernicla bernicla*
Canadian light-bellied brent goose *Branta bernicla hrota*
Svalbard light-bellied brent goose *Branta bernicla hrota*
Shelduck *Tadorna tadorna*
Wigeon *Anas penelope*
Gadwall *Anas strepera*
Teal *Anas crecca*

Marsh harrier *Circus aeruginosus* Hen harrier *Circus cyaneus* Golden eagle *Aquila chrysaetos* Osprey *Pandion haliaetus* Merlin *Falco columbarius* Peregrine *Falco peregrinus* Short-eared owl *Asio flammeus* **Other bird species** Fair Isle wren *Troglodytes troglodytes fridariensis* Chough *Pyrrhocorax pyrrhocorax*	Mallard *Anas platyrhynchos* Pintail *Anas acuta* Shoveler *Anas clypeata* Pochard *Aythya ferina* Tufted duck *Aythya fuligula* Scaup *Aythya marila* Eider *Somateria mollissima* Long-tailed duck *Clangula hyemalis* Common scoter *Melanitta nigra* Velvet scoter *Melanitta fusca* Goldeneye *Bucephala clangula* Red-breasted merganser *Mergus serrator* Goosander *Mergus merganser*

Map A.1: Location of SPAs – northern and central North Sea



Map A.2: Location of SPAs – southern North Sea



Map A.3: Location of SPAs – east Irish Sea

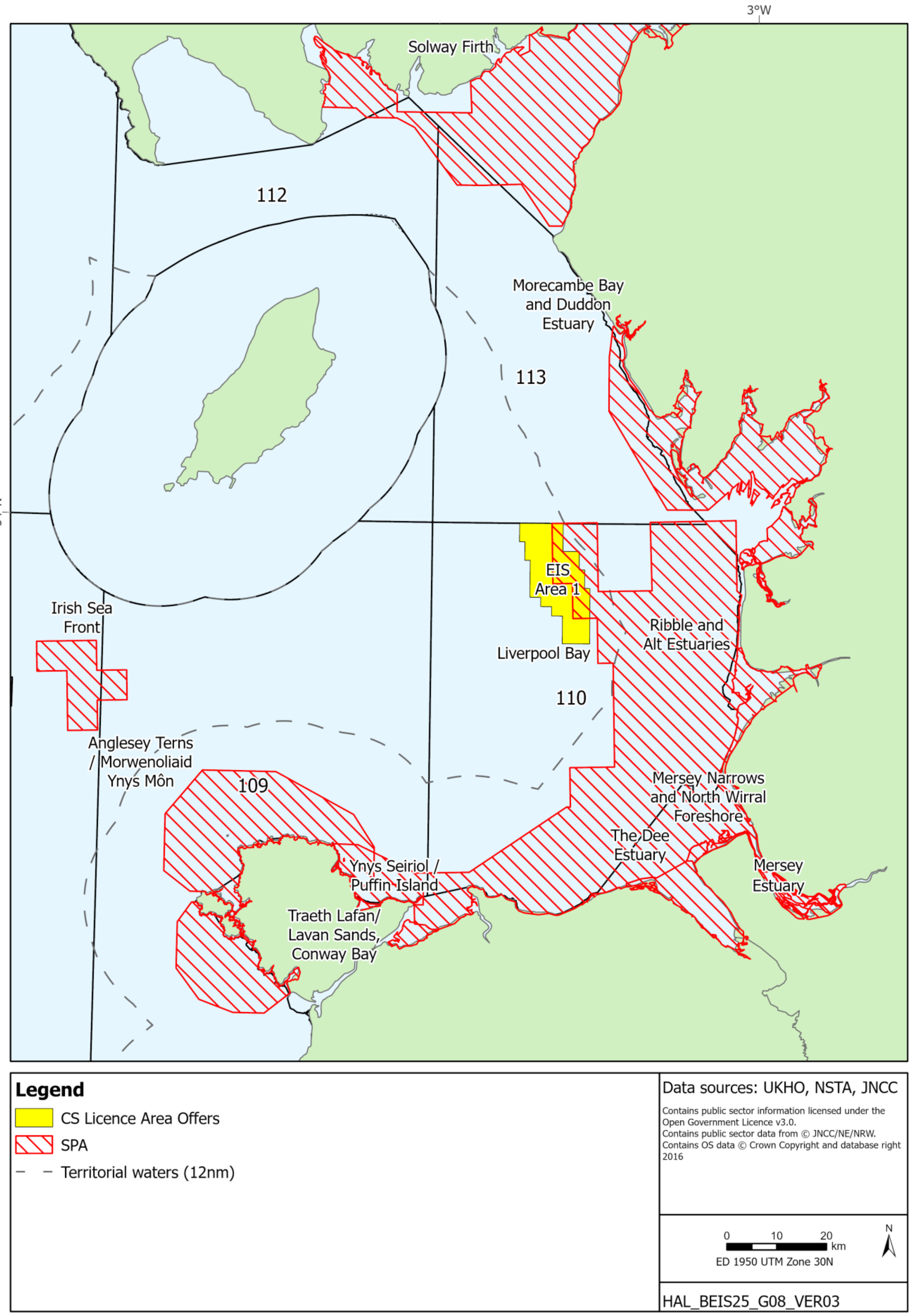


Table A.1: SPAs and their Qualifying Features

Site Name	Area (ha)	Article 4.1 Species	Article 4.2 Migratory Species	Article 4.2 Assemblages[63]
CENTRAL AND NORTHERN NORTH SEA				
Hermaness, Saxa Vord and Valla Field SPA	6832.36	Breeding: Red-throated diver	Breeding: Gannet Great skua Puffin	Breeding: Seabirds
Fetlar SPA	16964.69	Breeding: Arctic tern Red-necked phalarope	Breeding: Dunlin Great skua Whimbrel	Breeding: Seabirds
Otterswick and Graveland SPA	2239.59	Breeding: Red-throated diver	N/A	N/A
Ronas Hill-North Roe and Tingon SPA	5474.35	Breeding: Red-throated diver	Breeding: Great skua	N/A
Papa Stour SPA	569.6	Breeding: Arctic tern	Breeding: Ringed plover	N/A
East Mainland Coast, Shetland SPA	25646.67	Breeding: Red-throated diver Over winter: Great northern diver Slavonian grebe	N/A	N/A
Bluemull and Colgrave Sounds SPA	3823.27	Breeding: Red-throated diver	N/A	N/A
Noss SPA	3338.38	N/A	Breeding: Gannet Great skua Guillemot	Breeding: Seabirds
Mousa SPA	196.85	Breeding: Arctic tern Storm petrel	N/A	N/A
Sumburgh Head SPA	2478.91	Breeding: Arctic tern	N/A	Breeding: Seabirds
Fair Isle SPA	6825.1	Breeding: Arctic tern Fair Isle wren	Breeding: Guillemot	Breeding: Seabirds
Papa Westray (North Hill and Holm) SPA	245.94	Breeding: Arctic tern	Breeding: Arctic skua	N/A
West Westray SPA	3780.16	Breeding: Arctic tern	Breeding: Guillemot	Breeding: Seabirds
East Sanday Coast SPA	1508.2	Over winter: Bar-tailed godwit	Over winter: Purple sandpiper Turnstone	N/A
Calf of Eday SPA	2671.77	N/A	N/A	Breeding: Seabirds
Foula SPA	7985.49	Breeding: Arctic tern Leach's petrel Red-throated diver	Breeding: Great skua Guillemot Puffin Shag	Breeding: Seabirds

[63] A seabird assemblage of international importance: the area regularly supports at least 20,000 seabirds. Or a wetland of international importance: the area regularly supports at least 20,000 waterfowl.

