Department for Energy Security & Net Zero

1st Offshore Carbon Dioxide Storage Licensing Round

Habitats Regulations Assessment

Appropriate Assessment

May 2023

May 2023

Contents

1 Introduction

1.1 Background, overview of the plan and legislative context

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 eastern Irish Sea. The licensing round closed on 13th September 2022, with 26 applications covering all or part of the 13 areas offered. Following further evaluation of the applications by the NSTA, 21 licence areas covering all or parts of the 13 areas offered are proposed.

The plan/programme covering the launch of this carbon storage licensing round was 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 the OESEA4 Environmental Report concluded on 27th May 2022 and the Government Response was published in September 2022, at which time the new plan/programme was adopted.

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 Oil & Gas Authority (OGA, now operating as 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)[1] provide a regulatory regime for certain activities, including carbon dioxide storage, that could affect Special Protected Areas (SPAs) and Special areas of Conservation (SACs) in UK

[1] The Regulations transposed the EU Habitats Directive (92/43/EEC), and are retained EU law under the *European Union (Withdrawal) Act 2018*. Under that Act, at the time of this assessment the Directive remains relevant to interpretation of the meaning and effect of the Regulations.

territorial seas and on the UK Continental Shelf (UKCS)[2]. The *Conservation of Offshore Marine Habitats and Species Regulations 2017* cover other relevant activities in offshore waters (i.e. excluding territorial seas). Within territorial seas, the following apply, *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.

As the carbon storage licensing aspects of the plan/programme are not directly connected with or necessary for nature conservation management of SPAs and SACs, to comply with its obligations under the relevant regulations, the Department for Energy Security and Net Zero (formerly part of the Department for Business, Energy and Industrial Strategy)[3] (the Department) is undertaking a Habitats Regulations Assessment (HRA). The Secretary of State undertook a screening assessment under the *Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001* (as amended) (summarised in Section 1.2) to determine whether the award of any of the areas offered would be likely to have a significant effect on a relevant site, either individually or in combination[4] with other plans or projects (BEIS 2022b). In doing so, the Department has applied the statutory test, as elucidated by relevant case law[5], 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.*

1.2 Areas subject to assessment

A screening assessment (including consultation with the statutory conservation agencies/bodies) formed the first stage of the HRA process. The assessment was undertaken in the period within which applications were being accepted, and therefore considered the potential for activity in all areas on offer to lead to a likely significant effect. The screening

[2] 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.*
[3] Note that while certain licensing and related regulatory functions were passed to the OGA (a government company wholly owned by the Secretary of State) 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).
[4] 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).
[5] See, in particular, the European Court of Justice case of Waddenzee (C-127/02). At the time of this assessment, this remains relevant to interpretation of the UK's legislation as retained EU case law under the *European Union (Withdrawal) Act 2018*.

identified that ten of the areas offered would require further assessment prior to the NSTA making decisions on whether to grant licences, subject to all or part of these areas being applied for. Following the closing date for applications, and the publication of the screening document[6], it was concluded that all ten areas identified would be subject to further assessment (Appropriate Assessment). The licence areas to be subject to Appropriate Assessment (AA) cover all or parts of the following areas, see Figure 1.1:

- Central North Sea (CNS): Area 1
- Southern North Sea (SNS): Area 1, Area 2, Area 3, Area 4, Area 5, Area 6, Area 7, Area 8
- Eastern Irish Sea (EIS): Area 1

1.3 Relevant Natura 2000 sites

The screening assessment identified the relevant sites and related areas on offer requiring further assessment (refer to Appendix B of BEIS 2022b), which are shown in Table 1.1 and Figure 1.1.

Table 1.1: Relevant sites requiring further assessment

Relevant site and features	Relevant areas applied for	Sources of potential effect
Central North Sea		
Scanner Pockmark SAC Annex I habitat: Submarine structures made by leaking gases	CNS 1	Physical disturbance and drilling: rig siting, drilling discharges
Southern North Sea		
Humber Estuary SPA Breeding: avocet, bittern, little tern*, marsh harrier Over winter: avocet, bar-tailed godwit, bittern, black-tailed godwit, dunlin, golden plover, hen harrier, knot, redshank, ruff, shelduck, Waterbird assemblage	SNS 3	Physical disturbance and drilling: rig siting, drilling discharges
North Norfolk Coast SPA Breeding: avocet, bittern, common tern, little tern, Sandwich tern, marsh harrier, Montagu's harrier Over winter: dark-bellied brent goose, knot, pink-footed goose, wigeon, Waterbird assemblage	SNS 3	Physical disturbance and drilling: rig siting, drilling discharges

[6] Since the publication of the Habitats Regulations Assessment Stage 1 (HRA Stage 1) - Site Screening, a minor revision (of the order of 1.5 metres) has been made to the western boundary of CNS Area 2. The scale of this change is such that it does not make any material difference to the scale, nature or impact of anything that might be done or any activities that might be carried out pursuant to the licence, which were considered in the HRA Stage 1 assessment. The screening conclusions reached therefore remain unchanged.

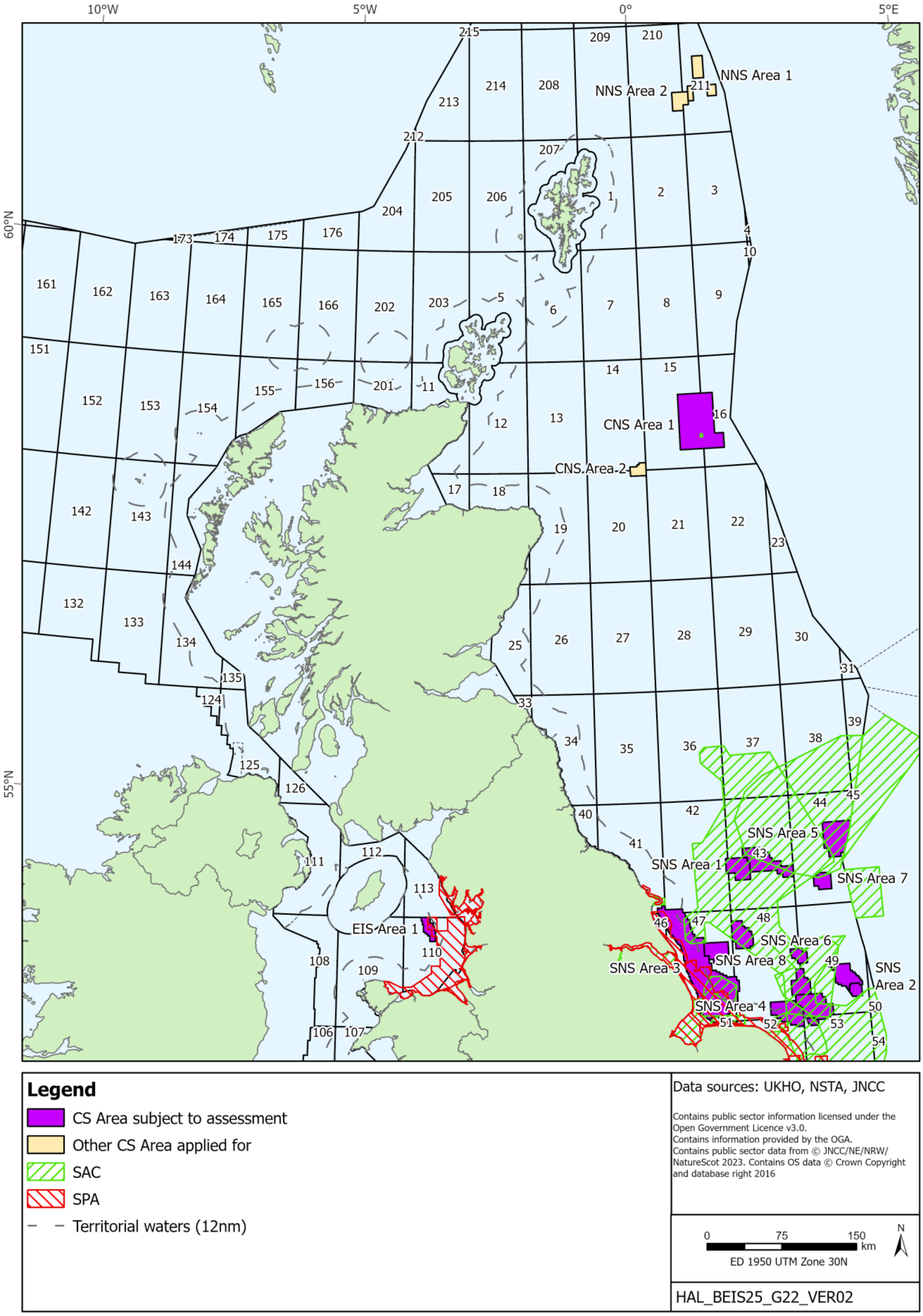
Relevant site and features	Relevant areas applied for	Sources of potential effect
Greater Wash SPA Breeding: Sandwich tern, common tern, little tern Over winter: little gull, red-throated diver, common scoter	SNS 3	Physical disturbance and drilling: rig siting, drilling discharges
Over winter: red-throated diver, common scoter	SNS 4, SNS 6	Underwater noise: deep geological seismic survey, rig site survey, vertical seismic profiling (VSP), conductor piling, drilling, vessel & rig movements
The Wash SPA Breeding: little tern*	SNS 3	Physical disturbance and drilling: rig siting, drilling discharges
Over winter: common scoter	SNS 3	Physical disturbance and drilling: rig siting, drilling discharges Underwater noise: deep geological seismic survey, rig site survey, VSP, conductor piling, drilling, vessel & rig movements
Gibraltar point SPA* Breeding: little tern	SNS 3	Physical disturbance and drilling: rig siting, drilling discharges
Great Yarmouth North Denes SPA* Breeding: little tern	SNS 3	Physical disturbance and drilling: rig siting, drilling discharges
Breydon Water SPA* Breeding: common tern	SNS 3	Physical disturbance and drilling: rig siting, drilling discharges
Outer Thames Estuary SPA* Breeding: little tern*, breeding common tern*	SNS 3	Physical disturbance and drilling: rig siting, drilling discharges
Over winter: red-throated diver*	SNS3, SNS 4	Underwater noise: deep geological seismic survey, rig site survey, VSP, conductor piling, drilling, vessel & rig movements
Flamborough & Filey Coast SPA Breeding: gannet, kittiwake, razorbill, guillemot, fulmar, breeding seabird assemblage	SNS 3	Physical disturbance and drilling: rig siting, drilling discharges
Breeding: gannet	SNS 3	Underwater noise: deep geological seismic survey, rig site survey, VSP, conductor piling, drilling, vessel & rig movements
Southern North Sea SAC Annex II species: harbour porpoise	SNS 1, SNS 2, SNS 3, SNS 4, SNS 5, SNS 6, SNS 7, SNS 8	Underwater noise: deep geological seismic survey, rig site survey, VSP, conductor piling, drilling, vessel & rig movements
	SNS 1, SNS 2, SNS 3, SNS 4, SNS 5, SNS 6, SNS 7, SNS 8	Physical disturbance and drilling: rig siting, drilling discharges
Flamborough Head SAC Annex I habitats: reefs, sandbanks	SNS 3	Physical disturbance and drilling: rig siting, drilling discharges
Humber Estuary SAC	SNS 3, SNS 6	Underwater noise: deep geological seismic survey, rig site survey, VSP, conductor piling, drilling, vessel & rig movements

Relevant site and features	Relevant areas applied for	Sources of potential effect
Annex II species: grey seal, sea lamprey Annex I habitats: estuaries, mudflats and sandflats, sandbanks, saltmarsh and salt meadows, coastal lagoons, coastal dunes	SNS 3	Physical disturbance and drilling: rig siting, drilling discharges
The Wash and North Norfolk Coast SAC Annex II species: harbour seal	SNS 3	Underwater noise: deep geological seismic survey, rig site survey, VSP, conductor piling, drilling, vessel & rig movements
Annex I habitats: reefs, sandbanks Annex II species: harbour seal	SNS 3	Physical disturbance and drilling: rig siting, drilling discharges
North Norfolk Sandbanks and Saturn Reef SAC Annex I habitats: reefs, sandbanks	SNS 2, SNS 4, SNS 8	Physical disturbance and drilling: rig siting, drilling discharges
Haisborough, Hammond and Winterton SAC Annex I habitats: reefs, sandbanks	SNS 4	Physical disturbance and drilling: rig siting, drilling discharges
Inner Dowsing, Race Bank and North Ridge SAC Annex I habitats: reefs, sandbanks	SNS 3	Physical disturbance and drilling: rig siting, drilling discharges
Dogger Bank SAC Annex I habitat: sandbanks which are slightly covered by sea water all the time	SNS 1, SNS 5, SNS 7	Physical disturbance and drilling: rig siting, drilling discharges
Doggersbank SAC (Netherlands) Annex II species: grey seal, harbour seal, harbour porpoise	SNS 5	Underwater noise: deep geological seismic survey, rig site survey, VSP, conductor piling, drilling, vessel & rig movements
	SNS 5	Physical disturbance and drilling: rig siting, drilling discharges
Klaverbank SAC (Netherlands) Annex II species: grey seal, harbour seal, harbour porpoise	SNS 5, SNS 7	Underwater noise: deep geological seismic survey, rig site survey, VSP, conductor piling, drilling, vessel & rig movements
Eastern Irish Sea		
Liverpool Bay SPA Breeding: little tern, common tern Over winter: red-throated diver, little gull, common scoter Wintering waterbird assemblage (cormorant, red-breasted merganser)	EIS 1	Physical disturbance and drilling: rig siting, drilling discharges
Over winter: red-throated diver, common scoter Wintering waterbird assemblage (cormorant, red-breasted merganser)		Underwater noise: deep geological seismic survey, rig site survey, VSP, conductor piling, drilling, vessel & rig movements
The Dee Estuary SPA* Breeding: common tern and little tern		Physical disturbance and drilling: rig siting, drilling discharges
Mersey Narrows and North Wirral Foreshore SPA* Breeding: common tern		Physical disturbance and drilling: rig siting, drilling discharges

Relevant site and features	Relevant areas applied for	Sources of potential effect
Ribble and Alt Estuaries SPA* Breeding: common tern		Physical disturbance and drilling: rig siting, drilling discharges
Morecambe Bay & Duddon Estuary SPA* Breeding: common tern, little tern		Physical disturbance and drilling: rig siting, drilling discharges

Notes: *screened in for being a source colony, or adjoining waterbird site with likely connectivity

Figure 1.1: Licence areas applied for and sites relevant to this Appropriate Assessment



1.4 Assessment overview

This document sets out the key assumptions and approach to the AA, the evidence base underpinning the assessment and the assessment of relevant areas applied for and sites. The document is organised as follows:

- Overview of the licensing process and nature of the activities that could follow including assumptions used to underpin the AA process (Section 2)
- Description of the approach to identifying any adverse effects on the integrity of relevant sites (Section 3)
- Evidence base on the environmental effects of offshore carbon dioxide exploration/appraisal activities to inform the assessment (Section 4)
- The assessment of effects on the integrity of relevant sites, including in-combination with other plans or projects (Section 5)
- Overall conclusion (Section 6)

As part of this HRA process, a draft of the AA document was subject to consultation with appropriate nature conservation bodies and the public (via the 1st Carbon Dioxide Storage Round Appropriate Assessment consultation page of the gov.uk website) and has been amended as appropriate in light of comments received.

2 Licensing and potential activities

2.1 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 extend beyond these, and more than one licence application may be received for the areas offered. A Licence grants exclusive rights to the holders to undertake 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 HRA under the Habitats Regulations.

Carbon dioxide storage licences contain three terms covering exploration and appraisal (Appraisal or Initial Term[7]), operation, and post-closure. The appraisal term (see below for summary of the four stages) includes a work programme to evaluate the potential for a storage project 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, but will 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)

[7] 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.

- Site Characterisation (definition of the proposed Storage Site and Complex, geophysical surveys, appraisal drilling)
- 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.

2.2 Activities that could follow licensing

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 of 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 in 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 specify in writing no later than three months before the deadline that the commitment is no longer required and on what grounds.

It should be noted that the award of a Carbon Storage Licence does not automatically allow a licensee to carry out any offshore activities from then on. Figure 2.1 provides an overview of the plan process associated with the 1st Carbon Storage Licensing Round and the various environmental assessments including HRA. Offshore activities such as drilling are subject to relevant activity specific environmental assessments by the Department (see Figures 2.2 and 2.3), and there are other regulatory provisions exercised by 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.

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: Stages of plan level environmental assessment

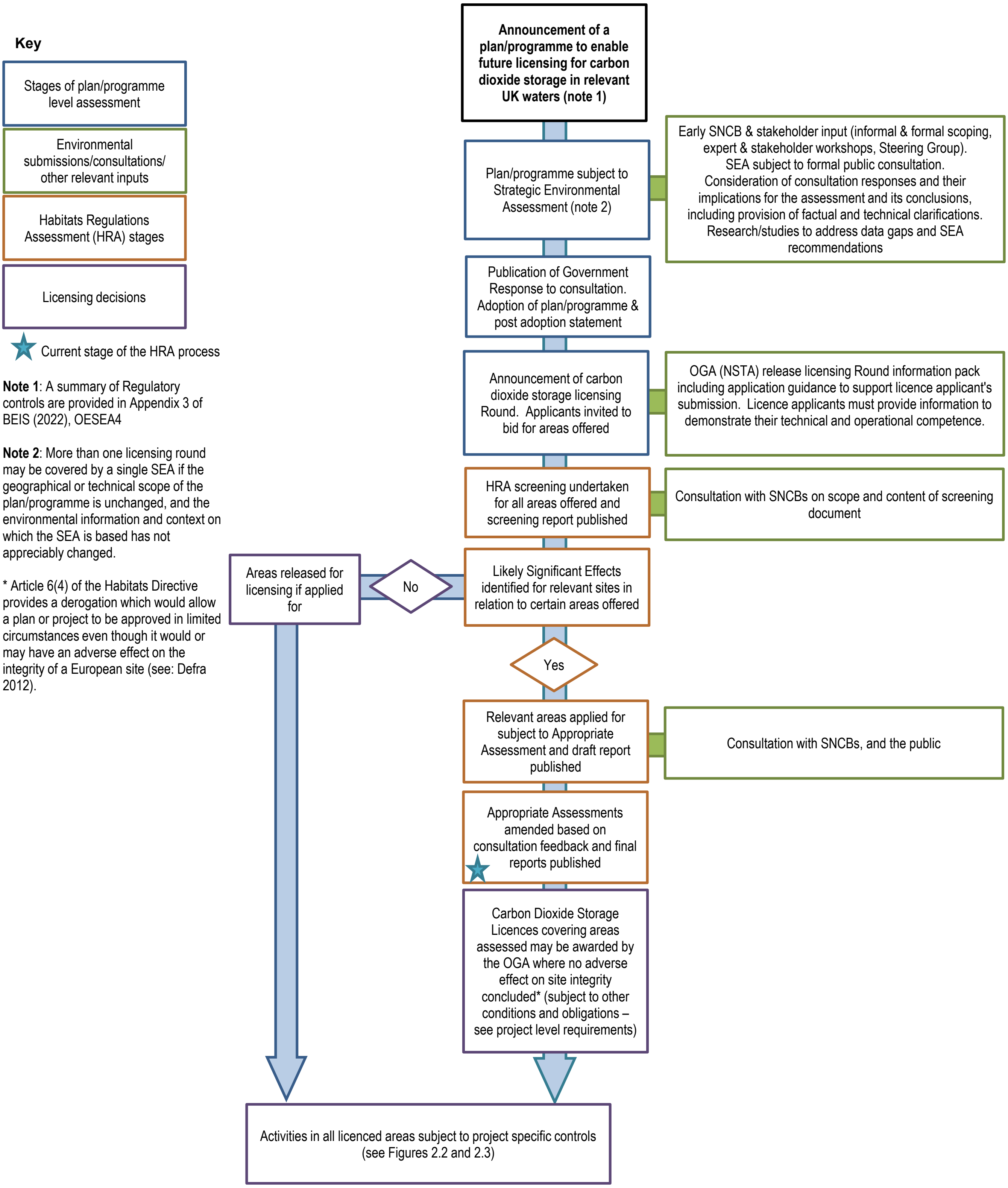
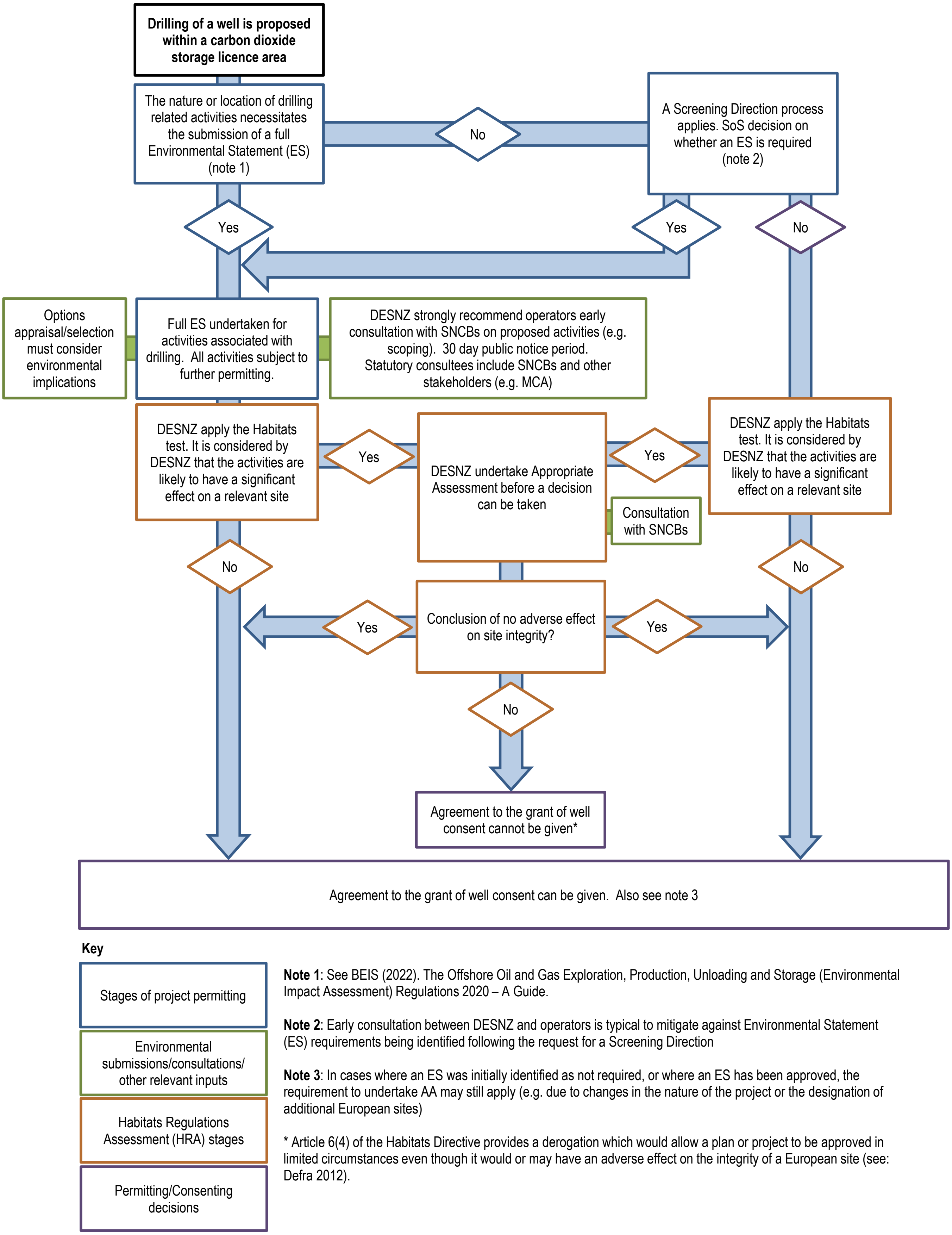


Figure 2.2: High level overview of exploration/appraisal drilling environmental requirements



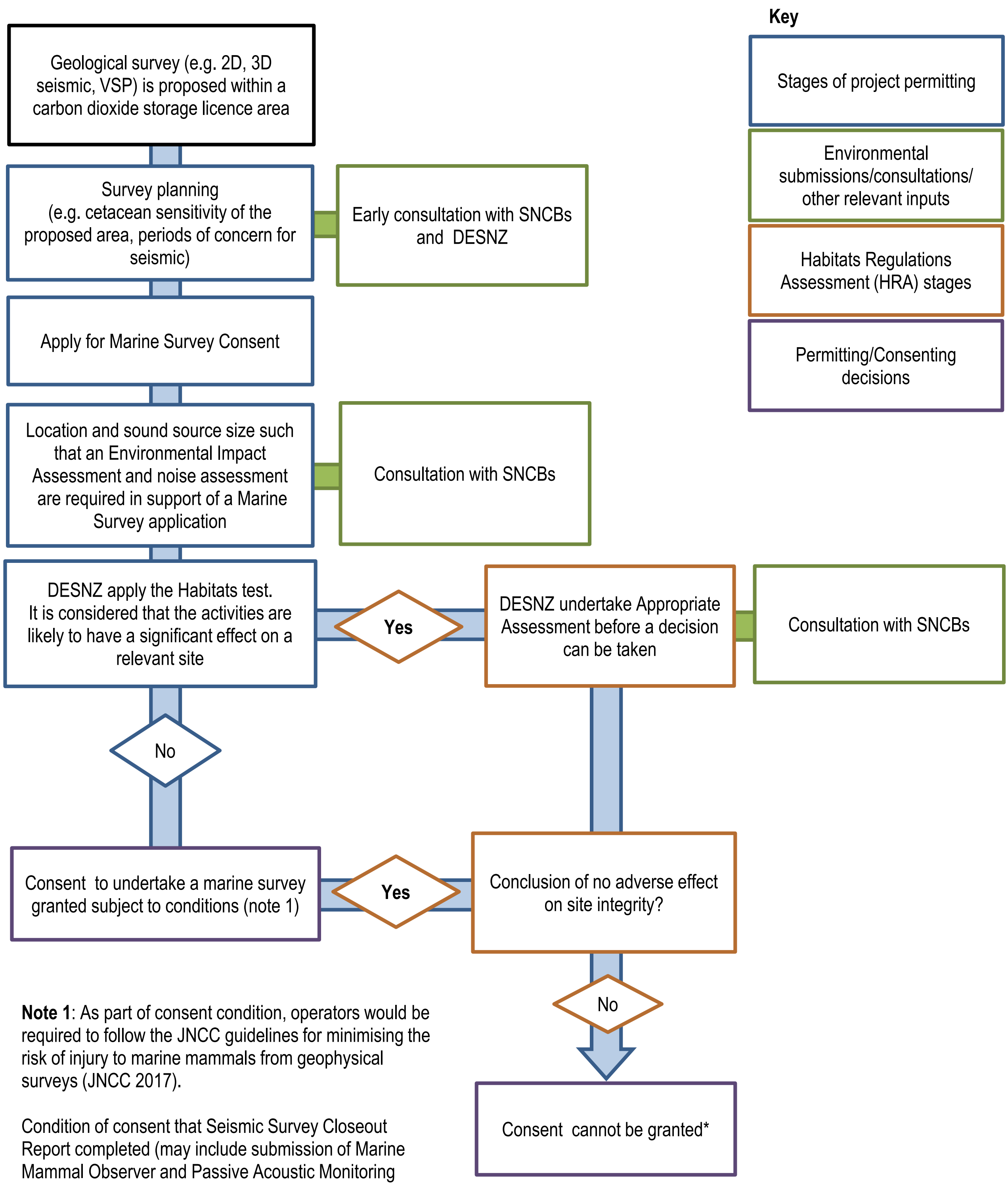
Note 1: See BEIS (2022). The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 – A Guide.

Note 2: Early consultation between DESNZ and operators is typical to mitigate against Environmental Statement (ES) requirements being identified following the request for a Screening Direction

Note 3: In cases where an ES was initially identified as not required, or where an ES has been approved, the requirement to undertake AA may still apply (e.g. due to changes in the nature of the project or the designation of additional European sites)

* Article 6(4) of the Habitats Directive provides a derogation which would allow a plan or project to be approved in limited circumstances even though it would or may have an adverse effect on the integrity of a European site (see: Defra 2012).

Figure 2.3: High level overview of seismic survey environmental requirements



Note 1: As part of consent condition, operators would be required to follow the JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys (JNCC 2017).

Condition of consent that Seismic Survey Closeout Report completed (may include submission of Marine Mammal Observer and Passive Acoustic Monitoring reports)

* Article 6(4) of the Habitats Directive provides a derogation which would allow a plan or project to be approved in limited circumstances even though it would or may have an adverse effect on the integrity of a European site (see: Defra 2012).

2.2.1 Likely scale of activity and carbon storage appraisal activities considered by the HRA

As this is the first carbon dioxide storage licensing round, it is not possible to gauge the potential for any of the areas to proceed to the permit application stage based on previous experience. Licensees that fulfil the Appraisal/Initial Terms and progress to applying for a storage permit may require further drilling, installation of infrastructure such as wellheads, pipelines, and possibly fixed platform injection facilities. The nature, extent and timescale of such 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 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/or for permits to be refused if necessary. Therefore, only activities as part of the work programmes associated with the appraisal term will be considered in this HRA (see Table 2.2).

Potential accidental events, including spills, are not considered in the AA as they are not part of the work programme. Measures to prevent accidental events and potential impacts in the receiving environment, along with proposed response plans 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.

The approach used in this assessment has been to take the proposed activity for each of the carbon storage licence areas as being the maximum of any application for that area, and to assume that all activity takes place. The maximum estimates of work commitments for the relevant areas derived from the applications received by the NSTA or that may be considered by the NSTA to be required to enable appropriate appraisal of the areas are shown in Table 2.1 overleaf. Licence applications for the parts of each area contain different work programme elements that may or may not involve offshore activities such as the drilling of wells or the shooting of new seismic survey. The areas where field activities are proposed are shown in Figure 2.4. No offshore activities are proposed for the entirety of CNS Area 1 and SNS Area 8, the shooting of new seismic is not proposed for SNS Area 2 and parts of SNS Area 1 and SNS Area 4, and wells are not proposed for part of SNS Area 6. Where offshore activities are not proposed related effects are not considered further in this assessment.

Completion of the work programmes is likely to involve one or more of the activities summarised in Table 2.2. A series of assumptions has been developed on the nature and scale of activities to be assessed informed by the evidence base for potential effects presented in Section 4. Subsequent 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 activity specific screening procedures and tests under the relevant legislation.

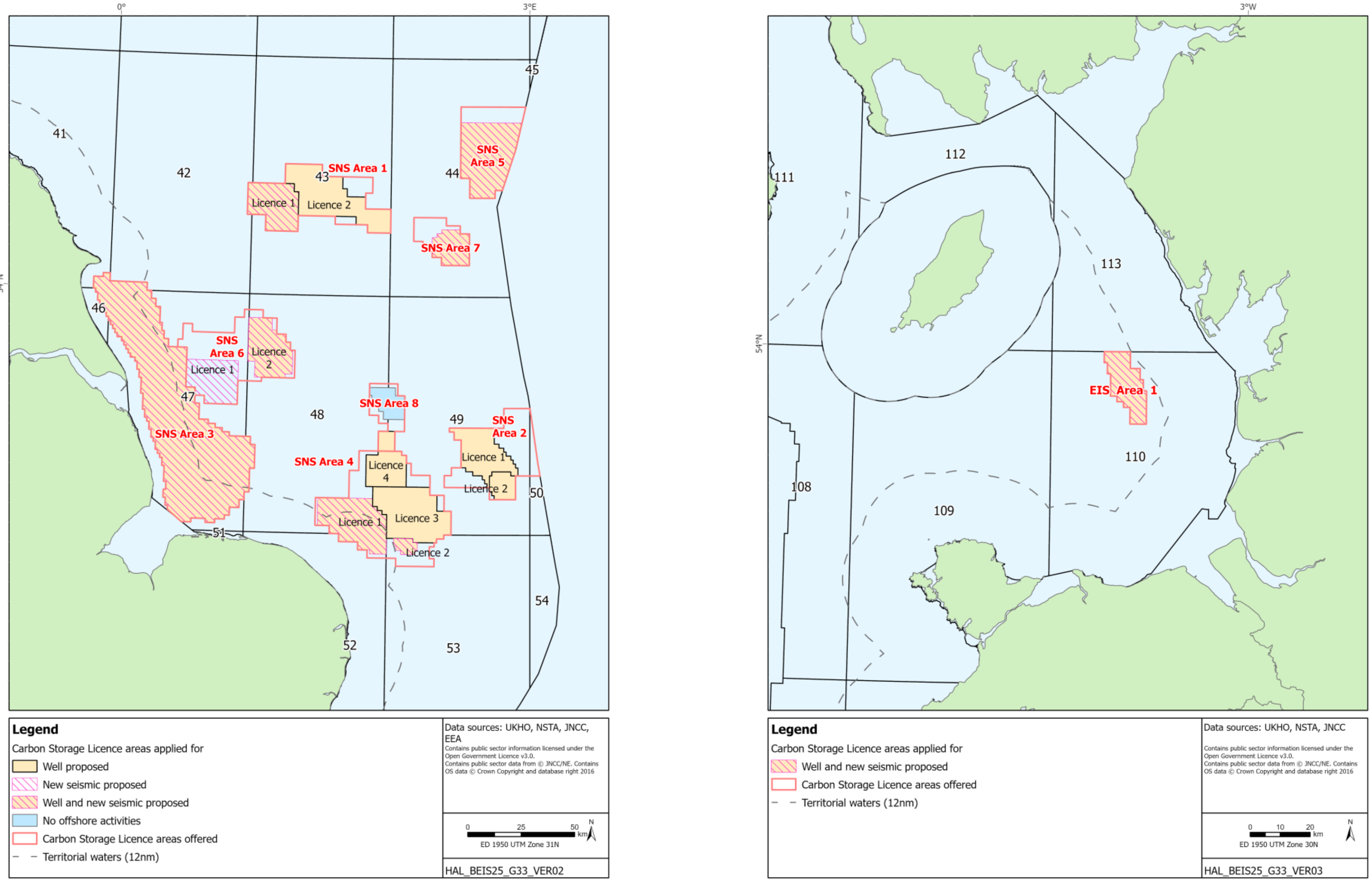
Table 2.1: High case work programmes relevant to the areas considered in this assessment

Area	Obtain[8] and/or reprocess 2D or 3D seismic data	Shoot 3D seismic	Appraisal/exploration wells
EIS Area 1	-	✓	One
CNS Area 1	✓	-	-
SNS Area 1 (Licence 1)	✓	✓	One
SNS Area 1 (Licence 2)	✓	-	One
SNS Area 2 (Licence 1)	✓	-	One
SNS Area 2 (Licence 2)	✓	-	One
SNS Area 3	✓	✓	Two
SNS Area 4 (Licence 1)	✓	✓	One
SNS Area 4 (Licence 2)	✓	✓	One
SNS Area 4 (Licence 3)	✓	-	One
SNS Area 4 (Licence 4)	✓	-	One
SNS Area 5	✓	✓	One
SNS Area 6 (Licence 1)	✓	✓	-
SNS Area 6 (Licence 2)	✓	✓	One
SNS Area 7	✓	✓	One
SNS Area 8	✓	-	-

[8] To obtain seismic data means purchasing or otherwise getting the use of existing data and does not involve shooting new seismic.

Figure 2.4: Work programmes including the shooting of new seismic or the drilling of a well by licence application

Southern North Sea | **Eastern Irish Sea**



Note: Licence numbers are only distinguished where more than once licence application has been made within an area offered.

Table 2.2: Indicative overview of potential activities and related environmental aspects that could arise from the appraisal term

Potential activity / environmental aspect	Description	Assumptions used for assessment
Geophysical survey		
Seismic (2D and 3D) survey – underwater noise	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 – underwater noise	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). Studies (Crocker & Fratantonio 2016, Halvorsen & Heaney 2018 (also see Labak 2019), Pace *et al.* 2021) of the acoustic characteristics of example geophysical survey equipment types including through open water testing, have provided a better understanding of the source levels, frequencies, and potential effects of using such equipment.	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 – physical presence	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.
	Semi-submersible rigs are used in deeper waters (normally >120m). Mooring is achieved using either anchors (deployed and recovered by	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

Potential activity / environmental aspect	Description	Assumptions used for assessment
Rig placement/ anchoring – seabed disturbance	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).	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.
	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[9], 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. Mud mats are routinely used in offshore oil & gas and offshore wind infrastructure. In particular they tend to be used below templates and pipeline end manifolds to control vertical and lateral movements of the structures, and also on the footings of jacket-type structures to provide on-bottom stability prior to the installation of piles, particularly on soft sediments (Dunne & Martin 2017, IFC 2021, Shell 2022, Ørsted 2022). Mud mats are generally made from steel, and are used to distribute the weight of the overlying infrastructure to prevent sinking into the sediment but also control lateral movements (Dunne & Martin 2017). Mud mats are also used for jack-up rig drilling (Stewart 2007) as an alternative to rock placement, though examples are fewer than for fixed infrastructure. Mud mats, if used, would be expected to be removed as part of the overall drilling programme,

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

Potential activity / environmental aspect	Description	Assumptions used for assessment
		and would therefore, be only a temporary feature which would be permanently removed on completion of the work programme.
Drilling activities - Marine discharges and seabed disturbance	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 – underwater noise	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. 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	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.

Potential activity / environmental aspect	Description	Assumptions used for assessment
	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 - underwater noise	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).
Well evaluation (e.g. Vertical Seismic Profiling) – underwater noise	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 cubic inches 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).

2.3 Existing regulatory requirements and controls

The AA assumes that the high-level controls described below are applied as standard to activities since they are legislative requirements. These are distinct from further control measures which may be identified and employed to avoid likely significant effects on relevant sites. These further control measures are identified in Sections 5.1-5.3 with reference to the two main sources of effect identified: physical disturbance and underwater noise. The legislation covering environmental regulation of *Petroleum Act* related activities was effectively modified to incorporate carbon dioxide storage by the *Energy Act (Consequential Modifications) (Offshore Environmental Protection) Order 2010*. Therefore, the regulatory requirements and controls for exploration and appraisal of carbon dioxide stores are broadly comparable to those for oil and gas exploration and appraisal.

2.3.1 Physical disturbance and marine discharges

The routine sources of potential physical disturbance and drilling effects associated with exploration and appraisal are assessed and controlled through a range of regulatory processes, such as *The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020* as part of the Drilling Operations Application and, where relevant, HRA to inform decisions on those applications[10].

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)[11]. 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 sensitive habitats by such survey (including those under Annex I of the Habitats Directive) may influence the Department's decision on a project-level consent.

Discharges from offshore facilities, including drilling rigs, are subject to stringent regulatory controls (see review in BEIS 2022a, and related Appendices 2 and 3) 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 which would be 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.

2.3.2 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

[10] https://www.gov.uk/guidance/oil-and-gas-offshore-environmental-legislation
[11] BEIS (2021c). The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 - A guide. July 2021 - Revision 3.

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).

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 specifying timing or other specific control measures) or advise against consent. The SNCBs (JNCC, Natural England and DAERA) have published guidance for assessing the significance of noise disturbance against conservation objectives of harbour porpoise SACs (JNCC *et al*. 2020). This has been developed through several years of inter-agency work and stakeholder discussion, including a period of consultation on draft guidance in February/March 2020. Key elements of the guidance include recommended effective deterrence ranges (EDRs) to estimate temporary habitat loss from different noise-generating activities, coupled with a definition of significant disturbance that is based on daily and seasonal spatial thresholds of porpoise exclusion. Any plan or project which, individually or in combination, could breach these area/time thresholds could be deemed to have an adverse effect on site integrity, necessitating noise management measures such as adjustment of activity schedules, the use of alternative technologies and noise abatement. Following receipt of the guidance, the Department (OPRED) is working on an implementation approach for industry, including preparing and publishing a policy statement. The Department (OPRED) are also engaging with the SNCBs and the relevant Southern North Sea (SNS) Regulators on implementation of the guidance[12]. In the intervening period, there is no expectation from the Department that this guidance is applied to applications involving mobile noise sources, for example geological survey applications, but it is advised that the guidance is appropriate to apply to specific activities, namely piling and unexploded ordnance detonation.

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*[13]. The updated 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 minimises sound generated and consequent likely impacts, and to implement best practice measures described in the guidelines.

[12] https://www.gov.uk/guidance/oil-and-gas-offshore-environmental-legislation#sncb-noise-guidance
[13] 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.

3 Appropriate Assessment Process

3.1 Process

In carrying out this AA, so as to determine whether it is possible to agree to the grant of licences, in accordance with Regulation 5(1) of *The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001* (as amended), the Department has:

- Considered, on the basis of the precautionary principle, whether it could be concluded that the integrity of relevant sites would not be affected. This impact prediction involved a consideration of the in-combination effects.

- Examined, in relation to elements of the plan where it was not possible to conclude that the integrity of relevant sites would not be affected, whether appropriate mitigation measures could be designed which negated or minimised any potential adverse effects identified.

In considering the above the Department has taken the following approach, so that:

- Prior to the grant of any licence all activities which may be carried out during the appraisal term of such a licence, and which by themselves or in combination with other activities can affect the site's conservation objectives, are identified in the light of the best scientific knowledge in the field.

- A licence can only be granted if the Department has made certain that the activities to be carried out during the appraisal term under such a licence will not adversely affect the integrity of that site (i.e. cause deterioration to a qualifying habitat or habitat of qualifying species, and/or undermine the conservation objectives of any given site). That is the case where no reasonable scientific doubt remains as to the absence of such effects.

3.2 Site integrity

The integrity of a site is defined by government policy and clarified by the courts (Cairngorms judicial review case[14]) as being: *'…the coherence of its ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and/or the levels of populations of the species for which it was classified/[designated].'* This is consistent with the definitions of favourable conservation status in Article 1 of the Habitats Directive (JNCC 2002). The integrity of a site relates to the site's conservation objectives. These objectives are assigned at the time of designation to ensure that the site continues, in the long-term, to make an appropriate contribution to achieving favourable conservation status for the qualifying interest features. An adverse effect would be something that impacts the site features, either directly or indirectly, and results in disruption or harm to the ecological structure and functioning of the site and/or affects the ability of the site to meet its conservation objectives. For example, it is possible that a plan or project will adversely affect the integrity of a site only in a visual sense or only with respect to habitat types or species other than those listed in Annex I or Annex II. In such cases, the effects do not amount to an adverse effect for

[14] WWF UK Ltd v Secretary of State for Scotland [1999] 1 C.M.L.R. 1021.

purposes of Regulation 6 of the *Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001*, provided that the coherence of the network is not affected. The AA must therefore conclude whether the proposed activity adversely affects the integrity of the site, in the light of its conservation objectives.

3.3 Assessment of effects on site integrity

The assessment has been undertaken in accordance with the European Commission Guidance (EC 2019) and with reference to other guidance, reports, and policy, including the Habitats Regulations Guidance Notes (English Nature 1997, Defra 2012, SEERAD 2000), SNH (2015), the National Planning Policy Framework (MHCLG 2021), the Marine Policy Statement (HM Government 2011), English Nature report No. 704 (Hoskin & Tyldesley 2006) and Natural England report NECR205 (Chapman & Tyldesley 2016).

The assessment of effects on site integrity is documented in Section 5. It has been informed by an evidence base on the environmental effects of oil and gas activities on the UKCS and elsewhere (Section 4) which are considered to be a proxy for carbon storage activities, and has utilised a number of assumptions on the nature and scale of potential activities that could follow licensing (Table 2.2), along with the characteristics and specific environmental conditions of the relevant sites (see Section 5). Activities which may be carried out following the grant of a licence, and which by themselves or in combination with other activities can affect the conservation objectives of relevant sites are discussed under the following broad headings in each of the regional sections:

- Physical disturbance and drilling effects
- Underwater noise effects
- In-combination effects

4 Evidence base for assessment

4.1 Introduction

The AAs are informed by an evidence base on the environmental effects of carbon dioxide storage appraisal related activities and analogous oil and gas activities derived from the scientific literature, relevant Strategic Environmental Assessments (e.g. DECC 2009, 2011, 2016, 2016, BEIS 2018, 2022a) and other literature. Recent operator Environmental Statements for offshore exploration and appraisal activities on the UKCS have also been reviewed, noting that appraisal drilling for carbon dioxide storage will be broadly similar to that undertaken for oil and gas project. These provide, for example, a more specific indication of the range of spatial footprints associated with relevant drilling activities to inform the further consideration of those sites where physical disturbance and drilling effects may be considered likely.

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 approach underpins advice on operations for a number of the sites included in this assessment (e.g. Dogger Bank SAC, Humber Estuary SAC, The Wash and North Norfolk Coast SAC, North Norfolk Coast SPA, North Norfolk Sandbanks and Saturn Reef SAC). The advice identifies a range of pressures for the sites in relation to oil, gas and carbon dioxide storage exploration activity, for which the site features are regarded to be either sensitive, not sensitive; or where a sensitivity assessment has not been made, or it is concluded there is insufficient evidence for a sensitivity assessment to be made at the pressure benchmark[15]. Whilst the matrices provided as part of the advice are informative and note relevant pressures associated with hydrocarbon exploration and gas storage, resultant effects are not inevitable consequences of activity since often they can 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 hydrocarbon (and by extrapolation, carbon storage) exploration from

[15] Note that the advice does not take into account the intensity, frequency or cumulative impacts from activities, and pressure benchmarks are used as reference points to assess sensitivity and are not thresholds that identify a likely significant effect within the meaning of Habitats Regulations (JNCC 2017a)

successive Offshore Energy SEA, including the most recent OESEA4 (BEIS 2022a) covers the range of pressures identified in the advice for the relevant sites (as summarised in Sections 4.2-4.3) 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. hydrocarbon contamination, 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 carbon dioxide storage or oil and gas activities (as outlined in Section 2.3) 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 advice on operations, the conservation objectives and any Supplementary Advice on Conservation Objectives (SACO) have been taken into account. The following sections provide a summary of the evidence informing the site-specific assessment of effects provided in Section 5. To focus the presentation of relevant information, the sections take account of the environments in which those areas applied for and relevant sites to be subject to further assessment are located (Figure 1.1).

4.2 Physical disturbance and drilling effects

The pressures[16] which may result from exploration/appraisal activities and cause physical disturbance and drilling effects on relevant sites assessed in Section 5.2 are described below with respect to rig siting, drilling discharges and other effects. The information base relies on evidence from the drilling of oil and gas exploration/appraisal and development wells, as these are broadly comparable to carbon dioxide storage wells.

4.2.1 Rig siting

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 dynamically positioned (DP) drill ships or DP semi-submersible rigs. These use a number of thrusters and accurate positioning information to maintain their station. Semi-submersible rigs could be used in CNS Area 1, but jack-ups rigs (see below) may also be an option depending on water depths at the intended drilling location.

Jack-up rigs, normally used in shallower water (<120m), leave three or four seabed depressions from the feet of the rig (the spud cans) 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 associated

[16] Relevant pressures identified from advice on operations for sites and JNCC PAD (2018).

with the drilling of a previous 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). Similar results are noted for Lincs wind farm (EGS 2016), with post construction monitoring indicating bathymetric changes to the seabed of up to 1.2m from jack-up depressions, and their infilling over time. 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). Jack-up rigs are likely to be used in all of the SNS and EIS areas applied for, and may be used in CNS Area 1 depending on water depths at the drilling location.

The drilling of the well surface hole and installation of the conductor will result in highly localised changes to the substrate below the surface of the seabed, for example, a typical conductor may have a diameter of 26 inches. 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 generated from installing jack-up rigs, some natural infilling and recovery of the seabed would be expected following conductor removal, subject to local hydrodynamic conditions.

Broadly, physical effects of seabed disturbance may include mortality to benthic fauna as a result of physical trauma, smothering by re-suspended sediment. The majority of seabed species recorded from the European continental shelf are known, or believed to have, short lifespans (a few years or less) and relatively high reproductive rates, indicating the potential for rapid population recovery, typically between one to five years (Jennings & Kaiser 1998). In general, macrofaunal population levels are limited by post-settlement factors rather than larval availability.

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, and related habitat loss, which in the context of HRA, could lead to a reduction in feature extent that would need to be considered in relation to the site's conservation objectives and conservation status. 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 UKCS, 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[17] programme. Phase 1 projects (2015-2017) are now complete; those of relevance

[17] https://www.insitenorthsea.org/

suggest that man-made structures may influence benthic community structure and function but only on a limited spatial scale. Modelling indicates the strong potential for biological connectivity between structures in the North Sea (e.g. Henry *et al.* 2018, Mayorga-Adame *et al.* 2022), 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 man-made structures in the marine environment, building on phases 1 and 2 of the INSITE programme.

