Hornsea Three Sandbank Implementation Plan

Appendix One:
Marine Debris Removal Campaign Desktop Study

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Acronyms

Acronym	Definition
ALDFG	Abandoned, lost or otherwise discarded fishing gear
AoS	Area of Search
BEIS	Department for Business, Energy and Industrial Strategy
DCO	Development Consent Order
EIFCA	Eastern Inshore Fisheries and Conservation Authority
MALSF	Marine Aggregates Levy Sustainability Fund
MMO	Marine Management Organisation
NNSSR	North Norfolk Sandbanks and Saturn Reef SAC
OGUK	Oil and Gas UK
REC	Regional Environmental Characterisation
SAC	Special Area of Conservation
SBIP	Sandbanks Implementation Plan
UXO	Unexploded Ordnance
VMS	Vessel Monitoring System
WNNC	The Wash and North Norfolk Coast SAC
SG	Steering Group

1 Introduction

1.1 Project background

1. A Development Consent Order (DCO) was awarded to Hornsea Three on 31st December 2020.

2. Part 2 of Schedule 14 of the Hornsea Three DCO (the DCO) outlines the required benthic compensation measures which must accord with the Sandbanks Compensation Strategy[1] and be drafted into separate Sandbank Implementation Plans (SBIPs) for the North Norfolk Coast (WNNC) Special Area of Conservation (SAC) and North Norfolk Sandbanks and Saturn Reef (NNSSR) SAC and submitted to the Secretary of State for approval.

3. The SBIPs should include those requirements listed in Schedule 14 Part 2 requirement 13 which includes:

   (c) details of the area(s) of search (AoS) for a marine debris removal campaign, which should equate to no less than 41.80 ha at NNSSR and 2.77 ha at WNNC;

1.2 Purpose of this report

4. This report is in relation to requirement 13 (c) of the DCO in that it presents the methodology and findings of the Desktop Study to identify Areas of Search (AoS) for the marine debris removal campaign. This report is presented as Appendix 1 to the SBIPs.

5. This report is comprised of the following sections:

   i. **Section 1**: An introduction and background to Hornsea Three and the DCO requirements;

   ii. **Section 2**: An overview of the marine debris removal campaign and its rationale;

   iii. **Section 3**: Description of the approach to the AoS identification exercise, including an overview of the data sources used;

   iv. **Section 4**: A description of the physical processes at NNSSR and WNNC SAC to identify key sandbank habitats and physical conditions that require consideration in identifying AoS

   v. **Section 5**: Constraints mapping to indicate areas excluded from AoS identification;

   vi. **Section 6**: A 'scoring' exercise undertaken to narrow down the most appropriate AoS based on data regarding confirmed or potential sources of marine debris;

   vii. **Section 7**: A refinement process to further narrow down the potential AoS based on the habitat present and a conceptual analysis of physical processes;

   viii. **Section 8**: A summary for target and adaptive management AoS to be taken forward into the marine debris removal campaign.

   ix. **Section 9**: Conclusions.

2 Marine debris removal campaign

2.1 Rationale and aims for the campaign

6. The rationale which underpins the benefits of conducting a campaign of marine debris removal is outlined in the Sandbanks Compensation Strategy[2], which was submitted in February 2020 to support the Hornsea Three derogation case. It is anticipated that the removal of marine debris will serve the following purposes:

   - Removal of debris will help to support the restoration of the Annex I habitat '*Sandbanks which are slightly covered by sea water all the time*' within the SACs, as it will increase the availability of

[1] EN010080-003190-HOW03_CON02_Appendix2A_SandbanksCompensationStrategy.pdf (planninginspectorate.gov.uk)
[2] EN010080-003190-HOW03_CON02_Appendix2A_SandbanksCompensationStrategy.pdf (planninginspectorate.gov.uk)

sediment for transportation within the SAC systems, thereby increasing the functionality of the sandbank habitats;

- Mobile debris (i.e., items which may be moved along, or just above, the seabed by hydrodynamic / sedimentary forces) may threaten biogenic reefs found within the SACs if there is direct contact, therefore removal of mobile debris may reduce the risk of damage to such habitat; and
- Removal of debris, both mobile and non-mobile, would allow the seabed to perform more naturally and provide an equivalent area of seabed habitat to be available for colonisation and / or transit of mobile epifauna.

7. In line with the DCO requirements for the SBIPs, the AoS for marine debris must cover an area of at least 41.8 ha in the NNSSR SAC and at least 2.77 ha in the WNNC SAC. These areas may be broken down into smaller units depending on the density of marine debris within each area. **Figure 2.1** demonstrates representative sizes of these areas, in the context of the SACs. The 'demonstration' areas depicted in the figure are not intended as (nor should they be interpreted as) reference sites for further study. They are randomly placed areas in **Figure 2.1** which demonstrate the spatial scale of the marine debris removal campaign relative to the SACs (i.e., they give an indication of what an area of 2.77 ha and an area of 41.8 ha 'look like' in the context of the wider area).

8. It should be noted that, alongside the removal of existing marine debris in NNSSR SAC and WNNC SAC, a reduction and awareness campaign will be implemented to reduce the marine debris entering the SACs and provide a longer-term compensation measure. The reduction and awareness campaign will focus on stakeholder engagement to promote a 'stopping at source' approach to reducing marine debris and encourage the uptake & participation in local / national schemes and initiatives, such as 'Fishing for Litter'. The aim of the awareness campaign will be to reduce the incidence of, and improve the recovery of, abandoned, lost, or otherwise discarded fishing gear (ALDFG) and other marine debris. This awareness campaign is being prepared in consultation with the Steering Group (SG) and is discussed further in the Hornsea Three Proposed Marine Debris Awareness Campaign Scope of Works (Hornsea Three, 2021); however, the awareness campaign and the debris removal campaign will complement each other.

9. Following approval of the SBIPs (which this appended report supports), a single marine debris removal campaign will be conducted in the summer season of 2022 (June to September) to utilise the good weather window. This single campaign is in line with that proposed in paragraph 3.25 of the Sandbanks Compensation Strategy.

2.2 Scope of the term 'marine debris'

10. For the purpose of the Hornsea Three benthic compensation measures, 'marine debris' consists of any non-natural or introduced material on the seabed which does not offer a practical purpose, has low biodiversity value and may detract from the extent and functionality of the qualifying features of the NNSSR and WNNC SACs. Given that the purpose of the compensation is to assist in the restoration of sandbank functionality, it is marine debris associated with Annex I sandbank habitat that will form the focus of the measures. 'Marine debris' in this instance will only include items that are on, or partially buried within, the seabed and therefore can be targeted to a certain extent through the information-gathering process described throughout this document.

11. It is important to be pragmatic in determining what marine debris would be practicably detectable and removable during the campaign. Target marine debris items would include (for example) ALDFG such as trawl, gill and seine nets, pots / fish traps and tickler chains, and debris lost from, for example, anchorages and wrecks (excluding any that are associated with protected wrecks). Debris and debris clusters large enough to be identified during side scan sonar surveys would be primarily targeted (although smaller items may be removed on an *ad hoc* basis during delivery of the campaign), since geophysical surveys (e.g., side scan sonar or similar) are anticipated for the purpose of confirming the presence of debris in the AoS identified in this Desktop Study. Debris targeted (or clusters of debris) will be a minimum of 1 m in dimension. Upper size limits of individual debris items are determined by the capability of vessels and equipment used for the removal. Removal should avoid extensive dredging to remove the buried object. As a general guide, anything that appears from geophysical data or observation (judged by the size of the item and if it is obvious what it is) to be buried to a depth which will require excavation to a depth greater than 1 m it should remain *in situ*.

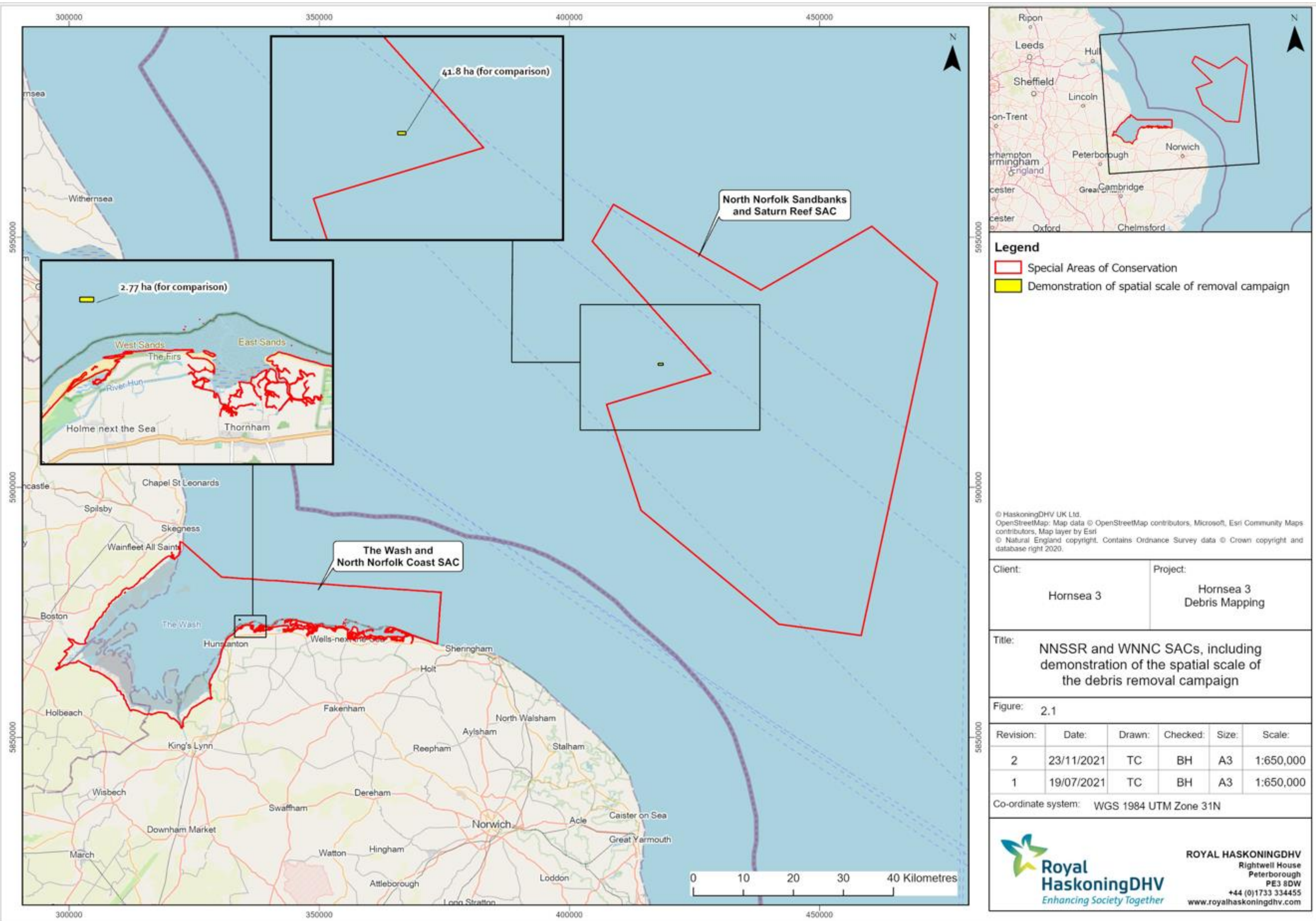

Figure 2.1: Location of the NNSSR and WNNC SACs including representative areas presenting spatial scale of the debris removal campaign.

3 Approach to AoS identification

3.1 Methodology

12. This section describes the methodology that has been employed in order to identify potential AoS for the marine debris removal campaign. A systematic, score-based approach to the exercise has been employed, which uses the data obtained from a number of sources to identify higher 'scoring' areas (i.e., areas with a greater perceived potential for containing a high density of marine debris), and then refines these areas based on physical and biological parameters.

13. The stages in this exercise are presented in **Figure 3.1**.

Stage 1: Identify exclusion zones to narrow down overall search area

Stage 2: Use debris data to identify areas with perceived high debris density

Stage 3: Refine AoS based on habitats present

Stage 4: Further refine based on conceptual analysis of the physical environment

Figure 3.1: Stages of the process used for identifying AoS.

14. For scoring discrete areas within the SACs, the SACs have been subdivided into smaller 'blocks' that could each act as a possible AoS, with the above stages then applied to each block. As stated in the Scope of Works document and discussed with the SG at the second SG meeting on the 30th March 2021 (as detailed within the Consultation Summary 07124534_A), the NNSSR SAC and the WNNC SAC have been subdivided into 100 ha blocks and 10 ha blocks, respectively. The different approaches are based on the fact that the AoS for the WNNC SAC is to be considerably smaller than that in the NNSSR SAC.

15. **Stage One** of the process involves eliminating those 100 ha / 10 ha blocks that sit within areas excluded from further consideration based on the presence of obstructions, hazards and / or environmental sensitivities. The process for determine the exclusion zone is described in **Section 5**.

16. **Stage Two** uses a scoring mechanism, based on data regarding debris occurrence or proxies (i.e., other activities that may increase the potential for marine debris to be present), to initially differentiate between each individual block in the two SACs. This gives an initial indication of the preferable potential AoS (see **Section 6.4**).

17. **Stage Three** takes into account the highest scoring blocks (i.e., the most likely candidates as AoS) and assesses the habitat present in each to identify priorities for AoS (see **Section 7.1**). Priority blocks are then considered in stage four.

18. **Stage Four** uses conceptual analysis of physical conditions in the site to further refine the priority AoS (see **Section 7.2**).

3.2 Overview of data sources

19. Several publicly available / requestable data sources have been utilised for the purpose of identifying potential AoS. An initial list of data sources was presented to the SG in the Marine Debris Removal Scope of Works (Hornsea Three, 2021) and discussed at SG meeting #2 on the 30th March 2021. An overview of how these data sources have been used, plus an indication of further data sources considered, has been presented in **Table 3.1**. Further details on the data sources used within this exercise are provided throughout the report.

Table 3.1: Data sources used to inform AoS selection.

Data source	Information type	How it has been used
Cefas North East Atlantic Seafloor Marine Litter data[3]	Cefas' datahub includes litter data obtained during fish and environmental surveys in UK waters, including the central and southern North Sea, from 1992 to 2014. Data on litter is provided using the classification system set out by Galgani *et al.* (2013), allowing for different types of debris / litter to be identified (including ALDFG). Cefas has also examined the distribution and abundance of marine litter on the seafloor off the UK coast within 39 independent scientific surveys. Such work was conducted between 1992 and 2017 within the International Bottom Trawl Survey (IBTS), the ICES Ground Fish Surveys (Q4SW) and the Clean Seas Environment Monitoring Programme (CSEMP) (Maes et al., 2018).	The resolution of the data is low and, while the data may allow differentiation at a broad geographical scale, it would not allow comparisons to be drawn at smaller scale (i.e., between different areas within a given SAC). Direct consultation with Cefas indicated that data at a finer resolution is not available. However, the data does provide evidence of the likely presence of debris across the two SACs and has been referred to in **Section 6.2.**
Marine Management Organisation (MMO)	To fulfil the conditions of marine licences, the MMO requires that items dropped from vessels or infrastructure involved with the licensable activities are reported via the Dropped Object Procedure Form. The MMO has been approached regarding the availability of this data.	Following consultation with the MMO in April 2021, it was confirmed that the MMO do not chart dropped objects, therefore spatial data was not available. MMO did recommend consultation with UKHO as a potential source of information (see below).
Marine Aggregates Levy Sustainability Fund (MALSF) aggregates data	MALSF data includes outputs from regional environmental characterisation (REC) surveys between 2004 and 2011. During REC surveys, side-scan sonar, magnetometer, and bathymetry survey data are acquired. This data was signposted by the Crown Estate during a consultation meeting held in April 2021.	Geophysical surveys undertaken in the Humber region were of insufficient resolution or methodology to identify potential items of debris. Bathymetry data was available but more comprehensive bathymetry for the area was available from the European marine observation and data network (EMODNet). After discussion with marine aggregates operators active within the NNSSR, it was confirmed that no debris has been recorded by them to date during dredging activities and that side scan surveys carried out had not detected any areas with higher risk of debris to be encountered during dredging activities, apart from some minor localised contacts.

[redacted]

Data source	Information type	How it has been used
UKHO / Admiralty data portal[4]	The UKHO / Admiralty hosts a portal for maintained information on wrecks and navigational obstructions / foul ground within Northwest Europe.	The presence of protected wrecks has provided information on areas to be excluded from the exercise for sensitivity issues (**Section 5**), plus wider areas surrounding wrecks where associated debris may be located (**Section 6.3**). Conversation was held with UKHO regarding obstruction / foul ground data; however, the data refers to large navigational hazards[5] and as such was not representative of the debris targeted in this campaign.
National Heritage list for England[6]	Historic England's National Heritage list sets out the locations of protected wrecks and other designated heritage sites to avoid. https://historicengland.org.uk/listing/the-list/	Following consultation with this list, it was confirmed that there were no protected wrecks in (or near to) the SACs among those presented in the Admiralty data
JNCC SAC supporting evidence	There is underpinning evidence presented in the SAC Selection Assessment for NNSSR SAC. The distribution of features of interest within both SACs has been mapped out in the JNCC MPA Mapper[7], based on scientific evidence collected for the purpose of SAC designation and management.	This data source has been used to provide information on Annex I sandbank habitat extent and physical / biological properties of the SACs (see **Section 7**). Annex I Reef point and polygon distribution data has also been used to inform exclusion zones (see **Section 5**).
Natural England evidence base / Defra MAGiC application	Natural England's evidence base, presented in the MAGiC application[8], provides further information on the distribution of SAC habitat features in the WNNC SAC, as both points and polygons.	This data source has been used to provide information on Annex I sandbank habitat extent in WNNC SAC (see **Section 7**). Annex I Reef point and polygon distribution data has also been used to inform exclusion zones (see **Section 5**).
The Crown Estate Marine Data Exchange	The Crown Estate's Marine Data Exchange[9] is a repository for all survey data from marine aggregate and offshore wind farm developments in the UK. Data is publicly available and can be requested directly from the Crown Estate. Any available seabed imagery data from NNSSR SAC and WNNC SAC, including side scan sonar, multibeam and other geophysical survey data, will be requested from the Crown Estate. Relevant to this exercise, the specific data considered from the Data Exchange was the REC dataset for the Humber Region, which included geophysical data from sample tracks.	As noted above, during consultation with the Crown Estate regarding information available on the Marine Data Exchange, they referred to REC survey data for the Humber region. The REC data was acquired from the Marine Data Exchange, but it was of insufficient resolution or collection methodology to identify potential items of debris. Bathymetry data was available, however more comprehensive bathymetry for the area was available from the European marine observation and data network (EMODNet) which was used in this assessment.
UK Vessel Monitoring	The MMO hosts Vessel Monitoring System (VMS) data for UK vessels operating in English waters. VMS data	UK VMS data has been used to identify areas of heavy vessel traffic, which has

[4] [redacted]
[5] Navigational hazards include wrecks / potential wrecks or undefined objects that have been charted as they pose a navigational risk – this has been captured separately through other data sources described in the table (i.e., Admiralty charts).
[6] [redacted]
[7] https://jncc.gov.uk/our-work/marine-protected-area-mapper/
[8] https://magic.defra.gov.uk/MagicMap.aspx
[redacted]

Data source	Information type	How it has been used
System (VMS) data[10]	regarding all vessel types for the period 2019, 2020 and 2021 was obtained from the MMO. Fishing vessel-specific VMS data is applicable only to vessels over 12m in length, as per EU law. Information on nearshore vessel activity, likely to be smaller than 12m, has instead been captured in data from the MMO Marine Activity Data portal (see below).	been used as a proxy for areas of potentially high marine debris density. Additionally, UK fishing vessel specific VMS data from 2018 and 2019 has been used as a proxy for areas of potentially high prevalence of ALDFG. See **Section 6.3.**
MMO Marine Activity Data portal[11]	The MMO have a planning portal which provides spatial data on marine activity for the purpose of marine spatial planning in English waters. This database provides information on, *inter alia*: • Fishing intensity within NNSSR SAC and WNNC SAC, including Fishermap data for small vessels; • Areas of high navigation density; • Vessel anchorages; • Dredged areas; and, • Other infrastructure within the marine area. Other data may indicate areas to be excluded when identifying suitable removal locations, for example due to the presence of third-party assets.	Data from the MMO portal has been used in identifying potential areas of high marine debris density (see **Section 6**), as well as the locations of sensitivities that should be excluded (**Section 5**).
Global Marine Geocable GIS	Global Marine's GeoCable database provides information on submarine telecoms cables and can be procured to identify telecom cable routes in NNSSR SAC which would be avoided during removal campaigns.	The presence of submarine telecoms cables has provided an indication of areas to be excluded from site selection.
British Geological Survey Seabed Sediment Maps	All these sources present information that characterises the seabed sedimentary system and can be used to identify mobile bed forms.	Upon reviewing these data sources, it was determined that the broadscale habitat mapping from EMODNet was more appropriate for characterising seabed characteristics.
Southern North Sea Sediment Transport Study		
British Geological Survey Technical Reports		
EMODNet	Bathymetry data, EUNIS habits and broadscale seabed habitats / sediment types are provided on the EMODNet portal.	Bathymetry data from EMODNet has been used in the geomorphological review of potential debris accumulation (**Section 7.2**). Habitat types have also been used in identifying preferential AoS (**Section 7.1**).
Sea Search	The Sea Search voluntary organisation undertake regular marine survey dives to monitor marine life. During dives, the presence of debris or litter is recorded, and GPS locations of dives are logged.	Incidental debris sightings logged by Sea Search have been used in the process of identifying potential AoS (see **Section 6.1**).
UK Fisheries Monitoring Centre	The UKFMC hosts data regarding the last known location of lost gear reported by fishermen.	Due to privacy and confidentiality issues, this data could not be obtained.

[10] Further information is provided in **Section 6.3.1**
[11] [redacted]

Data source	Information type	How it has been used
Maritime and Coastguard Agency (MCA)	The MCA were consulted with regarding potential data that they may hold. However, they responded stating that debris data is not reported to them and instead referred to foul ground and obstruction data held by UKHO, described above.	No data was available from the MCA.
Hornsea Two, Race Bank and Lincs Offshore Wind Farm geophysical data	Orsted have provided data from geophysical (i.e., side scan sonar, magnetometer) surveys within the cable corridors for Hornsea Two, Race Bank and Lincs OWF. Geophysical data identifies items of debris within the surveyed area.	These surveys have been considered as they provide general evidence of the likely presence and density of debris. Note that the Hornsea Two data lies out with the SACs; however, it provides information on the potential presence and density of marine debris in the wider southern North Sea area, as referred to in **Section 6.2**.

3.3 Fisheries consultation

20. In addition to the above, consultation has been undertaken by Brown and May Marine Ltd. with fishing associations and individual fishing operators who operate within the WNNC SAC or NNSSR SAC to gather anecdotal evidence of any potential 'hot-spots' for marine debris. Hornsea Three conducted consultation with nearshore potters and whelk fishers in relation to the WNNC SAC, whereas consultation in relation to the offshore NNSSR SAC was extended to include larger boats. The fisheries consultation culminated in Brown and May Marine Ltd. demarcating likely areas of interest, in the form of a GIS shapefile, which encompasses areas identified during consultation as being of relatively high potential for the presence of ALDFG. The output from the fisheries consultation is provided as an Annex to this report (see **Annex 1**).

4 Importance of sandbanks to wider SAC sediment movements

21. This section provides a conceptual review of the geomorphology and functioning of the sandbanks within the SACs from the perspective of marine sedimentary processes. Although it is recognised that sediment transport is not a key principle for designation and is not part of the Conservation Objectives for the WNNC and NNSSR SACs (which are detailed in **Section 2** of the WNNC and NNSSR SBIPs), the relative strengths of those processes is important in determining their ability to transport and accumulate debris on the seabed. Hence, the discussion in this section reflects the objectives of this Desktop Study (to define those sandbanks with the necessary mobility to transport sediment and debris, and hence a high priority for debris removal), rather than the Conservation Objectives and designation criteria.

4.1 North Norfolk Sandbanks and Saturn Reef SAC

22. The NNSSR SAC extends from approximately 40km to 110km from the northeast coast of Norfolk and is comprised of a series of northwest to southeast oriented linear sandbanks (approximately parallel to the coast) (Eggleton et al., 2020). The sandbanks are Leman, Ower, Inner, Well, Broken, Swarte, two partly merged banks known as the Vikings and two banks furthest called the Indefatigables (**Figure 4.1**).

23. The crests of the sandbanks are in water depths shallower than 20m with their flanks extending into water depths up to 40m. They have crest spacings varying from about 5km to 11km. They are asymmetric in profile with their steeper slope (up to 7°) facing towards the northeast. Gentler gradients occur on the southwest flanks, where they are up to about 2° (Holmes and Wild, 2003). The Annex I Sandbank feature is considered to cover the full extent of the designated site area, encompassing the whole sandbank system, including areas deeper than 20m.

24. The morphology of the active sandbanks arises through the development of distinct flood and ebb pathways in the tidal streams, with the flood tide current flowing northwest to southeast and the ebb tide current flowing southeast to northwest. The sandbanks located closer inshore (Leman, Ower, Inner, Well, Broken) are active under present-day hydrodynamic conditions, whereas the offshore sandbanks (Viking and Indefatigable) are relict (Holmes and Wild, 2003; Kenyon et al., 1981). Swarte Bank may also be relict (Cooper et al., 2008).

25. Tidal current speeds increase from around 1.5m/s in the southwest part of the SAC reducing to less than 1.0m/s in the deeper and furthest offshore part of the site (Eggleton et al., 2020). The sediment composition of the sandbanks generally reflects the strength of the prevailing tidal currents. Where the currents are strongest, the inshore sandbanks are mainly characterised by medium sand. The sandbanks further offshore are comprised of fine to medium sand. The Indefatigable Banks comprise coarser sediments, and according to Holmes and Wild (2003), these sediments reflect the relict nature of the banks and longer-term erosion of the seabed in that area. They further suggest that these banks are undergoing a process of permanent natural destruction.

26. The southwest two-thirds of the NNSSR SAC, containing the active sandbanks (Leman, Ower, Inner, Well and Broken) is important with respect to wider sediment in the SAC. Holmes and Wild (2003) suggested that the pathways for bedload transport across the active sandbanks are coupled across the troughs that separate them. This means that disturbances to any one of the banks will be reflected in the adjacent troughs and banks. Overall, the active sandbanks and the sand waves superimposed upon them have accumulated and moved collectively as a result of bedload sediment transport as one component of the total sediment flux throughout the SAC (Holmes and Wild, 2003).

27. The relict sandbanks located in the deeper northeast third of the SAC (Vikings, Indefatigables and possibly Swarte) contribute less to sediment transport mechanisms across the site because they are not active. They are eroding and are not likely to contribute as suppliers of sediment because the net sediment transport direction is away from the active sandbanks, not towards them.

