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Norfolk Projects Offshore Wind Farms

Benthic Implementation and Monitoring Plan

Annex 3 Marine Debris Search Area Identification Desk Study

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Executive Summary

The Development Consent Orders (DCO) for both Norfolk Boreas and Norfolk Vanguard offshore wind farms (together known as the Norfolk Projects), include a requirement to remove marine debris from the Haisborough, Hammond and Winterton (HHW) Special Area of Conservation (SAC) to compensate for adverse effects on its designated features.

The study has been undertaken to identify areas likely to exhibit higher quantities of marine debris with the intention of informing a marine survey programmed for summer/ autumn 2022 in order to increase its likelihood of locating marine debris. This report details the assessment of 1km^2 blocks (selected for their resolution), scored and multiplied according to the confidence in accuracy and appropriateness of each data set in a process known as 'heat mapping'. Scoring relied on primary source marine debris data sets, proxy data to indicate areas of high human use and expert knowledge, to inform GIS mapping exercises and outputs.

The intention is to use the findings of this study to identify priority Areas of Search (AoS) for a survey campaign in 2022, with additional adaptive management AoS identified should further surveys be required.

The data analysed included:

- exclusion zones around hard constraints, such as infrastructure and protected features (The Crown Estate Open Data Portal, JNCC, Natural England, Norfolk Projects existing survey data),
- the presence of debris based on debris data (Cefas and ICES Marine Litter data,
- the potential for debris based on proxy data (VMS, MMO activity data, UKHO Admiralty data),
- consultation and engagement to identify potential debris hotspots (consultation), and
- debris accumulation locations based on physical processes (EMODNet Bathymetric data).

In summary, the south eastern corner of the HHW SAC was highlighted as an area most likely to contain debris, with north western corner and the eastern edge of the SAC also indicating relatively high likelihood. The troughs in-between sandwaves were also identified as locations where debris had the potential to accumulate.

As a result of this analysis, two AoS have been selected (primary and adaptive) in areas most likely to contain marine debris.

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Glossary of Acronyms

AEoI	Adverse Effect on Integrity
AIS	Automatic Identification System
ALDFG	Abandoned, Lost and Discarded Fishing Gear
AoS	Area of Search
BIMP	Benthic Implementation and Monitoring Plan
BSG	Benthic Steering Group
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CSEMP	Clean Seas Environment Monitoring Programme
DCO	Development Consent Order
EMODNet	European Marine Observation and Data Network
ES	Environmental Statement
EU	European Union
EUNIS	European Nature Information System
FCS	Favourable Conservation Status
GES	Good Environmental Status
GIS	Geographic Information System
ha	Hectares
HHW	Haisborough, Hammond and Winterton
HM	Her Majesty's
IBTS	International Bottom Trawl Survey
ICES	International Council for the Exploration of the Sea
JNCC	Joint Nature Conservation Committee
MALSF	Marine Aggregates Levy Sustainability Fund
MMO	Marine Management Organisation
MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
NB	Norfolk Boreas
NV	Norfolk Vanguard
OD	Ordnance Datum
REC	Regional Environmental Characterisation
SAC	Special Area of Conservation
UKHO	UK Hydrographic Office
UXO	Unexploded Ordnance
VMS	Vessel Monitoring System

1 Project and Document Background

1.1 Project Background

2. A Development Consent Order (DCO) was awarded to Norfolk Boreas on the 10th of December 2021, and subsequently to Norfolk Vanguard on the 11th of February 2022. Schedule 19 Part 3 of the Norfolk Boreas DCO and Schedule 17 Part 3 of the Norfolk Vanguard DCOs detail the benthic compensation measures required in line with the Haisborough Hammond and Winterton (HHW) Special Area of Conservation (SAC) Compensation Plan[1] (document 8.25).

3. There is a requirement under both DCOs to produce a Benthic Implementation and Monitoring Plan (BIMP) which will include details on two compensation strands

> *"(a) the identification and retrieval of marine debris; and*
> *(b) education, awareness and facilities to limit further marine debris,*
>
> *which are described as Strand 2 and Strand 3 respectively in section 4.3.4 of the HHW SAC compensation plan"*

to compensate for any potential adverse impacts on integrity to the HHW SAC and it's protected features '*Sandbanks slightly covered by sea water all the time'* and '*Reefs*'.

1.1.1 The Haisborough, Hammond and Winterton SAC

4. The Haisborough Hammond and Winterton SAC is designated for Annex I Sandbanks which are slightly covered by seawater all the time and Annex I Reefs (*Sabellaria spinulosa*).

5. The HHW SAC Conservation objectives are 'maintain' and 'restore' for both features:

- Annex I 'Reefs' (*Sabellaria spinulosa* biogenic reef), and
- Annex I 'Sandbanks which are slightly covered by sea water all the time'.

6. These objectives aim to ensure that qualifying habitats of HHW SAC, subject to natural change, are maintained or restored to ensure the integrity of the site and that the site contributes to achieving the Favourable Conservation Status (FCS). 'Favourable Condition' is the term used in the UK to represent 'FCS for the interest features of SACs. For an Annex I habitat, FCS occurs under the Habitats Directive when (JNCC and Natural England, 2013):

[11] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010087/EN010087-002829-8.25%20In%20Principle%20Habitats%20Regulations%20Derogation,%20Provision%20of%20Evidence%20Appendix%203%20Haisborough,%20Hammond%20and%20Winterton%20SAC%20In%20Principle%20Compensation.pdf

- "Its natural range and area it covers within that range are stable or increasing;
- The specific structure and functions, which are necessary for its long-term maintenance, exist and are likely to continue to exist for the foreseeable future; and
- The conservation status of its typical species is favourable" (JNCC, 2021)

7. In relation to the Norfolk Projects, the HHW SAC is located to the west of NV West, and the shared offshore cable corridor passes through the SAC.

8. The sandbank ridges within the HHW SAC consist of sinusoidal banks which have evolved over the last 5,000 years and comprise of Haisborough Sand, Haisborough Tail, Hammond Knoll, Winterton Ridge and Hearty Knoll. Older sandbanks, Hewett Ridge and Smiths Knoll, are present along the outer site boundary and have formed over the last 7,000 years. The more geologically recent sandbanks of Newarp Banks and North and Middle Cross Sands lie on the south west corner of the SAC.

9. The Joint Nature Conservation Committee (JNCC) HHW Site Details[2] state that *S. spinulosa* reef has been recorded at Haisborough Tail, Haisborough Gat and between Winterton Ridge and Hewett Ridge. *S. spinulosa* reefs within the HHW SAC can have an elevation of 5cm to 10cm and in areas where reef has been recorded, this can have between 30% to 100% coverage.

10. As the cable corridor for the Norfolk Projects will pass through the HHW SAC, the condition stated in section 1.1 was included in the DCO to ensure no adverse effect on the integrity of the site through the compensation measures.

1.2 Document Purpose

11. This document details a desk based study undertaken to identify areas within the HHW SAC that have the highest likelihood of containing marine debris from which priority areas of search can be developed. This is pursuant of discharging the following condition stated within the Norfolk Boreas and Norfolk Vanguard DCOs:

"(a) the identification and retrieval of marine debris"

12. This report is comprised of the following sections:

- Section 1 Project and Document Background, this provides the project background, context for this report and the DCO requirements
- Section 2 Marine Debris Removal Campaign, which contains an overview of the marine debris removal campaign and its rationale.

[2] https://sac.jncc.gov.uk/site/UK0030369

- Section 3 Heat mapping methodology and mechanism to identify Areas of Search (AoS)
- Section 4 details the constraints mapping to identify the areas excluded from the AoS.
- Section 5 Areas identified as hotspots, this section shows figures based on data gathered and detailed analysis including debris data, proxy data and a refinement exercise to identify where debris may accumulate or gather based on physical processes.
- Section 6 provides the results of the 'Scoring' within the SAC, following the mechanisms detailed in section 3.2, undertaken to narrow down the most appropriate AoS from the blocks within the SAC to identify areas likely to include marine debris;
- Section 7 identifies the target AoS locations for surveying (priority areas) and further AoS locations identified for future surveying under adaptive management if required under the marine debris removal campaign.

1.3 Legislation underpinning need to remove marine debris and litter

13. Commitments have been made to reduce the release of debris or litter into the marine environment by both the UK Government and internationally. The laws, aims and goals drafted all aim to reduce current negative impacts and improve the status of the existing environments.

14. The European Marine Strategy Framework Directive (MSFD), transposed into UK Law as the Marine Strategy Regulations 2010 (as amended[3]) sets out descriptors for assessing the achievement of 'good environmental status'. One of these (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".

15. The East Inshore and Offshore Marine Plans (encompassing the HHW SAC), 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.

16. In Europe, specific legislation was introduced to tackle the marine litter issue and its impact on the coastal and marine environment under the MSFD)(European Parliament and Council of the European Union, 2008). The MSFD incorporates an indicator specifically in relation to litter and requires evidence that member states are moving towards Good Environmental Status (GES). More specifically, the MSFD operates by monitoring, amongst others, trends in the amount of litter deposited on

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

the sea floor, including analysis of its composition, spatial distribution and, where possible, sources (European Parliament and Council of the European Union, 2008).

2 Marine Debris Removal Campaign

17. Derelict abandoned, lost and discarded fishing gear have been found to have profoundly adverse effects in the marine environment, including consequences such as "ghost fishing, transfer of microplastics and toxins into food webs, spread of invasive alien species and harmful microalgae, habitat degradation, obstruction of navigation and in-use fishing gear, and coastal socio-economic impacts" (Gilman et al., 2021). In recent years there has been increasing international recognition of the need for multilateral efforts to address the detrimental effects of abandoned, lost and discarded fishing gear (ALDFG) to reduce habitat alteration and degradation (Gilman et al., 2021).

18. This can be seen through commitments made through the United Nations Sustainable Development Goals, the Marine Strategy Framework Directive (MSFD) and other national and international goals, aims and legislation.

19. Sustainable Development Goal 14.1 aims to:
"by 2025, prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution" (United Nations General Assembly, 2015).

20. The MSFD, transposed as the Marine Strategy Regulations 2010, as amended (Marine Environment (Amendment) (EU Exit) Regulations 2018), sets out descriptors for assessing the achievement of 'good environmental status'. 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".

2.1 Marine Debris Definition

21. For the purpose of the compensation requirement, 'marine debris' was specified as 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 HHW SAC. Examples of marine debris include discarded or lost fishing gear, dropped objects either from vessels or offshore structures, maritime disasters or illegally jettisoned waste.

22. The compensation measures required under the DCO (see section 1.1) have been selected to assist in the restoration of sandbank functionality and reduce pressures on Annex I Reef. Therefore the removal campaign will focus on 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. It is important to be pragmatic in determining what marine debris would be both practicably detectable as well as removable during the campaign, without causing further damage to protected features.

2.2 Debris Removal Campaign Aims

2.2.1 Overview of Compensation Aims

23. The benefits of conducting a campaign of marine debris removal are outlined in the Benthic Compensation Plan[4] (document 8.25), submitted as part of the in principle derogation documents. The removal of marine debris was suggested as compensation as it is anticipated to:

    1. support the restoration of Annex I habitat '*Sandbanks which are slightly covered by sea water all the time*' within the SACs, as sediment for transportation within the SAC systems will have increased availability, thereby increasing the functionality of the sandbank habitats;

    2. reduce potential damage or related negative impacts of marine debris or litter, caused by movement due to physical processes, on Annex I reef biogenic reef which may be threaten the habitat; and

    3. removal of debris would allow the seabed to perform more naturally and provide habitat available for colonisation and / or transit of mobile epifauna.

24. The success criteria to ensure the requirements are met will be defined and agreed with the Benthic Steering Group (BSG), in line with the BIMP.

25. Figure 1 shows the location of the HHW SAC which is designated for annex I features and the boundary within which the cable route will run. Debris removal should take place within the HHW SAC as shown in Figure 1.