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[18]. The Convention includes Regulations with specified technical standards and requirements (IMO Globallast website[19]). Further, carbon dioxide exploration and appraisal activity is unlikely to change the risk of the 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.

4.2.2 Drilling discharges

Abrasion/disturbance of the substrate on the surface of the seabed, changes in suspended solids (water clarity), smothering and siltation rate changes (light), physical change (to another sediment type) and habitat structure changes – removal of substratum (extraction)

The pressures described in this section relate to physical ones associated with the discharge and settlement of cuttings during exploration well drilling rather than potential chemical pressures (described below). 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 2022a, 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

[18] 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
[19] http://archive.iwlearn.net/globallast.imo.org/the-bwmc-and-its-guidelines/index.html

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).

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).

Contamination[20]

In contrast to historic discharges of cuttings from oil and gas wells drilled with oil based mud (prior to 2001)[21], effects on seabed fauna resulting from the discharge of cuttings drilled with water based muds (WBM), such as would be discharged from drilling carbon dioxide storage wells, 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 2009, 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. Analysis of UKBenthos data (Henry *et al.* 2017) for 19 installations spanning the northern, central and southern North Sea, found strong benthic responses for 12 structures, with 10 having their maximum ecological footprint within 1km of the discharge, and the remaining two within 1.2km, with recovery time varying between zero years (i.e. no effect) to between 6.8 and 8.3 years. The datasets are of limited applicability to this assessment as they largely reflected the effects of historic (pre-2001) discharges from drilling with OBM rather

[20] Including contamination from transition elements and organo-metals, hydrocarbons and PAHs, synthetic compounds and the introduction of other substances (solid, liquid or gas).
[21] 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.

than WBM, and the authors could not disentangle the effects of OBMs and WBMs in terms of persistence with the available data.

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) treated two “fine” and “coarse” sediment samples with water-based drill cuttings and placed these in water depths of 27-37m. After six months there were 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 sedimentation depth 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 sedimentation 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.

4.2.3 Other effects

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. 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[22] recommends for most species a standard displacement buffer of 2km with the exception of the species groups of divers and sea ducks. Divers and sea ducks have been assessed as being the most sensitive species groups to offshore development and associated boat and helicopter traffic. Therefore for divers and sea ducks a 4km displacement buffer is recommended. Whilst displacement effects for divers have been detected at greater distances (e.g. 5-7km, Webb 2016; 8km, HiDef 2017; 10-

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

16.5km, Mendel *et al.* 2019, Heinänen *et al.* 2020, APEM 2021; 10km, MacArthur Green 2019; 10-15km, Dorsch *et al.* 2019), 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. JNCC and Natural England advise the use at a project level, of displacement buffers of at least 2km and 2.5km relation to vessel traffic for red-throated diver and common scoter respectively.

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 per well), limiting the potential for significant interaction with migratory bird populations. Given the seasonal nature 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[23] provides relevant shipping density information[24]. 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).

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[25] indicates that post

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

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).

4.3 Underwater noise effects[26]

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 2022a). The following description of noise sources and potential effects builds on these previous publications, augmented with more recent literature sources, and can inform the impacts from exploration and appraisal drilling of carbon dioxide storage wells.

4.3.1 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 2022a).

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, but with some reaching into higher frequencies (>10,000 Hz) (Breitzke *et al*. 2008; Landrø *et al*. 2011; Hermannsen *et al*. 2015).

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[27] 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

[26] Note that all underwater noise effects fall within the “underwater noise change” and “vibration” pressure definitions.
[27] 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 2017a).

seawater is approximately -36dB/km at 100kHz, rising to -61dB at 200kHz (Lurton 2016). 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.

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.

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; SPL = Sound Pressure Level; SEL = Sound Exposure Level. Source: Crocker & Fratantonio (2016).

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).

4.3.2 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, JNCC (2017a) 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[28]. 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^{2}s. 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). Pace *et al.* (2022) considered the cumulative exposure from a typical geophysical survey which incorporated vessel noise, sub-bottom profilers (parametric and sparker), MBES, and SSS with USBL positioning, which indicated that TTS thresholds for the SEL were exceeded <10m from the source for all functional hearing groups (Southall *et al.* 2019) other than very-high frequency cetaceans (333m), which was the only group to exceed PTS thresholds, within a range of 7.2m (90% CI of 502.2m and 16.9m respectively). 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).

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

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

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 26km radius (BEIS 2022a).

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.

Graham *et al*. (2019) provided evidence that the probability of harbour porpoise behavioural responses to wind farm piling (noting that the piles used at the wind farm studied were considerably larger than conductors) was low at distances >10km and unlikely to exceed 20km, and diminished over time, which is consistent with the SNCB advice (JNCC 2020) which assumes a 15km zone of disturbance for conductor piling. 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, Pace *et al.* 2022).

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)[29]; 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 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

[29] 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.

(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[30]. 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 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).

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

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).

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

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.

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).

5 Assessment

The screening process (BEIS 2022b) identified a number of sites where there was the potential for likely significant underwater noise, physical disturbance and/or drilling effects associated with proposed activities that could follow licensing of the areas offered in the 1st Carbon Dioxide Storage Licensing Round. Further assessment of those areas applied for (see Section 1.2) is documented below. This assessment has been informed by the evidence base on the environmental effects of the types of activities associated with carbon dioxide exploration/appraisal (Sections 4.2 and 4.3), and the assumed nature and scale of potential activities (Table 2.2). Because of the wide distribution of the areas applied for around the UKCS, the AA has been presented in three regional sections as follows:

- Central North Sea (Section 5.1)
- Southern North Sea (Section 5.2)
- Eastern Irish Sea (Section 5.3)

Each regional section contains sub-sections documenting the assessment of underwater noise and physical disturbance and/or drilling effects. In-combination effects are addressed in Section 6.

5.1 Central North Sea

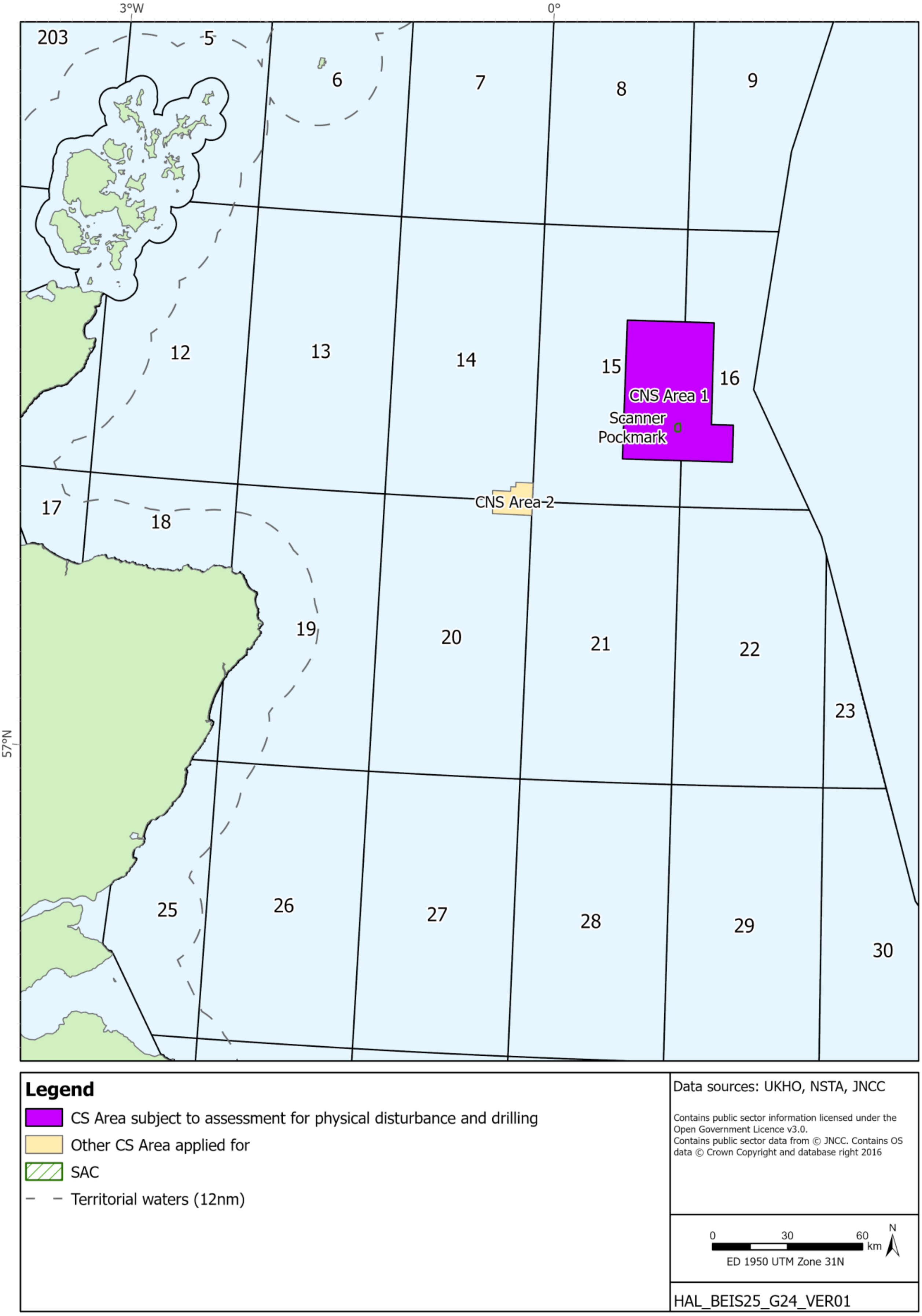
5.1.1 Relevant sites

Scanner Pockmark SAC

The Scanner Pockmark SAC site contains a total of 67 pockmarks, four of which have a considerably larger volume than the others within the site (Judd & Hovland 2007). The formation processes of these pockmarks are believed to result from the venting of biogenic/petrogenic fluids or gases into the water column, and methane derived authigenic carbonate (MDAC) has also been recorded at the base of several pockmarks. MDAC and carbonate structures are ecologically significant because they provide a habitat for marine fauna usually associated with rocky reef, and chemosynthetic organisms which feed off both methane (seeping from beneath the sea floor) and its microbial degradation by-product under anaerobic conditions, hydrogen sulphide. The carbonate structures are colonised by large numbers of anemones (*Urticina felina* and *Metridium senile*) and squat lobsters (Dando *et al.* 1991) and also support chemosynthesizers (Judd 2001). The gutless nematode *Astomonema southwardorum* occurs at this site, from where it was first described, and may have a symbiotic relationship with chemosynthetic bacteria (Austen *et al.* 1993). Various fish (hagfish, haddock, wolf-fish and small redfish) appear to use the pockmarks and MDAC for shelter.

In the south of the site, the Scanner Pockmark complex contains two large pockmarks with a combined area of some 320,000m^2 and depths of up to 16.7m (Gafeira & Long 2015b). To the north of these and still within the site boundaries, the Scotia pockmark complex contains two deeper features with active methane seeps (Dando 2001). Survey data (Rance *et al.* 2017) indicates the presence of harder substrate within the Scotia complex but further work is needed to confirm if this is MDAC (Gafeira & Long 2015b).

Figure 5.1: Sites and areas to be subject to further assessment for physical disturbance and drilling effects in the Central North Sea



The Scanner Pockmark is likely to have been impacted by fishing, with evidence provided by VMS data and the presence of trawl scarring within the site (Rance *et al.* 2017). Some pockmark slope failure is evident in both sites, but it is not known if this is the result of anthropogenic or natural processes (Gafeira & Long 2015a, b). The features for which the site has been designated are presently regarded to be in unfavourable condition due to the influence of demersal trawling (JNCC 2019). The structure has a restore objective, specifically for the restoration of characteristic biological communities associated with MDAC that have been subject to removal or abrasion pressures associated with demersal trawling. All other site objectives (e.g. extend and distribution, supporting processes) are to maintain the current site condition.

5.1.2 Assessment of physical disturbance and drilling effects

The conservation objectives of the Scanner Pockmark SAC and other relevant information relating to site selection and advice on operations has been considered against the work programme for the area applied for (CNS Area 1) to determine whether it could adversely affect site integrity. The results are given in Table 5.1 below.

Table 5.1: Consideration of potential physical disturbance and drilling effects and relevant site conservation objectives

Scanner Pockmark SAC[31]
Site Information
Area (ha): 674 **Relevant qualifying features**: Submarine structures made by leaking gases **Conservation objectives**: For the feature to be in favourable condition thus ensuring site integrity in the long term and contribution to Favourable Conservation Status of Annex I Submarine structures made by leaking gases. This contribution would be achieved by maintaining or restoring, subject to natural change: • The extent and distribution of the qualifying habitat in the site; • The structure and function of the qualifying habitat in the site; and • The supporting processes on which the qualifying habitat relies.
Relevant licence areas with potential for physical disturbance and drilling effects
CNS Area 1
Assessment of effects on site integrity
The work programme does not include any appraisal/exploration well drilling or any other activities in the field and so adverse effects on site integrity are discounted.

5.1.3 Conclusions of CNS regional assessment

Likely significant effects were identified with regards to physical damage to the seabed, drilling discharges and other effects (see Section 5.1.2) for the Scanner Pockmark SAC (BEIS 2022b). That conclusion was made in advance of the closing date for licence applications, and without knowledge of the proposed work programmes for the areas applied for. The work programme for CNS Area 1 relies on the reprocessing of existing 3D seismic data and the analysis of 3D seismic data collected separately from the licence application process; no appraisal/exploration wells are proposed. The absence of any activities which could represent a source of effect for the Scanner Pockmark SAC leads to the conclusion that the licensing of CNS Area 1 would not result in adverse effects on the site integrity.

[31] https://hub.jncc.gov.uk/assets/800ba4e2-a661-403d-baa5-155b956779ba

5.2 Southern North Sea

5.2.1 Relevant sites

Southern North Sea SAC

The Southern North Sea SAC is an area with predicted persistent high densities of harbour porpoise. Individuals in the UK 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). From a management and conservation perspective however, three distinct UK Management Units (MU) have been identified; the North Sea, West Scotland and the Celtic & Irish Seas (IAMMWG 2022). The Southern North Sea SAC supports an estimated 17.5% of the UK North Sea Management Unit (MU) population. It was selected primarily on the basis of preferential and prolonged use by harbour porpoises in contrast to other areas of the North Sea, but variability in numbers within the site and across the North Sea (seasonally and between years) is known to be high. Approximately two thirds of the site, the northern part, is recognised as important for porpoises during the summer season, whilst the southern part supports persistently higher densities during the winter (see Figure 5.3). A large southerly shift in distribution was reported across the North Sea between 1994 and 2005 when SCANS and SCANS-II surveys took place (Hammond *et al*. 2013). As part of the site identification process, analysis of the observed density of harbour porpoise against different environmental variables (Heinänen & Skov 2015) indicated that the coarseness of the seabed sediment was an important determinant of porpoise density, with porpoises showing a preference for coarser sediments (such as sand/gravel) rather than fine sediments (e.g. mud). Sandeels, which are known prey for harbour porpoises, exhibit a strong association with sandy substrates. The majority of the substrate types within the site are categorised as sublittoral sand and sublittoral coarse sediment. Moderate energy levels at the seabed (including wave and tidal energy) are estimated across the majority of the site[32]. The conservation objectives[33] indicate that the concept of 'site population' may not be appropriate for this species. It highlights the need to assess impacts on the site based on how the proposed activities translate into effects on the relevant MU population. In the case of this AA, it refers to the North Sea MU ranging from the east coast of the UK to part of Denmark (Skagerrak and northern Kattegat). The abundance of harbour porpoise for the North Sea MU was estimated in 2016 (Hammond *et al.* 2021) as part of SCANS-III (369,560, CV = 0.22), which is similar to the 2005 estimate (335,000 CV = 0.22); the most recent estimate (IAMMWG 2022) is 364,601 (CV = 0.09).

Dogger Bank SAC

The Dogger Bank SAC was formed by glacial processes before being submerged through sea level rise during the last marine transgression (by *ca*. 8,000 years BP). The southern part of the bank is covered by water seldom deeper than 20m and extends within the SAC in UK waters down to 35-40m deep. The bank structure slopes down to greater than 50m deep in UK, Dutch and German waters and its location in open sea exposes the bank to substantial wave energy preventing the colonisation of the sand by vegetation on the shallower parts of

---

[32] https://hub.jncc.gov.uk/assets/206f2222-5c2b-4312-99ba-d59dfd1dec1d#SouthernNorthSea-SAC-selection-assessment-document.pdf
[33] https://hub.jncc.gov.uk/assets/206f2222-5c2b-4312-99ba-d59dfd1dec1d#SouthernNorthSea-conservation-advice.pdf

the bank. Large parts of the Dogger Bank are situated above the storm-wave base (Connor *et al.* 2006) and it is estimated that during a storm event, sediment up to medium sand particles can be mobilised in 60m water depth at the northern slope of the Dogger Bank (Klein *et al*. 1999). Models of natural disturbance have estimated that the Dogger Bank is disturbed to 4cm depth at least once every year by tides and waves (Diesing *et al*. 2013). The majority of sediments present across the Dogger Bank consist of fine sands with mud content below 5% (JNCC 2011) with sandy gravel in patches mainly concentrated on the western edge of Dogger Bank. There is evidence of small mixed sediment patches near the centre of the site. Coarse sediment patches are widespread, most of which are relatively small, but a few larger patches are notable towards the western and southern edges of the site. There are also a few muddy sediments in the central north area (Eggleton *et al.* 2017). Key and influential species associated with the sandbank feature include a variety of bioturbators, predators and grazers which have been recorded from surveys within the site, such as polychaete worms *(Spiophanes bombyx),* brittle stars *(Amphiura filiformis)*, as well as sea urchins, gastropods, hermit crabs and other unidentified crustaceans (Eggleton *et al*. 2017). The most frequently observed taxonomic groups in the epifauna were Asteroidea *(Asterias rubens, Astropecten irregularis)*, the Cnidarian, *Alcyonium digitatum*, the bryozoan *Flustra* sp. and Paguridae *(Pagurus bernhardus*) although these varied widely with sediment composition (Eggleton *et al*. 2017). Sandeels have been recorded on the western side of the bank (Forewind 2013).

The condition of the Annex I sandbank feature for which the site is designated is considered to be unfavourable (Eggleton *et al.* 2017), such that the SACO for the Dogger Bank SAC[34] advises that the site feature extent and distribution, and structure and function should be restored, while supporting processes be maintained. The MMO introduced The Dogger Bank Special Area of Conservation (Specified Area) Bottom Towed Fishing Gear Byelaw 2022 which came into effect in June 2022. The byelaw effectively prohibits the use of use of all bottom towed fishing gear across the Dogger Bank.

Doggersbank SAC & Klaverbank SAC (Netherlands)

A profile of the habitat type associated with the Dutch Doggersbank SAC site is not available[35] but it is a continuation of the UK Dogger Bank SAC and contains similar habitat types[36]. Similarly, a profile of the reef habitat of the Dutch Klaverbank SAC is not available[37]. Both sites have grey and harbour seal and harbour porpoise listed as qualifying features although this reflects that animal's range throughout the Dutch EEZ rather than the sites having special significance for reproduction, foraging or otherwise (Jak *et al.* 2009). Models based on grey seals (Jones & Russell 2016) and harbour seals tagged in the UK (Jones *et al.* 2017) and Dutch coast (Aarts *et al*. 2016) suggest a low density of both species in the sites and surrounding area (i.e. < 0.1 seal per km^2). Data from grey seals tagged on the Dutch coast also suggest limited presence of grey seals in the area compared to coastal waters, although animals do pass through the sites when moving between Dutch and UK waters (Brasseur *et al.* 2015). While the sandbank and reef habitats and associated fish communities may provide valuable foraging opportunities for seals, the sites are located >180km from the nearest UK and continental landfalls, placing them beyond the 50km (harbour) and 100km (grey) ranges from haul-out sites where the majority of foraging activity occurs (Jones *et al*. 2015). For both species, their abundance in the site was assessed as 0-2% of the national (Dutch) population, although no specific values were available. Harbour porpoise abundance within the site was assessed as 2-15% of the national (Dutch) population, with no specific values available, and

[34] https://hub.jncc.gov.uk/assets/26659f8d-271e-403d-8a6b-300defcabcb1#DoggerBank-3-SACO-v1.0.pdf
[35] https://www.noordzeeloket.nl/en/policy/noordzee-natura-2000/gebieden/doggersbank/dogger-bank/habitattype/
[36] https://www.emodnet-seabedhabitats.eu/
[37] https://www.noordzeeloket.nl/en/policy/noordzee-natura-2000/gebieden/klaverbank/cleaver-bank/habitattype/

modelling studies estimate that the site represents an area of higher harbour porpoise density relative to many other areas in the North Sea. Those further west, in UK waters (i.e. the Southern North Sea SAC), typically support the highest densities in the region, although the distribution of this highly mobile, wide-ranging species varies (Heinänen & Skov 2015; Gilles *et al.* 2016).

Humber Estuary SAC

The Humber Estuary SAC is a muddy, macro-tidal estuary, fed by a number of rivers including the Rivers Ouse, Trent and Hull. Suspended sediment concentrations are high, and are derived from a variety of sources, including marine sediments and eroding boulder clay along the Holderness coast. The extensive mud and sand flats support a range of benthic communities, which in turn are an important feeding resource for birds and fish. Wave exposed sandy shores are found in the outer/open coast areas of the estuary. These change to the more moderately exposed sandy shores and then to sheltered muddy shores within the main body of the estuary and up into the tidal rivers. Fish species include river lamprey *Lampetra fluviatilis* and sea lamprey *Petromyzon marinus* which breed in the River Derwent, a tributary of the River Ouse.

Grey seals *Halichoerus grypus* come ashore in autumn to form breeding colonies on the sandy shores of the south bank at the mouth of the Humber at Donna Nook, where annual pup production has almost doubled in the past 10 years to approximately 2,000 pups in the 2019 breeding season (SCOS 2021, Lincolnshire Wildlife Trust[38]). Colonies on the mainland coast and especially in the southern North Sea, have increased rapidly since 2000, but the rate of increase has been lower in recent years (*ca.* 10.1% p.a., 2016-2019 compared to 22% p.a., 2010-2014), perhaps an early indication it is approaching a carrying capacity (SCOS 2021). Tagging studies show that grey seals use offshore areas (up to 100km from the coast) connected to their haul-out sites by prominent corridors, although density is greatest in coastal waters adjacent to colonies.

Models of the at-sea distribution of grey seals (e.g. Jones *et al.* 2015, Russell *et al.* 2017, Carter *et al.* 2020) show that 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. While the highest predicted densities of ≥100 seals per grid cell are within *ca*. 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 *ca*. 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.

The Wash and North Norfolk Coast SAC

Subtidal sandbanks and reefs are widespread throughout The Wash and North Norfolk coast, with the site containing a significant proportion of the *Sabellaria spinulosa* reef located on the eastern coast of the UK. The large areas of intertidal sand and mudflats form important habitat

[38] Lincolnshire Wildlife Trust website: http://www.lincstrust.org.uk/donna-nook/weekly-update

for polychaete worms, bivalves and crustaceans and foraging ground for wading bird species (see The Wash SPA and North Norfolk Coast SPA). Further inland, the site supports saltmarsh and saline reedbeds, with *Salicornia* and saltmarsh communities colonising the sand and mudflats. Atlantic salt meadows in the site form one of the most diverse and extensive examples of this habitat in the UK. The salt meadow expanse within the site also includes the only location in the UK where all the more typically Mediterranean species that characterise Mediterranean and thermo-Atlantic halophilous scrubs occur together.

Harbour seals haul-out to rest on the sandbanks at Blakeney Point and in the Wash with numbers varying throughout the year. In winter, seals appear to spend more time at sea, during the breeding season (late June – early July) they appear more dispersed and in smaller groups than during their moult. Throughout the annual moult, late July to early September, groups tend to be larger than at other times and the numbers at haul-out sites reaches a maximum. Population numbers across the site have decreased in recent years, with 2,724 adults in The Wash and 135 at Blakeney Point in 2021, relative to 3,762 and 460 in 2015 at those locations respectively (SCOS 2021).

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 reflects this, with a large area of higher use (relative to the majority of UK and Irish waters) extending north-east from The Wash, with values of 10-50 seals per 5 x 5km grid cell up to approximately 100km from the site boundary (Russell *et al*. 2017). From tracks of individual seals tagged at The Wash, and consideration of the distribution of adjacent colonies, it can be assumed that the majority of harbour seals using this offshore area are associated with The Wash and North Norfolk Coast SAC.

The condition of relevant marine features of the SAC were assessed in 2019, concluding that 72% of the sandbank feature of the site was in favourable condition with the remainder unfavourable recovering. Only 1% of the reef feature was considered to be in favourable condition, with the remainder either unfavourable recovering (37%) or unfavourable with no change (61%). Additionally, adverse impacts on site integrity were concluded for the Hornsea Three offshore wind farm project, specifically in relation to habitat loss and modification associated with cable protection. A Sandbank Implementation Plan was submitted as part of the planning process for the project, in keeping with its DCO requirements, and was approved in April 2022.

North Norfolk Sandbanks and Saturn Reef SAC

The North Norfolk Sandbanks and Saturn Reef SAC contains the most extensive example of offshore linear ridge sandbanks in UK waters, and encompasses an area where previous seabed surveys identified an extensive biogenic reef created by the ross worm *Sabellaria spinulosa*, called Saturn reef (Jenkins *et al*. 2015). The sandbanks are subject to a range of current strengths which are strongest on the banks closest to shore and are dominated by sandy sediments (see Parry *et al.* 2015). Whilst the sandbanks are very similar in terms of the biological communities present, increasing species numbers have been recorded on the outermost banks, likely related to the change in hydrodynamic regime with increasing distance from the coast[39]. First discovered in 2002, the Saturn reef covered an area approximately 750m by 500m just to the south of Swarte Bank. More recent surveys failed to identify the

[39] http://jncc.defra.gov.uk/page-6537

extensive areas of *S. spinulosa* reef previously observed but did find reefs in the area which highlights the ephemeral nature of the feature and indicates that favourable conditions for *S. spinulosa* formation occur within the site (see JNCC website and Jenkins *et al*. 2015). The reef and sandbank features of the site are considered to be in unfavourable condition, being subject to a range of pressures including those from demersal fishing, aggregate extraction, and offshore energy related activity. The site is subject to significant fisheries pressures, which the MMO concluded were likely to have an adverse effect on site integrity. The MMO are presently considering the need for, and nature of, any fisheries management measures for the site[40]. The unfavourable status of the site, and the setting of restore objectives for the site, is based on expert judgement[41], relating the sensitivity of the features to the prevailing nature of activities affecting the site. While monitoring surveys have been undertaken of the site, their related reports (McIlwaine *et al.* 2017, Eggleton *et al.* 2020) do not make any judgement of feature condition, but may inform a consideration of the status of the site features in the future by representing an initial point in a monitoring time series[42].

Haisborough, Hammond and Winterton SAC

The Haisborough, Hammond and Winterton SAC contains a series of sandbanks that run parallel to the coast. The sandy sediments within the site are very mobile in the strong tidal currents of the area, and though large-scale bank migration or movement appears to be slow, there is a level of sediment movement around and across the banks evidenced by megaripple and sandwave formations. Infaunal communities of the sandy bank tops are consequently of low biodiversity, characterised by mobile polychaetes and amphipods which are able to rapidly re-bury themselves into the dynamic sediment environments. Along the flanks of the banks, and towards the troughs between the banks the sediments tend to be slightly more stable with gravels exposed in areas. In these regions of the site, infaunal and epifaunal communities are much more diverse. *Sabellaria spinulosa* reefs are located at Haisborough Tail, Haisborough Gat and between Winterton Ridge and Hewett Ridge and arise from the surrounding coarse sandy seabed to heights of between 5cm to 10cm. The site is subject to significant fisheries pressures, which the MMO has concluded are likely to have an adverse effect on site integrity. Some parts of the site in territorial waters are subject to fisheries bylaws that prevent the use of bottom-towed fishing gear, however, offshore areas are not subject to measures but are subject to demersal fisheries pressures. The MMO are presently considering whether fisheries management measures in the offshore area of the site would be appropriate[43]. The unfavourable status of the site, and the setting of restore objectives for the site, is based on expert judgement, relating the sensitivity of the features to the prevailing nature of activities affecting the site. While monitoring surveys have been undertaken of the site, their related reports (McIlwaine *et al.* 2017, Eggleton *et al.* 2020) do not make any judgement of feature condition, but may inform a consideration of the status of the site features in the future by representing an initial point in a monitoring time series.

Inner Dowsing, Race Bank and North Ridge SAC

The Inner Dowsing, Race Bank and North Ridge SAC occupies The Wash Approaches. Water depths are mostly shallow (<30m) and the site encompasses a wide range of sandbank types and biogenic reef formed by *Sabellaria spinulosa*. The group of banks within the Wash Approaches are made up of fine to medium sands derived from coastal erosion processes following the last glacial retreat and marine inundation. Inner Dowsing is a sandbank of coarse

[40] https://www.gov.uk/government/publications/managing-fisheries-in-marine-protection-areas-call-for-evidence
[41] https://hub.jncc.gov.uk/assets/d4c43bd4-a38d-439e-a93f-95d29636cb17#NNSSR-3-SACO-v1.0.pdf
[42] https://jncc.gov.uk/our-work/north-norfolk-sandbanks-and-saturn-reef-mpa/
[43] https://www.gov.uk/government/publications/managing-fisheries-in-marine-protection-areas-call-for-evidence

sand with some areas of gravel to the west of the site, with a distinctive elongate shape maintained by the tidal currents in the area. The Race Bank-North Ridge-Dudgeon Shoal sandbank system is an example of a sinusoidal sandbank that also has a complex pattern of smaller sandbanks associated with it. The tops of the sandbanks are characterised by low diversity communities dominated by polychaete worms and mobile amphipod crustaceans. The trough areas between the sandbanks are composed of mixed and gravelly sands, predominantly as veneers over glacial till. In these areas diverse mosaics of biotopes occur, which are dominated by the ascidian *Molgula* sp. along with a number of nemertean worms and polychaetes. Abundant *S. spinulosa* agglomerations have consistently been recorded and these support attached epifauna such as bryozoans, hydroids, sponges and anemones[44]. The site has been subject to significant fisheries pressures, which the MMO concluded were likely to have an adverse effect on site integrity. The site is now subject to fisheries management measures, with all bottom-towed gear prohibited across the reef and sandbank features of the site, and all static gear prohibited in areas to be managed as reef[45]. The unfavourable status of the site, and the setting of restore objectives for the site, is based on expert judgement, relating the sensitivity of the features to the prevailing nature of activities affecting the site. While monitoring surveys have been undertaken of the site, their related reports (McIlwaine *et al.* 2017, Eggleton *et al.* 2020) do not make any judgement of feature condition, but may inform a consideration of the status of the site features in the future by representing an initial point in a monitoring time series.

Flamborough & Filey Coast SPA

Originally classified as Flamborough Head and Bempton Cliffs SPA, the site was extended in 2018 to include the north cliffs of Filey and inshore waters to 2km. This extension also included the addition of gannet, guillemot and razorbill as qualifying features. The cliffs of Flamborough Head rise to 135 metres and are composed of chalk and other sedimentary rocks. These soft cliffs have been eroded into a series of bays, arches, pinnacles, and gullies with an extensive system of caves at sea-level. The numerous ledges, crevices and caves provide ideal nesting and roosting sites for seabirds, supporting a colony of national and international importance, and currently the largest mainland seabird colony in England. The SPA supports the only mainland gannetry in England, the largest kittiwake colony in the UK and the largest guillemot and razorbill colonies in England. The colonies are situated along the cliffs on the southern and northern sides of Filey Bay and the north and south sides of Flamborough Head. They support over 200,000 seabirds during the breeding season, many of which are extremely limited in breeding range throughout the UK. The waters adjacent to the colonies are used by large numbers of seabirds for a wide range of activities, including bathing, preening, displaying, loafing and local foraging. The proximity to the productive Flamborough Front also provides rich feeding ground for birds related to the SPA.

The condition of the site features is not available[46], however, the kittiwake population has apparently declined from that recorded for the citation of the original site at 83,700 pairs in 1987, to an average of 44,520 pairs between 2008 and 2011, such that an unfavourable status may be inferred for this feature, in view of the site's conservation objectives. The status of this feature, the population trend in kittiwake numbers more generally (e.g. JNCC 2021), and the

---

[44] https://jncc.gov.uk/our-work/inner-dowsing-race-bank-and-north-ridge/
[45] https://www.gov.uk/government/publications/the-inner-dowsing-race-bank-and-north-ridge-special-area-of-conservation-specified-areas-prohibited-fishing-gears-byelaw-2022b
[46] https://designatedsites.naturalengland.org.uk/Marine/MarineFeatureCondition.aspx?SiteCode=UK9006101 (accessed 27/10/2022)

potential for effects from offshore wind farm development, has led to a number of wind farm proposals seeking derogation as part of their HRA processes.

Greater Wash SPA

The Greater Wash SPA extends from Bridlington Bay in the north, to the boundary of the Outer Thames Estuary SPA in the south. In the northernmost section of the site, off the Holderness coast, seabed habitats primarily comprise coarse sediments, with occasional areas of sand, mud and mixed sediments. The inshore environment is highly dynamic, with large volumes of material being eroded from the shoreline and seabed and transported southwards. Water depth is generally shallow, reaching up to 20m towards the offshore boundary. Subtidal sandbanks occur at the mouth of the Humber Estuary, primarily comprising sand and coarse sediments. The site is classified for the protection of red-throated diver, common scoter, and little gull during the non-breeding season, and for breeding sandwich tern, common tern and little tern. The seaward boundary is defined by the area of importance to red-throated diver, and by the foraging area of sandwich tern off the north Norfolk Coast. Red-throated diver are distributed throughout the SPA with 1,511 individuals or 8.9% of the GB wintering population estimated to be present within the site. Higher densities of birds were recorded close inshore, particularly in the area outside The Wash SPA, north of the Humber Estuary, along the eastern part of North Norfolk Coast and in the south of the site where it abuts the Outer Thames Estuary SPA (Lawson *et al.* 2015c). Highest densities of common scoter were observed in the area outside The Wash SPA and along the North Norfolk Coast SPA[47].

The Wash SPA

The Wash SPA is composed of tidal rivers, estuaries, lagoons, mud, and sand flats and in the centre, deep channels surrounded by shallower waters. These areas predominantly consist of saltmarsh, intertidal banks of sand and mud, sandy and shingle beaches, and subtidal sandy sediments. Shallow coastal waters support small fish which are preyed upon by tern species. Intertidal mud and sand flats support a variety of polychaete worms and bivalve molluscs including cockle and mussel beds which alongside algae provide rich foraging grounds for a number of bird species including common scoter and goldeneye. Other relevant diving species which are part of the non-breeding waterbird assemblage include cormorant, eider and little grebe[48].

North Norfolk Coast SPA

The North Norfolk Coast SPA extends 40km along the northern coastline of Norfolk from Holme to Weybourne. Coastal waters within the site are shallow and follow the complex series of harbours and inlets along the coast. These support large populations of small fish including sand eel and sprat which provide vital food for breeding tern populations upon which breeding success depends. In summer, the site and its surroundings are important for breeding populations of waders, four species of tern, bittern and wetland raptors including the marsh harrier. In winter, the site becomes important for large numbers of geese, sea-ducks, other

---

[47] https://consult.defra.gov.uk/natural-england-marine/greater-wash-potential-special-protection-area-com/supporting_documents/V9%20FINAL%20Greater%20Wash%20Departmental%20Brief%2017%20October%202016%20ready%20for%20consultation.pdf

[48] https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK9008021&SiteName=wash&SiteNameDisplay=The%20Wash%20SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=21&HasCA=1

ducks, and waders using the site for roosting and feeding[49], with common scoter a component of the waterfowl assemblage[50]. Some species, such as the breeding terns and overwintering common scoter feed in coastal waters outside but adjacent to the SPA and are included as qualifying features of the Greater Wash SPA. The site is of also important to migrating birds in the spring and autumn passage periods[51].

Outer Thames Estuary SPA

The Outer Thames Estuary SPA is classified for the protection of wintering red-throated diver, breeding little terns and breeding common terns. The area supports the largest aggregations of wintering red-throated diver in the UK, 38% of the GB population[52]. Red-throated divers occur throughout the entire area, but at greatest density and with greatest frequency off the coast of Suffolk and over sandbanks in the centre of the estuary and those extending toward the coast of south Essex and part of north Kent. To the north, the site is continuous with the Greater Wash SPA and red-throated diver are likely to move between sites (see Greater Wash SPA summary above). The site contains areas of shallow and deeper water, with high tidal current streams and a range of mobile sediments, including several shallow sandbanks. The sandbanks may have a functional role (as nursery, spawning, or feeding grounds or in providing shelter) in supporting prey species of the red-throated diver (small fish such as gadoids, sprat, herring and sandeel; Guse *et al*. 2009)[53]. The seabed in the area of the Norfolk and Suffolk coast is of a similar composition to that in the main Thames estuary with large shallow areas of mud, sand, silt and gravely sediments but, in the absence of main port areas within this area, there is consequently less disturbance through shipping or dredging.

5.2.2 Assessment of physical disturbance and drilling effects

The conservation objectives of relevant sites that could be impacted by physical disturbance and drilling effects, and information relating to site selection and advice on operations have been considered against the activities in the proposed work programmes for the licence areas applied for to determine whether they could adversely affect site integrity. The results are given in Table 5.2 below. All mandatory control requirements (as given in Section 2.3.1), are assumed to be in place as a standard for all activities assessed.

49 https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK9009031&SiteName=north%20norfolk&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&HasCA=1&NumMarineSeasonality=11&SiteNameDisplay=North%20Norfolk%20Coast%20SPA

50 https://consult.defra.gov.uk/natural-england-marine/greater-wash-potential-special-protection-area-com/supporting_documents/V9%20FINAL%20Greater%20Wash%20Departmental%20Brief%2017%20October%202016%20ready%20for%20consultation.pdf

51 https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK9009031&SiteName=north%20norfolk&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&HasCA=1&NumMarineSeasonality=11&SiteNameDisplay=North%20Norfolk%20Coast%20SPA

52 https://jncc.gov.uk/our-work/outer-thames-estuary-spa/

53 https://designatedsites.naturalengland.org.uk/Marine/SupAdvice.aspx?SiteCode=UK9020309

Figure 5.2: Sites and areas to be subject to further assessment for physical disturbance and drilling effects in the southern North Sea

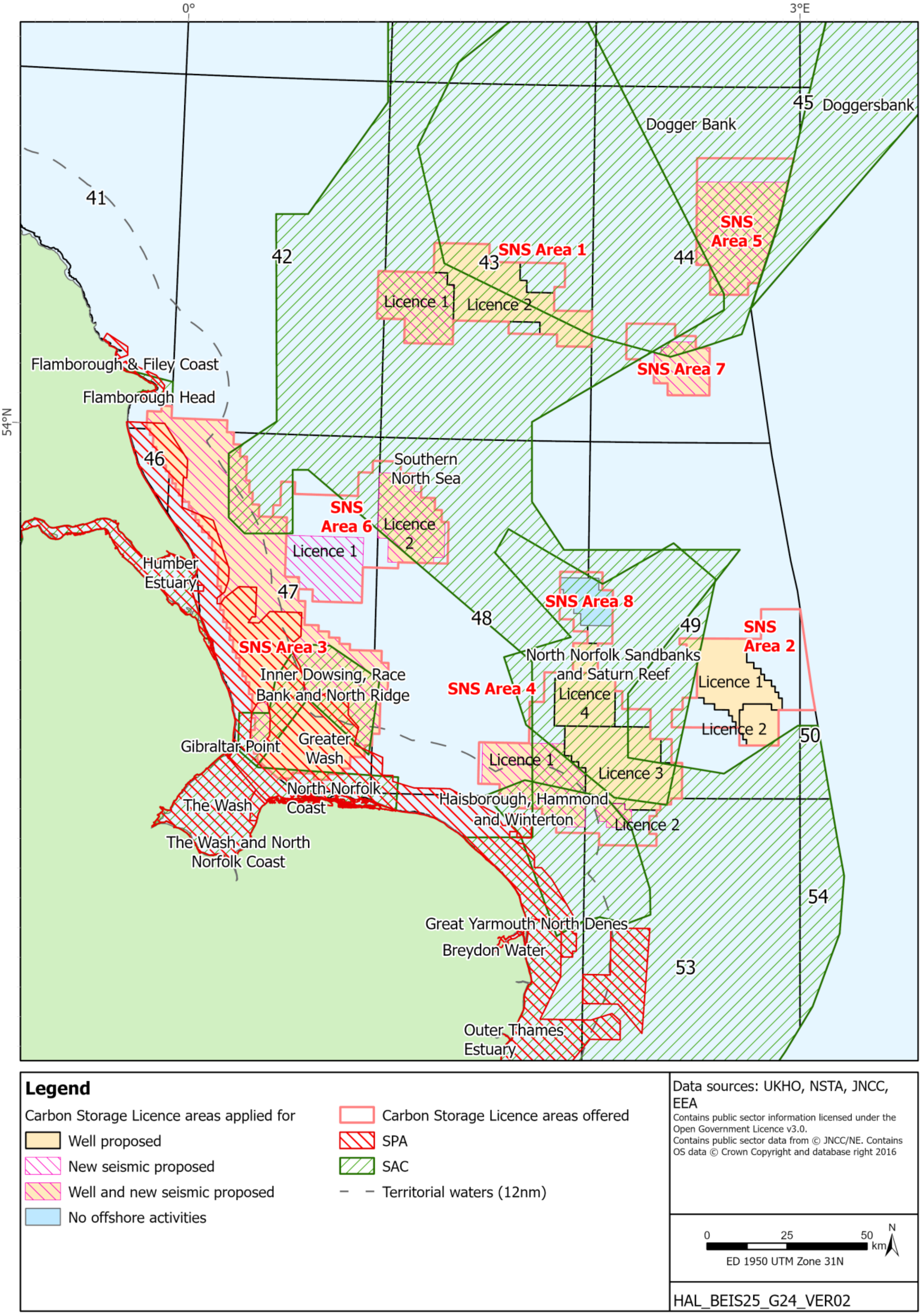


Table 5.2: Consideration of potential physical disturbance and drilling effects and relevant site conservation objectives

Southern North Sea SAC[54]
Site Information
Area (ha/km²): 3,695,054/36,951 **Relevant qualifying features:** Harbour porpoise **Conservation objectives:** To avoid deterioration of the habitats of the harbour porpoise or significant disturbance to the harbour porpoise, thus ensuring that the integrity of the site is maintained, and the site makes an appropriate contribution to maintaining Favourable Conservation Status (FCS) for the UK harbour porpoise. To ensure for harbour porpoise that, subject to natural change, the following attributes are maintained or restored in the long term: • The species is a viable component of the site. • There is no significant disturbance of the species. • The supporting habitats and processes relevant to harbour porpoises and their prey are maintained.
Relevant licence areas with potential for physical disturbance and drilling effects
SNS 1, SNS 2, SNS 3, SNS 4, SNS 5, SNS 6, SNS 7
Activities associated with the proposed work programmes within the relevant licence areas
Drilling up to 13 wells involving - siting of rig, drilling discharges
Assessment of effects on site integrity
Rig siting ***(Relevant pressures:*** *No relevant pressures identified[55]. In view of available pressure definitions (e.g. the current JNCC pressures-activity database) and the focus of the Conservation Objectives on addressing pressures that affect site integrity, including significantly damaging relevant habitats, the following pressures are considered: penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion; abrasion/disturbance of the substrate on the surface of the seabed and physical change (to another seabed/sediment type))* The delineation of the Southern North Sea SAC site was based on the prediction of 'harbour porpoise habitat' within the North Sea (Heinänen & Skov 2015). The analysis indicated a preference for water depths between 30 and 50m throughout the year, and in general, the coarseness of the seabed sediment was important, with porpoises showing a preference for coarser sediments (such as sand/gravel)[56]. Physical disturbance or abrasion to surface and subsurface substrates by the placement of spud cans as part of rig installation has the potential to impact the extent of supporting habitat within the site. SNS Areas 2, 3, 5 and 7 have significant areas outside the site boundaries in which rig siting would be possible, and therefore interaction with the supporting habitats of the qualifying features could be avoided. With respect to SNS Areas 1, 4, and SNS Area 6 (Licence 2), these are largely or wholly within the site, the maximum spatial footprint of physical damage associated with jack-up rig siting is small (0.8km², Table 2.2) compared to the large site (covering 0.002%). Recovery from physical damage in relevant sand/gravel habitats across the relatively shallow and dynamic site (majority of site less than 40m) is expected to be relatively rapid. The small scale and temporary nature of the potential physical damage, and the mobile nature of the qualifying features will ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity. The requirement for rig stabilisation measures would be determined by site survey of local conditions. In soft sediments, rock placement may cause smothering of existing sediments and a physical change to another seabed type. The majority of the substrate types within the site are categorised as sublittoral sand and sublittoral coarse sediment. It is assumed that rock placement (if required) would be within 500m of the rig and cover an estimated area of 0.001-0.004km² per rig siting (Table 2.2). Hence, the potential loss of extent of sandy sediment is small compared to the widespread nature of this sediment type across the very large site (36,958km²). There is the potential for alternatives to rock placement (Section 5.2.3), allowing the conclusion that the site conservation objectives will not be undermined and there will be no adverse effect on site integrity.

[54] https://jncc.gov.uk/our-work/southern-north-sea-mpa/
[55] https://hub.jncc.gov.uk/assets/206f2222-5c2b-4312-99ba-d59dfd1dec1d#SouthernNorthSea-conservation-advice.pdf
[56] http://jncc.defra.gov.uk/pdf/SouthernNorthSeaSelectionAssessmentDocument.pdf

Drilling discharges
(Relevant pressures: *Contaminants. In view of available pressure definitions and given the focus of the Conservation Objectives on addressing pressures that affect site integrity including significantly damaging relevant habitats, the following pressures are considered: abrasion/disturbance of the substrate on the surface of the seabed; changes in suspended solids (water clarity); smothering and siltation rate changes (light), physical change (to another sediment type) and habitat structure changes – removal of substratum (extraction))*

The advice on operations indicates that use of most of the relevant pollutants with respect to harbour porpoise have been effectively phased out by action under the OSPAR Convention and the EU (e.g. PCBs). However, their chemical stability will lead to them remaining in the marine environment for some time and, consequently, human activities such as dredging may cause the re-release of these chemicals into the environment or introduce other contaminants of which the impacts are poorly known. In view of the small scale and temporary nature of drilling discharges and the mandatory controls on drilling chemical use and discharge (Section 2.3.1), site conservation objectives will not be undermined and there will be no adverse effects on site integrity.

It is assumed that effects relating to drilling discharges occur within 500m of the well location (Table 2.2). SNS Areas 2, 3, 5 and 7 have significant areas outside the site boundaries in which drilling would be possible, and therefore impacts on supporting habitats could be largely avoided. For the areas that are largely or wholly within the site (SNS Areas 1, 4 and SNS Area 6 (Licence 2)), the maximum spatial footprint within which smothering of surface sediments or habitat structure changes may occur (0.8km^2, Table 2.2) is small (representing 0.002% of the total site area) and recovery from smothering in relevant sand/gravel habitats across the relatively shallow and exposed site (majority of site less than 40m) is expected to be rapid. Therefore, site conservation objectives will not be undermined.

Other effects
N/A

In-combination effects
Intra-plan in-combination effects are possible although spatial footprints associated with rig installation and drilling discharges in the three areas entirely or largely within the site are localised and temporary, and unlikely to overlap between areas applied for either spatially or temporally. The combined spatial footprint within which physical disturbance and drilling effects could occur (within 500m of the rig/well location) across the areas applied for (an improbable worst-case scenario that all 13 wells are drilled) is estimated at 10.4km^2 (<0.03% of the site area). For rig stabilisation, this would be for an area of up to 0.05km^2 or 0.0001% of the site. The temporary and/or small scale nature of the disturbance, the mobile nature of the qualifying feature and mandatory control measures (Section 2.3.1), and other measures (Section 5.2.3) will ensure that site conservation objectives are not undermined. Section 6.2 provides a consideration of potential activities in-combination with other relevant plans and projects.

Dogger Bank SAC[57]

Site Information

Area (ha/km^2): 1,233,115/12,331
Relevant qualifying features: Sandbanks which are slightly covered by sea water all the time.