Site Name	Area (ha)	Article 4.1 Species	Article 4.2 Migratory Species	Article 4.2 Assemblages63
Seas off Foula SPA	341215	N/A	Breeding: Great skua	Breeding: Seabirds Over winter: Seabirds
Rousay SPA	5480.84	Breeding: Arctic tern	N/A	Breeding: Seabirds
North Orkney SPA	22695.17	Breeding: Red-throated diver Over winter: Great northern diver Slavonian grebe	Over winter: Velvet scoter	N/A
Marwick Head SPA	475.54	N/A	Breeding: Guillemot	Breeding: Seabirds
Orkney Mainland Moors SPA	5342.44	Breeding: Hen harrier Red-throated diver Short-eared owl Over winter: Hen harrier	N/A	N/A
Auskerry SPA	103.11	Breeding: Arctic tern Storm petrel	N/A	N/A
Copinsay SPA	3607.7	N/A	N/A	Breeding: Seabirds
Hoy SPA	18123.91	Breeding: Peregrine Red-throated diver	Breeding: Great skua	Breeding: Seabirds
Scapa Flow SPA	37065.53	Breeding: Red-throated diver Over winter: Great northern diver Black-throated diver Slavonian grebe	Over winter: Shag Eider Long-tailed duck Red-breasted merganser	N/A
Pentland Firth Islands SPA	170.0	Breeding: Arctic tern	N/A	N/A
Caithness & Sutherland Peatlands SPA	145312.97	Breeding: Black-throated diver Golden eagle Golden plover Hen harrier Merlin Red-throated diver Short-eared owl Wood sandpiper Dunlin	Breeding: Common scoter Greenshank Wigeon	N/A
North Caithness Cliffs SPA	14628.77	Breeding: Peregrine	Breeding: Guillemot	Breeding: Seabird
East Caithness Cliffs SPA	11696.37	Breeding: Peregrine	Breeding: Razorbill Herring gull Shag Kittiwake Guillemot	Breeding: Seabird

Site Name	Area (ha)	Article 4.1 Species	Article 4.2 Migratory Species	Article 4.2 Assemblages63
Moray Firth SPA	176235.95	Over winter: Great northern diver Red-throated diver Slavonian grebe	Breeding: Shag Over winter: Scaup Eider Long-tailed duck Common scoter Velvet scoter Common goldeneye Red-breasted merganser Shag	N/A
Dornoch Firth and Loch Fleet SPA	7856.54	Breeding: Osprey Over winter: Bar-tailed godwit	Over winter: Greylag goose Wigeon	Over winter: Waterfowl
Cromarty Firth SPA	3247.95	Breeding: Common tern Osprey Over winter: Bar-tailed godwit Whooper swan	Over winter: Greylag goose	Over winter: Waterfowl
Inner Moray Firth SPA	2290.25	Breeding: Common tern Osprey Over winter: Bar-tailed godwit	Over winter: Greylag goose Red-breasted merganser Redshank	Over winter: Waterfowl
Moray and Nairn Coast SPA	2325.67	Breeding: Osprey Over winter: Bar-tailed godwit	Over winter: Greylag goose Pink-footed goose Redshank	Over winter: Waterfowl
Troup, Pennan and Lion's Heads SPA	3365.2	N/A	Breeding: Guillemot Kittiwake Fulmar Razorbill Herring gull	Breeding: Seabirds
Loch of Strathbeg SPA	616.26	Breeding: Sandwich tern Over winter: Whooper swan Barnacle goose	Over winter: Teal Greylag goose Pink-footed goose Goldeneye	Over winter: Waterfowl
Buchan Ness to Collieston Coast SPA	5400.76	N/A	N/A	Breeding: Seabirds
Ythan Estuary, Sands of Forvie and Meikle Loch SPA	1014.62	Breeding: Common tern Little tern Sandwich tern	Over winter: Pink-footed goose	Over winter: Waterfowl
Fowlsheugh SPA	1303.23	N/A	Breeding: Guillemot Kittiwake	Breeding: Seabirds

Site Name	Area (ha)	Article 4.1 Species	Article 4.2 Migratory Species	Article 4.2 Assemblages63
Montrose Basin SPA	981.19	N/A	Over winter: Pink-footed goose Greylag goose Shelduck Wigeon Eider Oystercatcher Redshank Knot Dunlin	Over winter: Waterfowl
Firth of Tay and Eden Estuary SPA	6947.62	Breeding: Little tern Marsh harrier Over winter: Bar-tailed godwit	Over winter: Greylag goose Pink-footed goose Redshank	Over winter: Waterfowl
Outer Firth of Forth and St Andrews Bay Complex SPA	272068.09	Breeding: Common tern Arctic tern Over-winter: Red-throated diver Little gull Slavonian grebe	Breeding: Shag Gannet Over-winter: Eider	Breeding: Seabirds Over winter: Seabirds Waterfowl
Firth of Forth SPA	6317.69	Over winter: Red-throated diver Bar-tailed godwit Golden plover Slavonian grebe On passage: Sandwich tern	Over winter: Pink-footed goose Turnstone Knot Shelduck Redshank	Over winter: Waterfowl
SOUTHERN NORTH SEA				
Flamborough and Filey Coast SPA	8039.6	N/A	Breeding: Kittiwake Gannet Guillemot Razorbill	Breeding: Seabirds
Hornsea Mere SPA	232.25	N/A	Breeding: Mute swan Over winter: Gadwall	N/A
Humber Estuary SPA	37630.24	Breeding: Bittern Marsh harrier Avocet Little tern Over winter: Bittern Avocet Hen harrier Bar-tailed godwit Golden plover On passage: Ruff	Over winter: Dunlin Knot Shelduck Black-tailed godwit Redshank On passage: Knot Dunlin Black-tailed godwit Redshank	Non-breeding: Waterfowl
Gibraltar Point SPA	422.2	Breeding: Little tern Over winter: Bar-tailed godwit	Over winter: Grey plover Sanderling	N/A

Site Name	Area (ha)	Article 4.1 Species	Article 4.2 Migratory Species	Article 4.2 Assemblages63
Greater Wash SPA	344267	Breeding: Little tern Sandwich tern Common tern Over winter: Little gull Red-throated diver	Over winter: Common scoter	N/A
The Wash SPA	62044.14	Breeding: Common tern Little tern Over winter: Bewick's swan	Over winter: Pintail Wigeon Gadwall Pink-footed goose Turnstone Dark-bellied brent goose Goldeneye Sanderling Dunlin Knot Oystercatcher Black-tailed godwit Common scoter Curlew Grey plover Shelduck Redshank Bar-tailed godwit	Over winter: Waterfowl
North Norfolk Coast SPA	7862.27	Breeding: Avocet Bittern Common tern Little tern Marsh harrier Sandwich tern Montagu's harrier Over winter: Avocet	Over winter: Wigeon Pink-footed goose Dark-bellied brent goose Knot	Over winter: Waterfowl
Broadland SPA	5508.88	Breeding: Bittern Marsh harrier Over winter: Hen harrier Bewick's swan Whooper swan	Over winter: Gadwall	N/A
Great Yarmouth North Denes SPA	160.37	Breeding: Little tern	N/A	N/A
Outer Thames Estuary SPA	392451.66	Breeding: Little tern Common tern Over winter: Red-throated diver	N/A	N/A