[4] In Principle Habitats Regulations Derogation, Provision of Evidence Appendix 3 Haisborough, Hammond and Winterton SAC In Principle Compensation, Norfolk Boreas and Norfolk Vanguard

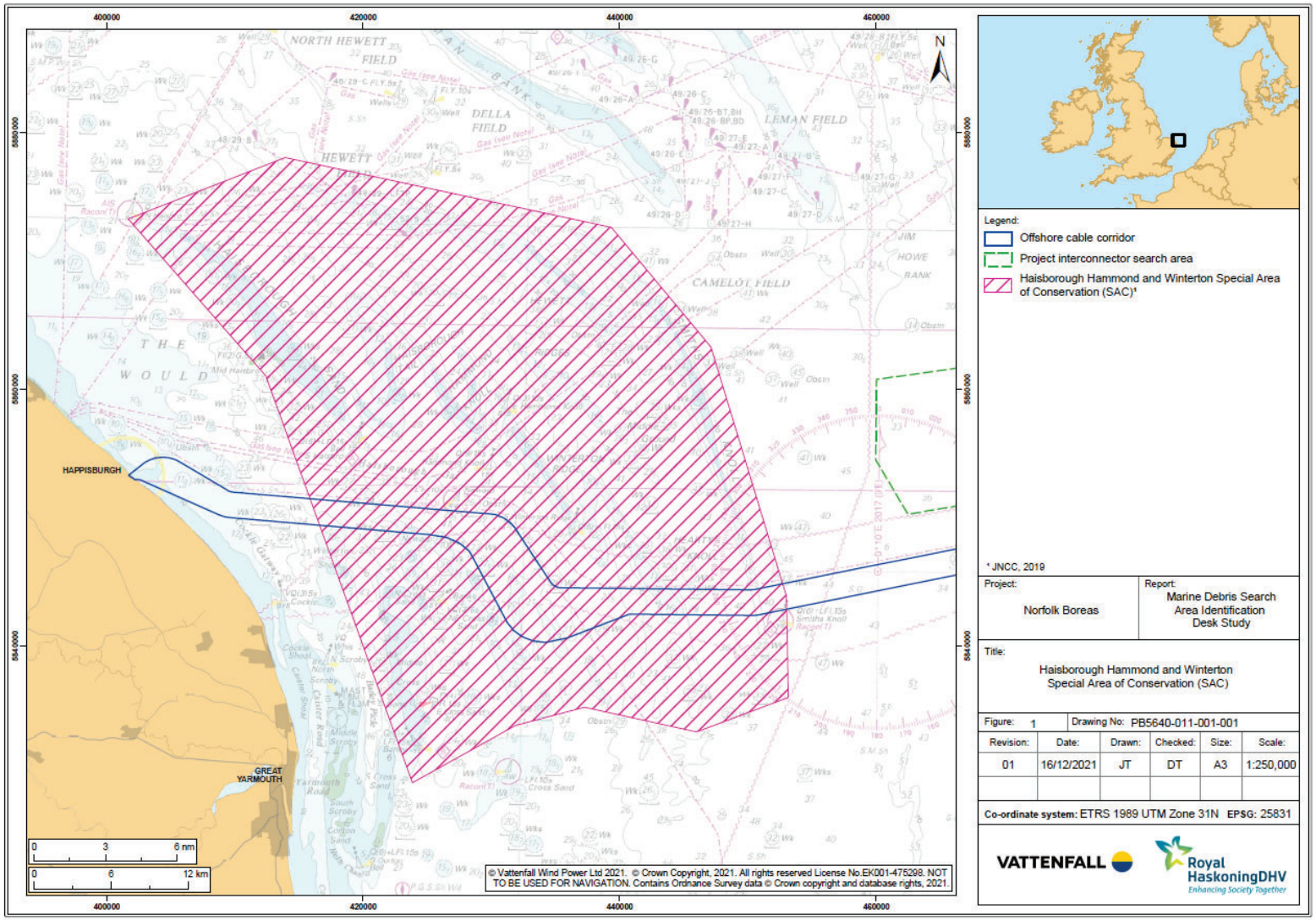

Figure 1. Haisborough Hammond and Winterton Special Area of Conservation (SAC)

26. In addition to the marine debris removal campaign, The Norfolk Projects will both undertake a second strand of compensation if the form of an "e*ducation, awareness and facilities to limit further marine debris*" campaign with the aim of reducing future marine debris entering the SAC and providing a longer-term compensation measure. The awareness campaign is discussed in more detail in the BIMP.

27. Both strands of compensation (1. removal of marine debris, and 2. awareness campaign) will complement each other and aim to provide a long term positive impact to the HHW SAC, by removing existing pressures and reducing the potential for future pressures.

2.2.2 Targeted Debris and Removal Aims

28. As marine debris removal is being undertaken to reduce pressures on the protected features within the HHW SAC, the campaign will aim not to adversely affect protected features during removal work.

29. Target marine debris items would include but not be limited to abandoned, lost, or otherwise discarded fishing gear such as nets, pots, and tickler chains, and debris lost from, for example, anchorages and (non-protected) wrecks.

30. 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), as geophysical surveys (e.g., side scan sonar or similar) are anticipated for the purpose of confirming the presence of debris in each 1km^2 block of the SAC, and therefore within the proposed AoS identified in this Desktop Study.

31. Debris targeted (or clusters of debris) will be a minimum of 1m in dimension due to the ability for surveys to pick up smaller items and also to reduce any potential impacts to protected features during the removal of smaller or insignificant items of marine debris. Upper size limits of individual debris items will be determined by the capability of vessels and equipment undertaking removal. Dredging to remove the buried object will not be used as it would cause excessive disturbance to the seabed and only minimal jetting would occur were absolutely necessary to aid removal.

32. 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.

3 Heat mapping Methodology and Mechanism for identifying area of search

33. The rationale which underpins the benefits of conducting a campaign of marine debris removal is outlined in the Benthic Compensation Plans for both Norfolk Vanguard[5] and Norfolk Boreas[6].

34. The HHW SAC In Principle Compensation Plan sets out the process for the Norfolk Projects to agree all works, potential mitigation measures and monitoring associated with offshore cable installation (including seabed preparation works and cable protection) and maintenance within the HHW SAC, with the Marine Management Organisation (MMO) in consultation with Natural England.

3.1 Methodology

35. In order to identify and retrieve marine debris in the most efficient way, a desk based study was designed to identify AoS for the marine debris removal campaign in the HHW SAC.

36. This section describes the methodology employed to identify potential AoS for the marine debris removal campaign. The methodology uses a systematic, score-based approach, using data to identify higher 'scoring' blocks measuring 1km^2 (i.e., areas with a greater perceived potential for containing a high density of marine debris) which were refined based on physical and biological parameters (see section 3.2). The SAC was split into 1km^2 blocks as this was deemed the appropriate resolution for visualising the data and also constitutes a scale suitable for undertaking effective surveying campaigns.

37. High scoring blocks will be identified as either priority AoS (for initial surveys) or adaptive management AoS (for subsequent surveys should the initial survey and removal campaign not meet the requirements of the DCO).

38. The stages of the AoS identification and refinement process are detailed in Figure 2.

[5] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010079/EN010079-004422-8.25%20In%20Principle%20Habitats%20Regulations%20Derogation%20Provision%20of%20Evidence%20Appendix%203%20Haisborough%20Hammond%20and%20Winterton%20SAC%20In%20Principle%20Compensation%20(Version%203).pdf

[6] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010087/EN010087-002829-8.25%20In%20Principle%20Habitats%20Regulations%20Derogation %20Provision%20of%20Evidence%20Appendix%203%20Haisborough %20Hammond%20and%20Winterton%20SAC%20In%20Principle%20Compensation.pdf

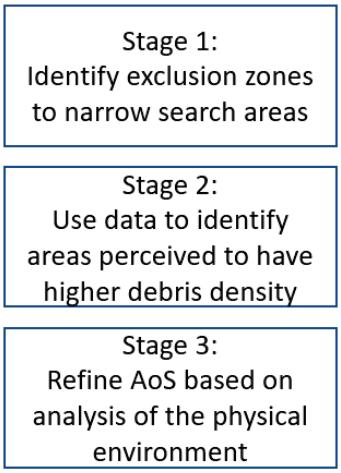

Figure 2. Stages of the process used to identity and refine the AoS.

39. **Stage One** involves eliminating areas within the SAC, due to constraints which will make surveying or eventual removal of debris unfeasible.

40. **Stage Two** relies on marine debris and proxy data being gathered and appropriately scored to reveal the highest scoring 1km^2 'blocks'. These blocks will form the basis to identify the AoS where marine debris is most likely to be present.

    - The methods of finding locations with a high potential for marine debris includes conducting a desk based review using
        i. integrated VMS) data showing high fishing intensity areas which was used as a proxy for dropped objects,
        ii. consultation with fishermen
        iii. marine debris data including archaeological anomalies and associated engagement with the diving community.

41. **Stage Three** uses conceptual analysis of the physical conditions within the SAC to refine the areas within the HHW SAC where marine debris is most likely to accumulate.

42. Following consultation with the Benthic Steering Group at the first meeting on the 7th April 2022 on the initial heat mapping methodology, locations where relevant data sets and physical conditions indicated that there was likely to be a comparatively high level of marine debris present, and as a result were considered to be prime AoS locations for targeted ground-truthing surveys and subsequent removal campaigns, were identified. A primary AoS and a further adaptive management AoS were selected, based on analysis of the results and expert judgement.

43. As each marine survey has the potential to have a large carbon footprint, it is crucial to ensure surveys for marine debris are targeted, efficient and in areas where

removal of debris is considered feasible. A pragmatic approach is therefore key in determining what marine debris would be practicably detectable and removable.

44. This desk based study proposes one primary and one adaptive management AoS within the HHW SAC for exploration in the 2022 survey campaign, to be conducted alongside geophysical surveys to reduce the carbon footprint of conducting the surveys, as well as further adaptive management AoS locations should they be required.

45. In the event that the survey does not reveal any marine debris that can be removed, a hierarchical approach will need to be employed to identify other SACs designated for the same features (Annex I Reef and Sandbanks) for consideration.

3.2 Data Sources

3.2.1 Open Source Data

46. The following data sets were used to inform the assessment and undertake the scoring exercise described above:

Table 3.1 Data sources used to inform AoS

Data Source	Information Type	Data Usage
Cefas North East Atlantic Seafloor Marine Litter data	Cefas' datahub[7] includes litter data obtained during fish and environmental surveys in UK waters, including the central and southern North Sea, from 1992 to 2014. 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).	Cefas data (while low resolution) provides evidence of the likely presence of debris in the vicinity of the HHW SAC
The Crown Estate Open Data Portal	The Crown Estate's Open data portal[8] is a repository which provides access to all the data that The Crown Estate publishes including survey data from marine aggregate and offshore wind farm developments in the UK	Data was acquired from the Open Data Portal, to identify exclusion zones
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 and to identify habitat types which have also been used to identify preferential AoS.
Ghost Fishing UK	Ghost fishing UK is a voluntary organisation of divers who receive marine debris data, record	Consultation with Ghost Fishing UK informed that areas surrounding

[7] [redacted]

Data Source	Information Type	Data Usage
	the presence of debris or litter and then coordinate diving teams to remove debris. They have input into locations where debris is likely to gather, accumulate and snag based on information provided to them.	wrecks often are snagging locations and the vicinity of wrecks are more likely to debris sightings logged by Sea Search have been used in the process of identifying potential AoS
Global Marine Geocable GIS	Global Marine's GeoCable database provides information on submarine telecoms cables and can be procured to identify telecom cable routes.	The presence of submarine telecoms cables has provided an indication of areas to be excluded from site selection
JNCC SAC supporting evidence	There is underpinning evidence presented in the SAC Selection Assessment	This data source has been used to provide information on Annex I sandbank habitat extent and physical / biological properties of the SACs. Annex I Reef distribution data has been used to inform exclusion zones.
MMO Marine Activity Data portal	The MMO have a planning portal[9] 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, including Fishermap data for small vessels; • Areas of high navigation density; • Vessel anchorages; • Dredged areas; and, • Other infrastructure within the marine area.	Data from the MMO portal has been used in identifying potential areas of high marine debris density, as well as the locations of sensitivities that should be excluded.
National Heritage list for England	Historic England's National Heritage list sets out the locations of protected wrecks and other designated heritage sites to avoid.	Data was used to confirm no protected wrecks in (or near to) the SAC among those presented in the Admiralty data
Natural England evidence base / Defra MAGiC application	Natural England's evidence base, presented in Natural England's open data portal[10], provides further information on the distribution of SAC habitat features.	This data source provided information on Annex I sandbank habitat. Annex I Reef distribution data has been used to inform exclusion zones.
UKHO / Admiralty data portal	The UKHO / Admiralty hosts a portal[11] for maintained information on wrecks and navigational obstructions / foul ground within Northwest Europe.	The presence of protected wrecks has provided information on exclusion areas due to sensitivity issues, and the wider areas surrounding wrecks were identified as locations where associated debris may be located.
UK VMS data	The MMO hosts Vessel Monitoring System (VMS) data for UK fishing vessels operating in English waters. VMS data regarding all vessel types for the period 2017 - 2021 was obtained from the MMO.	UK VMS data has been used to identify areas of heavy fishing vessel activity, which has been used as a proxy for areas of potentially high marine debris density and areas of potentially high prevalence of ALDFG.

[redacted]

Data Source	Information Type	Data Usage
	Fishing vessel-specific VMS data is applicable only to vessels over 12m in length, as per EU law.	