Conservation objectives:
For the feature to be in favourable condition thus ensuring site integrity in the long term and contribution to Favourable Conservation Status of Annex 1 sandbanks. This contribution would be achieved by maintaining or restoring, subject to natural change:

- The extent and distribution of the qualifying habitat in the site;
- The structure and function of the qualifying habitat in the site; and
- The supporting processes on which the qualifying habitat relies.

- Attributes and related targets have been set for the site features which are presented in the site SACO[58].

Relevant licence areas with potential for physical disturbance and drilling effects

SNS 1, SNS 5, SNS 7

[57] https://jncc.gov.uk/our-work/dogger-bank-mpa/
[58] https://hub.jncc.gov.uk/assets/26659f8d-271e-403d-8a6b-300defcabcb1#DoggerBank-3-SACO-v1.0.pdf

Activities associated with the proposed work programmes within the relevant licence areas
Drilling up to four wells involving - siting of rig, drilling discharges
Assessment of effects on site integrity
Rig siting *(**Relevant pressures:** penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion; abrasion/disturbance of the substrate on the surface of the seabed, physical change (to another seabed type) and introduction or spread of non-indigenous species)* The qualifying feature is sensitive to penetration and/or disturbance of the seabed surface and subsurface[59] by the placement of spud cans as part of rig siting. SNS Area 1 (Licence 2) and SNS Area 7 have significant areas outside the site boundaries in which rig siting would be possible, and SNS Area 1 (Licence 1) is entirely outside of the site, and therefore interaction with the qualifying features could be avoided, noting the assumed distance from a jack-up rig within which effects may occur (500m, see Table 2.2). With respect to SNS Area 5, which is entirely within the site, the maximum spatial footprint of the penetration and/or disturbance pressure associated with jack-up rig siting is small (0.8km^2, see Table 2.2) compared to the large site (covering 0.006%), in relatively shallow water depths (15-40m). As a result, it is exposed to substantial wave energy, particularly during storm events which may cause significant natural disturbance of sediments (see Section 5.1). Recovery of damage to surface and sub-surface features of the scale associated with temporary rig placement is expected to be rapid due to its localised scale and the energetic nature of the environment. Additionally, the communities present on the bank are known to be well-adapted to both natural disturbance and dominated by robust, short-lived organisms, and the recovery potential of any area affected by rig siting is expected to be rapid (Kröncke *et al.* 2011). Further mitigation measures are also available and will be required as appropriate as part of consenting (e.g. rig siting to ensure sensitive seabed surface features are avoided, see Section 5.2.3). The siting of a rig will not result in adverse effects on site integrity as it will not result in a long term reduction in the extent and distribution, structure and function, or supporting process of the site. There may be a requirement for rig stabilisation depending on local seabed conditions. In soft sediments, deposited rock may cover existing sediments resulting in a physical change (to another seabed type), and the qualifying feature is considered highly sensitive to this pressure, which assumes a permanent change of habitat. The Dogger Bank SACO (2018) indicates that introduced substrates, such as rock placement, normally consisting of gravel or pebbles have been deposited onto the seabed although it is not clear how much of the material there is within the site, and consequently it is unclear what impact this may have on site sediment composition and distribution. JNCC advise that activities must look to minimise, as far as is practicable, changes in substratum within the site to minimise further impact on feature extent and distribution, and associated changes in biological communities. While the Dogger Bank is classified as an Annex I sandbank, Holocene sands generally form a thin veneer across the site except in glacially-derived depressions where they may locally be more than 25m thick (Cotterill *et al.* 2017). The sediment surface is largely characterised by fine sands, though they vary between sand to gravelly sand, and muddy sand, with coarse sediments including gravel, recorded in the south and west of the bank (Diesing *et al.* 2009) Cotterill *et al.* (2017) also note the presence of extensive areas of flint-rich, medium to coarse gravel in the south and west of the bank, either near the seabed or sometimes locally exposed, which often contained large cobbles and thick laminae of fine gravel, thought to have been formed as a result of the hydrodynamic winnowing of fines from glacial deposits. While rock placement may not represent the introduction of a novel sediment type on the Dogger Bank, it is noted that the difference in composition of this material to any glacially-derived deposit and its location within the site may still contribute to a change in habitat extent, though it is less clear that it would represent a significant change in structure and function. It is assumed that rock placement (if required) would be within 500m of the rig and cover an estimated area of 0.001-0.004km^2 per rig siting (Table 2.2). Hence, the potential loss of sandy sediment extent is small compared to the predominance of this sediment type across the very large site (12,331km^2). It is noted that physical damage to the sandbank habitat, including habitat loss from the use of protection materials, has led to conclusions in other plan level HRA (TCE 2022) of adverse effects on site integrity in view of the site's conservation objectives, the condition of the site features and advice on operations (see 5.2.1 above). As noted above, recovery of the sandbank feature following cessation of appraisal/exploration drilling would be expected to be rapid and not result in permanent habitat change. The use of rock placement for rig stabilisation, which is not easily removed, would likely result in a localised but permanent change in habitat, for which adverse effects on site integrity could not be ruled out. In order to avoid such adverse effects, any well being drilled within the boundaries of the Dogger Bank SAC must use alternatives to rock placement if rig stabilisation is required, for example, removable mud mats or anti-scour mats (see Section 5.2.3). Further assessment, including HRA where appropriate, would be undertaken at the project level, at which stage the assessment would be informed

[59] http://jncc.defra.gov.uk/docs/DoggerBank_AoO_Workbook_v1_0.xlsx

by specific rig siting information (which for SNS Area 1 and SNS Area 7 may be outside of the site boundaries). SNS Area 5 is located wholly within the boundaries of Dogger Bank SAC, and so any requirement for rig stabilisation must use removeable methods.

As noted in Section 4.2.1, management of the spread of non-native species from vessels and rigs is being progressed through international measures, and the risk is limited by the operational range of rigs on the UKCS.

Drilling discharges
*(**Relevant pressures:** abrasion/disturbance of the substrate on the surface of the seabed, changes in suspended solids (water clarity); smothering and siltation rate changes (light); physical change (to another sediment type), habitat structure changes – removal of substratum (extraction) and contaminants)*

The advice on operations indicates that the qualifying feature is sensitive to the above pressures, most of which relate to seabed disturbance and habitat changes associated with smothering by drill cuttings near the well location, and that these cuttings can accumulate in piles where currents are generally weak. It is assumed that effects relating to drilling discharges occur within 500m of the well location (Table 2.2). Therefore, with respect to SNS Area 1 (Licence 2) and SNS Area 7 which have significant areas outside the site boundaries in which drilling will be possible, or are entirely outside of the site in the case of SNS Area 1 (Licence 1), drilling discharges will not significantly impact the extent and distribution or the structure and function of the qualifying habitat. For the areas applied for within the site, the maximum spatial footprint within which smothering by drilling discharges and associated habitat structure changes may occur (0.8km^2) is small (representing 0.006% of the total site area) and given the site's exposure to wave energy, redistribution of drilling discharges and recovery from smothering would be rapid, and there would be no permanent change in site habitat. Therefore, site conservation objectives will not be undermined.

The advice on operations indicates that the qualifying feature is not sensitive or there is insufficient evidence on the contamination pressures listed above and described in Section 4.2.3. The SACO indicates that the available evidence of contamination is inconclusive regarding sediment quality within the site. However, the small scale and temporary nature of drilling discharges and the mandatory control requirements with respect to drilling chemical use and discharge (Section 2.3.1) will ensure that site conservation objectives are not undermined.

Other effects
N/A

In-combination effects
Intra-plan in-combination effects are possible although spatial footprints associated with rig installation and drilling discharges in SNS Areas 1 (Licence 2), 5 and 7 (i.e. those areas entirely or partly within the site) will be localised and temporary, and unlikely to overlap between these areas either spatially or temporally. Given the indicative work programmes, the combined spatial footprint within which physical disturbance and drilling effects could occur (within 500m of the rig/well location) across the areas applied for (a worst case scenario of up to three wells) is estimated at 2.4km^2 (0.02% of the site). For rig stabilisation, noting the mitigation outlined above and in Section 5.2.3, this would be for an area of up to 0.01km^2 or 0.0001% of the site. However, the temporary nature of the disturbance, energetic nature of the environment, required controls and mitigation, including the avoidance of permanent habitat change (Sections 2.3.1 and 5.2.3), will ensure that site conservation objectives are not undermined as there will be no permanent change to the habitat. Section 6.2 provides a consideration of potential activities in-combination with other relevant plans and projects.

Doggersbank SAC (Netherlands)

Site Information

Area (ha/km^2): 473,500/4,735
Relevant qualifying features: Sandbanks, grey seal, harbour seal, harbour porpoise

Conservation objectives:
- For harbour porpoise, grey seal and harbour seal: Maintain extent and quality of habitat in order to maintain population

Relevant licence areas with potential for physical disturbance and drilling effects

SNS Area 5

Activities associated with the proposed work programmes within the relevant licence areas

Drilling up to one well involving - siting of rig, drilling discharges

Assessment of effects on site integrity

Rig siting
SNS Area 5 is immediately adjacent to the site. Given the assumed distance from a jack-up rig within which effects may occur (500m, see Table 2.2) and the considerable area within SNS Area 5 within which a rig may be sited, rig installation will not significantly impact the extent and quality of the sandbank habitat. Therefore, rig siting will not adversely affect site integrity.

Drilling discharges
It is assumed that effects relating to drilling discharges occur within 500m of the well location (Table 2.2). Therefore, with respect to SNS Area 5, drilling discharges will not significantly impact the extent and quality of the sandbank habitat. Therefore, drilling discharges will not adversely affect site integrity.

Other effects
N/A

In-combination effects
No intra-plan in-combination effects are likely given that SNS Area 5 is the only area applied that is of relevance to the site, and is not within the site boundaries. Section 6.2 provides a consideration of potential activities in-combination with other relevant plans and projects.

Humber Estuary SAC[60]

Site information

Area (ha/km^2): 36,657/367
Relevant qualifying features: Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*), Coastal lagoons, Dunes with *Hippophae rhamnoides*, embryonic shifting dunes, estuaries, fixed dunes with herbaceous vegetation ("Grey dunes"), shifting dunes along the shoreline with *Ammophila arenaria* ("White dunes"), mudflats and sandflats not covered by seawater at low tide, *Salicornia* and other annuals colonising mud and sand, sandbanks which are slightly covered by sea water all the time, grey seal, river lamprey, sea lamprey.

See Natural England guidance for details of qualifying features[61].

Conservation objectives:
The site's conservation objectives apply to the site and the individual species and/or assemblage of species for which the site has been classified.
The objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the Favourable Conservation Status of its qualifying features, by maintaining or restoring:

- The extent and distribution of qualifying natural habitats and habitats of qualifying species
- The structure and function (including typical species) of qualifying natural habitats
- The structure and function of the habitats of qualifying species
- The supporting processes on which qualifying natural habitats and habitats of qualifying species rely
- The populations of qualifying species, and,
- The distribution of qualifying species within the site.

Attributes and related targets have been set for the site features which are presented in the site SACO[62]. Advice on seasonality for the site indicates year-round grey seal presence at the site.

Relevant licence areas with potential for physical disturbance and drilling effects

SNS 3

Activities associated with the proposed work programmes within the relevant licence areas

Drilling up to two wells involving - siting of rig, drilling discharges

[60] https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK0030170
[61] https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK0030170&SiteName=humber&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&HasCA=1&NumMarineSeasonality=8&SiteNameDisplay=Humber%20Estuary%20SAC
[62] https://designatedsites.naturalengland.org.uk/Marine/SupAdvice.aspx?SiteCode=UK0030170&SiteName=humber&SiteNameDisplay=Humber+Estuary+SAC&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=8

Assessment of effects on site integrity
Rig siting (***Relevant pressures:*** *penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion; abrasion/disturbance of the substrate on the surface of the seabed, physical change (to another seabed type) and introduction or spread of invasive non-indigenous species)* While SNS Area 3 is located 10km from the Humber Estuary SAC, rig siting could theoretically impact the extent and distribution of grey seal habitat outside of the site. The maximum spatial footprint of physical damage associated with jack-up rig siting is small (0.8km^2), potential supporting habitats (e.g. sand and gravel) are widespread over the region and recovery from physical damage of the scale associated with rig placement is expected to be rapid given the combined influence of tidal currents and waves in this relatively shallow area. The small scale and temporary nature of the potential physical damage, which would take place well outside the site boundary, will ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity. As noted in Section 4.2.1, management of the spread of non-native species from vessels and rigs is being progressed through international measures, and the risk is limited by the operational range of rigs on the UKCS. **Drilling discharges** (***Relevant pressures:*** *abrasion/disturbance of the substrate on the surface of the seabed, changes in suspended solids (water clarity); smothering and siltation rate changes (light); physical change (to another sediment type), habitat structure changes – removal of substratum (extraction) and contaminants)* The maximum spatial footprint within which smothering by drilling discharges may occur (0.8km^2) is small and given the environmental conditions, the redistribution of drilling discharges and recovery from smothering would be rapid and would not impact the extent and distribution or structure and function of the habitats, including those of mobile species which travel beyond the site boundaries, including grey seal. Additionally, the environment off the Holderness coast and Humber is highly dynamic, with large volumes of material eroded from the shoreline and seabed and transported southwards. The small scale and temporary nature of the potential physical damage, all of which will take place beyond the site boundaries (at least 10km distance), and mandatory control requirements with respect to drilling chemical use and discharge (Section 2.3.1) will ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity. **Other effects** N/A **In-combination effects** With respect to habitats supporting grey seal outside of the site, intra-plan in-combination effects are possible although spatial footprints associated with rig installation and drilling discharges are localised and temporary, and unlikely to overlap between the areas applied for either spatially or temporally. Given the indicative work programme, the combined spatial footprint within which physical disturbance and drilling effects could occur (within 500m of the rig/well location) across the two areas (a worst case scenario of two wells) is estimated at 1.6km^2. As noted above, supporting habitat beyond the site boundary for grey seal is widespread, and the temporary and localised nature of any impact would not result on an adverse effect for this feature. No potential for intra-plan in-combinations effects is considered possible for the habitats within the Humber Estuary SAC as the areas applied for are between 10km and 30km from the site, relative to the footprint of potential effects (500m). Site conservation objectives of the Humber Estuary SAC will not be undermined from physical disturbance resulting from the licensing of SNS Area 3. Section 6.2 provides a consideration of potential activities in-combination with other relevant plans and projects.
The Wash and North Norfolk Coast SAC[63]
Site information
Area (ha/km^2): 107,761/1,078 **Relevant qualifying features:** reefs, sandbanks, harbour seal

[63] https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK0017075

See Natural England guidance for details of qualifying features[64]. **Conservation objectives:** The site's conservation objectives apply to the site and the individual species and/or assemblage of species for which the site has been classified. The objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the Favourable Conservation Status of its qualifying features, by maintaining or restoring: • The extent and distribution of qualifying natural habitats and habitats of qualifying species • The structure and function (including typical species) of qualifying natural habitats • The structure and function of the habitats of qualifying species • The supporting processes on which qualifying natural habitats and habitats of qualifying species rely • The populations of qualifying species, and, • The distribution of qualifying species within the site. Attributes and related targets have been set for the site features which are presented in the site SACO[65]. Advice on seasonality for the site indicates year-round grey seal presence at the site.
Relevant licence areas with potential for physical disturbance and drilling effects
SNS 3
Activities associated with the proposed work programmes within the relevant licence areas
Drilling up to two wells involving - siting of rig, drilling discharges
Assessment of effects on site integrity
Rig siting *(**Relevant pressures:** penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion; abrasion/disturbance of the substrate on the surface of the seabed, physical change (to another seabed/sediment type) and introduction or spread of invasive non-indigenous species)* A small area of SNS Area 3 overlaps the site, outside of the Wash and to the north of north Norfolk Coast. The qualifying features most likely to be impacted by the placement of spud cans as part of rig siting are reef and sandbanks. SNS Area 3 has a significant area outside the site boundaries in which rig siting would be possible, and therefore interaction with the qualifying features could be avoided, noting the assumed distance from a jack-up rig within which effects may occur (500m, see Table 2.2). Should a rig be located within the site, the maximum spatial footprint of the penetration and/or disturbance pressure associated with jack-up rig siting is small (0.8km^2) compared to the site area (covering 0.07%). For the sandbank feature, recovery of damage to surface and sub-surface features of the scale associated with temporary rig placement is expected to be rapid due to its localised scale and the energetic nature of the environment. With regards to reef, recovery would take substantially longer, and further mitigation measures are available and will be required as appropriate as part of consenting (e.g. rig siting to ensure sensitive seabed surface features are avoided, see Section 5.2.3). This will ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity. In relation to habitat used by harbour seal both within the site and beyond the site boundaries, the feature is not considered to be sensitive to the pressures noted above, and the small scale and temporary nature of physical damage are such that there would not be an adverse effect on site integrity. There may be a requirement for rig stabilisation depending on local seabed conditions. In soft sediments, deposited rock may cover existing sediments resulting in a physical change (to another seabed type), and the qualifying features which have the potential to be impacted by rig siting are considered to be sensitive to this pressure, which assumes a permanent change of habitat. Physical damage caused by fisheries activities and wind farm cabling are referred to as factors affecting the feature condition of reef and sandbanks at the site (though with low confidence), and as noted in Section 5.2.1. Whilst it is not considered that rig placement (above) would result in permanent change to the sandbank habitat, the use of rock placement for rig stabilisation, which is not easily removed, would likely result in a localised but permanent change in habitat structure, extent and

64 https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK0017075&SiteName=&countyCode=&responsiblePerson=&unitId=&SeaArea=&IFCAArea=&HasCA=1&NumMarineSeasonality=2&SiteNameDisplay=The%20Wash%20and%20North%20Norfolk%20Coast%20SAC

65 https://designatedsites.naturalengland.org.uk/Marine/SupAdvice.aspx?SiteCode=UK0017075&SiteName=&SiteNameDisplay=The+Wash+and+North+Norfolk+Coast+SAC&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=2

distribution, for which adverse effects on site integrity could not be ruled out. While the potential loss of sandy sediment from rig stabilisation is small (estimated area of 0.001-0.004km² per rig siting, see Table 2.2) compared to the predominance of this sediment type across the site feature, in view of the unfavourable nature of the feature and in the context of compensatory measures being required for other, albeit larger and more permanent projects (see Section 5.2.1 and 6.2), any requirement for rig stabilisation materials, should a well be drilled within the Wash and North Norfolk SAC, must use removable methods (e.g. mud-mats or anti-scour mats); see Section 5.2.3. It should be further noted that a considerable proportion of SNS Area 3 is located outside of the site boundaries, such that effects may be avoided through rig siting.

As noted in Section 4.2.1, management of the spread of non-native species from vessels and rigs is being progressed through international measures, and the risk is limited by the operational range of rigs on the UKCS.

Drilling discharges
*(**Relevant pressures:** abrasion/disturbance of the substrate on the surface of the seabed, changes in suspended solids (water clarity); smothering and siltation rate changes (light); physical change (to another sediment type), habitat structure changes – removal of substratum (extraction) and contaminants)*

The advice on operations indicates that the relevant qualifying features are sensitive to the above pressures, most of which relate to seabed disturbance and habitat changes associated with smothering by drill cuttings near the well location, and that these cuttings can accumulate in piles where currents are generally weak, noting that tidal currents within the site are moderate within the site. It is assumed that effects relating to drilling discharges occur within 500m of the well location (Table 2.2). Therefore, with respect to SNS Area 3 which has significant areas outside the site boundaries in which drilling will be possible, drilling discharges will not significantly impact the extent and distribution or the structure and function of the qualifying habitat. Should wells be drilled within the site boundaries, the maximum spatial footprint within which smothering by drilling discharges and associated habitat structure changes may occur, assuming two wells are drilled, (1.6km²) is small (representing 0.15% of the total site area) and given the site's exposure to tidal energy, redistribution of drilling discharges and recovery from smothering would be rapid, and there would be no permanent change in site habitat. Therefore, site conservation objectives will not be undermined.

Other effects
N/A

In-combination effects
Intra-plan in-combination effects are possible although spatial footprints associated with rig installation and drilling discharges in SNS Area 3 are localised and temporary, and unlikely to overlap either spatially or temporally. Given the indicative work programmes, the combined spatial footprint within which physical disturbance and drilling effects could occur (a worst case scenario of two wells) is estimated at 1.6km² (0.15% of the site). With regards to rig stabilisation, should two wells be drilled within the site, this could cover an area of 0.008km² or 0.0007% of the SAC area. The localised and temporary nature of the disturbance, the considerable area outside of site boundaries in which to site a rig, and available mitigation (Section 5.2.3) are such that intra-plan in-combination effects are not considered likely. Section 6.2 provides a consideration of potential licence activities in-combination with other relevant plans and projects.

North Norfolk Sandbanks and Saturn Reef SAC[66]

Site information

Area (ha/km²): 360,341/3,603
Relevant qualifying features: Sandbanks, reefs

Conservation objectives:
For the features to be in favourable condition thus ensuring site integrity in the long term and contribution to Favourable Conservation Status of Annex I Sandbanks which are slightly covered by sea water all of the time and Annex I Reefs. This contribution would be achieved by maintaining or restoring, subject to natural change:

- The extent and distribution of the qualifying habitats in the site;
- The structure and function of the qualifying habitats in the site; and
- The supporting processes on which the qualifying habitats rely

Attributes and related targets have been set for the site features which are presented in the site SACO[67].

[66] https://jncc.gov.uk/our-work/north-norfolk-sandbanks-and-saturn-reef-mpa/
[67] https://hub.jncc.gov.uk/assets/d4c43bd4-a38d-439e-a93f-95d29636cb17#NNSSR-3-SACO-v1.0.pdf

Relevant licence areas with potential for physical disturbance and drilling effects
SNS 2, SNS 4
Activities associated with the proposed work programmes within the relevant licence areas
Drilling up to four wells involving - siting of rig, drilling discharges
Assessment of effects on site integrity

Rig siting
*(**Relevant pressures:** penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion; abrasion/disturbance of the substrate on the surface of the seabed, physical change (to another seabed type) and introduction or spread of invasive non-indigenous species)*

Both the sandbank and reef qualifying features are sensitive to penetration and/or disturbance of the seabed surface and subsurface[68] by the placement of spud cans as part of rig siting. SNS Area 2 (Licence 1) and SNS Area 4 (Licence 1) have significant areas outside the site boundaries in which a rig may be sited, and interaction with the site is unlikely or could be avoided through rig site selection. SNS Area 2 (Licence 2) and SNS Area 4 (Licence 2) are entirely outside of the site boundaries and are least 15km and 1.4km from the site respectively. There remains substantial overlap with the site and the most easterly and northerly licence areas applied for in SNS Area 4, and it therefore seems likely that a rig would be sited within the SAC if these licences were awarded. The site includes fauna representative of both disturbed and more stable communities, with the former more prevalent on the inner banks which are subject to stronger currents (JNCC 2010), also corresponding to the general location of the easterly licence area identified above. The maximum spatial footprint of the penetration and/or disturbance pressure associated with jack-up rig siting is small (0.8km^2, see Table 2.2) compared to the large site (covering 0.02%). While the reef and sandbank features are considered to be in unfavourable condition[69] (see Section 5.2.1), the recovery of the sandbank feature from physical disturbance of the scale associated with rig placement is expected to be rapid given the dynamic nature of the site. Additionally, further mitigation measures are available to avoid interaction with reef features, for example, through rig site selection. As noted in Section 5.2.3, rig site surveys will inform individual rig siting, and should be used to confirm whether Annex I reef is present, noting the ephemeral nature of the *Sabellaria* reefs in the site. These measures will be required, where appropriate, to ensure that impacts do not result in long-term or permanent change to the habitats and that the site conservation objectives are not undermined, and there is no adverse effect on site integrity.

There may be a requirement for rig stabilisation depending on local seabed conditions. The advice on operations notes that the sandbank and reef features are considered sensitive to physical change to another seabed type (but only with respect to pipelines which are not part of this AA). The SACO notes that the deposition of material (rock) may lead to a persistent change in substrate which is not suitable habitat for characterising sandbank communities and advise that activities must look to minimise, as far as is practicable, changes in substratum and the biological assemblages within the site to minimise further impact on feature extent and distribution. As indicated by Parry *et al*. (2015), sandy sediment dominates the site covering approximately 80% of the seabed. Of note is that patches of coarse and mixed sediment including pebbles and cobbles are present within the site (see Section 5.2.1). It is likely that if rock placement is required it would be within 500m of a rig and based on a review of submitted ESs it is estimated this could cover an area of 0.001-0.004km^2 (Table 2.2). Hence, the potential loss of extent of sandy sediment is small compared to the predominance of this sediment type across the large site (3,603km^2). However, in view of the unfavourable conservation status of the sandbank feature, further mitigation measures must be used such as removable mud mats or anti-scour mats as an alternative to rock placement (Section 5.2.3) to avoid further reduction in the extent and distribution of the feature within the site. These will be required, where appropriate, to ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

As noted in Section 4.2.1, management of the spread of non-native species from vessels and rigs is being progressed through international measures, and the risk is limited by the operational range of rigs on the UKCS.

Drilling discharges
*(**Relevant pressures:** abrasion/disturbance of the substrate on the surface of the seabed, changes in suspended solids (water clarity); smothering and siltation rate changes (light); physical change (to another sediment type), habitat structure changes – removal of substratum (extraction) and contaminants)*

The sandbank and reef qualifying features are sensitive to abrasion/disturbance of the seabed surface, siltation rate changes including smothering and habitat structure changes, removal of substratum (extraction) pressures

[68] https://hub.jncc.gov.uk/assets/d4c43bd4-a38d-439e-a93f-95d29636cb17#NNSSR-5-AoO-v1.0.xlsx
[69] https://hub.jncc.gov.uk/assets/d4c43bd4-a38d-439e-a93f-95d29636cb17#NNSSR-4-Statements-v1.0.pdf

associated with drilling discharges. The advice on operations indicates that the qualifying features are not sensitive to the contaminants pressures and physical change (to another sediment type) is not included within the advice. The SACO notes that alteration of surface sediment by drill cuttings may lead to a persistent change in substrate which is not suitable habitat for characterising sandbank communities. However, the impacts from such discharges are localised and transient, and as noted in Section 4.2, such drill cuttings piles do not generally accumulate in shallow, high energy waters, such as in the southern North Sea.

SNS Area 4 (Licence 2) and SNS Area 2 (Licence 2) are entirely outside of the site, and at a distance (at least 1.4km) greater than that within which effects are from drilling discharges are expected to occur (within 500m of the well location, Table 2.2). For each well that could be located within the site, the maximum spatial footprint within which smothering by drilling discharges may occur (0.8km^2) is small (representing 0.02% of the total site area) and given the site's dynamic nature, redistribution of drilling discharges and recovery from smothering would be rapid. It should be noted that SNS Area 2 (Licence 1) and SNS Area 4 (Licence 1) have substantial area outside of the SAC within which rig siting may be possible, avoiding interaction with the site. The small scale and temporary nature of potential smothering, as well as mandatory control requirements with respect to drilling chemical use and discharge (Section 2.3.1), will ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

Other effects
N/A

In-combination effects
Intra-plan in-combination effects are possible although spatial footprints associated with rig installation and drilling discharges in SNS Area 2 and SNS Area 4 which largely or partly within the site are localised and temporary, and unlikely to overlap either spatially or temporally. Given the indicative work programmes of the licences applied for, the combined spatial footprint within which physical disturbance and drilling effects could occur (within 500m of the rig/well location) across these two areas (a high case scenario of four wells) is estimated at 3.2km^2 (0.09% of the site). With regards to rig stabilisation, should all four wells be drilled within the site, this could cover an area of 0.016km^2 or 0.0004% of the SAC area. The localised and temporary nature of the disturbance and available mitigation to prevent permanent change to the extent and distribution of the sandbank and reef features within the site (Sections 2.3.1 and 5.2.3), will ensure that site conservation objectives are not undermined. Section 6.2 provides a consideration of potential activities in-combination with other relevant plans and projects.

Haisborough, Hammond and Winterton SAC[70]

Site information

Area (ha/km^2): 146,759/1,468
Relevant qualifying features: sandbanks, reefs

Conservation objectives:
The objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the Favourable Conservation Status of its qualifying features, by maintaining or restoring:

- the extent and distribution of qualifying natural habitats and habitats of the qualifying species
- the structure and function (including typical species) of qualifying natural habitats
- the structure and function of the habitats of the qualifying species
- the supporting processes on which qualifying natural habitats and the habitats of qualifying species rely
- the populations of each of the qualifying species
- the distribution of qualifying species within the site

Attributes and related targets have been set for the site features which are presented in the site SACO[71].

Relevant licence areas with potential for physical disturbance and drilling effects

SNS 4

Activities associated with the proposed work programmes within the relevant licence areas

Drilling up to three wells involving – siting of rig, drilling discharges

Assessment of effects on site integrity

Rig siting

[70] https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK0030369
[71] https://designatedsites.naturalengland.org.uk/Marine/SupAdvice.aspx?SiteCode=UK0030369

(***Relevant pressures:*** *penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion; abrasion/disturbance of the substrate on the surface of the seabed, physical change (to another seabed/sediment type) and introduction or spread of invasive non-indigenous species)*

Both the sandbank and reef qualifying features are sensitive to penetration and/or disturbance of the seabed surface and subsurface by the placement of spud cans as part of rig siting. SNS Area 4 (Licence 1, Licence 3, and to a lesser extent Licence 2) have significant areas outside the site boundaries in which a rig may be sited, and therefore, there is considerable potential that physical disturbance effects may be avoided. SNS Area 4 (Licence 4) is 18.5km to the north of the site, and rig siting within the licence area will have no physical disturbance effects on the site. Should a well be drilled within the site boundaries, the maximum spatial footprint of the penetration and/or disturbance pressure associated with jack-up rig siting is small (0.8km^2, see Table 2.2) compared to the large site (covering 0.05%). It is noted that the entirety of both the reef and sandbank features are considered to be in unfavourable condition[72] (see Section 5.2.1; there is a low confidence in this condition assessment), however, recovery of the sandbank feature from physical disturbance of the scale associated with rig placement is expected to be rapid given the dynamic nature of the site. Additionally, further mitigation measures are available to avoid interaction with reef features, for example, through rig site selection (see Section 5.2.3). These measures will be required, where appropriate, to ensure that impacts do not result in long-term or permanent change to the habitats and that the site conservation objectives are not undermined, and there is no adverse effect on site integrity.

There may be a requirement for rig stabilisation depending on local seabed conditions. The sandbanks and reefs features are considered sensitive to physical change to another seabed/sediment type. The SACO notes that there are pipelines within the site which are rock armoured in places, leading to a reduction in the extent and distribution of the sandbank feature within the site. The deposition of additional rock as part of rig stabilisation may lead to a persistent change in substrate which is not suitable habitat for characterising sandbank communities, and is not compatible with the restore target for the feature. While gravel is present within the site, notably on the flanks of some banks and their troughs, and the addition of rock may not represent a novel sediment type within the site, the difference in composition of this material to any exposure of natural material in, and its location within the site, may still contribute to a change in habitat extent, though it is less clear that it would represent a significant change in structure and function. The entire area of the site is not considered to contain the Annex I sandbank feature (Eggleton *et al.* 2020), but the intervening sediments are considered to support the conservation objectives of the site and to be sensitive to physical change to another seabed/sediment type (JNCC, consultation feedback), such that rock placement in any area of the site has the potential to undermine the site conservation objectives in view of the feature condition. It is likely that if rock placement is required it would be within 500m of a rig and based on a review of submitted ESs it is estimated this could cover an area of 0.001-0.004km^2 (Table 2.2). Hence, the potential loss of extent of sandy sediment is small compared to the predominance of this sediment type across the large site (1,468km^2). However, in view of the unfavourable conservation status of the sandbank feature, further mitigation measures must be used such as removable mud mats or anti-scour mats as an alternative to rock placement (Section 5.2.3) to avoid further reduction in the extent and distribution of the feature within the site. These will be required, where appropriate, to ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

As noted in Section 4.2.1, management of the spread of non-native species from vessels and rigs is being progressed through international measures, and the risk is limited by the operational range of rigs on the UKCS.

Drilling discharges
(***Relevant pressures:*** *abrasion/disturbance of the substrate on the surface of the seabed, changes in suspended solids (water clarity); smothering and siltation rate changes (light); physical change (to another sediment type), habitat structure changes – removal of substratum (extraction) and contaminants)*

The sandbank and reef qualifying features are sensitive to abrasion/disturbance of the seabed surface, siltation rate changes including smothering and habitat structure changes, removal of substratum (extraction) pressures associated with drilling discharges. The advice on operations indicates that the qualifying features have not been assessed against whether they are sensitive to contaminants pressures, but they are considered to be a moderate-high risk. Any discharge from exploration well drilling would be subject to risk assessment as part of existing regulatory controls (see Section 2.3.1). It is assumed that effects relating to drilling discharges occur within 500m of the well location (Table 2.2). All of the areas applied for are partly or largely within the site. For each well, the maximum spatial footprint within which smothering by drilling discharges may occur (0.8km^2) is small (representing 0.05% of the total site area) and given the site's dynamic nature, redistribution of drilling discharges and recovery from smothering would be rapid. Drill cuttings piles do not generally accumulate in

[72] https://designatedsites.naturalengland.org.uk/Marine/MarineFeatureCondition.aspx?SiteCode=UK0030369

shallow, high energy waters, such as in the southern North Sea. It should be noted that SNS Area 4 (Licence 1, Licence 3, and to a lesser extent also Licence 2) has substantial areas outside of the SAC within which rig siting may be possible, avoiding interaction with the site. SNS Area 4 (Licence 4) is entirely outside of the site boundary and at a distance (18.5km) greater than that within which effects relating to drilling discharges are assumed to occur (500m). The small scale and temporary nature of potential smothering, as well as mandatory control requirements with respect to drilling chemical use and discharge (Section 2.3.1), will ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

Other effects
N/A

In-combination effects
Intra-plan in-combination effects are unlikely as only SNS Area 4 overlaps with the site. The combined spatial footprint within which physical disturbance and drilling effects could occur (within 500m of the rig/well location) across the area based on a worst case scenario of three wells which are included in the work programmes for SNS Area 4, is estimated at 2.4km^2 (0.16% of the site). With regards to rig stabilisation, should all three wells be drilled within the site, this could cover an area of 0.001km^2 or 0.0008% of the SAC area. The localised and temporary nature of the disturbance and mitigation to prevent permanent change to the extent, distribution and structure of the sandbank and reef features within the site (Sections 2.3.1 and 5.2.3), will ensure that site conservation objectives are not undermined. Section 6.2 provides a consideration of potential activities in-combination with other relevant plans and projects.

Inner Dowsing, Race Bank and North Ridge SAC[73]

Site information

Area (ha/km^2): 84,514/845
Relevant qualifying features: sandbanks, reefs

Conservation objectives:
The objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the Favourable Conservation Status of its qualifying features, by maintaining or restoring:

- the extent and distribution of qualifying natural habitats and habitats of the qualifying species
- the structure and function (including typical species) of qualifying natural habitats
- the structure and function of the habitats of the qualifying species
- the supporting processes on which qualifying natural habitats and the habitats of qualifying species rely
- the populations of each of the qualifying species
- the distribution of qualifying species within the site

Attributes and related targets have been set for the site features which are presented in the site SACO[74].

Relevant licence areas with potential for physical disturbance and drilling effects

SNS 3

Activities associated with the proposed work programmes within the relevant licence areas

Drilling up to two wells involving - siting of rig, drilling discharges

Assessment of effects on site integrity

Rig siting
(***Relevant pressures:*** *penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion; abrasion/disturbance of the substrate on the surface of the seabed, physical change (to another seabed/sediment type) and introduction or spread of invasive non-indigenous species)*

Both the sandbank and reef qualifying features are sensitive to penetration and/or disturbance of the seabed surface and subsurface by the placement of spud cans as part of rig siting. SNS Area 3 covers a substantial area of the site. Should a well be drilled within the site boundaries, the maximum spatial footprint of the penetration and/or disturbance pressure associated with jack-up rig siting is small (0.8km^2, see Table 2.2) compared to the large site (covering 0.05%). It is noted that the entirety of the reef feature, and at least 33% of the sandbank feature are considered to be in unfavourable condition[75] (see Section 5.2.1; there is a low

[73] https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK0030370
[74] https://designatedsites.naturalengland.org.uk/Marine/SupAdvice.aspx?SiteCode=UK0030370
[75] https://designatedsites.naturalengland.org.uk/Marine/MarineFeatureCondition.aspx?SiteCode=UK0030370

confidence in these condition assessments), however, recovery of the sandbank feature from physical disturbance of the scale associated with rig placement is expected to be rapid given the dynamic nature of the site. Additionally, further mitigation measures are available (see Section 5.2.3) to avoid interaction with reef features, for example, through rig site selection. These measures will be required, where appropriate, to ensure that impacts do not result in long-term or permanent change to the habitats and that the site conservation objectives are not undermined, and there is no adverse effect on site integrity.

There may be a requirement for rig stabilisation depending on local seabed conditions. The sandbanks and reefs features are considered sensitive to physical change to another seabed/sediment type. The SACO notes that cable and scour protection has been installed within the site at Race Bank offshore wind farm, leading to a reduction in the extent and distribution, and structure, of the sandbank feature within the site. The deposition of additional rock as part of rig stabilisation may lead to a persistent change in substrate which is not suitable habitat for characterising sandbank communities, and is not compatible with the restore target for the feature. While gravel is present within the site, notably in the west and on Inner Dowsing, and the addition of rock may not represent a novel sediment type within the site, the difference in composition of this material to any exposure of natural material in, and its location within the site, may still contribute to a change in habitat extent, though it is less clear that it would represent a significant change in structure and function. The entire area of the site is not considered to contain the Annex I sandbank feature (Eggleton *et al.* 2020), but the intervening sediments are considered to support the conservation objectives of the site and be sensitive to physical change to another seabed/sediment type (JNCC, consultation feedback), such that rock placement in any area of the site has the potential to undermine the site conservation objectives in view of the feature condition. It is likely that if rock placement is required it would be within 500m of a rig and based on a review of submitted ESs it is estimated this could cover an area of 0.001-0.004km^2 (Table 2.2). Hence, the potential loss of extent of sandy sediment is small compared to the predominance of this sediment type across the large site (845km^2). However, in view of the unfavourable conservation status of much the sandbank feature, further mitigation measures must be used such as removable mud mats or anti-scour mats as an alternative to rock placement (Section 5.2.3) to avoid further reduction in the extent and distribution of the feature within the site. These will be required, where appropriate, to ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

As noted in Section 4.2.1, management of the spread of non-native species from vessels and rigs is being progressed through international measures, and the risk is limited by the operational range of rigs on the UKCS

Drilling discharges
*(**Relevant pressures:** abrasion/disturbance of the substrate on the surface of the seabed, changes in suspended solids (water clarity); smothering and siltation rate changes (light); physical change (to another sediment type), habitat structure changes – removal of substratum (extraction) and contaminants)*

The sandbank and reef qualifying features are sensitive to abrasion/disturbance of the seabed surface, siltation rate changes including smothering and habitat structure changes, removal of substratum (extraction) pressures associated with drilling discharges. The advice on operations indicates that the qualifying features have not been assessed against whether they are sensitive to contaminants pressures, but they are considered to be a moderate-high risk. Any discharge from exploration well drilling would be subject to risk assessment as part of existing regulatory controls (see Section 2.3.1). It is assumed that effects relating to drilling discharges occur within 500m of the well location (Table 2.2). All of the areas applied for are partly or largely within the site. For each well, the maximum spatial footprint within which smothering by drilling discharges may occur (0.8km^2) is small (representing 0.09% of the total site area) and given the site's dynamic nature, redistribution of drilling discharges and recovery from smothering would be rapid. Drill cuttings piles do not generally accumulate in shallow, high energy waters, such as in the southern North Sea. There is potential, through rig site selection, to avoid the features of the site, despite SNS Area 3 covering a substantial area of the SAC, however, should this not be possible, the small scale and temporary nature of potential smothering, as well as mandatory control requirements with respect to drilling chemical use and discharge (Section 2.3.1), will ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

Other effects
N/A

In-combination effects
Intra-plan in-combination effects are unlikely as only SNS Area 3 overlaps with the site. The combined spatial footprint within which physical disturbance and drilling effects could occur (within 500m of the rig/well location) across the area based on a worst case scenario of two wells which are included in the work programmes for SNS Area 3, is estimated at 1.6km^2 (0.19% of the site). With regards to rig stabilisation, should two wells be drilled

within the site, this could cover an area of 0.008km² or 0.00095% of the SAC area. The localised and temporary nature of the disturbance and mitigation to prevent permanent change to the extent, distribution and structure of the sandbank and reef features within the site by using removeable stabilisation materials, if these are required (Section 5.2.3), will ensure that site conservation objectives are not undermined. Section 6.2 provides a consideration of potential activities in-combination with other relevant plans and projects.

Flamborough Head SAC[76]

Site information

Area (ha/km²): 6,312/63
Relevant qualifying features: Sandbanks, reefs

Conservation objectives:
The objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the Favourable Conservation Status of its qualifying features, by maintaining or restoring:

- the extent and distribution of qualifying natural habitats and habitats of the qualifying species
- the structure and function (including typical species) of qualifying natural habitats
- the structure and function of the habitats of the qualifying species
- the supporting processes on which qualifying natural habitats and the habitats of qualifying species rely
- the populations of each of the qualifying species
- the distribution of qualifying species within the site

Attributes and related targets have been set for the site features which are presented in the site SACO[77].

Relevant licence areas with potential for physical disturbance and drilling effects

SNS 3

Activities associated with the proposed work programmes within the relevant licence areas

Drilling up to two wells involving - siting of rig, drilling discharges

Assessment of effects on site integrity

Rig siting
*(**Relevant pressures:** penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion; abrasion/disturbance of the substrate on the surface of the seabed, physical change (to another seabed/sediment type) and introduction or spread of invasive non-indigenous species)*

Both the sandbank and reef qualifying features are sensitive to penetration and/or disturbance of the seabed surface and subsurface by the placement of spud cans as part of rig siting. SNS Area 3 is at least 1.5km from the boundary of the site, and in view of the distance from the rig in which potential effects are considered likely (500m), direct effects on the reef and sandbank features of Flamborough Head SAC are not expected. There may be a requirement for rig stabilisation depending on local seabed conditions, and similar to rig siting, it is likely that if rock placement is required it would be within 500m of a rig, and based on a review of submitted ESs it is estimated this could cover an area of 0.001-0.004km² (Table 2.2). In view of the distance of the site from SNS Area 3, there would be no effect on the extent and distribution, structure or function of the site's habitats and there will be no adverse effect on site integrity.

As noted in Section 4.2.1, management of the spread of non-native species from vessels and rigs is being progressed through international measures, and the risk is limited by the operational range of rigs on the UKCS

Drilling discharges
*(**Relevant pressures:** abrasion/disturbance of the substrate on the surface of the seabed, changes in suspended solids (water clarity); smothering and siltation rate changes (light); physical change (to another sediment type), habitat structure changes – removal of substratum (extraction) and contaminants)*

The sandbank and reef qualifying features are sensitive to abrasion/disturbance of the seabed surface, siltation rate changes including smothering and habitat structure changes, removal of substratum (extraction) pressures associated with drilling discharges. The advice on operations indicates that the qualifying features have not been assessed against whether they are sensitive to contaminants pressures, but they are considered to be a moderate-high risk. Any discharge from exploration well drilling would be subject to risk assessment as part of

[76] https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK0013036
[77] https://designatedsites.naturalengland.org.uk/Marine/SupAdvice.aspx?SiteCode=UK0013036

existing regulatory controls (see Section 2.3.1). It is assumed that effects relating to drilling discharges occur within 500m of the well location (Table 2.2), which is substantially less than the minimum distance from SNS Area 3 to the site. This, combined with mandatory control requirements with respect to drilling chemical use and discharge (Section 2.3.1), will ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

Other effects
N/A

In-combination effects
Intra-plan in-combination effects are unlikely as only SNS Area 3 was identified as relevant to the assessment, and it, and any related wells (up to two), is too distant for physical or discharge related effects to lead to an adverse impact on site integrity. Section 6.2 provides a consideration of potential activities in-combination with other relevant plans and projects.

Flamborough & Filey Coast SPA[78]

Site Information

Area (ha/km^2): 8,040/80
Relevant qualifying features: breeding: gannet, kittiwake, razorbill, guillemot, fulmar

Conservation objectives: The objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring:

- the extent and distribution of the habitats of the qualifying features
- the structure and function of the habitats of the qualifying features
- the supporting processes on which the habitats of the qualifying features rely
- the populations of each of the qualifying features
- the distribution of qualifying features within the site

Relevant licence areas with potential for physical disturbance and drilling effects

SNS 3

Activities associated with the proposed work programmes within the relevant licence areas

Drilling up to two wells involving - siting of rig, drilling discharges

Assessment of effects on site integrity

Rig siting
*(**Relevant pressures:** penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion; abrasion/disturbance of the substrate on the surface of the seabed, physical change (to another seabed/sediment type))*

The advice on operations indicates that the supporting habitats for the features are sensitive to the above pressures, however, the assessment relates the habitats within the site boundaries which form only a small part of that which is used by the features (e.g. see the utilisation distributions for kittiwake and fulmar in Cleasby *et al.* 2018, and those for gannet in Wakefield *et al.* 2013, 2015 and Langston & Teuten 2018). Direct impacts on the supporting habitat within the site will not occur, as SNS Area 3 is located further from the site (3km) than the assumed distance within which effects would take place (500m). The maximum spatial footprint of physical damage (penetration and/or disturbance pressure) associated with jack-up rig siting, assuming three wells are drilled, is small (1.6km^2, Table 2.2) compared to the large area of available habitat for the qualifying features (e.g. see references above and Woodward *et al.* 2019). Recovery from physical disturbance of the scale associated with rig siting is expected to be relatively rapid given the moderate to high energy seabed environment across much of the southern North Sea. The small scale and temporary nature of the potential physical disturbance will not have a significant effect on the extent and distribution of the supporting habitats of the features either in the site or within their wider foraging ranges, and therefore, there will be no adverse effect on site integrity.

The requirement for rig stabilisation measures would be determined by site survey of local conditions. In soft sediments, rock placement may cause smothering of existing sediments and a physical change to another seabed type. As noted above, SNS Area 3 is ~3km from the SPA site boundary, and no direct effects on the habitat within the site will occur. It is assumed that rock placement (if required) would be within 500m of the rig and cover an estimated area of 0.001-0.004km^2 per rig siting (Table 2.2). Hence, the potential change in the

[78] https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK9006101

extent of habitat is small compared to the wide areas over which birds forage, site conservation objectives will not be undermined and there will be no adverse effect on site integrity.

Drilling discharges
*(**Relevant pressures:** abrasion/disturbance of the substrate on the surface of the seabed, changes in suspended solids (water clarity); smothering and siltation rate changes (light); physical change (to another seabed/sediment type), habitat structure changes – removal of substratum (extraction) and contaminants)*

The supporting habitat is sensitive to abrasion/disturbance of the seabed surface, siltation rate changes including smothering and habitat structure changes, removal of substratum (extraction) pressures associated with drilling discharges. The advice on operations indicates that the qualifying features have not been assessed against whether they are sensitive to contaminants pressures, but they are considered to be a moderate-high risk. Any discharge from exploration well drilling would be subject to risk assessment as part of existing regulatory controls (see Section 2.3.1). It is assumed that effects relating to drilling discharges occur within 500m of the well location (Table 2.2), which is substantially less than the minimum distance from SNS Area 3 to the site (3km). This, combined with mandatory control requirements with respect to drilling chemical use and discharge (Section 2.3.1), will ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

Other effects
(Relevant pressures: *visual disturbance, above water noise)*
Note that the above pressures are considered to represent a low risk to the site qualifying features[79], and are only considered briefly here. Of the qualifying features, guillemot and razorbill have a moderate to higher sensitive to disturbance by ship and helicopter traffic with the other features being of low sensitivity (Garthe & Hüppop 2004, Furness *et al*. 2013, Fliessbach *et al.* 2019). Shipping in the area is concentrated along established routes off the Yorkshire Coast and to the Humber and beyond, and is moderate to high across much of SNS Area 3 (see Section 6.2). The temporary and localised nature of drilling activities and limited number of associated supply vessel and helicopter trips (see Table 2.2), which would likely use established routes, are such that they will not likely lead to an impact the qualifying features' distribution and use of the site such that their ability to survive and/or breed is compromised in the longer term.