Site Name	Area (ha)	Article 4.1 Species	Article 4.2 Migratory Species	Article 4.2 Assemblages63
Breydon Water SPA	1203.5	Breeding: Common tern Over winter: Bewick's swan Avocet Golden plover On passage: Ruff	Over winter: Lapwing	Over winter: Waterfowl
IRISH SEA				
Loch of Inch and Torrs Warren SPA	2110.5	Non-breeding: Greenland white-fronted goose Hen harrier	N/A	N/A
Solway Firth SPA	135749.34	Non-breeding: Red-throated diver Whooper swans Barnacle geese Golden plover Bar-tailed godwit	Non-breeding: Pink-footed goose Pintail Scaup Oystercatcher Knot Curlew Redshank On passage: Ringed plover	Over winter: Waterfowl
Morecambe Bay & Duddon Estuary SPA	66899	Breeding: Common tern Sandwich tern Little tern Over winter: Whooper swan Little egret Golden plover Ruff Bar-tailed godwit Mediterranean gull	Breeding: Lesser black-backed gull Herring gull On passage: Pink-footed goose Shelduck Oystercatcher Ringed plover Grey plover Knot Sanderling Dunlin Black-tailed godwit Curlew Pintail Turnstone Redshank Lesser black-backed gull	Any season: Seabird Any season: Waterfowl

Site Name	Area (ha)	Article 4.1 Species	Article 4.2 Migratory Species	Article 4.2 Assemblages63
Ribble and Alt Estuaries SPA	12449.92	Breeding: Common tern Ruff Over winter: Bar-tailed godwit Bewick's swan Golden plover Whooper swan	Breeding: Lesser black-backed gull Black-headed gull On passage: Ringed plover Sanderling Redshank Whimbrel Over winter: Pintail Teal Wigeon Pink-footed goose Scaup Sanderling Dunlin Knot Oystercatcher Black-tailed godwit Common scoter Curlew Cormorant Grey plover Shelduck Redshank Lapwing	Breeding: Seabirds Over winter: Waterfowl
Mersey Narrows and North Wirral Foreshore SPA	2078.36	Breeding: Common tern On passage: Little gull Common tern Over winter: Bar-tailed godwit	Over winter: Knot	Over winter: Waterfowl
Mersey Estuary SPA	5023.35	Over winter: Golden plover	On passage: Redshank Over winter: Dunlin Pintail Redshank Shelduck Teal Lapwing Great crested grebe Grey plover Curlew Black-tailed godwit Wigeon	N/A

Site Name	Area (ha)	Article 4.1 Species	Article 4.2 Migratory Species	Article 4.2 Assemblages63
The Dee Estuary SPA	14294.95	Breeding: Common tern Little tern On passage: Sandwich tern Over winter: Bar-tailed godwit	On passage: Redshank Over winter: Pintail Teal Dunlin Knot Oystercatcher Black-tailed godwit Curlew Grey plover Shelduck Redshank	Over winter: Waterfowl
Liverpool Bay SPA	252773	Breeding: Little tern Common tern Over winter: Red-throated diver Little gull	Over winter: Common scoter	Over winter: Waterfowl
Traeth Lafan/ Lavan Sands, Conway Bay SPA	2703.13	N/A	Over winter: Oystercatcher Curlew On passage: Great crested grebe	N/A
Ynys Seiriol / Puffin Island SPA	31.32	N/A	Breeding: Cormorant	N/A
Anglesey Terns / Morwenoliaid Ynys Môn SPA	101931.08	Breeding: Roseate tern Common tern Arctic tern Sandwich tern	N/A	N/A
Irish Sea Front SPA	18000	N/A	Breeding: Manx shearwater	N/A
Glannau Ynys Gybi/Holy Island Coast SPA	604.39	Over winter: Chough	N/A	N/A

A3 Coastal and Marine Special Areas of Conservation

This section includes coastal and marine Special Areas of Conservation (SAC) which contain one or more of the Annex I habitats listed in Box A.2 (below) or Annex II qualifying marine species. Relevant SACs in the waters of adjacent Member States are listed in Section A4. All relevant SACs are included on Maps A.6 to A.10.

Abbreviations for the Annex I habitats used in SAC site summaries (Tables A.2 to A.4) are listed in Box A.2. Common names of Annex II species are used in SAC site summaries with corresponding scientific names listed in Box A.3.

