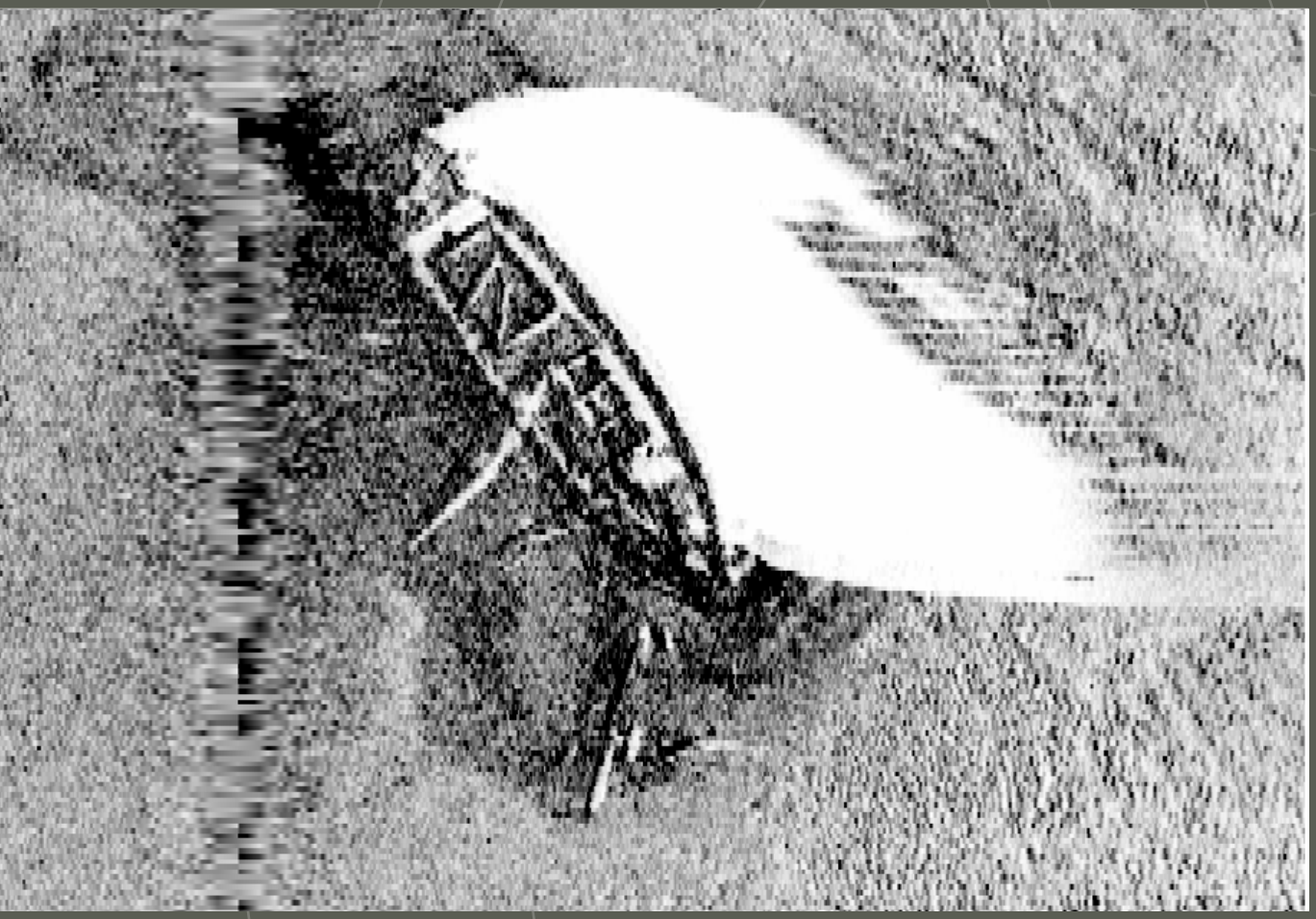
KRIEGERS FLAK II
Geoarchaeological analysis of Kriegers Flak II North and South Wind Farms and Associated Cable Corridor (2nd rev.)

VIR 3050



John Howorth

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January 2025

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VIR 3050

KRIEGERS FLAK II

STED- OG LOK. NR. 401740-198

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Contents

Appendices

Abstract

Energinet has requested that the Viking Ship Museum (VIR) identify potential cultural heritage objects (CHOs) within the areas of two planned wind farms, Kriegers Flak II North and South, and the associated cable corridor.