In-combination effects
Intra-plan in-combination effects are unlikely as only SNS Area 3 was identified as relevant to the assessment, and both the area applied for and any related wells (up to two), are too distant for physical or discharge related effects to lead to an adverse impact on site integrity. Section 6.2 provides a consideration of potential activities in-combination with other relevant plans and projects.

Greater Wash SPA[80]

Site Information

Area (ha/km^2): 353,578/3,536
Relevant qualifying features: breeding: Sandwich tern, common tern*, little tern*; non-breeding: little gull, red-throated diver*, common scoter

Conservation objectives: With regard to the SPA and the individual species and/or assemblage of species for which the site has been classified, and subject to natural change;
Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring;

- The extent and distribution of the habitats of the qualifying features
- The structure and function of the habitats of the qualifying features
- The supporting processes on which the habitats of the qualifying features rely
- The population of each of the qualifying features, and,
- The distribution of the qualifying features within the site.

*the common tern and little tern features of this site are associated with colonies relating to Gibraltar point SPA, Great Yarmouth North Denes SPA, The Wash SPA, Humber Estuary SPA (little tern), and; Breydon Water SPA (common tern), and the Outer Thames Estuary SPA (common tern, little tern, red-throated diver). The following assessment also covers the relevant tern features of these sites.

[79] https://designatedsites.naturalengland.org.uk/Marine/FAPMatrix.aspx?SiteCode=UK9006101
[80] https://jncc.gov.uk/our-work/greater-wash-spa/

Relevant licence areas with potential for physical disturbance and drilling effects
SNS 3
Activities associated with the proposed work programmes within the relevant licence areas
Drilling up to two wells involving - siting of rig, drilling discharges
Assessment of effects on site integrity
Rig siting (***Relevant pressures:*** *penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion; abrasion/disturbance of the substrate on the surface of the seabed, physical change (to another seabed/sediment type))* Advice on operations is not presently available for the site, but the above pressures are considered to be relevant to a consideration of potential effects on the supporting habitat of the site. SNS Area 3 overlaps a substantial portion of the site, particularly south of the Humber, off the Wash and North Norfolk Coast, but there is also a substantial part of the area applied for which is outside of the site, and which a rig may be sited. The maximum spatial footprint of physical damage associated with jack-up rig siting is small (0.8km^2, Table 2.2) relative to the area over which Sandwich and common terns may forage, and the area used by wintering little gull. Interaction with little tern habitat is unlikely due to their limited foraging range from the coastline (the reported mean maximum foraging ranges little tern is 5km) (see Woodward *et al.* 2019 and BEIS 2022b, noting also that tern colonies associated with the site are also those related to the Wash SPA and North Norfolk Coast SPA, both discussed below). Red-throated diver are widely distributed throughout the site, with this distribution largely forming the basis for the site boundaries (Lawson *et al.* 2015c), and the scale of any physical damage would be small relative to the large site, though common scoter has a more restricted distribution (Lawson *et al.* 2015c). Recovery from physical disturbance of the scale associated with rig siting is expected to be relatively rapid given the moderate to high energy seabed environment across much of the area. The small scale and temporary nature of the potential physical disturbance will not have a significant effect on the extent and distribution of the supporting habitats of the features either in the site or within their wider foraging ranges, and therefore, there will be no adverse effect on site integrity. The requirement for rig stabilisation measures would be determined by site survey of local conditions. In soft sediments, rock placement may cause smothering of existing sediments and a physical change to another seabed type. It is assumed that rock placement (if required) would be within 500m of the rig and cover an estimated area of 0.001-0.004km^2 per rig siting (Table 2.2). Hence, the potential change in the extent of habitat is small compared to the wide areas over which birds forage, and when considered in the context of available project level mitigation (see Section 5.2.3), site conservation objectives will not be undermined and there will be no adverse effect on site integrity. **Drilling discharges** (***Relevant pressures:*** *abrasion/disturbance of the substrate on the surface of the seabed, changes in suspended solids (water clarity); smothering and siltation rate changes (light); physical change (to another sediment type), habitat structure changes – removal of substratum (extraction) and contaminants)* It is assumed that effects relating to drilling discharges occur within 500m of the well location (Table 2.2). There are significant areas of SNS Area 3 which are outside the site in which drilling discharges would not impact the site. However, if located within the site, the maximum spatial footprint within which smothering by drilling discharges may occur (0.8km^2) is small (representing 0.02% of the total site area). As indicated in Section 5.2.1, the environment off the Holderness coast is highly dynamic, with large volumes of material eroded from the shoreline and seabed and transported southwards, and in general, this area has relatively high levels of suspended sediments compared to other areas of the UKCS (Cefas 2016). The small scale and temporary nature of potential smothering, and mandatory mitigation requirements with respect to drilling chemical use and discharge (Section 2.3.1), will ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity. **Other effects** **(Relevant pressures:** *visual disturbance, above water noise***)** Of the qualifying features, terns and little gull have a low sensitivity to disturbance by ship and helicopter traffic, while red-throated diver and common scoter are both known to be highly sensitive to visual disturbance (Garthe & Hüppop 2004, also see Schwemmer *et al.* 2011, MMO 2018, and Mendel *et al.* 2019, and Section 4.2.3). There is considerable scope for drilling to take place outside of the site boundaries, and considering the seasonal nature of the sensitivity, operators should seek to undertake exploration/appraisal activity outside of the wintering period (1st November-31st March inclusive) to avoid the potential for effects on scoter and red-throated diver features.

Should rig siting take place within the site, and in the wintering period, disturbance of divers or scoters is possible. JNCC (2022) provide advice on potential displacement for sensitive species including seaduck and red-throated diver in relation to wind farm development. The scale and duration of exploration/appraisal drilling is significantly less than that for the installation of an offshore wind farm. JNCC/NE advise at least a 2km and 2.5km displacement buffer be considered at the project level for vessels in relation to red-throated diver and common scoter respectively. This should be considered in the context of existing levels of vessel activity in the area (see Section 6.2) and where possible, established vessel traffic routes to the drilling location should be used. The scoter and red-throated diver features of the Greater Wash SPA are not uniformly distributed throughout the site (see Section 5.2.1 and Lawson *et al.* 2016), and should rig siting take place within the site, and within the wintering period, operators should seek to avoid the core areas of use by the species (see Section 5.2.3).

The temporary and localised nature of drilling activities and limited number of associated supply vessel and helicopter trips (see Table 2.2), which would likely use established routes, are such that they will not likely lead to an impact the qualifying features' distribution and use of the site such that the population within the site would be affected in the long-term. It should be noted that the effect of displacement on mortality is unknown, as are any effects on the populations of affected areas. For example, surveys of the Outer Thames Estuary SPA (O'Brien *et al.* 2008, Goodship *et al.* 2015, Irwin *et al.* 2019), while for varying purposes and using a variety of techniques, do not appear to show a corresponding population response of red-throated diver to the estimated displacement of divers by windfarms to date (see also Vilela *et al.* 2022). It is not considered that the licensing of SNS Area 3 on its own, and the related level of vessel traffic and potential displacement, would lead to adverse effects on site integrity through displacement of red-throated diver or common scoter.

In-combination effects
Intra-plan in-combination effects are unlikely as only SNS Area 3 overlaps with the site. The combined spatial footprint within which physical disturbance and drilling effects could occur (within 500m of the rig/well location) across the area based on a worst case scenario of two wells which are included in the work programme for SNS Area 3, is estimated at 1.6km^2 (0.05% of the site). With regards to rig stabilisation, should all wells be drilled within the site, this could cover an area of 0.008km^2 or 0.0003% of the site area. The localised and temporary nature of the disturbance, and available mitigation (Section 5.2.3) is such that intra-plan in-combination effects are unlikely. Section 6.2 provides a consideration of potential activities in-combination with other relevant plans and projects.

North Norfolk Coast SPA[81]

Site Information

Area (ha/km^2): 7,887/79
Relevant qualifying features: breeding: avocet, bittern, common tern, little tern, Sandwich tern, marsh harrier, Montagu's harrier, non-breeding: dark-bellied brent goose, knot, pink-footed goose, wigeon, Waterbird assemblage

Conservation objectives: The objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring:

- the extent and distribution of the habitats of the qualifying features
- the structure and function of the habitats of the qualifying features
- the supporting processes on which the habitats of the qualifying features rely
- the populations of each of the qualifying features
- the distribution of qualifying features within the site

Relevant licence areas with potential for physical disturbance and drilling effects

SNS 3

Activities associated with the proposed work programmes within the relevant licence areas

Drilling up to two wells involving - siting of rig, drilling discharges

Assessment of effects on site integrity

Rig siting
*(**Relevant pressures:** penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion; abrasion/disturbance of the substrate on the surface of the seabed, physical change (to another seabed/sediment type))*

[81] https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK9009031

The advice on operations indicates that the supporting habitats for the features are sensitive to the above pressures, however, SNS Area 3 is 6km from the site, and given the assumed distance from a jack-up rig within which effects may occur (500m, see Table 2.2), rig installation will not significantly impact the extent and distribution of the habitats of the qualifying features within the site. Additionally, the maximum spatial footprint of physical damage associated with jack-up rig siting is small (0.8km^2, Table 2.2) relative to the area over which terns may forage (e.g. see Section 4.6.1 of BEIS 2022b and Woodward *et al.* 2019) outside of the site boundaries. Recovery from physical disturbance of the scale associated with rig siting is expected to be relatively rapid given the moderate to high energy seabed environment across much of the southern North Sea. The small scale and temporary nature of the potential physical disturbance will not have a significant effect on the extent and distribution of the supporting habitats of the features either in the site or within their wider foraging ranges, and therefore, there will be no adverse effect on site integrity.

The requirement for rig stabilisation measures would be determined by site survey of local conditions. In soft sediments, rock placement may cause smothering of existing sediments and a physical change to another seabed type. As noted above, SNS Area 3 is ~6km from the SPA site boundary, and no direct effects on the habitat within the site will occur. It is assumed that rock placement (if required) would be within 500m of the rig and cover an estimated area of 0.001-0.004km^2 per rig siting (Table 2.2). Hence, the potential change in the extent of habitat is small compared to the wide areas over which birds forage, site conservation objectives will not be undermined and there will be no adverse effect on site integrity.

Drilling discharges
*(**Relevant pressures:** abrasion/disturbance of the substrate on the surface of the seabed; smothering and siltation rate changes (light); physical change (to another seabed/sediment type), habitat structure changes – removal of substratum (extraction) and contaminants)*

The supporting habitat is sensitive to the above pressures associated with drilling discharges. The advice on operations indicates that the qualifying features and their supporting habitats have not been assessed against whether they are sensitive to contaminants pressures, but they are considered to be a moderate-high risk. Any discharge from exploration well drilling would be subject to risk assessment as part of existing regulatory controls (see Section 2.3.1). It is assumed that effects relating to drilling discharges occur within 500m of the well location (Table 2.2), which is substantially less than the minimum distance from SNS Area 3 to the site (6km). This, combined with mandatory control requirements with respect to drilling chemical use and discharge (Section 2.3.1), will ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

Other effects
(Relevant pressures: *visual disturbance, above water noise)*
Note that the above pressures are considered to represent a low risk to the site qualifying features[82], and are only considered briefly here. Of the qualifying features, terns have a low sensitivity to disturbance by ship and helicopter traffic (Garthe & Hüppop 2004, Furness *et al*. 2013, Fliessbach *et al.* 2019), with the distribution of the other features within the site relative to the shortest distance to SNS Area 3 (6km) such that disturbance is not considered to be likely. Shipping in the area is concentrated along established routes through The Wash and north towards the Humber Estuary, and is moderate to high across much of SNS Area 3, though with lower levels of traffic off the North Norfolk Coast (see Section 6.2). The temporary and localised nature of drilling activities and limited number of associated supply vessel and helicopter trips (see Table 2.2), which would likely use established routes, are such that they will not likely lead to an impact on the qualifying features' distribution and use of the site such that their ability to survive and/or breed is compromised in the longer term.

In-combination effects
Intra-plan in-combination effects are unlikely as only SNS Area 3 was identified as relevant to the assessment, and for rig siting and discharges, the area applied for is beyond the distance at which effects from these activities are anticipated. Section 6.2 provides a consideration of potential activities in-combination with other relevant plans and projects.

The Wash SPA[83]

Site Information

Area (ha/km^2): 62,211/622
Relevant qualifying features: breeding: little tern*, non-breeding: common scoter

[82] https://designatedsites.naturalengland.org.uk/Marine/FAPMatrix.aspx?SiteCode=UK9009031
[83] https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK9008021

Conservation objectives: The objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring:

- the extent and distribution of the habitats of the qualifying features
- the structure and function of the habitats of the qualifying features
- the supporting processes on which the habitats of the qualifying features rely
- the populations of each of the qualifying features
- the distribution of qualifying features within the site

*screened in as the site includes a little tern source colony related the Greater Wash SPA. The assessment of little tern in relation to the Greater Wash SPA, above, also covers the assessment for little tern in relation the Wash SPA.

Relevant licence areas with potential for physical disturbance and drilling effects

SNS 3

Activities associated with the proposed work programmes within the relevant licence areas

Drilling up to two wells involving - siting of rig, drilling discharges

Assessment of effects on site integrity

Rig siting
*(**Relevant pressures:** penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion; abrasion/disturbance of the substrate on the surface of the seabed, physical change (to another seabed/sediment type))*

The advice on operations indicates that the supporting habitats for the features are sensitive to the above pressures, however, SNS Area 3 is 6.5km from the site, and given the assumed distance from a jack-up rig within which effects may occur (500m, see Table 2.2), rig installation will not impact the extent and distribution of the habitats of the qualifying features within the site, such that the site conservation objectives will not be undermined and there will be no adverse effect on site integrity. Similarly, as any rig stabilisation materials (if required) would be within 500m of the rig, it is not considered that its use would result in any change in the extent of the supporting habitat of the site, and when considered in the context of available project level mitigation (see Section 5.2.3), site conservation objectives will not be undermined and there will be no adverse effect on site integrity.

Drilling discharges
*(**Relevant pressures:** abrasion/disturbance of the substrate on the surface of the seabed, changes in suspended solids (water clarity); smothering and siltation rate changes (light); physical change (to another sediment type), habitat structure changes – removal of substratum (extraction) and contaminants)*

The supporting habitat is sensitive to the above pressures associated with drilling discharges. The advice on operations indicates that the qualifying features and their supporting habitats have not been assessed against whether they are sensitive to contaminant pressures, but they are considered to be a moderate-high risk. Any discharge from exploration well drilling would be subject to risk assessment as part of existing regulatory controls (see Section 2.3.1). It is assumed that effects relating to drilling discharges occur within 500m of the well location (Table 2.2), which is substantially less than the minimum distance from SNS Area 3 to the site (6.5km). This, combined with mandatory control requirements with respect to drilling chemical use and discharge (Section 2.3.1), will ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

Other effects
(Relevant pressures: *visual disturbance, above water noise)*
Common scoter is known to be highly sensitive to visual disturbance (Garthe & Hüppop 2004, also see Schwemmer *et al.* 2011, MMO 2018, and Mendel *et al.* 2019, and Section 4.2.3). JNCC (2017) provide advice on displacement for sensitive species including seaduck in relation to wind farm development. While the scale and duration of exploration/appraisal drilling is significantly less than that for installation of an offshore wind farm, a worst case displacement of up to 4km could be possible for the presence of the drilling rig and any associated vessels, but this should be considered in the context of existing levels of vessel activity in the area (see Section 6.2). Scoter using the Wash SPA are likely to use the Greater Wash SPA (considered above), and based on the assessment for that site, and that SNS Area 3 is greater than 4km from the site boundary, adverse effects on site integrity through displacement of common scoter is discounted in relation to rig placement. The temporary and localised nature of drilling activities and limited number of associated supply vessel and helicopter trips (see Table 2.2), which would likely use established routes, are such that they will not likely lead to an impact the

qualifying features' distribution and use of the site such that the population within the site would be affected in the long-term. It is not considered that the licensing of SNS Area 3 on its own would lead to adverse effects on site integrity through displacement of red-throated diver or common scoter.

In-combination effects
Intra-plan in-combination effects are unlikely as only SNS Area 3 was identified as relevant to the assessment, and both the area applied for and any related wells (up to two), are too distant for physical or discharge related effects to lead to an adverse impact on site integrity. Section 6.2 provides a consideration of potential activities in-combination with other relevant plans and projects.

Humber Estuary SPA[84]

Site Information

Area (ha/km^2): 37,630/376
Relevant qualifying features: breeding: avocet, bittern, little tern*, marsh harrier, non-breeding: avocet, bar-tailed godwit, black-tailed godwit, dunlin, golden plover, hen harrier, knot, redshank, ruff, shelduck, Waterbird assemblage

Conservation objectives: The objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring:

- the extent and distribution of the habitats of the qualifying features
- the structure and function of the habitats of the qualifying features
- the supporting processes on which the habitats of the qualifying features rely
- the populations of each of the qualifying features
- the distribution of qualifying features within the site

*screened in as the site includes a little tern source colony related the Greater Wash SPA. The assessment of little tern in relation to the Greater Wash SPA, above, also covers the assessment for little tern in relation the Wash SPA.

Relevant licence areas with potential for physical disturbance and drilling effects

SNS 3

Activities associated with the proposed work programmes within the relevant licence areas

Drilling up to two wells involving - siting of rig, drilling discharges

Assessment of effects on site integrity

Rig siting
*(**Relevant pressures:** penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion; abrasion/disturbance of the substrate on the surface of the seabed, physical change (to another seabed/sediment type))*

The advice on operations indicates that the supporting habitats for the features are sensitive to the above pressures, however, SNS Area 3 is 6.5km from the site, and given the assumed distance from a jack-up rig within which effects may occur (500m, see Table 2.2), rig installation will not impact the extent and distribution of the habitats of the qualifying features within the site, such that the site conservation objectives will not be undermined and there will be no adverse effect on site integrity. Similarly, as any rig stabilisation materials (if required) would be within 500m of the rig, it is not considered that its use would result in any change in the extent of the supporting habitat of the site, and when considered in the context of available project level mitigation (see Section 5.2.3), site conservation objectives will not be undermined and there will be no adverse effect on site integrity.

Drilling discharges
*(**Relevant pressures:** abrasion/disturbance of the substrate on the surface of the seabed, changes in suspended solids (water clarity); smothering and siltation rate changes (light); physical change (to another sediment type), habitat structure changes – removal of substratum (extraction) and contaminants)*

The supporting habitat is sensitive to the above pressures associated with drilling discharges. The advice on operations indicates that the qualifying features and their supporting habitats have not been assessed against whether they are sensitive to contaminants pressures, but they are considered to be a moderate-high risk. Any discharge from exploration well drilling would be subject to risk assessment as part of existing regulatory controls

[84] https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK9006111

(see Section 2.3.1). It is assumed that effects relating to drilling discharges occur within 500m of the well location (Table 2.2), which is substantially less than the minimum distance from SNS Area 3 to the site (6.5km). This, combined with mandatory control requirements with respect to drilling chemical use and discharge (Section 2.3.1), will ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

Other effects
(Relevant pressures:** visual disturbance, above water noise**)
The site features are part of a waterbird assemblage which would be closely associated with the coast, and in view of the distance of SNS Area 3 from the site (6.5km), visual disturbance (to which the features are considered sensitive to for exploration/appraisal activities but at low risk) is not expected to result in a change to the distribution of the features, or the site population, which could lead to adverse effects on site integrity.

In-combination effects
Intra-plan in-combination effects are unlikely as only SNS Area 3 was identified as relevant to the assessment, and it, and any related wells (up to two), is too distant for physical or discharge related effects to lead to an adverse impact on site integrity. Section 6.2 provides a consideration of potential activities in-combination with other relevant plans and projects.

5.2.3 Further physical disturbance and drilling mitigation measures

Further mitigation measures are available which are identified through the EIA process and operator's environmental management and the Departmental permitting processes. These considerations are informed by project specific plans and the nature of the sensitivities identified from detailed seabed information collected in advance of field activities taking place. Site surveys are required to be undertaken before drilling rig placement (for safety and environmental reasons) and the results of such surveys (survey reports) allow for the identification of further mitigation including the re-siting of activities (e.g. wellhead or rig leg positions) to ensure sensitive seabed surface features (such as reefs) are avoided and potential rig stabilisation issues (e.g. from scouring around spud cans, or soft sediment conditions) are minimised. Survey reports are used to underpin operator environmental submissions (e.g. EIAs) and where requested, survey reports are made available to nature conservation bodies during the consultation phases of these assessments.

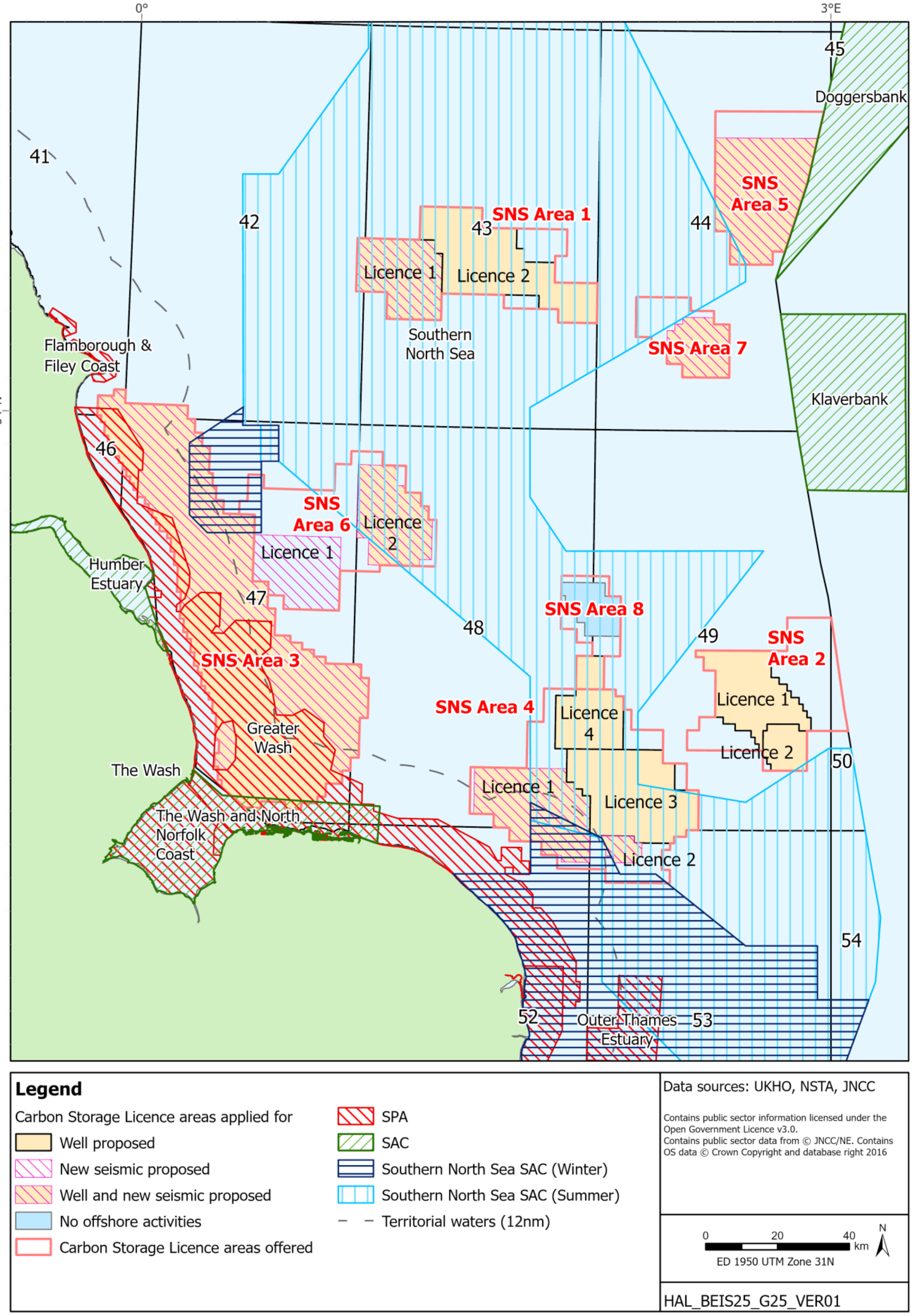
It is not typical for rig stabilisation to be required, but this will be informed by site-specific survey and project specific plans which are not currently available. Where rig stabilisation is required, the Department will expect operators to provide adequate justification for the stabilisation option proposed (including for rig siting beyond site boundaries, if practical) and consider use of systems (e.g. anti-scour mats, mud mats) that can be removed following drilling. Where rock placement is required for rig stabilisation, the Department will expect operators to minimise the volume of rock deposited. Should rig stabilisation be required for drilling within the Dogger Bank SAC, the Wash and North Norfolk Coast SAC, the North Norfolk Sandbanks and Saturn Reef SAC, Inner Dowsing, Race Bank and North Ridge SAC, and Haisborough, Hammond and Winterton SAC, removeable methods that avoid permanent habitat change must be used, subject to these meeting the technical and safety requirements of rig placement at a particular location. This would be identified at the project level, at which time, further assessment including HRA would be required.

The red-throated diver and common scoter features of the Greater Wash SPA are highly sensitive to vessel traffic, but are only present seasonally (winter). Operators should seek to avoid activities within the site during the wintering period (1st November to 31st March inclusive). If this is not possible and a rig needs to be located within the site, the rig and related vessels should seek to avoid high areas of diver and scoter use. Where possible, vessels should use establishing routes, where diver and scoter densities are generally lower. Further assessment, including HRA, may be required at the project level.

5.2.4 Conclusions of SNS regional assessment

Likely significant effects identified with regards to physical damage to the seabed, drilling discharges and other effects (see Section 5.2.2) when considered along with project-level mitigation (Section 5.2.3) and relevant activity permitting requirements (see Section 2.3.1), will not have an adverse effect on the integrity of the sites considered in this assessment. This conclusion relies on the implementation of plan level mitigation to avoid permanent habitat change to selected sites. Specifically, that should rig stabilisation be required for any well drilled in the Dogger Bank SAC, the Wash and North Norfolk Coast SAC, the North Norfolk Sandbanks and Saturn Reef SAC, Inner Dowsing, Race Bank and North Ridge SAC, and Haisborough, Hammond and Winterton SAC, removeable methods must be used, subject to these meeting the technical and safety requirements of rig placement at a particular location – this would be identified once project plans are known. Additionally, mitigation is proposed for the Greater Wash SPA in relation to red-throated diver and common scoter. At the project level, there is a legal framework through the implementation of the EIA Regulations and the Habitats Regulations, to ensure that there are no adverse effects on the integrity of SACs and SPAs. Their application at the project level allows for an assessment to be made of likely significant effects on the basis of detailed project-specific information and allows for applicants to propose project specific mitigation measures.

Figure 5.3: Sites and areas offered in the southern North Sea to be subject to further assessment for underwater noise effects



5.2.5 Assessment of underwater noise effects

The site conservation objectives and other relevant information relating to site selection and advice on operations has been considered against indicative work programmes (see Section 2.2.1) to determine whether they could adversely affect site integrity. New seismic surveys have been proposed in the work programmes relating to licence applications for parts of SNS Area 1, SNS Area 4, SNS Area 6, and all of SNS Area 3, SNS Area 5 and SNS Area 7 (Figure 5.3). No offshore activities are proposed for SNS Area 8. Sites relevant to this part of the assessment are shown in Figure 5.3 and the results are given in Table 5.3 below. All mandatory control requirements (as given in Section 2.3.2) are assumed to be in place as a standard for all activities assessed at this stage.

Table 5.3: Consideration of potential underwater noise effects and relevant site conservation objectives

Southern North Sea SAC
Site Information
Area (ha/km²): 3,695,054/36,951 **Relevant qualifying features:** Harbour porpoise **Conservation objectives:** See Table 5.2 above.
Relevant licence areas with potential for underwater noise effects
SNS 1, SNS 3, SNS 4, SNS 5, SNS 6, SNS 7,
Assessment of effects on site integrity
Impulsive noise (2D/3D seismic survey, rig site survey, VSP, conductor piling) *(**Relevant pressures:** underwater noise change, vibration)* Individuals within approximately 12km of the airgun arrays may be affected, through temporary local displacement and reduced foraging opportunities. While a 3D survey may take up to several weeks to complete, in many cases it would be of shorter duration, and airgun activity would not be continuous throughout this period. Further, as the survey vessel travels along transects, ensonification is variable across the area surveyed. The habitat is open in nature, and harbour porpoises are known to be able to travel over large distances (>20km) within a day. While habitat quality is not uniform across the southern North Sea, considering that preliminary investigations suggest that sufficient prey are widely available both within and outside the site boundary (Ransijn *et al*. 2019) and the wide distribution of relatively high densities of harbour porpoise across this region, the spatial and temporal scale of potential displacement resulting from relevant activities is not expected to result in individuals losing access to suitable habitat. Considering: the maximum likely duration of the activity (Table 2.2); that the survey activity is likely to be spatially and/or temporally disparate across the relevant areas applied for and unlikely to result in long-term and large-scale displacement of porpoises from the area (Sarnocińska *et al.* 2020); that further mitigation measures are available (Section 5.2.6), and will be required, where appropriate, it is concluded that a 3D seismic survey will not result in an adverse effect on site integrity. In the case of rig site survey and VSP noise, given the lower amplitude source, the effects radius can reasonably be expected to be smaller (in the order of 5-10km) than that of 3D seismic survey and be of smaller spatial footprint and shorter duration (days). Consequently, it is concluded that rig site survey and VSP will not result in an adverse effect on site integrity. The impulsive underwater noise produced should conductors need to be piled into the seabed is of significantly lower magnitude than that generated in the piling of offshore wind turbine monopile foundations (see Table 2.2). Considering the noise source characteristics, the short duration of the activity, and the uncommon use of this technique to meet technical requirements; when combined with mandatory control measures (Section 2.3.2), disturbance to harbour porpoise within the site will be highly localised, short-term, and will not result in an adverse effect on site integrity. With regard to SNCB guidance on spatio-temporal thresholds for noise disturbance within the SAC[85], should a seismic survey take place wholly within the boundaries of the summer portion of the SAC (such surveys typically

85 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/889842/SACNoiseGuidanceJune2020.pdf

occur between Apr-Sep, see Figure 5.3 which shows the summer and winter areas), an approximate conservative estimate of the proportion of the relevant area from which harbour porpoise may be disturbed is 9.4%[86]. This is less than half the 20% daily threshold for what could be considered significant disturbance. With regard to season disturbance thresholds, recent HRAs for two different planned seismic surveys with partial overlap with the Southern North Sea SAC (BEIS 2021a, 2021b) estimate a worst-base of 1.3-5.4% average seasonal (summer) disturbance[87], which is below the 10% seasonal threshold; note also that both of these surveys were larger than any proposed as part of the licence applications which are relevant to the Southern North Sea SAC. The proportion of the site potentially disturbed by site survey, VSP and potential conductor piling will be considerably less, with these activities either being static or covering a very limited spatial footprint.

Negative indirect effects of impulsive noise on harbour porpoise may potentially arise through effects on prey species, primarily small fish, if those prey are subject to injury or disturbance which reduce their availability to harbour porpoise. While there is some evidence that a reduction in catches of some fish species can be associated with seismic survey activity, these are temporary in nature. Any such effects associated with VSP, rig site survey or conductor piling are expected to be minor, considering their shorter duration, smaller spatial extent and lower amplitude source relative to 2D and 3D seismic surveys (to which most reported effects relate). Additionally, the disturbance of sensitive spawning periods for potential fish prey species will be considered through the activity consenting process. Consequently, any underwater noise effects on fish associated with the licensing of relevant areas applied for are not anticipated to result in significant effects on the food resources of the harbour porpoise.

Continuous noise (drilling, vessel & rig movements)
*(**Relevant pressures:** underwater noise change, vibration)*

Harbour porpoise are considered sensitive to underwater noise from shipping which could make preferred habitats less attractive as a result of disturbance (habitat displacement, area avoidance). There are currently a number of large ports on the east coast which result in large vessel shipping routes throughout the site. Given existing levels of shipping activity over the site and elevated porpoise densities, the temporary nature of drilling activities and limited number of associated supply vessels will not represent a significant increase in the level of disturbance that could lead to the exclusion of harbour porpoise from a significant portion of the site for a significant period of time. Further mitigation measures are also available (Section 5.2.6) and will be required, where appropriate, to ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

In-combination effects
Eight of the licence areas applied for in the southern North Sea covering all or part of six of the areas offered in the round, overlap with the SAC or are within 15km of the site, and have work programmes which propose 3D seismic survey. Considering the following: the current understanding of the site and its feature being in favourable condition; the level of current and past seismic survey, drilling and vessel activity within the site; that further mitigation measures are available (Section 5.2.6) and will be required, where appropriate, including potential controls on activity timing; and, that evidence suggests that seismic surveys are unlikely to result in long-term and large-scale displacement of porpoises from the area (Sarnocińska *et al.* 2020), adverse effects on site integrity are not expected.

Humber Estuary SAC
Site Information
Area (ha/km^2): 36,657/367 **Relevant qualifying features:** grey seal, sea lamprey **Conservation objectives:** See Table 5.2 above.
Relevant licence areas with potential for underwater noise effects
SNS 3, SNS 6
Assessment of effects on site integrity
Impulsive noise (2D/3D seismic survey, rig site survey, VSP, conductor piling) *(**Relevant pressures:** underwater noise change, vibration)*

[86] Assuming a typical vessel speed of 4.5kts (8.3km/h), a survey line length of 100km and a 3hr line change, resulting in a total of 174km of lines surveyed within a 24hr period. Combined with a 12km EDR, this provides a total daily area of disturbance of 2,540km^2, which is 9.4% of the summer SAC area.
[87] Based on worst-case scenarios of 21-153 days of disturbance during the survey.

Seismic surveys are proposed for SNS Area 3 and SNS Area 6. The latter area is greater than 15km from the stie boundary of the Humber Estuary SAC, but is considered relevant to this assessment as it overlaps an area of higher relative density of grey seals extending from the Humber Estuary (see BEIS 2022b).

Considering the distance SNS Area 3 and SNS Area 6 from the site (6.5km and 27.5km respectively) and location of the breeding colony at Donna Nook, there would be limited propagation of noise from activities such as rig site surveys and VSP into the site and areas of greatest importance for seals, although emitted sound fields would overlap an area of assumed foraging habitat occurring at distance from the site; there is, however, the potential for sound generated by high amplitude, low frequency seismic survey to travel further. For VSP and rig site survey, a conservative estimate of the likely effects on qualifying features is considered to be short-term and temporary displacement of grey seals within 5-10km of the activities. Such effects would be likely to last for the duration of the activity (several hours), with evidence suggesting a return to baseline animal distribution and activity within a matter of hours of the noise-generating activity ceasing, even in the case of louder noise sources such as high energy impact piling of wind turbine foundations (e.g. Russell *et al*. 2016). As such, no adverse effects on the integrity of the site are expected. For 3D seismic survey, while these have the potential to generate sound that exceeds thresholds of injury, this is only within a limited range from source (tens to hundreds of metres). Any survey would be required to follow the JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys (see Section 2.3.2), and would be subject to assessment, including HRA where appropriate, once project plans are known. The temporary and transient nature of any seismic survey, and the application of mandatory control measures, are such that adverse effects on the integrity of the site from 3D seismic survey are not predicted.

Negative indirect effects of impulsive noise on grey seal may arise through effects on prey species, primarily small fish such as sandeels, if those prey are subject to injury or disturbance which reduce their availability to the qualifying feature. While there is some evidence that a reduction in catches of some fish species can be associated with seismic survey activity, these are temporary in nature. Furthermore, evidence suggest that sandeels (a key prey species of grey seals in the southern North Sea) have a low sensitivity to low frequency noise. Any such effects associated with VSP or rig site survey are expected to be minor, considering their shorter duration, smaller spatial extent and lower amplitude source relative to the 2D and 3D seismic surveys (to which most reported effects relate). Additionally, the disturbance of sensitive spawning periods for potential fish prey species will be considered through the activity consenting process. Consequently, any underwater noise effects on fish associated with the licensing of relevant areas applied for are not anticipated to result in significant effects on the food resources of the grey seal qualifying features.

Sea lamprey use marine habitats for feeding prior to returning to freshwater to spawn; however, their distribution in marine habitats is largely restricted to estuaries and nearshore coastal waters (Silva *et al.* 2014), with designated UK sites considered to provide an important migration route (to spawning rivers) and/or feeding grounds. Given the limited evidence of physical injury to fish from exposure to high amplitude low-frequency seismic survey noise (Section 4.3, also see BEIS 2022a, b), the conservation objectives of the site are not expected to be undermined in relation to sea lamprey. The location and timing of any seismic survey is presently unknown, but would be subject to assessment (Section 5.2.6) including, where appropriate, HRA prior to consent being granted.

The impulsive underwater noise produced should conductors need to be piled into the seabed is of significantly lower magnitude than that generated in the piling of offshore wind turbine monopile foundations (see Table 2.2). Considering the noise source characteristics, the short duration of the activity, and the uncommon use of this technique to meet technical requirements; when combined with mandatory control measures (Section 2.3.2), disturbance to the grey seal qualifying features beyond the site boundaries will be highly localised, short-term, and will not result in an adverse effect on site integrity.

Continuous noise (drilling, vessel & rig movements)
*(**Relevant pressures:** underwater noise change, vibration)*

Grey seals are considered sensitive to underwater noise from shipping which could make preferred habitats less attractive as a result of disturbance (habitat displacement, area avoidance). Given existing levels of shipping activity over the relevant areas applied for (see Section 6.2), the temporary nature of drilling activities and limited number of associated supply vessels will not represent a significant increase in the level of disturbance that could lead to the exclusion of grey seal from potential important areas outside of the site for a significant period of time. Further mitigation measures are also available (Section 5.2.6) and will be required, where appropriate, to ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

In-combination effects
Intra-plan in-combination underwater noise effects are considered highly unlikely given the low potential for effects identified above and the likely temporal and spatial separation of any individual licence activities which could take place. Section 6.2 provides a consideration of potential licence activities in-combination with other relevant plans and projects.

The Wash and North Norfolk Coast SAC

Site Information

Area (ha/km^2): 10,761/1,078
Relevant qualifying features: harbour seal

Conservation objectives: See Table 5.2 above.

Relevant licence areas with potential for underwater noise effects

SNS 3

Assessment of effects on site integrity

Impulsive noise (2D/3D seismic survey, rig site survey, VSP, conductor piling)
*(**Relevant pressures:** underwater noise change, vibration)*

SNS Area 3 has a small area of overlap with the Wash and North Norfolk Coast SPA, with the majority of the area is located outside of the site, within which drilling related activities including rig site surveys and VSP could take place, limiting the propagation of noise from such activities into the site. 3D seismic survey is also proposed for the area, which could result in the propagation of seismic noise into the site. Additionally, at-sea distribution modelling suggests that the majority of harbour seals of relevance to The Wash use a wider area of SNS Area 3, with highest densities being located from the south of the Humber to the North Norfolk Coast (Carter *et al.* 2020), which may also be affected by seismic survey and drilling related geophysical survey. For VSP and rig site survey, a conservative estimate of the likely effects on qualifying features is considered to be short-term and temporary displacement of harbour seals within 5-10km of the activities. Such effects would be likely to last for the duration of the activity (several hours), with evidence suggesting a return to baseline animal distribution and activity within a matter of hours of the noise-generating activity ceasing, even in the case of louder noise sources such as high energy impact piling of wind turbine foundations (e.g. Russell *et al*. 2016). As such, no adverse effects on the integrity of the site are expected. For 3D seismic survey, while these have the potential to generate sound that exceeds thresholds of injury, this is only within a limited range from source (tens to hundreds of metres). Any survey would be required to follow the JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys (see Section 2.3.2), and would be subject to assessment, including HRA where appropriate, once project plans are known. The temporary and transient nature of any seismic survey, and the application of mandatory control measures, are such that adverse effects on the integrity of the site from 3D seismic survey are not predicted.

Negative indirect effects of impulsive noise on harbour seal may arise through effects on prey species, primarily small fish such as sandeels, if those prey are subject to injury or disturbance which reduce their availability to the qualifying feature. While there is some evidence that a reduction in catches of some fish species can be associated with seismic survey activity, these are temporary in nature. Furthermore, evidence suggest that sandeels (a key prey species of harbour seals in the southern North Sea) have a low sensitivity to low frequency noise. Any such effects associated with VSP or rig site survey are expected to be minor, considering their shorter duration, smaller spatial extent, and lower amplitude source relative to the 2D and 3D seismic surveys (to which most reported effects relate). Additionally, the disturbance of sensitive spawning periods for potential fish prey species will be considered through the activity consenting process. Consequently, any underwater noise effects on fish associated with the licensing of SNS Area 3 are not anticipated to result in significant effects on the food resources of the harbour seal qualifying features.

The impulsive underwater noise produced should conductors need to be piled into the seabed is of significantly lower magnitude than that generated in the piling of offshore wind turbine monopile foundations (see Table 2.2). Considering the noise source characteristics, the short duration of the activity, and the uncommon use of this technique to meet technical requirements; when combined with mandatory control measures (Section 2.3.2), disturbance to the harbour seal qualifying features beyond the site boundaries will be highly localised, short-term, and will not result in an adverse effect on site integrity.

Continuous noise (drilling, vessel & rig movements)
*(**Relevant pressures:** underwater noise change, vibration)*

Harbour seals are considered sensitive to underwater noise from shipping which could make preferred habitats less attractive as a result of disturbance (habitat displacement, area avoidance). Given existing levels of shipping activity over SNS Area 3 (see Section 6.2), the temporary nature of drilling activities and limited number of associated supply vessels will not represent a significant increase in the level of disturbance that could lead to the exclusion of harbour seal from potential important areas outside of the site for a significant period of time. Further mitigation measures are also available (Section 5.2.6) and will be required, where appropriate, to ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

In-combination effects
Intra-plan in-combination underwater noise effects are considered highly unlikely given the low potential for effects identified above and the likely temporal and spatial separation of any individual licence activities which could take place. Section 6.2 provides a consideration of potential licence activities in-combination with other relevant plans and projects.

Doggersbank SAC (Netherlands)

Site Information

Area (ha/km^2): 473,500/4,735
Relevant qualifying features: grey seal, harbour seal, harbour porpoise.

Conservation objectives: See Table 5.2 above.

Relevant licence areas with potential for underwater noise effects

SNS 5

Assessment of effects on site integrity

Impulsive noise (2D/3D seismic survey, rig site survey, VSP, conductor piling)
*(**Relevant pressures:** underwater noise change, vibration)*

New 3D seismic survey has been proposed in the work programme for SNS Area 5, which is immediately adjacent to Doggersbank SAC.

Porpoise and seals within approximately 12km of the airgun arrays may be affected, through temporary local displacement and reduced foraging opportunities. While a 3D survey may take up to several weeks to complete, in many cases it would be of shorter duration, airgun activity would not be continuous throughout this period, and there would be no direct overlap with the site. Further, as the survey vessel travels along transects, ensonification is variable across the area surveyed. The habitat is open in nature, and harbour porpoises are known to be able to travel over large distances (>20km) within a day, and it is likely that there would be sufficient access to suitable habitat, and any effect on the extent and quality of the habitat would be short-term and would not affect the population. There would be very limited propagation of noise from activities such as rig site surveys and VSP into the site. Given the lower amplitude source, the effects radius can reasonably be expected to be smaller (in the order of 5-10km) than that of 3D seismic survey and be of smaller spatial footprint and shorter duration (days). For these activities, a conservative estimate of the likely effects on qualifying features is considered to be short-term and temporary displacement of harbour porpoise and, to a lesser extent, seals (see Section 5.2.1), from the periphery of the site. Such effects are likely to last for the duration of the activity (up to several days), with evidence suggesting a return to baseline animal distribution and activity within a matter of hours of the noise-generating activity ceasing, even in the case of louder noise sources than site survey or VSP. Consequently, and considering that further mitigation measures are available, no adverse effects on the integrity of the site are expected.

Negative indirect effects of seismic and rig site survey, and VSP, on the qualifying features may potentially arise through effects on prey species, primarily small fish, if those prey are subject to injury or disturbance which reduce their availability to seals and harbour porpoise. While there is some evidence that a reduction in catches of some fish species can be associated with seismic survey activity, these are temporary in nature. Furthermore, evidence suggests that sandeels (a key prey species of marine mammals in the Dogger Bank area) have a low sensitivity to low frequency noise. Any such effects associated with VSP or rig site survey are expected to be minor, considering their shorter duration, smaller spatial extent, and lower amplitude source relative to the 2D and 3D seismic surveys (to which most reported effects relate). Additionally, the disturbance of sensitive spawning periods for potential fish prey species will be considered through the activity consenting process. Consequently, any underwater noise effects on fish associated with the licensing of SNS Area 5 are not anticipated to result in significant effects on the food resources of the qualifying features.

The impulsive underwater noise produced should conductors need to be piled into the seabed is of significantly lower magnitude than that generated in the piling of offshore wind turbine monopile foundations (see Table 2.2). Considering the noise source characteristics, the short duration of the activity, and the uncommon use of this technique to meet technical requirements; when combined with mandatory control measures (Section 2.3.2), disturbance to harbour porpoise and seals within the site will be highly localised, short-term, and will not result in an adverse effect on site integrity.

Continuous noise (drilling, vessel & rig movements)
*(**Relevant pressures:** underwater noise change, vibration)*

Harbour porpoise and seals are considered sensitive to underwater noise from shipping which could make preferred habitats less attractive as a result of disturbance (habitat displacement, area avoidance). SNS Area 5 does not overlap the site, which along with the likelihood that survey and support vessels associated with the work programme will travel from UK ports, the temporary nature of survey and drilling activities, and the limited number of associated supply vessel trips (Table 2.2), the activities will not represent a significant increase in the level of disturbance that could lead to the exclusion of harbour porpoise from a significant portion of the site for a significant period of time. Further mitigation measures are also available (Section 5.2.6) and will be required, where appropriate, to ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

In-combination effects
Intra-plan in-combination underwater noise effects are considered highly unlikely given the low potential for effects identified above and the likely temporal and spatial separation of any individual licence activities which could take place, noting that SNS Area 5 is the only area applied for of relevance to the underwater noise assessment for this site. Section 6.2 provides a consideration of potential licence activities in-combination with other relevant plans and projects.

Klaverbank SAC (Netherlands)

Site Information

Area (ha/km^2): 153,900/1,539
Relevant qualifying features: grey seal, harbour seal, harbour porpoise.

Conservation objectives: See Table 5.2 above.

Relevant licence areas with potential for underwater noise effects

SNS 5, SNS 7

Assessment of effects on site integrity

Impulsive noise (2D/3D seismic survey, rig site survey, VSP, conductor piling)
*(**Relevant pressures:** underwater noise change, vibration)*

New 3D seismic survey has been proposed in the work programme for SNS Area 5 and SNS Area 7, which are 13km and 14.5km away from Klaverbank SAC respectively.

Porpoise and seals within approximately 12km of the airgun arrays may be affected, through temporary local displacement and reduced foraging opportunities. While a 3D survey may take up to several weeks to complete, in many cases it would be of shorter duration, airgun activity would not be continuous throughout this period, and there would be no direct overlap with the site. Further, as the survey vessel travels along transects, ensonification is variable across the area surveyed. The habitat is open in nature, and harbour porpoises are known to be able to travel over large distances (>20km) within a day, and it is likely that there would be sufficient access to suitable habitat, and any effect on the extent and quality of the habitat would be short-term and would not affect the population. There would be very limited propagation of noise from activities such as rig site surveys and VSP into the site. Given the lower amplitude source, the effects radius can reasonably be expected to be smaller (in the order of 5-10km) than that of 3D seismic survey and be of smaller spatial footprint and shorter duration (days). As the areas applied for are at least 13km from the site boundaries, the potential for adverse effects are discounted for these activities.

Negative indirect effects of seismic survey activities on the qualifying features may potentially arise through effects on prey species, primarily small fish, if those prey are subject to injury or disturbance which reduce their availability to seals and harbour porpoise. While there is some evidence that a reduction in catches of some fish species can be associated with seismic survey activity, these are temporary in nature. Any such effects associated with VSP or rig site survey are expected to be minor, considering their shorter duration, smaller spatial extent and lower amplitude source relative to the 2D and 3D seismic surveys (to which most reported effects relate). Additionally, the disturbance of sensitive spawning periods for potential fish prey species will be considered through the activity consenting process. Consequently, any underwater noise effects on fish associated with the licensing of SNS Area 5 are not anticipated to result in significant effects on the food resources of the qualifying features.