Box A.2: Annex I habitat abbreviations used in site summaries

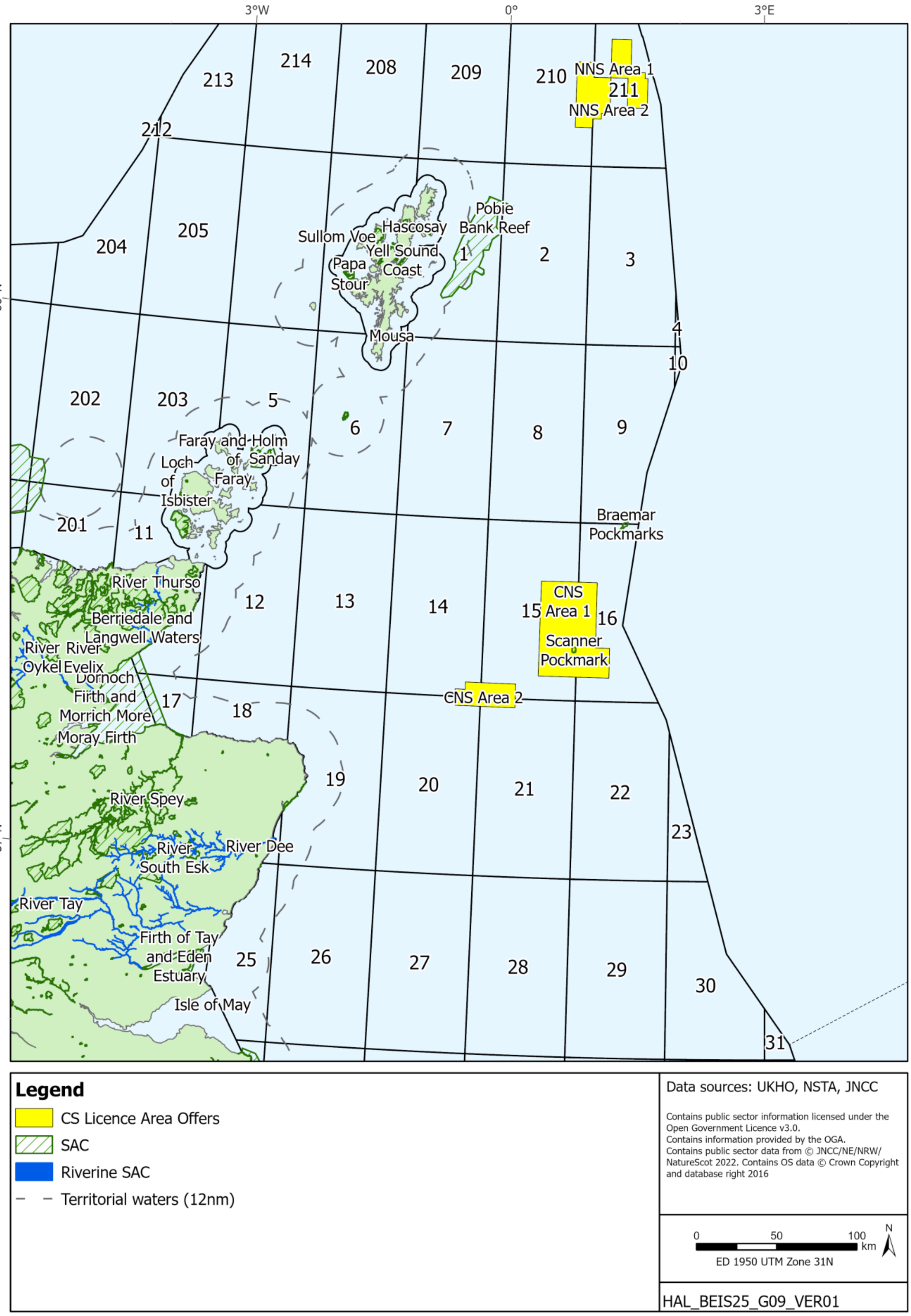
Annex I habitat (abbreviated)	Annex I habitat(s) (full description)
Bogs	Blanket bogs * Priority feature Transition mires and quaking bogs Depressions on peat substrates of the *Rhynchosporion* Active raised bogs * Priority feature Degraded raised bogs still capable of natural regeneration Bog Woodland * Priority feature
Coastal dunes	Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes") Fixed coastal dunes with herbaceous vegetation ("grey dunes") * Priority feature Humid dune slacks Embryonic shifting dunes Decalcified fixed dunes with *Empetrum nigrum* * Priority feature Atlantic decalcified fixed dunes (*Calluno-Ulicetea*) * Priority feature Dunes with *Salix repens* ssp. *argentea* (*Salicion arenariae*) Coastal dunes with *Juniperus* spp. Dunes with *Hippophae rhamnoides* Fixed dunes with herbaceous vegetation (`grey dunes`) * Priority feature
Coastal lagoons	Coastal lagoons * Priority feature
Estuaries	Estuaries
Fens	Alkaline fens Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* * Priority feature Petrifying springs with tufa formation (*Cratoneurion*) * Priority feature
Forest	Western acidic oak woodland Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) * Priority feature *Taxus baccata* woods of the British Isles *Priority feature *Tilio-Acerion* forests of slopes, screes and ravines * Priority feature Old sessile oak woods and *Ilex* and *Blechnum* in the British Isles Old sessile oak woods with *Quercus robur* on sandy plains

Annex I habitat (abbreviated)	Annex I habitat(s) (full description)
Grasslands	Alpine and subalpine calcareous grasslands Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels Siliceous alpine and boreal grasslands Species-rich *Nardus* grassland, on siliceous substrates in mountain areas (and submountain areas in continental Europe) * Priority feature Alpine pioneer formations of the *Caricion bicoloris-atrofuscae* * Priority feature Calaminarian grasslands of the *Violetalia calaminariae* *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) Semi-natural dry grasslands and scrubland facies: on calcareous substrates (*Festuco-Brometalia*) (important orchid sites) * Priority feature
Heaths	Northern Atlantic wet heaths with *Erica tetralix* European dry heaths Alpine and Boreal heaths Dry Atlantic coastal heaths with *Erica vagans*
Inlets and bays	Large shallow inlets and bays
Limestone pavements	Limestone pavements * Priority feature
Machairs	Machairs
Mudflats and sandflats	Mudflats and sandflats not covered by seawater at low tide
Reefs	Reefs
Rocky slopes	Calcareous rocky slopes with chasmophytic vegetation Calcareous and calcshist screes of the montane to alpine levels (*Thlaspietea rotundifolii*) Siliceous rocky slopes with chasmophytic vegetation
Running freshwater	Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation
Saltmarsh and salt meadows	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) *Salicornia* and other annuals colonising mud and sand *Spartina* swards (*Spartinion maritimae*)
Sandbanks	Sandbanks which are slightly covered by sea water all the time
Scree	Siliceous scree of the montane to snow levels (*Androsacetalia alpinae* and *Galeopsietalia ladani*) Calcareous and calcshist screes of the montane to alpine levels (*Thlaspietea rotundifolii*)
Scrub	*Juniperus communis* formations on heaths or calcareous grasslands Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)
Sea caves	Submerged or partially submerged sea caves
Sea cliffs	Vegetated sea cliffs of the Atlantic and Baltic Coasts
Standing freshwater	Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea* Natural dystrophic lakes and ponds Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp. Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* - type vegetation Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*)
Vegetation of drift line	Annual vegetation of drift lines
Vegetation of stony banks	Perennial vegetation of stony banks

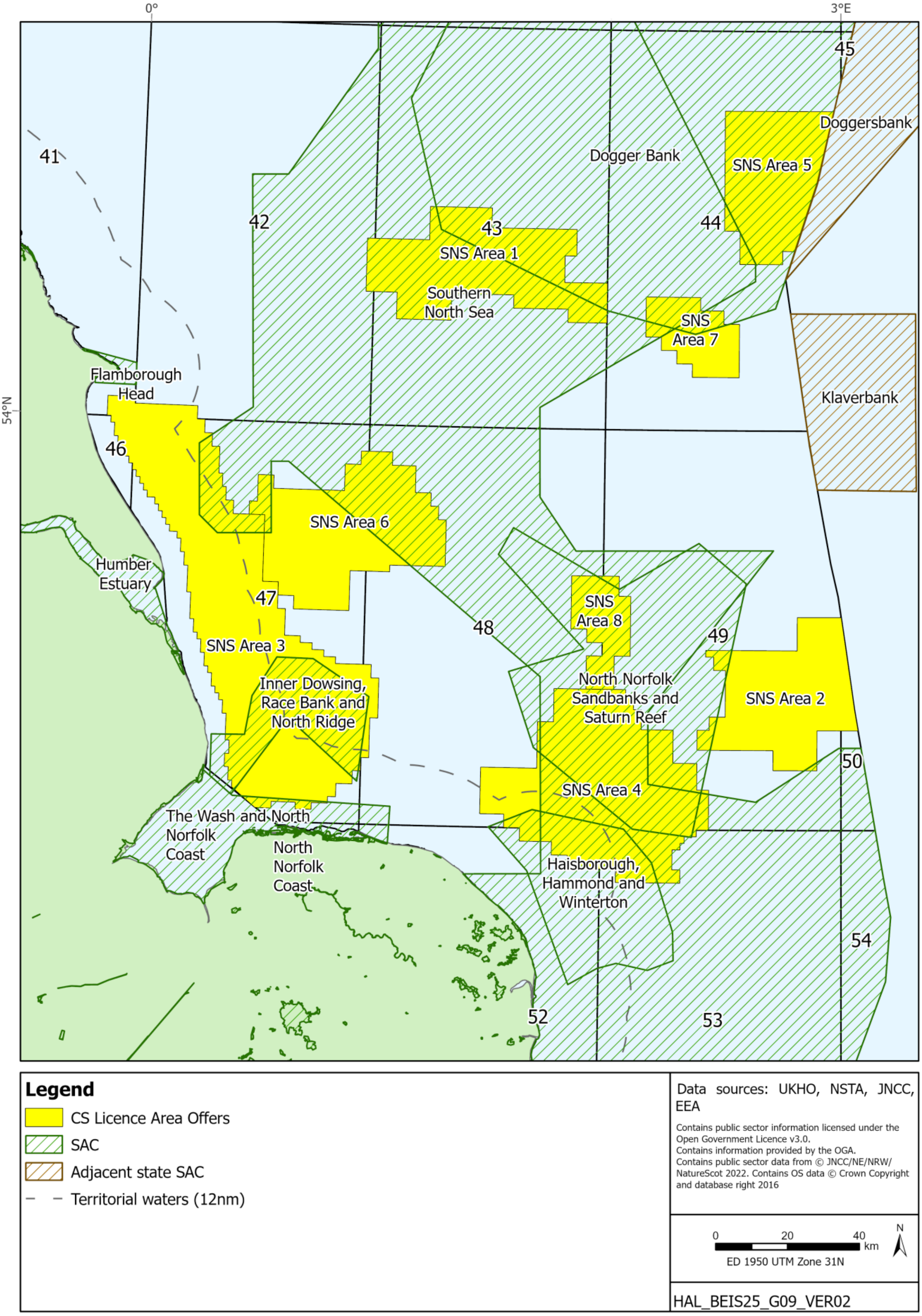
Box A.3: Annex II species common names used in site summaries and scientific names