3.2.2 Private Source Data

3.2.2.1 Fisheries Data and Consultation

47. In addition to the above data used, consultation was undertaken by Brown and May Marine Ltd. with fishing associations and individual fishing operators who operate within the HHW SAC to gather both fisheries vessel data (Dutch and Belgian, as detailed in section 5.1.2), and anecdotal evidence from UK national and international fishermen to identify any potential 'hot-spots' for marine debris collection via consultation and engagement.

48. The fisheries consultation culminated in the identification of 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 presented in section 5.1.3.

3.3 Scoring Mechanism

49. This section presents a step-by-step guide of the scoring process used for the blocks within the HHW SAC.

50. The HHW SAC was subdivided into 1km^2 blocks, for the purpose of 'scoring' which will inform the heat mapping exercise undertaken in section 5.1.5 which will form the basis of selecting AoS.

51. For each data source, a block can either score high (a score of 1000), medium (a score of 100) or low (a score of 1), using a logarithmic scale to highlight the contrast between the scored blocks. 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 3.2. The scores have then been adjusted by multipliers described in sections 3.3.1, 3.3.2 and 3.3.3.

52. AoS were then established based on the blocks scores and their perceived likelihood to contain marine debris (i.e. areas with a greater perceived potential for containing a high density of marine debris, will score higher). Overall scores for each block are an accumulation of the individual scores based on the data sources, and then the target areas for surveying were identified following an assessment to identify potential accumulation or gathering zones for the marine debris. The selected areas for surveying were then classified as either priority AoS or adaptive management AoS.

3.3.1 Scoring Marine Debris Data

53. Of the data sources set out in section 3.2 Data Sources, the following provide information on marine debris recorded in and around the HHW SAC:

- ICES Marine Debris, and
- Fisheries consultation.

54. More information on these data sources is provided in section 3.2 Data Sources.

55. The main limitation of the above data sources is the restricted spatial coverage associated with them, which do not cover large swathes of the SAC. As there is limited marine debris data within the SAC, further proxies have been used to help identify AoS where marine debris is more likely to be present.

3.3.2 Scoring Proxy Debris Data

56. Several data sources were used as proxies, as they did not provide direct evidence of marine debris in the SACs but instead represented activities that may act as a source of debris. Proxy data sources used are as follows:

- VMS data;
- MMO fishing intensity data (FisherMap and AIS (automatic identification system)); and
- Admiralty wreck data.

57. Onshore sources (such as key tourism locations) may also result in the presence of marine debris, however this is likely to be limited to coastline areas, and items of very mobile debris, with a high level of dispersal. Therefore, it was not considered appropriate to consider onshore sources as a proxy for debris.

3.3.3 Confidence Multipliers

58. The overall scoring of a block has been influenced by the level of confidence in the data from the sources presented in Table 3.1 Data sources used to inform AoS. The expected accuracy and precision of the data used from that source directly relates to the confidence level. Empirical data gathered by experts using technical and effective scientific means would likely have a high level of confidence attached, whereas 'hearsay' or anecdotal evidence based on non-scientific methods would has a lower level of confidence attached.

Table 3.2 Data Value Definitions

Data source	Range	'Low' scoring threshold (score of 1)	'Medium' scoring threshold (score of 100)	'High' scoring threshold (score of 1000)
Admiralty wreck data	0 to 3 wrecks	No wrecks in block	1 wreck	2 or more wrecks

Data source	Range	'Low' scoring threshold (score of 1)	'Medium' scoring threshold (score of 100)	'High' scoring threshold (score of 1000)
Cefas North East Atlantic Seafloor Marine Litter data	0 to 5+ items of debris	No items of debris identified in block	1 – 5 items of debris identified	>5 items of debris identified
UK Fisheries VMS data 2017 to 2021	0 to 19 counts of fishing activity	1 - 5 counts of fishing activity	5.01 - 10 counts of fishing activity	>10.1 counts of fishing activity
Dutch and Belgian VMS Effort (Days) 2014 - 2018	0 to 100 days of fishing effort	0 - 5 days	5.01 - 20 days	>20.01 days
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

59. To score a block, a multiplier based on the confidence level has been added, meaning that the scoring of a block is weighted by the reliability of the data sources. Table 3.3 indicates the multiplier attached to the confidence level.

Table 3.3 Definition of scoring multiplier based on the confidence level attached to a given data source.

Score	Confidence Level
1	Low
2	Medium
3	High

60. The data sources used in the scoring process are assigned a value (low / medium / high) to help score blocks to inform the AoS (section 5.1 Stage 2: Identifying the areas most likely to hold debris) and identify areas most likely to contain marine debris. The assigned values levels for each are listed in Table 3.4, along with a justification for the value assigned.

Table 3.4 Confidence score of the data sources used

Data source	Value	Justification
Geophysical Data	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 more likely to fish closer inshore, on the Western side of the SAC
UK Fisheries VMS data 2017 to 2021	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.

Data source	Value	Justification
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.

61. With the multipliers defined here, the potential scores for any given block and data source are presented in Table 3.5. The overall score for a block can then be calculated as the sum of the scores for each data source, the results of which are detailed in section 5.1 Stage 2: Identifying the areas most likely to hold debris.

Table 3.5 Method to Calculate the overall score of each block.

Data source	Data Confidence Score Table 3.3	Data Value (based on scoring set out in Table 3.2)	Total score for data source
Geophysical data	2	100.0	Based on score x multipliers
Sea Search surveys	2	1000.0	
Fishermap value	2	1000.0	
UK Fisheries VMS data 2017 to 2021	3	1000.0 or 100.0 based on vessel counts	
VMS data (all vessels)	3	100.0 or 1.0 based on days	
Admiralty wreck data	2	1000.0 or 100.0 based on number of wrecks	
Fisheries Consultation	1	1000.0	
Overall score for the block			Cumulative score of the above

4 Stage 1: Areas Excluded and Constraints Mapping

4.1 Areas excluded

62. Areas in which existing safety, ecological or marine spatial planning issues may constrain marine debris surveys or removal operations have been mapped and excluded at this stage.

63. Removal of debris posing technical feasibility issues (including buried debris), ownership liability issues or health and safety risks (such as the presence of unexploded ordnance) will not be proposed for removal. Standard exclusion zones of 500m have therefore been implemented around existing infrastructure.

64. Areas of Annex I habitat *Sabellaria spinulosa* reef (including 'Areas to be managed as Reef', as designated by JNCC where reefs spatial extent are uncertain) would also be avoided with an appropriate buffer of 50m to ensure no damage is caused to any reef features.

65. It is recognised that *Sabellaria spinulosa* reef is ephemeral and therefore, areas of new reef can develop quickly where previously they were not recorded. Therefore, should survey campaigns identify the presence of uncharted reef (or potential reef), then such areas would be avoided when progressing the campaign.

66. A decision tree will be discussed and finalised with the Benthic Steering Group (set up as required under both Norfolk Projects DCOs) to secure the process should biogenic or geogenic reef not identified during Stage 1 of the campaign, be identified during the survey or removal campaigns.

4.2 Constraint Mapping

67. Areas that must be excluded from the AoS, considered the following constraints:

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.

68. The data sources used for indicating the locations of the above have been set out in Table 4.1.

Table 4.1 Data sources used in identifying exclusion areas for constraints mapping

Item	Data Source	Description	Exclusion Rationale
Areas of Annex I reef	JNCC MPA Mapper	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 protected and sensitive habitats. Methods used for debris removal may cause damage negatively impacting the feature. Debris present in such areas additionally may have been colonised by the reef and although not then considered as a conservation feature in their own right (as they are not colonising 'natural' habitat), the debris 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 HHW SAC.	As above.
Oil and gas structures / substructures	O & G Authority	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 Authority	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.

Item	Data Source	Description	Exclusion Rationale
Licensed aggregate zones	The Crown Estate	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	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	EMODNet	EMODNet provides bathymetry data for the North Sea area, including within the HW SAC.	Marine debris removal vessels would likely have vessel access and working issues in water shallower than ten metres.

69. The buffers defined in section 4 (500m around third-party assets, 50m around Annex I reef and wrecks) have been used to identify areas within the HHW SAC, which contain obstructions or constraints listed in Table 5.1, presented spatially in Figure 3, and will be presented in the Plan of Works, to be agreed with the BSG.

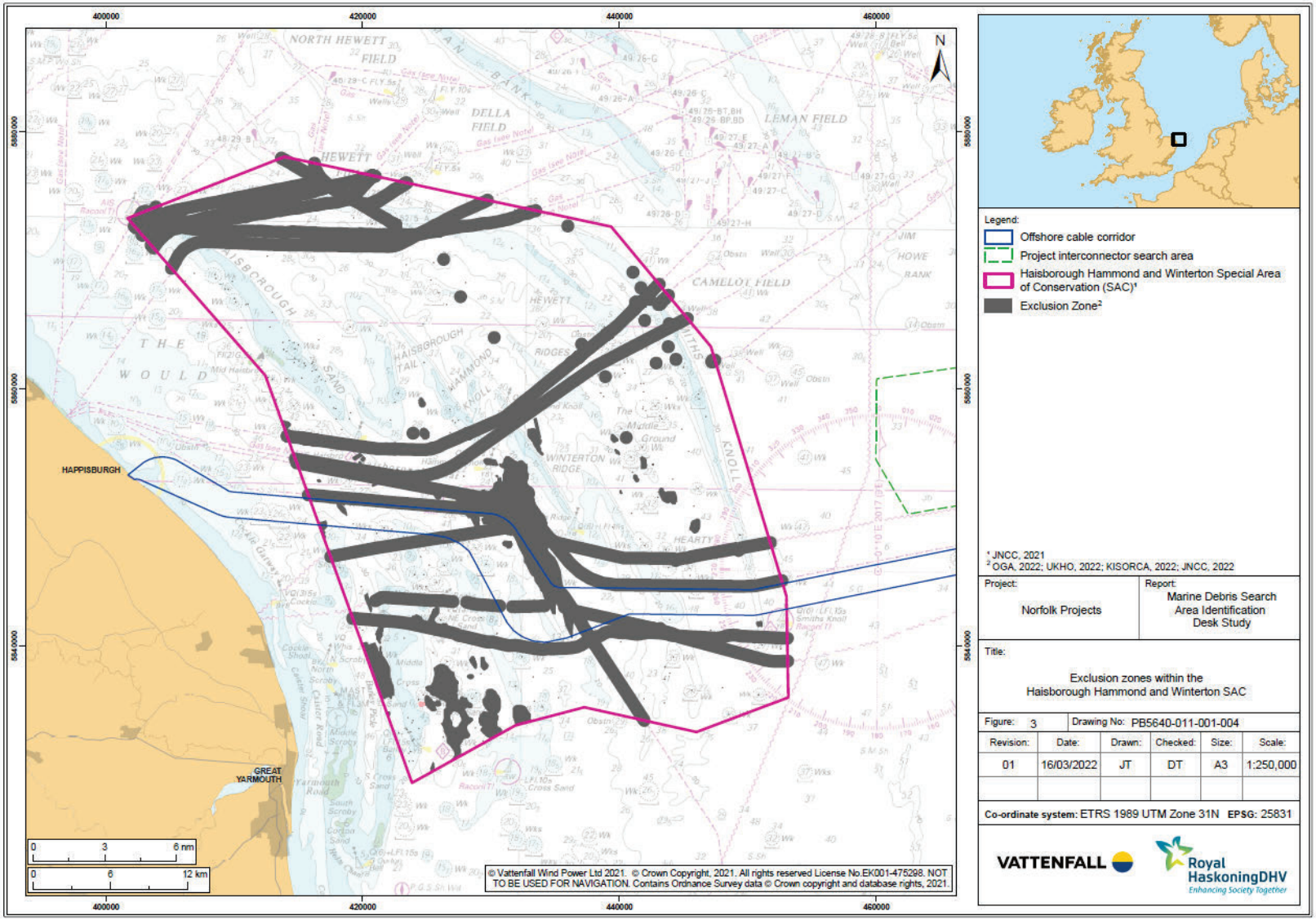

Figure 3. Exclusion zones within the Haisborough, Hammond and Winterton SAC

4.3 Unexploded Ordnance

70. Geophysical surveys to identify areas with potential UXO's, will begin in summer 2023, so areas have not been excluded due to the presence of UXOs as of yet, but a cautious approach was taken based on the Ordtek UXO Review submitted as part of the Norfolk Boreas Offshore Wind Farm Environmental Statement (ES) in 2019 as Appendix 5.3 (document reference 6.3.5.3).

71. A marine debris identification survey is planned for 2022 and will be conducted using an appropriate approach and mechanism to identify targets without risk. The results will be fully analysed prior to any removal or retrieval campaigns.

72. The Ordtek UXO Review identified areas of potential WWI and WWII German marine mine lays, OSPAR Munition encounters, dump sites and wrecks of military interest and within the HHW SAC as shown in Figure 4. Ordtek UXO Review Figure showing potential UXOs with HHW SAC Overlaid. This gives an overview of the potential UXO within the HHW SAC prior to undertaking geophysical surveys in 2022.