The impulsive underwater noise produced should conductors need to be piled into the seabed is of significantly lower magnitude than that generated in the piling of offshore wind turbine monopile foundations (see Table 2.2). Considering the noise source characteristics, the short duration of the activity, and the uncommon use of this technique to meet technical requirements; when combined with mandatory control measures (Section 2.3.2), and the distance from the site from SNS Area 5, disturbance to harbour porpoise and seals within the site is not expected, and will not result in an adverse effect on site integrity.

Continuous noise (drilling, vessel & rig movements)
*(**Relevant pressures:** underwater noise change, vibration)*

Harbour porpoise are considered sensitive to underwater noise from shipping which could make preferred habitats less attractive as a result of disturbance (habitat displacement, area avoidance). Given the offshore nature of the site and the distance of the areas applied for from the site boundary (13km), the temporary nature of drilling activities and limited number of associated supply vessels will not represent a significant increase in the level of disturbance that could lead to the exclusion of harbour porpoise or seals from a significant portion of the site for a significant period of time, and will not result in an adverse effect on site integrity.

In-combination effects
Intra-plan in-combination underwater noise effects are considered highly unlikely given the low potential for effects identified above and the likely temporal and spatial separation of any individual licence activities which could take place in the areas applied for. Section 6.2 provides a consideration of potential Block activities in-combination with other relevant plans and projects.

Flamborough & Filey Coast SPA

Site Information

Area (ha/km^2): 8,040/80
Relevant qualifying features: breeding: gannet, guillemot, razorbill

Conservation objectives: See Table 5.2 above.

Relevant licence areas with potential for underwater noise effects

SNS 3

Assessment of effects on site integrity

Impulsive noise (2D/3D seismic survey, rig site survey, VSP, conductor piling)
*(**Relevant pressures:** underwater noise change, vibration)*

The advice on operations for the site[88] notes that those features listed above are sensitive to underwater noise changes. As detailed in Section 4.3.2, there is very little evidence of impacts of underwater noise on diving birds. Mortality of seabirds has not been observed during extensive seismic operations in the North Sea and elsewhere, and flushing disturbance associated with the physical presence of survey vessels and rigs would be expected to displace most diving seabirds from close proximity to noise sources. Such avoidance behaviour is also expected to reduce the potential for diving birds to be exposed to noise levels which may result in potential behavioural disturbance, although it is noted that very little evidence for such effects exist and, should they occur, they would be expected to be short-term, temporary and of limited spatial extent.

Like birds, there is limited evidence of physical injury to fish from exposure to high amplitude low-frequency seismic survey noise (see Section 4.3.2), however, negative indirect effects of seismic survey activities on qualifying features may arise through effects on prey species, primarily sandeels and other small fish, if these prey are subject to injury or disturbance which reduce their availability to qualifying seabirds. While there is evidence that a reduction in fish catches can be associated with seismic survey activity, these are temporary in nature. The disturbance of sensitive spawning periods for potential fish prey species will also be considered through the activity consenting process. Consequently, any underwater noise effects on fish associated with the

[88] https://designatedsites.naturalengland.org.uk/Marine/FAPMatrix.aspx?SiteCode=UK9006101

licensing of SNS Area 3 are not anticipated to result in significant effects on the food resources of the qualifying diving bird features.

Considering the limited potential for effects of 2D/3D seismic survey on diving birds identified above and in Section 4.3.2, and the lower amplitude, shorter duration and smaller geographic footprint associated with other impulsive noise such as VSP, rig site survey and conductor piling, it is concluded that these activities, in SNS Area 3, will not result in an adverse effect on the integrity of the site.

Continuous noise (drilling, vessel & rig movements)
*(**Relevant pressures:** underwater noise change, vibration)*
No significant effects on gannet, guillemot or puffin are anticipated from continuous underwater noise from drilling and vessel movements, due to the lower amplitude and non-impulsive nature of the sound resulting in no potential for acute trauma and no evidence of significant disturbance.

In-combination effects
Intra-plan in-combination underwater noise effects are considered highly unlikely given the low potential for effects identified above and the likely temporal and spatial separation of any individual licence activities which could take place. Section 6.2 provides a consideration of potential licence activities in-combination with other relevant plans and projects.

Greater Wash SPA

Site Information

Area (ha/km^2): 353,578/3,536
Relevant qualifying features: non-breeding: red-throated diver, common scoter

Conservation objectives: See Table 5.2 above.

Relevant licence areas with potential for underwater noise effects

SNS 3, SNS 4

Assessment of effects on site integrity

Impulsive noise (2D/3D seismic survey, rig site survey, VSP, conductor piling)
*(**Relevant pressures:** underwater noise change, vibration)*

Red-throated diver are widespread throughout the site, though with highest concentrations along the Holderness coast, the outer Wash along the south Lincolnshire coast and North Norfolk Coast, and to the east, along the Norfolk Coast and into the adjoining Outer Thames Estuary SPA (Lawson *et al.* 2015c). SNS Area 3 overlaps a substantial portion of the area of higher density to the north and east of The Wash, and SNS Area 4 (Licence 1) is located relatively close (~2km) to a small area of higher use in the east of the site. All other licences applied for in SNS Area 4 are substantially further away (at least 18km). Visual disturbance of the red-throated diver and common scoter features of the site have already been discussed in Section 5.2.2. Should a survey be undertaken which overlaps with Greater Wash SPA and the higher areas of use for red-throated diver and common scoter, exclusively in the winter months when the features are present, the risk of injury or significant disturbance from survey activities is considered to be low due to i) the evidence (albeit limited) of low hearing sensitivity and a lack of reported injury or disturbance effects; and ii) likely avoidance of the physical presence of survey vessel(s) and airguns.

Negative indirect effects of seismic survey activities on qualifying features may arise through effects on prey species, primarily small fish such as gadoids, sprat, herring and sandeel, if these prey are subject to injury or disturbance which reduce their availability to qualifying seabirds. While there is some evidence that a reduction in fish catches or abundance can be associated with seismic survey activity, these are temporary in nature, and the sensitivity of the relevant prey species to underwater noise is considered to be generally low. The disturbance of sensitive spawning periods will be considered through the activity consenting process. As such, any underwater noise effects on fish associated with licensing SNS Area 3 or SNS Area 4 are not anticipated to result in significant effects on the food resources of the qualifying seabird features.

Considering the limited potential for effects of 2D/3D seismic survey on diving birds identified above and in Section 4.3.2, and the lower amplitude, shorter duration and smaller geographic footprint associated with other impulsive noise such as VSP, rig site survey and conductor piling, it is concluded that these activities, whether undertaken in SNS Area 3 or SNS Area 4, will not result in an adverse effect on the integrity of the site, or those adjoining sites with red-throated diver and scoter features, namely, the Outer Thames Estuary SPA and The Wash SPA.

Continuous noise (drilling, vessel & rig movements)
*(**Relevant pressures:** underwater noise change, vibration)*
No significant effects on red-throated diver and common scoter are anticipated from continuous underwater noise from drilling and vessel movements, due to the lower amplitude and non-impulsive nature of the sound resulting in no potential for acute trauma and no evidence of significant disturbance.

In-combination effects
Intra-plan in-combination underwater noise effects are considered highly unlikely given the low potential for effects identified above and the likely temporal and spatial separation of any individual licence activities which could take place. Section 6.2 provides a consideration of potential licence activities in-combination with other relevant plans and projects.

5.2.6 Further underwater noise mitigation measures

The Department require operators to provide sufficient information in the EIA, which includes a noise assessment, on the potential impact of proposed activities on relevant sites and their qualifying features as well as proposed further mitigation measures in their applications for a relevant consent. Due to the temporary nature of the activities, mitigation measures could include activity timing to avoid the most sensitive periods. Operators must demonstrate how seasonal sensitivities have been taken into account when planning operations (see BEIS 2021c). The information provided by operators must be detailed enough for the Department to make a decision on whether the activities could lead to a likely significant effect, and whether the activities should require HRA. Depending on the nature and scale of the proposed activities (e.g. area of survey, source size, timing and proposed mitigation measures) and whether likely effects are identified for these, the Department may undertake further HRA to assess the potential for adverse effects on the integrity of sites at the activity specific level. A standard consent condition requires operators to follow the JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys.

Consent for project-level activities will not be granted unless the operator can demonstrate that the proposed activities, which may include seismic survey, small-scale geophysical rig site survey, VSP and drilling (which may incorporate conductor piling), will not have an adverse effect on the integrity of relevant sites.

The planning of seismic surveys should endeavour to minimise exposure of noise-sensitive qualifying features, including harbour porpoises, to underwater noise by careful consideration of the timing with respect to: 1) seasonal differences in the distribution of relevant species across their ranges in relation to relevant sites, and 2) the presence of other underwater noise-generating activities (i.e. other geophysical surveys and impact piling). It is advised that the licensees of the areas of relevance for underwater noise effects (listed in Table 5.2) establish early discussions with the Department and also the leaseholders of OWF areas, to understand the nature and timing of proposed activities such that significant in-combination effects can be avoided (see Section 6.2). Early consultation with the relevant SNCBs is also recommended.

For those areas applied for where proposed activities could result in the physical disturbance of marine mammals by the presence and movement of vessels, available mitigation measures include strict use of existing shipping routes, and timing controls on temporary activities to avoid sensitive periods.

5.2.7 Conclusions of SNS regional assessment

Although underwater sound generated during project-level activities, specifically seismic surveys, has the potential to injure and disturb individual harbour porpoises, seals, fish (including qualifying features and prey) and diving birds, the actual risk is minimised by the controls currently in place.

For any of the relevant sites, it is concluded that the likely level of activity expected to take place within the relevant areas applied for listed in Table 5.2 will not cause an adverse effect on site integrity, taking account of the following:

- Should a 3D seismic survey be proposed in any of the areas applied for, further HRA may be required to assess the potential for adverse effects on the integrity of the site once the area of survey, source size, timing and proposed mitigation measures are known and can form the basis for a definitive assessment;

- Individual activities (e.g. drilling, seismic) require individual consents which will not be granted unless the operator can demonstrate that the proposed activities, which may include 3D seismic surveys, will not adversely affect the site integrity of relevant sites. These activities will be subject to activity level EIA and, where appropriate, HRA.

5.3 Eastern Irish Sea

5.3.1 Relevant sites

Liverpool Bay SPA was the only site directly screened in for assessment (BEIS 2022b). Those other sites listed below were screened in on the basis of their connection with that site by containing source colonies for features screened in for further assessment.

Liverpool Bay SPA

The Liverpool Bay SPA borders northern England and north Wales, and runs as a broad arc from Morecambe Bay to the east coast of Anglesey. The seabed and waters of the site provide an important habitat in the non-breeding season for major concentrations of red-throated divers and sea ducks, notably common scoter, which visit the area to feed on fish, molluscs, and crustaceans. Annual aerial surveys over winter from 2004-2011 revealed the distribution and abundance of red-throated diver, common scoter and other bird species within the site and adjacent waters (Lawson *et al*. 2015a). Red-throated diver were widely distributed throughout the site, with highest densities off the north Wales coast, the Wirral, Formby and the mouth of the Ribble Estuary; areas of higher density were also recorded off the Duddon Estuary and south of outer Morecambe Bay. Common scoter were less widely distributed, with two areas of notably high density: off the north Wales coast from Rhos on Sea to the mouth of the Dee estuary, and off Blackpool from Fleetwood south to the Ribble Estuary. Peak winter abundance shows large fluctuations between years; mean peak winter abundance estimates across the five years of survey were 1,409 red-throated diver and 57,995 common scoter, in addition to 826 for cormorant and 160 for red-breasted merganser. The site was extended in the north and west in 2017 to include an area identified to support non-breeding little gulls. The highest densities of little gull were consistently located offshore of Blackpool and the Ribble Estuary, close to the 12 nautical mile line (Lawson *et al.* 2015a). The site also includes a marine foraging area for little terns breeding within The Dee Estuary SPA and the predicted foraging area for common terns breeding within Mersey Narrows & North Wirral Foreshore SPA. The seabed of the SPA consists of a wide range of mobile sediments. Large areas of muddy sand stretch from Rossall Point to the Ribble Estuary, and sand predominates in the remaining areas, with a concentrated area of gravelly sand off the Mersey Estuary[89]. Tidal currents throughout the Bay are generally weak and this combined with a relatively extended tidal range of 6 to 8m along the Lancashire coastline facilitates the deposition of sediments, encouraging mud and sand belts to accumulate[90].

Mersey Narrows and North Wirral Foreshore SPA and The Dee Estuary SPA

Contiguous with Liverpool Bay SPA are the Mersey Narrows and North Wirral Foreshore SPA and The Dee Estuary SPA, which are designated for a variety of species during different times of the year. The relevant features to this AA are breeding little tern (The Dee Estuary SPA) and breeding common tern (Mersey Narrows and north Wirral Foreshore SPA), as these two species forage within the Liverpool Bay SPA - therefore providing a potential pathway to effects. The mean reported maximum foraging ranges of breeding common tern is 18km (mean foraging range = 6.4km) and for little tern is 5km (mean = 3.5km), meaning that these two qualifying features of the two colony SPAs will likely forage within waters of the colony SPAs themselves and waters in the southern part of Liverpool Bay SPA.

[89] http://publications.naturalengland.org.uk/file/5301807986769920
[90] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/566835/liverpool-bay-bae-lerpwl-spa-departmental-brief.pdf

Ribble and Alt Estuaries SPA

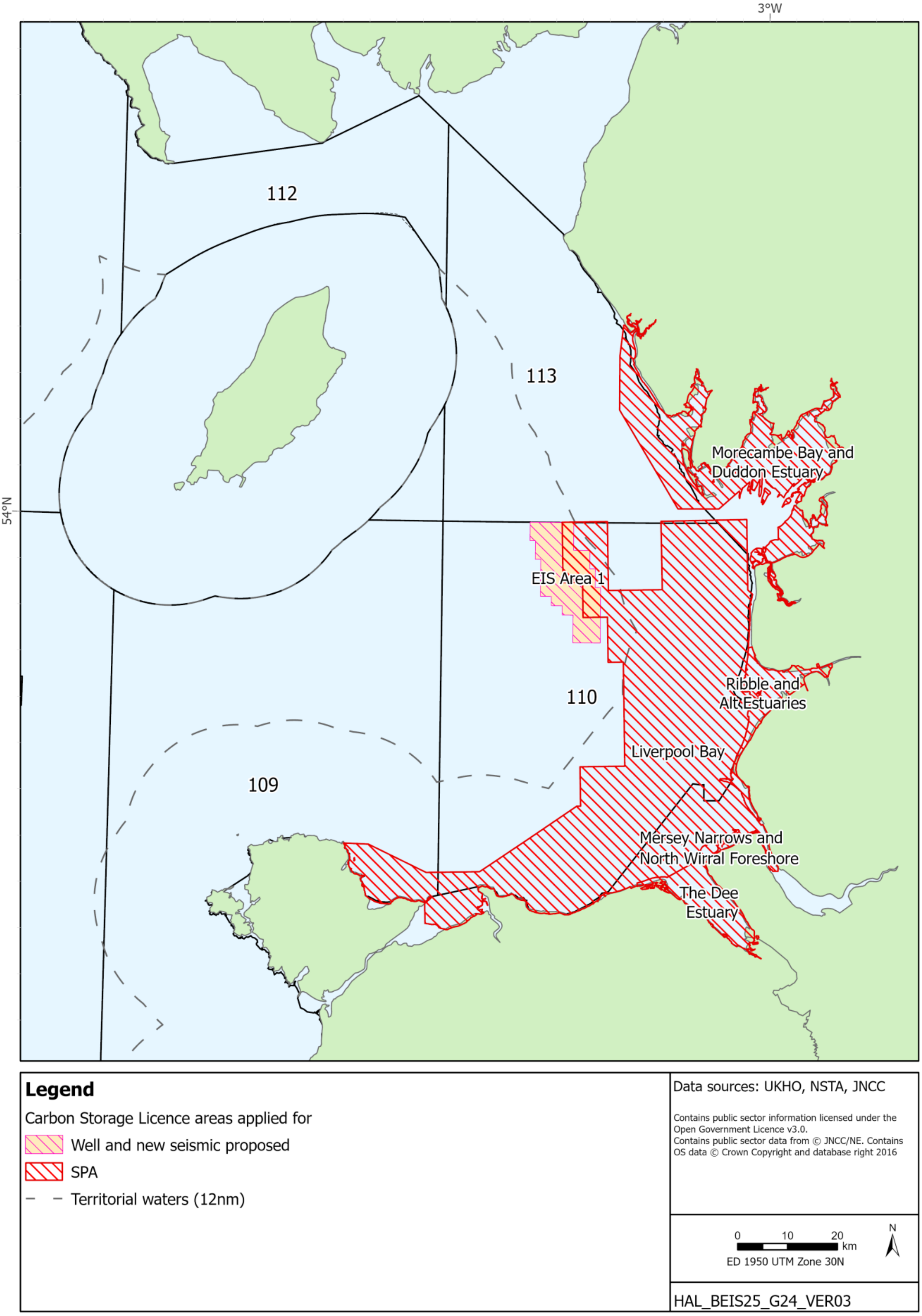
The Ribble and Alt Estuaries SPA comprises two estuaries, of which the Ribble Estuary is the larger, together with an extensive area of sandy foreshore along the Sefton Coast. The site consists of extensive sand- and mud-flats and, particularly in the Ribble Estuary, large areas of saltmarsh. There are also areas of coastal grazing marsh located behind the sea embankments. The highest densities of feeding birds are on the muddier substrates of the Ribble, though sandy shores throughout are also used. The saltmarshes and coastal grazing marshes support high densities of grazing and seed-eating wildfowl and these, together with the intertidal sand- and mud-flats, are used as high-tide roosts. Important populations of waterbirds occur in winter, including swans, geese, ducks and waders. The SPA is also of major importance during the spring and autumn migration periods, especially for wader populations moving along the west coast of Britain. The larger expanses of saltmarsh and areas of coastal grazing marsh support breeding birds during the summer, including large concentrations of gulls and terns. These seabirds feed both offshore and inland, outside the SPA. In total, 21 species of waterbirds and seabirds (gulls and terns) are seasonally present in qualifying numbers (≥1% of GB/biogeographic population); qualifying assemblages of seabirds (breeding) and waterbirds (over-winter) are present. Of importance for this assessment, is the sites' contiguous location with Liverpool Bay SPA, and its related colony of common terns.

Morecambe Bay and Duddon Estuary SPA

The boundary of the Morecambe Bay and Duddon Estuary SPA is formed by the recent amalgamation of two existing SPAs (Morecambe Bay SPA and Duddon Estuary SPA); and the addition of a marine foraging area for terns identified and defined by the modelled foraging area for sandwich terns breeding at Hodbarrow Lagoon. In total, 25 species of waterbirds and seabirds (gulls and terns) are present in qualifying numbers (≥1% of GB/biogeographic population); qualifying assemblages (in any season) of seabirds and waterbirds are present, with the latter including the diving species of eider, goldeneye, red-breasted merganser and cormorant[91]. While red-throated diver are not listed as qualifying features, aerial surveys indicate their presence within the site, particularly off the mouth of the Duddon Estuary. Morecambe Bay is a large, very shallow, predominantly sandy bay at the confluence of four principal estuaries, the Leven, Kent, Lune and Wyre. The Duddon Estuary is to the north of Morecambe Bay, although directly connected to it by Walney Channel. At low tide vast areas of intertidal sandflats are exposed, with small areas of mudflat, particularly in the upper reaches of the associated estuaries. The sediments of the bay are mobile and support a range of community types, from those typical of open coasts (mobile, well-sorted fine sands), grading through sheltered sandy sediments to low-salinity sands and muds in the upper reaches. Apart from the areas of intertidal flats and subtidal sandbanks, Morecambe Bay supports exceptionally large beds of mussels *Mytilus edulis* on exposed "scars" of boulder and cobble, and small areas of reefs with fucoid algal communities. Of particular note is the rich community of sponges and other associated fauna on tide-swept pebbles and cobbles at the southern end of Walney Channel[92]. Extensive intertidal eelgrass beds are present around Foulney Island and in the south Walney Channel. The Duddon and Ravenglass Estuaries support saltmarsh, intertidal mud and sand communities and sand dune systems with small areas of stony reef[93]. Of importance for this assessment, is the sites' contiguous location with Liverpool Bay SPA, and its related colonies of common and little terns.

[91] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/641980/morecambe-duddon-citation.pdf
[92] http://publications.naturalengland.org.uk/file/4531557855395840
[93] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/492891/morecambe-duddon-departmental-brief.pdf

Figure 5.4: Sites and areas to be subject to further assessment for physical disturbance and drilling effects in the eastern Irish Sea



5.3.2 Assessment of physical disturbance and drilling effects

The conservation objectives of relevant sites and information relating to site selection and advice on operations have been considered against the work programme for the area applied for (EIS Area 1) to determine whether it could adversely affect site integrity. The results are given in Table 5.4 below. All mandatory control requirements (as given in Section 2.3.1), are assumed to be in place as a standard for all activities assessed. The applicant for EIS Area 1 has noted that injectivity testing could be undertaken using an existing Morecambe Field well. Only the Morecambe DP8 platform is located within the Liverpool Bay SPA. In view of the uncertainty as to the location and possibility of such a test, this assessment assumes a worst case scenario of a new well being drilled within the SPA boundaries.

Table 5.4: Consideration of potential physical disturbance and drilling effects and relevant site conservation objectives

Liverpool Bay SPA
Site Information
Area (ha/km^2): 252,773/2,528 **Relevant qualifying features**: breeding: little tern, common tern; non-breeding: red-throated diver, little gull, common scoter. Wintering waterbird assemblage (including red-throated diver, little gull, common scoter, cormorant, red-breasted merganser). See Natura 2000 standard data form for details of qualifying features [94] **Conservation objectives**: Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring: • the extent and distribution of the habitats of the qualifying features • the structure and function of the habitats of the qualifying features • the supporting processes on which the habitats of the qualifying features rely • the population of each of the qualifying features • the distribution of the qualifying features within the site There is currently no advice on seasonality for the site. However, the presence of breeding (April-September, from NE advice on seasonality for Mersey Narrows and North Wirral Foreshore SPA[95]) and non-breeding (October-March, Lawson *et al.* 2015a) features indicate year round presence of qualifying interests. Further relevant information on seasonality is provided below.
Relevant licence areas with potential for physical disturbance and drilling effects
EIS Area 1
Activities associated with the proposed work programmes within the relevant licence areas
Drilling up to one well involving - siting of rig, drilling discharges
Assessment of effects on site integrity
Rig siting (**Relevant pressures:** *penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion; physical change (to another sediment/seabed type), introduction or spread of non-indigenous species*)[96] EIS Area 1 overlaps with the north western most part of the SPA, an area which was part of a site extension, classified in 2017 for wintering little gull. Seabed sediments in the area of overlap are likely to consist of

[94] https://jncc.gov.uk/jncc-assets/SPA-N2K/UK9020294.pdf

[95] https://designatedsites.naturalengland.org.uk/Marine/Seasonality.aspx?SiteCode=UK9020287&SiteName=mersey&SiteNameDisplay=Mersey+Narrows+and+North+Wirral+Foreshore+SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=

[96] http://publications.naturalengland.org.uk/file/5733149452009472 - note that the "pressure" nomenclature has changed since the publication of the Regulation 35 advice for Liverpool Bay SPA. For the purposes of this assessment, they have been reviewed against the current JNCC pressure-activity database (JNCC 2022) and those considered to be relevant are listed and considered above.

Liverpool Bay SPA

circalittoral mud which are widespread within the eastern Irish Sea. It is assumed that if rock placement is required it would be within 500m of a rig and based on a review of submitted ESs could cover an area of 0.001-0.004km^2 (Table 2.2). Hence, the potential loss of extent of sediment is small compared to the widespread nature of these sediment types across the large site (2,258km^2). Further mitigation measures are available which include use of removable mud mats or anti-scour mats as an alternative to rock placement. Such measures will be required, where appropriate, to ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity. Further assessment, including HRA where appropriate, would be undertaken at the project level, at which stage the assessment would be informed by specific rig siting information. There is considerable scope for drilling to take place outside of the site boundaries as a large proportion of EIS Area 1 is not within the site.

EIS Area 1 is partly within the site and coincides with foraging areas for little gull (Lawson *et al.* 2015a) (non-breeding, significant numbers noted March-May and August-November). The foraging ranges of common and little terns (see BEIS 2022b) are substantially less than the distance between the shore and EIS Area 1, such that these species are unlikely to interact with EIA Area 1. Sites associated with Liverpool Bay SPA include, Mersey Narrows and North Wirral Foreshore SPA, Ribble and Alt Estuaries SPA and Morecambe Bay and Duddon Estuary SPA. Common tern colonies associated with these sites are coastal (e.g. Seaforth Nature Reserve, Hodbarrow, Banks Marsh, Longton Marsh and Cabin Hill NNR), all are at greater distances from EIS Area 1 than the reported mean maximum foraging range for common tern of 18km (Woodward *et al*. 2019). Similarly in relation to little tern associated with The Dee Estuary SPA, and Morecambe Bay and Duddon Estuary SPA, the area offered is 69km and 30km respectively from colonies at Shotton Lagoons and Reedbeds and Foulney Island respectively, compared to a reported mean maximum foraging range for little tern of 5km (Woodward *et al*. 2019). EIS Area 1 is partly outside the site boundaries and rig siting could, therefore, be possible away from the site, avoiding interaction with the habitats of the qualifying features, and any direct interaction would be in the area used by wintering little gull. In the event that a rig is placed in the site, the maximum spatial footprint of physical damage associated with jack-up rig siting is small (0.8km^2) relative to the size of the site, and effects would be temporary.

Based on the surface densities presented in Lawson *et al.* (2015a), EIS Area 1 Is located some distance from areas of higher use by common scoter, the distribution of which is strongly associated with the distribution of its benthic prey species (Kaiser *et al*. 2006). Wintering red-throated diver occur throughout much of the Liverpool Bay SPA, with greatest densities found off the Ribble Estuary, North Wales and the North Wirral Foreshore (Webb *et al.* 2006), likely coinciding with sandbanks which support key prey species. Benthic communities of sandy sediments are in general relatively resilient to physical damage, however, repeated damage to the habitats (through changes in suspended sediment or physical disturbance such as anchoring) could adversely affect the ability of the habitats to recover, leading to permanent damage and ultimately lead to loss of prey species. This may result in a reduction in the value of habitats as foraging sites for the overwintering populations of common scoter and red-throated diver. Overall, the vulnerability of overwintering red-throated divers and common scoters in the Liverpool Bay and associated habitats to physical damage (through siltation and abrasion) and loss (through habitat removal and smothering) is considered to be low or moderate. Additionally, the distance between EIS Area 1 and areas of higher use for common scoter and red-throated diver is such that effects on key habitats for these species is considered to be unlikely. Cormorant and red-breasted merganser are named assemblage features of the site as they represent >1% of the GB population. The mean density surface for the assemblage presented in Lawson *et al.* (2015a) suggests that densities of birds are very low or not present in EIS Area 1, these being concentrated off the North Wales coast and the Morecambe and Ribble estuaries. The coastal foraging nature of the species also makes them less likely to use habitat within EIS Area 1.

In view of the physical scale and temporary nature of the activities, site conservation objectives will not be undermined as a result of abrasion/disturbance resulting from rig siting or the use of stabilisation materials, and there will be no adverse effect on site integrity.

As noted in Section 4.2.1, management of the spread of non-native species from vessels and rigs is being progressed through international measures, and the risk is limited by the operational range of rigs on the UKCS.

Drilling discharges
(**Relevant pressures:** *abrasion/disturbance of the substrate on the surface of the seabed; habitat structure changes - removal of substratum (extraction), contaminants)*

It is assumed that effects relating to drilling discharges occur within 500m of the well location (Table 2.2). The maximum spatial footprint within which smothering by drilling discharges may occur (0.8km^2) is small. Physical

Liverpool Bay SPA

loss by smothering of any of the habitats on which site qualifying interests depend may result in the loss of foraging sites and therefore the reduction of the food resource for the overwintering population. This would consequently be detrimental to the favourable condition of the interest feature. The overwintering population is considered to be moderately vulnerable to physical loss of habitat through its removal or smothering. However, the small scale (as compared to the extent of supporting habitat) and temporary nature of potential smothering, mandatory control requirements with respect to drilling chemical use and discharge (Section 2.3.1), and the location of EIS Area 1 relative to areas of higher use for species including common scoter, red-throated diver, red-breasted merganser, and shag, will ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

Other effects
(Relevant pressures: *visual disturbance, above water noise***)**

Red-throated diver, common scoter, red-breasted merganser and cormorant (all likely to be present October-March) of the wintering waterbird assemblage are highly sensitive to disturbance from ship and helicopter traffic (Garthe & Hüppop 2004, also see Schwemmer *et al.* 2011, MMO 2018, and Mendel *et al.* 2019) and by extension, are likely to be equally sensitive to other sources of non-physical disturbance, especially those creating noise and/or movement. Disturbance can cause birds to reduce or cease feeding in a given area or to fly away from an area (i.e. be displaced), and advice on operations for the Liverpool Bay SPA notes that vulnerability to such disturbance is high for both the common scoter and red-throated diver features. Other features of relevance to the assessment (common and little tern, wintering little gull) are not considered to be particularly sensitive to disturbance from vessels (Fliessbach *et al.* 2019), and are similarly unlikely to be particularly sensitive to vessel and rig movements associated with exploration activity. There is considerable scope for drilling to take place outside of the site boundaries as a large proportion of EIS Area 1 is not within the site, additionally, the area of overlap is part of the 2017 Liverpool Bay SPA site extension which was for wintering little gull.

There is the potential for disturbance to impact the distribution of qualifying features within the site from the movement of supply vessels and helicopters to drilling rigs (that may or may not be located outside of the site). EIS Area 1 is already exposed to high shipping densities (see Section 5.3.4) and the addition of 2-3 vessels per week (see Table 2.2) is unlikely to be significant in view of weekly variations in overall traffic for the region. In view of the location of EIS Area 1 within the Liverpool Bay SPA and to existing helicopter routes from Blackpool to the Morecambe Bay (Millom, Morecambe and Calder fields) and Liverpool Bay (Douglas, Hamilton and Lennox fields) areas[97], there is considerable scope for these established routes to be used, thus reducing additional overflight disturbance. Further mitigation measures are available which include seasonal controls. Where appropriate, these will be required to ensure that site conservation objectives are not undermined and there is no adverse effect on site integrity.

In-combination effects
Intra-plan in-combination effects are not considered to be possible as only EIS Area 1 was identified as relevant to the assessment and only one related work programme has been proposed for a single well. Section 6.3 provides a consideration of potential activities in-combination with other relevant plans and projects.

5.3.3 Further physical disturbance and drilling mitigation measures

Further mitigation measures are available which would be identified through the EIA process and operator's environmental management system and the Departmental permitting processes. These considerations are informed by specific project plans and the nature of the sensitivities identified from detailed seabed information collected in advance of field activities taking place. Site surveys are required to be undertaken before drilling rig placement (for safety and environmental reasons) and the results of such surveys (survey reports) allow for the identification of further mitigation including the re-siting of activities (e.g. wellhead or anchor positions) to ensure sensitive seabed surface or subsurface features (such as shallow gas accumulations) are avoided. Survey reports are used to underpin operator environmental

[97] https://www.aurora.nats.co.uk/htmlAIP/Publications/2019-01-31-AIRAC/graphics/41010.pdf

submissions (e.g. EIAs) and where requested, survey reports are made available to nature conservation bodies during the statutory consultation phase on these assessments[98].

It is not typical for rig stabilisation to be required, but this will be informed by site-specific survey and project specific plans which are not currently available. Where rig stabilisation is required, the Department will expect operators to provide adequate justification for the stabilisation option proposed (including for rig siting beyond site boundaries if practical), and consider use of systems (e.g. anti-scour mats, mud mats) that can be removed following drilling. Where rock placement is required for rig stabilisation, the Department will expect operators to minimise the volume of rock deposited.

Where proposed activities could result in the physical disturbance of sensitive qualifying features by vessels and aircraft traffic (e.g. divers and scoter for example in relation to Liverpool Bay SPA), available mitigation measures include, as far as possible, strict use of existing shipping and aircraft routes, and timing controls on temporary activities to avoid sensitive periods (these are identified in Table 5.4 above). Operators must demonstrate awareness of relevant seasonal sensitivities, and that these have been taken into account in the planning of their operations to avoid highly sensitive periods (see BEIS 2021c). In areas of high sensitivity, the Department expect operators to liaise with relevant SNCBs on the timing of their intended activities to minimise or avoid effects on seasonally sensitive qualifying interests.

In all instances, consent for project-level activities will not be granted unless the operator can demonstrate that the proposed exploration activities will not have an adverse effect on the integrity of relevant sites. The information provided by operators in their applications must be detailed enough for the Department (and its advisors) to make a decision on whether the activities could lead to a likely significant effect.

5.3.4 Conclusions of EIS regional assessment

Likely significant effects identified with regards to physical damage to the seabed, drilling discharges and other effects (see Section 5.3.2) when considered along with project level mitigation (above) and relevant activity permitting requirements (see Section 2.3), will not have an adverse effect on the integrity of Liverpool Bay SPA, The Dee Estuary SPA, Mersey Narrows and North Wirral Foreshore SPA, Ribble and Alt Estuaries SPA and Morecambe Bay & Duddon Estuary SPA. At the project level, there is a legal framework through the implementation of the EIA Regulations[99] and the Habitats Regulations, to ensure that there are no adverse effects on the integrity of the site. Their application at the project level allows for an assessment to be made of likely significant effects on the basis of detailed project-specific information and allows for applicants to propose project specific mitigation measures.

Taking account of the information presented above, it is concluded that activities arising from the licensing of EIS Area 1, insofar as it might generate physical disturbance and drilling effects, will not cause an adverse effect on the integrity of the Liverpool Bay SPA, and by association with that site, the Dee Estuary SPA, Mersey Narrows and North Wirral Foreshore SPA, Ribble and Alt Estuaries SPA and Morecambe Bay & Duddon Estuary SPA. Consent for activities will not be granted unless the operator can demonstrate that the proposed activities

[98] Whether within or outside an SAC, rig site survey typically includes a consideration of the presence of, amongst other sensitivities, Annex I habitats.
[99] *Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020*

which may include the drilling of a number of wells and any related activity including the placement of a drilling rig, will not have an adverse effect on the integrity of relevant sites.

5.3.5 Assessment of underwater noise effects

The site conservation objectives and other relevant information relating to site selection and advice on operations has been considered against indicative work programmes (see Section 2.2.1) to determine whether they could adversely affect site integrity, i.e. impacts the site features, either directly or indirectly, and result in altering the ecological structure and functioning of the site and/or affects the ability of the site to meet its conservation objectives. The results are given in Table 5.5 below. All mandatory control requirements (as given in Section 2.3.2) are assumed to be in place as a standard for all activities assessed at this stage.

Figure 5.5: Sites and areas offered in the Irish Sea to be subject to further assessment for underwater noise effects

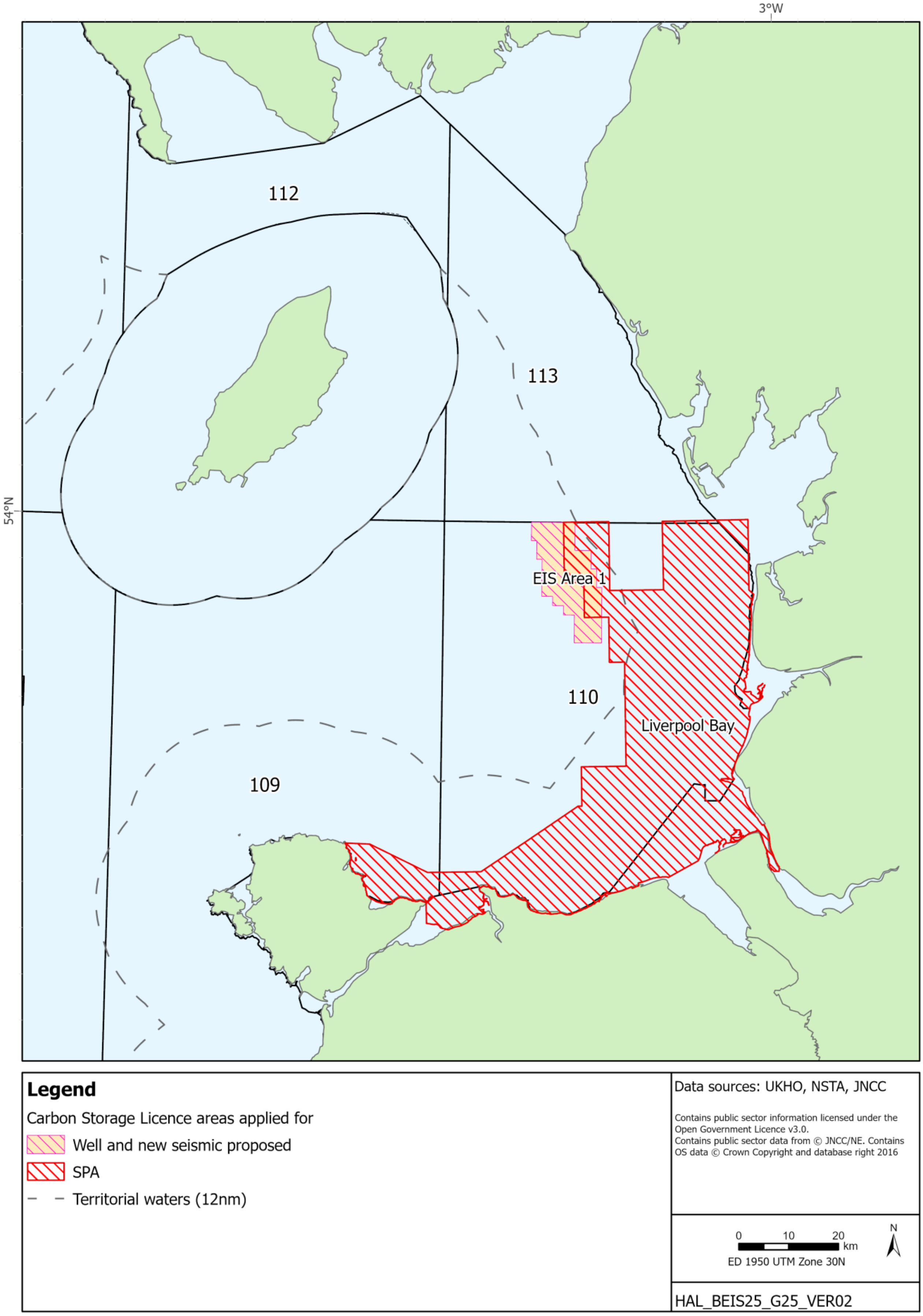


Table 5.5: Consideration of potential underwater noise effects and relevant site conservation objectives

Liverpool Bay SPA
Site Information
Area (ha/km^2): 252,773/2,528 **Relevant qualifying features (diving species only):** non-breeding: red-throated diver, common scoter; overwintering waterbird assemblage (including common scoter, red-throated diver, red-breasted merganser, and cormorant). **Conservation objectives:** See Table 5.4 above.
Relevant licence areas with potential for underwater noise effects
EIS Area 1
Assessment of effects on site integrity
Impulsive noise (2D/3D seismic survey, rig site survey, VSP, conductor piling) *(**Relevant pressures:** underwater noise change, vibration)* Approximately half of EIS Area 1 overlaps the site. The areas within Liverpool Bay SPA identified as supporting the highest densities of red-throated diver over winter are to the south and east of EIS Area 1 (Lawson *et al.* 2015a). While the distribution of these mobile species within the site will vary, there appears to be limited spatial overlap between EIS Area 1 and those areas of greatest importance for divers and common scoter, and other assemblage features including cormorant and red-breasted merganser, and therefore there is a low potential for underwater noise effects. As detailed in Section 4.3.2, there is very little evidence of impacts of underwater noise on diving birds. Mortality of seabirds has not been observed during extensive seismic operations in the North Sea and elsewhere, and flushing disturbance associated with the physical presence of survey vessels and rigs would be expected to displace most diving seabirds from close proximity to noise sources, particularly in the case of divers and scoters which are known to display a large avoidance radius of vessels and surface infrastructure (up to several kilometres – see Section 4.2.3 and 5.3.2). Such avoidance behaviour is also expected to reduce the potential for diving birds to be exposed to noise levels which may result in potential behavioural disturbance, although it is noted that very little evidence for such effects exist and, should they occur, they would be expected to be short-term, temporary and of limited spatial extent. Considering the seasonal nature of the sensitivity, where necessary, control of timing of offshore activities allows for mitigation, which would be identified once project plans are known. Negative indirect effects of impulsive noise on qualifying features may arise through effects on prey species, primarily small fish, if those prey are subject to injury or disturbance which reduce their availability to qualifying seabirds. Such effects relate to the primarily piscivorous red-throated diver, as the winter diet of common scoter is largely restricted to sessile bivalves on the seabed (Fox 2003). While there is some evidence that a reduction in fish catches or abundance can be associated with seismic survey activity, these are temporary in nature, and the sensitivity of the relevant prey species to underwater noise is considered to be generally low. The disturbance of sensitive spawning periods will be considered through the activity consenting process. As such, any underwater noise effects on fish associated with licensing EIS Area 1 are not anticipated to result in significant effects on the food resources of the qualifying diving bird features. Considering the limited potential for effects of 2D/3D seismic survey on diving birds identified above and in Section 4.3.2, and the lower amplitude, shorter duration and smaller geographic footprint associated with other impulsive noise such as VSP, rig site survey and conductor piling, any disturbance to qualifying features or their prey will be highly localised, short-term, and will not result in an adverse effect on the integrity of the site or its source colony sites. **Continuous noise (drilling, vessel & rig movements)** *(**Relevant pressures:** underwater noise change, vibration)* No significant effects on the relevant qualifying species are anticipated from continuous underwater noise from drilling and vessel movements due to the lower amplitude and non-impulsive nature of the sound resulting in no potential for acute trauma and no evidence of significant disturbance to diving birds from such sources.

Liverpool Bay SPA
In-combination effects Intra-plan in-combination underwater noise effects are considered highly unlikely given the low potential for effects identified above and that only EIS Area 1 was identified as relevant to the assessment, and only one work programme has been proposed. Section 6.3 provides a consideration of potential activities in-combination with other relevant plans and projects.

5.3.6 Further underwater noise mitigation measures

The Department require operators to provide sufficient information in the EIA on the potential impact of proposed activities on relevant sites and their qualifying features as well as proposed further mitigation measures in their applications for a relevant consent. Due to the temporary nature of the activities, mitigation measures could include activity timing to avoid the most sensitive periods. Operators must demonstrate how seasonal sensitivities have been taken into account when planning operations (see BEIS 2021c). The information provided by operators must be detailed enough for the Department to make a decision on whether the activities could lead to a likely significant effect, and whether the activities should require HRA. Depending on the nature and scale of the proposed activities (e.g. area of survey, source size, timing and proposed mitigation measures) and whether likely effects are identified for these, the Department may undertake further HRA to assess the potential for adverse effects on the integrity of sites at the activity specific level.

Consent for project-level activities will not be granted unless the operator can demonstrate that the proposed activities, which may include seismic survey, small-scale geophysical rig site survey, VSP and drilling (which may incorporate conductor piling), will not have an adverse effect on the integrity of relevant sites.

5.3.7 Conclusions of EIS regional assessment

The risks of injury and disturbance to relevant qualifying features is limited both by the nature of the indicative work programme for the area applied for and controls currently in place, such that it is concluded that activities arising from the licensing of EIS Area 1, in so far as they may generate underwater noise effects, will not cause an adverse effect on the integrity of Liverpool Bay SPA. Consent for project specific activities will not be granted unless the operator can demonstrate that the proposed activities will not have an adverse effect on the integrity of relevant sites. These activities may be subject to activity level EIA and where appropriate, HRA.

6 In-combination effects

Potential incremental, cumulative, synergistic, and secondary effects from a range of operations, discharges and emissions (including noise) were considered in the latest Offshore Energy SEA (BEIS 2022a). There are a number of potential interactions between activities that may follow licensing and those existing or planned activities, for instance in relation to renewable energy, offshore oil and gas and gas storage, fishing, shipping, and aggregate extraction. These activities are subject to individual permitting or consenting mechanisms or are otherwise managed at a national level. The areas applied for are located within the Scottish National Marine Plan area, the East Inshore and Offshore Marine Plan areas, and the North West Inshore and Offshore Marine Plan areas. These plans set out objectives and policies to guide development in these areas, and are referred to where relevant, in the following sections.

The potential for intra-plan in-combination effects was considered for those sites subject to AA in Sections 5.2 and 5.3 (i.e. that multiple areas applied for have the potential to be licensed and are relevant to the same site). The following section considers the potential for in-combination effects with other relevant plans and programmes.

Sources of potential effect

Projects for which potential interactions with operations that could arise from the licensing of the carbon storage areas applied for (see Section 1.2) have been identified. Interactions were identified on the basis of the nature and location of existing or proposed activities in relation to the relevant sites considered in this assessment and the areas which have been applied for, and also the sources of potential effect from these projects for which in-combination effects were considered to be possible. Projects relevant to this in-combination effects assessment, along with their status and the relevant sites are tabulated in Table 6.1 and Table 6.2 for the southern North Sea and eastern Irish Sea respectively.

The principal sources of in-combination effects are regarded to be related to underwater noise, physical disturbance, and physical presence, primarily arising from offshore wind development, though physical disturbance from other activities such as the installation of interconnectors and oil or gas pipelines, aggregate extraction or fisheries are also relevant to this assessment, and are represented by multiple projects. OWF development will introduce underwater noise and disturbance sources (particularly during construction) and present an additional physical presence in the marine environment. Offshore wind leasing (e.g. those associated with Round 4 or the 2017 wind farm extensions) have already been subject to SEA and plan-level HRA, and any related projects have been, or will be, subject to their own individual assessment and HRA processes[100]. Figure 6.2 and Figure 6.5 indicate the location of wind farms/wind farm zones in relation to the areas applied for subject to this assessment and relevant sites.

The UK Government believes that the carbon dioxide storage and the renewables industry can successfully co-exist. Early discussions between the developers will ensure that any potential

[100] For those sites having already been subject to HRA, note that the competent authority is under an obligation to reconsider and review consents for projects that are likely to have a significant effect on new SAC and SPA sites once they become a candidate site. Consultation on an HRA exercise for a review of consents for the Southern North Sea SAC took place between November and December 2018, and a review of consents for SPAs is ongoing. See: https://www.gov.uk/government/consultations/southern-north-sea-review-of-consents-draft-habitats-regulations-assessment-hra and https://www.gov.uk/government/publications/review-of-consents-for-major-energy-infrastructure-projects

conflict can be mitigated so that both developments can proceed with minimal delay and without the need to determine any part of an existing Crown Estate Lease or Agreement for Lease. In addition to renewables activities, early engagement with other users (e.g. through fisheries liaison, vessel traffic surveys, consultation with the MoD or holders of other Crown Estate offshore interests)[101] where scheduling overlaps may occur should allow both for developer cooperation, and the mitigation of potential cumulative or in-combination effects.

East Marine Plan policy CCS1 defines a range of areas of potential carbon dioxide storage, which includes existing gas fields and related infrastructure and saline aquifers, in which proposals should not prevent storage, or else indicate how impacts on storage will be minimised, mitigated, or else suitably justify a case for proceeding. Paragraph 329 of the Plans indicate that "*Policy CCS1 is included to help ensure that sufficient storage sites are available for Carbon Capture and Storage over the long-term in view of the large number of such sites, on a national and international scale. Carbon Capture and Storage is spatially restricted to where storage locations occur.*" This is supported in plan policies such as GOV2 and GOV3, which respectively promote the maximisation of activity co-existence, and the demonstration that activity displacement will be avoided, minimised, or mitigated. The North West Marine Plans include a policy in support of carbon capture and storage (NW-CCUS-3) that, "*Proposals associated with the deployment of low carbon infrastructure for industrial clusters should be supported*", and like the East Marine Plans, include separate policies covering co-existence and co-location of developments NW-CO-1) that seek to ensure that space is optimised and outline what must be demonstrated in proposals should they have likely significant impacts on existing activities. The Scottish National Marine Plan contains similar policies (e.g. GEN 4 Co-existence. All of the marine plans include policies promoting the re-use of oil and gas infrastructure for carbon dioxide storage (East Plans CCS2, NW-CCS-1 and 2, the Scottish National Marine Plan notes this as a policy area for consideration in regional marine plans), and this, amongst other relevant marine plan policies, are referred to in the following sections.