Group	Annex II species common name (scientific name)
Fish	sea lamprey (*Petromyzon marinus)* brook lamprey (*Lampetra planeri)* river lamprey (*Lampetra fluviatilis)* Atlantic salmon (*Salmo salar)* bullhead (*Cottus gobio)*
Mammals	grey seal (*Halichoerus grypus*) harbour seal (*Phoca vitulina*) otter (*Lutra lutra*) harbour porpoise (*Phocoena phocoena*) bottlenose dolphin (*Tursiops truncatus*)

Map A.6: Location of SACs – northern and central North Sea



Map A.7: Location of SACs – southern North Sea



Map A.8: Location of SACs – east Irish Sea

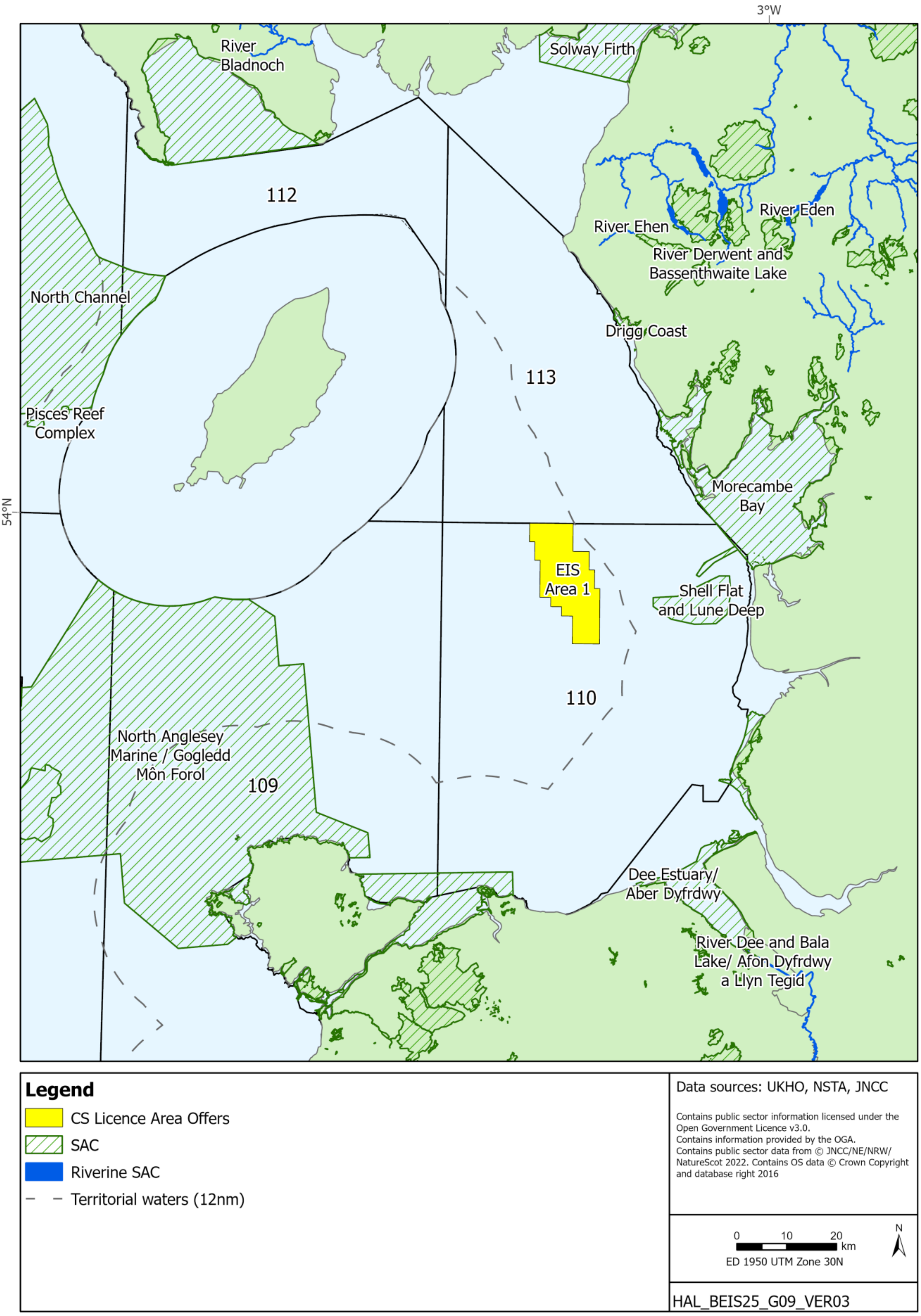


Table A.2: SACs and their Qualifying Features

Site Name	Area (ha)	Annex I Habitat Primary	Annex I Habitat Qualifying	Annex II Species Primary	Annex II Species Qualifying
CENTRAL AND NORTHERN NORTH SEA					
Pobie Bank Reef SAC	96575	Reefs	N/A	N/A	N/A
Hascosay SAC	164.19	Bogs	N/A	N/A	Otter
Yell Sound Coast SAC	1544.44	N/A	N/A	Otter Harbour seal	N/A
North Fetlar SAC	1585.18	Heaths Fens	N/A	N/A	N/A
Sullom Voe SAC	2691.43	Inlets and bays	Coastal lagoons Reefs	N/A	N/A
Mousa SAC	529.74	N/A	Reefs Sea caves	Harbour seal	N/A
The Vadills SAC	62.42	Coastal lagoons	N/A	N/A	N/A
Papa Stour SAC	2072.9	Reefs Sea caves	N/A	N/A	N/A
Tingon SAC	570.78	Bogs	Standing freshwater	N/A	N/A
Ronas Hill – North Roe SAC	4903.57	Standing freshwater Heaths Bogs	Heaths Scree	N/A	N/A
Keen of Hamar SAC	39.87	Grasslands Scree	Heaths	N/A	N/A
Fair Isle SAC	561.05	Sea cliffs	Heaths	N/A	N/A
Sanday SAC	10976.97	Reefs	Sandbanks Mudflats and sandflats	Harbour seal	N/A
Faray and Holm of Faray SAC	781.33	N/A	N/A	Grey seal	N/A
Stromness Heaths and Coast SAC	638.26	Sea cliffs Heaths	Fens	N/A	N/A
Loch of Stenness SAC	792.59	Coastal lagoons	N/A	N/A	N/A
Hoy SAC	9501.27	Sea cliffs Standing freshwater Heaths Bog	Heaths Fens Rocky slopes	N/A	N/A
East Caithness Cliffs SAC	457.48	Sea cliffs	N/A	N/A	N/A
Caithness and Sutherland Peatlands SAC	143561.47	Standing freshwater Bogs	Heaths Bogs	Otter Marsh saxifrage	N/A
River Naver SAC	1044.15	N/A	N/A	Freshwater pearl mussel Atlantic salmon	N/A
River Thurso SAC	348.25	N/A	N/A	Atlantic salmon	N/A
Berriedale and Langwell Waters SAC	58.25	N/A	N/A	Atlantic salmon	N/A
Moray Firth SAC	151273.99	N/A	Sandbanks	Bottlenose dolphin	N/A
Mound Alderwoods SAC	299.52	Forest	N/A	N/A	N/A
River Oykel	921.46	N/A	N/A	Freshwater pearl mussel	Atlantic salmon

Site Name	Area (ha)	Annex I Habitat Primary	Annex I Habitat Qualifying	Annex II Species Primary	Annex II Species Qualifying
River Evelix	23.6	N/A	N/A	Freshwater pearl mussel	N/A
Dornoch Firth and Morrich More SAC	8701.22	Estuaries Mudflats and sandflats Saltmarsh and salt meadows Coastal dunes	Sandbanks Reefs	Otter Harbour seal	N/A
Culbin Bar SAC	580.99	Vegetation of stony banks	Saltmarsh and salt meadows Coastal dunes	N/A	N/A
Lower River Spey - Spey Bay SAC	654.26	Vegetation of stony banks Forests	N/A	N/A	N/A
River Spey SAC	5759.72	N/A	N/A	Freshwater pearl mussel Sea lamprey Atlantic salmon Otter	N/A