73. Should any UXO's be identified within the AoS while surveying, an appropriate buffer will be utilised to ensure safety when retrieving marine debris during any recovery campaigns.

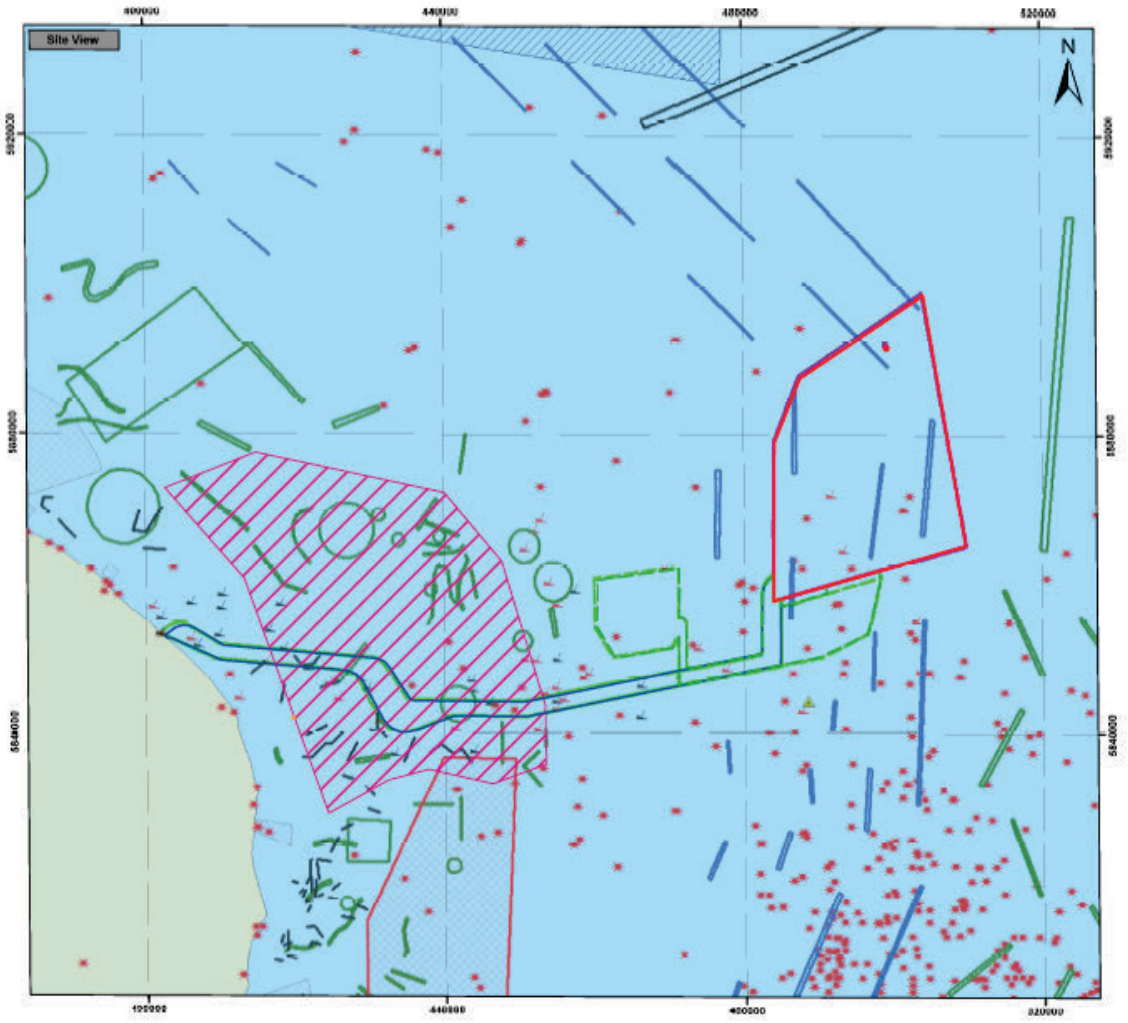

Figure 4. Ordtek UXO Review Figure showing potential UXOs with HHW SAC Overlaid

74. The geophysical surveys to be undertaken in summer 2022 will inform any buffer zones or exclusion areas to be considered during the removal campaigns. Locations that may contain UXOs would also be further identified during the survey campaign itself and excluded with an appropriate buffer zone of 50m left around such locations for health and safety reasons.

75. The CIRIA guidance (2015) on UXO was used to develop a method for risk analysis of such areas. In line with CIRIA guidance regarding UXOs for the construction industry (2009), any identified UXOs would be reported to HM Coastguard and any further actions required would be determined by the UK military.

5 Data assessment to identify areas likely to contain marine debris

5.1 Stage 2: Identifying the areas most likely to hold debris

5.1.1 Debris identified within the SAC and wider area

76. Cefas North East Atlantic Seafloor Marine Litter data for the North Sea was used to map any areas identified as having marine litter. There are no records of marine litter within the HHW SAC based on this data set. Despite the CEFAS data showing no marine debris within the SAC, there is potential that marine debris is present within the general area, with a higher likelihood of being found present on the Eastern side of the SAC based on the data showing debris outside the SAC to the East.

77. Notably, CEFAS marine debris data is gathered from trawl surveys which represents a limited view of the North Sea. As a result, trawls may not have been undertaken within the SAC highlighting a potential data gap, as opposed to a lack of debris present within the HHW SAC. Further studies undertaken have indicated high levels of marine litter within the Southern North Sea (SNS) (Figure 5) however this may not be indicative of larger scale removable debris.

78. A further 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, to determine the average presence of litter or debris across British waters. The data was used to create figures representing spatial smoothed predictions of litter distribution and density, with a figure showing the median total litter per square kilometre is included here as Figure 5. Although data specific to the HHW SAC is not available, the trends in the mapping indicate that the average density may be around 15-25 items of debris per square kilometre within the vicinity.

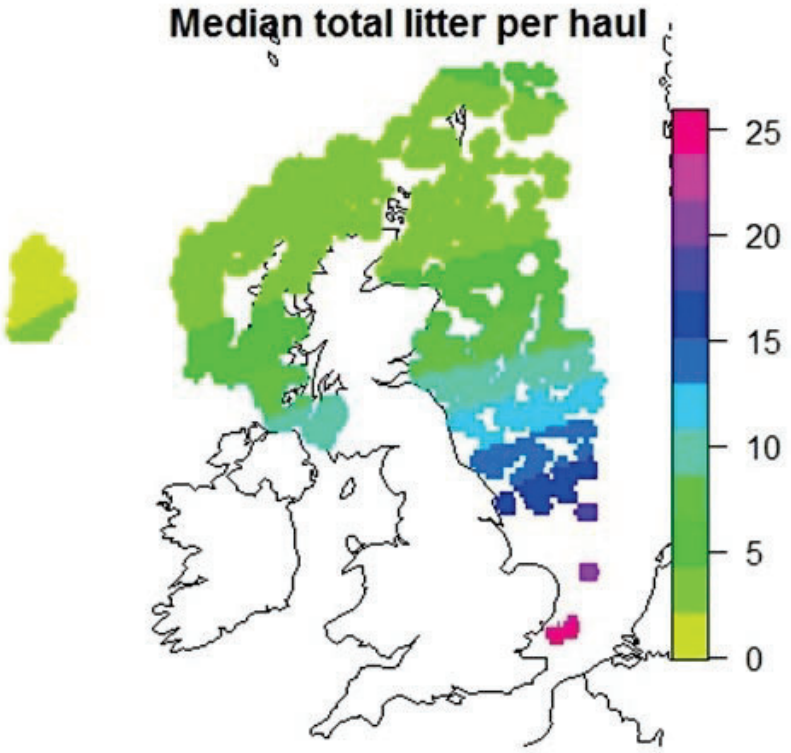

Figure 5. Map of smoothed median total litter per square kilometre (Maes and Barry,2018)

79. Based on the data sources suggested in this section, it is evident that debris may be widespread and prevalent throughout 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.

80. The marine debris data in this section has been used to inform the heatmap created to identify several target areas of search detailed in section 5.1.5, using the scoring mechanism and methodology in section 3.2.

5.1.2 Areas with high fishing vessel density

81. UK VMS data from the MMO VMS data hub was mapped (Figure 6) to provide a clear indication of where marine debris is most likely to have been dropped in and around the HHW SAC due to increased vessel presence.

82. UK VMS data indicates vessel movements are generally higher in the southeast of the SAC, with a smaller area of more intense vessel activity in northwest corner of the SAC. Used as a proxy this data can be interpreted to indicate the areas most likely to have ALDFG. The north western and south eastern corners of the SAC show a high number of VMS pings. The southern western corner of the SAC shows a moderate level of fishing activity, but notably has Annex I reef present, which has

been excluded in section 4 due to the potential challenges associated with a removals campaign which will not adversely affect designated features.

83. Figure 6 shows the south eastern and north western corners of the SAC with the highest aggregation of VMS data points, suggesting these areas have the potential, due to the high level of UK fishing vessel activity, to exhibit comparatively high density of marine debris (assuming physical processes were not to play a factor in the movement of debris). This data, alongside all other data presented in section 5.1, was then assessed in relation to the physical environment and oceanography of the area to identify locations where marine debris is most likely to accumulate and be recoverable (see section 5.2).

84. There are some additional vessel patterns seen on a local scale in the troughs between the sandbanks, which may indicate that vessels are targeting these areas when actively fishing.

85. Dutch and Belgian VMS data was largely comparable to UK MMO VMS data, albeit showing a higher density of activity in the southeast area of the SAC, and along the eastern edge. However, given the lack of defined resolution for non-UK vessels, and given that the Dutch and Belgian VMS data presented was specific to beam trawling vessels as this is the main fishing method used in the area, the fisheries VMS data obtained from the MMO for UK-registered vessels is considered to be more inclusive and therefore had a higher confidence multiplier when scoring for the heat mapping exercise.

86. The VMS data in this section has been used as a proxy to identify several target areas of search detailed in section 5.1.5, using the scoring mechanism and methodology in section 3.2.

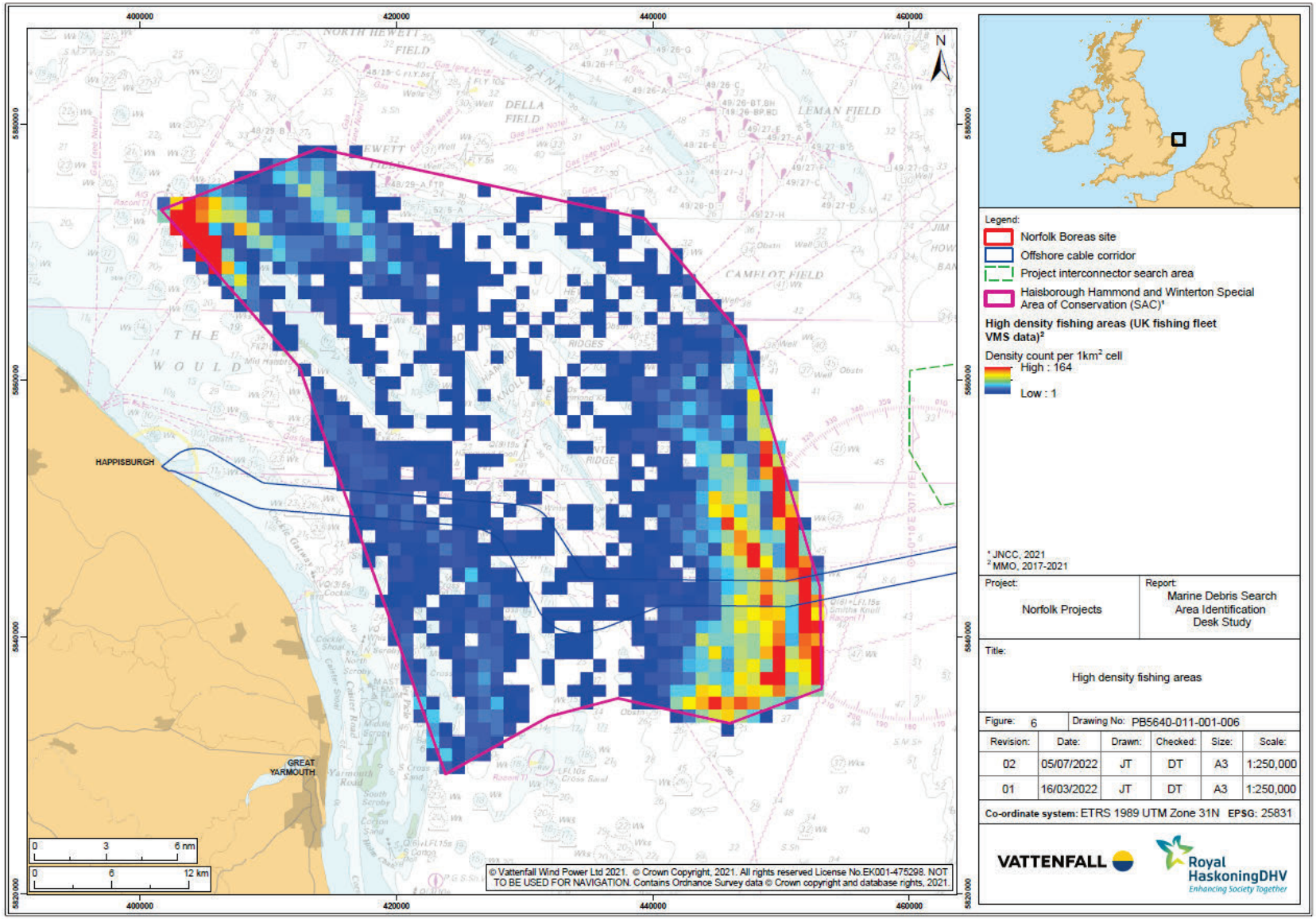

Figure 6. MMO UK VMS Data indicating high density fishing within the HHW SAC

5.1.3 Areas identified as having marine debris present via consultation

87. Consultation with fishermen undertaken by Brown and May also identified areas within which fishing gear has snagged or been lost as shown in Figure 7.