In total, VIR has identified 1256 possible CHOs on the seabed within the geophysical data; 40 potential *wrecks*, 39 potential *anchors*, 64 *mounds* (including 1 *mound no height*), 92 anomalies classed as *rope, chain* or *cable*, 928 *linear objects* (including 40 *linear angled* and 53 so-called *linear no height*), 44 targets categorised as *debris*, and 44 targets categorised as *other*. Four anomalies are classified as *Hollow Contour* (a depression in the seabed which has the potential to be a wreck) and one feature has been classified as a possible *structure*. Moreover, sub-bottom profiler data and vibrocore samples were used to identify any areas in which Mesolithic archaeology may be encountered.

Dansk resumé

Energinet har anmodet Vikingeskibsmuseet (VIR) om at udpege potentielle kulturhistoriske objekter (CHOs) i de planlagte områder af to vindmølleparker, Kriegers Flak II Nord og Syd, og tilhørende kabelrute korridor.

I alt har VIR udpeget 1256 potentielle CHOs på havbunden i de geofysiske data; 40 potentielle *vrag*, 39 potentielle *ankre*, 64 *mounds*, forhøjninger (inklusive en så kaldt *Mound no height*), 92 anomalier klassificeret som *reb, kæde* eller *kabel*, 928 *lineære objekter* (inklusive 40 så kaldt *Linear angled*, og 53 så kaldt *Linear no height*) og 44 kategoriseret som *affald* (debris) og 44 kategoriseret som *andre (Other)*. Fire anomalier er kategoriseret som *Hollow Contour* (en fordybning i havbunden, som kunne vær et potentielt vrag) og en anomali er kategoriseret som en mulig *struktur*. Desuden blev sub-bottom profiler data og boreprøver brugt til at identificere område, hvor mesolitisk arkæologi kan stødes på.

Introduction

Denmark is currently on the path to establishing offshore energy infrastructure in the Baltic Sea to bring more renewable energy to the Danish mainland. This current project consists of two large offshore wind farms, Kriegers Flak II North and Kriegers Flak II South and an associated cable corridor between the wind farms and the Danish mainland (Figure 1).