Braemar Pockmarks SAC	1143	Submarine structures made by leaking gases	N/A	N/A	N/A
Scanner Pockmark SAC	674	Submarine structures made by leaking gases	N/A	N/A	N/A
Buchan Ness to Collieston SAC	206.03	Sea cliffs	N/A	N/A	N/A
Sands of Forvie SAC	735.48	Coastal dunes	N/A	N/A	N/A
River Dee SAC	2334.48	N/A	N/A	Freshwater pearl mussel Atlantic salmon Otter	N/A
Garron Point SAC	15.01	N/A	N/A	Narrow-mouthed whorl snail	N/A
River South Esk SAC	471.85	N/A	N/A	Freshwater pearl mussel Atlantic salmon	N/A
River Tay SAC	9461.63	N/A	Standing freshwater	Atlantic salmon	Sea lamprey Brook lamprey River lamprey Otter
Firth of Tay and Eden Estuary SAC	15441.63	Estuaries	Sandbanks Mudflats and sandflats	Harbour seal	N/A
Isle of May SAC	356.64	N/A	Reefs	Grey seal	N/A
SOUTHERN NORTH SEA					
Southern North Sea SAC	3695054	N/A	N/A	Harbour porpoise	N/A
Dogger Bank SAC	1233115	Sandbanks	N/A	N/A	N/A
Beast Cliff - Whitby (Robin Hood's Bay) SAC	265.48	Sea cliffs	N/A	N/A	N/A
Flamborough Head SAC	6320.87	Reefs Sea cliffs Sea caves	N/A	N/A	N/A
River Derwent SAC	397.87	Running freshwater	N/A	River lamprey	Sea lamprey Bullhead Otter
Humber Estuary SAC	36657.15	Estuaries Mudflats and sandflats	Sandbanks	N/A	River lamprey Sea lamprey

Site Name	Area (ha)	Annex I Habitat Primary	Annex I Habitat Qualifying	Annex II Species Primary	Annex II Species Qualifying
			Saltmarsh and salt meadows Coastal lagoons Coastal dunes		Grey seal
Inner Dowsing, Race Bank and North Ridge SAC	84514	Sandbanks Reefs	N/A	N/A	N/A
Saltfleetby - Theddlethorpe Dunes and Gibraltar Point SAC	967.65	Coastal dunes	Coastal dunes	N/A	N/A
The Wash and North Norfolk Coast SAC	107718	Sandbanks Mudflats and sandflats Inlets and bays Reefs Saltmarsh and salt meadows	Coastal lagoons	Harbour seal	Otter
North Norfolk Coast SAC	3148.6	Coastal lagoons Vegetation of stony banks Saltmarsh and salt meadows Coastal dunes	N/A	N/A	Otter Petalwort
Overstrand Cliffs SAC	30.02	Sea cliffs	N/A	N/A	N/A
North Norfolk Sandbanks and Saturn Reef SAC	360341	Sandbanks Reefs	N/A	N/A	N/A
Haisborough, Hammond and Winterton SAC	146759	Sandbanks Reefs	N/A	N/A	N/A
Winterton - Horsey Dunes SAC	426.96	Coastal dunes	Coastal dunes	N/A	N/A
Benacre to Easton Bavents Lagoons SAC	326.7	Coastal lagoons	N/A	N/A	N/A
Minsmere to Walberswick Heaths and Marshes SAC	1256.57	Vegetation of drift lines Heaths	Vegetation of stony banks	N/A	N/A
Alde, Ore and Butley Estuaries SAC	1632.63	Estuaries	Mudflats and sandflats Saltmarsh and salt meadows	N/A	N/A
Orfordness-Shingle Street SAC	888	Coastal lagoons Vegetation of drift lines Vegetation of stony banks	N/A	N/A	N/A
Hamford Water SAC	50.34	N/A	N/A	Fisher's estuarine moth	N/A
IRISH SEA					
North Channel SAC	160367	N/A	N/A	Harbour porpoise	N/A
Luce Bay and Sands SAC	48759.28	Inlets and bays Coastal dunes	Sandbanks Mudflats and sandflats Reefs	N/A	Great crested newt
Solway Firth SAC	43636.72	Sandbanks Estuaries Mudflats and sandflats	Reefs Vegetation of stony banks Coastal dunes	Sea lamprey River lamprey	N/A