88. Further consultation with Ghost Fishing UK identified that marine debris is likely to gather where it can snag, for example on wrecks, rock or reef systems, or other obstructions.

89. Consultation revealed (as shown circled in Figure 7):

- WWII debris present within the SAC (such as UXOs etc) shown in blue,
- Debris (shown in green) including
    i. nets, timbers of wrecks inside the Haisborough Sands,
    ii. lost gear around Newarp Bank (however due to the mobility of the sandwaves in this area, debris is often reburied quickly), and
    iii. fishing gear (likely beam trawls) lost east of Winterton Ridge
- Nearshore fishing gear including lobsters pots, whelk pots and nets in the western, nearshore part of the SAC shown in orange.

90. Further engagement and consultation then identified an additional two locations where lost fishing gear and other marine debris is likely to be present, as shown in Figure 8.

91. The consultation data in this section has been used as a to identify several higher scoring blocks detailed in section 5.1.5, using the scoring mechanism and methodology in section 3.2 to ensure appropriate weight and value is given to the data.

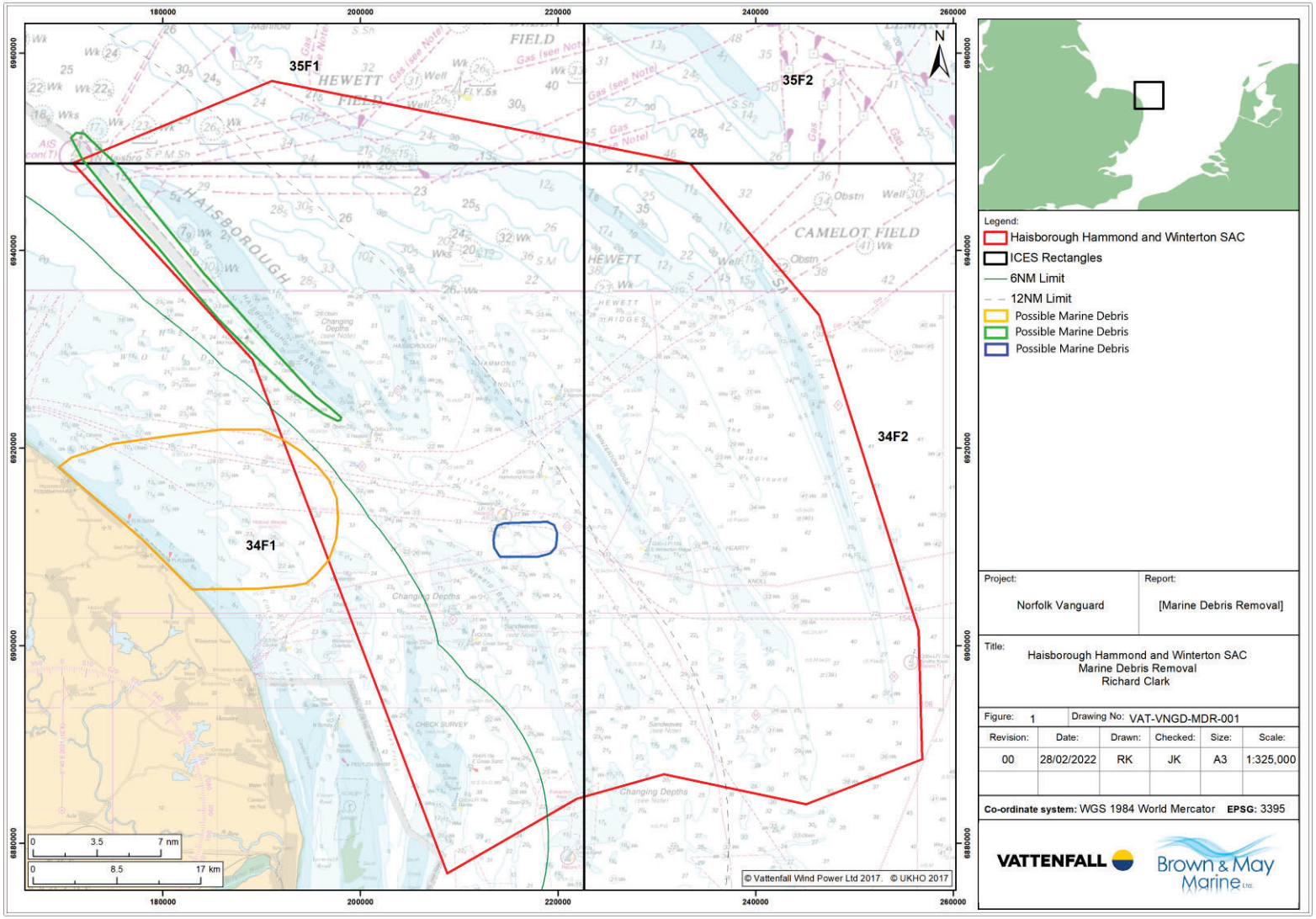

Figure 7. Areas to the West of the HHW SAC identified in consultation with fisherman, which are more likely to have marine debris present

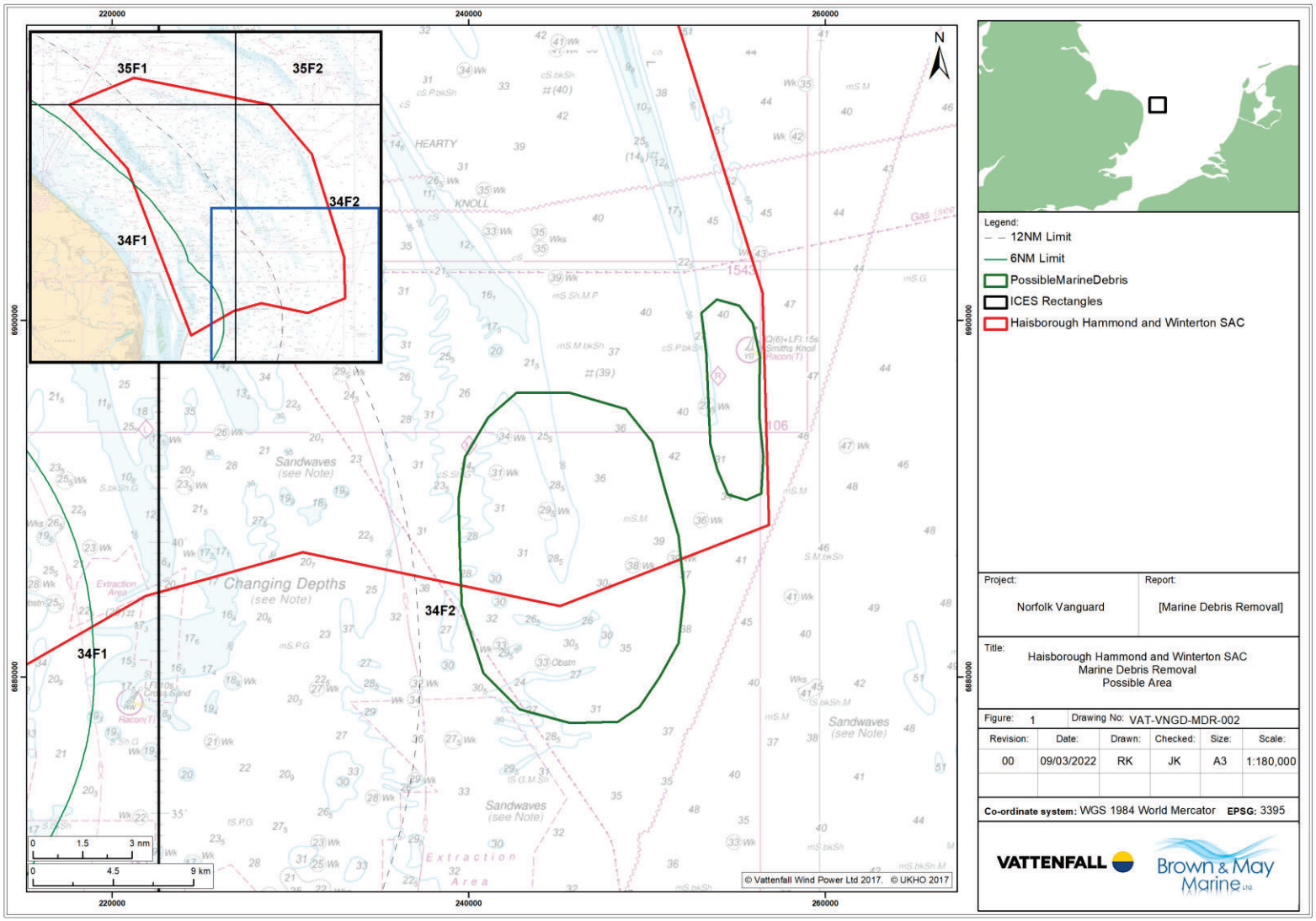

Figure 8. Areas to the East of the HHW SAC identified in consultation with fisherman, which are more likely to have marine debris present

5.1.4 Archaeological Anomalies and other sea bed obstructions

92. 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 therefore would not be targeted specifically during the debris removal campaign.

93. However, engagement with Ghost Fishing UK and smaller independent diving groups, has identified that debris often gathers around wrecks and can snag on archaeological features. The surrounding seabed areas may therefore quantities of debris associated with the wrecks themselves as well as debris that has snagged or gathered around them Therefore, 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.

94. Numerous wrecks and other seabed obstructions are located within the HHW SAC (see Figure 9), with a higher density along present along its western edge. In general, there is a tendency for wrecks to be located near to the base of sandbanks, indicating that they have settled there through gravitational means.