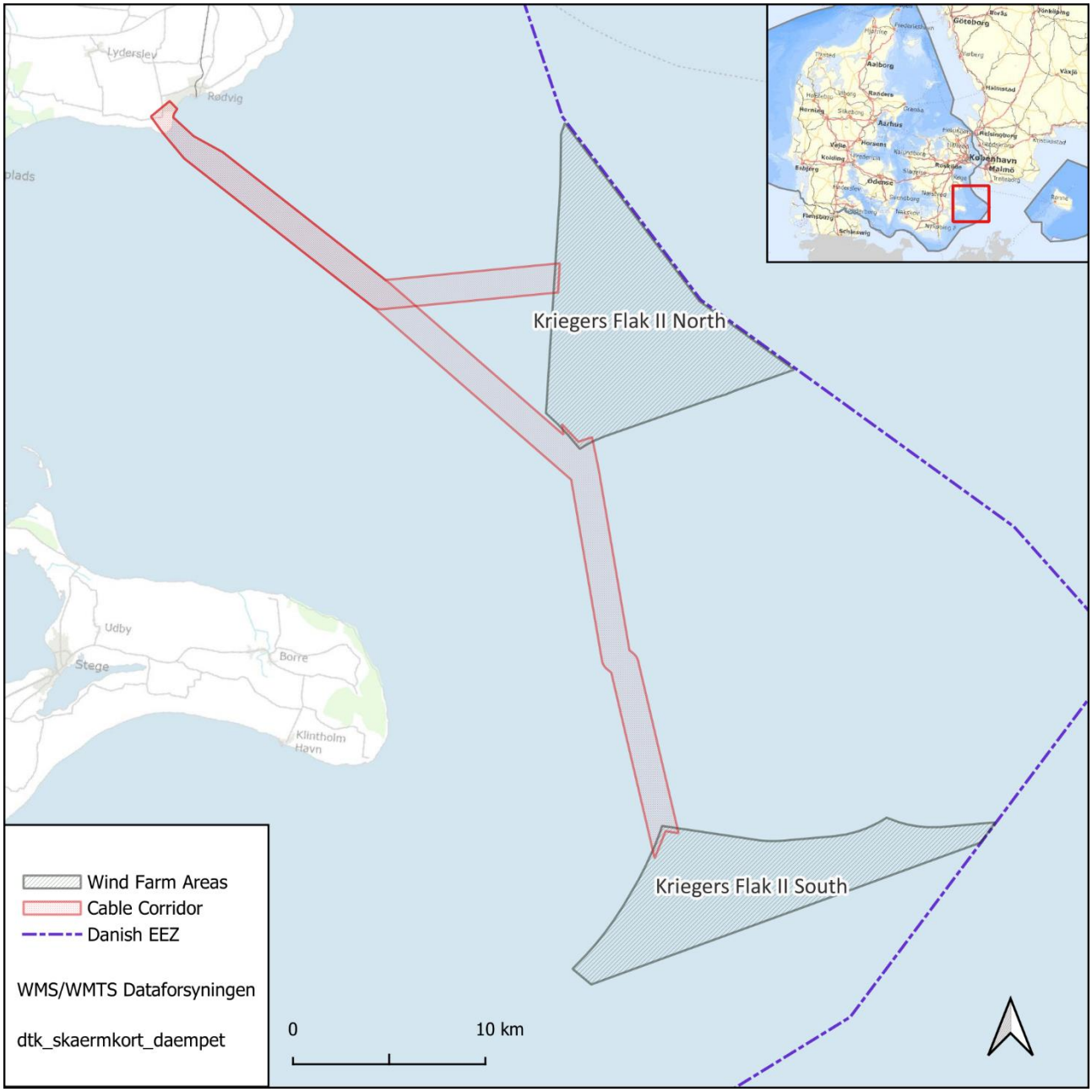

Figure 1. Location of planned wind farm sites and cable corridor at Kriegers Flak II. Illustration: John Howorth © Vikingeskibsmuseet. (CC BY 4.0) Contains data from Klimadatastyrelsen.

Table 1. Abbreviations used in the text

BP	Before Present (i.e. before 1950)	Før nutiden (Før 1950)
CHO	Cultural historical object	Kulturhistorisk objekt
EEZ	Exclusive economic zone	Eksklusiv økonomisk zone
ETRS89	European Terrestrial Reference System 1989	
GIS	Geographical information system	Geografisk informationssystem
HF	High frequency	Højfrekvent
MAG	Magnetometer, magnetic	Magnetometer, magnetisk
MBES	Multibeam echo sounder	Flerstråleekkolod
MMO	Man-made object	Menneskeskabt objekt
ROV	Remotely operated vehicle	Fjernstyret undervandsfartøj
RSL	Relative sea level (curve)	Relativ havspejlskurve
SBP	Sub-bottom profiler	Bundpenetrerende ekkolod
SGU	Geological Survey of Sweden	Sveriges Geologiska Undersökning
SSS	Side-scan Sonar	Sideseende sonar
UTM	Universal Transverse Mercator	
VIR	Viking Ship Museum, Roskilde	Vikingeskibsmuseet i Roskilde

Project data

The side-scan sonar (SSS) data screening and assessment of stone age potential for Kriegers Flak II North and South and associated cable corridor was completed at the Viking Ship Museum in Roskilde, Denmark by maritime archaeologist John Howorth.

The entire project archive is filed at VIR under file no. 3050.

Topography, terrain and geology

Kriegers Flak II North and South and the associated cable corridor are located in the Danish Baltic Sea to the southeast of Denmark. The two windfarm areas lie to the northeast and southeast of the island of Møn. A cable corridor connects the two windfarms to the mainland near the town of Rødvig.

Kriegers Flak II North is located in water 25 - 35 m deep and the seabed in this area is relatively flat. The seabed sediment is mostly muddy sand towards the east with a mixture of till/diamicton, gravel and coarse sand, and sand towards the north and along the western edge (Figure 2).