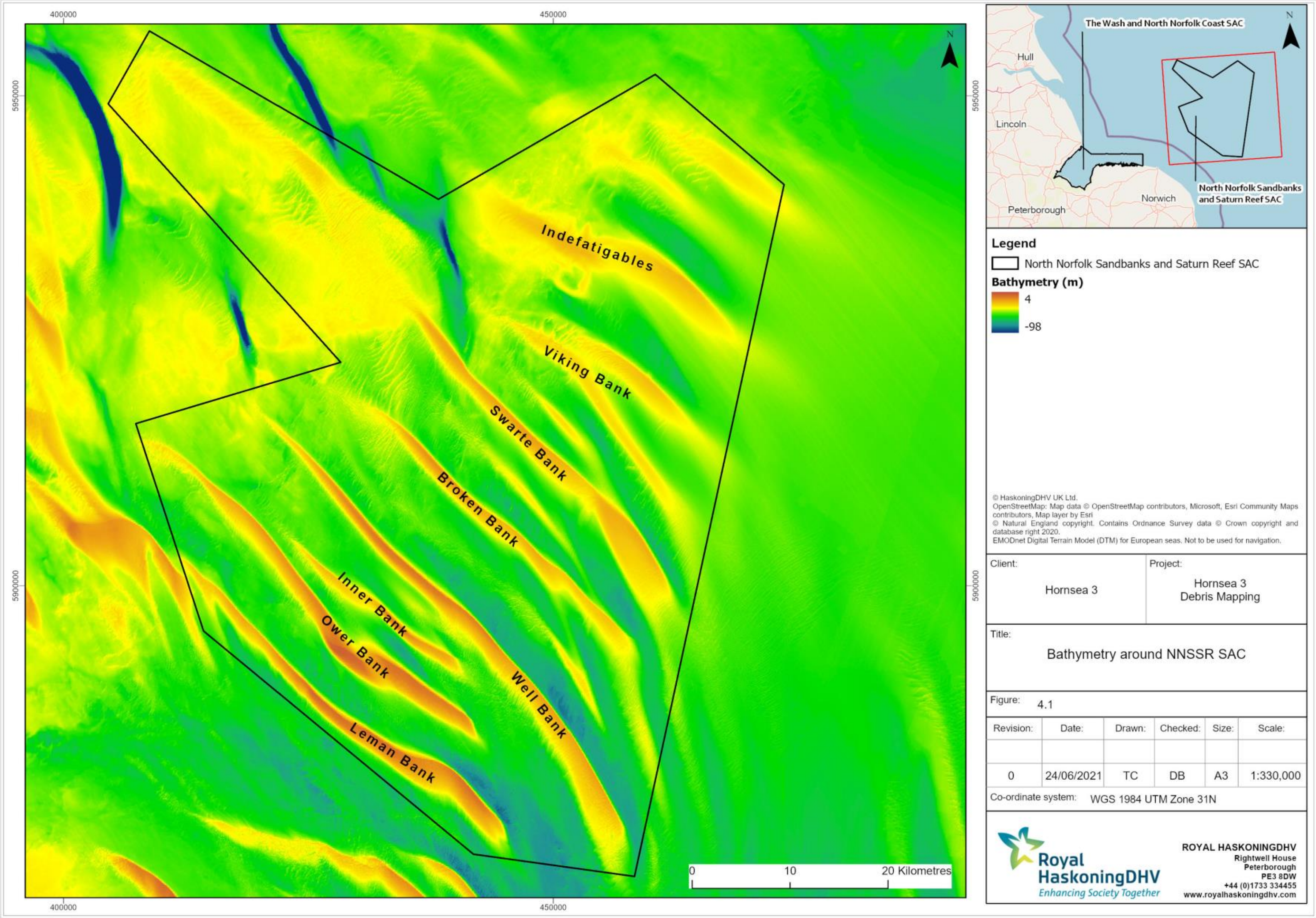

Figure 4.1: Sandbanks in NNSSR SAC.

4.2 Wash and North Norfolk Coast SAC

28. The Wash is the presently active, unfilled part, of what was once a much larger embayment. It provides a sheltered, low-energy environment in which tides are the main factor controlling sedimentary processes. The Wash has a broad intertidal zone comprising a complex series of sandbanks, sandflats and mudflats that are exposed at low tide[12]. The present-day Wash has an area of about 600 km^2 and an average depth of less than 10m. The entrance to The Wash is about 20km wide. The central parts of The Wash are also characterised by a series of sandbanks, separated by tidal channels, including the Well, Lynn Deeps and Seal Deeps (**Figure 4.2**), which have maximum water depths of 40-50m (Brew, 1997). Although minor modifications have occurred since the 1970s, the sandbanks are still essentially the same shape and in the same location as they have been over the past few decades. Indeed, many of these sand bodies can be recognised on navigation charts of The Wash from the 1600s and 1700s (Inglis and Kestner, 1958).

29. The general distribution of sediment in The Wash has been controlled predominantly by tidal currents, with wave-induced processes locally important around the shallow periphery (Evans, 1965; Amos and Collins, 1978; Collins *et al.*, 1981). The tidal currents approaching The Wash from the adjacent offshore area consist of two systems. The first, and strongest, approaches along the north Lincolnshire coast before turning southwest to enter The Wash. The second moves east to west along the north Norfolk coast, also turning southwest to enter The Wash.

30. The sandbanks are composed of two main facies; clean sand, and sand with mud laminae (Wingfield et al., 1978). Clean sand occurs around the outer margins of the banks and in the tidal channels, where mega ripples may be prevalent (McCave and Geiser, 1978). Sand with mud laminae (characterised by over 70% sand) is mainly found on the inner margins of the banks.

31. Wingfield et al. (1978) divided the bed of The Wash into erosion-dominant and deposition-dominant areas. The erosion-dominant areas lie mainly in the outer tidal channels (The Well, Lynn Deeps Boston Deep and Seal Deeps) where bedrock and till are exposed at the seabed. However, even in these areas there may be local deposition in the form of small mobile sand waves. The deposition-dominant areas are in the inner part of The Wash and include the intertidal areas and sandbanks (Inner Dogs Head, Long Sand, Roger Sand, Gat Sand, Seal Sand, Sunk Sand) (**Figure 4.2**), some of which are exposed at low water.

32. Overall, in The Wash, the sandbanks are relatively static with little change in position, height and form. This means that they are likely to be mainly self-contained systems with little sediment transport connectivity with adjacent sandbanks across the erosive tidal channels that separate them.

[12] Hornsea Three note that the debris removal campaign will not target habitats which are exposed at low tide.

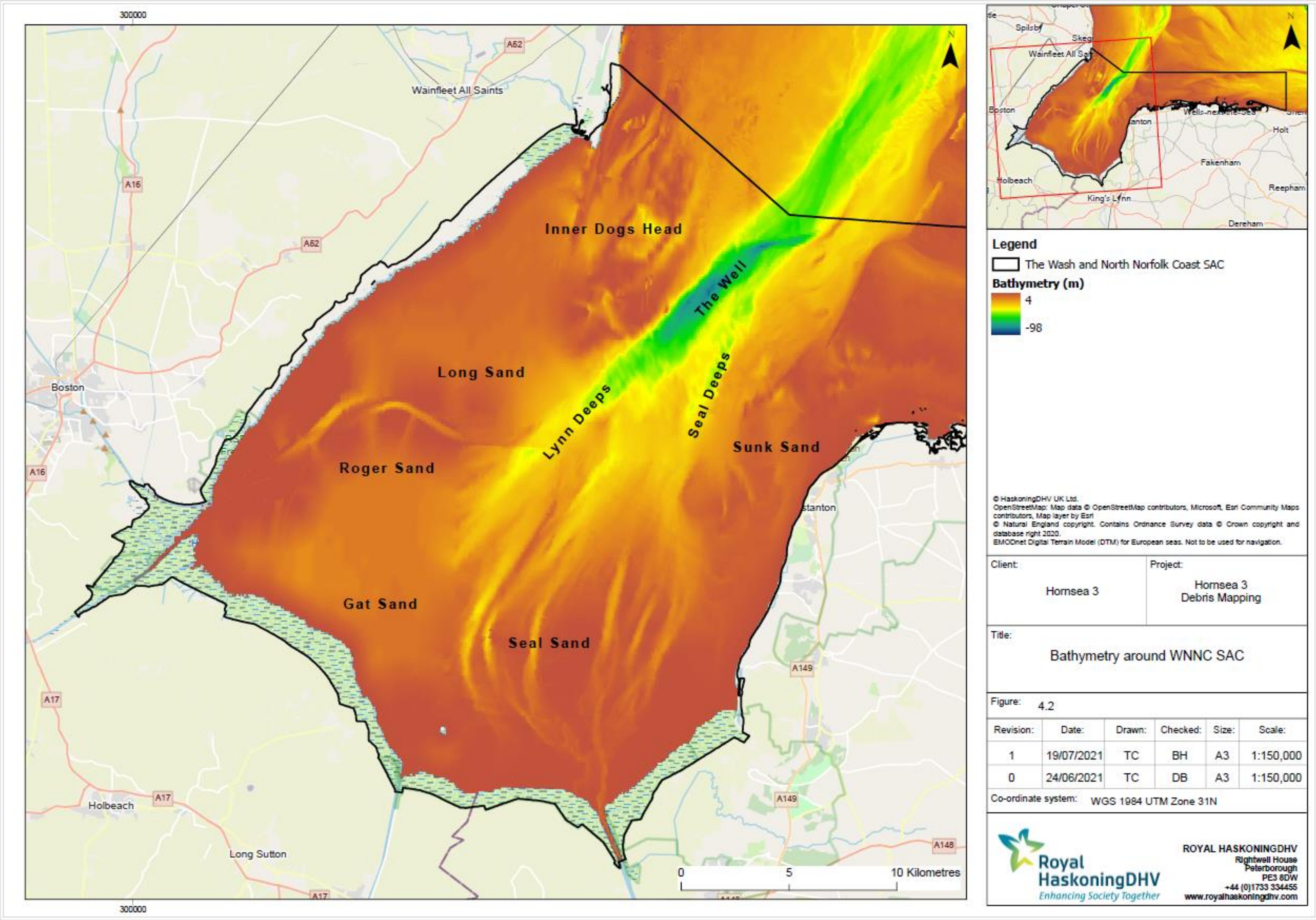

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Figure 4.2: Sandbanks and tidal channels in The Wash part of the WNNC SAC.

5 Excluded areas

33. The logical first step in identifying potential AoS within the NNSSR and WNNC SACs was to exclude areas in which existing safety, ecological or marine spatial planning issues may cause prohibitive constraints to the undertaking of marine debris removal operations.

34. As per the Sandbanks Compensation Strategy, removal of debris posing technical feasibility issues (including buried debris), ownership liability issues and / or health and safety risks (such as the presence of unexploded ordnance) will not be proposed for removal. Exclusion zones of 500m have therefore been implemented around oil and gas assets, such as subsea pipelines and platforms, undersea cable routes and other existing structures.

35. Areas of biological and / or sensitive ecological features are also excluded. Areas of the Annex I habitat *Sabellaria spinulosa* biogenic reef (including 'Areas to be managed as Reef', as designated by JNCC where the spatial extent of reefs is uncertain) would be avoided with an appropriate buffer of 50m to ensure no damage is caused to any reef features. It is recognised that areas of new reef can develop in a relatively short period of time and may not have been previously recorded; as such, should Stage 1 of the campaign identify the presence of uncharted reef (or potential reef), then such areas would be avoided when progressing to Stage 3 of the campaign. A decision tree is set out in the SBIPs to secure the process should biogenic or geogenic reef not identified during Stage 1 of the campaign, be identified during Stage 3[13]. Debris items that represent sites of archaeological value (for example, debris associated with historic wrecks) would also be excluded and 50m buffers applied to prevent accidental damage during debris removal.

36. Locations that may contain Unexploded Ordnance (UXO) would be identified during the removal campaign itself and excluded with an appropriate buffer zone of 50m left around such locations for health and safety reasons. The CIRIA guidance (2015) on UXO has been used to develop a method for risk analysis of such areas. In line with further CIRIA guidance regarding UXOs for the construction industry (2009), Hornsea Three will not remove or detonate identified UXOs. Any identified UXOs would be reported to HM Coastguard and any further actions required would be determined by the UK military and would not be undertaken by Hornsea Three.

37. Areas of active fishing gear will also be identified during the marine debris removal campaign, with subsequent exclusion of the area applied (including an appropriate buffer) if required. Hornsea Three anticipate obtaining full clearance of static fishing gear and fishing activity of the relevant areas and will compensate the impacted operators via evidence based payments as appropriate.

5.1 Constraint mapping data sources

38. To identify areas that must be excluded as AoS, the following items have been considered:

a. Areas of biogenic reef;

b. Oil and gas structures / substructures;

c. Existing cable and pipeline routes;

d. Licensed aggregate zones;

e. Wrecks; and

f. Bathymetry.

39. The data sources used for indicating the locations of the above have been set out in **Table 5.1**.

[13] Hornsea Three note that a detailed decision tree, providing further regard to biogenic and geogenic reef, will be submitted with the Marine License application to support the debris removal campaign.

Table 5.1: Data sources used in identifying exclusionary areas.

Item	Data source	Description	Rationale for exclusion
Areas of Annex I reef	JNCC MPA Mapper[14]	The MPA Mapper presents the distribution of SAC features of interest, based on scientific evidence used in the designation and management of sites.	Annex I reefs are sensitive habitats and methods used for debris removal may cause damage. Debris present in such areas may have been colonised as part of the reef and although not then considered as a conservation feature in their own right (as they are not colonising 'natural' habitat) could be associated with reef features.
Areas of Annex I reef	Natural England evidence base / Defra MAGiC application	This provides additional information on H1170 (Reef) distribution through point and polygon data in the WNNC SAC.	As above.
Oil and gas structures / substructures	O & G UK	Data layer showing the locations of surface and subsurface infrastructure, including platforms, terminals, buoys, wellheads, valves, berms, protection, storage tanks and other obstructions.	Safety issues associated with operating in close proximity to surface and subsurface structures, as well as liability issues for damage.
Cable routes	KIS-ORCA	Data layer showing the locations of subsea telecom and electrical cables.	Safety issues associated with operating in close proximity to subsea cables, as well as liability issues for damage.
Pipeline routes	O & G UK	Data layer showing the location of O&G pipelines, including active, inactive and abandoned pipelines.	Safety issues associated with operating in close proximity to subsea pipelines, as well as liability issues for damage.
Licensed aggregate zones	MMO Marine Activity Data Portal[15]	Data layer showing locations of licensed production, exploration and option areas in the Humber region, last updated in 2019.	Potential conflict with licence owners. Hornsea Three does not consider removing debris, and therefore restoring that area of sandbank habitat, to be appropriate to conduct in an area in use for aggregate extraction
Wrecks	UKHO / Admiralty[16]	UKHO / Admiralty chart the presence of wrecks and seabed obstructions due to the risk posed to navigation and marine activities. Data retrieved in 2021.	Sensitivities around removal or disturbance of wrecks (even those not listed as Protected Wrecks).
Bathymetry	Minimum of ten metres draft	EMODNet provides bathymetry data for the North Sea area, including within the NNSSR and WNNC SAC.	Marine debris removal vessels would likely have vessel access and working issues in water shallower than ten metres.

5.2 Map of constraints

40. To identify excluded AoS areas which would not be located, the obstructions and constraints listed in **Table 5.1** have been presented spatially, and stated buffers of 500m (around third-party assets) and 50m (around Annex I reef and wrecks) applied. Buffers were presented in the Scope of Works and consulted with the SG. Areas within the 10m depth contour have also been excluded for practical and logistical reasons. Additionally, areas within the Hornsea Three Order Limits have been excluded.

[14] https://jncc.gov.uk/our-work/marine-protected-area-mapper/
[15] https://explore-marine-plans.marineservices.org.uk/
[16] https://datahub.admiralty.co.uk/portal/apps/sites/#/marine-data-portal

41. The constraints maps are presented in **Figure 5.1** to **Figure 5.3**. In **Figure 5.1** and **Figure 5.2**, all areas within 500m of third-party assets, 50m of Annex I reef and wrecks and shallower than the 10.0m contour have been indicated. These figures indicate areas that are omitted when identifying the AoS. Blocks lying entirely with these areas are therefore not considered further.

42. Within NNSSR SAC, exclusions are based on presence of third-party infrastructure, such as pipeline and telecoms cable routes. A number of wrecks within NNSSR also represent discrete exclusion zones.

43. Within WNNC SAC, fewer exclusions are presented from third party infrastructure with a small number of wrecks present. The largest exclusions arise from depth restriction associated with debris removal methodology (the preferred shallowest depth is 10 m). On consideration of the size of the exclusion zone that the 10 m depth restriction presents, exclusions were assessed based on an 8 m depth to understand whether adapting methodology to include areas as shallow as 8 m depth would greatly decrease the size of the exclusion area. **Figure 5.3** shows that increasing depth of the debris removal campaign does not offer substantially more area within the SACs, and therefore the 10 m depth maximum has been maintained.

44. As well as the exclusions described above, any pots / other static fishing gear which are marked at the surface (or are part of a string of gear that is marked at the surface) will be treated as active or 'wet stored' and will be avoided, although by necessity this will be determined at the time of the removal campaign. Issue of Notices to Mariners in advance of the removal would allow fishers with unmarked stored gear in the targeted area to either retrieve or mark their gear ahead of the campaign. The Offshore Fisheries Liaison Officer (OFLO) on the vessel will coordinate the approach to managing any gear potentially active within the AoS during the debris removal campaign.

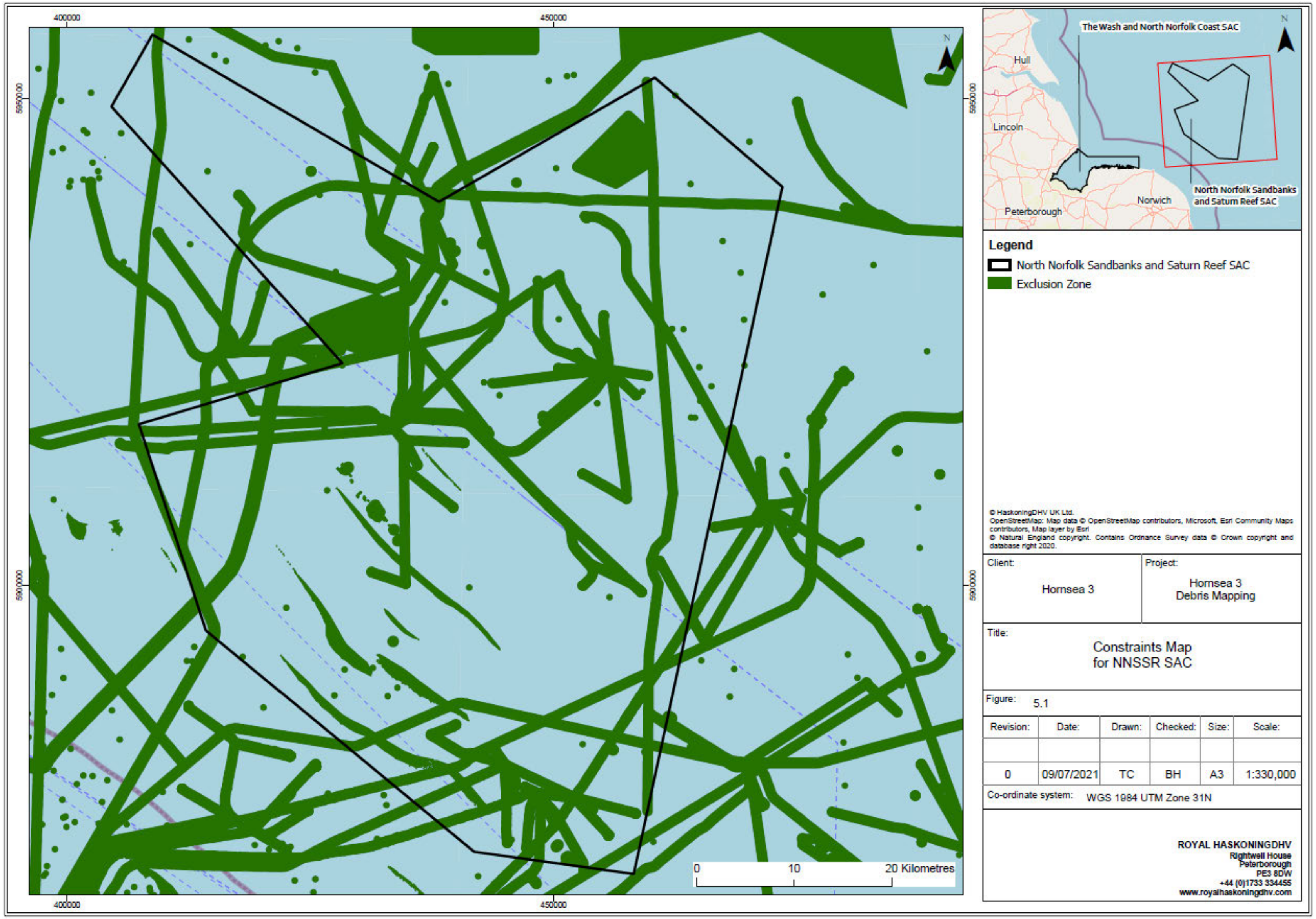


Figure 5.1: Constraints map (including 10.0m contour) at NNSSR SAC.

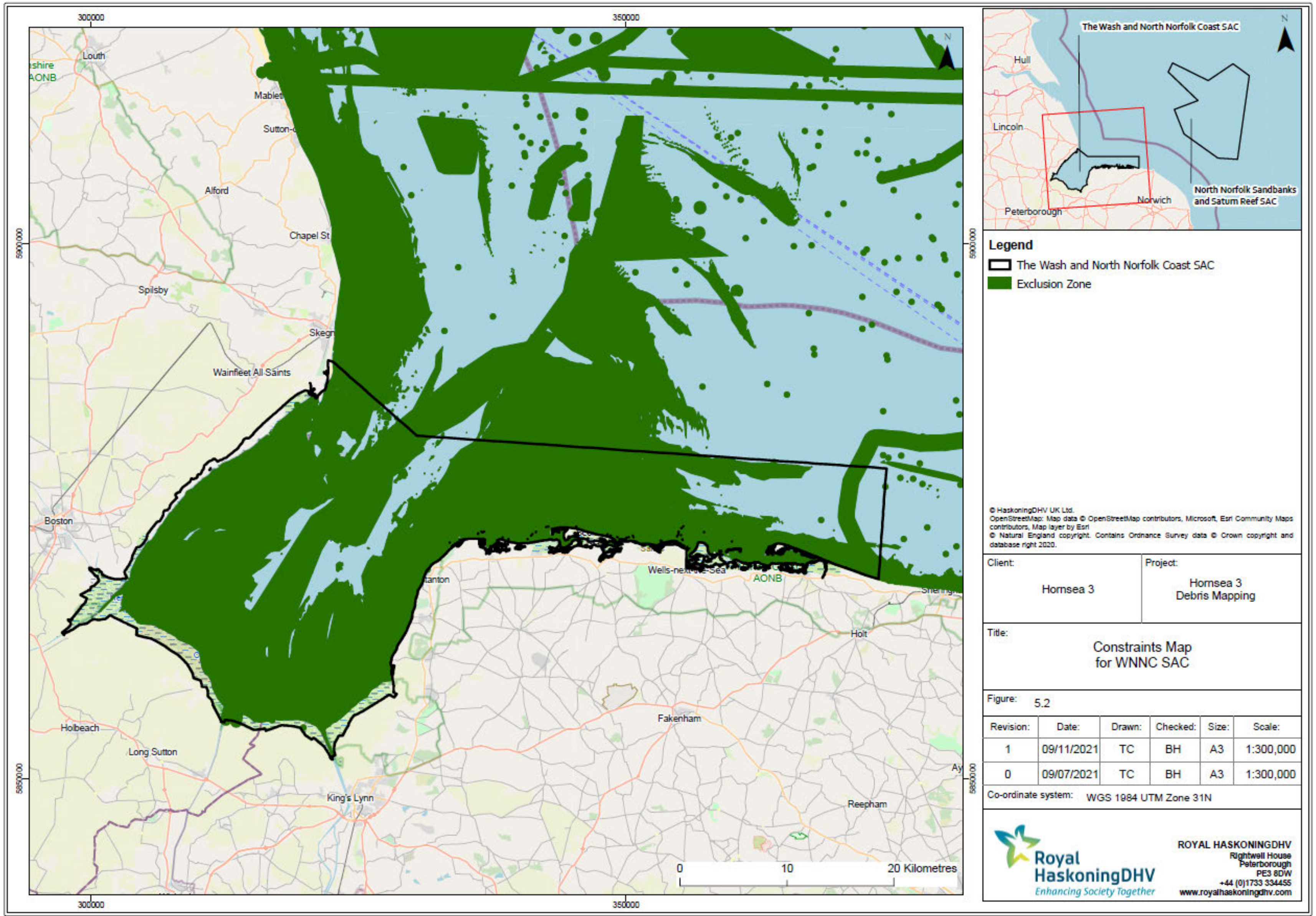


Figure 5.2: Constraints map (including 10.0m contour) at WNNC SAC.

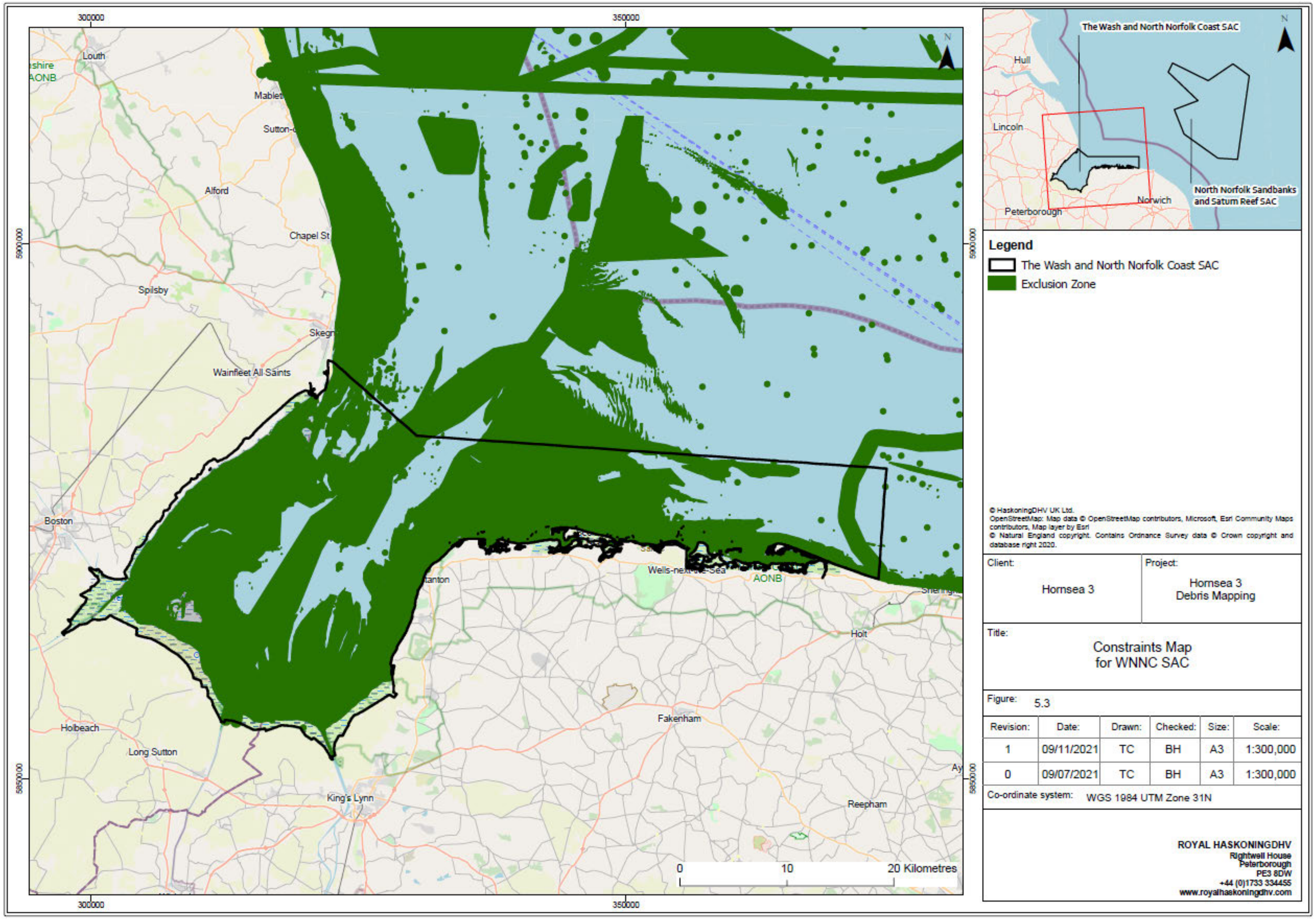


Figure 5.3: Constraints map (including 8.0m contour) at WNNC SAC.