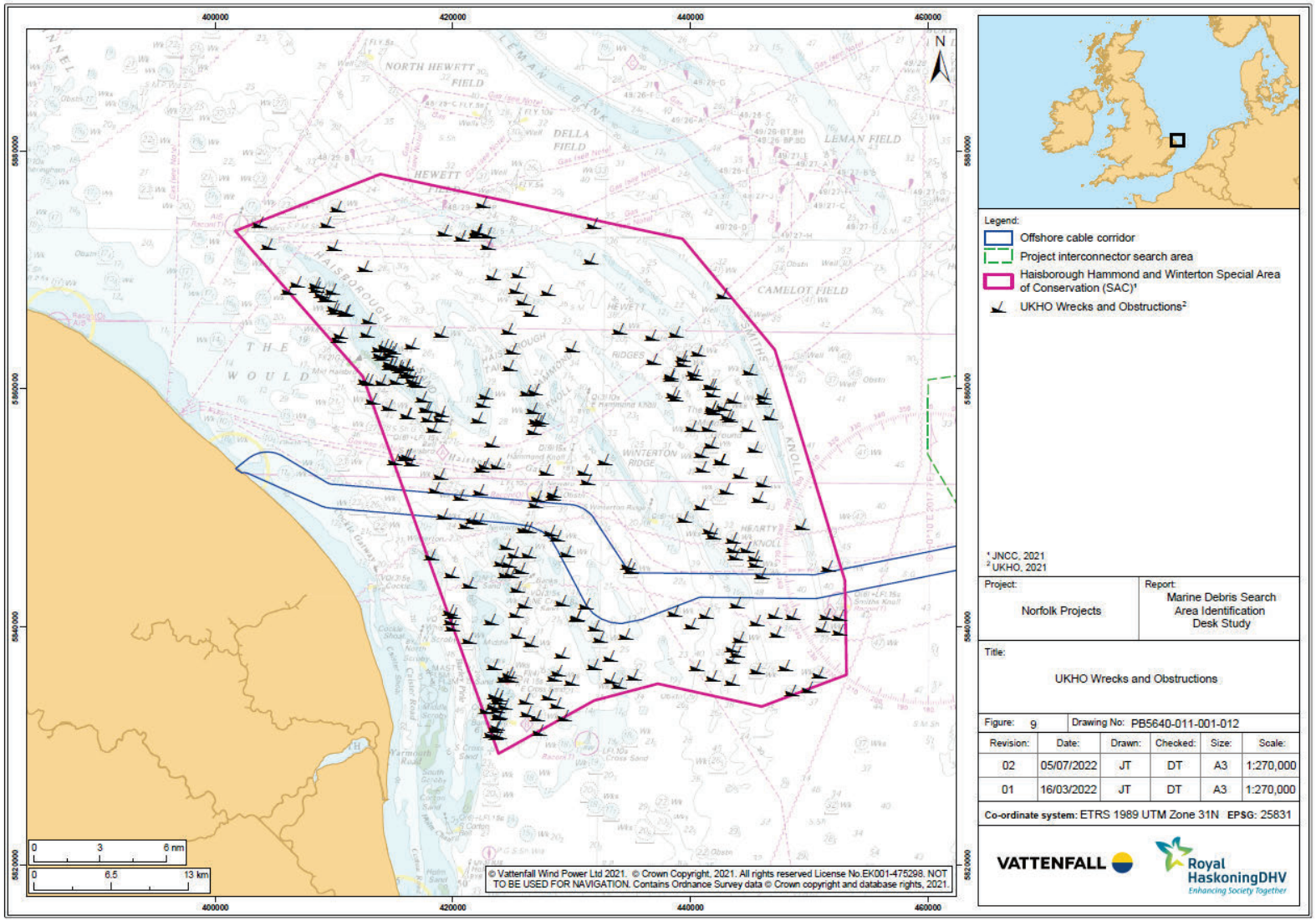

Figure 9. UKHO Wrecks and Obstructions within the Haisborough Hammond and Winterton SAC

95. As wrecks and other archaeological anomalies have been assigned exclusionary buffer zones, but have also been identified through consultation as debris hotspots, the data has been carefully weighted using the scoring mechanism and methodology in section 3.2 to inform the assessment to identify AoS from the blocks, in section 5.1.5.

5.1.5 Heat Map of blocks, based on debris and proxy data

96. Both the debris and proxy data detailed from section 5.1.1 to section 5.1.4, have been combined and systematically scored to create a heat map which highlights the areas most likely to contain marine debris or litter based on available data.

97. The method and mechanism (as described in detail in section 3.2) used to score each 1km^2 block included scoring:

- data confidence low to high (1 -3) based on the reliability of the data source,
- data within each 1km^2 based on the number of data points, entries or other, low to high along a logarithmic scale (1,100,1000) to highlight the variances in the data and produce a clear map.

98. This scoring mechanism was deployed for each data set, using the 1km^2 grid. The grided data sets were then overlaid in GIS to indicate the areas with the highest potential to hold marine debris based on the data from numerous sources in a single map. The colour coding utilised in Figure 10 allows for clear interpretation of the layered data.

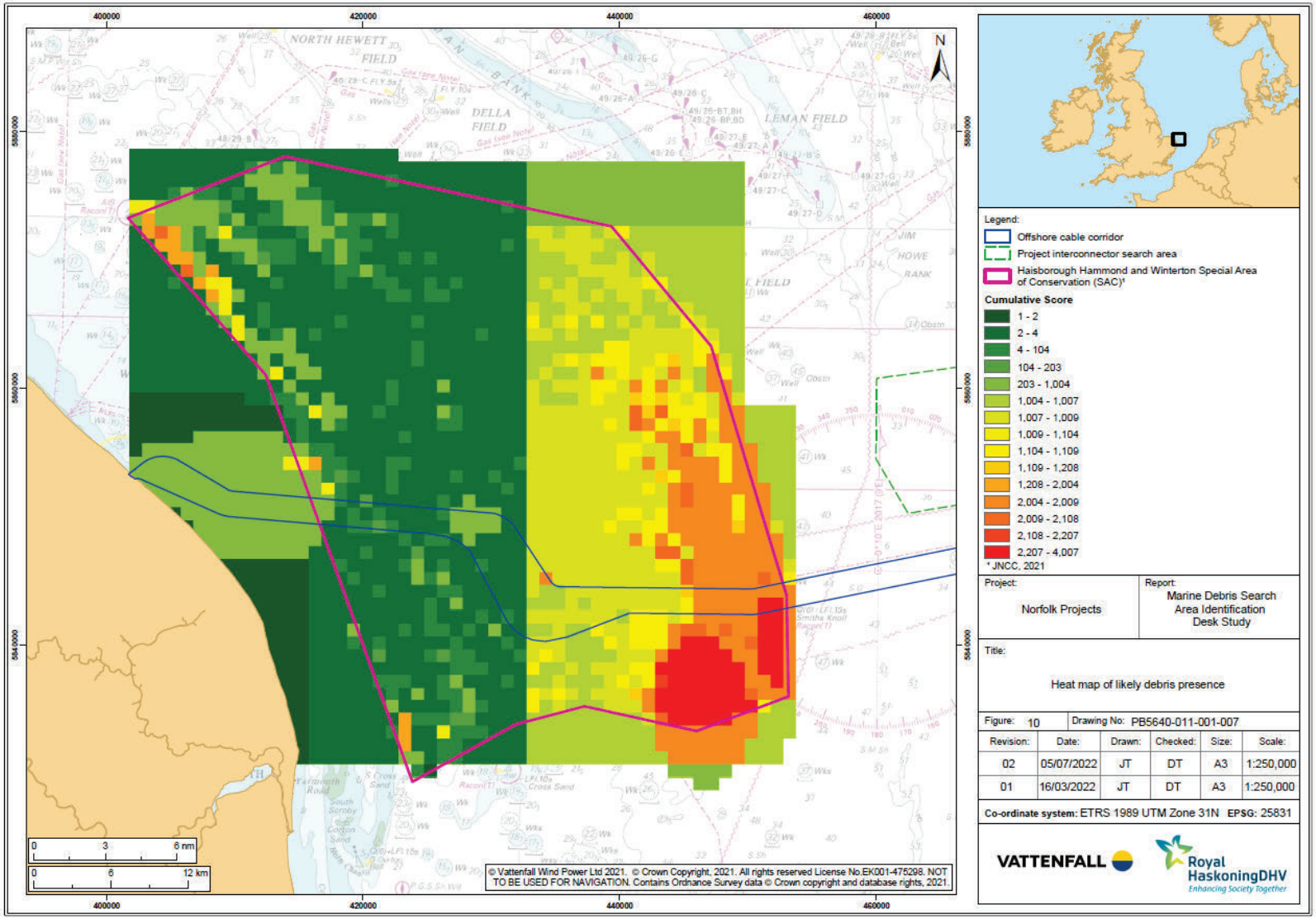

Figure 10. Heat Map of Likely Debris Presence

99. As shown in Figure 10, the block scores range between 1 and 4007 points with the highest scoring blocks located in the south-eastern parts of the SAC, with a mid-high scoring area located in the north-western part of the SAC. A further mid-high scoring areas has been identified running down the eastern edge of the SAC where there are high levels of fishing activity and a high level of vessel presence.

100. Additionally, there are a few medium scoring blocks in the south western section of the SAC however due to the known presence of *Sabellaria* reef in that area, these blocks attain a much lower score than those in non-reef areas.

101. Higher scoring blocks are generally located around the edges of the SAC, with the central sections scoring lower, which may be due to avoidance given the high levels of protection within the SAC.

102. Figure 11 overlays the exclusion zone set out in section 4.2 Constraint Mapping, namely Figure 3 over the scored blocks shown in Figure 10. Within HHW SAC, the exclusion zones do not greatly reduce the availability of high scoring blocks, but notably higher scoring areas in the north western sections of the HHW SAC become less available for ground truthing surveys and subsequent removals campaigns.

103. Figure 11 presents the initial indication and long list of potential search areas the surveyors should focus on, which will be further refined in section 5.2 based on the physical processes within the HHW SAC and how this may result in debris accumulation zones.

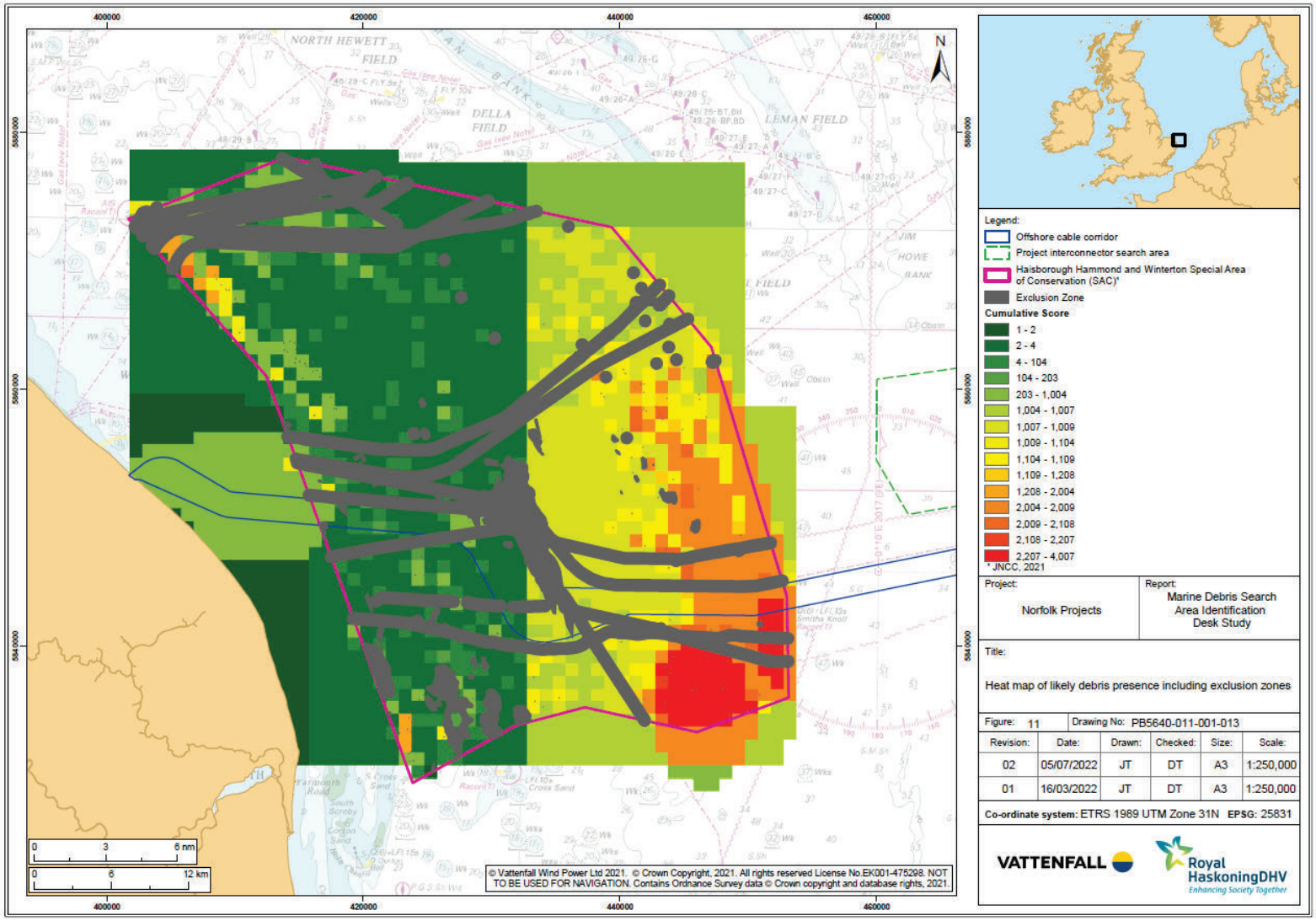

Figure 11. Heat Map of Likely Debris Presence including exclusion zones

5.2 Stage 3: Refinement of Areas based on Physical Processes

104. Two potential pathways which can lead to marine debris accumulation through movement by physical and/or sedimentary processes include

- the accumulation of lighter, transportable debris through natural transport processes (predominantly tidal currents) at the seabed; and
- accumulation of lighter and transportable debris due to gravity moving debris down slopes (i.e. sandbanks).

105. 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 would likely be too heavy to be transported under existing tidal current conditions. There is still, however, the potential for this type of transport for lighter pieces of fishing gear, as included in the assessment.