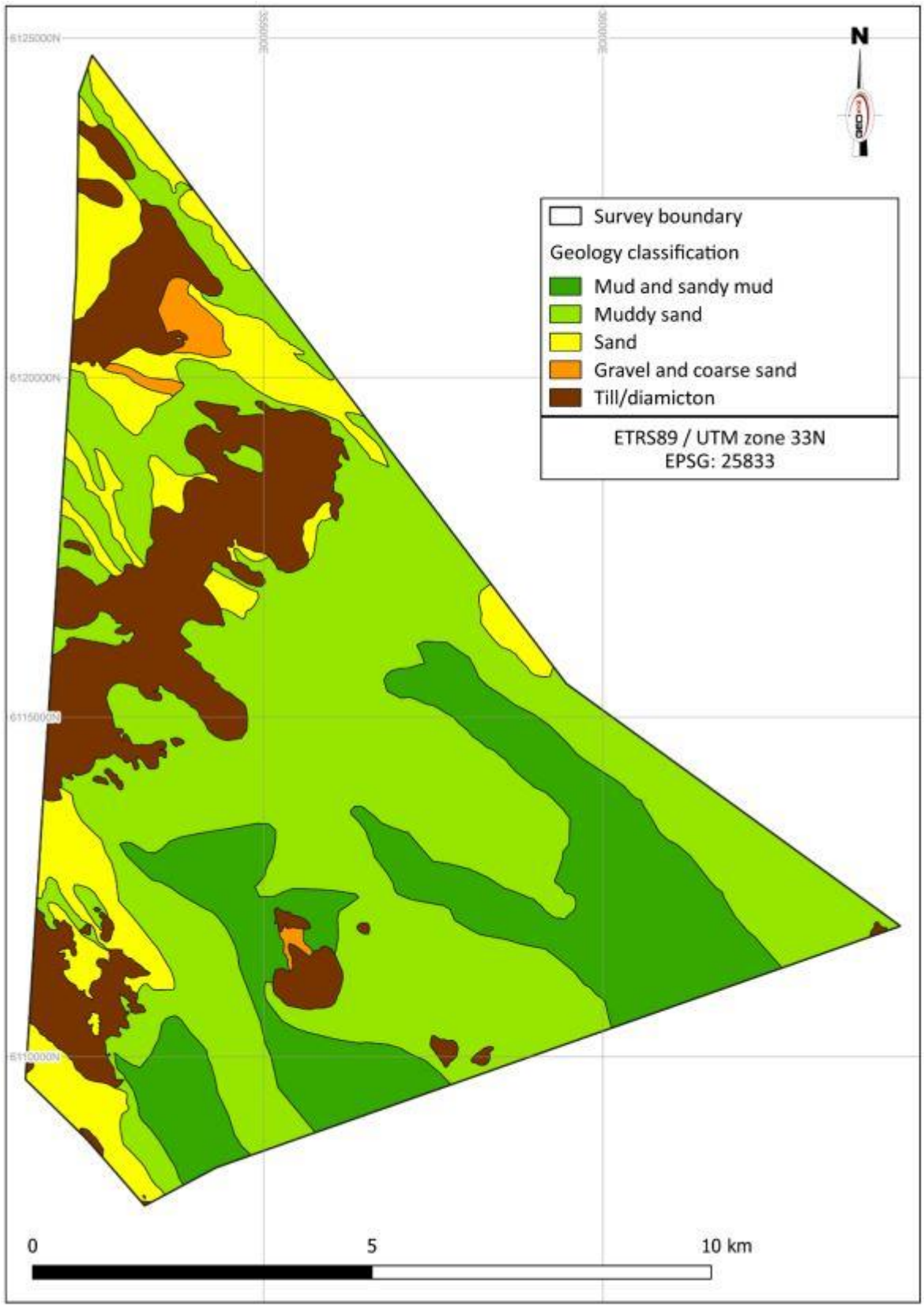

Figure 2. Seabed surface geology classification within the Kriegers Flak II North Wind Farm area. Illustration from Geophysical Survey (GEOxyz, 2024).

The seabed at Kriegers Flak II South slopes from around 18 m deep in the west to around 41 m deep in the east. The seabed sediment in the west is sand which becomes muddy sand towards the east (Figure 3).