6 Scoring of SAC blocks

45. This section presents a step-by-step walkthrough of the process undertaken to determine initial scoring of the individuals blocks in the NNSSR SAC and WNNC SAC.

6.1 Sources of debris information in NNSSR and WNNC SAC

46. Of the data sources set out in **Table 5.1**, the following provide information on marine debris recorded within the boundaries of the SACs:

a. Geophysical surveys in the Hornsea Two cable corridor AoS;

b. SeaSearch data; and

c. Fisheries consultation.

47. More information on these data sources is provided below. The main limitation of the above data sources is the restricted spatial coverage associated with them; the survey areas for SeaSearch and the geophysical surveys in particular, by their very nature, do not cover large swathes of the SACs.

6.1.1 Geophysical surveys at Hornsea Three

48. Provided by Orsted, this data source consists of point data identifying the locations of confirmed or potential debris / obstructions on the seabed. Locations are based on interpretation of side scan sonar imagery from the entire length of the Hornsea Three cable corridor AoS, undertaken between 2016 and 2019 by experienced marine survey contractors.

49. Potential debris was recorded throughout the surveyed area within the SACs, notably near to the land fall on the north Norfolk coast. Debris was, in some instances, recorded merely as a linear or sonar contact on the geophysical imagery; however, in some instances it could be specified as fishing gear, rope or chain, cable and mooring clump weight. See **Section 6.2** for further information on marine debris recorded in geophysical surveys in the general area.

50. Although targeted to within the proposed cable corridor AoS, the data from the geophysical surveys provides an indication of possible debris densities within the two SACs. In total, 24km^2 of the WNNC SAC has been surveyed, as part of three different surveys in 2016, 2017 and 2018, and a total of 309 contacts were identified as potential or confirmed debris (including ALDFG). This suggests an average density of around 13 items of debris / km^2 in the WNNC, with higher densities closer to shore (see **Figure 6.1**). In the NNSSR SAC, a total of 203 contacts were identified from a surveyed area of 28.5 km^2 (from surveys in 2018 and 2019), indicating an average density of around 7 items of debris / km^2.

6.1.2 Fisheries consultation

51. The fisheries consultation, undertaken by Brown and May Marine Ltd., used local knowledge to indicate a potential area of interest from a ALDFG and marine debris perspective. The methodology used to undertake the consultation and define the potential area of interest is provided in Sections 3.0 and 4.0 of **Annex I** to this report.

6.1.3 SeaSearch debris sightings

52. Following a request for information, SeaSearch provided a spreadsheet of survey records indicating dives in which marine debris had been observed. GPS coordinates of dives associated with marine debris sightings were included (although it did not provide exact GPS coordinates of individual debris items). Data was available from 2007 to 2019, at dive sites along the North Norfolk Coast and within the Wash. SeaSearch do not undertake offshore dives within the NNSSR SAC. While some of the debris is associated with wrecks (including those of ecological value, hence the reason for marine fauna / flora surveys at that location), other items (such as ALDFG, chains etc.) were recorded (see **Figure 6.2**).

53. Based on the SeaSearch data, there is a cluster of sites at the eastern end of the WNNC where several debris records have been pinpointed. However, it is likely that this cluster is a product of the fact that this area is monitored more regularly than most given that it overlaps with the Cromer Shoal Chalk Beds MCZ.

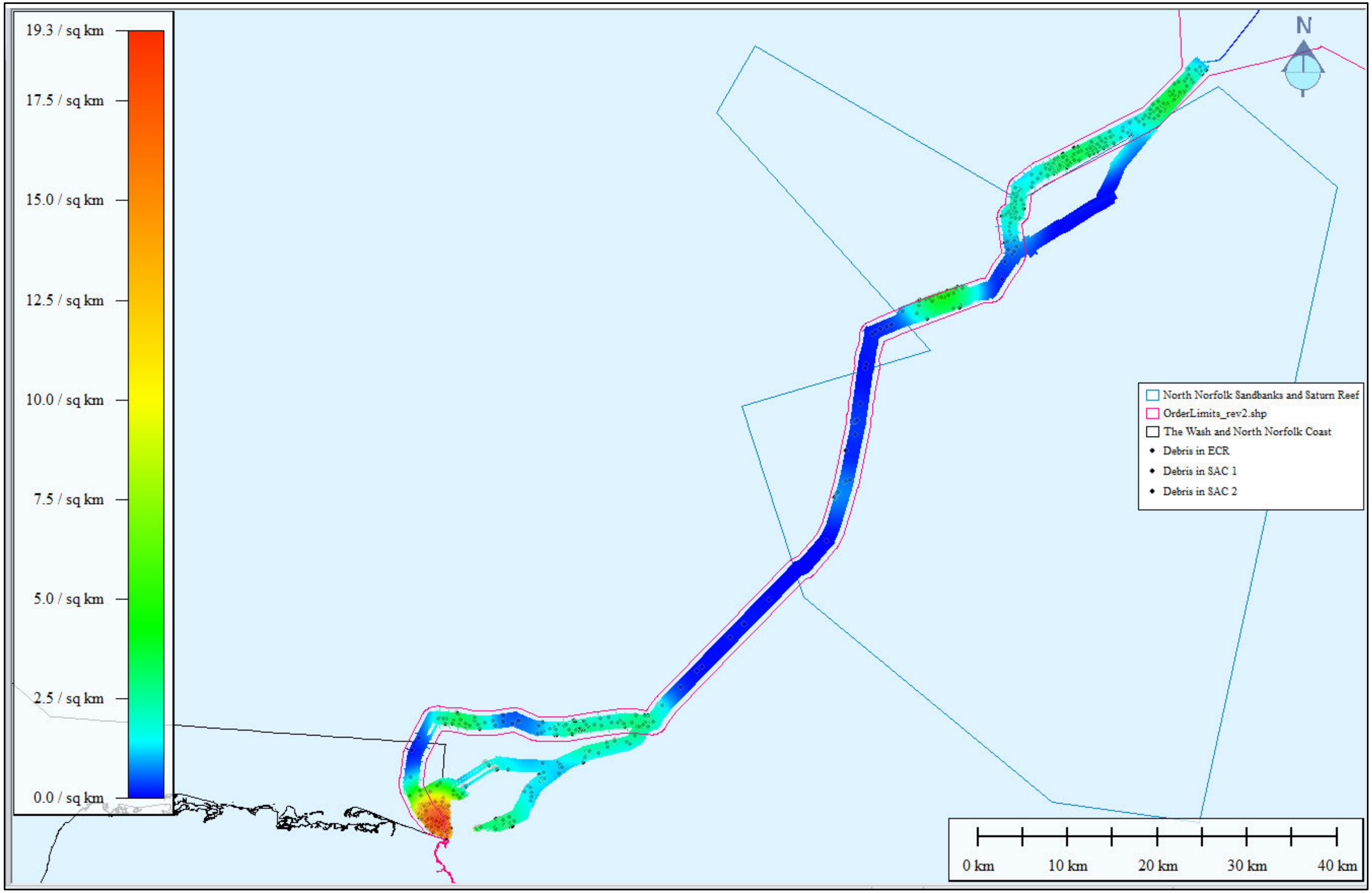


Figure 6.1: Density of debris as indicated by geophysical surveys in the Hornsea Three cable corridor AoS.

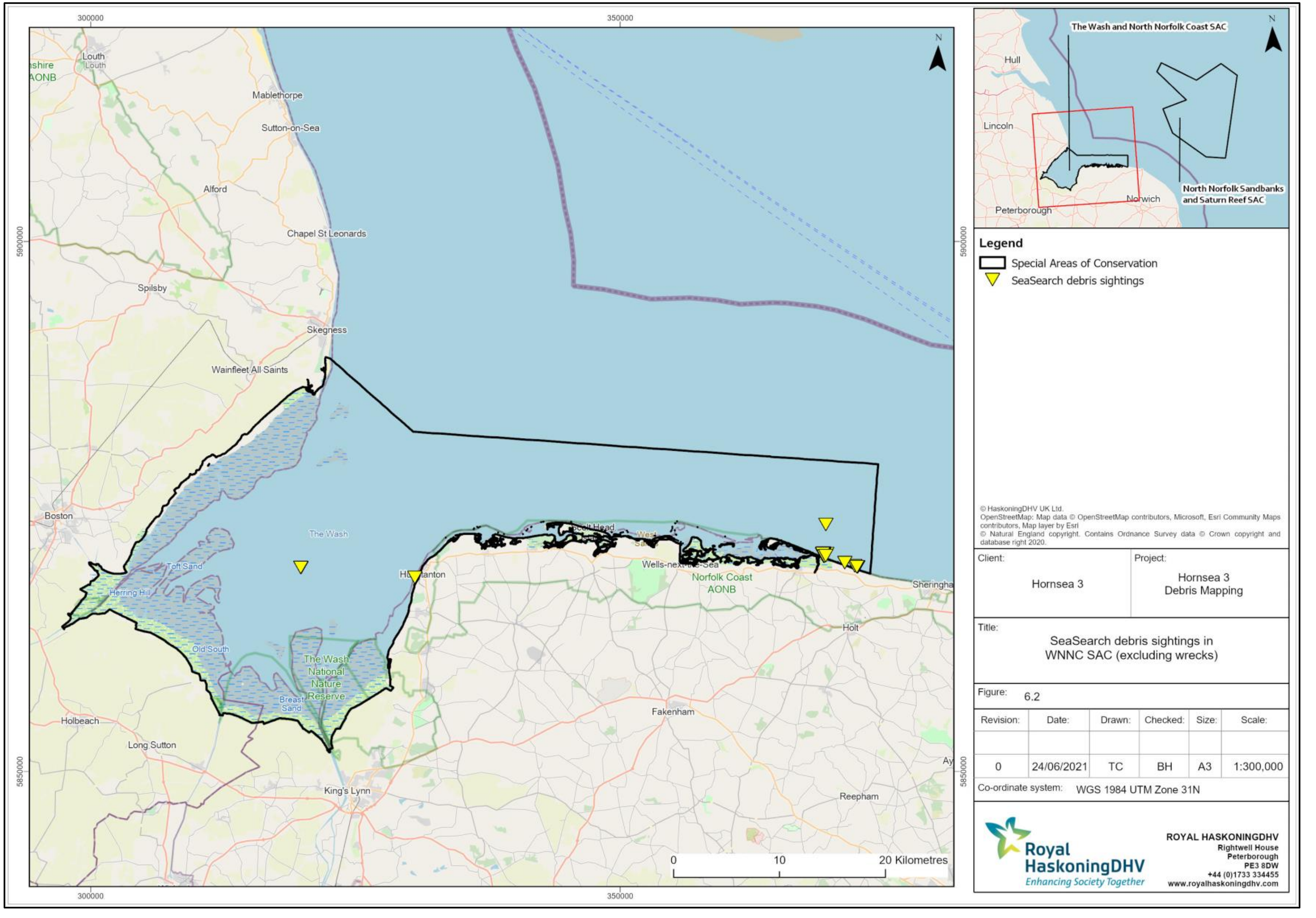


Figure 6.2: SeaSearch debris sightings in WNNC SAC (excluding wrecks).

6.2 Debris in the wider area

54. The Marine Strategy Framework Directive (MSFD), transposed as the Marine Strategy Regulations 2010, as amended[17], sets out descriptors for assessing the achievement of 'good environmental status', one of which (Descriptor 10) states that good environmental status can be achieved when *"properties and quantities of marine litter do not cause harm to the coastal and marine environment"*. The East Inshore and Offshore Marine Plans (the plan areas for which extend to the boundary of the Exclusive Economic Zone between Flamborough Head and Felixstowe, thereby encompass the two SACs), adopted in 2014, are designed to be mindful of the achievement of good environmental status under the MSFD. The plans specifically identify marine litter as an issue within the marine plan area and, therefore, potentially within the SACs.

55. While acknowledging that the spatial coverage of the studies / data sources listed in **Section 6.1** is limited (in terms of overall coverage of the SACs), there is data available either at wider scale or in other locations in the general area that can be used to infer the likely presence of debris, as described below.

56. Geophysical surveys were undertaken in the cable corridors for Race Bank, Lincs, Hornsea Two and Hornsea Three OWFs for the purpose of determining seabed topography and indicating potential obstructions or hazards when laying cables. The surveys were not undertaken to search specifically for debris, however, for each survey undertaken, the seabed imagery was reviewed by the surveyor and items of potential marine debris were identified. GPS coordinates were assigned to locations where potential debris was detected, and those locations are presented in **Figure 6.3**. This data comprises debris only and does not include pUXO or boulders which were also identified during the geophysical surveys.

57. Whilst acknowledging that some of the debris locations are out with the SACs, it is evident that the presence of marine debris is ubiquitous throughout the entire survey areas for each. Calculations have been undertaken for each to quantify the density of debris recorded, as set out in **Table 6.1** below. This provides strong supporting evidence that, despite an apparent paucity of evidence within the SACs, it is likely that marine debris is present across the site, and even a randomly placed AoS would likely result in the recovery of debris during the removal campaign.

Table 6.1: Calculated potential debris densities from geophysical surveys in the wider area.

Survey	Survey area	No. of potential debris contacts	Potential debris density
Race Bank (within WNNC SAC)	5.67 km^2	513	91 items / km^2
Lincs (within WNNC SAC)	5.41 km^2	119	22 items / km^2
HOW02	1,905 km^2	435	4.4 items / km^2
Hornsea Three (within NNSSR SAC)	28.5 km^2	203	7.1 items / km^2
Hornsea Three (within WNNC SAC)	24 km^2	309	13 items / km^2

58. A study of marine seabed litter was undertaken by Cefas (*Trends and status in UK seafloor litter*; Maes and Barry, 2018) using data from fish trawls undertaken between 2012 and 2015: The data was used to create figures representing spatial smoothed predictions of litter distribution and density. A figure showing the median total litter per square kilometre is presented in **Figure 6.4**. Although data specific to the two SACs for the North Norfolk coast is unavailable, the trends in the mapping suggest that the average density may be around 10-15 items of debris per square kilometre.

59. Based on the data sources suggested in this section, it is evident that debris is likely to be widespread and prevalent throughout most of the area, and an exercise to target areas of particularly high debris using proxies, such as vessel density information and fishing intensity, is likely to be successful.

[17] As amended by the Marine Environment (Amendment) (EU Exit) Regulations 2018

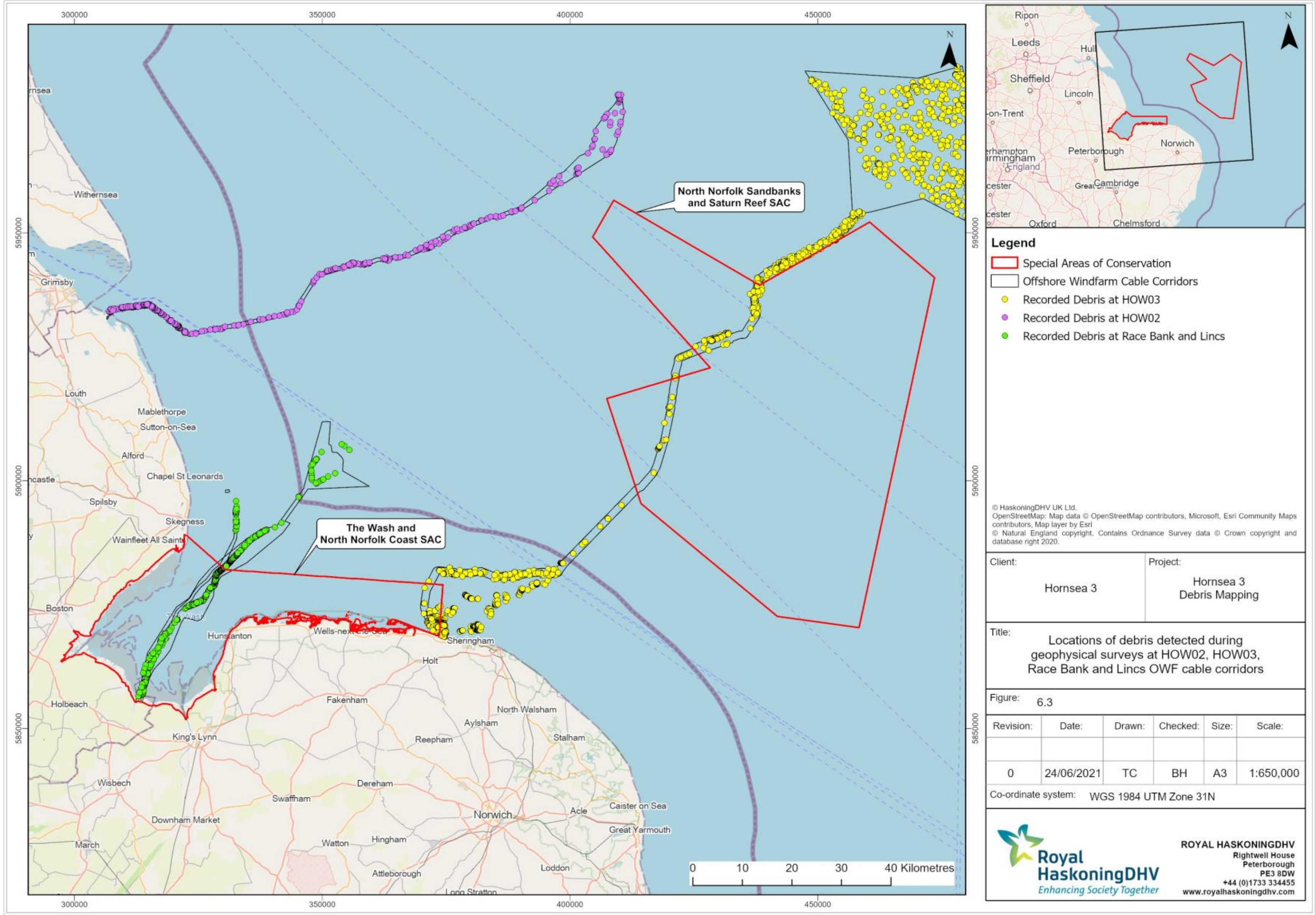


Figure 6.3: Locations of debris detected during geophysical surveys at Hornsea Two, Hornsea Three, Race Bank and Lincs OWF.

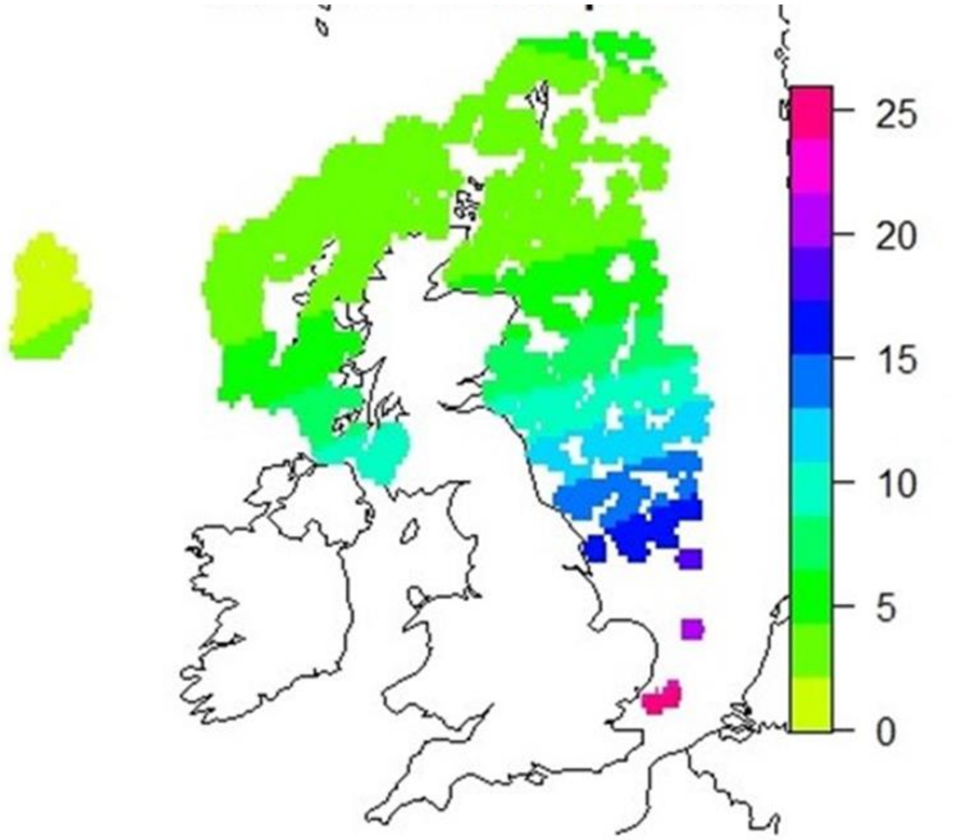


Figure 6.4: Map of smoothed median total litter per square kilometre (Maes and Barry, 2018).

6.3 Proxies for debris

60. Data sources which do not provide direct evidence of marine debris in the SACs but instead are likely to act as proxies (e.g. due to the presence of activities that may act as a source of debris) are described here. Proxy data sources used are as follows:

    a. VMS data;

    b. MMO fishing intensity data (FisherMap); and

    c. Admiralty wreck data.

61. While debris may arise from onshore sources (such as key tourism locations), such areas along the coastline are frequent and likely to introduce items of very mobile debris, with high dispersal. With this in mind, it was not considered appropriate to consider these as a proxy for debris.

6.3.1 UK VMS data

62. Two types of VMS data have been obtained from the MMO and used in this exercise. The first provides distribution information on all UK-registered vessels (fishing and non-fishing) between May 2018 and May 2021, which provides an indication of areas where marine traffic is at its highest in the SACs. The second is specific to UK-registered fishing vessels and describes the fishing effort (hours fished) over the two years 2018 and 2019.

63. UK VMS data (see **Figure 6.5**) indicate that, in the NNSSR SAC, the number of vessel movements (fishing and non-fishing) are generally higher in the northeast two thirds of the SAC and are higher on a local scale in the troughs between the sandbanks. This is to be expected because the water depths are greater further northeast, and the crests of the banks would be hazardous to shipping navigation. VMS coverage

in the WNNC SAC is limited, but vessel numbers are lower, and it is likely that the only significant vessel traffic is concentrated within the approach channels into ports located off The Wash (see **Figure 6.6**).

64. The 2018 and 2019 fishing vessel effort data (see **Figure 6.7** and **Figure 6.8**) indicate that the highest concentration of fishing activity in the NNSSR SAC is within the west of the site, with low activity elsewhere, including across the shallow inner sandbanks and adjacent deeper troughs (noting that UK VMS data provides information only on vessels that are 12m or more in length and as such does not include the smaller vessels working in the area). Within the WNNC, there is relatively high fishing activity off the north Norfolk coast as well as relatively level areas within the Wash (i.e. not within areas of sandbank habitat). The focus of potential debris disposal (especially that associated with ALDFG) is likely to be in the areas where fishing effort is highest.

65. Fisheries VMS data for non-UK vessels was not included as part of the VMS data that was used in the scoring exercise that follows in **Section 6.4**, as the data obtained from the MMO is specific to UK vessels. VMS value data specific to UK and Dutch beam trawling vessels operating in the NNSSR SAC during the periods 2015 to 2019 and 2014 to 2018, respectively, is presented in the Fisheries Consultation Report provided by Brown and May Marine Ltd. (see Figures 2-1 and 2-2 of **Annex 1**).

66. Areas where Dutch VMS values were relatively high (within the centre of the SAC) are similar to those for UK vessels over their respective time periods, although there is a greater degree of trawling by Dutch vessels in the eastern half of the SAC (albeit the Dutch VMS data is at a far lower resolution). Given the lack of defined resolution for non-UK vessels, and the fact that the VMS data presented in the Fisheries Consultation Report is specific to beam trawling vessels (and therefore is not indicative of other fishing gear uses), the fisheries VMS data obtained from the MMO for UK-registered vessels only is considered to be appropriate for use in the scoring exercise.

6.3.2 Wrecks

67. Wreck data from Admiralty / UKHO provides up to date information on the presence of known wrecks and seabed obstructions across the UK. Wrecks themselves may have sensitivity issues (this could be archaeological, political, ecological etc.) and, as set out in **Section 5**, would not be targeted specifically during the debris removal campaign. However, surrounding seabed areas may hold debris associated with such wrecks, hence blocks containing one or more wreck(s) would gain additional scoring (albeit with exclusion zones in the immediate vicinity of wrecks and ensuring that any debris source is reviewed by a qualified maritime archaeologist. All works would be conducted in accordance with a campaign specific Method Statement agreed with Historic England.

68. Wrecks / seabed obstructions are scattered across both SACs (see **Figure 6.9**), with relatively high density in The Wash but less so in the eastern half of the WNNC or anywhere within the NNSSR SAC. In general, there is a tendency for wrecks to be located near to the base of sandbanks, presumably as they have settled there through gravitational means.

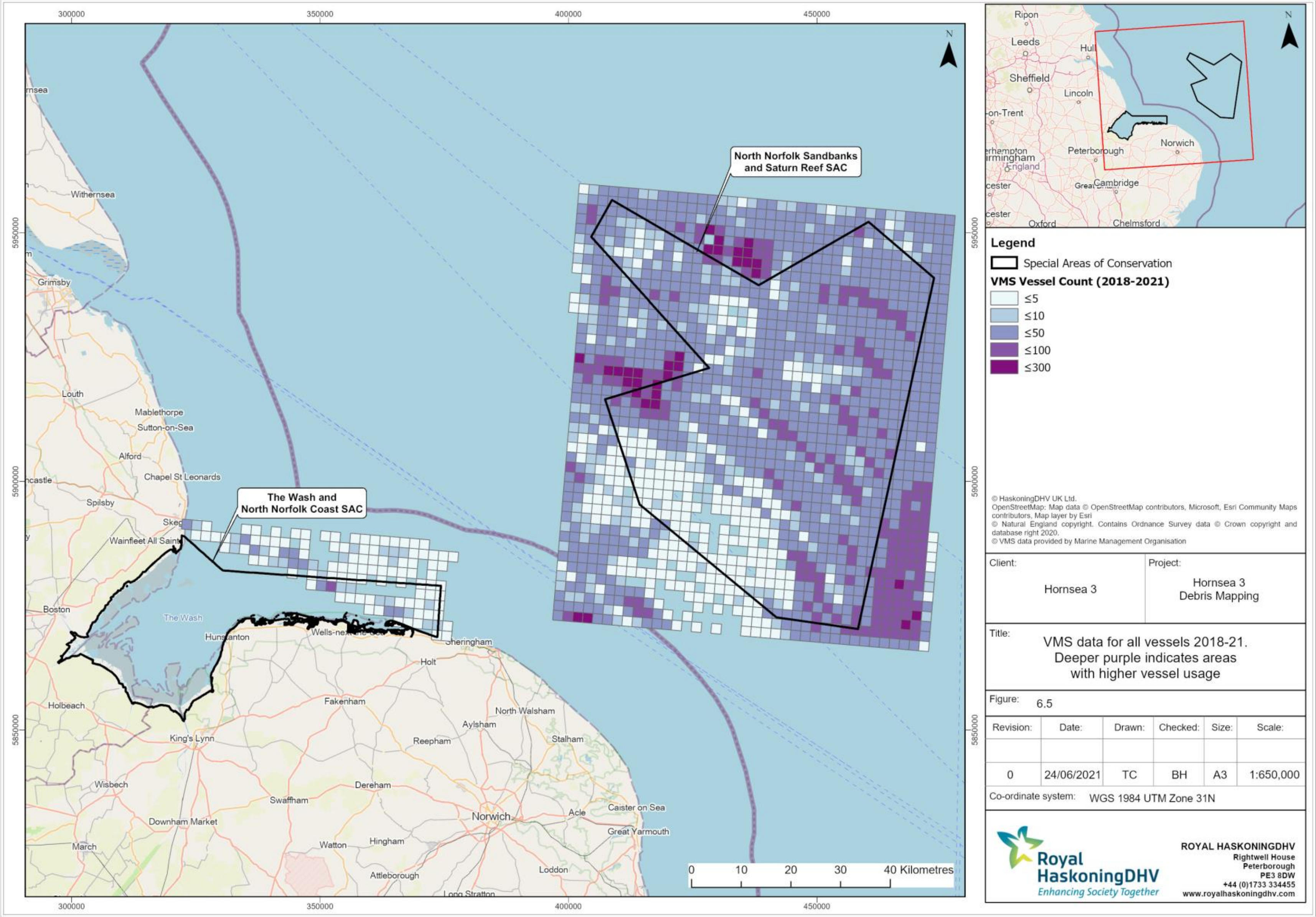


Figure 6.5: UK VMS data for all vessels 2018-21. Deeper purple indicates areas with higher vessel usage.