6.1 Central North Sea

While a number of projects are relevant to an in-combination effects assessment for physical disturbance effects on the Scanner Pockmark SAC, the lack of any offshore activities in the work programme for CNS Area 1 precludes the ability for any in-combination effect to take place. It is concluded that the licensing of CNS Area 1 would not result in adverse in-combination effects on the Scanner Pockmark SAC.

[101] https://opendata-thecrownestate.opendata.arcgis.com/

6.2 Southern North Sea

Table 6.1: Projects relevant to the in-combination effects assessment for the southern North Sea

Relevant plan or project	Project summary	Project status/indicative timing	Relevant sites[1]
Offshore renewables and interconnectors			
Dogger Bank A Dogger Bank B	Located some 131km offshore, these two wind farms will collectively contain up to 200 turbines with a total capacity of up to 2,400MW within an area of. 1,114km^2. The turbines may be fixed to the seabed using monopile, jacket or gravity base foundations. Additionally, collector and converter stations will be required offshore. Export cables will have their landfall on the coast of the East Riding of Yorkshire.	Under construction. Operation expected between 2023 and 2024.	Dogger Bank SAC, Southern North Sea SAC
Dogger Bank C	Located approximately 200km north-east of Flamborough Head (Yorkshire coast), the wind farm will feature up to 200 turbines with a maximum capacity of 1,200MW, along with collector, converter and other platforms. Turbines may be fixed to the seabed using monopile, multi-leg or gravity base foundations. The project will connect to the Lackenby substation in Teesside, North Yorkshire.	Consented. Earliest likely offshore construction from 2023.	Dogger Bank SAC, Southern North Sea SAC
Sofia	Located approximately 165km east of Teesside (Yorkshire coast), the wind farm will feature 100 turbines with a maximum capacity of 1,400MW, along with an offshore converter platform. Turbines will be fixed to the seabed using monopile foundations. Export cables will have landfall on the Teesside coast and connect to a new converter station near Lazenby.	Consented. Offshore construction expected from 2023.	Dogger Bank SAC, Southern North Sea SAC
Hornsea Project One	Located approximately 100km to the east of the Yorkshire coast, Hornsea Project One has a total installed capacity of 1,218MW delivered by 174 turbines within an area of 407km^2. The turbines were installed using monopile foundations. The export cable route travels to the south west and has its landfall at Horse Shoe Point to the south of Grimsby.	Fully commissioned. Construction completed in 2019.	Southern North Sea SAC
Hornsea Project Two	The wind farm has a proposed capacity of 1,800MW generated by 165 wind turbines within an area of 462km^2 and located *ca*. 90km from the Yorkshire coast. The turbines were installed using monopile foundations. The export cable route shares that of Project One.	Fully commissioned. Construction completed in 2022.	Southern North Sea SAC
Hornsea Project Three	The wind farm is proposed to have a capacity of up to 2,400MW generated by 231 turbines using fixed foundations (i.e. monopile, jacket, gravity base) within an area of 696km^2. It is expected that up to 6 cables will take power ashore in a corridor extending from the south west corner of the zone to a landfall on the North Norfolk Coast.	Consented. Offshore construction expected from 2024.	Southern North Sea SAC, North Norfolk Sandbanks and Saturn Reef SAC, Wash and North Norfolk Coast SAC

Relevant plan or project	Project summary	Project status/indicative timing	Relevant sites[1]
Hornsea Project Four	The wind farm is proposed to have a capacity of up to 2,600MW generated by 180 turbines using fixed foundations (i.e. monopile, jacket, gravity base) within an array area of 846km^2. The array is located approximately 65km to the east of Flamborough Head, and the export cable corridor follows a relatively direct route to a landfall on the East Riding of Yorkshire coastline. Up to six export cables will be installed.	In planning. Decision expected in July 2023.	Southern North Sea SAC, Greater Wash SPA
Sheringham and Dudgeon extension projects	The two projects which propose to extend the Sheringham and Dudgeon wind farms have a capacity of 317MW and 402MW respectively, and use a joint export cable system. The extensions could have up to 23 and 30 wind turbines respectively.	In planning	Wash and North Norfolk Coast SAC, Greater Wash SPA, Inner Dowsing, Race Bank and North Ridge SAC
Humber Gateway offshore wind farm	The project has 73 turbines providing an installed capacity of 219MW, with export cabling having its landfall on the south of the Holderness coast near Easington.	Operational	Greater Wash SPA
Westermost Rough offshore wind farm	The project includes 35 turbines providing an installed capacity of 210MW, with export cabling having its landfall on the Holderness coast near Withernsea.	Operational	Greater Wash SPA
Race Bank offshore wind farm	The project includes 90 turbines providing an installed capacity of 857MW, with export cabling passing through The Wash to a landfall north of Sutton Bridge.	Operational	Greater Wash SPA
Lincs, Lynn and Inner Dowsing offshore wind farms	Lynn and Inner Dowsing each have 27 turbines and capacities of 97.2MW, with Lincs having 75 turbines and a capacity of 270MW. They are all constructed relatively close to the Lincolnshire coast, where their export cables have their landfall.	Operational	Greater Wash SPA
Triton Knoll offshore wind farm	The project includes 90 turbines providing an installed capacity of 857MW. Export cables have their landfall on the Lincolnshire coast north of Anderby Creek.	Operational	Greater Wash SPA
Round 4 Preferred Projects 1 and 2	Two preferred project areas are located to the south of Dogger Bank. No firm project plans are known at this stage.	Pre-application	Dogger Bank SAC, Southern North Sea SAC
Round 4 Preferred Project 3	One preferred project area is located approximately 50km to the east of the Humber. No firm project plans are known at this stage.	Pre-application	Southern North Sea SAC
Norfolk Boreas	An offshore wind farm of capacity up to 1,800MW using up to 158 turbines and with up to four export cables with a landfall near Happisburgh.	Consented	Southern North Sea SAC

Relevant plan or project	Project summary	Project status/indicative timing	Relevant sites[1]
Norfolk Vanguard	An offshore wind farm of capacity up to 1,800MW using up to 158 turbines and with up to four export cables with a landfall near Happisburgh.	Consented	Southern North Sea SAC
East Anglia Three	An offshore wind farm of capacity up to 1,400MW, likely using 95 14.7MW turbines and a network of subsea inter-array cables and up to four export cables, with a landfall at Bawdsey.	Consented	Southern North Sea SAC
Eastern Green Link 2	A proposed HVDC cable of approximately 436km in length, running from Sandford Bay in Scotland to Fraisthorpe Sands in Yorkshire. The cables may be installed as a bundle of three cables or separately, along with a fibre optic line.	In-planning	Greater Wash SPA
Viking Link	A 1,400MW interconnector between Bicker Fen in Lincolnshire and Revsing in South Jutland, Denmark. The cable will be trenched and buried in the North Sea, with the landfall completed using trenchless methods.	Under construction	Southern North Sea SAC, Greater Wash SPA
Offshore Transmission Network Review: National GridESO Holistic Network Design (HND)	The HND recommends the optimal transmission network for offshore wind and has been developed to enable detailed network design which will allow for decisions to be made about connecting specific assets.	Published July 2022. Follow on work to make recommendations to developers early 2023.	Southern North Sea SAC, Greater Wash SPA, Inner Dowsing, Race Bank and North Ridge SAC
Gas storage			
Carbon Storage Licence CS001	The carbon storage licence was awarded in 2012 and was later amended in 2020 to extent the appraisal period, with an application for a storage permit due in 2024.	Pre-planning	Southern North Sea SAC
Carbon Storage Licence CS005	The carbon storage licence was awarded in 2021, with site characterisation expected to be complete by 2023, which includes the reprocessing of seismic data. The end of the "Assess" phase is due in 2024, with a storage permit application to be made in 2025.	Pre-planning	Southern North Sea SAC, North Norfolk Sandbanks and Saturn Reef SAC
Carbon Storage Licence CS006	The carbon storage licence was awarded in 2022, with site characterisation expected to be complete by 2026. New seismic is to be required over the site by 2023, with a contingent well to be completed by 2027. A storage permit application is to be made by November 2029.	Pre-planning	Southern North Sea SAC
Carbon Storage Licence CS007	The carbon storage licence was awarded in 2022, with site characterisation expected to be complete by 2028. Contingent new seismic is to be required over the site by 2025, with a contingent well to be completed by 2025. A storage permit application is to be made by November 2027.	Pre-planning	Southern North Sea SAC

Relevant plan or project	Project summary	Project status/indicative timing	Relevant sites[1]
Rough Gas storage	A gas storage licence was issued in July 2022 covering the Rough field. The field was previously used for gas storage, and its present phase does not include any new offshore work, i.e. existing wells, pipelines and platforms are to be used to storge gas at Rough.	In operation	Southern North Sea SAC
Oil and gas			
Tolmount	Located in Block 42/28d, the Tolmount gas field development includes a minimal facilities platform and a new gas export pipeline to shore.	Producing	Southern North Sea SAC
Tolmount East	A single gas condensate well tied back to the Tolmount platform.	Approved	Southern North Sea SAC
Blythe Hub development	Located in Blocks 48/22b, c and 49/21c, the Blythe hub development includes a subsea tie-back (Elgood) to a new platform (Blythe), and a separate field (Southwark), re-using the existing Thames export pipeline to Bacton.	Producing, Southwark production expected late 2022	Southern North Sea SAC, North Norfolk Sandbanks and Saturn Reef SAC
33rd seaward oil and gas licensing round	115 bids across 258 UKCS Blocks or part-Blocks were received as part of the 33rd Round, covering parts of the southern North Sea.	Licence applications are being considered by NSTA.	All SNS sites relevant to this assessment,
Oil and gas decommissioning projects			
Fields and infrastructure associated with and tied back to Murdoch	Various decommissioning programmes are associated with the Caister-Murdoch area including for the Caister CM platform and associated pipelines, the Boulton BM, Katy KT, Kelvin TM, Munro MH platforms, and the CMS subsea installations including Boulton HM, Hawksley EM, McAdam MM, Murdoch K.KM and Watt QM, and all related pipelines and umbilicals, and the Murdoch MA, Murdoch MC, Murdoch MD platforms and export pipeline to Theddlethorpe. Additionally, the Ketch, Schooner, Rita and Hunter fields, also tied back to Murdoch, are subject to decommissioning. The plans variously involve the removal of platform topsides, jackets and subsea installations to shore for recycling, and the leaving *in situ* of buried pipelines, and removal of exposed ones, with rock remediation for some projects.	Approved. Murdoch MA, MC and MD platforms removed August 2022	Dogger Bank SAC, Southern North Sea SAC
Cavendish Field	Topsides and jacket to be removed and returned to shore. The pipelines will be partially removed (buried sections to remain in situ).	Approved	Dogger Bank SAC, Southern North Sea SAC
Windermere Field	Topsides and jacket will be removed and returned to shore. The pipelines will be partially removed. All concrete mattresses and grout bags will be recovered to shore.	Approved	Klaverbank SAC (Netherlands)

Relevant plan or project	Project summary	Project status/indicative timing	Relevant sites[1]
Anglia Field	Platform will be removed and transported to shore for re-use or recycling. Subsea wells will be plugged and abandoned using a drilling rig. Pipelines will remain in-situ. All tie-in spools for the 8" import line, 12" export line and 3" Methanol line will be completely removed.	Approved	Southern North Sea, North Norfolk Sandbanks and Saturn Reef SAC
Hewett Field	Six platforms to be removed and returned to shore.	Approved	Southern North Sea SAC
	Subsea installations. Proposes recovery to shore for reuse, recycling or disposal.	Draft DP under consideration	
Ensign Field installation and pipelines	Topsides and jacket will be removed and transported to shore for recycling. All wells will be plugged and abandoned. Buried pipelines will be left *in situ* except the exposed ends which will be cut and removed.	Approved	Southern North Sea SAC, North Norfolk Sandbanks and Saturn Reef SAC
Viking platforms, Vixen and associated pipelines (VDP2)	Removal to shore for re-use, recycling or disposal of Viking surface installations KD, LD, AR, Viking Bravo Hub BA, BC, BP, BD and Vixen sub-sea tieback in Blocks 49/12a and 49/17a. Buried pipelines left *in situ*.	Approved. Platforms were removed 2019 and 2020.	Southern North Sea SAC, North Norfolk Sandbanks and Saturn Reef SAC
Victor (VDP3)	Victor platform and subsea installation in Blocks 49/22 and 49/1 removed to shore for re-use, recycling or disposal. Buried pipelines left *in situ*.	Approved	Southern North Sea SAC, North Norfolk Sandbanks and Saturn Reef SAC
Tyne South installations	Topsides, jacket and subsea installation in Block 44/18a removed to shore for reuse, recycling or disposal.	Approved	Southern North Sea SAC, Dogger Bank SAC
LOGGS Satellites Jupiter Area	Decommissioning programmes covering two Lincolnshire Offshore Gas Gathering System (LOGGS) Satellite installations (Ganymede ZD and Europa EZ installations) and pipelines and two subsea tiebacks (Callisto ZM and NW Bell ZX) with wellhead protection structures and pipelines. Installations are in Block 49/22. All installations will be recovered to shore for re-use or recycling. NW Bell pipelines will be recovered to shore. Ganymede, Europa and Callisto interfield pipelines will be decommissioned *in situ*.	Approved. Ganymede and Europa installations removed in 2020.	Southern North Sea SAC, North Norfolk Sandbanks and Saturn Reef SAC
Wenlock	The platform, mid line tee protection structure, exposed tie-in spools and stabilisation features will be removed to shore. Trenched and buried pipelines will remain *in situ,* which includes an export pipeline to the Indefatigable (Inde 23AC) platform (also subject to decommissioning.	Approved	Southern North Sea SAC, North Norfolk Sandbanks and Saturn Reef SAC

Relevant plan or project	Project summary	Project status/indicative timing	Relevant sites[1]
Leman 27H and 27J topsides	Topsides to be recovered to shore.	Draft DP under consideration	Southern North Sea SAC, North Norfolk Sandbanks and Saturn Reef SAC
Johnston	Subsea installations to be recovered to shore for recycling and disposal. Trenched and buried pipelines to be left in situ with ends remediated using rock. Flexible flowlines and umbilicals/spools/jumpers to be removed.	Draft DP under consideration	Southern North Sea SAC
Aggregate areas			
2021/2022 aggregates tender round[102]	A number of provision tender areas located in the southern North Sea have been released. These are yet to be subject to HRA.	HRA likely to be concluded early 2023, following which six-year exploration and option agreements may be offered.	Greater Wash SPA, Southern North Sea SAC,
Humber production areas 1-4 (514/1-4)	These areas are licensed for the extraction of marine aggregates. As part of the wider Humber region, 32.16km^2 were actively dredged in 2021, representing 10.3% of the total licensed area, with 90% of effort in 14.90km^2. Dredging intensity over these areas was generally low to medium (TCE & BMAPA 2022).	Leased production area	Greater Wash SPA
Outer Dowsing (515/1)		Leased production area	Inner Dowsing, Race Bank and North Ridge SAC
Humber Overfalls (493)		Leased production area	Greater Wash SPA
Humber Estuary (106/1-3 and 400)		Leased production area	Greater Wash SPA
Off Saltfleet (197)		Leased production area	Greater Wash SPA
Humber 3 (484)		Leased production area	Southern North Sea SAC, North Norfolk Sandbanks and Saturn Reef SAC

Sources: relevant Development Consent Orders and related post-consent modifications (https://infrastructure.planninginspectorate.gov.uk/), BEIS oil & gas: decommissioning of offshore installations and pipelines (https://www.gov.uk/guidance/oil-and-gas-decommissioning-of-offshore-installations-and-pipelines), TCE & BMAPA (2022), TCE Open Data Portal (https://thecrownestate.maps.arcgis.com/apps/webappviewer/index.html?id=b7f375021ea845fcabd46f83f1d48f0b), NSTA carbon storage public register (https://www.nstauthority.co.uk/licensing-consents/carbon-storage/), NSTA gas storage and unloading webpage (https://www.nstauthority.co.uk/licensing-consents/gas-storage-and-unloading/)

Notes: [1] those sites considered to be relevant to 1st carbon dioxide storage round exploration activities.

[102] https://www.thecrownestate.co.uk/en-gb/media-and-insights/news/2022-the-crown-estate-confirms-areas-selected-for-202122-marine-aggregates-tender-round/

Figure 6.1: Location of areas applied for in relation to other projects in the southern North Sea

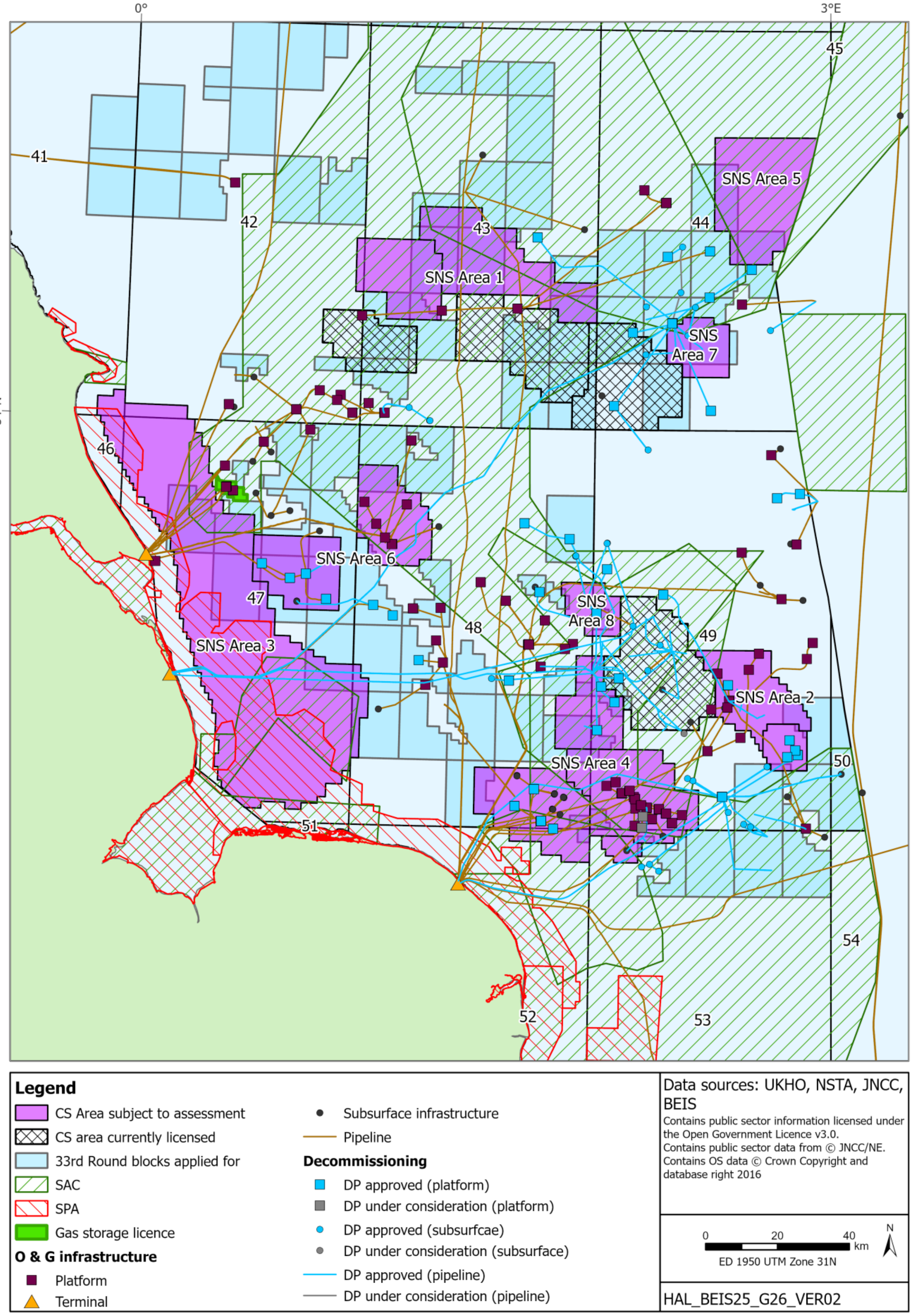


Figure 6.2: Location of areas applied for in relation to other projects in the southern North Sea (continued)

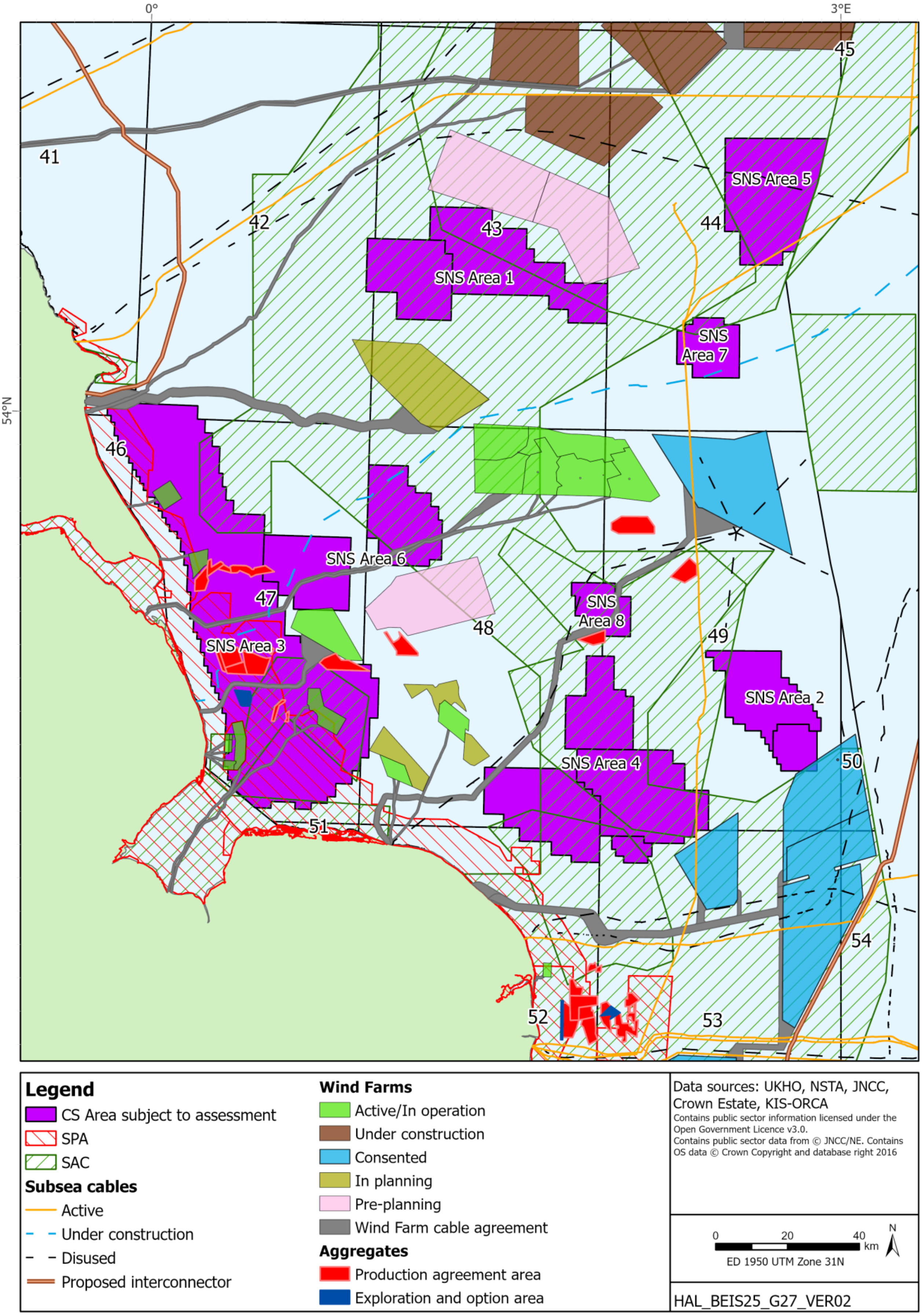
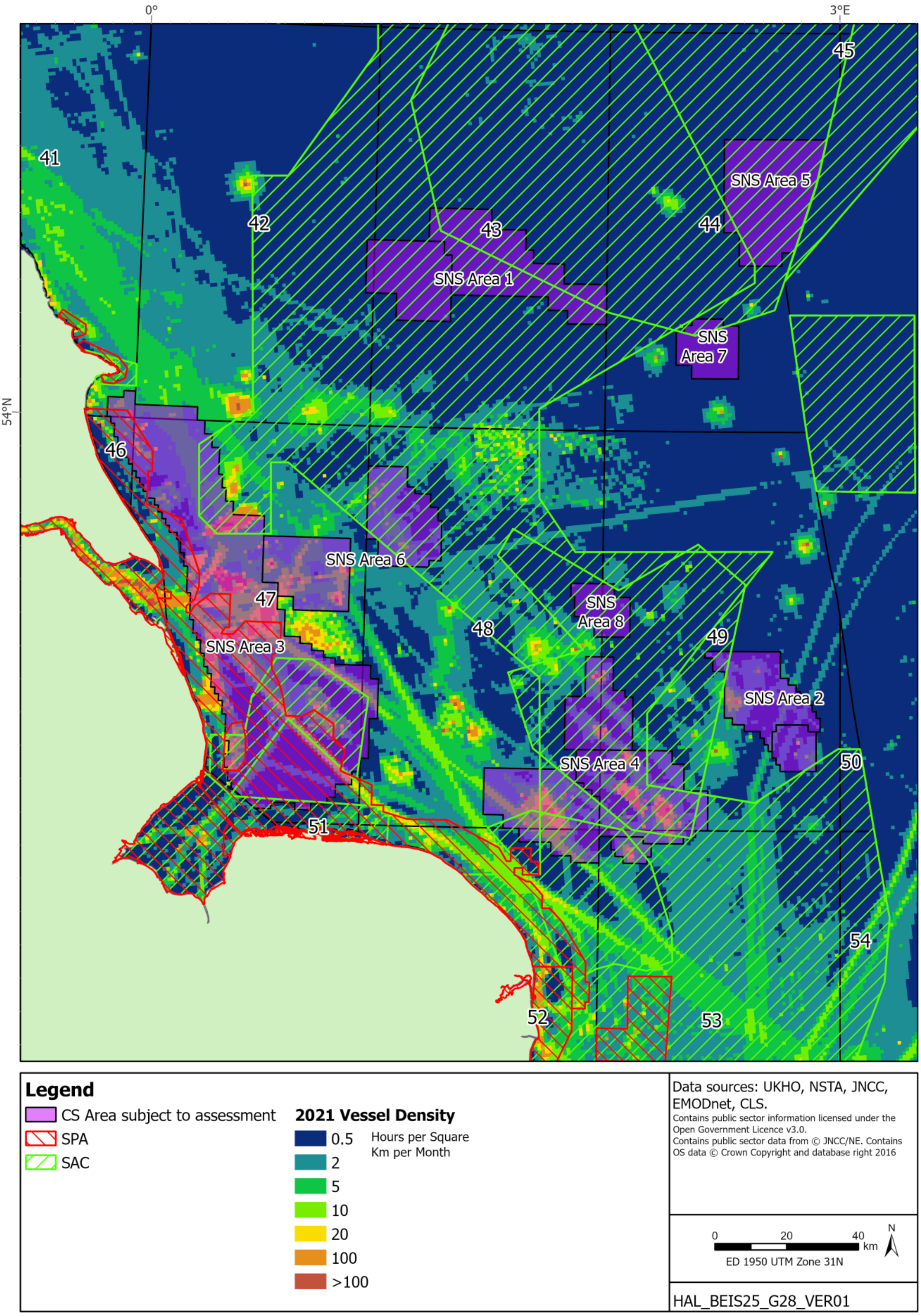


Figure 6.3: Vessel traffic in the southern North Sea



6.2.1 Physical disturbance and drilling effects

The pressures which may result from exploration/appraisal activities that could result from licensing and cause physical disturbance and drilling effects on the relevant sites were described in Section 4.2 and Section 5.2. The conclusions of Section 5.2 are considered in the following section in the context of those relevant projects identified in Table 6.1 above.

Though existing oil and gas infrastructure is widespread in the southern North Sea (Figure 6.1), the relative density and footprint of these is small. Assuming a conservative footprint of 0.8km^2 for every fixed installation in the southern North Sea (i.e. that covering the 500m safety zone), the total percentage area of the southern North Sea (defined here as Regional Sea 2) occupied by these platforms is 0.05%. Of the 167 installations considered, 48 of these have approved decommissioning plans or are subject to decommissioning planning and will be removed in the coming years. A review of field development projects (as of October 2022) indicates three projects which are relevant to sites considered in this assessment (Tolmount, Tolmount East and the Blythe Hub). The projects involved the installation of subsea wells or platforms, and related pipelines to existing infrastructure for export to terminals at Easington and Bacton (Table 6.1). The Blythe Hub and Tolmount are both complete, with Tolmount East proposed to be completed in 2023, such that it is likely to be in operation in advance of activities following the licensing of the areas applied for in the 1st carbon dioxide storage round. Tolmount is at least 10km from SNS Area 3 and the Blythe platform is at least 10km from SNS Area 4, with Southwark located within SNS Area 4. Only the Southwark platform is located within the North Norfolk Sandbanks and Saturn Reef SAC and the Southern North Sea SAC.

There are a number of decommissioning projects scheduled to take place in the southern North Sea in the coming years which are summarised in Table 6.1 and are also shown in Figure 6.1. These are primarily located in Quadrants 43, 44, 47, 48 and 49 and are partly or entirely relevant to the Southern North Sea SAC, North Norfolk Sandbanks and Saturn Reef SAC and Dogger Bank SAC. In addition to those listed in Table 6.1, a number of fields are likely to be decommissioned in the coming years, but decommissioning plans are yet to be submitted. Activities associated with decommissioning plans will result in some physical disturbance which will largely be within existing field development areas (e.g. from removal of pipeline spool pieces, pipeline sections, protection materials, subsea wellheads, manifolds and platform footings, well abandonment where this requires a mobile rig, and any anchoring and rock placement). Levels of activity (e.g. shipping) may not be significantly greater than ongoing operations in the southern North Sea, and will be temporary.

While the siting of a rig, in particular in SNS Area 4 has the potential to have in-combination effects with the decommissioning of gas field infrastructure, incremental disturbance will be temporary, and where required, mitigation will used to avoid permanent impacts on the habitats of sites (see Section 5.2.3). Where appropriate, the Department will undertake HRA in relation to oil and gas development and decommissioning activities, including a consideration of in-combination effects. The Department has undertaken such an assessment for the Viking and LOGGS decommissioning programmes in relation to the Southern North Sea SAC and North Norfolk Sandbanks and Saturn Reef SAC. Additionally, assessments have been undertaken for decommissioning of assets relevant to the Dogger Bank SAC, and also Chrysaor’s decommissioning of LDP2 and LDP5, assessed in relation to the North Norfolk Sandbanks and Saturn Reef SAC and the Southern North Sea SAC. These assessments concluded the various projects would not have an adverse effect on the integrity of the above listed sites[103].

[103] See the list of Habitats Regulations Assessments undertaken by the Department at: https://www.gov.uk/guidance/oil-and-gas-offshore-environmental-legislation#offshore-petroleum-activities-conservation-of-habitats-regulations-2001-as-amended

As noted above, it is recognised that further decommissioning programmes are likely to come forward in this area of the southern North Sea in coming years, which will be subject to further HRA as appropriate, including in relation to in-combination effects.

SNS Area 1, SNS Area 2, SNS Area 4, SNS Area 7 and SNS Area 8 are all immediately adjacent to existing carbon dioxide appraisal and storage licence areas and their related agreements for lease. All areas are partly or fully within the Southern North Sea SAC, with licence CS005 also overlapping the North Norfolk Sandbanks and Saturn Reef SAC. As part of the Net Zero Strategy, the Government set out its ambition to deliver four carbon capture usage and storage (CCUS) clusters, capturing 20-30 $MtCO_2$ across the economy, including 6 $MtCO_2$ of industrial emissions, per year by 2030, and 9 $MtCO_2$ per year by 2035. In line with this ambition, the HyNet and East Coast Clusters have been confirmed as being Track-1 clusters following the CCUS cluster sequencing process. Developed alongside hydrogen, CCUS will be part of creating transformative “SuperPlaces” in areas such as the Humber and North East, as well as the North West, Southern England, Scotland and Wales. The storage of carbon dioxide associated with these Track-1 clusters, and any future projects, may take place in any of the currently leased/licensed carbon dioxide storage areas, and in view of the targets set out in the Net Zero strategy, development of these stores should be anticipated over the next decade and beyond. In keeping with East Marine Plan policy CCS2, and the oil and gas decommissioning guidance set out by the Department (BEIS 2018), there is the potential for re-use of existing infrastructure for carbon dioxide transport and storage. A review of the possible re-use of oil and gas infrastructure for carbon dioxide was undertaken[104], the Government response to which gave a range of future actions including ones related to further re-use assessment of offshore oil and gas assets, making data available, updated policy proposals and regulatory review. The overlap of existing carbon dioxide storage licence areas, and those applied for in the 1st Round, with gas production infrastructure, much of which is subject to decommissioning (see Figure 6.1) infers the potential for re-use which may limit further sources of effect in relation to sites such as North Norfolk Sandbanks and Saturn Reef SAC, however, there are presently no firm proposals to consider.

There is a considerable overlap of Blocks applied for in the 33rd seaward oil and gas licensing round with most of the CS Round areas and the sites relevant to this AA (Figure 6.1). It is likely that work programmes for these Blocks will include the drilling of a well, however, the location and timing of any well in not yet understood. If drilled, the wells would result in a similar scale of effect to that for carbon dioxide storage exploration/appraisal wells (Table 2.2), and would likely be subject to similar types of mitigation for those relevant sites identified in Section 5.2. At this stage, adverse in-combination effects with the 1st CS licensing round are not considered to be likely due to the likely large spatial and temporal separation between any wells that would be drilled, the temporary nature of any effect, and the scope for mitigation that would avoid permanent changes in site habitat outlined in Section 5.2.3 and Section 7. The 33rd licensing round would be subject to a separate HRA process which will consider the potential for in-combination effects with reference to Block-specific work programmes.
Offshore wind farms are the only type of operational or proposed renewable energy projects in the southern North Sea. In addition, the Eastern Green Link 2 and Viking Link interconnector projects are of relevance. Sources of effect from physical disturbance associated with these projects include installation of turbines (using monopile, jacket or gravity base foundations) and associated infrastructure such as interconnecting and export cables. Cables would typically be trenched and buried (e.g. in keeping with East Marine Plan policy CAB1), with protection materials used strategically at cable/pipeline crossings or should there be difficulties achieving

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

burial depth due to the nature of the shallow geology. The current timelines for project proposals (Table 6.1) indicate the potential for some temporal overlap with exploration/appraisal activity as part of the 1st carbon dioxide storage round licences, subject to the issue of licences and the timing of individual exploration/appraisal activities. There is limited overlap with Round 4 preferred projects, and as these are in a pre-application stage in planning process, it is unlikely that there would be overlap with 1st round exploration/appraisal activities. Despite the limited potential for spatial overlap, there is the potential for incremental physical effects which are discussed below. Early engagement between any carbon dioxide storage licence holder and wind farm developer can help to avoid spatial conflict, and applicants taking part in the 1st carbon storage licensing round were made aware of such relevant Crown Estate interests through links to offshore activity maps[105]. The Eastern Green Link 2 interconnector is at an early stage in planning, and is routed to avoid direct interaction with any relevant site. The Viking Link interconnector passes through the Greater Wash SPA, with construction work within the site completed in 2021; the route for the interconnector avoids all other relevant sites, including Inner Dowsing, Race Bank and North Ridge SAC, and the Dogger Bank SAC. It is not considered that adverse in-combination effects on the supporting habitats of the Greater Wash SPA from Viking Link, Eastern Green Link 2 and rig siting will occur.

The HRA for The Crown Estate's Round 4 wind leasing[106] concluded that adverse effects on site integrity could not be discounted for Dogger Bank SAC in relation to habitat loss and damage from preferred projects 1 and 2, which are almost entirely within the SAC. This was due to the long-term (~60 years) impact on the habitat extent and distribution, the limited expected potential to recover, and the current site condition which is considered to be unfavourable. Additionally, a number of other wind farms, including Dogger Bank A, B, C and Sofia, are located within the Dogger Bank SAC, with a more limited coverage of gas field infrastructure (most subject to decommissioning, see Figure 6.1) to the south of the site. The HRA for Round 4 wind leasing covered potential compensation measures for Dogger Bank including: the removal of structures which are contributing to the unfavourable status of the sandbank feature (e.g. oil and gas pipelines and related protection materials), debris removal and habitat restoration either within Dogger Bank SAC or other sandbank sites across the National Site Network (though both lacking confidence as to their viability at this stage) and reduction of pressures from other activities. The only realistic option for the reduction of impacts from other industry was considered to be removal of demersal fishing pressure, but as the MMO had already made the byelaw prohibiting the use of bottom towed fishing gear in the Dogger Bank SAC, this was not considered to be a viable compensation option. The Round 4 HRA did note some further measures that could be taken, for example, a review of the range and scale of fishing activity to understand the potential contribution additional management measures might make. While additional management measures could not be defined in the Round 4 HRA, it was considered there was the potential for additionality to the MMO's measures that could be delivered at the project level, though not directly by the developer. The extension of the site to include more Annex I sandbank habitat was also considered, though there was general lack of support for this. Despite the potential limitations of the compensatory measures proposed, the preferred projects were not discounted at this stage, although decisions on the compensation measures that will be applied have yet to be taken.

Once firm project proposals are known for the Round 4 projects, existing statutory and planning processes allow for further consideration of interactions between carbon storage and

[105] https://opendata-thecrownestate.opendata.arcgis.com/
[106] https://www.marinedataexchange.co.uk/details/3582/2022-the-crown-estate-2020-offshore-wind-round-4-plan-habitats-regulations-assessment/

other activities and, where applicable, this would be subject to project level HRA which would include in-combination assessment. As noted in Section 5.2.2 and 5.2.3, any disturbance from the drilling of wells on the Dogger Bank is considered to be temporary, and with the exception of SNS Area 5, potentially avoidable through rig siting. Where rig siting would be required within the site, and only where rig stabilisation is required, mitigation must be used to prevent permanent habitat change (see Section 5.2.3 and Section 7). As there will be no long-term change to the habitat extent, structure or function, or supporting processes on which the qualifying habitats of Dogger Bank rely, it is not considered that these represent an in-combination effect with the permanent habitat changes identified for the Round 4 projects.

In addition to Round 4, The Crown Estate also undertook an HRA covering a number of wind farm extensions, which was concluded in 2019. Likely significant effects were determined for projects in relation to effects on the Annex I habitat of the Wash and North Norfolk Coast SAC and, North Norfolk Sandbanks and Saturn Reef SAC. For each of the sites, conclusions of no adverse effect were determined, including in-combination, through the adoption of a Cable Route Protocol as part of plan-level mitigation, in addition to not awarding rights to the Race Bank extension project due to adverse effects on the Inner Dowsing, Race Bank and North Ridge SAC[107]. The Cable Route Protocol contains requirements for offshore wind developers in the planning of offshore export cable routes, compliance for which is secured through offshore wind agreements for lease. An adverse effect on site integrity was concluded for the Wash and North Norfolk Coast SAC and the North Norfolk Sandbanks and Saturn Reef SAC in relation to Hornsea Project Three, specifically in relation to habitat loss and modification associated with cable protection. A Sandbank Implementation Plan was submitted as part of the planning process for the project which sets out mitigation and compensation measures, in keeping with its Development Consent Order (DCO) requirements, and was approved in April 2022. While there is the potential for in-combination effects between the above projects and the areas applied for in the 1st Carbon Storage Licensing Round, as the effects of rig siting are temporary, noting that for some licence areas there is considerable potential to avoid any interaction with sites, or else implement mitigation that avoids permanent habitat change, adverse in-combination effects will not occur.

In response to increasing offshore and onshore environmental and social challenges, and in particular in relation to the radial approach to offshore wind farm export cabling to date, the Offshore Transmission Network Review (OTNR) was launched in 2020[108]. The project is led by the Department with support from a number of other UK Government departments, devolved administrations, The Crown Estate and Crown Estate Scotland, the ESO and Ofgem. The OTNR has three workstreams which relate to wind farms at various stages of development, which are Early Opportunities (identify and implement changes which can be made in the immediate term), Pathway to 2030, and the Enduring Regime (Focussed on projects to be delivered after 2030). The Holistic Network Design (HND) project led by National Grid ESO was undertaken as part of the Pathway to 2030 workstream and is based around the principles of cost to consumers, deliverability and operability, environmental impact and impact on communities. The HND makes recommendations on potential location of infrastructure including offshore cable route corridors but this does not limit the detailed design process. Any final version of the HND, or elements of it, which are implemented in relation to specific Round 4, ScotWind, or other wind farm projects, is uncertain, however, the HND does

[107] https://www.marinedataexchange.co.uk/details/628/2019-the-crown-estate-2017-offshore-wind-extensions-plan-habitats-regulations-assessment-hra/
[108] https://www.gov.uk/government/groups/offshore-transmission-network-review

identify a number of SACs and SPAs of relevance the this HRA which will be unavoidable. These are: Dogger Bank SAC, Southern North Sea SAC, and Greater Wash SPA.

The Round 4 HRA considered the potential for adverse effects from export cabling on site integrity for sites including Dogger Bank SAC, Southern North Sea SAC, and Greater Wash SPA. As noted above, adverse effects on Dogger Bank SAC could not be discounted, but for the other sites listed above, mitigation was considered possible to avoid a conclusion of adverse effects. While there is the potential for in-combination effects with any wind farm export infrastructure associated with projects within the scope of the HND, the duration of the licence terms for the 1st Carbon Storage Round are such that there is limited potential for interaction. In addition, the stage of development of these projects and any detailed network design limits the ability to meaningfully assess the nature and scale of any in-combination effects. With the exception of Dogger Bank SAC, the mitigation identified in Section 5.2.4 and 5.2.4 is considered to be sufficient to conclude that adverse effects on the integrity of the Greater Wash SPA and Southern North SAC will not occur.

It was concluded in Section 5.2.2 that alone, the licensing of SNS Areas 1, 5 and 7 would not result in an adverse effect on the integrity of the Dogger Bank SAC as, subject to mitigation, there would be no permanent change in the structure or extent and distribution of the Annex I sandbanks habitat from exploration/appraisal activities. While the 1st carbon storage licence round areas applied for cover a significant portion of the Dogger Bank SAC, the intra-plan in-combination effects consideration (Section 5.2.2) noted that exploration/appraisal drilling may lead to temporary disturbance of up to 3.2km^2 or 0.03% of the overall site area. For the North Norfolk Sandbanks and Saturn Reef SAC, the coverage would be up to 3.2km^2 or 0.09% of temporary disturbance. As noted in Section 5.2.3, mitigation will be required to avoid the placement of rig stabilisation materials that would represent a permanent change to the habitat. It is considered that the minor and short-term disturbance generated by exploration/appraisal drilling, should this occur in the Dogger Bank SAC, will not result in adverse in-combination effects with other plans or programmes, when considered in the context of the mitigation already set out in Section 5.2.3, which is, that should rig stabilisation be required, removable methods must be used, subject to technical and safety considerations, and project level assessment. The only area applied for which is of relevance to the Wash and North Norfolk Coast SAC is SNS Area 3, for which there is only a small overlap (see Figure 5.2). There is considerable scope for any rig to be sited outside of the SAC, which would allow the avoidance of any direct impact on the site and would exclude any source of potential in-combination effect. In keeping with the proposed mitigation measures above, should any direct interaction with the site be necessary as part of drilling an exploration/appraisal well, and in the event that rig stabilisation is required, this must use removeable methods, subject to technical and safety requirements, and project level assessment, as noted in Section 5.2.3.

All of the areas applied for were identified on the basis of a potential for likely significant effect in relation to the Southern North Sea SAC, and were considered in Section 5.2.2. The proposed export cable for Hornsea Project Three passes through SNS Area 8, which is located within both the Southern North Sea SAC and the North Norfolk Sandbanks and Saturn Reef SAC. As noted above, none of the areas applied for substantially overlap any proposed wind farm, with activity within any active wind farm already precluded, however, in relation to proposed cables, the ability to locate any rig away from these will avoid the potential for in-combination effects, and further mitigation is available through activity timing/phasing, such that those sources of physical effect from wind farm installation and operation (e.g. as described in Section 5.4.3 of the OESEA4 Environmental Report, BEIS 2022) are not compounded by rig installation. The HRA for Round 4 proposed projects, which included three overlapping the Southern North Sea SAC, considered any physical effects of wind farm installation and operation on the site, alone or in-combination with other plans and projects, were negligible and would not lead to an adverse effect on site integrity. As noted in Section 5.2.2 (also see Table 2.2), the footprint of any drilling rig would be small and temporary, and in relation to the Southern North Sea SAC, the maximum potential area potentially affected by disturbance across all the areas applied for is 8.8km^2 or <0.02% of the site, though this is likely to be less given that some areas (e.g. SNS Area 3, SNS Area 5) are largely outside of the SAC. In view of the temporary nature of any effects from drilling rig placement or discharges (see below) and the very small area which could be subject to habitat change from the use of rock placement for rig stabilisation (0.0001% of the site), if required, there would be no adverse in-combination effects on the Southern North Sea SAC from these activities. Plan level mitigation has been identified for sites which overlap large portions of the Southern North Sea SAC, including the Dogger Bank SAC and North Norfolk Sandbanks and Saturn Reef SAC (see Section 5.2.3), such that stabilisation materials, if required, must be removable. That mitigation would, by association, apply to the Southern North Sea SAC where these overlaps occur.

With respect to drilling discharges, previous discharges of WBM cuttings in the UKCS have been shown to disperse rapidly and to have minimal ecological effects (See Section 4.2, also see individual site assessments in Section 5.2.2). Dispersion of further discharges of mud and cuttings could lead to localised accumulation in areas where reduced current allows the particles to accumulate on the seabed, however given the relatively shallow water depths (generally <50m), moderate tidal currents and potential for storm wave base interactions across the areas applied for (e.g. Klein *et al.* 1999), accumulations of cuttings piles are not considered likely from exploration/appraisal activity (see Section 5.2.2) or in-combination with other exploration and development wells associated with extant carbon dioxide storage licences, or licences associated with gas exploration. Additionally, the potential for in-combination effects relating to chemical usage and discharge from exploratory drilling is limited by the existing legislative and permitting controls that are in place (see Section 2.3.1 and 5.2.3), which the UK Marine Strategy[109] has identified as relevant measures contributing to managing discharges. Discharges are considered unlikely to be detectable and to have negligible in-combination effect (BEIS 2022a).

Advice on operations for the Dogger Bank SAC and Southern North Sea SAC (see Sections 5.2.2 and 5.2.3) both identify that the sites are sensitive to commercial fisheries, though for the latter the focus is harbour porpoise bycatch and removal of prey species. It is not regarded that the nature and scale of exploration/appraisal activities would result in a significant in-combination effect with porpoise bycatch. Physical disturbance related pressures from fisheries for which the Dogger Bank has been assessed as sensitive are relevant for those sources of effect from carbon dioxide storage activity (noted in Section 4.2 and assessed in Section 5.2.2), and the potential for in-combination effects with fisheries are considered below.

Fishing, and particularly bottom trawling, have historically contributed to seabed disturbance over extensive areas and was identified as an ongoing issue in the UK assessment of good environmental status[110]. Depending on the nature of future measures (e.g. in relation to MPA management in the wider environment and within MPAs), such effects are likely to be reduced and therefore some improvement in benthic habitats could be expected. A number of byelaws have recently been imposed on conservation sites which effectively prohibit the use of certain

[109] https://www.gov.uk/government/consultations/marine-strategy-part-three-programme-of-measures Note that the updated programme of measures is due to be published by the end of 2022.
[110] https://consult.defra.gov.uk/marine/updated-uk-marine-strategy-part-one/supporting_documents/UKmarinestrategypart1consultdocumentfinal.pdf

gears in all or part of certain SACs, including the Dogger Bank SAC and The Inner Dowsing, Race Bank and North Ridge SAC[111]. 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[112]; of most relevance to this assessment is the North Norfolk Sandbanks and Saturn Reef SAC. While there is limited information on the timescale under which the fisheries management measures could lead to a change in the condition of the sandbank feature of the site, recovery would be expected in the coming years.