106. Gravitational processes could occur both at the point of disposal with immediate movement downslope or could potentially occur at a later point in time with the process started by storm conditions affecting the seabed. During a storm event, the debris would initially be shifted a short distance along the seabed with a natural tendency to continue movement in a downslope direction before becoming stationary again. This may occur as an intermittent process, dictated by the driving forces at the seabed and the steepness of the seabed slope.

107. 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 settlement after 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.

5.2.1 Importance of Sandbanks to SAC Sediment Movement

108. This section provides a conceptual review of the geomorphology and functioning of the sandbanks within the SAC from the perspective of marine sedimentary processes.

109. It is recognised that sediment transport is not a key principle for designation and is not part of the Conservation Objectives for the HHW SAC, but nonetheless the process is critical in how it would manifest transport and accumulation of debris on the seabed.

110. Sandy and muddy seabed habitats may be less affected by marine debris than more sensitive seabed habitats such as reef systems, seagrass or coral (Barnette, 2001). However, impacts from debris can affect the complexity of benthic sediments available for a diverse set of animal, plant, and algal communities; abandoned and derelict fishing nets can impact benthic environments by smothering, abrading, and changing the seabed structure (Gilardi et al., 2010).

111. The discussion in the following section (section 5.2.2.1) reflects the objectives of this desk based study, which are to identify the sandbanks with the necessary mobility to transport debris, resulting in areas which are more likely to have higher quantities present and available for removal, rather than the Conservation Objectives and designation criteria.

5.2.2 The Haisborough Hammond and Winterton SAC

5.2.2.1 Accumulation via Natural Transport Mechanisms

112. Morphological change of the Haisborough sandbank system and their interconnecting seabed was analysed by Burningham and French (2016) using historical charts from six distinct time periods: 1840s, 1880s, 1910s, 1930s, 1950s and 1990s. The results show that the gross morphology of the banks has remained relatively consistent over the 160-year period. However, net change of seabed bathymetry describes erosion and accretion around the banks with a dominance of erosion over the wider seabed. The present-day bathymetry is presented in Figure 12.

113. The patterns of erosion and accretion around Haisborough Sand specifically (Figure 12) describe a small clockwise rotation of its along-bank orientation (accretion at its north-east and south-west ends with associated erosion on the opposite sides of the bank from the accretion). The southern part of the bank has moved shoreward and the northern part has moved seaward by similar average rates of 9m/year over 160 years (Burningham and French, 2016).

114. The analysis by Burningham and French (2016) shows that Haisborough Sand is an active and very dynamic feature, with historic large-scale natural changes having occurred over decadal periods. Although the analysis above relates to Haisborough Sand, the other sandbanks are likely to follow similar patterns of evolution.

115. The area within which the offshore cable corridor sits is an active and highly dynamic environment with development and maintenance of sand waves. Individual sand wave migration rates vary between 5 and 30m/year with both northerly and southerly migrating sand waves present within the cable corridor (ABPmer, 2018).

116. Regional bedload sediment transport pathways in the southern North Sea have been investigated by Kenyon and Cooper (2005). They analysed the results of modelling

studies and bedform indicators and showed that tidal currents are the dominant mechanism responsible for bedload transport. The dominant transport vectors are to the south and north along the export cable corridor, with very few transport vectors directed to the west or the east.

117. A study of sand waves in the Haisborough Hammond and Winterton SAC was undertaken by ABPmer in 2018 in support of the Norfolk Boreas EIA. The study demonstrated that medium sand on sand wave crests (-13m CD) would be mobilised by tidal currents alone 74% of the time and by waves alone 52% of the time, and by combined tidal currents and waves, 91% of the time. The proportion of time for movement on the sand wave flanks (-28m CD) is similar for tidal currents alone (71%) and reduces significantly to 5% for waves alone, although a combination of tidal currents and waves still moves medium sand 85% of the time. This information indicates that tidal currents are the dominant driver of sediment transport within the Haisborough Hammond and Winterton SAC, with secondary influence from waves.

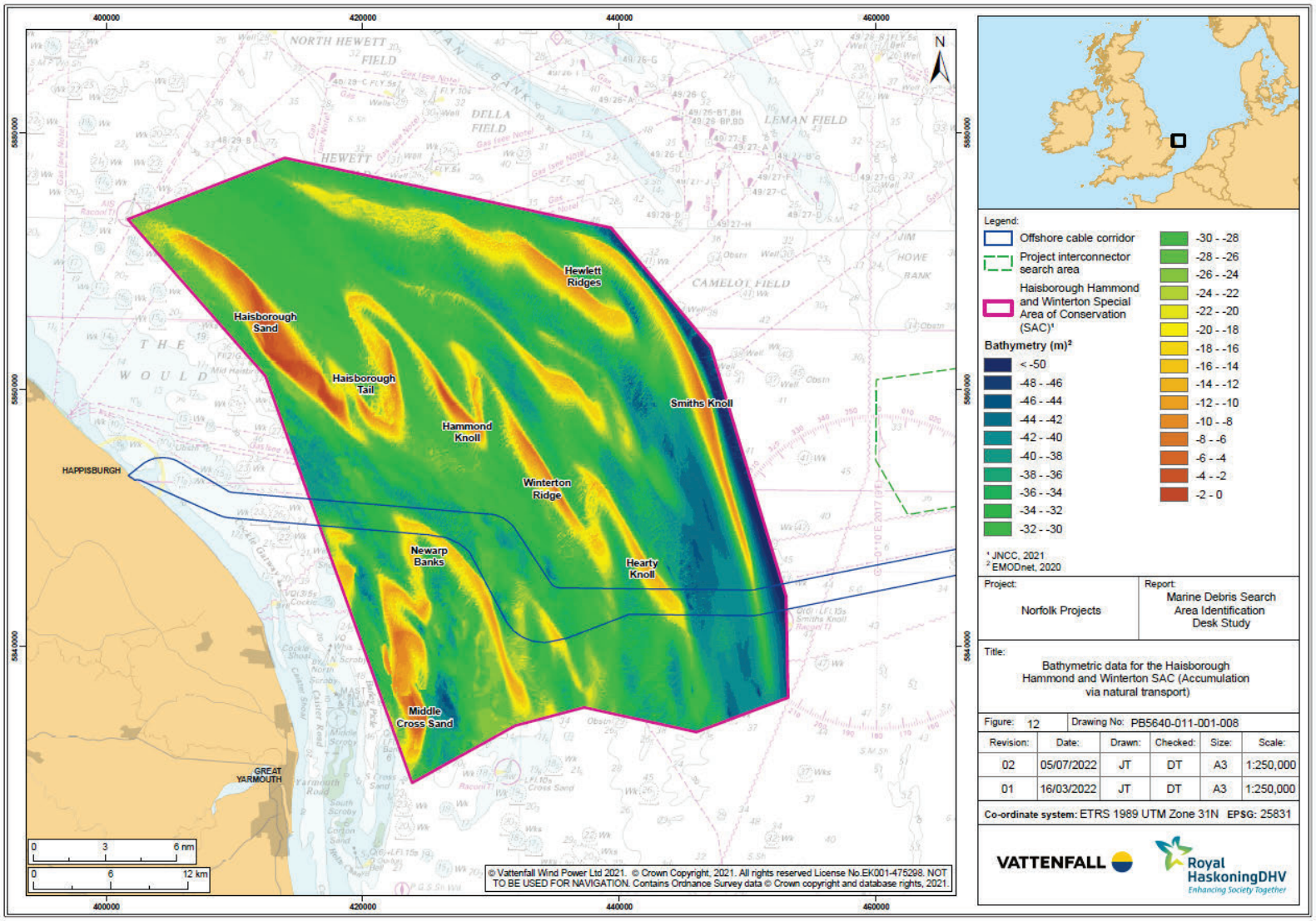

Figure 12 Bathymetric data within the Haisborough, Hammond and Winterton SAC

118. 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 (see Section 5.2.2.2).

5.2.2.2 Accumulation via Gravity

119. The steepest slopes across the SAC occur on the northeast flanks of the main active, echelon-shaped sandbanks (Haisborough Sand, Haisborough Tail, Winterton Ridge, Newarp Banks and Middle Cross Sand), where slopes up to 5° are recorded as shown in Figure 13. 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). Although Smiths Knoll and Hewitt Ridges have steep slopes on their northeastern flanks, these occur in deeper waters and are not as active as the banks to the west.

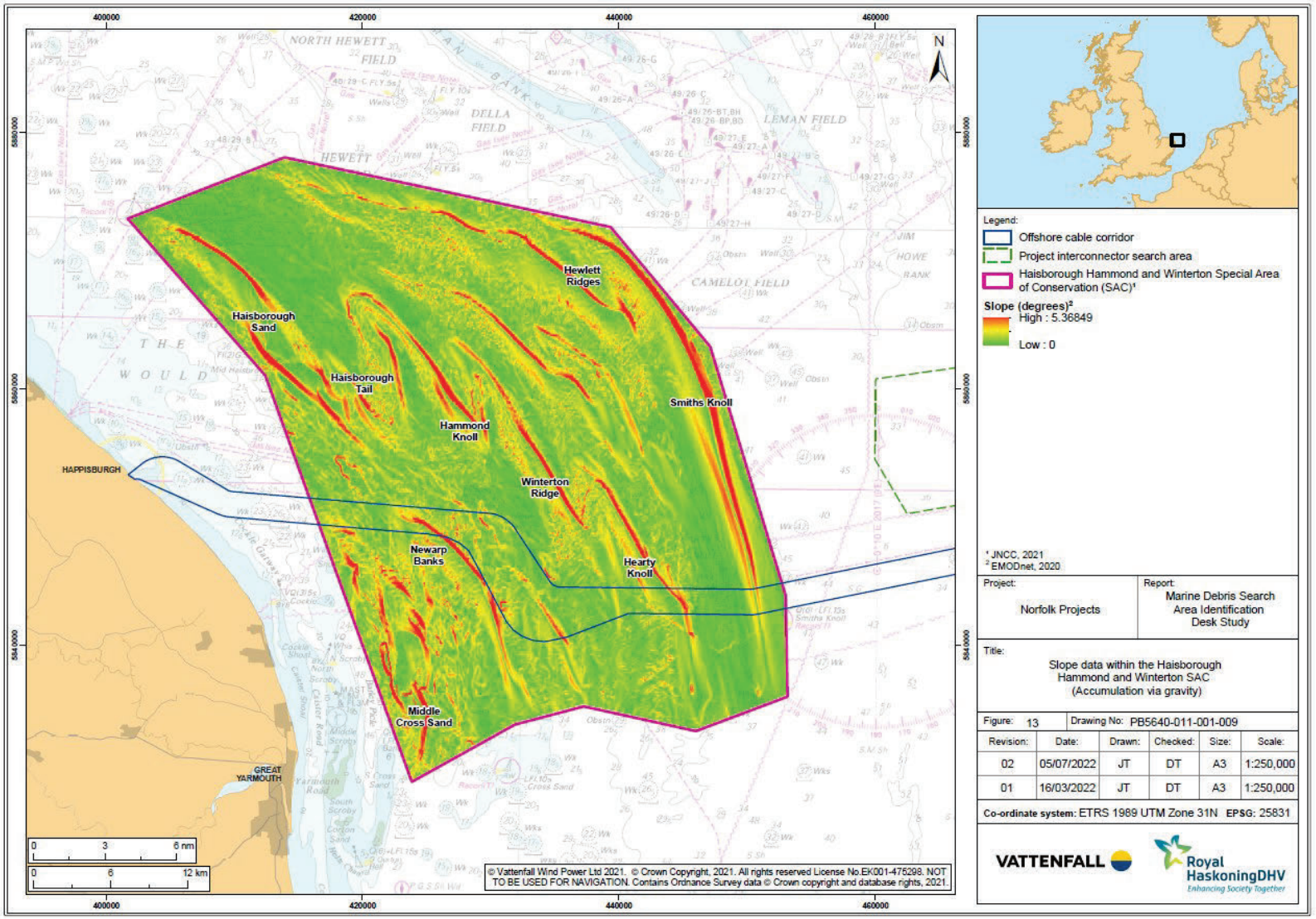

Figure 13 Slope data within the Haisborough, Hammond and Winterton SAC

120. 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 (Haisborough Sand, Haisborough Tail, Hammond Knoll, Winterton Ridge, Hearty Knoll, Newarp Banks and Middle Cross Sand) and adjacent to their steepest (up to 5°) slopes.

121. Figure 14 identifies these areas of potential debris accumulation as higher priority as this is where accumulation is likely to be highest. Higher priority areas were differentiated from lower priority areas given they had a steeper slope, whereas lower priority are those which are adjacent to sand banks with slightly shallower slopes.