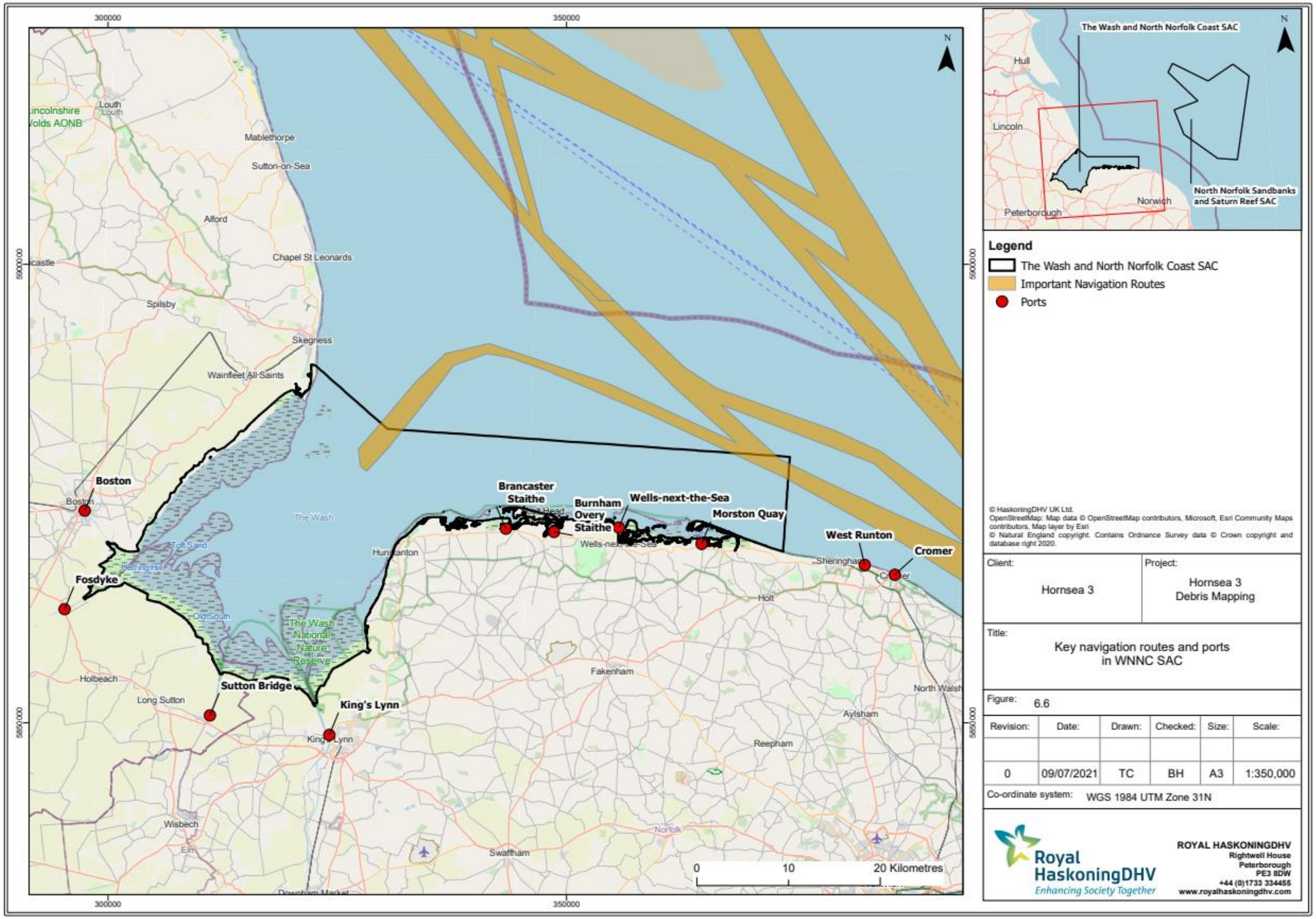


Figure 6.6: Navigation routes in to WNNC SAC.

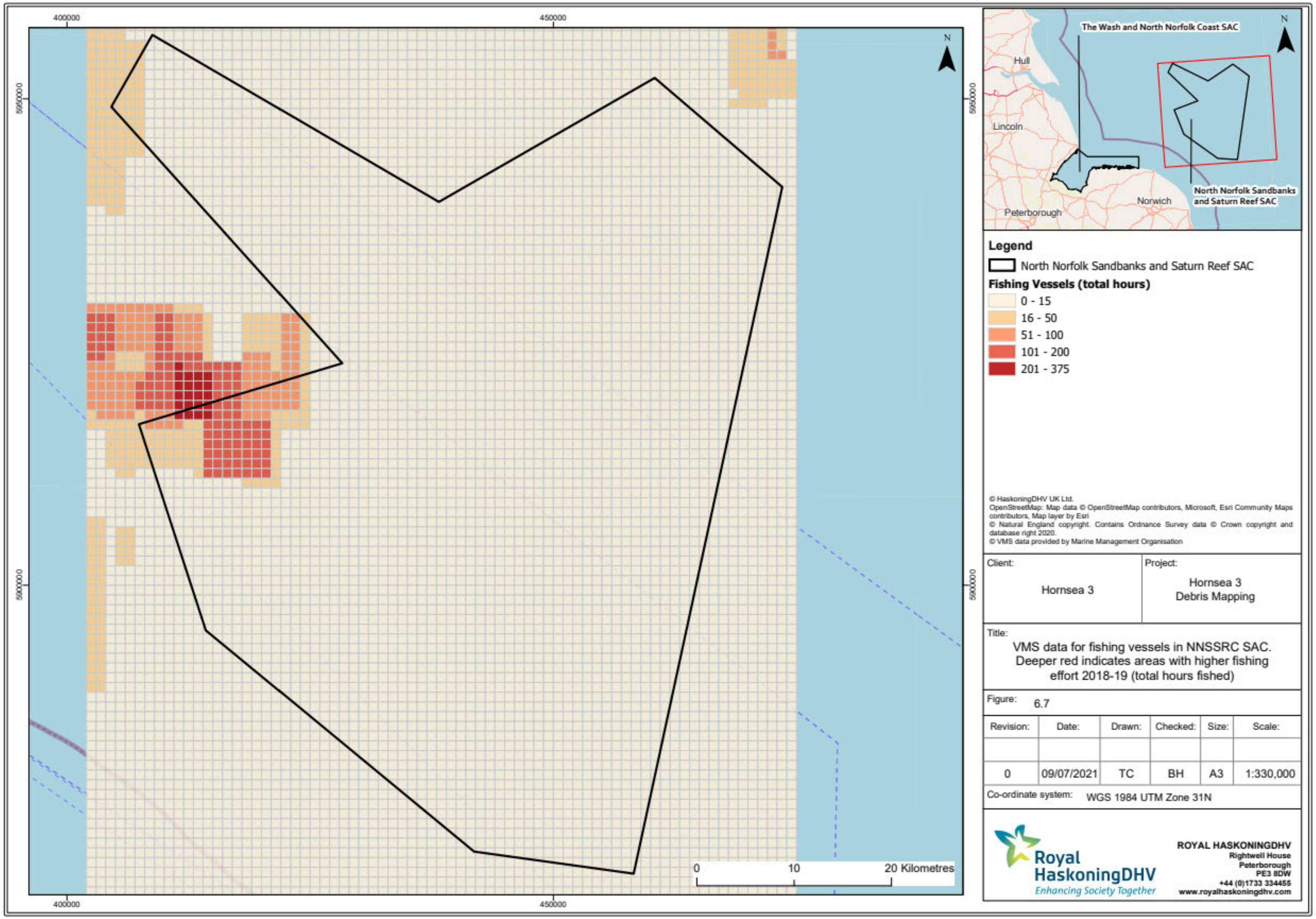


Figure 6.7: UK VMS data for fishing vessels in NNSSRC SAC. Deeper red indicates areas with higher fishing effort 2018-19 (total hours fished).

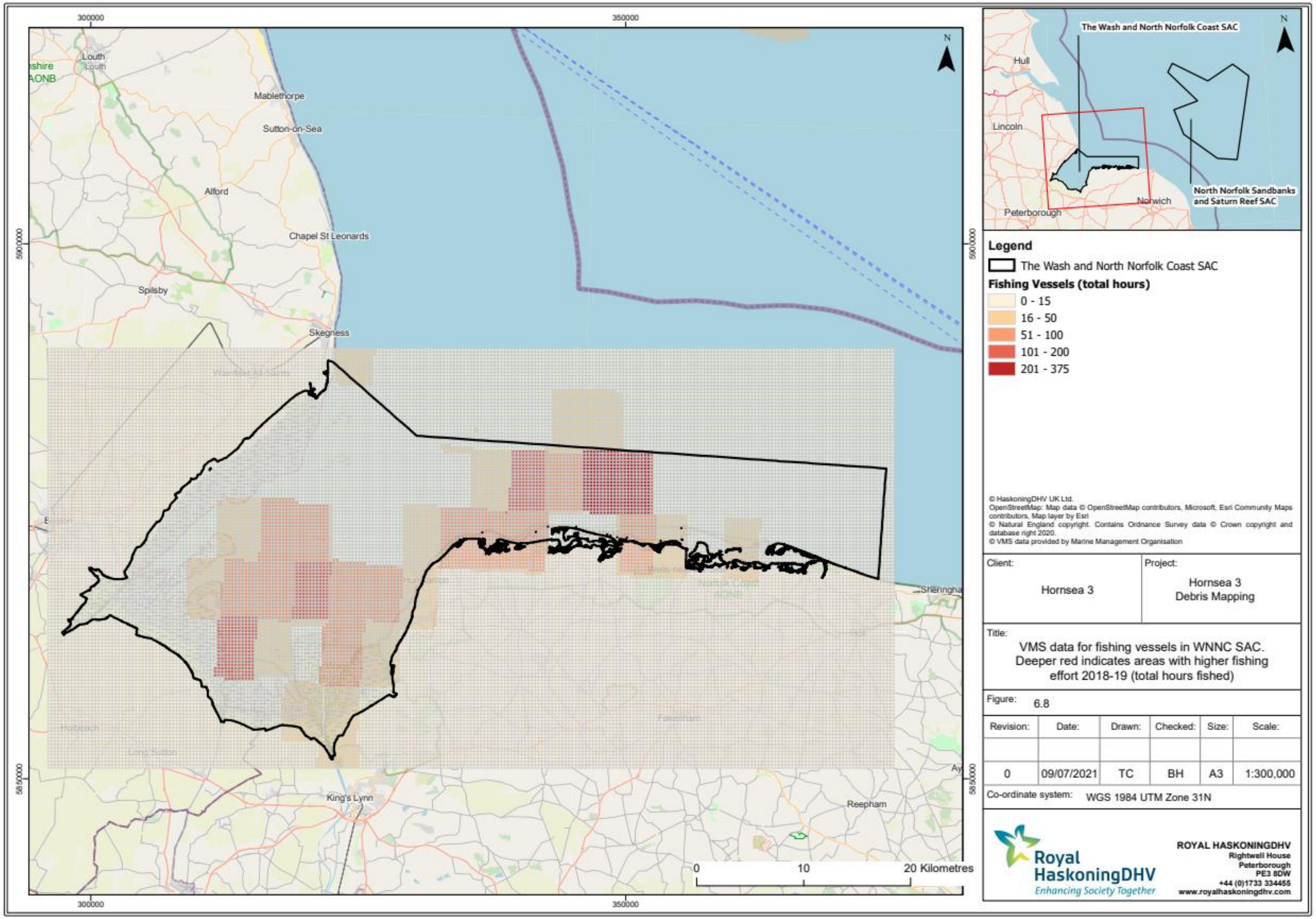


Figure 6.8: UK VMS data for fishing vessels in WNNC SAC. Deeper red indicates areas with higher fishing effort 2018-19 (total hours fished).

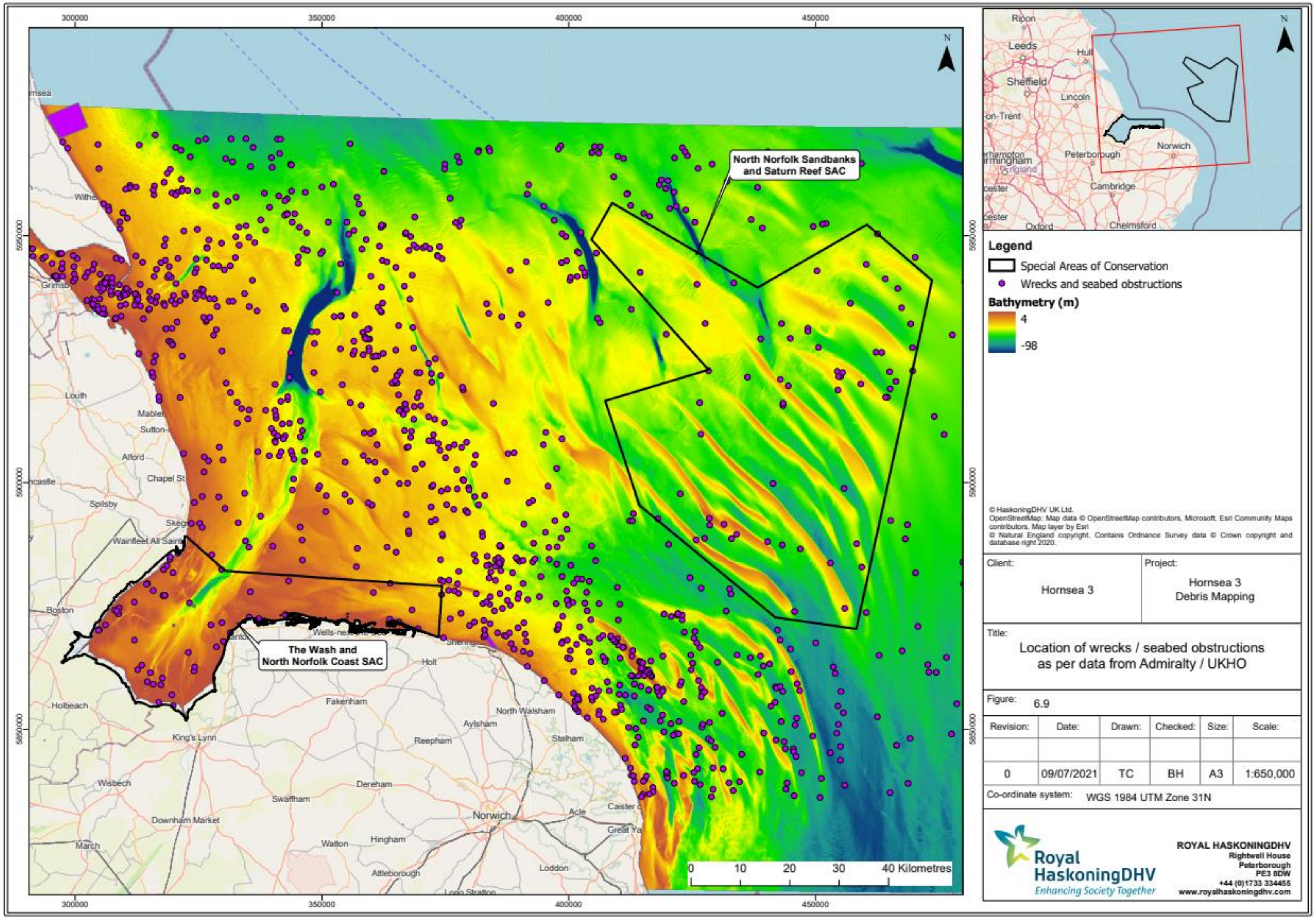


Figure 6.9: Location of wrecks / seabed obstructions as per data from Admiralty / UKHO.

6.4 Scoring

6.4.1 Scoring thresholds

69. As stated in the Scope of Works document and agreed with the SG, the NNSSR SAC and the WNNC SAC have been subdivided into 100 ha blocks and 10 ha blocks, respectively, for the purpose of 'scoring' (see **Figure 6.10** and **Figure 6.11**). The different approaches are based on the fact that the AoS for the WNNC SAC is to be considerably smaller than that in the NNSSR SAC. To establish priority areas, the blocks have been scored based on their perceived likelihood to contain marine debris. Overall scores for each block are an accumulation of individual scores based on the data sources described in **Sections 6.1** and **6.3**.

70. For each data source, a block can either score high (a score of 3), medium (a score of 2) or low (a score of 1). In order to determine what constitutes a high, medium or low score, the range of values, for each parameter, across all blocks has been taken into account and judgement has been applied to set appropriate thresholds. Definitions of the scoring are provided in **Table 6.2** and **Table 6.3** for NNSSR SAC and WNNC SAC, respectively. It should be noted from the table that, due to the difference in block size, scoring thresholds for NNSSR and WNNC SAC differ. The scores have then been adjusted by multipliers described in the following sections.

Table 6.2: Scoring definitions for NNSSR SAC.

Data source	Range	'Low' scoring threshold (score of 1)	'Medium' scoring threshold (score of 2)	'High' scoring threshold (score of 3)
NNSSR SAC				
Hornsea Three Geophysical. survey	0 to 39 items of debris	No items of debris identified in block	1 – 5 items of debris identified	>5 items of debris identified
Fishermap value	1 to 7	Fishermap intensity score of 1 or less in block	Fishermap intensity score of 1.1 to 2	Fishermap intensity score of >2
UK Fisheries VMS data 2018 to 2019	0 to 265 hours	Less than 1 hour of fishing activity	1.1 to 10 hours of fishing activity	Over 10 hours of fishing activity
UK VMS data (all vessels)	0 to 100 vessel 'pings'	<7 vessels recorded in block	7.1 to 15 vessels recorded	More than 15 vessels recorded
Admiralty wreck data	0 to 3 wrecks	No wrecks in block	1 wreck	2 or more wrecks

Table 6.3: Scoring definitions for WNNC SAC.

Data source	Range	'Low' scoring threshold (score of 1)	'Medium' scoring threshold (score of 2)	'High' scoring threshold (score of 3)
WNNC SAC				
Hornsea Three Geophysical. survey	0 to 53 items of debris	No items of debris identified	1 – 5 items of debris identified	>5 items of debris identified
Race Bank and Lincs survey	0 to 218 items of debris	No items of debris identified	1 – 5 items of debris identified	>5 items of debris identified
Sea Search surveys	0 to 33 items of debris	No items of debris identified	1 – 3 items of debris identified	>3 items of debris identified
Fishermap value	2 to 9 (no units)	Fishermap intensity score of 5 or less	Fishermap intensity score of 5.1 – 8	Fishermap intensity score of >8
UK Fisheries VMS data 2018 to 2019	0 to 304 hours	Less than 5 hours of fishing activity	5.1 to 25 hours of fishing activity	>25 hours of fishing activity
UK VMS data (all vessels)	0 to 27 vessel 'pings'	No vessels recorded in block	1 - 5 vessels recorded	More than 5 vessels
Admiralty wreck data	0 to 2 wrecks	No wrecks in block	1 wreck	2 wrecks

Data source	Range	'Low' scoring threshold (score of 1)	'Medium' scoring threshold (score of 2)	'High' scoring threshold (score of 3)
Fisheries consultation	N/A (blocks are either within or out with the area indicated)	Out with suggested areas of search	N/A	Within suggested AoS

6.4.2 Confidence multipliers

71. The overall scoring of a block has been influenced by the level of confidence in the data from the sources described in **Sections 6.1** and **6.3**. Confidence level refers to the expected accuracy and precision of the data used from that source. For example, empirical data gathered by experts using technical and effective scientific means would likely have a high level of confidence attached. Conversely, 'hearsay' or anecdotal evidence based on non-scientific methods would likely have a low level of confidence attached. In order to assign an overall score to a block, a multiplier based on the confidence level has been added, meaning that the scoring of a block in the AoS identification process is more heavily weighted by data from reliable sources. **Table 6.4** indicates the multiplier attached to the confidence level.

Table 6.4: Definition of scoring multiplier based on the confidence level attached to a given data source.

Score	Confidence level
1.0	Low
1.5	Medium
2.0	High

72. The data sources used in the scoring process have therefore each been assigned a confidence level. The assigned confidence levels for each are listed in **Table 6.5**, along with a justification for those assigned levels.

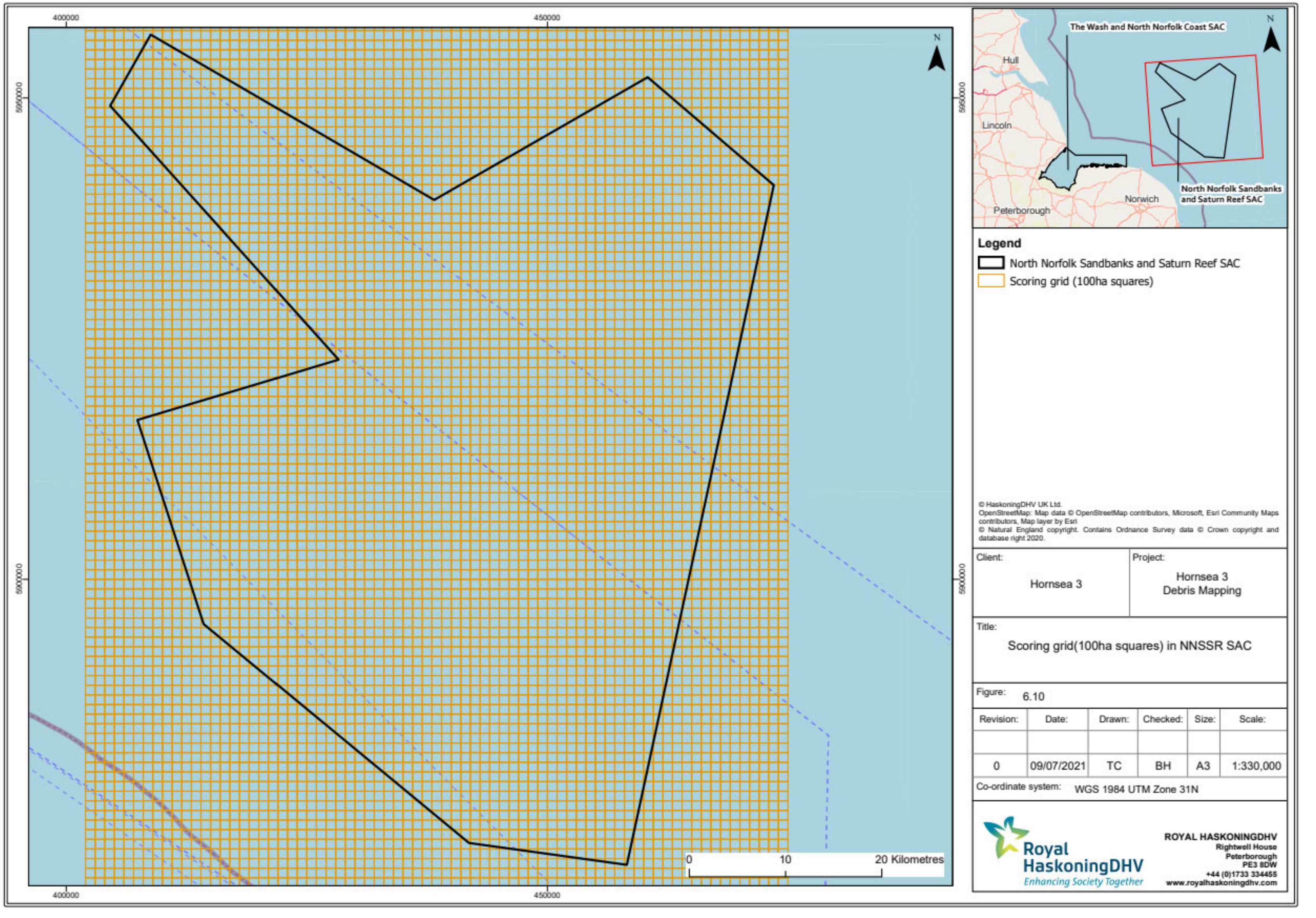


Figure 6.10: Scoring grid (100ha squares) in NNSSR SAC.

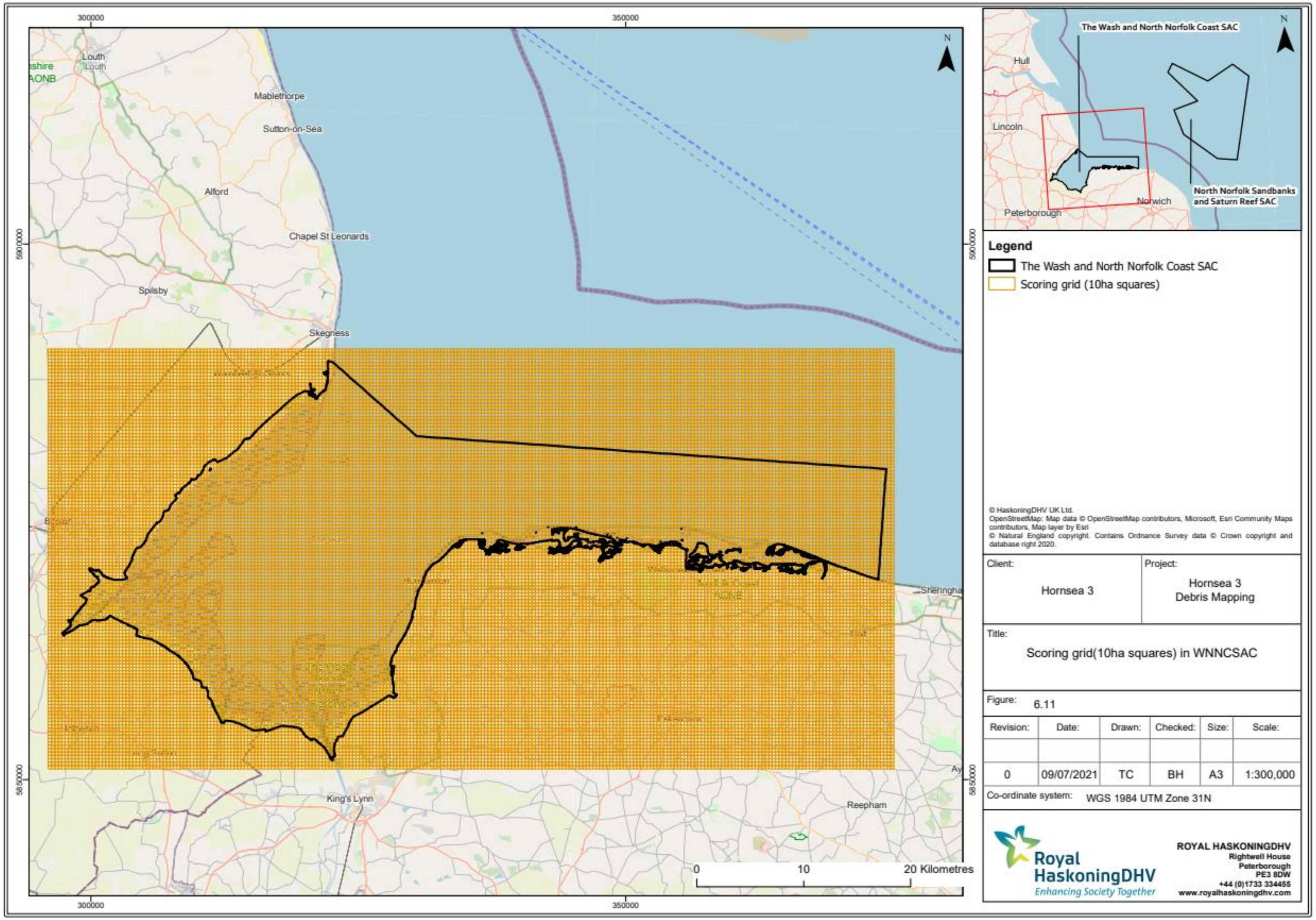


Figure 6.11: Scoring grid (10ha squares) in WNNC SAC.