Site Name	Area (ha)	Annex I Habitat Primary	Annex I Habitat Qualifying	Annex II Species Primary	Annex II Species Qualifying
		Saltmarsh and salt meadows			
River Eden SAC	2430.39	Standing freshwater Running freshwater Forests	N/A	White-clawed (or Atlantic stream) crayfish Sea lamprey Brook lamprey River lamprey Atlantic salmon Bullhead Otter	N/A
River Bladnoch SAC	272.6	N/A	N/A	Atlantic salmon	N/A
Shell Flat and Lune Deep	10565	Sandbanks Reefs	N/A	N/A	N/A
North Anglesey Marine / Gogledd Môn Forol	324949	N/A	N/A	Harbour porpoise	N/A
Bae Cemlyn/ Cemlyn Bay SAC	43.43	Coastal lagoons	Vegetation of stony banks	N/A	N/A
Glannau Ynys Gybi/ Holy Island Coast SAC	464.27	Sea cliffs Heaths	Heaths	N/A	N/A
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	1058	Saltmarsh and salt meadows	Estuaries Mudflats and sandflats	N/A	N/A
Y Twyni o Abermenai i Aberffraw/ Abermenai to Aberffraw Dunes SAC	1871.03	Coastal dunes	Standing freshwater	Petalwort Shore dock	N/A
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay	26482.67	Sandbanks Mudflats and sandflats Reefs	Inlets and bays Sea caves	N/A	N/A
Afon Gwyrfai a Llyn Cwellyn SAC	111.6	Standing freshwater Running freshwater	N/A	Atlantic salmon Floating water-plantain	Otter
Great Orme`s Head/ Pen y Gogarth SAC	302.63	Heaths Grasslands	Sea cliffs	N/A	N/A
Dee Estuary/ Aber Dyfrdwy	15805.89	Mudflats and sandflats Saltmarsh and salt meadows	Estuaries Sea cliffs Vegetation of drift lines Coastal dunes	N/A	River lamprey Sea lamprey Petalwort
River Dee and Bala Lake/ Afon Dyfrdwy a Llyn Tegid SAC	1308.93	Running freshwater	N/A	Atlantic salmon Floating water-plantain	Sea lamprey Brook lamprey River lamprey Bullhead Otter
Sefton Coast	4563.97	Coastal dunes	Coastal dunes	Petalwort	Great crested newt
Morecambe Bay	61506.22	Estuaries Mudflats and sandflats Inlets and bays Vegetation of stony banks Saltmarsh and salt meadows Coastal dunes	Sandbanks Coastal lagoons Reefs Coastal dunes	Great crested newt	N/A

Site Name	Area (ha)	Annex I Habitat Primary	Annex I Habitat Qualifying	Annex II Species Primary	Annex II Species Qualifying
Drigg Coast	1397.44	Estuaries Coastal dunes	Mudflats and sandflats Saltmarsh and salt meadows Coastal dunes	N/A	N/A
River Kent	88.9	N/A	Running freshwater	White-clawed (or Atlantic stream) crayfish	Freshwater pearl mussel Bullhead
River Ehen SAC	23.33	N/A	N/A	Freshwater pearl mussel	Atlantic salmon
River Derwent and Bassenthwaite Lake SAC	1793.8	Standing freshwater	Running freshwater	Marsh fritillary butterfly Sea lamprey Brook lamprey River lamprey Atlantic salmon Otter Floating water-plantain	N/A
Croker Carbonate Slabs SCI	6,591	Submarine structures made by leaking gases	N/A	N/A	N/A

A4 Sites in waters of adjacent states

Relevant sites in adjacent states are highlighted in the previous Table A.2 as well as listed separately in Table A.3 below. Offshore sites in the Netherlands (shown on Map A.3) were considered in this screening assessment.

Table A.4: SAC sites in the adjacent waters of other Member States

Site Name	Area (ha)	Annex 1 Habitat	Annex II Species
CENTRAL AND NORTHERN NORTH SEA; AND MID-NORTH SEA HIGH AND SOUTHERN NORTH SEA			
Doggerbank SAC (Germany)	169895	Sandbanks	Harbour porpoise Harbour seal
Doggersbank SAC (Netherlands)	473500	Sandbanks	Grey seal Harbour seal Harbour porpoise
Klaverbank SAC (Netherlands)	153900	Reefs	Grey seal Harbour seal Harbour porpoise

A5 Ramsar sites

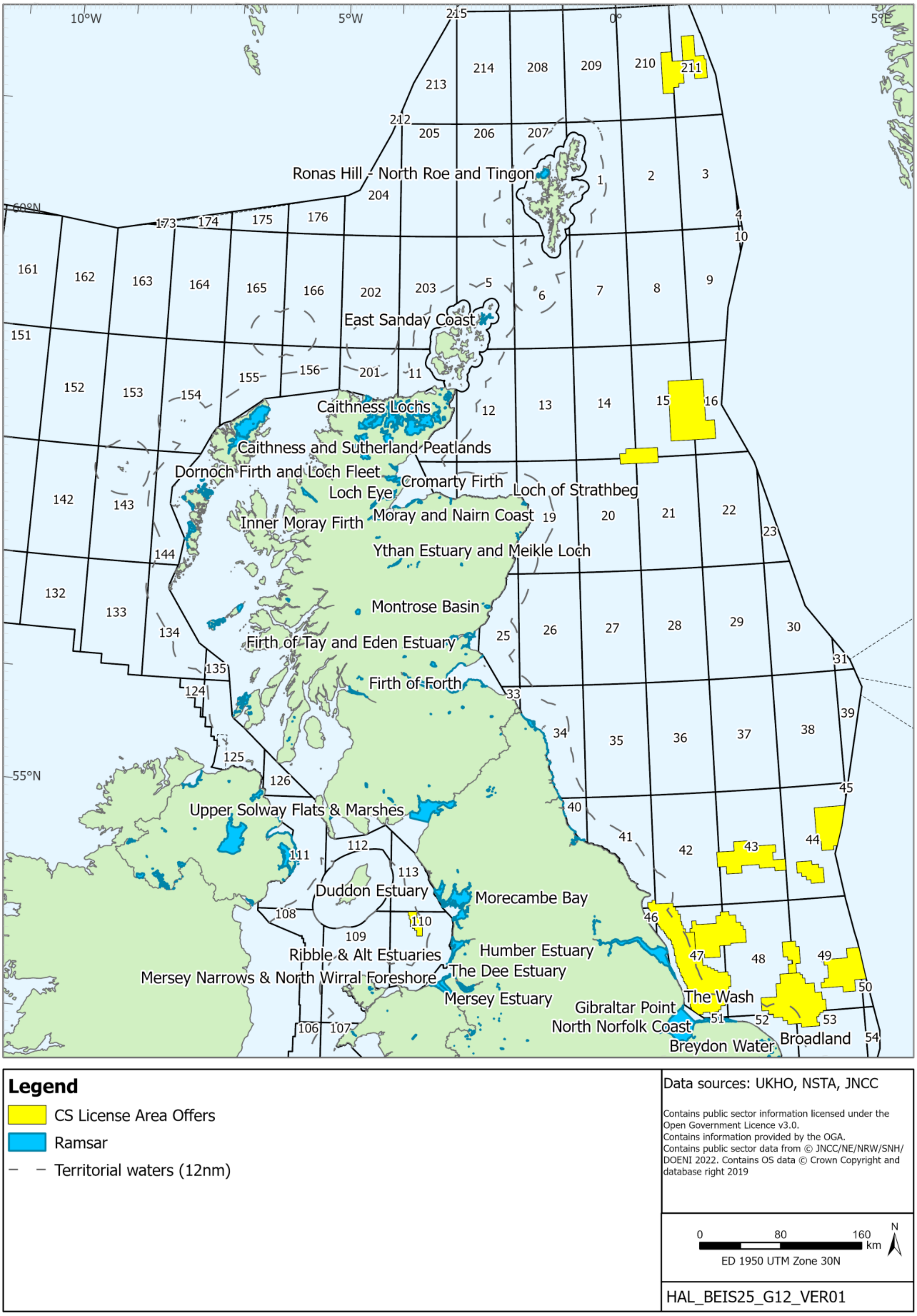
The coastal Ramsar sites listed in Table A.5 and shown on Map A.11 are also SPAs and/or SACs (although site boundaries are not always strictly coincident and a Ramsar site may comprise one or more SAC/SPA sites), see tabulation below.