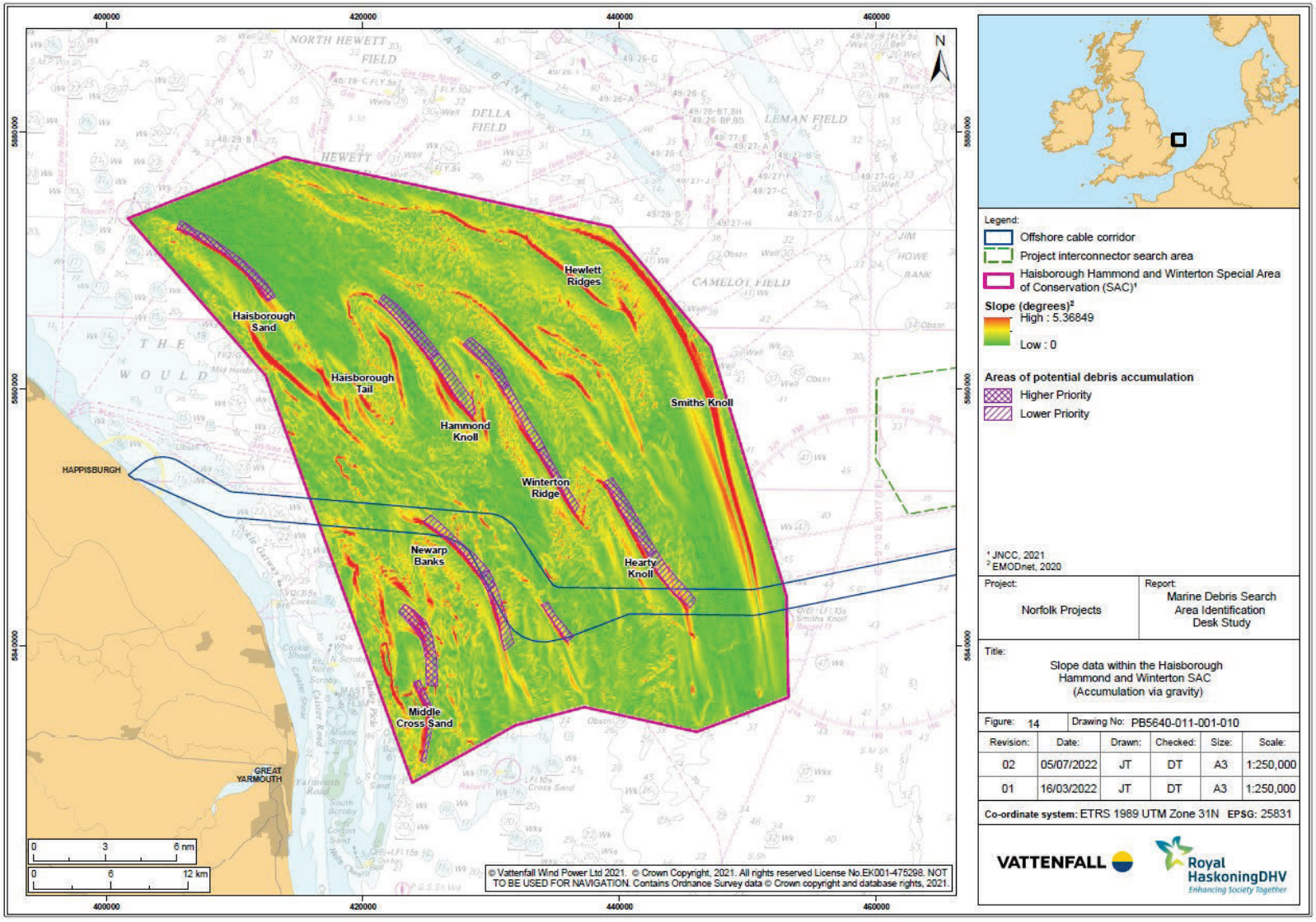

Figure 14. Debris accumulation areas based on slope data within the Haisborough, Hammond and Winterton SAC

6 Identification and selection of Primary and Adaptive Management AoS

122. As explained above in section 5 (Data assessment to identify areas likely to contain marine) numerous data sources have been systematically mapped, scored and refined to identify high scoring blocks (based on each data source). These will be used to inform selection of the primary and adaptive management AoS.

123. The data was compiled into a single heat map presented in section 5.1.5 and an independent exercise was undertaken in 5.2 to refine areas based on physical processes and areas where debris is likely to accumulate.

124. A final figure combining the heat map of debris presence and debris accumulation has been produced (see Figure 15) to inform the decision on where to locate the primary and adaptive management AoS for surveys in the 2022 campaign.

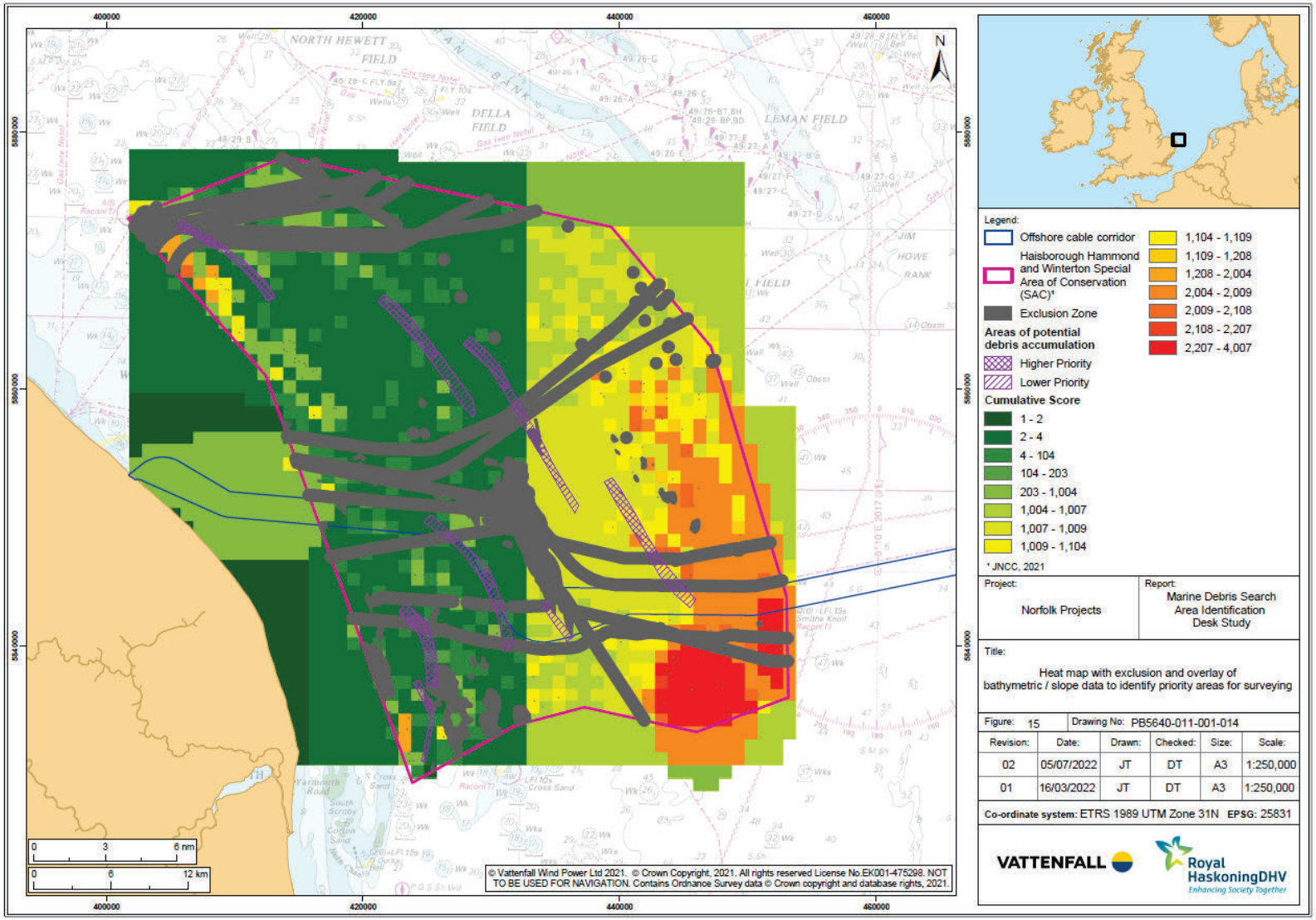

Figure 15 Heatmap of likely debris presence including exclusion zones priority accumulation areas

125. Following the output of the heat mapping exercise, the primary AoS was then selected from within an area of highest scoring blocks (Figure 16). This area was selected as it sits within an area of highest likelihood of marine debris and there are no known wrecks within the AoS to limit the area that can be targeted. However it is surrounded by squares which do have wrecks present within them which could snag fishing gear leading to increased debris in the surrounding area.

126. The adaptive management AoS was also selected from a high scoring area (Figure 16) but also took into account the ability to explore accumulation areas (troughs) set out by conceptual analysis of the physical drivers behind potential debris accumulation (see section 5.2). The adaptive management AoS has been located away from the primary AoS on the basis that if no debris was identified in the primary AoS then it would be unlikely that debris would be found in neighbouring squares.

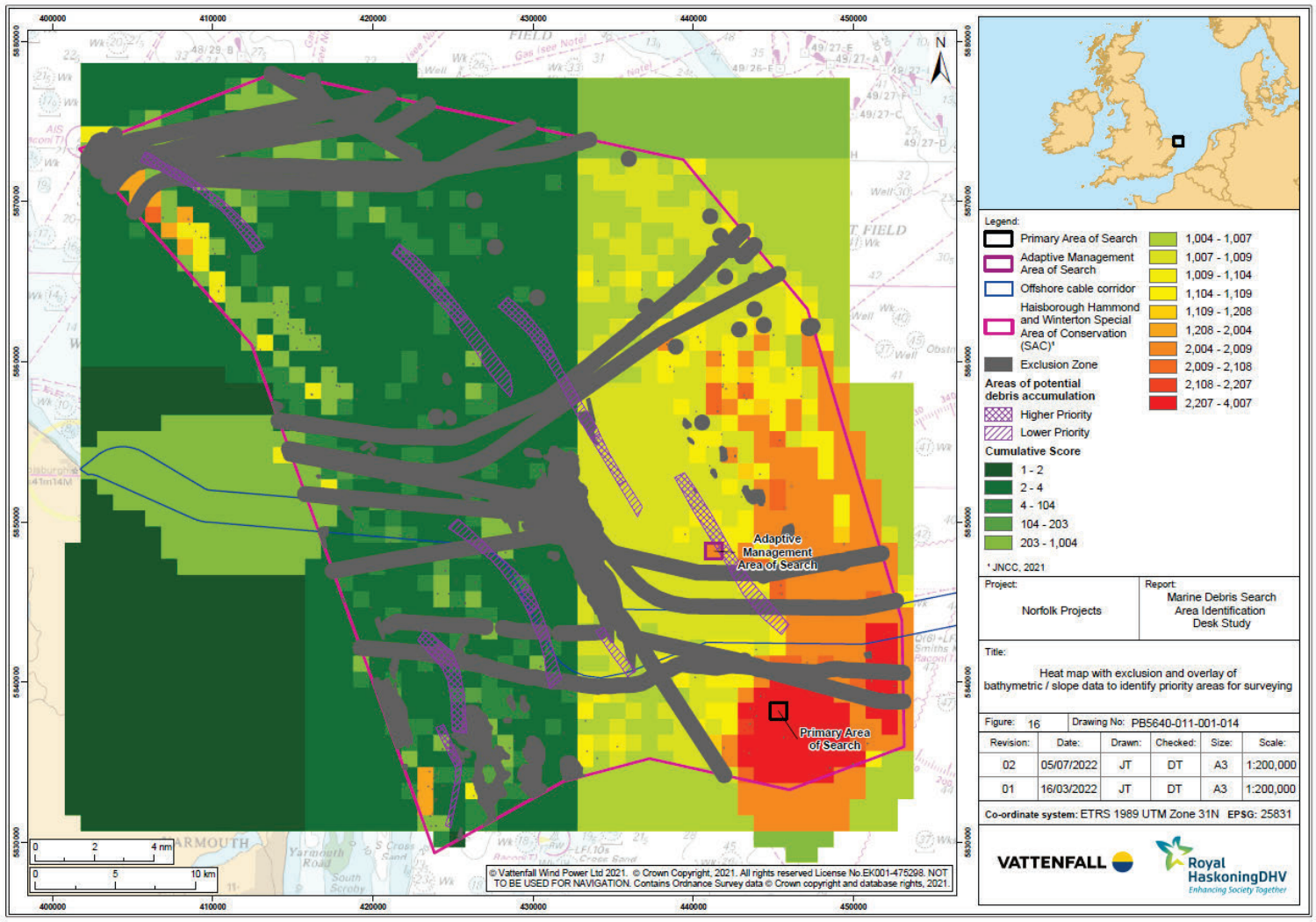

Figure 16 Primary and adaptive management AoS

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