Whilst fishing may be linked to historical damage to site features, and presents a continuing risk to these, recent, ongoing, and future management measures should limit the potential for in-combination effects with other activities. Exploration/appraisal drilling for carbon dioxide exploration/appraisal is analogous to similar oil and gas activities (see Sections 1 and 2). When any surface structure (fixed and floating installations) used for exploration/appraisal drilling becomes operational, a safety zone with a radius of 500m is created under the amendment to the *Petroleum Act 1987* made by the *Energy Act 2008* and other activities are excluded from taking place within the zone, including fisheries. Safety zones apply to mobile drilling rigs and are notified to other users of the sea (e.g. through notices to mariners and Kingfisher charts). In view of the differences in relative scale of physical impacts resulting from trawling and from carbon dioxide exploration/appraisal (both spatially and temporally), significant incremental effects following the licensing of 1st Round carbon dioxide storage areas are not predicted.

Marine aggregate extraction areas, relevant sites and areas offered are shown in Figure 6.2. 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. As noted in Table 6.1, dredging intensity over these areas has been generally low to medium in recent years (TCE & BMAPA 2022, also see TCE & BMAPA 2018). Additionally, two areas of relevance to the Greater Wash SPA (covered by Area 2103) may be offered exploration and option agreements, subject to HRA, in the 2021/2022 aggregates leasing round[113]. Analogous to the advice provided in relation to offshore wind farms, applicants should make contact with the relevant aggregate companies in order that any proposed carbon dioxide storage exploration/appraisal activity is undertaken in co-operation with the relevant lease or licence holders. While there is substantial overlap with these areas and SNS Area 3 in particular, there is the potential to site rigs away from aggregate extraction areas, and the nature and scale of physical effects associated with activity which may follow licensing is considered to be temporary, subject to the application of mitigation (see Sections 5.2.2 and 5.2.3). In-combination impacts which could lead to adverse effects on the integrity of sites considered in this AA, are not anticipated.

6.2.2 Physical presence

Physical presence of offshore infrastructure and support activities may potentially cause behavioural responses in fish, birds, and marine mammals (see Section 5.6 of BEIS 2022a). Previous SEAs have considered the majority of behavioural responses resulting from

[111] 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
[112] https://www.gov.uk/guidance/marine-conservation-byelaws#new-mmo-byelaws
https://consult.defra.gov.uk/mmo/call-for-evidence-stage-2/
[113] https://www.thecrownestate.co.uk/en-gb/media-and-insights/news/2022-the-crown-estate-confirms-areas-selected-for-202122-marine-aggregates-tender-round/

interactions with offshore oil and gas infrastructure (whether positive or negative) to be insignificant; in part because the number of surface facilities is relatively small (of the order of a few hundred) and because the majority are at a substantial distance offshore; rigs used for carbon dioxide storage exploration/appraisal will be of the same type as those used in oil and gas exploration. The larger numbers of individual surface or submerged structures associated with offshore wind developments, the presence of rotating turbine blades and considerations of their location and spatial distribution (e.g. in relation to coastal breeding or wintering locations for waterbirds and important areas for marine mammals), indicate a higher potential for physical presence effects.

Potential displacement and barrier effects, particularly for birds, have been an important consideration at the project level for the large offshore wind developments that are planned for the area of the southern North Sea (Figure 6.2) and formed an important part of associated HRAs. Additional in-combination physical presence effects are possible with proposed wind farm project extensions and/or any projects arising from Round 4 of wind leasing. As noted above, plan level HRA has been completed for both the extension projects and Round 4 preferred projects, and any subsequent projects will be subject to their own HRA processes. One of the major concerns relating to sites considered in this assessment, and in particular for Flamborough and Filey Coast SPA, is seabird mortality related to collision risk with turbines, and displacement of species (mainly auks including razorbill and guillemot). With regards to the former, advice on operations for the site, while noting the qualifying interests are sensitive to, *collision above the water with static or moving objects not naturally found in the marine environment (e.g., boats, machinery, and structures)*, indicate that exploration activities pose a low risk, and the temporary presence of a rig is not considered to be likely to act in-combination with operating wind farms such that it would lead to significant disturbance of birds and related mortality.

For the Southern North Sea SAC, shipping is noted to be a source of pressures including underwater noise (see Section 5.2.5) and death or injury by collision, with the latter not being considered a significant risk that requires management (JNCC 2016). Disturbance of red-throated diver and common scoter associated with the Greater Wash SPA is possible both in relation to support vessel movements and the presence of a drilling rig in parts of SNS Area 3 (see Section 5.2.2). Any sensitivity is limited to the winter months and may be avoided if activities take place outside of this period. SNCB advice[114] suggests displacement 4km and 2km for red-throated diver and common scoter respectively from vessels, and any displacement taking place as a result of carbon dioxide exploration/appraisal could be of this scale. A number of wind farms in or partly within the Greater Wash SPA including Humber Gateway, Westermost Rough, Race Bank, Lincs, Lynn and Inner Dowsing, are likely to present some form of displacement to divers within the Greater Wash SPA, though the scale of this displacement is not certain (see Section 4.2.3) as is any population level effect (see Section 5.2 and Vilela *et al.* 2022). There are established vessel approaches and anchorages associated with The Wash and the Humber, and routes between these and other ports in the UK and Europe, and offshore oil and gas infrastructure, which likely represent a baseline level of disturbance in advance of the Greater Wash SPA being designated, with some additional disturbance since then associated with wind farm operation and maintenance traffic. Vessel traffic in these routes is moderate to high (Figure 6.3), and the increment of two to three vessels per week is unlikely to represent a significant in-combination level of effect. The installation of Viking Link involved a cable lay barge or vessel activity in the nearshore and through the Greater Wash SPA, though as the first 51km of the cable was installed in summer 2021, with some post-cable lay works completed by October 2021, any in-combination

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

disturbance related effects with the siting of a drilling rig in SNS Area 3 is not considered possible. As noted in Section 5.2.2, JNCC/NE advise that displacement buffers of 2km and 2.5km are applied at the project level for the assessment of effects of vessel traffic on red-throated diver and common scoter respectively. This should be considered at the project level once project plans are known (see Section 7). The Outer Thames Estuary SPA was screened in for consideration by association with the Greater Wash SPA and the likelihood that birds move between these areas, however, the focus is on the potential for adverse effects on birds in the Greater Wash SPA. It is not regarded that the temporary addition of a drilling rig and associated shipping of a scale outlined in Table 2.2 will lead to adverse effects on site integrity for any of the relevant sites considered in this AA for which physical presence was identified as a potential source of likely significant effect (see Table 1.2).

6.2.3 Underwater noise effects

A number of projects are relevant to the consideration of in-combination effects with activities which may follow the licensing of the areas applied for (Table 6.1). The associated activities can generate noise levels with the potential to result in disturbance or injury to animals associated with relevant sites (see BEIS 2022a).

Of most relevance to the areas being considered are a series of Round 3, Round 4, and Round 2 extension wind farms. While the operation, maintenance and decommissioning of offshore wind energy developments will introduce noise into the marine environment, these are typically of low intensity compared to installation. The greatest noise levels arise during the construction phase, and it is these which have the greatest potential for acoustic disturbance effects (see BEIS 2022). Pile-driving of mono-pile foundations or pin piles used in jacket-type foundations is the principal source of construction noise, which will be qualitatively similar to pile-driving noise resulting from harbour works, bridge construction and oil and gas platform installation. Mono-pile foundations are the most commonly used for offshore wind farm developments in the southern North Sea to date (including in the studies looking at the effect of wind farm construction on harbour porpoise behaviour, as discussed in Section 4.3.2). However, for some proposed developments, sufficient flexibility in foundation type remains in their Development Consent Orders to allow for the potential use of gravity base and even tethered foundations, which would result in less noise on installation. The final selection of foundation type is uncertain for some developments as this will be subject to detailed design.

Of those wind farms listed in Table 6.1, the Dogger Bank A and B and Sofia developments and Hornsea Project Three are scheduled for construction from 2023 (see Section 2.5 and Appendix 1h of BEIS 2022[115]). A number of other developments are in the pre-application stage. These projects, if executed, are expected to result in temporary changes in harbour porpoise distribution and a reduction of foraging activity for those individuals within the impacted area. However, assessment of the integrity of the site must be undertaken with respect to the site contributing to maintaining the Favourable Conservation Status of the wider harbour porpoise population. It follows that projects across the whole North Sea Management Unit are therefore also relevant.

While progress is being made in estimating population-level effects of disturbance on marine mammals, the degree of uncertainty in extrapolating from individual empirical observations to modelled population estimates is still high. In particular, there remains very limited empirical data to support quantification of the links between physiological and behavioural changes (e.g.

[115] Also see: RenewableUK Offshore Wind Project Timelines (October 2020): https://www.renewableuk.com/news/532483/Offshore-Wind-Project-Timelines.htm

hearing loss, displacement) and changes in vital rates (e.g. survival, fertility), although updates to expert elicited values in iPCoD are noted (Booth & Heinis 2018, Booth *et al*. 2019). It has not yet been possible to establish criteria for determining limits of acceptable cumulative impact at the UK or EU level, but the collation of data through the Marine Noise Registry (https://mnr.jncc.gov.uk/) has been an important first-step. The Department is cognisant of the ongoing efforts to implement the UK's Marine Strategy and will review the results of the ongoing process closely with respect to the consenting of relevant activities which may result from future licensing, as well as other activities which generate noise in the marine environment.

A review of consents HRA was undertaken for six OWFs in relation to the Southern North Sea SAC, which included those which had not yet commenced operations or had HRAs undertaken in advance of the site being classified (Dudgeon, Greater Gabbard, Galloper, Hornsea Two, Dogger Bank A and B, Dogger Bank C and Sofia). This review augmented those HRAs already undertaken for these projects, specifically considering effects in relation the Southern North Sea SAC alone and in-combination with other projects, including those other OWFs of relevance to the wider site, and oil and gas activities. The HRA concluded that while the OWF projects assessed have the potential to generate likely significant effects for the site, adverse effects on site integrity will not occur alone or in-combination with other plans or projects (including that of existing oil and gas activities such as drilling and seismic survey), subject to mitigation measures secured through relevant Development Consent Orders and deemed Marine Licences (including a Site Integrity Plan)[116].

Significant in-combination underwater noise effects on the harbour porpoise feature of the Southern North Sea SAC are considered to be unlikely given the spatially limited, temporary nature and limited scale of noise generating activity associated with the exploration/appraisal activities associated with areas applied for (see Section 5.2.5), and that there is significant scope to avoid concurrent OWF construction[117], any survey associated with the 33rd seaward licensing round (the scale of which is presently unknown), and exploration well site survey activity either through dialogue with relevant lease/licence holders or by virtue of wind farm construction timelines, and through measures such as the SNS Activity Tracker (see below). Piling can be detrimental to seismic data collection, and these activities would not therefore be undertaken concurrently in close proximity. In addition to piling, unexploded ordnance (UXO) is commonly disposed of during offshore wind farm installation. UXO detonations have the potential to cause significant injury or death to marine mammals (Robinson *et al.* 2022) and project developers are bound by health and safety legislation to manage and reduce this risk, though low order techniques are available (e.g. Robinson *et al.* 2020) for which the Department and a number of other UK Government and Devolved administration departments have published recommendations in the form of a joint interim position statement[118].

The recent SNCB guidance on assessing the significance of noise disturbance against conservation objectives of harbour porpoise SACs (JNCC *et al*. 2020) presents thresholds for daily and seasonal disturbance as a proportion of the site from which harbour porpoise may be excluded. This gives a mechanism for assessing the potential in-combination effects of low frequency impulsive noise on the Southern North Sea SAC across multiple sources and industries. For example, in-combination effects with further wind farm construction of

[116] See the related proposed marine licence conditions for the Southern North Sea SAC: https://www.gov.uk/government/consultations/southern-north-sea-sci-proposed-marine-licence-condition
[117] Note that the encounter rate of UXO and its nature is uncertain and disposal operations are subject to separate marine licensing.
[118] https://www.gov.uk/government/publications/marine-environment-unexploded-ordnance-clearance-joint-interim-position-statement/marine-environment-unexploded-ordnance-clearance-joint-interim-position-statement

relevance to the site, in the context of the disturbance thresholds, can be partly addressed through the Site Integrity Plans required for certain offshore wind farms, where a baseline of activities that may act in-combination with wind farm activities to breach the thresholds must be maintained. The Department do not currently expect this guidance to be applied to industry applications involving mobile noise sources, and its application here is limited by uncertainty in the extent, location and timing of activities which may follow licensing of any of the areas applied for. However, its implementation for comparative purposes in the recent HRA for the planned ION 3D seismic survey (BEIS 2020b) illustrates how it can be used at the activity-specific stage to consider the nature and timing of relevant activities in an assessment of in-combination noise effects on a harbour porpoise SAC.

As noted in Section 6, in keeping with relevant marine plan policies, it is expected that early engagement between carbon storage licence holders and offshore wind farm developers would allow for activities to take place while avoiding potential in-combination effects. Further HRA will be undertaken, where appropriate, at the activity-specific level which will allow for the consideration of the spatial and temporal scope of seismic survey, including in-combination with other relevant projects.

There is the potential for seismic surveys to take place in areas covering parts of the areas applied for, or in areas close to or adjacent to these, under non-exclusive exploration licences. The timing, location and scale of other such surveys are unknown and a meaningful assessment of these cannot be made at this time, but they will be subject to activity-specific permitting, including, where appropriate, HRA. Such surveys would be captured in the UK Energy Portal, and in relation to the Southern North Sea SAC, in the SNS Activity Tracker[119], which assist in the consideration of project level in-combination effects. The Department (with other Government Departments and Regulators) has also recently requested that oil and gas operators who plan to undertake noise producing activities in the 2023 summer season for the site, but for which an application has not yet been made, provide details of their proposals as part of their ongoing commitment to manage impulsive noise within the Southern North Sea SAC, and to understand the potential for in-combination effects[120].

These considerations and conclusions are also applicable to other relevant sites and features considered in this AA for underwater noise, including diving birds (The Greater Wash SPA, The Wash SPA, The North Norfolk Coast SPA and Outer Thames Estuary SPA), grey and harbour seal features (The Humber Estuary SAC and The Wash and North Norfolk Coast SAC) and SACs of adjacent states; such that adverse in-combination effects on site integrity are not predicted.

In addition to those activities which may follow licensing of the areas applied for in the southern North Sea and the other potentially relevant projects listed in Table 6.1, there are a variety of other existing (e.g. gas production, fishing, shipping, military exercise areas, wildlife watching cruises) and planned (e.g. oil and gas exploration and production) noise-producing activities in overlapping or adjacent areas. Despite this, the Department is not aware of any projects or activities which are likely to cause cumulative and in-combination effects that, when taken in-combination with the potential number and scale of activities likely to result from the licensing of the areas applied for (Section 2.2), would adversely affect the integrity of the relevant sites. This is due to the presence of effective regulatory mechanisms (Section 5.2 and also Appendix 3 of BEIS 2022a) which ensure that operators, the Department, and other relevant consenting

[119] https://www.gov.uk/guidance/oil-and-gas-offshore-environmental-legislation#offshore-petroleum-activities-conservation-of-habitats-regulations-2001-as-amended
[120] https://www.gov.uk/government/publications/oil-and-gas-opred-communications

authorities take such considerations into account during activity permitting. These mechanisms generally allow for public participation in the process[121].

6.2.4 Conclusion

While exploration activity is identified as a pressure to which most of the sites considered in this assessment are sensitive (e.g. from physical effects or underwater noise), with SACO's for some identifying oil and gas infrastructure as contributing to unfavourable feature condition, though this is generally associated with pipelines or platforms which represent long-term or permanent changes to site habitat, which exploration activities would not. Available evidence (see e.g. UKBenthos database, OSPAR 2010 and the 2017 intermediate assessment) for the southern North Sea indicates that past oil and gas activity and discharges has not led to adverse impacts on the integrity of European sites in the area, noting that discharges associated with exploration or appraisal drilling for carbon dioxide storage will be broadly similar.

Any activities relating to the work programmes, and any subsequent development that may occur if site appraisal is successful, will be judged on its own merits and in the context of wider development in the North Sea (i.e. any potential incremental effects). The current controls on terrestrial and marine industrial activities, including activities that could follow licensing, can be expected to prevent significant in-combination effects affecting relevant sites.

The Department will assess the potential for in-combination effects whilst considering project-specific EIAs and, where appropriate, through HRAs. This process will ensure that mitigation measures are put in place to ensure that activities, if consented, will not result in adverse effects on integrity of the relevant sites. Therefore, it is concluded that the in-combination effects from activities arising from the licensing of the areas applied for in the 1st Carbon Dioxide Storage Licensing Round, with those from existing and planned activities in the southern North Sea, will not adversely affect the integrity of relevant Sites.

6.3 Eastern Irish Sea

Table 6.2: Projects relevant to the in-combination effects assessment for the eastern Irish Sea

Relevant project	Project summary	Project status/indicative timing	Relevant sites[1]
Offshore renewables and interconnectors			
Walney	Located approximately 14km from the Cumbrian coast, the project area contains 101 turbines with an overall installed capacity of 367MW. The export cable landfalls are near Heysham and Fleetwood.	In-operation	Liverpool Bay SPA
Walney extension	Located approximately 19km from the Cumbrian coast, and to the north west of the Walney I and II windfarms, the extension is due to have an installed capacity of 659MW generated from 87 turbines. The export cables are routed to the south of the Walney and West of Duddon Sands wind farms and have a landfall near Heysham.	In-operation	Liverpool Bay SPA

[121] *Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020*

Relevant project	Project summary	Project status/indicative timing	Relevant sites[1]
West of Duddon Sands	West of Duddon Sands is located approximately 14km offshore, and contains 108 turbines, with an overall installed capacity of 389MW. The export cable landfall is at Heysham.	In-operation	Liverpool Bay SPA
Barrow	Located approximately 7km from the Cumbrian coast, the project area contains 30 turbines and together have an overall installed capacity of 90MW. The wind farm export cable runs in parallel with those of the Ormonde, West of Duddon sands and Walney I offshore wind farms in the nearshore, having its landfall near Heysham.	In-operation	Liverpool Bay SPA
Burbo Bank	Located approximately 7km from the coast, with a cable landfall at Wallasey. Has an installed capacity of 90MW generated by 20 turbines.	In-operation	Liverpool Bay SPA
Burbo Bank extension	Located approximately 7km from the coast, with a cable landfall between Rhyl and Prestatyn. Has an installed capacity of 258MW generated by 32 turbines.	In-operation	Liverpool Bay SPA
Gwynt y Môr	Located approximately 13km from the coast, with a cable landfall at Pensarn. Has an installed capacity of 574MW generated by 160 turbines. The Crown Estate has indicated an extension with an installed capacity of up to 576MW has been applied for.	In-operation	Liverpool Bay SPA
Awel y Môr	The proposed wind farm is located immediately to the west of Gwynt y Môr, and may include 34-50 turbine. The overall capacity of the wind farm has not been set.	In-planning	Liverpool Bay SPA
North Hoyle	Located approximately 7km from the coast, with a cable landfall at Rhyl. Has an installed capacity of 60MW generated by 30 turbines.	In-operation	Liverpool Bay SPA
Rhyl Flats	Located approximately 8km from the coast, with a cable landfall at Towyn. Has an installed capacity of 90MW generated by 25 turbines.	In-operation	Liverpool Bay SPA
Round 4 preferred project area 5	The proposed project area covers 126km2 and has a potential installed capacity of 480MW. No firm project plans, including the scale and number of turbines or any export cable route, have been made.	Pre-planning	Liverpool Bay SPA
Gas storage			
Carbon Storage Licence CS004	The carbon storage licence was awarded in 2020 for an appraisal period of six years, with site characterisation due to be completed by 2023.	Pre-planning	Liverpool Bay SPA
Bains gas storage licence	A gas storage licence was applied for in June 2022 covering the depleted Bains gas storage field and was awarded in April 2023. No other details of the proposed work programme are known.	Licence awarded	Liverpool Bay SPA

Relevant project	Project summary	Project status/indicative timing	Relevant sites[1]
Oil and gas decommissioning			
Morecambe gas fields	The Morecambe Hub incorporates a number of manned and unmanned platforms and export infrastructure which is processed at the Barrow gas terminal.	In operation	Liverpool Bay SPA
South Morecambe decommissioning project	The decommissioning programme for South Morecambe DP3 and DP4 involved the removal of topsides and jackets to shore, with buried pipelines remaining *in situ*, and exposed sections being removed.	Completed	Liverpool Bay SPA
33rd seaward oil and gas licensing round	115 bids across 258 UKCS Blocks or part-Blocks were received as part of the 33rd Round, covering parts of the eastern Irish Sea.	Licence applications are being considered by NSTA.	All EIS sites relevant to this assessment,
Aggregate areas			
Aggregate areas 393 and 1808	As part of the wider north west region, 3.44km^2 were actively dredged in 2021, representing 3.97% of the total licensed area, with 90% of effort in 1.82km^2. Dredging intensity in the 393 area is considered to be high, covering 0.12km^2, with the wider remaining area being low to moderate. Area 1808	Active production areas	Liverpool Bay SPA

Sources: relevant Development Consent Orders and related post-consent modifications (https://infrastructure.planninginspectorate.gov.uk/), BEIS oil & gas: decommissioning of offshore installations and pipelines (https://www.gov.uk/guidance/oil-and-gas-decommissioning-of-offshore-installations-and-pipelines), TCE & BMAPA (2022), TCE Open Data Portal (https://thecrownestate.maps.arcgis.com/apps/webappviewer/index.html?id=b7f375021ea845fcabd46f83f1d48f0b), NSTA carbon storage public register (https://www.nstauthority.co.uk/licensing-consents/carbon-storage/), NSTA gas storage and unloading webpage (https://www.nstauthority.co.uk/licensing-consents/gas-storage-and-unloading/)

Notes: [1] those sites considered to be relevant to 1st carbon dioxide storage round exploration activities.

Figure 6.4: Location of areas applied for in relation to other projects in the Eastern Irish Sea

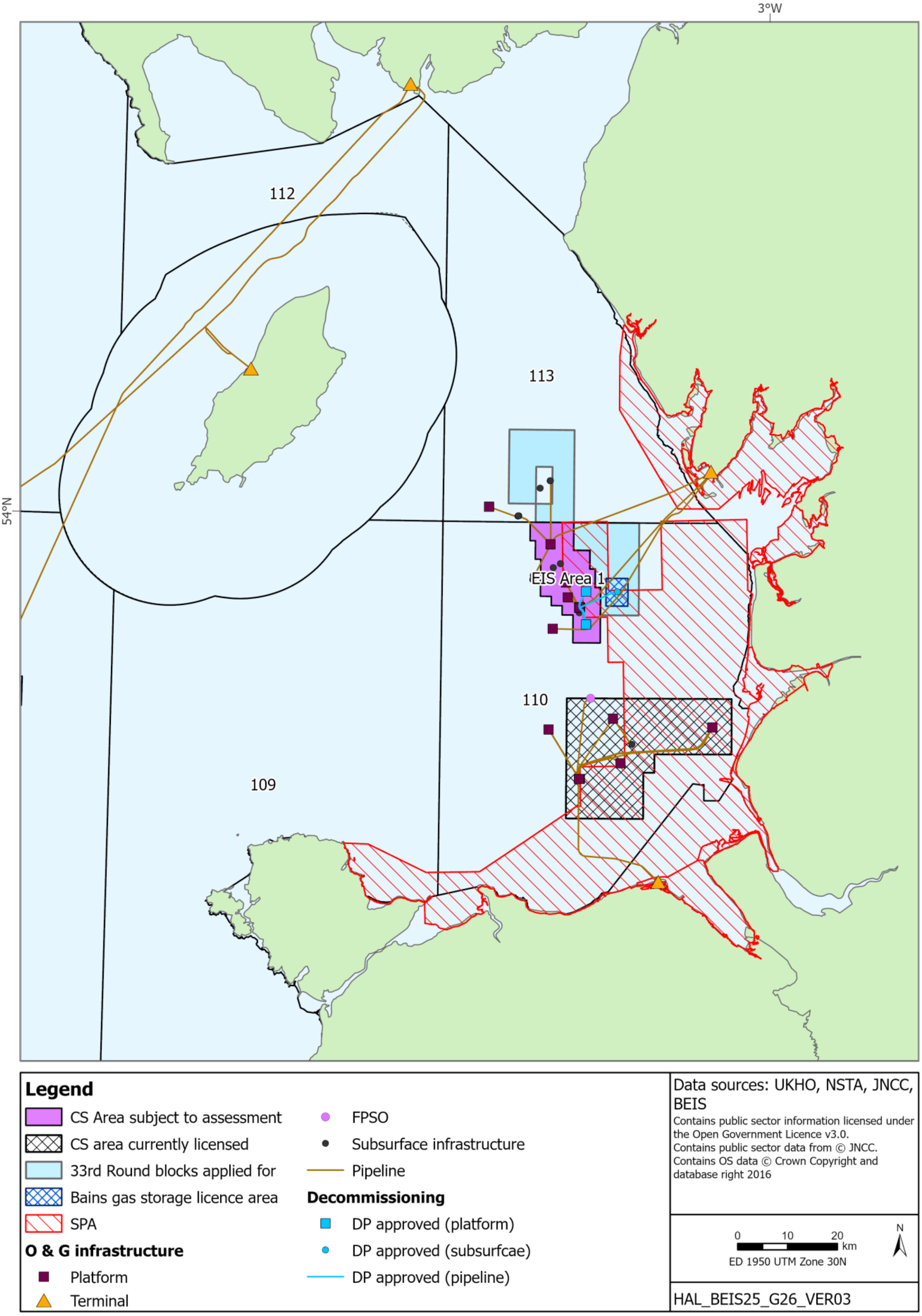


Figure 6.5: Location of areas applied for in relation to other projects in the Eastern Irish Sea (continued)

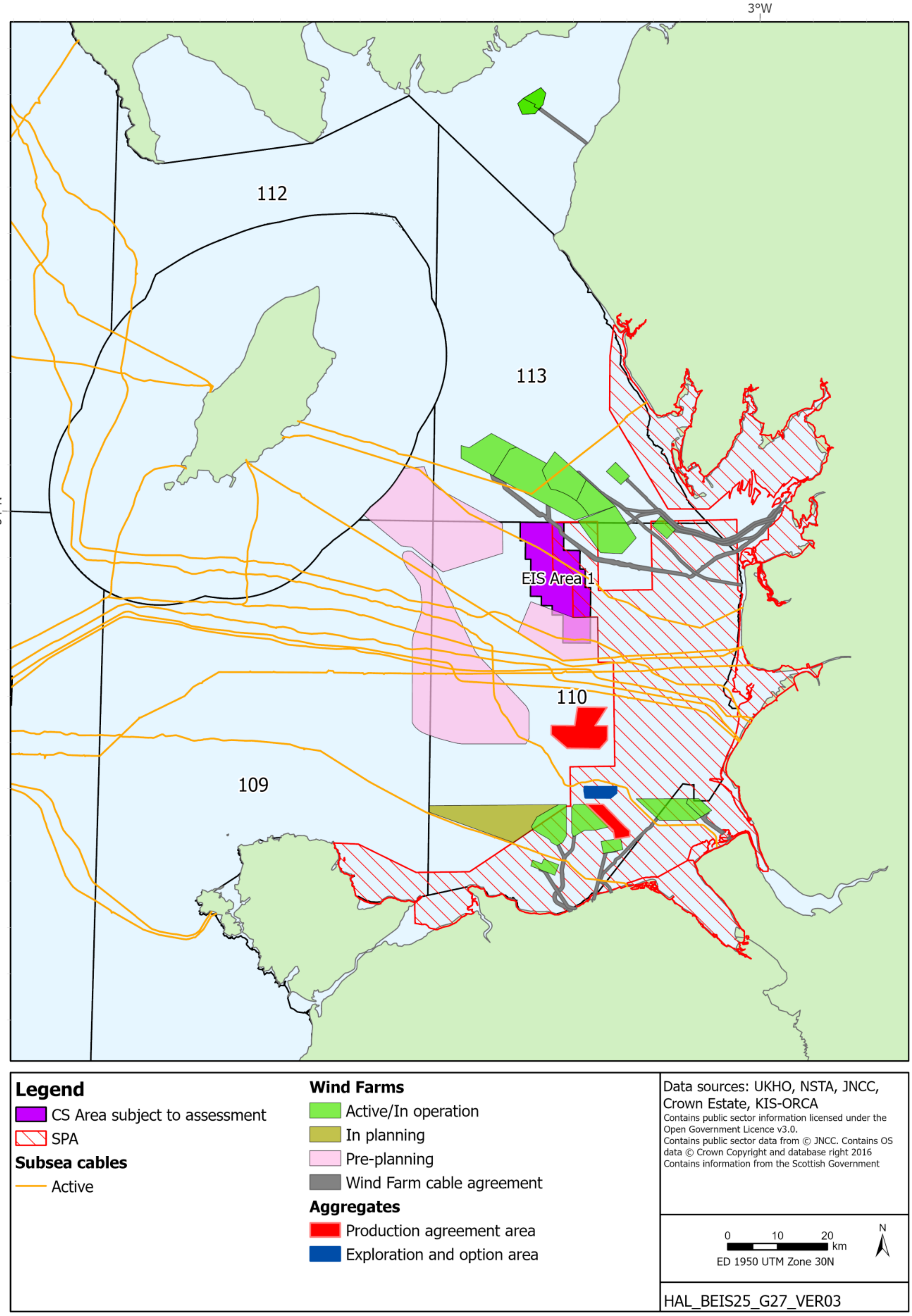
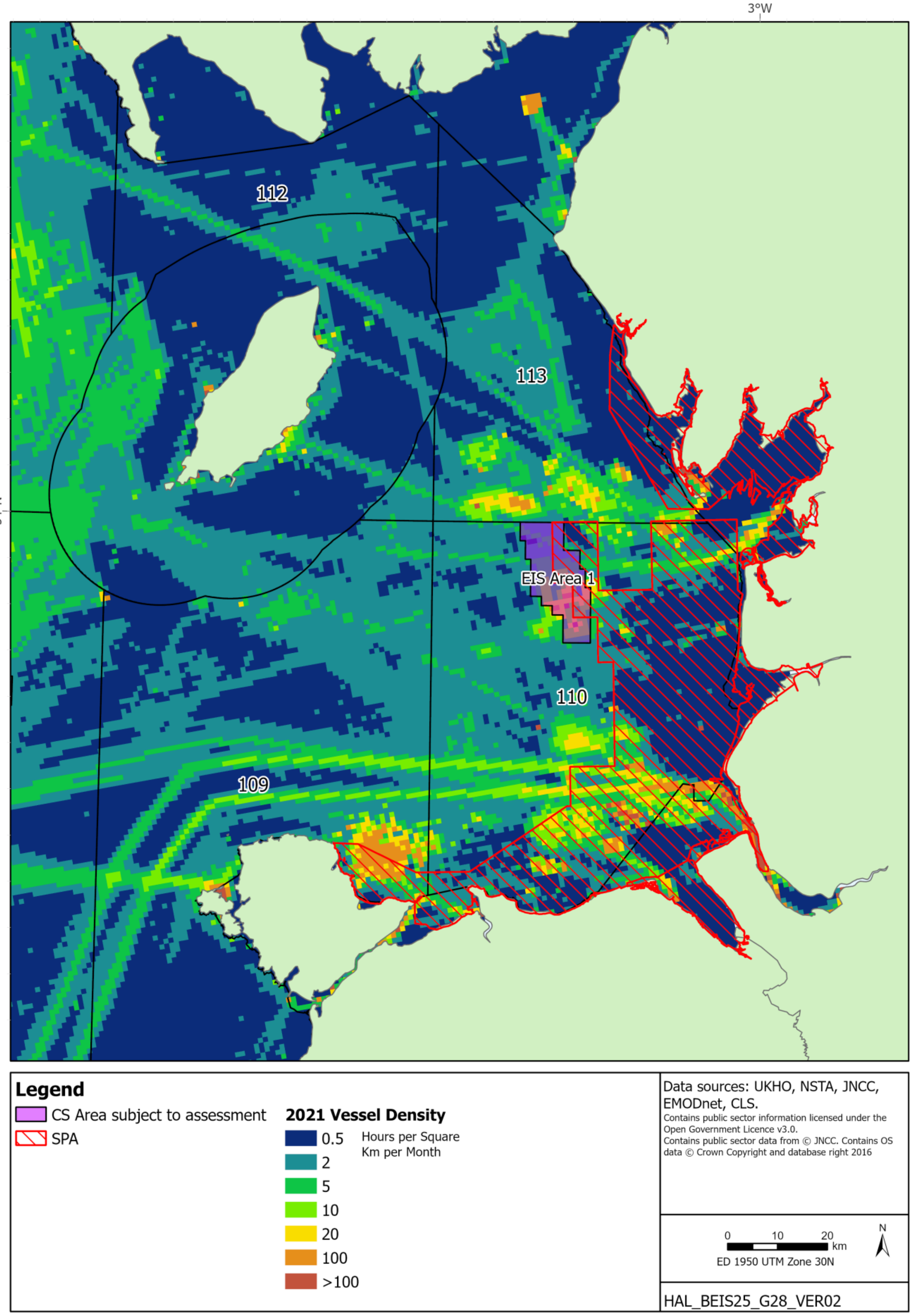


Figure 6.6: Vessel traffic in the Eastern Irish Sea



6.3.1 Physical disturbance and drilling effects

The pressures which may result from exploration activities that could result from licensing and cause physical disturbance and drilling effects on the relevant sites were described in Section 4.2 and Section 5.3. The conclusions of Section 5.3 are considered in the following section in the context of those relevant projects identified in Table 6.2 above.

Oil and gas infrastructure associated with the Morecambe Hub is largely coincident with EIS Area 1; two unmanned platforms associate with the South Morecambe field, DP3 and DP4, were removed in 2021 (Figure 6.5) but no further decommissioning plans have been submitted for other installations associated with the hub. As noted in Section 5.3, there is the potential to undertake injectivity tests associated with the work programme for EIS Area 1 using one of the existing wells associated with the Morecambe area fields, however, for the purposes of this assessment it has been assumed that a new well would be drilled. The Morecambe field installations are well-established, and in the absence of any further project plans for the fields, in-combination effects on the Liverpool Bay SPA from the drilling on a single well are not anticipated. Two blocks applied for in the 33rd seaward oil and gas licensing round are located immediately adjacent to EIS Area 1 (Figure 6.4). The details of the proposed work programmes for the licences are presently not known but may include the drilling of a well. The only site for which an in-combination effect is considered to be possible is the Liverpool Bay SPA, with the area used by wintering little gull overlapping both parts of the Blocks applied for, and the EIS Area 1. The scale and temporary nature of any disturbance associated with rig siting is such that impacts on the extent and distribution, structure and function or supporting processes of the habitat, are unlikely to be affected in a way that would lead to an adverse effect on the little gull feature. The 33rd Round is being subject to its own HRA process which will also consider the potential for in-combination effects with reference to Block-specific work programmes. Carbon storage licence CS004 is 11km to the south of EIS Area 1 and partly overlaps Liverpool Bay SPA. As noted in Table 6.2, the appraisal work programme covered by this licence should be complete in 2023, and therefore any potential temporal overlap with activities associated with EIS Area 1 is not expected, such that in-combination effects will not occur. As noted in Section 6.2.1, Hynet North West, to which CS004 relates, is one of the Track-1 clusters associated with the Government's programme to deploy CCUS in a minimum of two industrial clusters by the mid-2020s and four by 2030, however, the nature and timing of any subsequent carbon dioxide storage within CS004 is not known at this time. A gas storage licence was awarded in April 2023 covering the depleted Bains gas field, which ceased producing in 2017. The licence area is located ~1km to the east of EIS Area 1 and the proposed work programme in the application does not include any field activities, only desk based studies.

A number of offshore wind farms are located partly or wholly within Liverpool Bay SPA, as is one Round 4 preferred project. Like the southern North Sea, to date wind farms in the eastern Irish Sea have been installed using fixed, monopile, foundations, with inter array and export cables trenched and buried, and subject to cable protection where necessary; future cables should be installed in keeping with North West Marine Plan policy NW-CAB-1, that is that burial is preferred. EIS Area 1 overlaps an area of Liverpool Bay SPA which was extended to cover the distribution of wintering little gull. While no project level details are available for Round 4 preferred project 5, the plan level HRA for Round 4 concluded that, with the exception of collision risk, all other pressures would lead to a negligible impact on the little gull population, and adverse effects were discounted both alone and in-combination with other plans and projects. The drilling of one well in EIS Area 1, which would have a maximum area of disturbance of 0.8km^2, is unlikely to significantly contribute to physical disturbance of the supporting habitat for the little gull feature of Liverpool Bay SPA in-combination with currently operating wind farms, or preferred Round 4 project 5.

With respect to drilling discharges, previous discharges of WBM cuttings in the UKCS have been shown to disperse rapidly and to have minimal ecological effects (See Section 4.2, also see individual site assessments in Section 5.3.2). Dispersion of further discharges of mud and cuttings could lead to localised accumulation in areas where reduced current allows the particles to accumulate on the seabed, however given the relatively shallow water depths (generally <50m), moderate tidal currents and potential for storm wave base interactions across the areas applied for (e.g. Klein *et al.* 1999), accumulations of cuttings piles are not considered likely from exploration/appraisal activity (see Section 5.3.2) or in-combination with other exploration and development wells associated with extant carbon dioxide storage licences, or licences associated with gas exploration (i.e. those offered in the 31st Round). Additionally, the potential for in-combination effects relating to chemical usage and discharge from exploratory drilling is limited by the existing legislative and permitting controls that are in place (see Section 2.3.1 and 5.3.3), which the UK Marine Strategy[122] has identified as relevant measures contributing to managing discharges. Discharges are considered unlikely to be detectable and to have negligible in-combination effect (BEIS 2022a).

Fishing, and particularly bottom trawling, have historically contributed to seabed disturbance over extensive areas and was identified as an ongoing issue in the UK assessment of good environmental status[123]. Depending on the nature of future measures (e.g. in relation to MPA management in the wider environment and within MPAs), such effects are likely to be reduced and therefore some improvement in benthic habitats could be expected, though no bylaws within Liverpool Bay SPA have been proposed to date, with the exception of any overlap with Shell Flat and Lune Deep SAC (also see the MMO call for evidence on stage 2 draft fisheries assessment[124]). Whilst fishing may be linked to historical damage to site features, and presents a continuing risk to these, recent, ongoing, and future management measures should limit the potential for in-combination effects with other activities. Exploration/appraisal drilling for carbon dioxide exploration/appraisal is analogous to similar oil and gas activities (see Sections 1 and 2). When any surface structure (fixed and floating installations) used for exploration/appraisal drilling becomes operational, a safety zone with a radius of 500m is created under an amendment to the *Petroleum Act 1987* made by the *Energy Act 2008* and other activities are excluded from taking place within the zone, including fisheries. Safety zones apply to mobile drilling rigs and are notified to other users of the sea (e.g. through notices to mariners and Kingfisher charts). In view of the differences in relative scale of physical impacts resulting from trawling and from carbon dioxide exploration/appraisal (both spatially and temporally), significant incremental effects following the licensing of 1st Round carbon dioxide storage areas are not predicted.

6.3.2 Physical presence

Physical presence of offshore infrastructure and support activities may potentially cause behavioural responses in fish, birds, and marine mammals (see Section 5.6 of BEIS 2022a). Previous SEAs have considered the majority of behavioural responses resulting from

[122] https://www.gov.uk/government/consultations/marine-strategy-part-three-programme-of-measures Note that the updated programme of measures is due to be published by the end of 2022.
[123] https://consult.defra.gov.uk/marine/updated-uk-marine-strategy-part-one/supporting_documents/UKmarinestrategypart1consultdocumentfinal.pdf
[124] https://consult.defra.gov.uk/mmo/call-for-evidence-stage-2/supporting_documents/MMO%20Call%20for%20Evidence%20on%20Stage%202%20Draft%20MPA%20Fisheries%20Assessement%20Background%20%20May%202022.pdf

interactions with offshore oil and gas infrastructure (whether positive or negative) to be insignificant; in part because the number of surface facilities is relatively small (of the order of a few hundred) and because the majority are at a substantial distance offshore; rigs used for carbon dioxide storage exploration/appraisal will be of the same type as those used in oil and gas exploration. The larger numbers of individual surface or submerged structures associated with offshore wind developments, the presence of rotating turbine blades and considerations of their location and spatial distribution (e.g. in relation to coastal breeding or wintering locations for waterbirds and important areas for marine mammals), indicate a higher potential for physical presence effects.

Potential displacement and barrier effects, particularly for birds, have been an important consideration at the project level for the large offshore wind developments, including those which are planned for the area of the eastern Irish Sea (Figure 6.5). Additional in-combination physical presence effects are possible with proposed wind farm project extensions (Awel y Môr) and/or any projects arising from Round 4 of wind leasing. As noted above, plan level HRA has been completed for both the extension projects and Round 4 preferred projects, and any subsequent projects will be subject to their own HRA processes.

As noted above, the area of Liverpool Bay SPA covered by EIS Area 1 is relevant to the wintering little gull feature of the site, which are not considered to be particularly vulnerable to disturbance by shipping (Fliessbach *et al.* 2019). Support vessels could potentially traverse Liverpool Bay SPA, which has the potential to result in incremental disturbance to species which are sensitive to vessels, including red-throated diver, common scoter, red-breasted merganser and cormorant, however, the increment of two to three vessels per week to existing vessel traffic associated with gas field support, and wind farm operations and maintenance, and assuming that vessels would follow established routes, is not considered to be significant (see Figure 6.3), or would be completely avoided if activity took place outside of the wintering period. For the same reasons, it is unlikely that there would be in-combination physical presence effects from activities associated with the Blocks applied for in the 33rd seaward licensing round (Figure 6.4), however, it should be noted that the 33rd round is subject to its own HRA process and in-combination effects relating to those Blocks applied for will be considered in greater detail in any associated AA documents. It is not regarded that the temporary addition of a drilling rig and associated shipping of a scale outlined in Table 2.2 will lead to adverse effects on site integrity for any of the relevant sites considered in this AA for which physical presence was identified as a potential source of likely significant effect (see Table 1.1).

6.3.3 Underwater noise effects

A number of projects are relevant to the consideration of in-combination effects with activities which may follow the licensing of the areas applied for (Table 6.2). The associated activities can generate noise levels with the potential to result in disturbance or injury to animals associated with relevant sites (see BEIS 2022b). Here, we focus attention on diving birds, these being the most sensitive feature to underwater noise considered in this AA for the eastern Irish Sea.

The majority of wind farm projects listed in Table 6.2 are in operation, and the major noise sources for such projects is during construction (e.g. pile driving, UXO disposal). Of the remaining wind farm projects (Awel y Môr, Round 4 preferred project 5), the timescales for their consenting and construction are such that temporal overlap with wind farm construction activities and the work programme seismic surveys are highly unlikely given the likely duration of the exploration/appraisal terms of the licences (Section 2). However, the specific timing of any overlap in activities which could affect sites including Liverpool Bay SPA, should be considered once project plans are known. There is the potential for seismic surveys to take place in areas covering parts of the areas applied for, or in areas close to or adjacent to these, under non-exclusive exploration licences, as part of geophysical survey being undertaken to inform the engineering and planning of offshore wind farms, or as part of any Block awarded through the 33rd seaward oil and gas licensing round. The timing, location and scale of other such surveys are unknown and a meaningful assessment of these cannot be made at this time, but they will be subject to activity-specific permitting, including, where appropriate, HRA.

In addition to those activities which may follow licensing of EIS Area 1 and the other potentially relevant projects listed in Table 6.2, there are a variety of other existing (e.g. oil and gas production, fishing, shipping, military exercise areas, wildlife watching cruises) and planned (e.g. oil and gas exploration) noise-producing activities in overlapping or adjacent areas. Despite this, the Department is not aware of any projects or activities which are likely to cause cumulative and in-combination effects that, when taken in-combination with the potential number and scale of activities likely to result from the licensing of the areas applied for (Section 2.2), would adversely affect the integrity of the relevant sites. This is due to the presence of effective regulatory mechanisms (Section 5.2 and also Appendix 3 of BEIS 2022a) which ensure that operators, the Department, and other relevant consenting authorities take such considerations into account during activity permitting. These mechanisms generally allow for public participation in the process[125].

6.3.4 Conclusion

While exploration activity is identified as a pressure to which Liverpool Bay SPA is sensitive (e.g. from physical effects or underwater noise), the sources of effect associated with the licensing of EIS Area 1 are short-term and temporary. Available evidence (see e.g. UKBenthos database, OSPAR 2010 and the 2017 intermediate assessment) indicates that past oil and gas activity and discharges has not led to adverse impacts on the integrity of sites in the area, noting that discharges associated with exploration or appraisal drilling for carbon dioxide storage will be broadly similar.

Any activities relating to the work programmes, and any subsequent development that may occur if site appraisal is successful, will be judged on its own merits and in the context of wider development in the North Sea (i.e. any potential incremental effects). The current controls on terrestrial and marine industrial activities, including activities that could follow licensing, can be expected to prevent significant in-combination effects affecting relevant sites.

The Department will assess the potential for in-combination effects whilst considering project-specific EIAs and, where appropriate, through HRAs. This process will ensure that mitigation measures are put in place to ensure that activities, if consented, will not result in adverse effects on integrity of the relevant sites. Therefore, it is concluded that the in-combination effects from activities arising from the licensing of the areas applied for in the 1st Carbon Dioxide Storage Licensing Round, with those from existing and planned activities in the eastern Irish Sea, will not adversely affect the integrity of relevant sites.

[125] *The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020*

7 Overall Conclusion

Taking account of the evidence and assessment presented above, it has been determined that the licensing of Eastern Irish Sea Area 1, Central North Sea Area 1, and Southern North Sea Areas 1, 2, 3, 4, 5, 6, 7, and 8 through the 1st Carbon Dioxide Storage Licensing Round considered in this AA, will not have an adverse effect on the integrity of the relevant sites (identified in Section 1.3), and the Department have no objection to the OGA awarding carbon dioxide storage licences (subject to meeting application requirements) covering those areas listed in Section 1.2. This is because there is a sufficient degree of certainty that licensing of the areas applied for will not adversely affect the integrity of relevant sites (as described in Sections 5.1 to 5.3), taking account of the mitigation measures that can be imposed through existing permitting mechanisms on the planning and conduct of activities. Plan level mitigation was identified to avoid permanent habitat change to the following sites: Dogger Bank SAC, the Wash and North Norfolk Coast SAC, the North Norfolk Sandbanks and Saturn Reef SAC, Inner Dowsing, Race Bank and North Ridge SAC, and Haisborough, Hammond and Winterton SAC. If a well is proposed within these sites and rig stabilisation is required, removable stabilisation methods must be used, subject to these meeting the technical and safety requirements of rig placement at a particular location. Additionally, in sites with qualifying reef features, rig siting must be informed by recent survey data so that sensitive areas can be avoided. The mitigation measures are listed in Table 7.1 below and will be secured through licence and/or permit conditions.

These control measures are incorporated in respect of habitat and species interest features through the range of legislation and guidance (see https://www.gov.uk/guidance/oil-and-gas-offshore-environmental-legislation) which apply to activities which could follow licensing. Where necessary, project-specific HRA based on detailed project proposals would be undertaken by the Department to ensure that permits/consents are only granted where the proposed activity will not result in adverse effects on integrity of relevant sites.

Table 7.1: Plan-level mitigation

Area applied for	Relevant sites	Relevant feature	Required mitigation
Southern North Sea			
SNS Area 1 (Licence 2), SNS Area 2 (Licence 1), SNS Area 3, SNS Area 4 (all licences), SNS Area 5, SNS Area 7	Dogger Bank SAC, North Norfolk Sandbanks and Saturn Reef SAC, Inner Dowsing, Race Bank and North Ridge SAC, Haisborough, Hammond and Winterton SAC	Sandbanks which are slightly covered by seawater all the time	Where possible, rig siting should take place outside of site boundaries (>500m) to avoid all interaction with the site feature. If there is no alternative to siting the rig inside the site, rig stabilisation must use removable methods to avoid a permanent change to habitat type.

Area applied for	Relevant sites	Relevant feature	Required mitigation
SNS Area 2 (Licence 1), SNS Area 3, SNS Area 4 (all licences)	North Norfolk Sandbanks and Saturn Reef SAC, Inner Dowsing, Race Bank and North Ridge SAC, Haisborough, Hammond and Winterton SAC	Reefs	Where possible, rig siting should take place outside of site boundaries (>500m) to avoid all interaction with the site feature. If there is no alternative to siting the rig inside the site, it must avoid all interaction with reef features identified.
SNS Area 3	Greater Wash SPA	Red-throated diver, common scoter	Where possible, should activities take place within the site, they should avoid the wintering period (1st November to 31st March inclusive). Where this is not possible, vessels should use established routes and avoid areas of high diver or scoter density.