Table A.5: Coastal Ramsar sites and corresponding SPAs and SACs

Ramsar Name	SPA Name	SAC Name
Central and Northern North Sea		
Ronas Hill – North Roe and Tingon	Ronas Hill - North Roe and Tingon	Tingon Ronas Hill - North Roe
East Sanday Coast	East Sanday Coast	Sanday
Caithness Lochs	Caithness Lochs	-
Caithness and Sutherland Peatlands	Caithness and Sutherland Peatlands	Caithness and Sutherland Peatlands
Dornoch Firth and Loch Fleet	Moray Firth pSPA Dornoch Firth and Loch Fleet	Dornoch Firth and Morrich More Moray Firth
Cromarty Firth	Cromarty Firth	Moray Firth
Inner Moray Firth	Moray Firth pSPA Inner Moray Firth	Moray Firth
Loch Eye	Loch Eye	-
Moray & Nairn Coast	Moray Firth pSPA Moray and Nairn Coast	Culbin Bar Moray Firth Lower River Spey - Spey Bay River Spey
Loch of Strathbeg	Loch of Strathbeg	-
Ythan Estuary & Meikle Loch	Ythan Estuary, Sands of Forvie and Meikle Loch SPA Ythan Estuary, Sands of Forvie and Meikle Loch (extension) pSPA	Sands of Forvie
Montrose Basin	Montrose Basin	River South Esk
Firth of Tay & Eden Estuary	Outer Firth of Forth and St Andrews Bay Complex pSPA Firth of Tay & Eden Estuary	Firth of Tay and Eden Estuary
Firth of Forth	Outer Firth of Forth and St Andrews Bay Complex pSPA Firth of Forth Forth Islands	-
Southern North Sea		
Humber Estuary	Humber Estuary	Humber Estuary Saltfleetby-Theddlethorpe Dunes and Gibraltar Point
Gibraltar Point	Gibraltar Point The Wash	Saltfleetby–Theddlethorpe Dunes and Gibraltar Point The Wash and North Norfolk Coast
The Wash	Gibraltar Point North Norfolk Coast The Wash	The Wash and North Norfolk Coast
North Norfolk Coast	North Norfolk Coast The Wash	North Norfolk Coast The Wash and North Norfolk Coast
Broadland	Broadland	The Broads
Breydon Water	Breydon Water	-
Irish Sea		
Upper Solway Flats and Marshes	Upper Solway Flats and Marshes Solway Firth pSPA	Solway Firth
Duddon Estuary	Morecambe Bay and Duddon Estuary	Morecambe Bay

Ramsar Name	SPA Name	SAC Name
Mersey Estuary	Liverpool Bay / Bae Lerpwl Mersey Estuary	-
Morecambe Bay	Morecambe Bay and Duddon Estuary	Morecambe Bay
Ribble and Alt Estuaries	Ribble and Alt Estuaries Liverpool Bay / Bae Lerpwl	Sefton Coast
The Dee Estuary	The Dee Estuary Mersey Narrows and North Wirral Foreshore Liverpool Bay / Bae Lerpwl	River Dee and Bala Lake/ Afon Dyfrdwy a Llyn Tegid Dee Estuary/ Aber Dyfrdwy
Mersey Narrows and North Wirral Foreshore	The Dee Estuary Mersey Narrows and North Wirral Foreshore Liverpool Bay / Bae Lerpwl	Dee Estuary/ Aber Dyfrdwy

Map A.11: Location of coastal Ramsar sites



Appendix B – Sites screened in

B1 Introduction

The following tables list the areas and sites which have been screened in following application of the screening process described in Section 4. The areas and sites are listed according to the criteria by which they were screened in:

- Physical disturbance and drilling (Section 4.4, also see Figures 5.1 and 5.2)
- Underwater noise (Section 4.5, also see Figures 5.3 and 5.4)

These areas and sites will be subject to a second stage of HRA, Appropriate Assessment, if those areas are applied for and before licensing decisions are taken.

B2 Physical disturbance and drilling

Northern North Sea	
n/a	n/a
Central North Sea	
SACs	
CNS 1	Scanner Pockmark
Southern North Sea	
SPAs	
SNS 3	The Wash
	Humber Estuary
	North Norfolk Coast
	Flamborough & Filey Coast
	Greater Wash
	The Wash*
	Gibraltar Point*
	Great Yarmouth North Denes*
	Breydon Water*
	Outer Thames Estuary*
SNS 4	Greater Wash
SNS 6	Greater Wash
SACs	
SNS 1	Dogger Bank
	Southern North Sea
SNS 2	North Norfolk Sandbanks and Saturn Reef
	Southern North Sea
SNS 3	North Norfolk Coast
	Humber Estuary
	The Wash and North Norfolk Coast
	Flamborough Head
	Inner Dowsing, Race Bank and North Ridge
	Southern North Sea
SNS 4	Haisborough, Hammond and Winterton
	North Norfolk Sandbanks and Saturn Reef
	Southern North Sea
SNS 5	Dogger Bank
	Southern North Sea
	Doggersbank
SNS 6	Southern North Sea
	Humber Estuary
SNS 7	Dogger Bank
	Southern North Sea
SNS 8	North Norfolk Sandbanks and Saturn Reef
	Southern North Sea

East Irish Sea	
SPAs	
EIS 1	Liverpool Bay
	The Dee Estuary*
	Mersey Narrows and North Wirral Foreshore*
	Ribble and Alt Estuaries*
	Morecambe Bay & Duddon Estuary*

Notes: *screened in for being a source colony, or adjoining waterbird site with likely connectivity (see Section 4.6.1).

B3 Underwater noise

Northern North Sea	
n/a	n/a
Southern North Sea	
SPAs	
SNS 3	Greater Wash
	Flamborough & Filey Coast
	The Wash*
	Outer Thames Estuary SPA*
SNS 4	Greater Wash
	The Wash*
	Outer Thames Estuary SPA*
SNS 6	Greater Wash
	The Wash*
	Outer Thames Estuary SPA*
SACs	
SNS 1	Southern North Sea
SNS 2	Southern North Sea
SNS 3	Southern North Sea
	Humber Estuary
	The Wash and North Norfolk Coast
SNS 4	Southern North Sea
SNS 5	Southern North Sea
	Doggersbank
	Klaverbank
SNS 6	Southern North Sea
	Humber Estuary
SNS 7	Southern North Sea
	Klaverbank
SNS 8	Southern North Sea
East Irish Sea	
SPAs	
EIS 1	Liverpool Bay

Notes: *screened in for being a source colony, or adjoining waterbird site with likely connectivity for noise sensitive species (see Section 4.6.1).

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