Table 6.5: Confidence levels assigned to data sources.

Data source	Confidence level	Justification
Hornsea Three Geophysical. survey	Medium	The side scan / magnetometer surveys undertaken between 2016 and 2019 in the potential cable corridor were undertaken and interpreted by expert organisations (e.g. Fugro and Gardline). However, given that this was composed of separate surveys, there may be discrepancies between reporting. Debris targets identified have not been confirmed using imaging as part of pre-construction surveys.
Race Bank and Lincs Geophysical. surveys	High	The side scan / magnetometer surveys undertaken in the cable corridor for Race Bank and Lincs OWF were ground truthed - debris targets identified were incontrovertibly confirmed using remote operated vehicle.
Sea Search surveys	Medium	Diver surveys are an effective way of identifying first hand sources of debris, and data is available up to and including 2019. Data is provided by divers required to undertake training in marine surveys.
Fishermap value	Low	Fishermap data has been collated from a series of interviews with fishermen between 2007 and 2010, therefore is quite outdated and from unverified sources.
UK Fisheries VMS data 2018 to 2019	High	Data is automatically collated by the MMO due to a legal requirement for ships over 15m in length to have VMS capabilities on board and operational. Data is available up to 2019. Onboard GPS is generally extremely accurate.
UK VMS data (all vessels)	High	Data is automatically collated by the MMO due to a legal requirement for ships over 15m in length to have VMS capabilities on board and operational. Data is available up to 2019. Onboard GPS is generally extremely accurate.
Admiralty wreck data	High	Data is collected by the UK Hydrographic Office and charted for navigational safety purposes, therefore it is imperative that data is accurate and regularly updated. Data was requested in 2021.
Fisheries consultation	Low	Data is anecdotal and from a small sample size.

6.4.3 Value multipliers

73. As with the confidence levels attached to the data, overall scoring of a block has also been influenced by the judged value of the data for the purpose of identifying areas of marine debris. Essentially, this implies that the data sources have been prioritised, with more important data sources providing heavier weighting to the scoring of a block than less important sources. For example, a source of data that provides definitive, quantified evidence of marine debris (e.g. through seabed imagery) would provide heavier weighting than a source of data that provides proxies, whereby there is no direct evidence of marine debris presence other than an educated assumption that the associated activity would lead to an increase in debris. Again, in order to assign an overall score to a block, a multiplier has been added, this time based on the value assigned to each data source.

74. **Table 6.6** indicates the multiplier attached to the assigned value.

Table 6.6: Definition of scoring multiplier based on judged value of a given data source.

Score	Value
1.0	Low
1.5	Medium
2.0	High

75. The data sources used in the scoring process have therefore each been assigned a value (low / medium / high). The assigned values levels for each are listed in **Table 6.7**, along with justification for assigning such values.

Table 6.7: Value of data sources used in scoring of potential AoS.

Data source	Value	Justification
Hornsea Three Geophysical. survey	High	Seabed imagery from geophysical surveys provides irrefutable evidence of seabed debris present within the mapped areas.
Race Bank and Lincs Geophysical. survey	High	Seabed imagery from geophysical surveys provides irrefutable evidence of seabed debris present within the mapped areas.
Sea Search surveys	Low	Although data provides first hand evidence of seabed debris with approximate coordinates, it is possible that dive sites in which debris has been recorded are visited due to the fact that the debris has promoted colonisation by marine fauna / flora, therefore would not be preferentially targeted in the debris removal campaign.
Fishermap value	Medium	While this does not provide definitive evidence of the presence of marine debris, this is the best available mapping study of fishing intensity by fishers using smaller vessels (i.e., those exempt from VMS), which are likely to be the most prevalent in inshore areas such as the WNNC SAC.
UK Fisheries VMS data 2018 to 2019	Medium	Areas of relatively high intensity of fishing are likely to provide a greater intensity of debris activity; however, the value of this data is considered to be medium as VMS data does not specify gear type, and heavy use of bottom-towed gear may reduce the likelihood of finding debris to a certain extent.
UK VMS data (all vessels)	Medium	While this does not provide definitive evidence of the presence of marine debris, VMS data is a robust proxy as it is the best and most recently mapped evidence indicating areas of high vessel usage, which would suggest areas where debris is more frequently lost overboard.
Admiralty wreck data	Medium	This data does not provide definitive evidence of the presence of marine debris. However, the presence of wrecks indicates the presence of associated debris in nearby areas.
Fisheries consultation	Low	This provides anecdotal evidence of the approximate location of target marine debris (i.e. ALDFG), although does not give exact areas and instead only indicates a region.

76. With the multipliers included, the potential scores for a given block and given data source are presented in **Table 6.8**. The overall score for a block has then been calculated as the sum of the scores for each data source. The overall score of each block is indicated in **Figure 6.12** (a and b).

Table 6.8: Calculation of overall score per block.

Data source	Score	Confidence multiplier	Value multiplier	Total score for data source
Hornsea Three Geophysical survey	1.0, 2.0 or 3.0, based on scoring set out in **Table 6.2** and **Table 6.3**	1.5	2.0	Based on score x multipliers
Race Bank / Lincs Geophysical. survey		2.0	2.0	
Sea Search surveys		1.5	1.0	
Fishermap value		1.0	1.5	
UK Fisheries VMS data 2018 to 2019		2.0	1.5	
UK VMS data (all vessels)		2.0	1.5	
Admiralty wreck data		2.0	1.0	
Fisheries consultation		1.0	1.0	
OVERALL SCORE FOR BLOCK				Cumulative score of the above

77. As shown in **Figure 6.12 (a and b)**, the block scores at NNSSR SAC range between 12.5 and 26 points. Highest scoring blocks are generally located in the southern and western sections of the SAC. There are a few high scoring blocks that run adjacent to each other in a northwest-southeast orientation across the centre of the SAC.

78. Block scores at WNNC SAC are generally higher than NNSSR SAC, given that more criteria are considered, and range between 15 and 45 points. Higher scoring blocks are generally located in the deeper, central sections of the Wash, although there are also scattered locations in the eastern half of the SAC off the north Norfolk coast.

79. **Figure 6.13b (a and b)** overlays the exclusion zone set out in **Section 5**. Within NNSSR SAC, the exclusion zone does not greatly reduce the availability of high scoring blocks. However, in the WNNC SAC, the high scoring blocks are limited to deeper areas within the Wash and isolated areas in the east of the SAC.

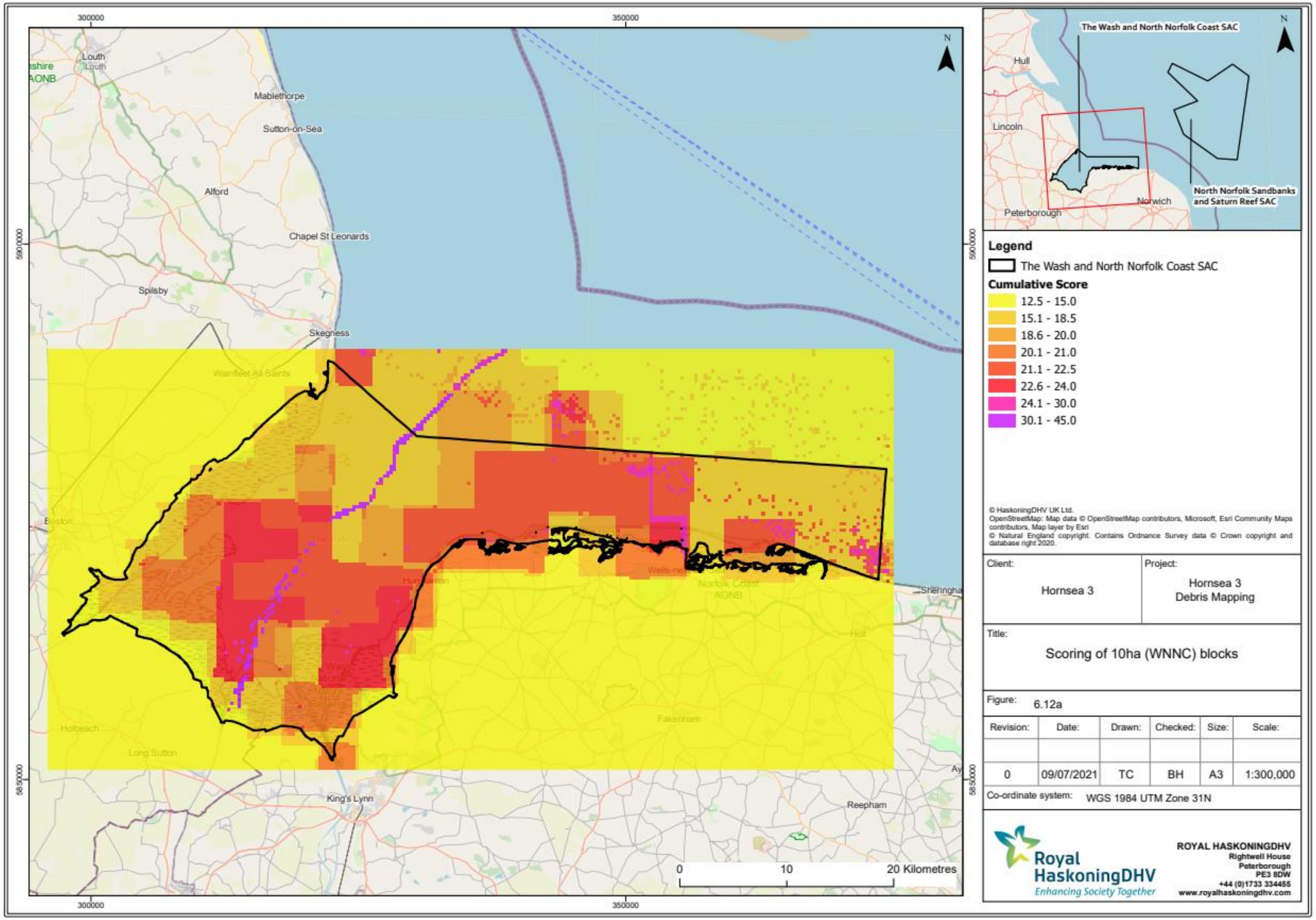


Figure 6.12a: Scoring of 10ha blocks at WNNC SAC.

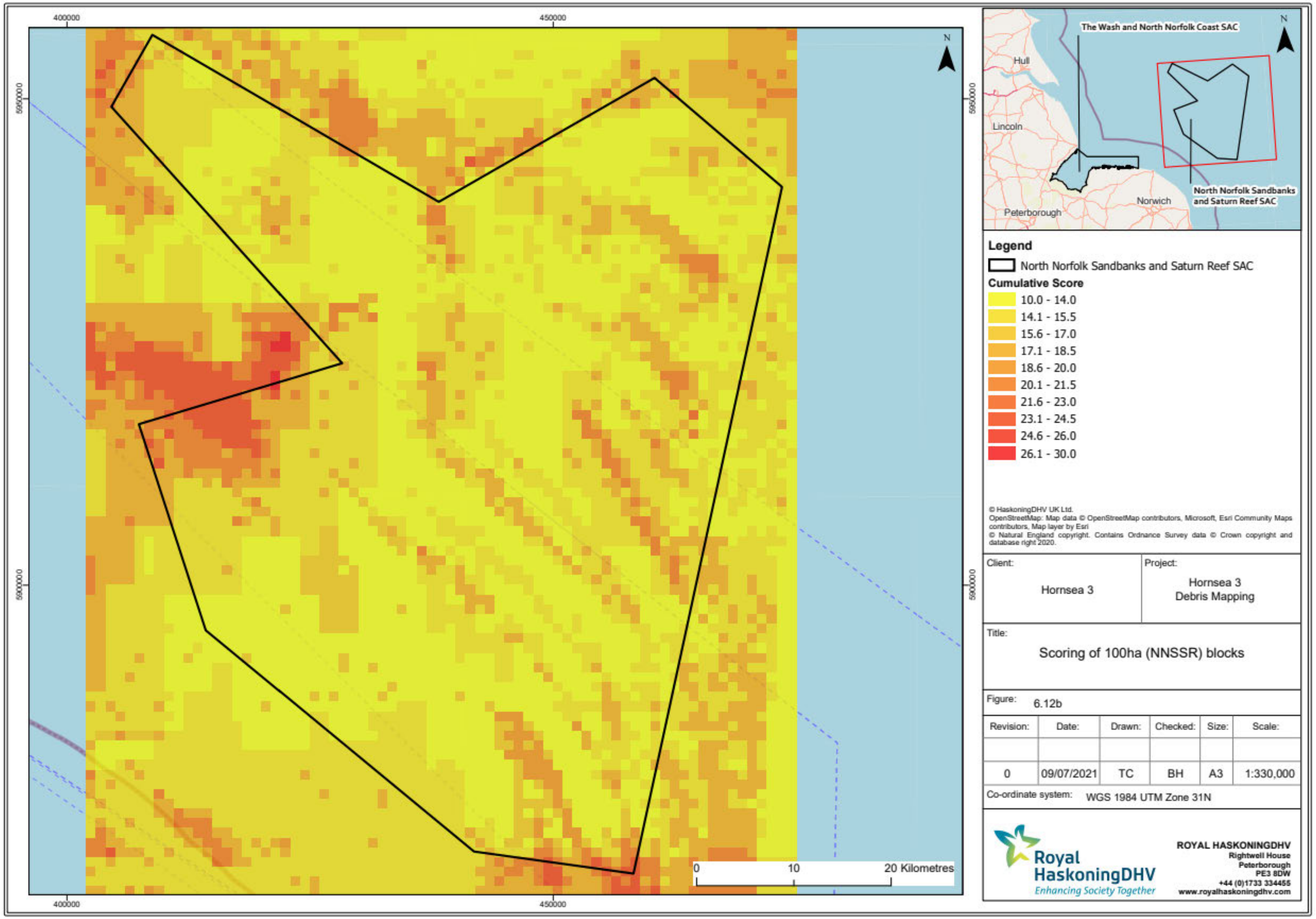


Figure 6.12b: Scoring of 100ha blocks at NNSSR SAC.

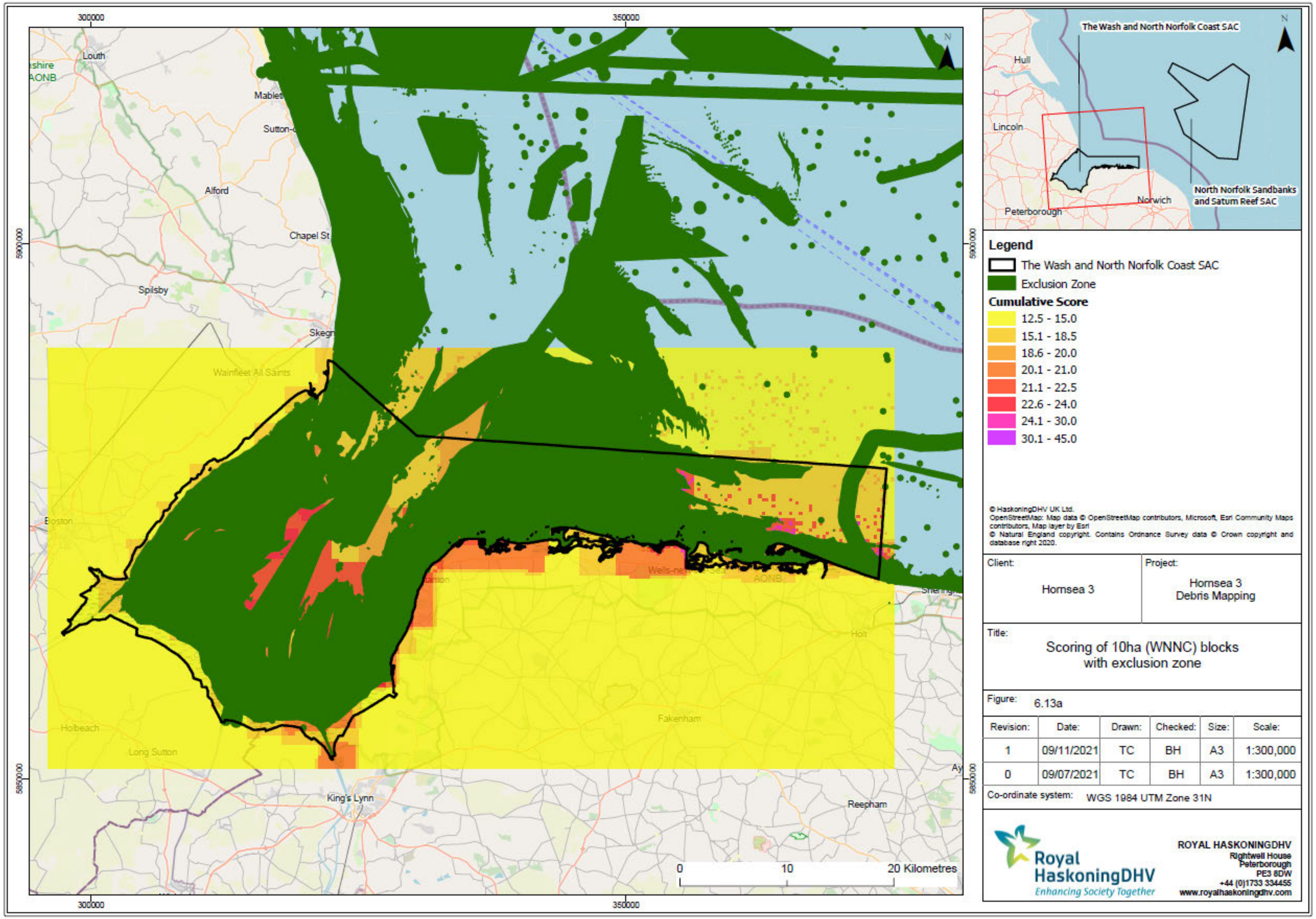


Figure 6.13a: Cumulative block scores overlaid by exclusion zones in WNNC SAC.

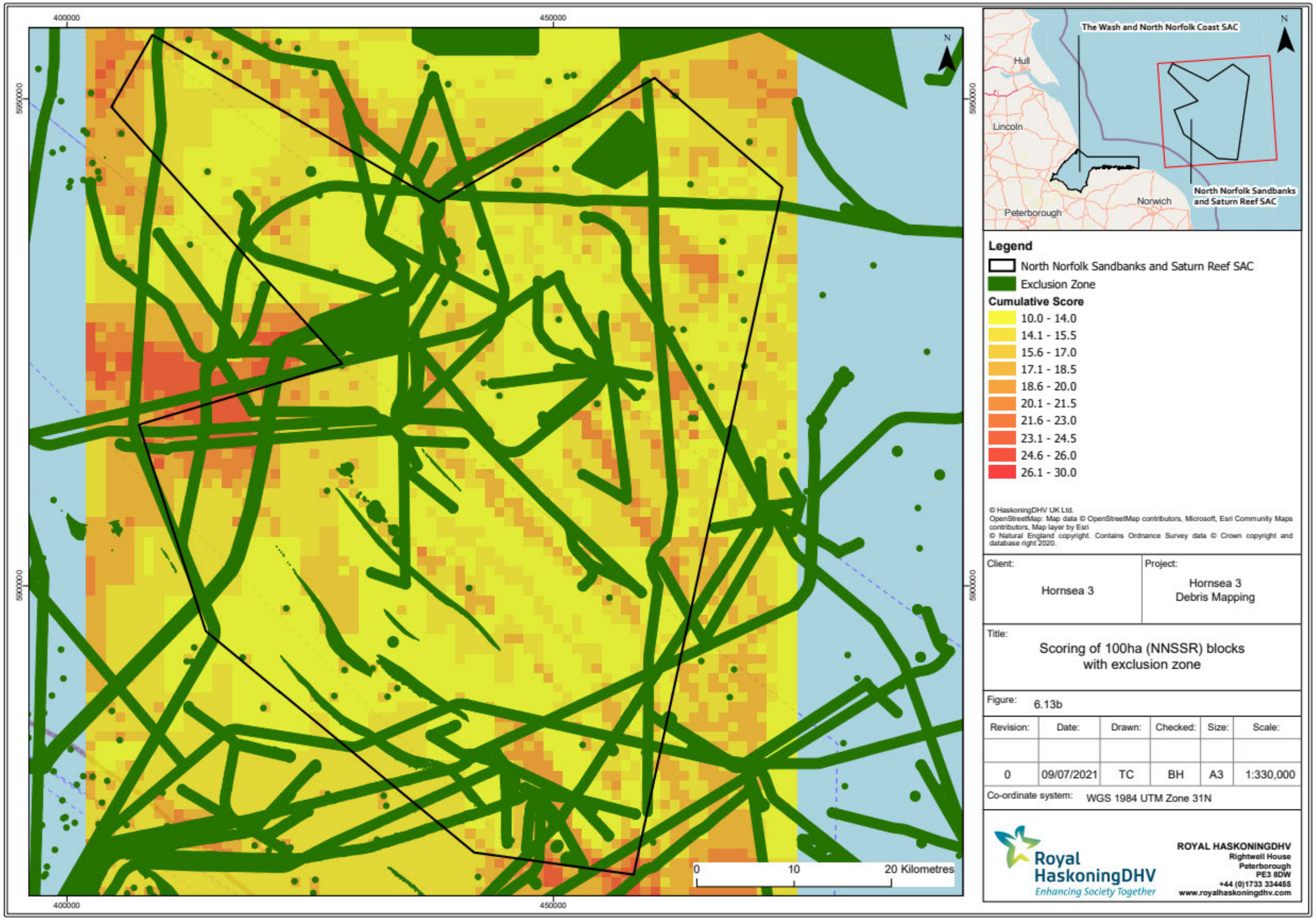


Figure 6.13b: Cumulative block scores overlaid by exclusion zones at NNSSR SAC.

7 Refinement of AoS

7.1 Refinement based on habitat present

80. As presented in **Figure 6.13b** (a and b) above, the scoring described in **Section 6.4** indicates areas where, based on reports of debris and an understanding of likely anthropogenic proxies, it is considered that a debris removal campaign would have most success. To further narrow down the potential AoS, the high scoring areas have been refined based on the habitat type present at the SACs.

81. There are two elements that have been taken into account when refining:

   a. The presence of priority habitat (i.e. Annex I sandbank, as indicated in JNCC MPA mapping). Note that areas containing biogenic reef have already been excluded from consideration given their sensitivity; and,

   b. The presence of habitat similar to that which would be lost during Hornsea Three cable protection deployment.

7.1.1 Annex I sandbank habitat

82. The distribution of this feature has been mapped by JNCC based on supporting scientific evidence for designation and management of the two SACs. **Figure 7.1** and **Figure 7.2** present the distribution of features of interest as set out in the JNCC Mapper[18]. All areas within NNSSR SAC are classified as sandbanks (for the purpose of MPA management), aside from those areas managed as Annex I reef. In WNNC SAC, there are areas classified as sandbank, plus areas of reef and undesignated habitat. Natural England data on Annex I sandbank distribution in WNNC SAC (available from Defra's MAGiC mapping application) has also been referred to. This data indicates a wider distribution of sandbank habitat in the SAC than the JNCC data; however, has not been presented herein given that the JNCC data provides a more conservative distribution of sandbank habitat considered appropriate for this assessment.

83. For the purpose of this exercise, priority at WNCC SAC is given first to blocks containing Annex I sandbank habitat (indicated in **Figure 7.2**). Clearly there are a large number of potential blocks that contain this habitat; however, it is an important step in narrowing down the potential AoS as debris removal in areas containing Annex I sandbank habitat is preferred. In the NNSSR SAC, however, the entirety of the site has been designated as Annex I sandbank habitat by JNCC (see **Figure 7.1**), therefore this method of prioritising is not appropriate.

7.1.2 Habitat loss resulting from cable protection deployment

84. Broad benthic habitat types expected to be lost during deployment of cable protection include areas of coarse substrate (gravel / sandy gravel / gravelly sand) and sand, indicated by the EUNIS habitat maps provided by EMODNet (see **Figure 7.3**). It is anticipated that areas containing coarser sediment are more likely to have a requirement for installation of cable protection along the cable route. As such, areas containing this broadscale habitat type are more likely to be affected than those characterised by finer sands. With this in mind, it has been deemed appropriate to preferentially target areas of coarser habitat as a 'like-for-like' approach to improving habitat condition. Again, there are a large number of potential blocks that contain the coarse broadscale sediment type, as indicated in the figure; however, it is a useful step in narrowing down the potential AoS and has been used in assessing the overall appropriateness of AoS identified in the final stage of this exercise (see **Section 8**).

85. Hornsea Three note that there is potentially higher likelihood of biogenic reef in areas of coarse sediment due to the process of biogenic reef formation. Stage 1 of the marine debris removal campaign (geophysical survey) will chart any unknown areas of Annex 1 reef and ensure those areas are excluded from further investigation. A decision tree is set out in the SBIPs to secure the process should biogenic reef not identified during Stage 1 of the campaign, be identified during Stage 3.

[18] https://jncc.gov.uk/our-work/marine-protected-area-mapper/

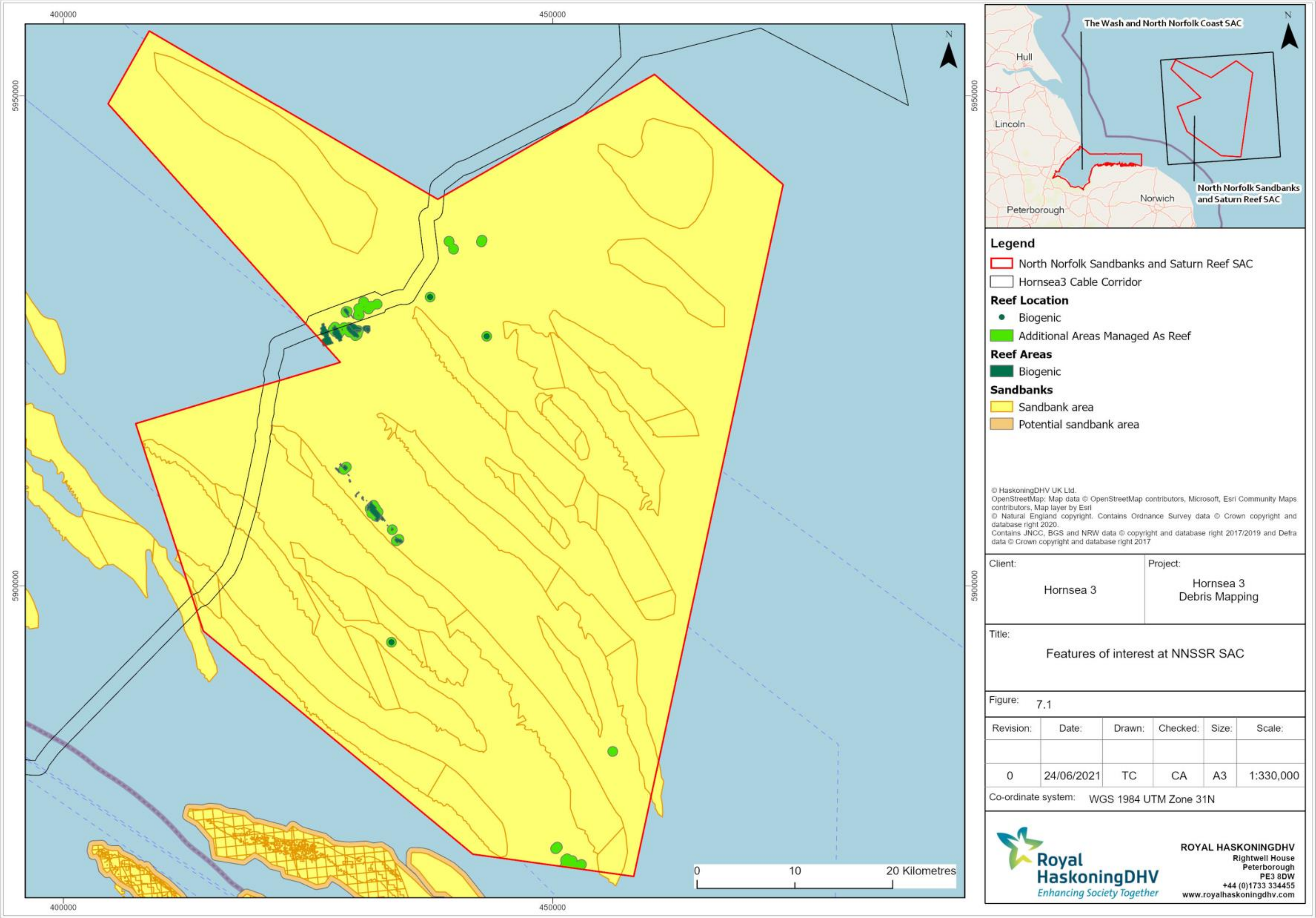


Figure 7.1: Features of interest at NNSSR SAC.