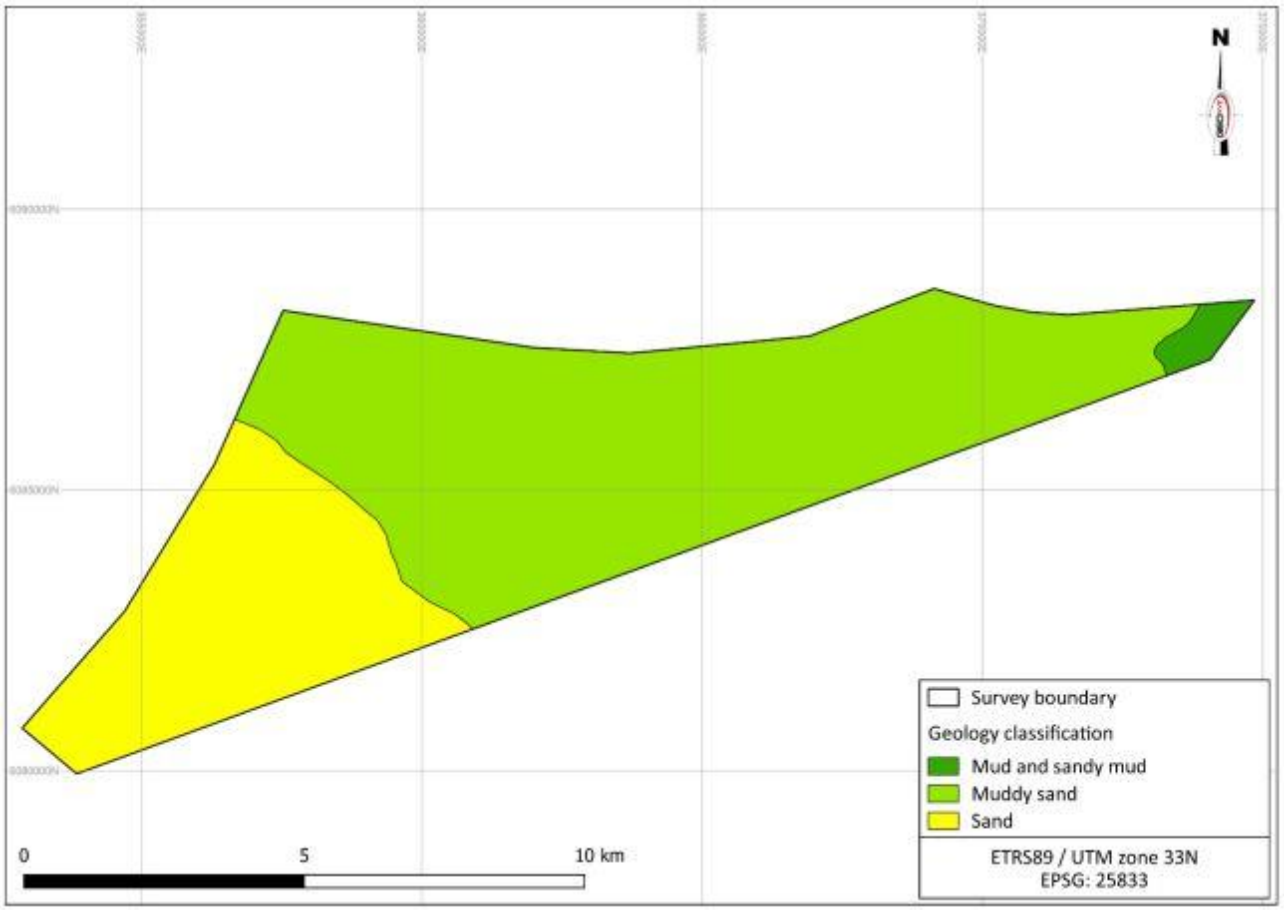

Figure 3. Seabed surface geology classification within the Kriegers Flak II South Wind Farm area. Illustration from Geophysical Survey (GEOxyz, 2024).

The seabed along the cable corridor is at its deepest in the south, where it joins with Kriegers Flak II South, at 31 m below sea level. It then gradually rises to the north towards landfall. The seabed sediment along the cable corridor is a mixture of sand and muddy sand in the south and parts of the north. The mid-section mainly consists of till/diamicton. At landfall, the cable corridors cross an area of exposed sedimentary rock (Figure 4).