Even where a site/interest feature has been screened out, or where a conclusion of no adverse effect on integrity has been reached 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.

8 References

Aagaard-Sørensen S, Junttila J & Dijkstra N (2018). Identifying past petroleum exploration related drill cutting releases and influences on the marine environment and benthic foraminiferal communities, Goliat Field, SW Barents Sea, Norway. *Marine Pollution Bulletin* **129**: 592-608.

Aarts G, Cremer J, Kirkwood R, van der Wal JT, Matthiopoulos J & Brasseur S (2016). Spatial distribution and habitat preference of harbour seals (*Phoca vitulina*) in the Dutch North Sea. Wageningen Marine Research report C118/16, 43pp.

Allers E, Abed RM, Wehrmann LM, Wang T, Larsson AI, Purser A & de Beer D (2013). Resistance of *Lophelia pertusa* to coverage by sediment and petroleum drill cuttings. *Marine Pollution Bulletin* **74**: 132-140.

Andersen LW, Holm LE, Siegismund HR, Clausen B, Kinze CC & Loeschcke V (1997). A combined DNA-microsatellite and isozyme analysis of the population structure of the harbour porpoise in Danish waters and West Greenland. *Heredity* **78**: 270–276.

Andersen LW, Ruzzante DE, Walton M, Berggren P, Bjørge A & Lockyer C (2001). Conservation genetics of the harbour porpoise, *Phocoena phocoena*, in eastern and central North Atlantic. *Conservation Genetics* **2**: 309-324.

Apache North Sea Limited (2006). Exploration Well in Block 18/05. Environmental Statement, September 2006. Prepared by Apache North Sea Ltd &Hartley Anderson Ltd, DTI Project Ref: W/3336/2006, 228pp.

APEM (2021). Final Ornithological Monitoring Report for London Array Offshore Wind Farm – 2021. 102pp. + appendices.

Austen MC, Warwick RM & Ryan KP (1993). *Astomonema southwardorum* sp. nov., a gutless nematode dominant in a methane seep area in the North Sea. *Journal of the Marine Biological Association of the United Kingdom* **73**: 627-634.

Bakke T, Klungsøyr J & Sanni S (2013). Environmental impacts of produced water and drilling waste discharges from the Norwegian offshore petroleum industry. *Marine Environmental Research* **92**: 154-169.

BEIS (2018). Decommissioning of Offshore Oil and Gas Installations and Pipelines. November 2018, 136pp.

BEIS (2021a). Record of the Habitats Regulations Assessment Undertaken Under Regulation 5 of the Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended). ION MNSH Phase 2B Seismic Survey September 2021. 81pp.

BEIS (2021b). Record of the Habitats Regulations Assessment Undertaken Under Regulation 5 of the Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended). ION Southern North Sea Seismic Survey 2021. 88pp.

BEIS (2021c). The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 – A Guide. July 2021, Revision 3, 71pp plus appendices.

BEIS (2022a). Offshore Energy Strategic Environmental Assessment 4, Environmental Report. Department for Business, Energy and Industrial Strategy, UK, 689pp plus appendices.

BEIS (2022b). Offshore Carbon Dioxide Storage Licensing Round. Habitats Regulations Assessment: Stage 1 - Site Screening. Department for Business, Energy and Industrial Strategy, UK, 113pp.

Boebel O, Clarkson OP, Coates R, LArter R, O'Brien PE, Ploetz J, Summerhayes C, Tyack T, Walton DWH & Wartzok D (2005). Risks posed to the Antarctic marine environment by acoustic instruments: a structured analysis. *Antarctic Science* **17**: 533-540.

Brandt M, Diederichs A, Betke K & Nehls G (2011). Responses of harbour porpoises to pile-driving at the Horns Rev II offshore wind farm in the Danish North Sea. *Marine Ecology Progress Series* **421**: 205-16.

Brandt MJ, Dragon A-C, Diederichs A, Bellmann MA, Wahl V, Piper W, Nabe-Nielsen J & Nehls G (2018). Disturbance of harbour porpoises during construction of the first seven offshore wind farms in Germany. *Marine Ecology Progress Series* **596**: 213-232.

Brasseur S, de Groot A, Aarts G, Dijkman E & Kirkwood R (2015). Pupping habitat of grey seals in the Dutch Wadden Sea. IMARES Report C009/15, 104pp.

Brasseur SMJM, van Polanen Petel TD, Gerrodette T, Meesters EHWG, Reijnders PJH & Aarts G (2015). Rapid recovery of Dutch gray seal colonies fueled by immigration. *Marine Mammal Science* **31**: 405–426

Breitzke M, Boebel O, El Naggar S, Jokat W, Werner B. 2008. Broad-band calibration of marine seismic sources used by R/V Polarstern for academic research in polar regions. *Geophysical Journal International* **174**: 505-524.

Bruce B, Bradford R, Foster S, Lee K, Lansdell M, Cooper S & Przeslawski R (2018). Quantifying fish behaviour and commercial catch rates in relation to a marine seismic survey. *Marine Environmental Research* **140**: 18-30.

Bulleri F & Chapman MG (2010). The introduction of coastal infrastructure as a driver of change in marine environments. *Journal of Applied Ecology* **47**: 26-35.

Carstensen J, Henriksen OD, Teilmann J & Pen O (2006). Impacts of offshore wind farm construction on harbour porpoises: acoustic monitoring of echolocation activity using porpoise detectors (TPODs). *Marine Ecology Progress Series* **321**: 295-308.

Carter MID, Boehme L, Duck CD, Grecian WJ, Hastie GD, McConnell BJ, Miller DJ, Morris CD, Thompson D, Thompson P & Russell DJF (2020). Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles. Report to BEIS, OESEA-16-76/OESEA-16-78. Sea Mammal Research Unit, University of St Andrews.

Chapman C & Tyldesley D (2016). Small-scale effects: How the scale of effects has been considered in respect of plans and projects affecting European sites - a review of authoritative decisions. Natural England Commissioned Reports, Number 205, 99pp.

Cleasby IR, Owen E, Wilson LJ, Bolton M (2018) Combining habitat modelling and hotspot analysis to reveal the location of high density seabird areas across the UK: Technical Report. RSPB Research Report no. 63, 135pp.

Cooper J (1982). Methods of reducing mortality of seabirds caused by underwater blasting. *Cormorant* **10**: 109-113.

Cotter E, Murphy P, Bassett C, Williamson B & Polagye B (2019). Acoustic characterization of sensors used for marine environmental monitoring. *Marine Pollution Bulletin* **144**: 205-215.

Cranmer G (1988). Environmental survey of the benthic sediments around three exploration well sites. Report No 88/02. Report to the United Kingdom Offshore Operators Association. Aberdeen University Marine Studies Ltd, Aberdeen, UK, 33pp.

Crocker SE & Fratantonio FD (2016). Characteristics of high-frequency sounds emitted during high-resolution geophysical surveys. OCS Study, BOEM 2016-44, NUWC-NPT Technical Report 12, 203pp.

Crowell S (2014). In-air and underwater hearing in ducks. Doctoral dissertation, University of Maryland.

Crowell SE, Wells-Berlin AM, Carr CE, Olsen GH, Therrien RE, Yannuzzi SE & Ketten DR (2015). A comparison of auditory brainstem responses across diving bird species. *Journal of Comparative Physiology A* **201**: 803-815.

Currie DR & Isaacs LR (2005). Impact of exploratory offshore drilling on benthic communities in the Minerva gas field, Port Campbell, Australia. *Marine Environmental Research* **59**: 217-233.

Daan R & Mulder M (1996). On the short-term and long-term impact of drilling activities in the Dutch sector of the North Sea. *ICES Journal of Marine Science* **53**: 1036-1044.

Dähne M, Gilles A, Lucke K, Peschko V, Adler S, Krügel K, Sundermeyer J & Siebert U (2013). Effects of pile-driving on harbour porpoises (*Phocoena phocoena*) at the first offshore wind farm in Germany. *Environmental Research Letters* **8**: 025002.

Dando PR, Austen MC, Burke RA, Kendall MA, Kennicutt MC, Judd AG, Moore DC, O'Hara SCM, Schmaljohann R & Southward AJ (1991). Ecology of a North Sea pockmark with an active methane seep. *Marine Ecology Progress Series* **70**: 49-63.

Danil K & St. Leger JA (2011). Seabird and dolphin mortality associated with underwater detonation exercises. *Marine Technology Society Journal* **45**: 89-95.

Deaville R & Jepson PD (2011). UK Cetacean Strandings Investigation Programme. Final Report for the period 1st January 2005 – 31st December 2010. 98pp.

DECC (2009). Offshore Energy Strategic Environmental Assessment, Environmental Report. Department of Energy and Climate Change, UK, 307pp plus appendices.

DECC (2011). Offshore Energy Strategic Environmental Assessment 2, Environmental Report. Department of Energy and Climate Change, UK, 443pp plus appendices.

DECC (2016). Offshore Energy Strategic Environmental Assessment 3, Environmental Report. Department of Energy and Climate Change, UK, 652pp plus appendices.

Defra (2012). The Habitats and Wild Birds Directives in England and its seas. Core guidance for developers, regulators & land/marine managers. December 2012 (draft for public consultation), 44pp.

Defra (2015). Validating an Activity-Pressure Matrix, Report R.2435, 73pp + appendices. Available from: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=19471

Diesing M, Stephens D & Aldridge J (2013). A proposed method for assessing the extent of the seabed significantly affected by demersal fishing in the Greater North Sea. *ICES Journal of Marine Science* **70**: 1085-1096.

Dijkstra N, Junttila J & Aagaard-Sørensen S (2020). Impact of drill cutting releases on benthic foraminifera at three exploration wells drilled between 1992 and 2012 in the SW Barents Sea, Norway. *Marine Pollution Bulletin* **150**: 110784.

Dorsch M, Burger C, Heinänen S, Kleinschmidt B, Morkūnas J, Nehls G, Quillfeldt P, Schubert A & Žydelis R (2019): DIVER – German tracking study of seabirds in areas of planned Offshore Wind Farms at the example of divers. Final report on the joint project DIVER, FKZ 0325747A/B, funded by the Federal Ministry of Economics and Energy (BMWi) on the basis of a decision by the German Bundestag.

Dunne HP & Martin CM (2017). Capacity of rectangular mudmat foundations on clay under combined loading. *Géotechnique* **67**: 168-180.

Dyndo M, Wisniewska DM, Rojano-Donate L & Madsen PT (2015). Harbour porpoises react to low levels of high frequency vessel noise. *Scientific Reports* **5**: 11083.

EC (2019). Managing Natura 2000 Sites. The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC, 69pp.

Edrén SMC, Wisz MS, Teilmann J, Dietz R & Söderkvist J (2010). Modelling spatial patterns in harbour porpoise satellite telemetry data using maximum entropy. *Ecography* **33**: 698-708.

Eggleton J, Murray J, McIlwaine P, Mason C, Noble-James T, Hinchen H, Nelson M, McBreen F, Ware S & Whomersley P (2017). Dogger Bank SCI 2014 Monitoring R&D Survey Report. JNCC/Cefas Partnership Report, No. 11.

Engås A, Løkkeborg S, Ona E & Soldal AV (1996). Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). *Canadian Journal of Fisheries and Aquatic Sciences* **53**: 2238-2249.

English Nature (1997). Habitats regulations guidance notes. Issued by English Nature.

Fliessbach KL, Borkenhagen K, Guse N, Markones N, Schwemmer P & Garthe S (2019). A Ship Traffic Disturbance Vulnerability Index for Northwest European Seabirds as a Tool for Marine Spatial Planning. *Frontiers in Marine Science* **6**: 192.

Foden J, Rogers SI & Jones AP (2009). Recovery rates of UK seabed habitats after cessation of aggregate extraction. *Marine Ecology Progress Series* **390**: 15-28.

Fontaine MC, Baird SJE, Piry S, Ray N *et al*. (2007). Rise of oceanographic barriers in continuous populations of a cetacean: the genetic structure of harbour porpoises in Old World waters. *BMC Biology* **5**: 30.

Frost PGH, Shaughnessy PD, Semmelink A, Sketch M & Siegfried WR (1975). The response of jackass penguins to killer whale vocalisations. *South African Journal of Science* **71**: 157-158.

Fujii T (2015). Temporal variation in environmental conditions and the structure of fish assemblages around an offshore oil platform in the North Sea. *Marine Environmental Research* **108**: 69-82.

Gafeira J & Long D (2015a). Geological investigation of pockmarks in the Braemar Pockmarks and surrounding area. JNCC Report No 571, 53pp.

Gafeira J & Long D (2015b). Geological investigation of pockmarks in the Scanner Pockmark SCI area. JNCC Report No 570, 80pp.

Garthe S & Hüppop O (2004). Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. *Journal of Applied Ecology* **41**: 724-734.

Gill AB & Bartlett M (2010). Literature review on the potential effects of electromagnetic fields and subsea noise from marine renewable energy developments on Atlantic salmon, sea trout and European eel. Scottish Natural Heritage Commissioned Report No.401, 43pp.

Gilles A, Viquerat S, Becker EA, Forney KA, Geelhoed SCV, Haelters J, Nabe-Nielsen J, Scheidat M, Siebert U, Sveegaard S, van Beest FM, van Bemmelen R & Aarts G (2016). Seasonal habitat-based density models for a marine top predator, the harbor porpoise, in a dynamic environment. *Ecosphere* **7**: e01367.

Gillett DJ, Gilbane L & Schiff KC (2020). Benthic habitat condition of the continental shelf surrounding oil and gas platforms in the Santa Barbara Channel, Southern California. *Marine Pollution Bulletin* **160**: 111662.

Gomez C, Lawson JW, Wright AJ, Buren AD, Tollit D & Lsage V (2016). A systematic review on the behavioural responses of wild marine mammals to noise: the disparity between science and policy. *Canadian Journal of Zoology* **94**: 801-819.

Goodship N, Caldow R, Clough S, Korda R, McGovern S, Rowlands N & Rehfisch M (2015). Surveys of Red-throated Divers in the Outer Thames Estuary SPA. *British Birds* **108**: 506-513.

Graham IM, Merchant ND, Farcas A, Barton TR, Cheney B, Bono S & Thompson PM (2019). Harbour porpoise responses to pile-driving diminish over time. *Royal Society Open Science* **6**: 190335.

Guse N, Garthe S & Schirmeister B (2009). Diet of red-throated divers *Gavia stellata* reflects the seasonal availability of Atlantic herring *Clupea harengus* in the southwestern Baltic Sea. *Journal of Sea Research* **62**: 268-275.

Halvorsen MB & Heaney KD (2018). Propagation characteristics of high-resolution geophysical surveys: open water testing. U.S. Department of the Interior, Bureau of Ocean Energy Management. Prepared by CSA Ocean Sciences Inc. OCS Study BOEM 2018-052, 806p.

Hammond PS, Lacey C, Gilles A, Viquerat S, Börjesson P, Herr H, Macleod K, Ridoux V, Santos M, Scheidat M, Teilmann J, Vingada J & Øien N (2021). Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys.

Hammond PS, Macleod K, Berggren P, Borchers DL, Burt L, Cañadas A, Desportes G, Donovan GP, Gilles A, Gillespie D, Gordon J, Hiby L, Kuklik I, Leaper R, Lehnert K, Leopold M, Lovell P, Øien N, Paxton CGM, Ridoux V, Rogan E, Samarra F, Scheidat M, Sequeira M, Siebert U, Skov H, Swift R, Tasker ML, Teilmann J, Van Canneyt O & Vázquez JA (2013). Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. *Biological Conservation* **164**: 107-122.

Hammond PS, Northridge SP, Thompson D, Gordon JCD, Hall AJ, Murphy SN & Embling CB (2008). Background information on marine mammals for Strategic Environmental Assessment 8. Report to the Department for Business, Enterprise and Regulatory Reform. Sea Mammal Research Unit, St. Andrews, Scotland, UK, 52pp.

Hansen KA, Maxwell A, Siebert U Larsen ON & Wahlberg M (2017). Great cormorants (*Phalacrocorax carbo*) can detect auditory cues while diving. *The Science of Nature* **104**: 45.

Harding H, Bruintjes R, Radford AN & Simpson SD (2016). Measurement of hearing in the Atlantic salmon (*Salmo salar*) using auditory evoked potentials, and effects of pile driving playback on salmon behaviour and physiology. Scottish Marine and Freshwater Science Report 7 No 11, 51pp.

Hartley Anderson Limited (2020). Underwater acoustic surveys: review of source characteristics, impacts on marine species, current regulatory framework and recommendations for potential management options. NRW Evidence Report No: 448, 136pp, NRW, Bangor, UK.

Harvey M, Gauthier D & Munro J (1998). Temporal changes in the composition and abundance of the macro-benthic invertebrate communities at dredged material disposal sites in the Anseà Beaufils, Baie des Chaleurs, Eastern Canada. *Marine Pollution Bulletin* **36**: 41-55.

Hassel A, Knutsen T, Dalen J, Skaar K, Løkkeborg S, Misund O, Østensen Ø, Fonn M & Haugland EK (2004). Influence of seismic shooting on the lesser sandeel (*Ammodytes marinus*). *ICES Journal of Marine Science* **61**: 1165-1173.

Heinänen S & Skov H (2015). The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area. JNCC Report No. 544, Joint Nature Conservation Committee, Peterborough, UK, 108pp.

Heinänen S, Žydelis R, Kleinschmidt B, Dorsch M, Burger C, Morkūnas J, Quillfeldt P, Nehls G (2020). Satellite telemetry and digital aerial surveys show strong displacement of red-throated divers (Gavia stellata) from offshore wind farms. *Marine Environmental Research* **160**: 104989.

Henry LA, Mayorga-Adame CG, Fox AD, Polton JA, Ferris JS, McLellan F, McCabe C, Kutti T, Roberts JM (2018). Ocean sprawl facilitates dispersal and connectivity of protected species. *Scientific Reports* **8**: 11346.

Hermannsen L, Tougaard J, Beedholm K, Nabe-Nielsen J, Madsen PT. 2015. Characteristics and propagation of airgun pulses in shallow water with implications for effects on small marine mammals. *PLoS ONE* **10**: e0133436.

HiDef (2017). Lincs Wind Farm. Third annual post-construction aerial ornithological monitoring report. 514pp.

HM Government (2011). UK Marine Policy Statement. HM Government, Northern Ireland Executive, Scottish Government, Welsh Assembly Government, 51pp.

Hoskin R & Tyldesley D (2006). How the scale of effects on internationally designated nature conservation sites in Britain has been considered in decision making: A review of authoritative decisions. English Nature Research Reports, No 704.

HSE (2004). Guidelines for jack-up rigs with particular reference to foundation integrity. Prepared by MSL Engineering Limited for the Health and Safety Executive, 91pp.

Hughes SJM, Jones DOB, Hauton C, Gates AR, Hawkins LE (2010). An assessment of drilling disturbance on *Echinus acutus* var. *norvegicus* based on *in situ* observations and experiments using a Remotely Operated Vehicle (ROV). *Journal of Experimental Marine Biology and Ecology* **39**: 37-47.

Hyland J, Hardin D, Steinhauer M, Coats D, Green R & Neff J (1994). Environmental impact of offshore oil development on the outer continental shelf and slope off Point Arguello, California. *Marine Environmental Research* **37**: 195-229.

IAMMWG (2022). Updated abundance estimates for cetacean Management Units in UK waters. JNCC Report no. 680, 16pp.

ICF (2021). Comparison of Environmental Effects from Different Offshore Wind Turbine Foundations. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Headquarters, Sterling, VA. OCS Study BOEM 2021-053. 48pp.

Intermoor website (accessed: 21st August 2019). Case studies for piled conductor installation for Shell Parque das Conchas fields, Brazil
http://www.intermoor.com/assets/uploads/cms/rows/files/164-4.pdf
and Petrobras/Chevron Papa Terra field, Brazil
http://www.intermoor.com/assets/uploads/cms/rows/files/1685-4-Papa-Terra-Case-Study-final.pdf

IPIECA & OGP (2010). Alien invasive species and the oil and gas industry. Guidance for prevention and management. The global oil and gas industry association for environmental and social issues and the International Association of Oil & Gas Producers, 88pp.

Irwin C, Scott MS, Humphries G & Webb A (2019). HiDef report to Natural England – Digital video aerial surveys of red-throated diver in the Outer Thames Estuary Special Protection Area 2018. Natural England Commissioned Reports, Number 260. http://publications.naturalengland.org.uk/publication/4813740218515456

ISAB (2018). The Influence of Man-made Structures in the North Sea (INSITE): synthesis and assessment of Phase 1. Prepared by the Independent Scientific Advisory Board (ISAB), 25pp. https://www.insitenorthsea.org/projects/isab-synthesis/

Jak RG, Bos OG, Witbaard R & Lindeboom HJ (2009). Conservation objectives for Natura 2000 sites (SACs and SPAs) in the Dutch sector of the North Sea. IMARES Wageningen UR, 190pp.

Järnegren J, Brooke S & Jensen H (2017). Effects of drill cuttings on larvae of the cold-water coral *Lophelia pertusa*. *Deep-Sea Research II* **137**: 454–462

Jenkins C, Eggleton J, Albrecht J, Barry J, Duncan G, Golding N & O'Connor J (2015). North Norfolk Sandbanks and Saturn Reef cSAC/SCI management investigation report. JNCC/Cefas Partnership Report, No. 7 http://jncc.defra.gov.uk/pdf/Web_Cefas_JNCC_No.7_a.pdf

Jiang J, Todd VL, Gardiner JC & Todd IB (2015). Measurements of underwater conductor hammering noise: compliance with the German UBA limit and relevance to the harbour porpoise (*Phocoena phocoena*). EuroNoise 31 May - 3 June, 2015, Maastricht. pp1369-1374.

JNCC (2002). JNCC committee meeting – December 2002. JNCC 02 D07. https://webarchive.nationalarchives.gov.uk/ukgwa/20190301143208/http://jncc.defra.gov.uk/PDF/comm02D07.pdf

JNCC (2010). The protection of marine European Protected Species from injury and disturbance. Guidance for the marine area in England and Wales and the UK offshore marine area. Joint Nature Conservation Committee, 118pp.

JNCC (2013). Progress towards the development of a standardised UK pressure-activities matrix. Paper for Healthy and Biologically Diverse Seas Evidence Group Meeting - 9th-10th October 2013, 13pp.

JNCC (2017). JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys. August 2017.
http://jncc.defra.gov.uk/pdf/jncc_guidelines_seismicsurvey_aug2017.pdf

JNCC (2017a). Advice on operations guidance note, 6pp.

JNCC (2019). Fourth Report by the United Kingdom under Article 17. Conservation status assessment for the habitat: H1180 - Submarine structures made by leaking gases, 23pp.

JNCC (2020). Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs. JNCC Report No. 654, JNCC, Peterborough, ISSN 0963-8091, 14pp.

JNCC (2021). Seabird Population Trends and Causes of Change: 1986–2019 Report https://jncc.gov.uk/our-work/smp-report-1986-2019

Jones DOB, Gates AR & Lausen B (2012). Recovery of deep-water megafaunal assemblages from hydrocarbon drilling disturbance in the Faroe-Shetland Channel. *Marine Ecology Progress Series* **461**: 71-82.

Jones DOB, Hudson IR & Bett BJ (2006). Effects of physical disturbance on the cold-water megafaunal communities of the Faroe-Shetland Channel. *Marine Ecology Progress Series* **319**: 43-54.

Jones EL & Russell DJF (2016). Updated grey seal (Halichoerus grypus) usage maps in the North Sea. Report to the Department of Energy and Climate Change (OESEA-15-65), Sea Mammal Research Unit, 15pp.

Jones EL, Hastie GD, Smout S, Onoufriou J, Merchant ND, Brookes KL & Thompson D (2017). Seals and shipping: quantifying population risk and individual exposure to vessel noise. *Journal of Applied Ecology* **54**: 1930-1940.

Jones EL, McConnell BJ, Smout S, Hammond PS, Duck CD, Morris CD, Thompson D, Russell DJF, Vincent C, Cronin M, Sharples RJ & Matthiopoulos J (2015). Patterns of space use in sympatric marine colonial predators reveal scales of spatial partitioning. *Marine Ecology Progress Series* **534**: 235-249.

Judd AD, Backhaus T & Goodsir F (2015). An effective set of principles for practical implementation of marine cumulative effects assessment. *Environmental Science & Policy* 54: **254**-262.

Judd AG & Hovland M (2007). Seabed Fluid Flow. The Impact on geology, biology and the marine environment. Cambridge University Press, 475pp.

Junttila J, Dijkstra N & Aagaard-Sørensen S (2018). Spreading of drill cuttings and sediment recovery of three exploration wells of different ages, SW Barents Sea, Norway. *Marine Pollution Bulletin* **135**: 224–238.

Kaiser MJ (2002). Predicting the displacement of common scoter *Melanitta nigra* from benthic feeding areas due to offshore windfarms. Centre for Applied Marine Sciences, School of Ocean Sciences, University of Wales, BANGOR. Report for COWRIE, 8pp.

Kaiser MJ, Galanidi M, Showler DA, Elliott AJ, Caldow RWG, Rees EIS, Stillman RA & Sutherland WJ (2006). Distribution and behaviour of common scoter *Melanitta nigra* relative to prey resources and environmental parameters. *Ibis* **148**: 110-128.

Klein H, Konig P & Frohse A (1999). Currents and near-bottom suspended matter dynamics in the central North Sea during stormy weather - Results of the PIPE'98 field experiment. *Deutsche Hydrographische Zeitschrift* **51**: 47-66.

Kober K, Webb A, Win I, Lewis M, O'Brien S, Wilson LJ & Reid JB (2010). An analysis of the numbers and distribution of seabirds within the British Fishery Limit aimed at identifying areas that qualify as possible marine SPAs. JNCC Report No. 431, Joint Nature Conservation Committee, Peterborough, UK, 83pp.

Kröncke I (2011). Changes in Dogger Bank macrofauna communities in the 20th century caused by fishing and climate. *Estuarine, Coastal and Shelf Science* **94**: 234-245

Labak SJ (2019). Memorandum for the Record, concerning utilization of the data and information in the Bureau of Ocean Management (BOEM) OCS Study 2018-052, "Propagation Characteristics of High-Resolution Geophysical Surveys: Open Water Testing," by Halvorsen MB & Heaney KD, 2018. 4pp.

Landrø M, Amundsen L, Barker D. 2011. High-frequency signals from air-gun arrays: *Geophysics* **76**: 19-27.

Langston R & Teuten (2018). Ranging behaviour of northern gannets. *British Birds* **111**: 131-143

Lawson J, Kober K, Win I, Allcock Z, Black J, Reid JB, Way L & O'Brien SH (2015a). An assessment of the numbers and distributions of wintering waterbirds and seabirds in Liverpool Bay/Bae Lerpwl area of search, JNCC Report 576, 47pp.

Lawson J, Kober K, Win I, Allcock Z, Black J, Reid JB, Way L & O'Brien SH (2015b). An assessment of the numbers and distributions of little gull *Hydrocoloeus minutus* and great cormorant *Phalacrocorax carbo* over winter in the Outer Thames Estuary, JNCC Report 575, 42pp.

Lawson J, Kober K, Win I, Allcock Z, Black J, Reid JB, Way L & O'Brien SH (2015c). An assessment of the numbers and distributions of wintering red-throated diver, little gull and common scoter in the Greater Wash, JNCC Report 574, 46pp.

Lawson J, Kober K, Win I, Bingham C, Buxton NE, Mudge G, Webb A, Reid JB, Black J, Way L & O'Brien SH (2018). An assessment of numbers of wintering divers, seaduck and grebes in inshore marine areas of Scotland (Revised May 2018), JNCC Report 567, 149pp.

Lepper PA, Gordon J, Booth C, Theobald P, Robinson SP, Northridge S & Wang L (2014). Establishing the sensitivity of cetaceans and seals to acoustic deterrent devices in Scotland. Scottish Natural Heritage Commissioned Report No. 517, 121pp.

Løkkeborg S, Humborstad O-B, Jørgensen T & Soldal A (2002). Spatio-temporal variations in gillnet catch rates in the vicinity of North Sea oil platforms. *ICES Journal of Marine Science* **59**: 294-299.

Lucke K, Siebert U, Lepper PA & Blanchet M-A (2009). Temporary shift in masked hearing thresholds in a harbour porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. *Journal of the Acoustical Society of America* **125**: 4060-4070.

Lurton X (2016). Modelling of the sound field radiated by multibeam echosounders for acoustical impact assessment. *Applied Acoustics* **101**: 201-221.

Lush MJ, Lush CE & Payne RD (2015). Understanding the impacts of invasive non-native species on protected sites. Report prepared by exeGesIS for Natural England and Environment Agency, 75pp. https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=1486

MacArthur Green (2019). Norfolk Vanguard offshore wind farm application: Appendices to Written Questions: Appendix 1.1; Appendix 3.1; Appendix 3.2; Appendix 3.3; Appendix 3.4.

MacGillivray A (2018). Underwater noise from pile driving of conductor casing at a deep-water oil platform. *Journal of the Acoustical Society of America* **143**: 450-459.

Maersk (2011). Environmental Statement. Flyndre and Cawdor Development, 194pp.

Maher E, Cramb P, de Ros Moliner A, Alexander D & Rengstorf A (2016). Assessing the sensitivity of sublittoral rock habitats to pressures associated with marine activities. JNCC Report No: 589B, 135pp + appendices.

Matthews M-NR (2014). Assessment of Airborne and Underwater Noise from Pile Driving Activities at the Harmony Platform: Preliminary Assessment. JASCO Document 00696, Version 5.1. Technical report by JASCO Applied Sciences Ltd. for ExxonMobil Exploration Co., 20pp.

Mattson MG, Thomas JA & Aubin DS (2005). Effects of boat activity on the behaviour of bottlenose dolphins (*Tursiops truncatus*) in waters surrounding Hilton Head Island, South Carolina. *Aquatic Mammals* **31**: 133-140.

Mayorga-Adame G, Polton JA, Fox AD & Henry L-A (2022). Spatiotemporal scales of larval dispersal and connectivity among oil and gas structures in the North Sea. *Marine Ecology Progress Series* **685**: 49-67.

McCauley RD (1994). Seismic surveys. *In: Swan, JM, Neff, JM and Young, PC (Eds) Environmental implications of offshore oil and gas developments in Australia - The findings of an independent scientific review.* Australian Petroleum Exploration Association, Sydney, NSW. 696pp.

Melvin EF, Parrish JK & Conquest LL (1999). Novel tools to reduce seabird bycatch in coastal gillnet fisheries. *Conservation Biology* **13**: 1386-1397.

Mendel B, Schwemmer P, Peschko V, Müller S, Schwemmer H, Mercker M & Garthe S (2019). Operational offshore wind farms and associated ship traffic cause profound changes in distribution patterns of Loons (*Gavia* spp.). *Journal of Environmental Management* **231**: 429-438.

MHCLG (2021). National Planning Policy Framework. Ministry of Housing, Communities & Local Government, Eland House, 62pp. + Appendices.

Mickle MF, Miehls S, Johnson NS & Higgs DM (2018). Hearing capabilities and behavioural response of sea lamprey (Petromyzon marinus) to low-frequency sounds. *Canadian Journal of Fisheries and Aquatic Sciences* **76**: 1541-1548.

MMO (2014a). A strategic framework for scoping cumulative effects. A report produced for the Marine Management Organisation, MMO Project No: 1055, 224pp.

MMO (2014b). Mapping UK shipping density and routes from AIS. A report produced for the Marine Management Organisation, MMO Project No: 1066, 35pp.

MMS (Minerals Management Service) (2004). Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf. Final Programmatic Environmental Assessment. Report no. MMS 2004-054. Report to the U.S. Department of the Interior Minerals Management Service, New Orleans, 487pp.

Neff JM, Bothner MH, Maciolek NJ & Grassle JF (1989). Impacts of exploratory drilling for oil and gas on the benthic environment of Georges Bank. *Marine Environmental Research* **27**: 77-114.

Nentwig W (Ed). (2007). Biological invasions. Ecological Studies – Analysis and Synthesis vol. 193, 443pp.

New LF, Harwood J, Thomas L, Donovan C, Clark JS, Hastie G, Thompson PM, Cheney B, Scott-Hayward L & Lusseau D (2013). Modelling the biological significance of behavioural change in coastal bottlenose dolphins in response to disturbance. *Functional Ecology* **27**: 314-322.

Newell RC, Seiderer LJ & Hitchcock DR (1998). The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed. *Oceanography and Marine Biology: An Annual Review* **36**: 127-178.

Nguyen TT,·Paulsen JE &·Landfald B (2021). Seafloor deposition of water-based drill cuttings generates distinctive and lengthy sediment bacterial community changes.· *Marine Pollution Bulletin* **164**: 111987.

NMFS (2016). Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing: underwater acoustic thresholds for onset of permanent and temporary threshold shifts. National Marine Fisheries Service, U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-55, 178pp.

NMFS (2018). 2018 Revisions to: Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (Version 2.0). National Marine Fisheries Service, U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-59, April 2018, 178pp.

O'Brien SH, Söhle I, Dean BJ, Webb A & Reid JB (2008). A further assessment of the numbers and distribution of inshore waterbirds using the Greater Thames during the non-breeding season using additional data from 2005-2007. JNCC Report.

OGP (2011). An overview of marine seismic operations. Report No. 448. International Association of Oil & Gas Producers. 50pp.

Ørsted (2022). Hornsea Project Four. Volume A4, Chapter 4: Project Description, 129pp.

OSPAR (2009). Assessment of impacts of offshore oil and gas activities in the North-East Atlantic. OSPAR Commission, 40pp.

OSPAR (2015). Guidelines to reduce the impacts of offshore installations lighting on birds in the OSPAR maritime area. OSPAR Agreement 2015-08.

Palka DL & Hammond PS (2001). Accounting for responsive movement in line transect estimates of abundance. *Canadian Journal of Fisheries and Aquatic Sciences* **58**: 777–787.

Parry M, Flavell B & Davies J (2015). The extent of Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef cSAC/SCI, 16pp.

Pearson WH, Skalski JR & Malme CI (1992). Effects of sounds from a geophysical survey device on behaviour of captive rockfish (*Sebastes* spp.). *Canadian Journal of Fisheries and Aquatic Science* **49**: 1357-1365.

Peña H, Handegard NO & Ona E (2013). Feeding herring schools do not react to seismic air gun surveys. *ICES Journal of Marine Science* **70**: 1174-1180.

Pérez-Domínguez R, Barrett Z, Busch M, Hubble M, Rehfisch M & Enever R (2016). Designing and applying a method to assess the sensitivities of highly mobile marine species to anthropogenic pressures. Natural England Commissioned Report 213, 25pp + appendices.

Pichegru L, Nyengera R, McInnes AM & Pistorius P (2017). Avoidance of seismic survey activities by penguins. *Scientific Reports* **7**: 16305.

Pirotta E, Brookes KL, Graham IM & Thompson PM (2014). Variation in harbour porpoise activity in response to seismic survey noise. *Biology Letters* **10**: 20131090.

Pirotta E, Merchant MD, Thompson PM, Barton TR & Lusseau D (2015). Quantifying the effect of boat disturbance on bottlenose dolphin foraging activity. *Biological Conservation* **181**: 82–89.

Pirotta E, Thompson PM, Miller PI, Brookes KL, Cheney B, Barton, TR, Graham IM & Lusseau D (2013). Scale-dependant foraging ecology of a marine top predator modelled using passive acoustic data. *Functional Ecology* **28**: 206-217.

Popper AN, Hawkins AD, Fay RR, Mann DA, Bartol S, Carlson TJ, Coombs S, Ellison WT, Gentry RL, Halvorsen MB, Løkkeborg S, Rogers PH, Southall BL, Zeddies DG & Tavolga WN (2014). Sound exposure guidelines for fishes and sea turtles: A technical report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI.

Rance J, Barrio Froján C & Schinaia S (2017). CEND 19x/12: Offshore seabed survey of Braemar Pockmarks SCI and Scanner Pockmark SCI. JNCC/Cefas Partnership Report Series, No. 14. JNCC, Peterborough, 76pp.

Risch D, Wilson B & Lepper P (2017). Acoustic assessment of SIMRAD EK60 high frequency echo sounder signals (120 & 200kHz) in the context of marine mammal monitoring. *Scottish Marine and Freshwater Science* **8**, No. 13, published by Marine Scotland Science, 27pp.

Robinson SP, Wang L, Cheong S-H, Lepper PA, Hartley JP, Thompson PM, Edwards E & Bellmann M (2022). Acoustic characterisation of unexploded ordnance disposal in the North Sea using high order detonations. *Marine Pollution Bulletin* **184** 114178

Robinson SP, Wang L, Cheong S-H, Lepper PA, Marubini F & Hartley JP (2020). Underwater acoustic characterisation of unexploded ordnance disposal using deflagration. *Marine Pollution Bulletin* **160**: 111646

Robson LM, Fincham J, Peckett FJ, Frost N, Jackson C, Carter AJ & Matear L (2018). UK Marine Pressures-Activities Database “PAD”: Methods Report, JNCC Report No. 624, JNCC, Peterborough, 24pp.

Rolland RM, Parks SE, Hunt KE, Castellote M, Corkeron PJ, Nowacek DP, Wasser SK & Kraus SD (2012). Evidence that ship noise increases stress in right whales. *Proceedings of the Royal Society B* **279**: 2363-2368.

Russell DJF, Hastie GD, Thompson D, Janik VM, Hammond PS, Scott-Hayward LA, Matthiopoulos J, Jones EL, McConnell BJ & Votier S (2016). Avoidance of wind farms by harbour seals is limited to pile driving activities. *Journal of Applied Ecology* **53**: 1642-1652.

Russell DJF, Jones EL & Morris CD (2017). Updated seal usage maps: the estimated at-sea distribution of grey and harbour seals. Scottish Marine and Freshwater Science Vol 8 No 25, 25pp. doi: 10.7489/2027-1 https://data.marine.gov.scot/sites/default/files//SMFS%200825.pdf

Rutenko AN & Ushchipovskii VG (2015). Estimates of noise generated by auxiliary vessels working with oil-drilling platforms. *Acoustical Physics* **61**: 556-563.

Schwemmer P, Mendel B, Sonntag N, Dierschke V & Garthe S (2011). Effects of ship traffic on seabirds in offshore waters: implications for marine conservation and spatial planning. *Ecological Applications* **21**: 1851-1860.

SCOS (2020). Scientific advice on matters related to the management of seal populations: 2019. Special Committee on Seals, 161pp.

SEERAD (2000). Nature conservation: implementation in Scotland of EC directives on the conservation of natural habitats and of wild flora and fauna and the conservation of wild birds ("the Habitats and Birds Directives"). June 2000. Revised guidance updating Scottish Office circular no. 6/199.

Shell (2022). Jackdaw Field Development. Environmental Statement. D/4260/2021, 388pp.

Skalski JR, Pearson WH & Malme CI (1992). Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes* spp*.). Canadian Journal of Fisheries and Aquatic Science* **49**: 1343-1356.

Skaret G, Axelsen BE, Nøttestad L, Ferno, A & Johannessen A (2005). The behaviour of spawning herring in relation to a survey vessel. *ICES Journal of Marine Science* **62**: 1061-1064.

Slabbekoorn H, Dalen J, de Haan D, Winter HV, Radford C, Ainslie MA, Heaney KD, van Kooten T, Thomas L & Harwood J (2019). Population-level consequences of seismic surveys on fishes: An interdisciplinary challenge. *Fish and Fisheries* **20**: 653-685.

Slotte A, Hansen K, Dalen J & Ona E (2004). Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. *Fisheries Research* **67**: 143-150.

Smit CJ & Visser GJM (1993). Effects of disturbance on shorebirds: a summary of existing knowledge from the Dutch Wadden Sea and Delta area. *Wader Study Group Bulletin* **68**: 6-19.

SNH (2015). Habitats Regulations Appraisal of Plans: Guidance for plan-making bodies in Scotland – Version 3.0. Scottish Natural Heritage report no. 1739, 77pp.

Southall B, Finneran JJ, Reichmuth C, Nachtigall PE, Ketten DR, Bowles AE, Ellison WT, Nowacek DP & Tyack PL (2019). Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. *Aquatic Mammals* **45**: 125-232.

Southall BL, Bowles AE, Ellison WT, Finneran JJ, Gentry RL, Greene Jr. CR, Kastak D, Ketten DR, Miller JH, Nachtigall PE, Richardson WJ, Thomas JA & Tyack PL (2007). Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals* **33**: 411-522.

Stanley DR & Wilson CA (1991). Factors affecting the abundance of selected fishes near oil and gas platforms in the northern Gulf of Mexico. *Fishery Bulletin* **89**: 149-159.

Stemp R (1985). Observations on the effects of seismic exploration on seabirds. In: Greene GD, Engelhardt FR & Paterson RJ (Eds) Proceedings of the workshop on effects of explosives use in the marine environment. Jan 29-31, 1985, Halifax, Canada.

Stewart WP (2007). Mat-Supported Jack-Up Foundation On Soft Clay – Overturning Storm Stability. Eleventh International Conference, The Jack-Up Platform - September 11th and 12th 2007 – London. 19pp.

Stone CJ (2015). Marine mammal observations during seismic surveys from 1994-2010. JNCC Report No. 463a, Joint Nature Conservation Committee, Peterborough, UK, 69pp.

Strachan MF & Kingston PF (2012). A comparative study on the effects of barite, ilmenite and bentonite on four suspension feeding bivalves. *Marine Pollution Bulletin* **64**: 2029-2038.

Strachan MF (2010). Studies on the impact of a water-based drilling mud weighting agent (Barite) on some benthic invertebrates. PhD Thesis, Heriot Watt University, School of Life Sciences, February 2010.

Suga T, Akamatsu T, Sawada K, Hashimoto H, Kawabe R, Hiraishi T & Yamamoto K (2005). Audiogram measurement based on the auditory brainstem response for juvenile Japanese sand lance *Ammodytes personatus*. *Fisheries Science* **71**: 287-292.

The Crown Estate and the British Marine Aggregate Producers Association (2022). The area involved 24th annual report. Marine aggregate extraction 2021. 18pp.

Thompson PM, Brookes KL, Cordes L, Barton TR, Cheney B & Graham IM (2013b). Assessing the potential impact of oil and gas exploration operations on cetaceans in the Moray Firth. Final Report to DECC, Scottish Government, COWRIE and Oil & Gas UK, 144pp.

Thompson PM, Brookes KL, Graham IM, Barton TR, Needham K, Bradbury G & Merchant ND (2013a). Short-term disturbance by a commercial two-dimensional seismic survey does not lead to long-term displacement of harbour porpoises. *Proceedings of the Royal Society B* **280**: 20132001.

Tillin HM & Tyler-Walters H (2014). Assessing the sensitivity of subtidal sedimentary habitats to pressures associated with marine activities: Phase 2 Report – Literature review and sensitivity assessments for ecological groups for circalittoral and offshore Level 5 biotopes. JNCC Report 512B, 270pp.

Tillin HM, Hull SC & Tyler-Walters H (2010). Development of a sensitivity matrix (pressures-MCZ/MPA features). Report to the Department for Environment, Food and Rural Affairs. Defra Contract No. MB0102 Task 3A, Report No. 22, 947pp.

Todd VLG & White PR (2012). Proximate measurements of acoustic emissions associated with the installation and operation of an exploration jackup drilling rig in the North Sea. In: Popper AN & Hawkins A (Eds.). The Effects of Noise on Aquatic Life. *Advances in Experimental Medicine and Biology* **730**: 463-468.

Tolley KA, Vikingsson G, Rosel P (2001). Mitochondrial DNA sequence variation and phylogeographic patterns in harbour porpoises (*Phocoena phocoena*) from the North Atlantic. *Conservation Genetics* **2**: 349–361.

Tougaard J, Carstensen J, Henriksen OH, Skov H & Teilmann J (2006). Harbour seals at Horns Reef before, during and after construction of Horns Rev Offshore Wind Farm. Final report to Vattenfall A/S. Biological papers from the Fisheries and Maritime Museum No.5, Esbjerg, Denmark, 67pp.

Tougaard J, Carstensen J, Teilmann J & Skov H (2009). Pile driving zone of responsiveness extends beyond 20km for harbour porpoises (*Phocoena phocoena* (L.)). *Journal of the Acoustical Society of America* **126**: 11-14.

Trannum HC, Setvik Å, Norling K & Nilsson HC (2011). Rapid macrofaunal colonization of water-based drill cuttings on different sediments. *Marine Pollution Bulletin* **62**: 2145–2156.

Tyler-Walters H, Tillin HM, d'Avack EAS, Perry F & Stamp T (2018). Marine Evidence-based Sensitivity Assessment (MarESA) – A Guide. Marine Life Information Network (MarLIN). Marine Biological Association of the UK, Plymouth, pp. 91.

UKMMAS (2010). Charting Progress 2: Healthy and Biological Diverse Seas Feeder Report. (Eds. Frost M & Hawkridge J) Published by Department for Environment Food and Rural Affairs on behalf of the UK Marine Monitoring and Assessment Strategy. 672pp.

Vabø R, Olsen K & Huse I (2002). The effect of vessel avoidance of wintering, Norwegian spring-spawning herring. *Fisheries Research* **58**: 59-77.

Vattenfall (2009). Kentish Flats offshore wind farm FEPA monitoring summary report, 74pp.

Veirs S, Veirs V & Wood JD (2016). Ship noise extends to frequencies used for echolocation by endangered killer whales. *PeerJ* **4**: e1657.

Vilela, R, Burger C, Diederichs A, Backl F, Szostek L, Freund A, Braasch A, Beckers B, Piper W & Nehls G (2022). Divers (*Gavia* spp.) in the German North Sea: Recent Changes in Abundance and Effects of Offshore Wind Farms. Report prepared by BioConsult, IBL & IfAÖ for Bundesverband der Windparkbetreiber Offshore e.V., 96pp.

Wakefield ED, Bodey TW, Bearhop S, Blackburn J, Colhoun K, Davies R, Dwyer RG, Green J, Grémillet D, Jackson AL, Jessopp MJ, Kane A, Langston RHW, Lescroël A, Murray S, Le Nuz M, Patrick SC, Péron C, Soanes L, Wanless S, Votier SC & Hamer KC (2013). Space Partitioning Without Territoriality in Gannets. *Science* **341**: 68-70.

Wakefield ED, Cleasby IR, Bearhop S, Bodey TW, Davies R, Miller PI, Newton J, Votier SC & Hamer KC (2015). Long-term individual foraging site fidelity – why some gannets don't change their spots. *Ecology* **96**: 3058–3074.

Wardle CS, Carter TJ, Urquhart GG, Johnstone ADF, Ziolkowski AM, Hampson G & Mackie D (2001). Effects of seismic air guns on marine fish. *Continental Shelf Research* **21**: 1005-1027.

Webb A (2016). Operational effects of Lincs and LID wind farms on red-throated divers in the Greater Wash. Presentation at the International Diver Workshop, Hamburg, 24-25 November 2016. http://www.divertracking.com/international-workshop-on-red-throated-divers-24-25-november-2016-hamburg/

Wever EG, Herman PN, Simmons JA & Hertzler DR (1969). Hearing in the blackfooted penguin, *Spheniscus demersus*, as represented by the cochlear potentials. *Proceedings of the National Academy of Sciences* **63**: 676-680.

Wiese FK, Montevecchi WA, Davoren GK, Huettmann, F, Diamond AW & Linke J (2001). Seabirds at risk around offshore oil platforms in the North-west Atlantic. *Marine Pollution Bulletin* **42**: 1285-1290.

Wisniewska DM, Johnson M, Teilmann J, Siebert U, Galatius A, Dietz R & Madsen PT (2018). High rates of vessel noise disrupt foraging in wild harbour porpoises (*Phocoena phocoena*). *Proceedings of the Royal Society B* **285**: 20172314. http://dx.doi.org/10.1098/rspb.2017.2314

Woodward I, Thaxter CB, Owen E & Cook ASCP (2019). Desk-based revision of seabird foraging ranges used for HRA screening. Report of work carried out by the British Trust for Ornithology on behalf of NIRAS and The Crown Estate. BTO Research Report No. 724, 139pp.

Yelverton JT, Richmond DR, Fletcher ER & Jones RK (1973). Safe distances from underwater explosions for mammals and birds. Report to the Defense Nuclear Agency. National Technical Information Service, US Department of Commerce, 64pp.

This publication is available from: https://www.gov.uk/guidance/offshore-energy-strategic-environmental-assessment-sea-an-overview-of-the-sea-process