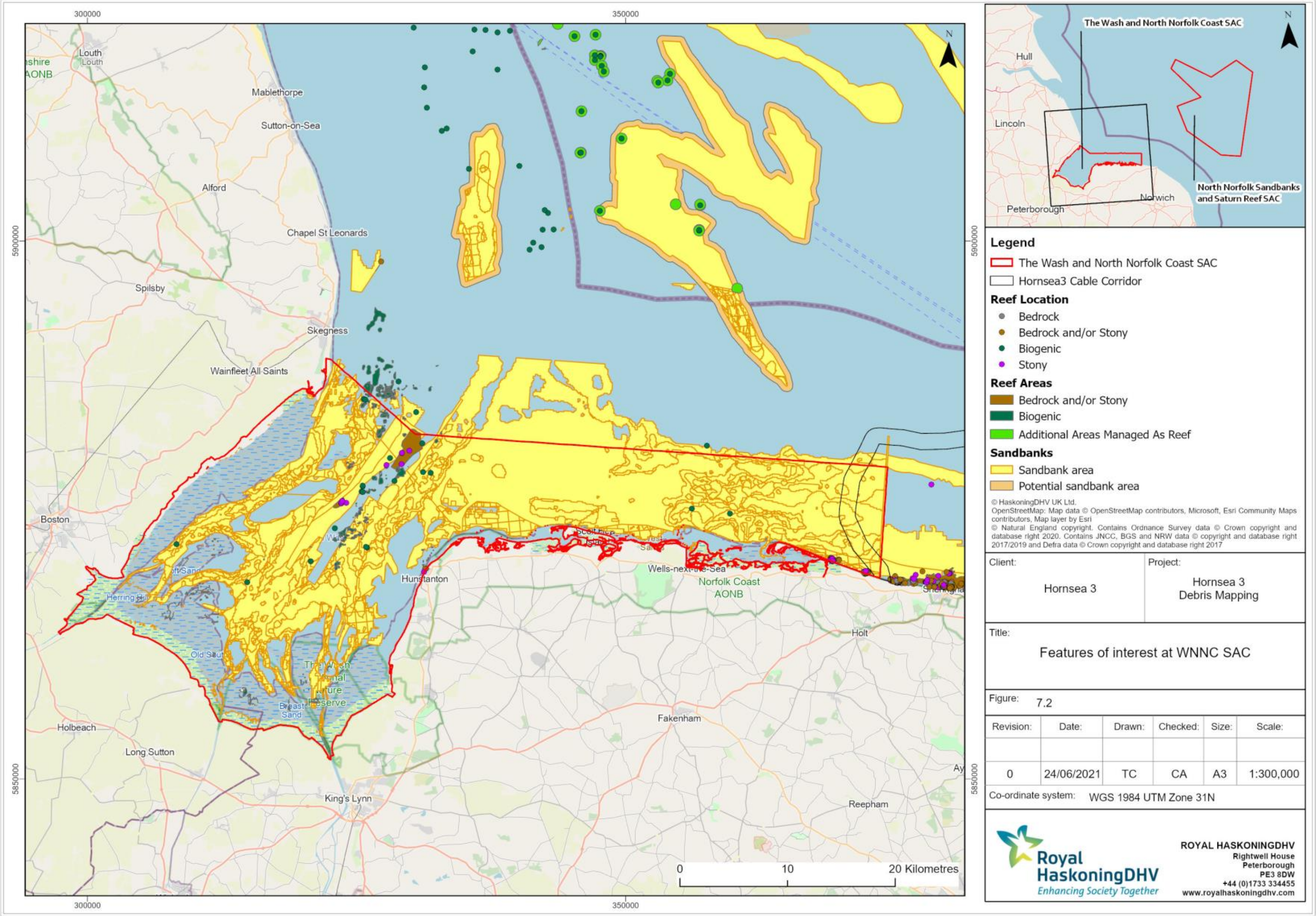


Figure 7.2: Features of interest at WNNC SAC.

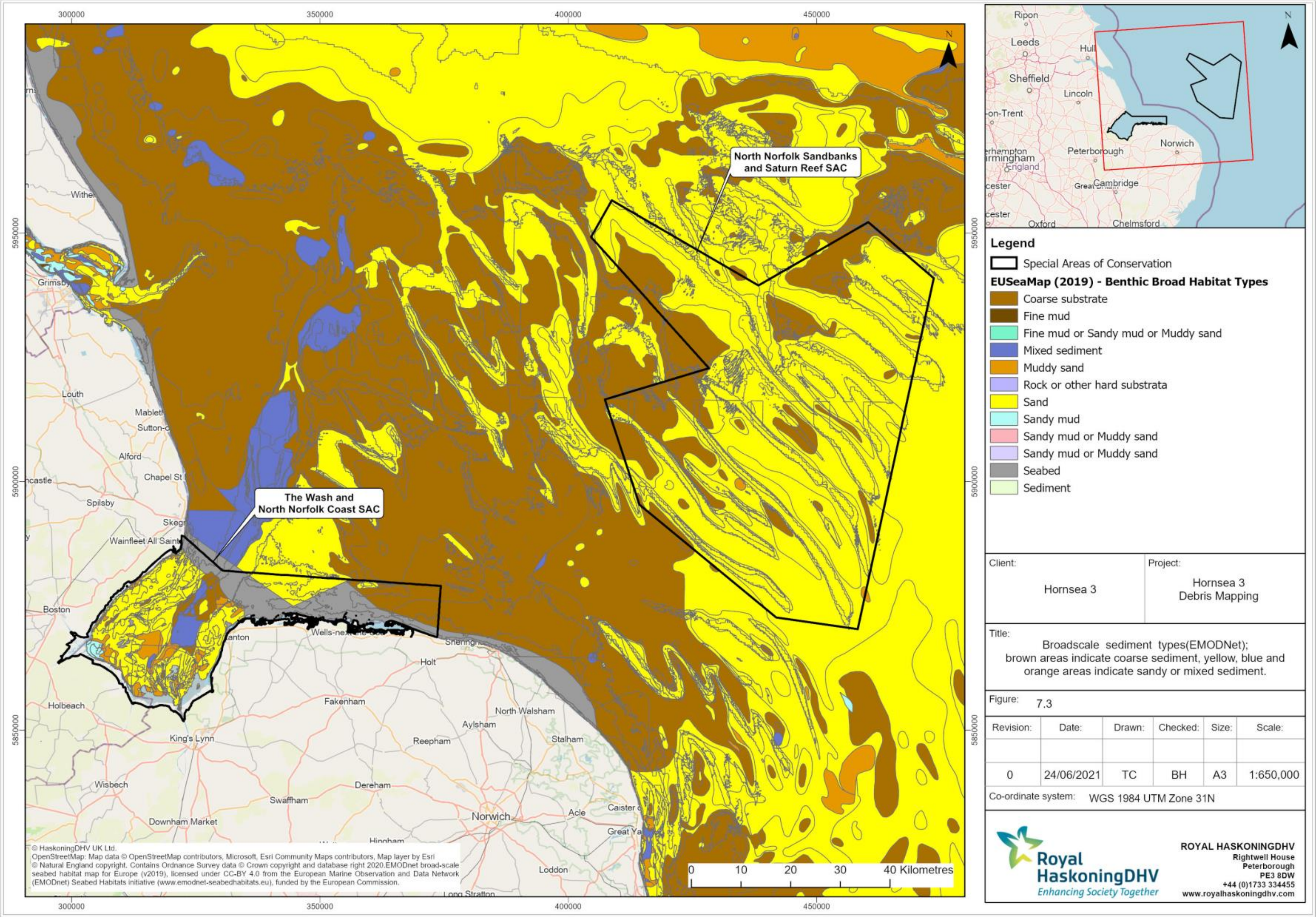


Figure 7.3: Broadscale sediment types (EMODNet); brown areas indicate coarse sediment, yellow, blue and orange areas indicate sandy or mixed sediment.

7.2 Refinement based on conceptual analysis of areas of marine debris accumulation

86. There are two potential ways in which marine debris could accumulate in larger quantities on the seabed in the SACs through movement by physical and/or sedimentary processes:

- Accumulation of lighter and transportable debris through natural transport processes (predominantly tidal currents) at the seabed. If the threshold for motion generated by the physical process is exceeded, then the small debris could be moved by rolling or sliding along the substrate (as bedload).; and
- Accumulation of lighter and transportable debris due to gravity and movement of the debris downslope.

87. Accumulation through natural transport processes is likely to be limited because most of the debris on the seabed is anticipated to be fishing gear or larger items of miscellaneous debris which is likely to be too heavy to have any transport potential under existing tidal current conditions. However, although limited, there is still the potential for this type of transport for any lighter pieces of fishing gear and it is included in the assessment.

88. Gravitational processes could occur at the point of disposal with immediate movement downslope or could potentially occur at a later time with the process started by a storm impacting on the seabed. During the storm, the debris would initially be shifted a short distance with a natural tendency to continue movement in a downslope direction before resting at the seabed again. This may occur as an intermittent process, dictated by the driving forces at the seabed and the degree of seabed slope.

89. Where the debris is too heavy to be transported by tidal currents or gravity, it will remain static on the seabed at the point of disposal. In this case there is no potential for accumulation of this debris and it will be an isolated location likely to be separate from other debris. In this case the continued exposure of the debris at the bed is controlled by the mobility of the sediment surrounding it and the potential for it to be buried through bedform migration and to be re-exposed once the bedform has passed over it.

7.2.1 Transport of lighter debris by physical and sedimentary processes at NNSSR SAC

90. Regional net bedload sediment transport in the NNSSR SAC is to the northwest. Holmes and Wild (2003) and Cooper et al. (2008) argued that the sandbanks are progressively migrating in a north-easterly (offshore) direction through gain of sediment at their northwest ends and loss of sediment at their southeast ends. Migration rates may vary from 1m/year to 16m/year (Caston, 1972; Stride, 1988). A comparison of the bathymetry and slope data supports this interpretation with the steepest slopes of the sandbanks on their northeast flanks.

91. This regional scale pattern of sediment transport is superimposed within the sandbank system where more complex local circulatory patterns of transport occur. Collins et al. (1995), HR Wallingford et al. (2002) and Holmes and Wild (2003) showed that circulation of water and sand around the active banks is clockwise with up-slope convergence at the crests.

92. Waves will tend to only periodically stir the seabed and will not contribute regularly to the net transport of sediment. However, storm surge activity can suspend large quantities of sediment from the sandbanks (Cooper et al., 2008), which tends to be transported northeast, with the banks acting as a series of 'stepping stones' (Eggleton et al., 2020). This mechanism is thought to be capable of moving sediment up to 100km seawards (Stride, 1988).

93. The SAC is also characterised by the presence of sand waves (Holmes and Wild, 2003). The most extensive sand wave fields are located on the inner sandbanks. No direct measurements of bedform migration rates are presently available for these features. The steeper slopes of the sand waves are directed towards the crest of the sandbanks.

94. The complexity of sediment transport processes with a local pattern superimposed on a regional pattern makes it difficult to define where debris could potentially accumulate through these processes. Hence, definition of debris accumulation is not considered for this process and reliance is placed on other forms of evidence, including gravitational processes.

7.2.2 Transport of lighter debris downslope by gravity at NNSSR SAC

95. The steepest slopes across the SAC occur on the northeast flanks of the main sandbanks, where slopes up to 5° are recorded. Slopes elsewhere across the SAC generally do not exceed 1.5° and are unlikely to invoke significant gravitational transport regardless of debris size and weight. Hence, these locations have the highest potential for movement of debris in a downslope direction through gravity (if the debris is light enough for initiation of transport). The process of movement would either be rolling along the seabed or by sliding if enough momentum can be achieved through the initial driving force and friction at the seabed is relatively low. Hence, the focus of potential accumulation of lighter debris through this process would be in the troughs immediately to the northeast of the active sandbanks of key importance (Leman, Ower, Inner, Well and Broken) adjacent to the steepest (up to 5°) slopes. **Figure 7.4** identifies these areas, including those of highest priority as this is where accumulation of debris is likely to be highest (note that areas termed 'lower priority' are still a priority, but less so than those termed 'higher priority').

7.2.3 Transport of lighter debris by physical and sedimentary processes in WNNC SAC

96. Inside the Wash, the large spring tidal range of 6.3m produces strong currents in the tidal channels. In the Well and Lynn Deeps, the flood velocities are higher than the ebb (Ke et al., 1996), producing residual currents in an onshore (southwest) direction. Mean-depth averaged flood current velocities are typically 0.5-0.7m/s at spring tides, while mean-depth averaged ebb current velocities are 0.4-0.6m/s. Boston Deep and the marginal intertidal areas of The Wash are dominated by residual seaward (northeast) water movement (Ke et al., 1996). Maximum velocities of up to 0.1-0.4m/s over the intertidal area have been recorded at Freiston Low and Butterwick Low (Collins et al., 1981; Ke et al., 1994).

97. Bedload transport in The Wash is important in shaping the seabed sediments into a variety of bedforms, which are particularly well developed along the margins of the sandbanks and in the tidal channels (Evans, 1965; Amos and Collins, 1978; McCave and Geiser, 1978; Wingfield et al., 1978). The flood-oriented asymmetry of the bedforms and the residual tidal currents indicate that the net movement of sediment transport is into The Wash. This environment favours accretion making the area an important sediment sink.

98. The strongest tidal currents in The Wash are in the channels directed parallel to the orientation of the main sand banks. The cross-bank transport of sediment driven by these tidal currents is limited due to the predominant direction (and speed) of current flow; the sand banks are essentially stable and not migrating into adjacent deeper areas. The margins of the banks in deeper water adjacent to the channels are sculped into a variety of bedforms, but these also migrate approximately parallel to the general orientation of the banks and channels. This means that debris disposed on the sand banks is likely to remain on the banks and not be transported into deeper areas by currents. Also, many of the banks are exposed at low tide, and so disposal of debris on the banks is highly unlikely as these areas would be hazardous to fishing vessels and therefore an unlikely source of debris.

99. Disposal of debris in The Wash is more likely to occur directly from a vessel into the channels where the water is deeper and more accessible. Transport of the lighter debris by tidal currents would be into (predominantly on the net residual current) and out of The Wash along these channels. Hence, the focus of potential accumulation of lighter debris through this process would be towards the landward parts of the channels to where the residual tidal currents have transported it, but speeds have reduced to a magnitude where they are not capable of transporting the debris any further.

7.2.4 Transport of lighter debris downslope by gravity at WNNC SAC

100. The steepest slopes across the SAC occur within the channels, where slopes up to 5° are recorded. Slopes elsewhere across the SAC, and across the main sandbanks, generally do not exceed 1° and are unlikely to invoke significant gravitational transport regardless of debris size and weight. Hence, the channels that cross the SAC have the highest potential for accumulation of debris through gravitational processes. Given that the sandbanks inside The Wash are static, any debris that has accumulated in the channels through gravitational means will not be buried by sediment from the adjacent banks and will remain exposed in the long-term. Hence, a similar potential zone of focus for debris accumulation to that defined by the physical and sedimentary processes assessment is defined for gravity, but with an extension seaward. **Figure 7.5** identifies this zone.

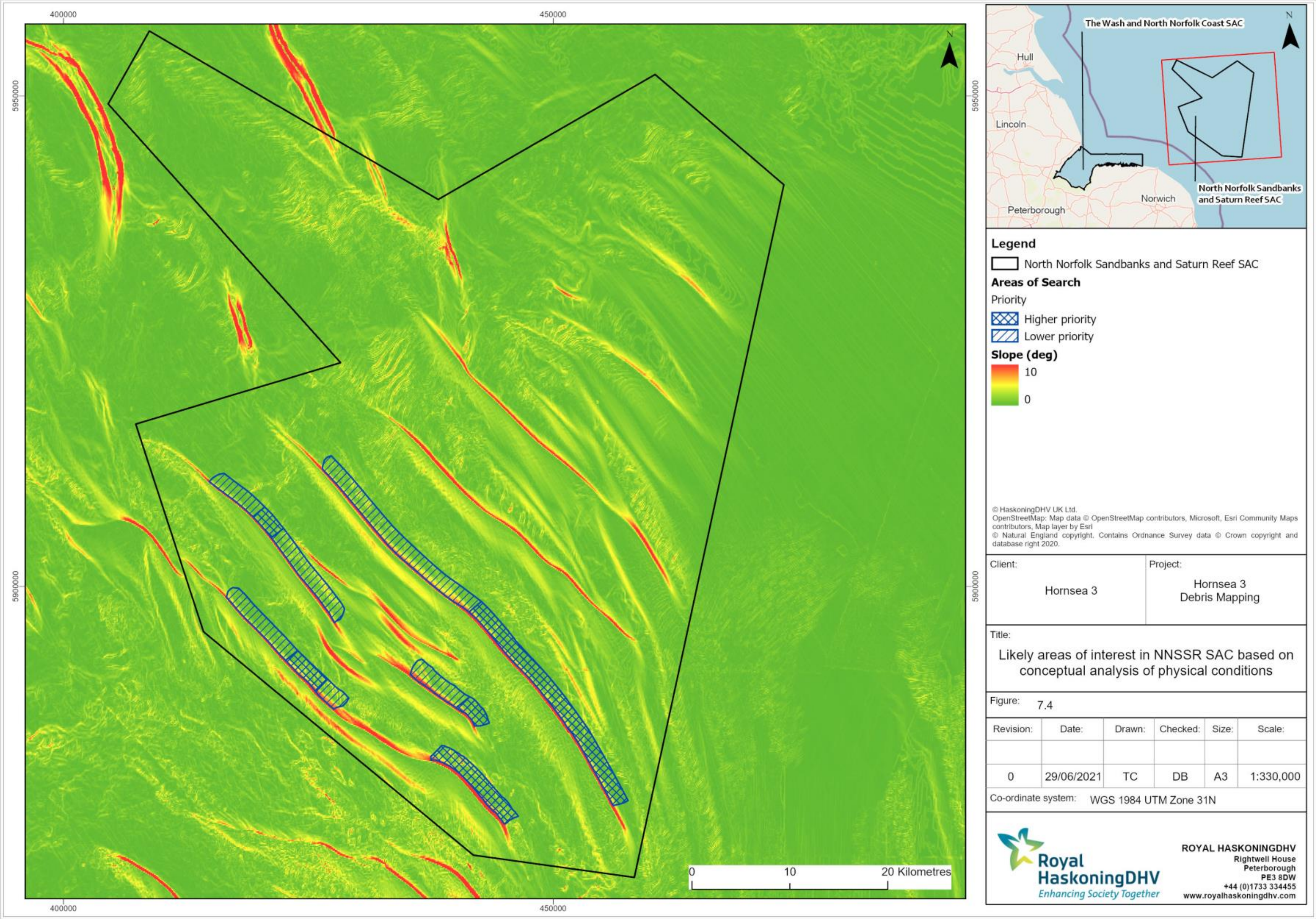


Figure 7.4: Likely areas of interest in NNSSR SAC based on conceptual analysis of physical conditions.

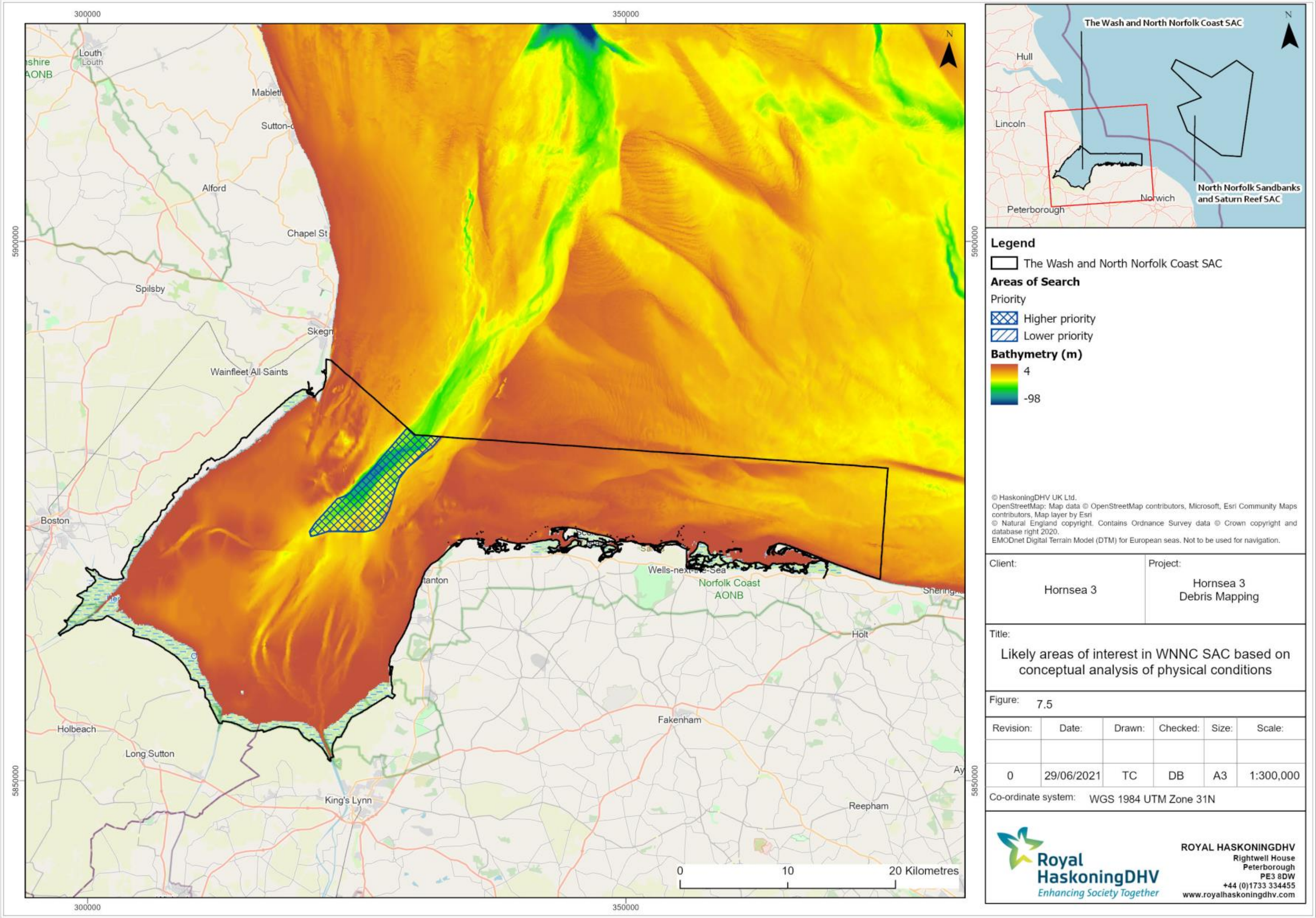


Figure 7.5: Likely areas of interest in WNNC SAC based on conceptual analysis of physical conditions.

8 Summary of AoS identification

8.1.1 AoS identification in NNSSR SAC

101. To determine the recommended AoS for the debris removal campaign in the NNSSR SAC, the 'higher' and 'lower' priority areas (based on conceptual analysis of physical processes) indicated in **Figure 7.4** have been overlaid with the block scoring indicators set out in **Figure 6.12** and the areas to be excluded as set out in **Figure 5.1.** This is presented in **Figure 8.1** below.

102. While there is no particular overlap between the highest priority areas and the highest-scoring blocks, there is a high scoring block, which would act as the recommended AoS, within the 'lower' ranked priority area at the point indicated in **Figure 8.1**. According to the EMODNet mapping of EUNIS habitat, the block contains both sand and coarse substrate. As stated in **Section 7**, blocks in the NNSSR SAC containing coarse substrate would be prioritised, therefore the recommended AoS fits in with this criterion. As such, it is considered that this block is the most suitable candidate for focusing marine debris removal efforts in the NNSSR SAC, on the basis of the exercise undertaken herein. Note that the orientation of this AoS has been 'rotated' so that aligns with the orientation of the adjacent Well Bank sandbank and therefore the ground truthing geophysical survey will be more effective.

8.1.2 AoS identification in WNNC SAC

103. To refine the AoS for the debris removal campaign in the WNNC SAC, the priority areas (based on conceptual analysis of physical processes – note only higher priority areas have been identified) indicated in **Figure 7.5** have been overlaid with the block scoring indicators set out in **Figure 6.12** and the areas to be excluded as set out in **Figure 5.1**. This is presented in **Figure 8.2** below.

104. The priority area identified in the conceptual analysis is located largely within areas that have been excluded from consideration as potential AoS based on the proximity of third party assets and the seabed bathymetry (much of the area is shallower than 10m). The section of the priority area that is not within an exclusion area overlaps only with relatively low scoring blocks. As such, it is considered that, rather than refining the choice of blocks so that they are directly within the priority area, the nearest high-scoring blocks (i.e. those scoring more than 23) should instead be targeted. As identified in **Figure 8.2**, there is a cluster of high-scoring blocks just to the west of the priority area. The recommended AoS identified in the figure has been selected based on the fact that the cluster are all equally high scoring, but this block is, logistically, the preferred choice for the purpose of ground truthing geophysical survey vessel access. This block is within the refined area set out in **Section 7.1** as it is located within a part of the SAC containing Annex I sandbank habitat, as per JNCC mapping.

8.1.3 Adaptive management AoS identification

105. The initial target AoS in each of the SACs will focus on high scoring, high priority areas (as identified from the steps outlined in **Sections 6** and **7**) to give the greatest likelihood of finding higher densities of debris.

106. However, as identified in the SBIPs for the respective SACs, there is a pathway for adaptive management of the debris removal campaign that incorporates an extension of the AoS. The increased area would remain within the SAC, looking into another area of high priority that focusses on an alternative driver as source of information. For example, should the target AoS be selected based in part on its proximity to an area where physical drivers may result in an accumulation of debris, the adaptive AoS would instead rely more on the likelihood of debris based on other data sources, such as the geophysical surveys from other Orsted projects. This means that if the target AoS does not contain suitable debris density, the alternative drivers relevant to the adaptive management AoS increase the chance of locating a suitable target area. The detailed adaptive management strategy is provided in the NNSR SBIP (07122823_A) and the WNNC SBIP (07103743_A).

107. Within the NNSSR SAC, an alternative 'adaptive management' block has been identified in **Figure 8.1.** The adaptive management AoS is one of a small cluster of high-scoring blocks which are equally viable candidates as an adaptive management AoS (based on this exercise) and has been selected as it is the logistically easiest option for vessel access. The drivers for this AoS differ from the initial target AoS in that, rather than being in part driven by an interpretation of physical processes, it is instead selected

solely on its high scoring in the initial phase of the exercise, principally as a result of it being relatively heavily used by marine vessels and its proximity to areas of debris recorded during Hornsea Three geophysical surveys.