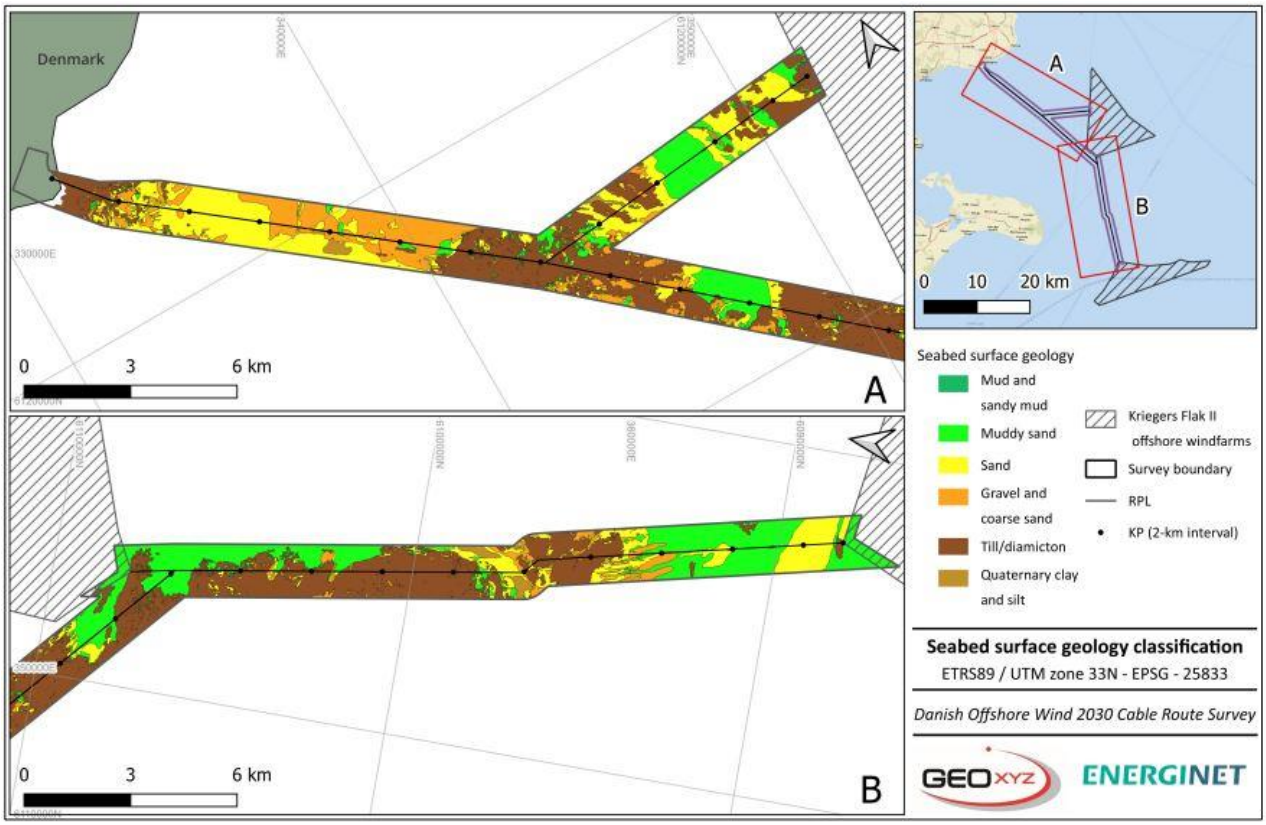

Figure 4. Seabed surface geology classification within the Kriegers Flak II Cable Corridor. Illustration from Geophysical Survey (GEOxyz, 2024).

Coordinate system

The present report and associated digital files archived at VIR use the coordinate system: ETRS89/UTM zone 33N, unless otherwise specified.

Methodology

Using SonarWiz (v.8.0.1) software, all High Frequency (HF) SSS data for Kriegers Flak II North and South and cable route were screened and potential archaeological targets were selected based on their shape and size, and the potential for being a CHO. See appendix 4 for detailed specifications on target picking. The targets were then exported to a mapping project in QGIS (v.3.36.2 – Maidenhead) and checked for matches in the following records:

- Danish National Sites and Monuments Register **(***Fund og Fortidsminder*) (https://www.kulturarv.dk/ffreg/).
- *Søfartsstyrelsens vragregister* – The Danish Maritime Authority's Register for Wrecks.
- *Vragguiden* – Denmark's largest online wreck database for and by recreational divers.
- *Holddatabasen* – a database from the Agency for Culture and Palaces which contains a list of potential wrecks where the positions have not yet been further investigated.

For an overview of the records see Howorth, 2023, *KRIEGERS FLAK 2 Archaeological Analysis of Kriegers Flak 2 North and South Windfarms and Associated Cable Corridors.* Comparisons were also made with archaeological discoveries from earlier projects which overlap with Kriegers Flak II; Kriegers Flak I (H. Thomsen, 2018), Baltic Pipe (H. Thomsen, 2020) (Jonsson & H. Thomsen, 2022), and Bornholm Energiø Interconnector (Howorth, 2023). A catalogue over Kriegers Flak II

targets that are within 10 meters of a known CHO, or an object from previous investigations is presented in Appendix 3. The catalogue, covering 47 targets, contains SSS images where available, MBES images where available, and all previous objects are shown in their registered location. The 10-meter radius was chosen based on the experience that there can be up to 10 meters difference between different SSS data sets.

To aid analysis for stone-age potential of the area, maps from a shoreline displacement model created by the Geological Survey of Sweden (SGU) (SGUs Kartvisare) were downloaded, georeferenced and digitised in the QGIS project. It should be noted that the SGU model was specifically designed for Swedish shoreline displacement and Kriegers Flak II North and South are located at the very limit of this model within Danish territory. Therefore, the model should not be taken as an accurate representation of the shoreline in the periods shown but can be used for illustrative purposes and to give an idea of how the coastline has changed through prehistory.