108. The 'adaptive management' AoS in WNNC SAC, shown in **Figure 8.2**, is one of a number of scattered blocks in the eastern portion of the SAC that scored highly (over 24). Given that these scattered blocks were all equally high scoring, the recommended block was selected as it is located furthest from the 10m contour, to ease vessel access. The drivers for debris are different from those of the target AoS in WNNC and are principally related to the proximity of the AoS to recorded / potential debris from surveys including the Hornsea Three geophysical surveys, SeaSearch dive records and fisheries consultation conducted by Brown and May Marine. While the adaptive management AoS does not lie within the priority zones indicated in the conceptual assessment in **Section 7.2**, it is located within an area of Annex I sandbank habitat.

109. It should be noted that the adaptive management AoS is located within an area restricted to the use of bottom towed gear under Eastern IFCA byelaws (in this instance byelaw area 31) designed to protect benthic habitat within the WNNC SAC from trawling activities. Byelaw area 31 does not exclude static fishing methods such as potting. The debris removal campaign will be undertaken using a highly targeted methodology, and with micro-siting commitments for all sensitive features such as Annex I reef, Hornsea Three would consider any removal of debris and resulting restoration of the benthic features will further improve the sandbank habitat within the byelaw area. Hornsea Three appreciate that additional consultation may be required with the required fishing associations in relation to the adaptive management AoS to ensure that it is made clear that the debris removal campaign is not in any way similar to those banned trawling activities and will communicate as such during consultation on the Marine License and associated fisheries clearance requirements.

110. The adaptive management AoS for the WNNC SAC is located approximately 2km from the nearest intertidal habitat, therefore there is no risk of disturbance to bird foraging grounds or seal haul outs in the event that adaptive management measures are applied. When operating in the WNNC and NNSSR SACs, the vessel(s) used during the marine debris removal campaign would be slow-moving (and stationary during the actual process of debris removal), thereby allowing seals and other marine mammals to avoid marine interactions therefore minimising the risk of collision or excessive disturbance.

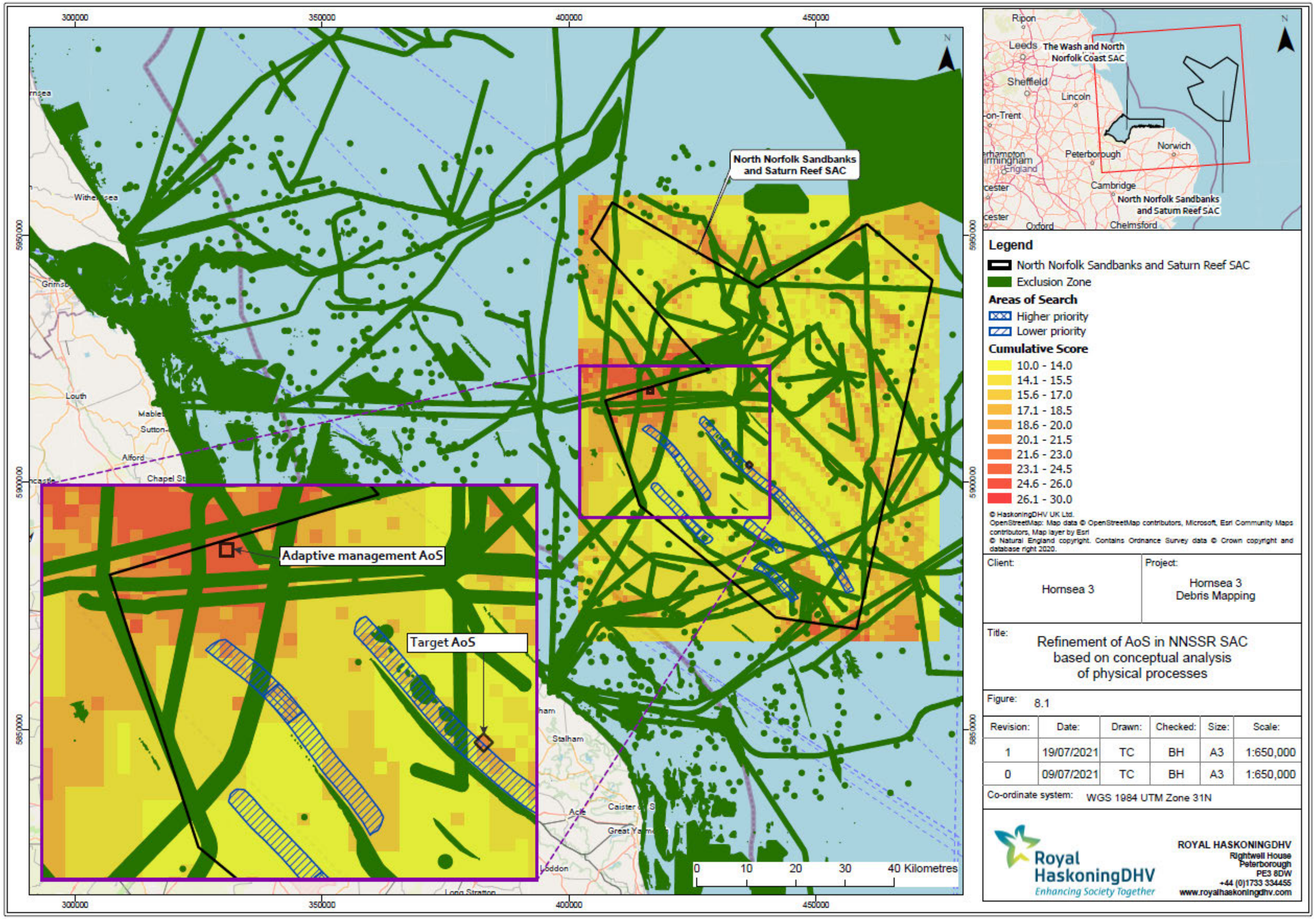


Figure 8.1: Refinement of AoS in NNSSR SAC based on conceptual analysis of physical processes.

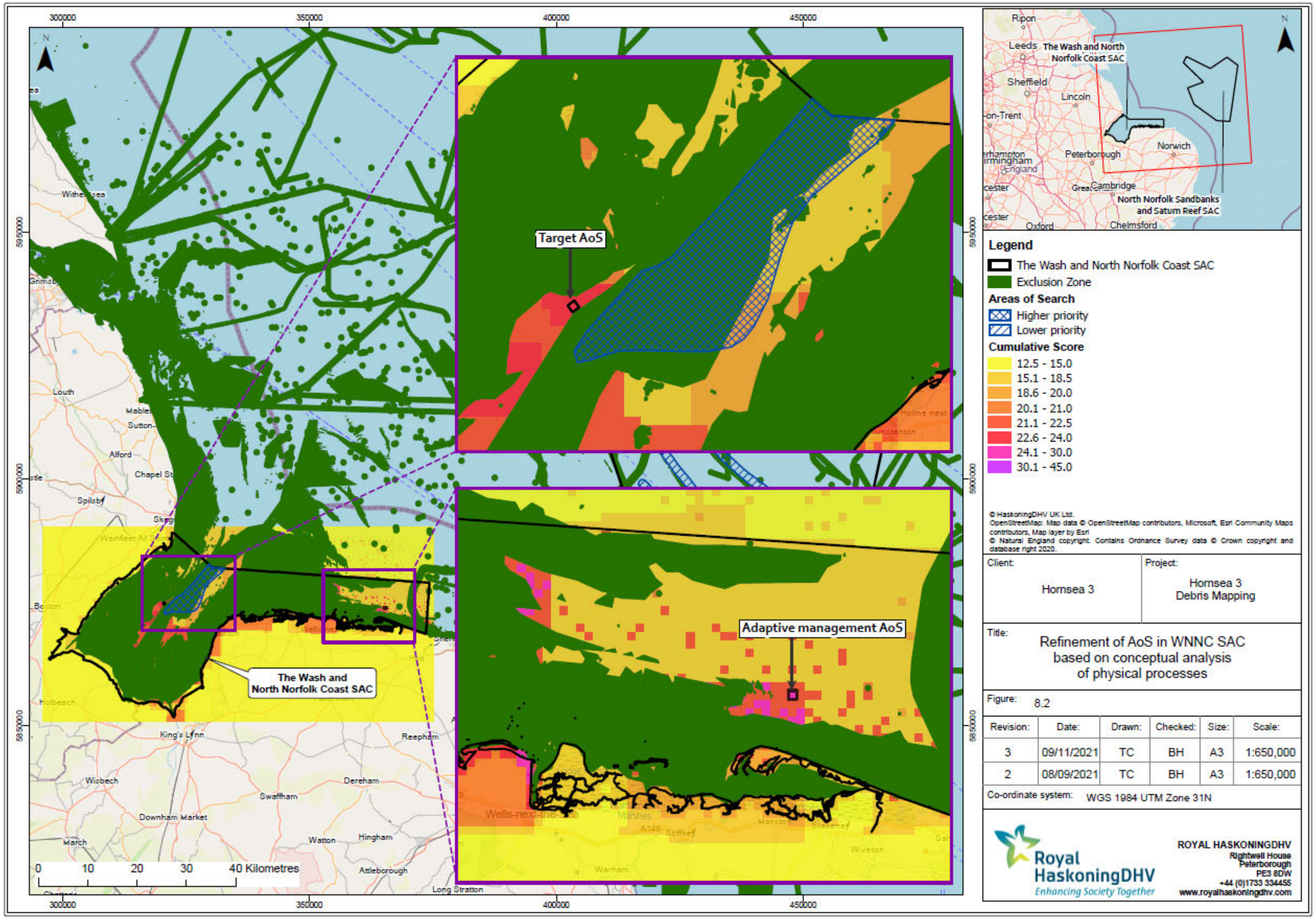


Figure 8.2: Refinement of AoS in WNNC SAC based on conceptual analysis of physical processes.

9 Conclusion

111. As demonstrated in **Figure 8.1**, the target AoS in the NNSSR is a 100 ha block in the western part of the site. This block lies approximately 60 km from the North Norfolk coastline in water depths of 35 to 40m, at the north-eastern foot of the Well Bank sandbank. It is located within an area recognised as Annex I sandbank habitat and contains sediment characterised as coarse substrate and sand. This block has been selected as it scored highly in the selection process set out in **Section 6.4**, principally based on the high vessel traffic and fishing activity in this area, as well as the fact that it overlaps with a priority area as set out by conceptual analysis of the physical drivers behind potential debris accumulation (see **Section 7.2**).

112. The target AoS in the WNNC (shown in **Figure 8.2**) is the most accessible of a cluster of 10 ha blocks situated together in The Wash (at Inner Dogs Head, just west of The Well), approximately 9 km from the nearest coastline. Water depth at this location is approximately 10 to 12 m, and the blocks contain sandy sediment and are located within the recognised boundaries of the Annex I sandbank habitat. Again, the selection is largely driven by the presence of vessels and fishing activity, and geophysical surveys undertaken nearby for the Race Bank and Lincs OWF have confirmed that this general area has a high level of debris. It is also the closest accessible point to a priority area as set out by conceptual analysis of the physical drivers behind potential debris accumulation (see **Section 7.2**).

113. The target AoS (10ha at WNNC SAC and 100ha at NNSSR SAC) are larger than the areas required under the DCO conditions (2.77ha at WNNC SAC and 41.8ha at NNSSR SAC), and ground truthing of the AoS using seabed imagery (e.g. geophysical surveys) will help to define specific areas within the AoS that should be targeted to meet such requirements. An adaptive management approach means that alternate AoS, identified in **Section 8**, can be explored if required. This approach is detailed further within the NNSSR and WNNC SBIPs (07122823_A and 07103743_A respectively).

10 References

Amos, C.L. and Collins, M.B (1978) The combined effects of wave motion and tidal currents on the morphology of intertidal ripple marks: The Wash, U.K. Journal of Sedimentary Petrology, 48, 849-856.

Brew, D.S (1997) The Quaternary history of the subtidal central Wash, eastern England. Journal of Quaternary Science, 12, 131-141.

Caston, V.N.D (1972) Linear sand banks in the Southern North Sea. Sedimentology, 18, 63-78.

CIRIA (2009). Unexploded ordnance (UXO) A guide for the construction industry (C681).

CIRIA (2015) Assessment and Management of unexploded ordnance (UXO) risk in the marine environment

Collins, M.B., Amos, C.L. and Evans, G (1981) Observations of some sediment-transport processes over intertidal flats, The Wash, UK. In: Nio, S-.D., Schuttenhelm, R.T.E. and Van Weering, T.C.E. (eds.), Holocene Marine Sedimentation in the North Sea Basin, International Association of Sedimentologists - Special Publication, 5, 81-98.

Collins, M.B., Shimwell, S.J., Gao, S., Powell, H., Hewitson, C. and Taylor, J.A (1995) Water and sediment movements in the vicinity of linear sandbanks: the Norfolk Banks, southern North Sea. Marine Geology, 123, 125-142.

Cooper, W.S., Townend, I.H. and Balson, P.S (2008) A synthesis of current knowledge on the genesis of the Great Yarmouth and Norfolk Bank Systems. The Crown Estate, 69pp.

Eggleton, J., Bolam, S., Benson, L., Archer-Rand, S., Mason, C., Noble-James, T., Jones, L., McBreen, F. and Roberts, G (2020) North Norfolk Sandbanks and Saturn Reef SAC, Haisborough, Hammond and Winterton SAC, and Inner Dowsing, Race Bank and North Ridge SAC Monitoring Report 2016. JNCC/Cefas Partnership Report No. 38. JNCC, Peterborough.

Evans, G (1965) Intertidal flat sediments and their environments of deposition in the Wash. Quarterly Journal of the Geological Society of London, 121, 209-245.

Galgani, F., Hanke, G., Werner, S., Oosterbaan, L., Nilsson, P., Fleet, D., Kinsey, S., Thompson, R.C., van Franeker, J., Vlachogianni, T., Scoullos, M., Veiga, J.M., Palatinus, A., Matiddi, M., Maes, T., Korpinen, S., Budziak, A., Leslie, H., Gago, J., Liebezeit, G., 2013. Monitoring guidance for marine litter in European seas. MSFD GES Technical Subgroup on Marine Litter (TSG-ML). Draft report, July 2013. 120 pp

Holmes, R. and Wild, J.B.L (2003) DTI Strategic Environmental Assessment Area 2 (SEA2) geological processes: (interpretation of multibeam, side scan sonar, chirp and grain size data acquired in 2001 from the seafloor on the Norfolk Banks and Dogger Bank, southern North Sea) British Geological Survey Internal Report, CR/03/188.

Hornsea Three (2021). Hornsea Three Benthic Compensation Marine Debris Removal Campaign: Proposed Scope of Work

HR Wallingford, Cefas, UEA, Posford Haskoning and D'Olier, B (2002) The Southern North Sea Sediment Transport Study. HR Wallingford Report EX4526. Report to Great Yarmouth Borough Council.

Inglis, C.C. and Kestner, F.J.T (1958) Changes in The Wash as affected by training walls and reclamation works. Proceedings of the Institution of Civil Engineers, 11, 435-466.

JNCC (2010) Offshore Special Area of Conservation: North Norfolk Sandbanks and Saturn Reef SAC Selection Assessment, Version 5.0.

Ke, X., Collins, M.B. and Poulos, S.E (1994) Velocity structure and seabed roughness associated with intertidal (sand and mud) flats and saltmarshes of The Wash, U.K. Journal of Coastal Research, 10, 702-715.

Ke, X., Evans, G. and Collins, M.B (1996) Hydrodynamics and sediment dynamics of The Wash embayment, eastern England. Sedimentology, 43, 157-174.

Kenyon, N.H., Belderson, R.H., Stride, A.H., Johnson, M.A (1981). Offshore tidal sandbanks as indicators of net sand transport and as potential deposits. Special Publication of the International Association of Sedimentologists, 5, 257-268.

Maes, T., Barry, J., Leslie, H., Vethaak, A., Nicolausa, E., Law, R., B. Lyons, R. Martineza, B, Harley, Thaine, J (2018) Below the surface: Twenty-five years of seafloor litter monitoring in coastal seas of North West Europe (1992–2017) [Online][redacted]Accessed March 2021]

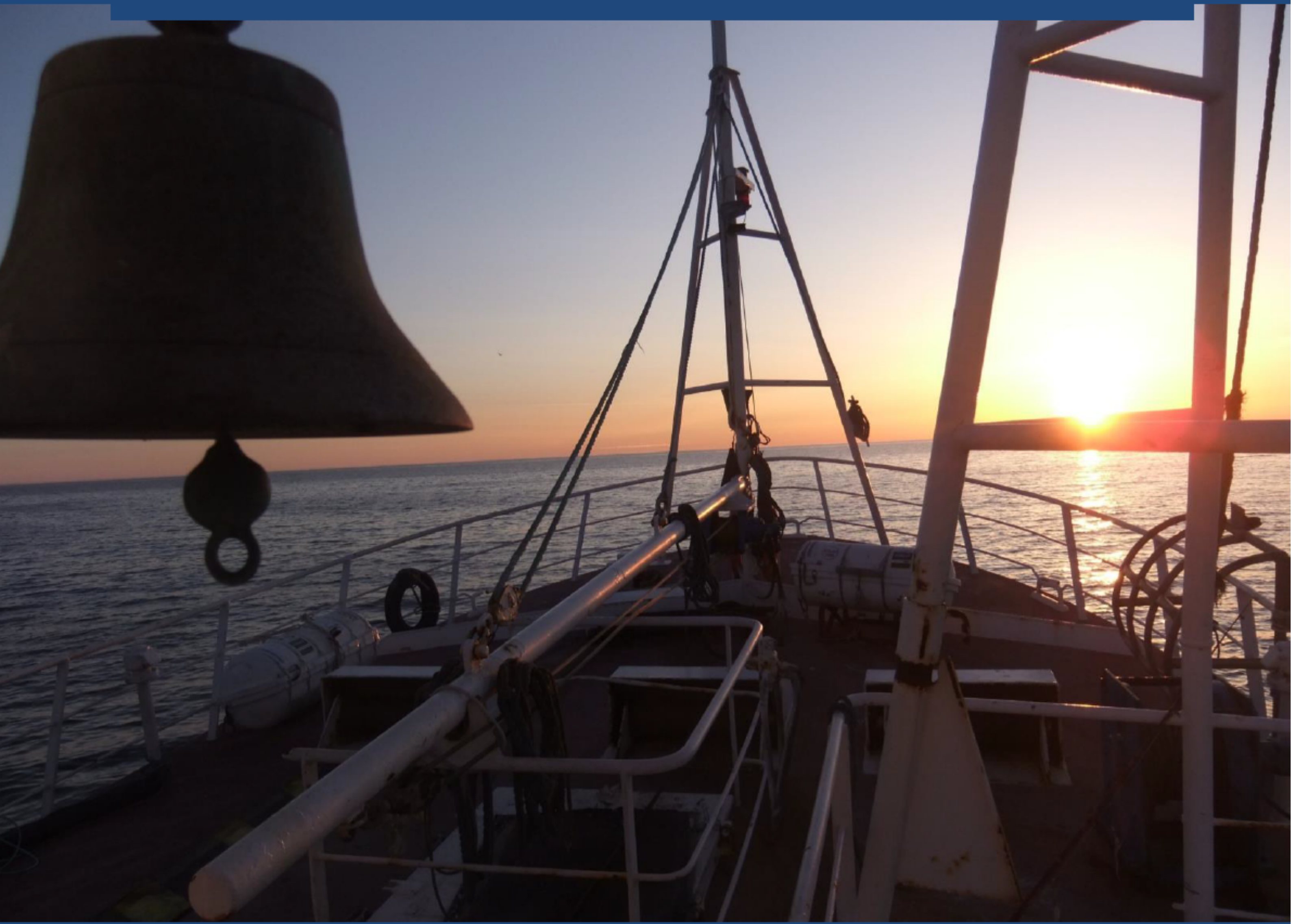
McCave, I.N. and Geiser, A.C (1978) Megaripples, ridges and runnels on the intertidal flats of The Wash, England. Sedimentology, 26, 353-369.

Stride, A.H (1988) Indications of long term episodic suspension transport of sand across the Norfolk Banks, North Sea, Marine Geology, 79, 55-64.

Wingfield, R.T.R., Evans, C.D.R., Deegan, S.E. and Floyd, R (1978) Geological and geophysical survey of The Wash. Report of the Institute of Geological Sciences, 78/18. Her Majesty's Stationery Office, London, 32pp.

Annex 1
Fisheries Consultation

Consultation Report



Hornsea Three Benthic Compensation - Fishermen Consultation

Brown & May Marine Ltd.

Hornsea Three

Consultation Report
Benthic Compensation

Undertaken by
Brown & May Marine Limited

Consultation Report: Benthic Compensation – Fishermen Consultation					
Client: Hornsea Three					
Document Ref.	**Rev.**	**Date**	**Author**	**Checked**	**Approved**
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Cover photo: Brown and May Marine Ltd.

Introduction

Hornsea Three has been asked by the Secretary of State (SoS) to implement a package of benthic compensation measures, as detailed in Schedule 14 Part 2 of the Development Consent Order (DCO). To facilitate consultation on the final scope of the compensation measures, the Secretary of State has instructed Hornsea Three to form a SG of key stakeholders to discuss and agree the measures which will be drafted into a Sandbanks Implementation Plan for each SAC and submitted to the Secretary of State.

The package of benthic compensation measures includes a campaign of marine debris removal within the Wash and North Norfolk Coast (WNNC) SAC and the North Norfolk Sandbanks and Saturn Reef (NNSSR) SAC. For the purpose of the Hornsea Three benthic compensation measures, 'marine debris' consists of any non-natural or introduced material on the seabed which does not offer a practical purpose. A key element to aid the identification of potential areas of high debris load within the SACS, within which the debris removal campaign areas of search could be targeted, will be the use of local knowledge from fishermen whom operate within the SACs. Whilst the primary focus of the consultation will be on the identification of areas where lost gear may be found within WNNC SAC and NNSSR SAC, consideration will also be given to relevant information which may arise during consultation of relevance to other SACs in the wider area, including Haisborough, Hammond and Winterton (HHW) SAC and Race Bank and North Ridge (IDRBNR) SAC (Figure 10.1) as vessels tend to operate throughout the wider area.

Consultation was carried between 23/02/2021 and 29/05/2021 by Brown and May Marine Limited (BMML). The consultation covered a wide range of different fishermen and industry representatives to gain a wide evidence base for the relevant area. The findings of the consultation are summarised in this report.

Brown & May Marine Ltd.

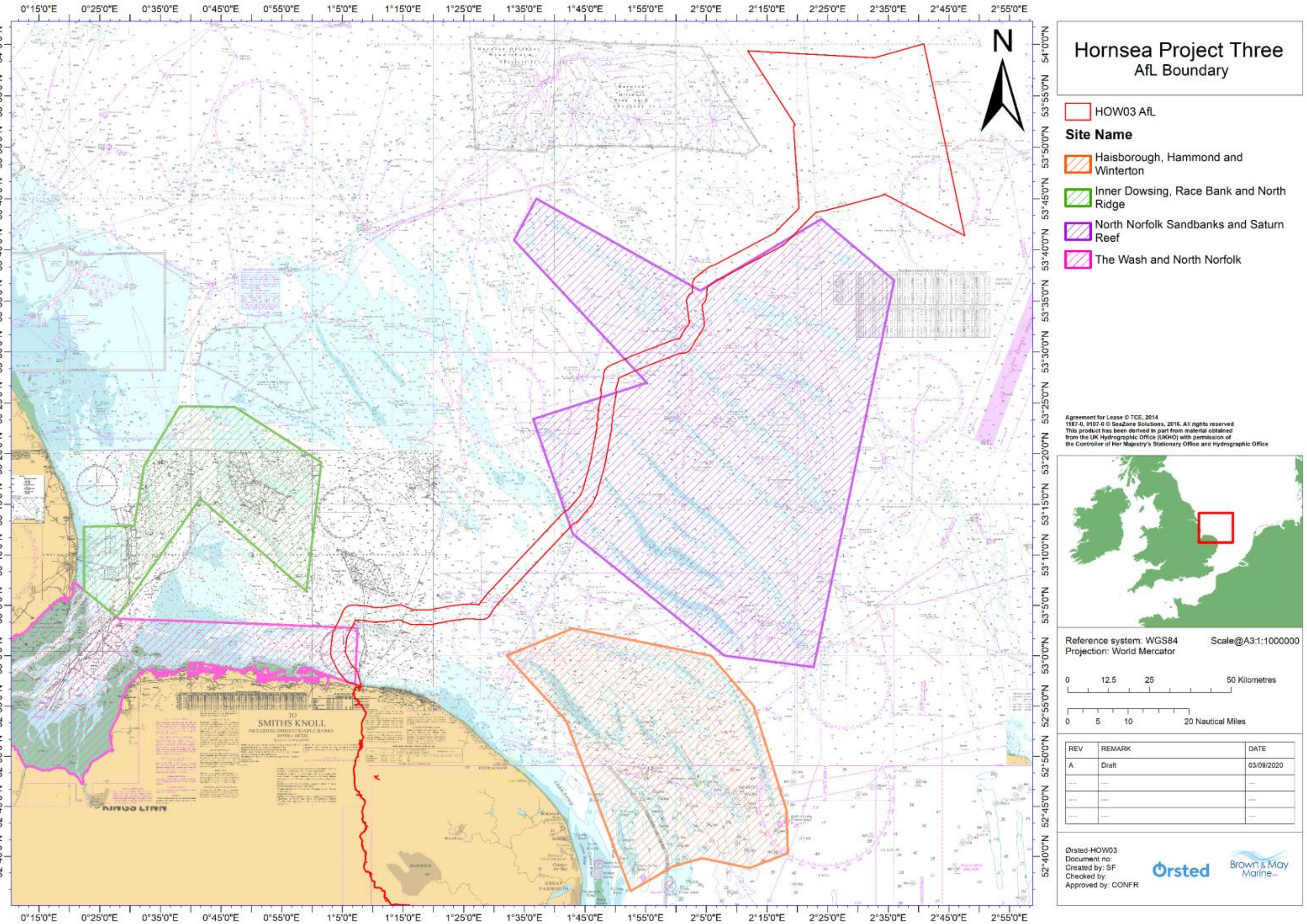


Figure 10.1: SACs in the proximity of Hornsea Three.

Background Information

The SACs under consideration support mobile fishing activity at varying degrees, both by UK and non-UK vessels (particularly Dutch). Vessels operating towed gears in these areas are predominantly beam trawlers. An indication of the distribution of fishing activity by UK and Dutch vessels operating beam trawls within the SACs is provided in Figure 10.3 to 10.3 based on VMS data.

A summary of the fishing activities identified within each SAC from these figures is provided below:
NNSSR SAC: Supports moderate activity by UK and Dutch beam trawls across the majority of the site;
WNNC SAC: Supports high levels of activity, predominantly by UK beam trawlers engaged in the Wash shrimp fishery.

It should be noted that in addition to the fishing activities identified above, the sites and the wider areas around them are known to support activity by vessels operating static gear, predominantly pots. Vessels engaged in this activity are generally under 12 m in length and therefore VMS data does not provide a good indication of fishing activity by this method.

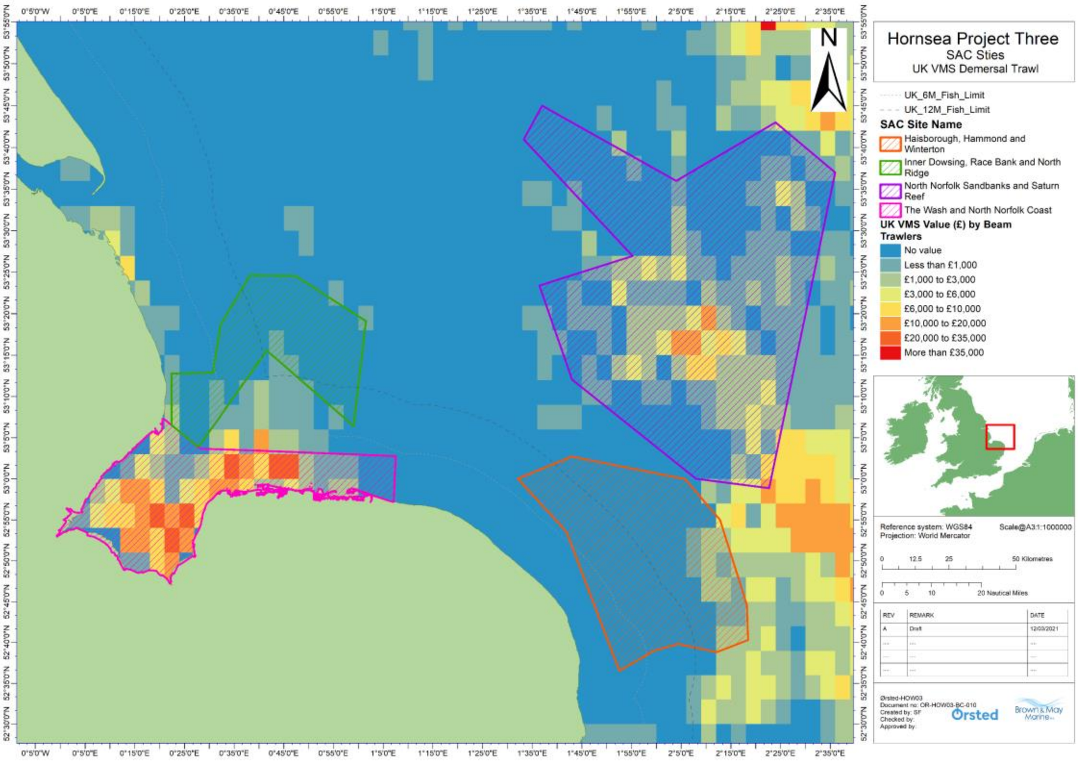


Figure 10.2: UK VMS Value Beam Trawlers (average 2015-2019) (Source MMO 2020).

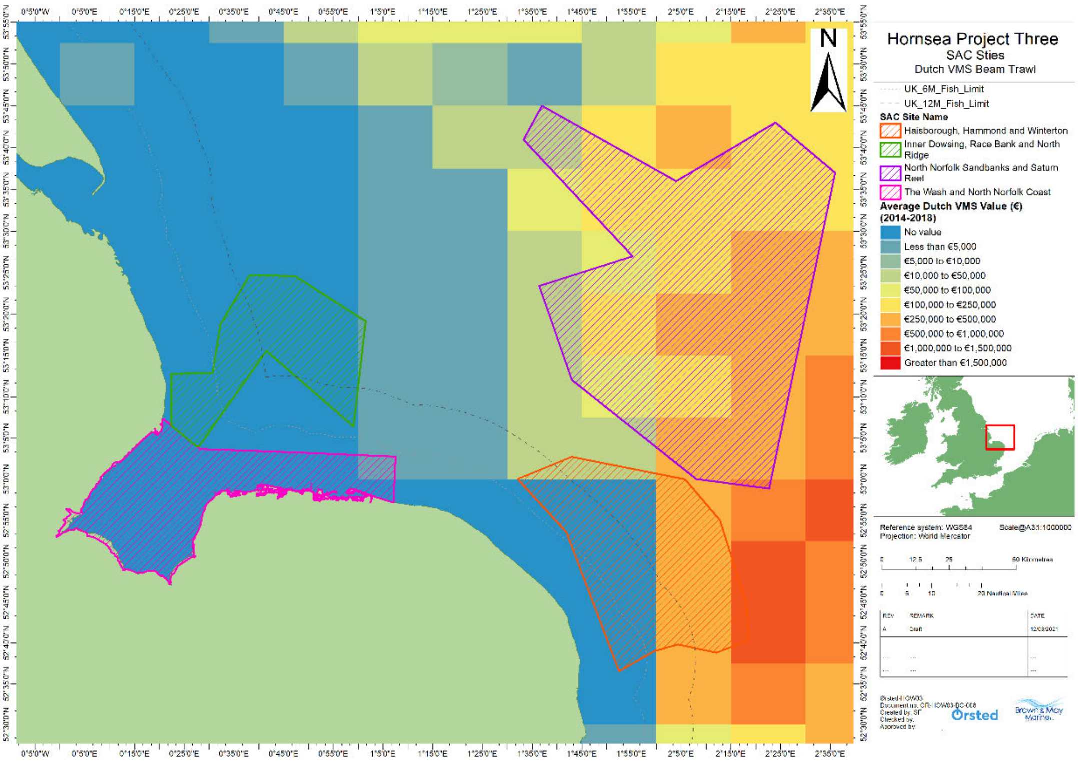


Figure 10.3: Dutch VMS value by beam trawl (average 2014-2018) (Source DFA 2019).

Consultation

A summary of the consultation undertaken is provided in Table 1. This consisted of face-to-face meetings with individual local fishermen, representatives of fishermen organisations and phone calls with a local Fisheries Industry Representative (FIR) and operators of Dutch trawlers. Consultees were provided with charts with the location of Hornsea Three and the SACs in its proximity and were asked three questions:

- Have you lost gear within the SACs shown on the map?
- Do you know of areas prone to snagging, areas where you tend to avoid?
- Do you know of any areas where there is marine debris?

Additional comments from the consultees in respect of seabed debris were also noted.

From the MMO vessels list of local ports, it is estimated 115 vessels could operate within the SACs. Approximately 50 vessels from these local ports were approached during the consultation process. It should be noted that some of the consultees approached represent a number of vessels. The below table summarises the responses from 15 scallop, shrimp, cockle, crab and lobster stakeholders who represent approximately 48 vessels based along the east coast from Cromer to Grimsby and one Dutch trawler.

Table 1: Consultation summary.[19]

Question	Responses
1. Have you lost any gear in the area on the map?	Most respondents confirmed that they had previously lost gear although there was mixed feedback on the cause of the loss (e.g. storm events or interactions with third parties) and on whether recovery had been successful.
2. Are there snagging areas you avoid?	Respondents confirmed there were not snagging areas they avoid, with the exception of chartered rough areas, exposed export cables and known wrecks.
3. Do you know where there may be marine debris?	Responses varied, with a number of respondents confirming they did not know where there may be marine debris or were not willing to share that information for commercial reasons (e.g. good fishing grounds). Other respondents identified the nearshore sections along the coast of the WNNC SAC as most likely areas for marine debris, and also in Race Bank windfarm.
4. Additional comments	One respondent stated that gear was valuable and therefore would not be purposefully abandoned, another suggested that whelk pots are frequently discarded by the industry. Separately, a respondent identified the presence of demersal trawlers (predominantly Dutch beam trawlers) on the eastern section of the North Norfolk Sandbanks and Saturn Reef MPA SAC.

[19] Hornsea Three note that a more detailed consultation summary was provided to the Steering Group during consultation on first and second draft SBIPs. This consultation summary has been summarised in Table 1 to protect the confidentiality of the responses.

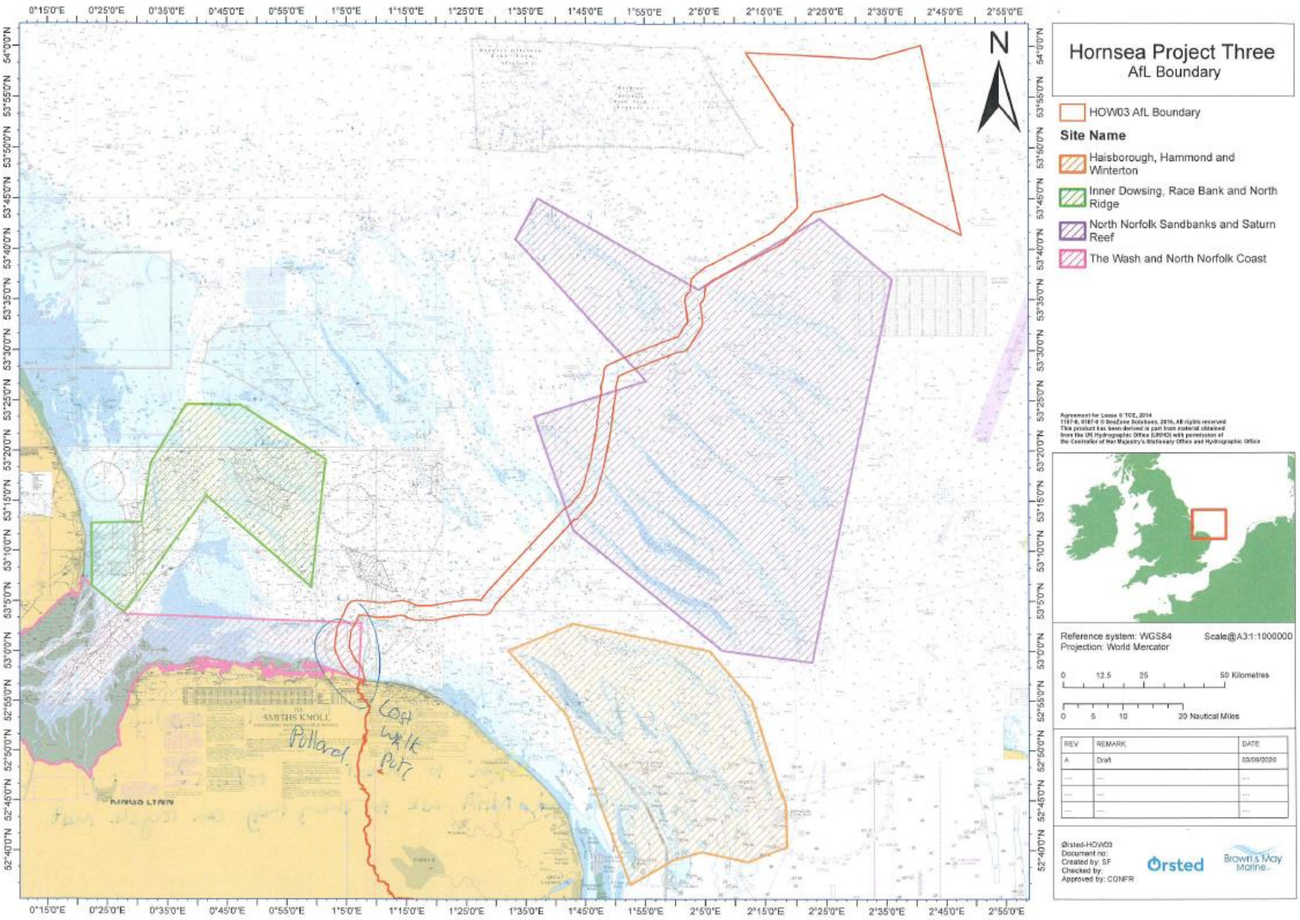


Figure 10.4: Location of lost whelk pots identified by Consultee.

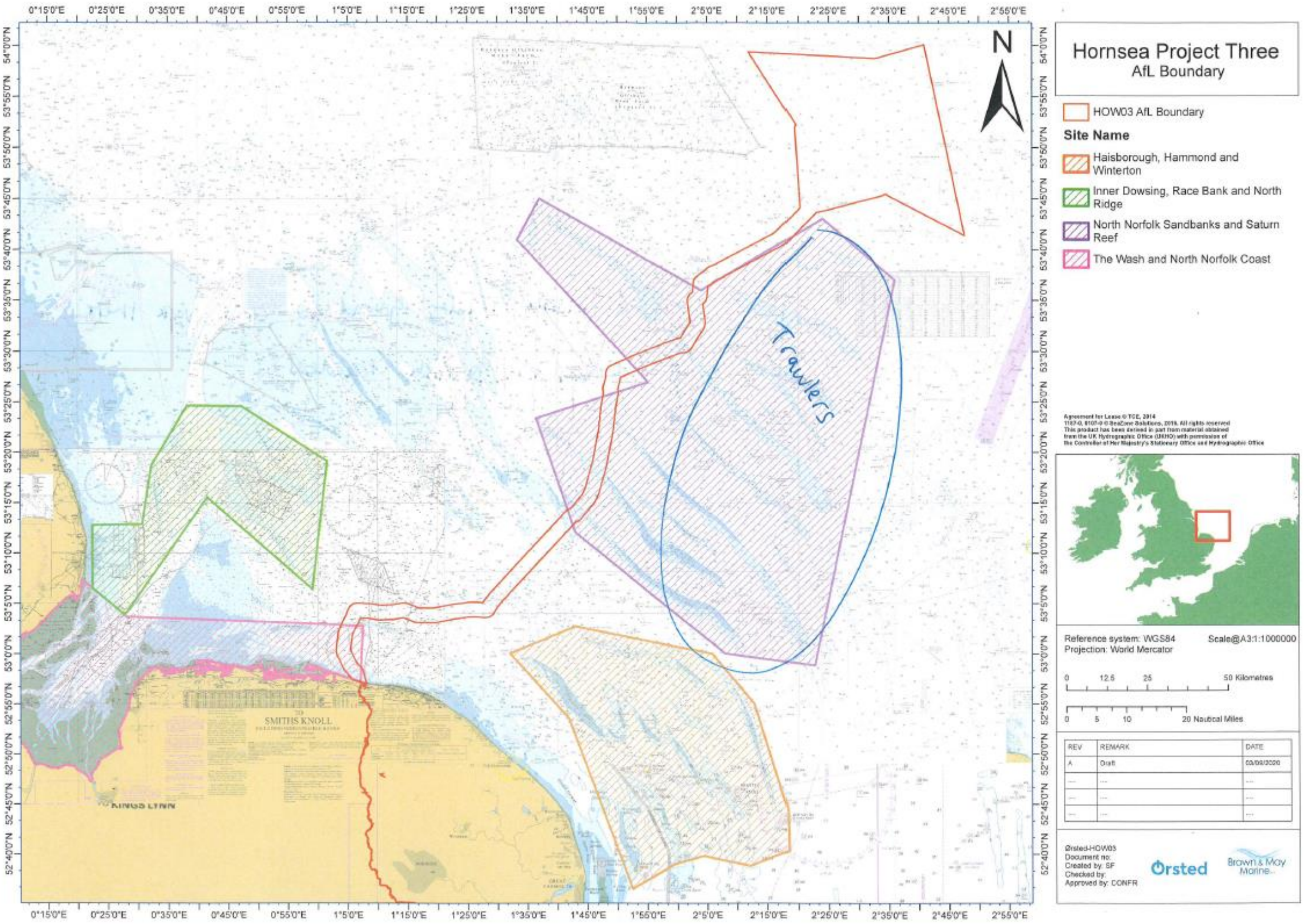


Figure 10.5 Area of high Danish beam trawling activity identified by Consultee.

Conclusions

Gear that is lost tends to be searched for extensively by fishermen due to the cost of replacing equipment. It is understood that abandonment only occurs when gear has been moved by trawlers, after bad storms or when other fishermen have interfered with the gear.

The fisheries stakeholders consulted stated that once they have searched for the gear and have been unable to locate it, they delete the gear mark from their plotter. As such, it is not possible to predict where the gear may have ended up by analysis of coastal processes data. Therefore, if the positions of lost gear were known the fishermen would have recovered this themselves. In general terms, the fisheries stakeholders consulted were not aware of any specific areas where debris may be found. During the consultation only one fisherman identified areas where he had previously lost gear and where it is likely that lost static gear may be found. The broad area identified by this fisherman is consistent with the area where seabed debris (entangled crab pots) were found during recent Hornsea Three survey work (see below).

Consultation with the Dutch based trawler did not reveal any areas of snagging in the NNSSR SAC. In areas of high trawling activity, it is unlikely that static methods such as potting are used, therefore lost static gear is less likely to be present in these areas. In addition, areas that support heavy trawling activity are unlikely to present significant debris/lost gear. If present, this would most likely already had been removed by trawlers active in the area.

A recommended AoS for lost fishing gear within WNNC SAC is provided in Figure 10.6, based on the evidence collected from consultation to date. The adaptive management alternative AoS in the WNNC SAC is located within this area as set out in Section 8.1.3 of the Marine Debris Removal Campaign Desktop Study, of which this report is appended. In the case of NNSSR SAC, a discrete AoS has not been defined, as no specific records of debris in the area have been identified during fisheries consultation. Neither the initial AoS, nor the adaptive management AoS for the NNSSR SAC have been located within the area identified in Figure 10.5 as being subject to intensive trawling as this may activity be removing or moving any marine debris present.

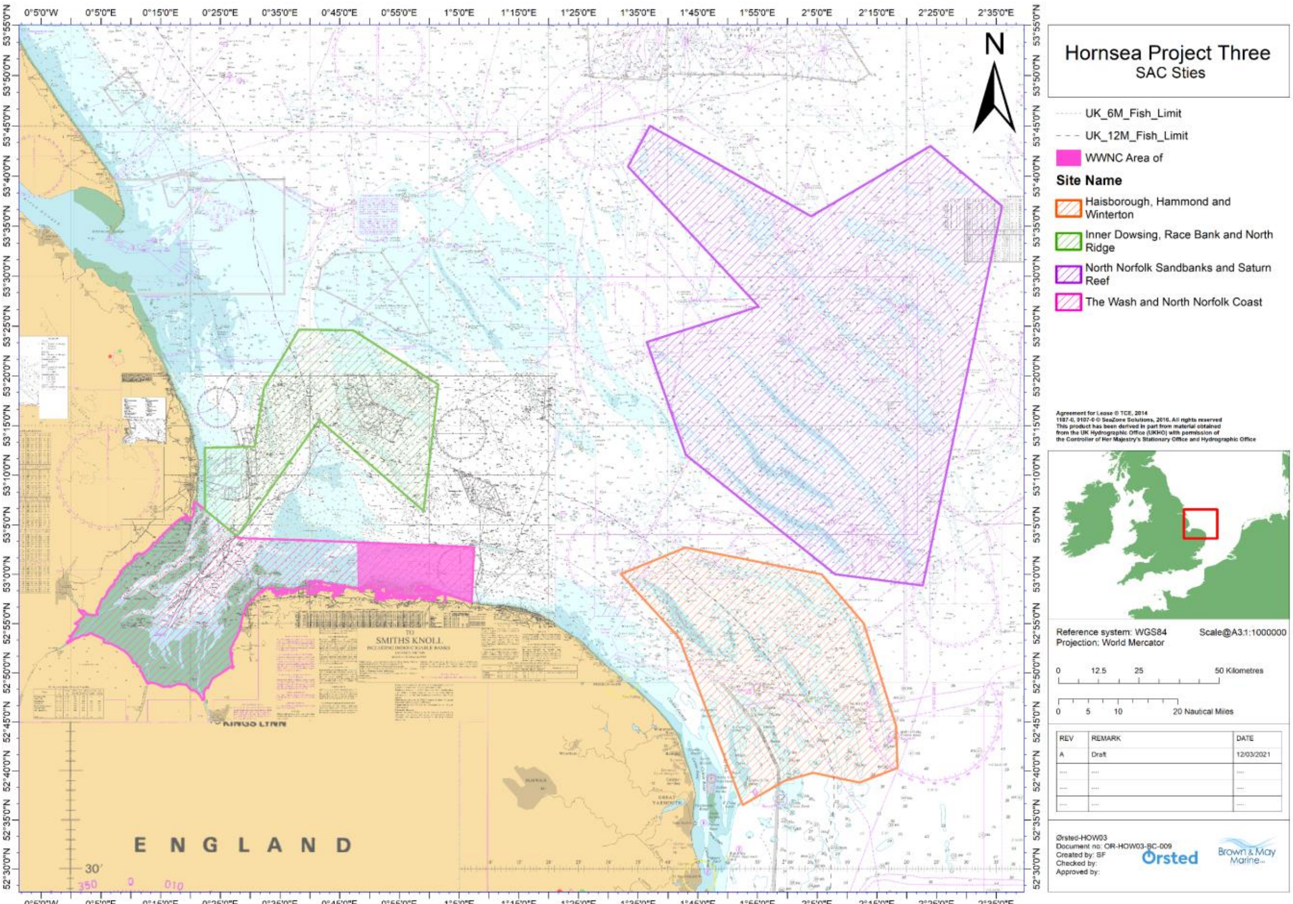


Figure 10.6: Recommended AoS from Consultation.

Debris Recorded during Hornsea Three Survey Work

A list of debris recovered during recent Hornsea Three survey work (Site Investigation surveys, April 2021) is provided in Table. This included fishing gear debris on the seabed (entangled pots) and floating gear markers and balloons.

Fishing gear/seabed debris

Two sets of crab pots were recovered from the seabed during recent surveys. Their locations are shown in Figure 10.7. The gear recovered was severely tangled, suggesting it had travelled from its original location. Both sets of gear had surface markers and were likely not recovered by fishermen either due to location not being known, or the gear was too tangled to be recovered by the smaller vessels that typically work this area (Table 2).

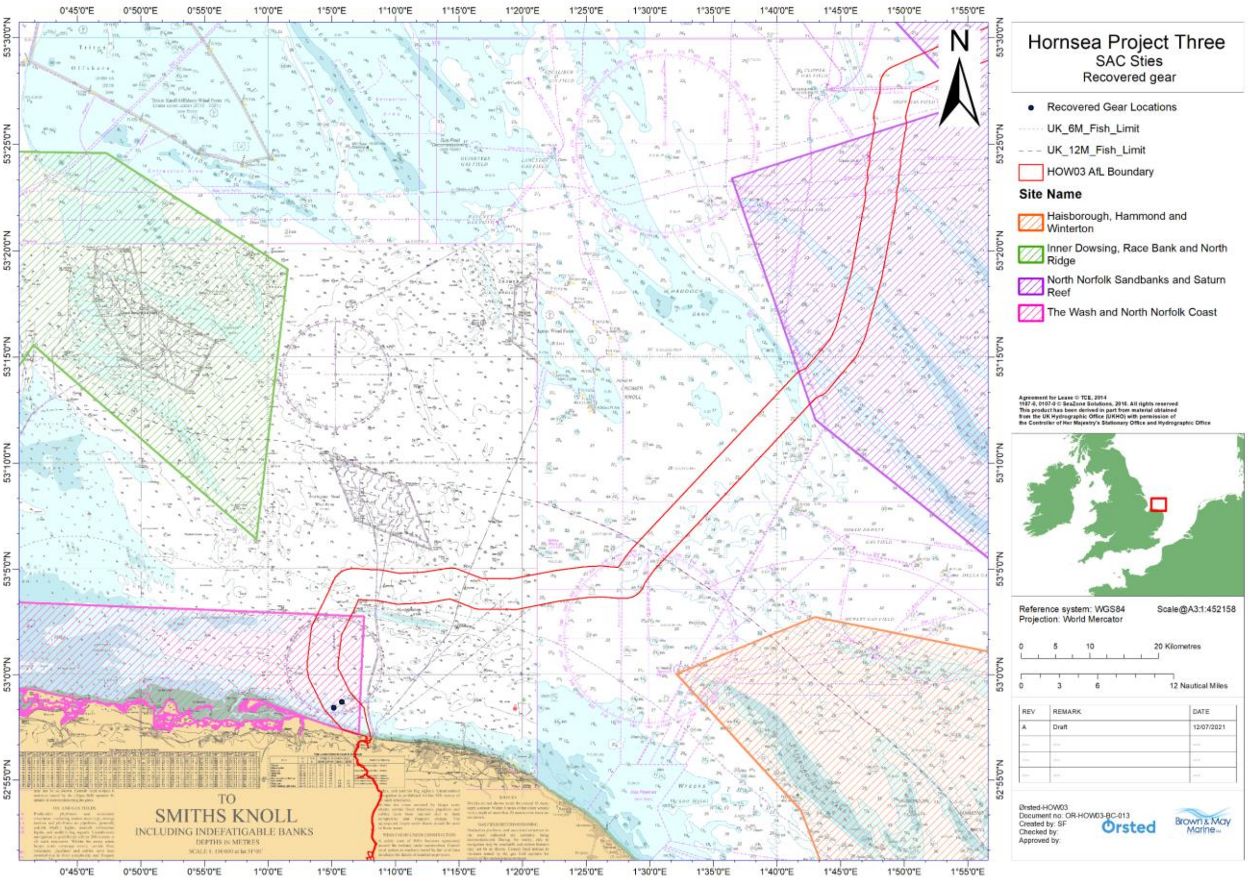
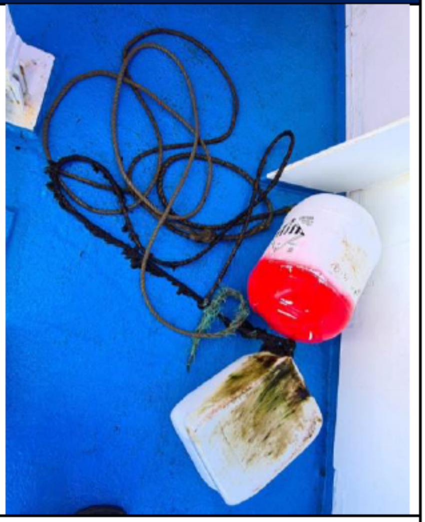
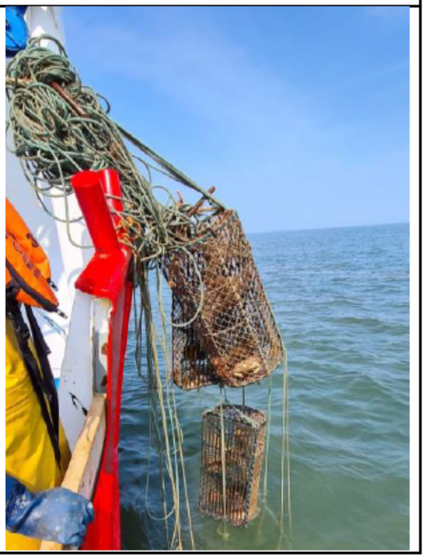


Figure 10.7: Locations of recovered gear during 2021 surveys.

Floating Debris

A total of 11 drifting gear markers and two balloons were retrieved during recent survey work. Gear markers tend to detach due to weather, or interactions with other vessels at the surface level and are often found floating in the North Sea. It should be noted that even if gear markers are lost, fishermen tend to be aware of where their pots are and try to retrieve them without a surface marker, often successfully. Therefore, the presence of floating debris is not necessarily indicative of gear being actually lost. Furthermore, as detached gear markers float and drift with currents, the location where they may be found is not necessarily indicative of the presence of static gear in that specific area.

Table2: Photos of debris retrieved during site investigation surveys

Date	Time	Latitude	Longitude	Description	Photo
16/04/2021	08:50	53 04.251 N	00 25.775 E	Red and white buoy no ID	
16/04/2021	08:59	53 04.653 N	001 23.431 E	White can no ID	
17/04/2021	11:44	53 04.518 N	001 12.513 E	Single white can	
17/04/2021	16:09	53 00.604 N	001 05.918 E	Double white can no ID	
19/04/2021	07:57	58.403 N	001 04.958 E	Orange buoy	
20/04/2021	09:24			drifter recovered	
20/04/2021	13:04	52 58.697 N	001 05.785 E	Tangled gear. Double yellow buoy no ID	

Date	Time	Latitude	Longitude	Description	Photo
20/04/2021	13:37	52 58.423 N	001 05.165 E	Tangled gear. black can no ID	
22/04/2021	11:44			picked up drifter	
17/05/2021	07:05			Sweet 16 balloons	
18/05/2021	12:08			Two white cans. No ID.	
18/05/2021	11:35			One white can. No ID	
19/05/2021	05:48			Birthday boy Balloon	

Date	Time	Latitude	Longitude	Description	Photo
20/05/2021	06:45	53 31.960 N	002 02.620 E	Two white cans, A red flagged dhan and lots of surface drifting rope	
20/05/2021	11:30	53 23.780 N	001 47.790 E	Two white cans