Results

In total 1256 targets were identified in the SSS data and geolocated within the surveyed areas (Figure 5). All targets are potentially CHOs and should be considered as such until investigated. Each target was assigned a category, the list of the categories used for this project can be seen below.

List of target categories

Each target category is described below:

Anchor	Anchor/potential anchor
Cable_Rope_Chain	Potential rope, chain, or cable
Debris	Manmade object, debris, possible cargo etc
Hollow Contour	Ship-shaped depression in the seabed
Linear Object	Linear object, possible wreck parts, cargo, fishing stakes, timber etc
Linear (Angled)	Angled linear object, possible constructions like wreck parts etc
Linear (No height)	Linear object of certain size, without shadow but still noteworthy
Mound	Mound, potentially ballast from broken down wreck.
Mound (No height)	Mound without shadow but still noteworthy
Other	Other type of object. See description
Structure	Potential prehistoric manmade structure
Wreck	Wreck/potential wreck.

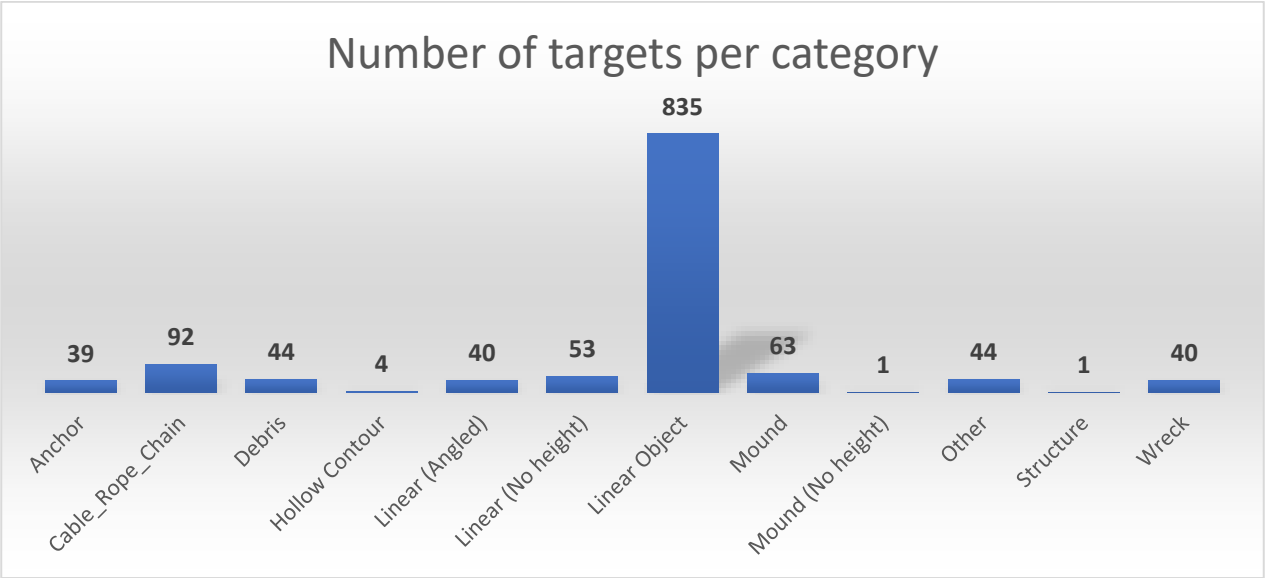

Figure 5. Target categories and number of occurrences within Kriegers Flak II North and South and associated cable corridor.

Due to the amount of data, the SSS results are split into three sections: Kriegers Flak II North, Kriegers Flak II South, and Cable Corridor.

Kriegers Flak II – North

A total of 433 targets were identified and geolocated in Kriegers Flak II North, including 13 potential wrecks, 15 potential anchors, 24 mounds and a so-called “mound no height” (Figure 6).

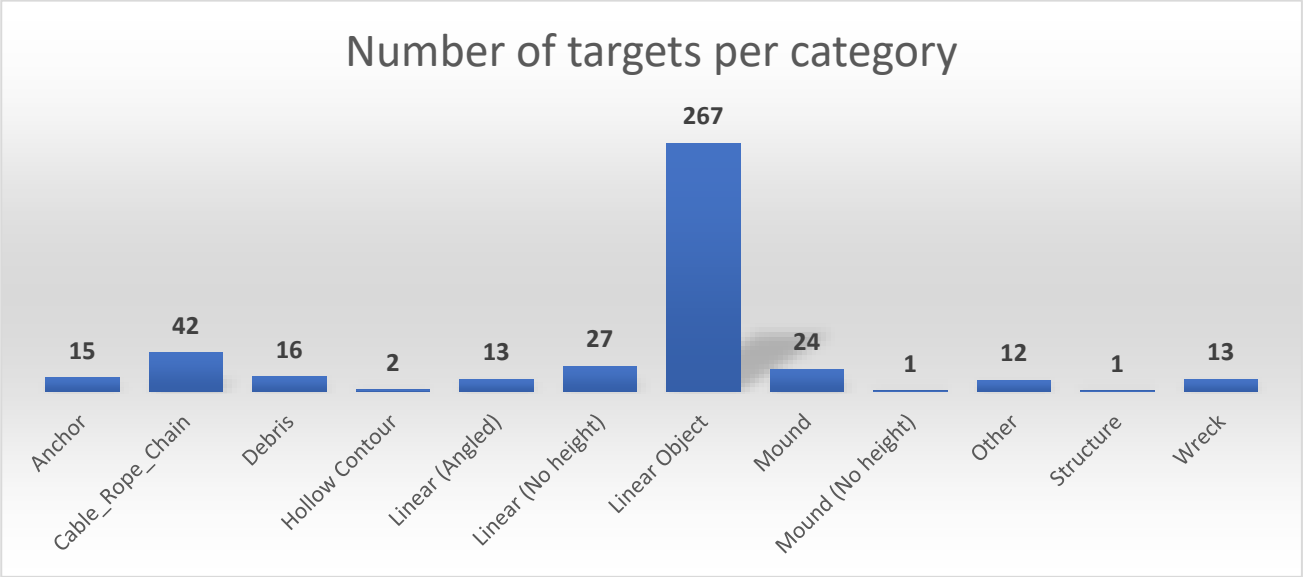

Figure 6. Target categories and number of occurrences within the surveyed area of Kriegers Flak II North.

Wrecks

As well as potential whole wrecks, the targets can represent partial shipwrecks and areas of potential wreck parts.

There are 13 targets identified as potential wrecks within the surveyed area of Kriegers Flak II North (Figure 7). Seven of these targets have previously been confirmed as wrecks and recorded in

either Fund og Fortidsminder or Vragguiden (Table 2). Six targets are not currently recorded in Fund og Fortidsminder or any other wreck database (Table 3). Three of these unrecorded targets can clearly be recognised as wrecks in the SSS and MBES data. The remaining three targets are potential wrecks but would need further investigation for clarification.

Out of the seven previously recorded shipwrecks, VIR3050_N_B01_SSS_0042 is known to have protected status. VIR3050_N_B01_SSS_0138 and VIR3050_N_B04_SSS_0031 were confirmed as wooden wrecks during the Baltic Pipe project (BP06_VIRSSS0125(same as VIR_SSS_0339) and BP06_VIRSSS0116 respectively) (Jonsson & H. Thomsen, 2022) and each given a 100 m exclusion zone but further investigations would be needed to ascertain CHO status. It should be noted that, at the time of the Baltic Pipe project, VIR3050_N_B01_SSS_0138 was assumed to be a 99-year old wreck, the site is now over 100 years old and would have protected status. The remaining four wrecks will need further investigation.

Table 2. Previously recorded shipwrecks within Kriegers Flak II North.

VIR3050_N_B01_SSS_0042	Large well-preserved wreck registered with Fund og Fortidsminder. It is either system number 154350, the SS Jacoff Prosoroff (named in some records as Gacoff Besoroff or Jacob Procoroff), dated to 1893, (VIR case number 2433) or system number 182808 or 183385
VIR3050_N_B01_SSS_0122	Large well-defined wreck surrounded by several wreck parts. Possible rigging or frame lies to the south. Same as surveyor's contacts KFII_N_B01_SSS_GO6_2580 and KFII_N_B01_MBES_GO6_0030.
VIR3050_N_B01_SSS_0138	Well defined wreck appears to be partially buried or heavily deteriorated. The wreck is surrounded by pieces of debris and wreck parts. Same as surveyor's contacts KFII_N_B01_SSS_GO6_3178 and KFII_N_B01_MBES_GO6_0026. Also related to MAG anomaly KFI
VIR3050_N_B02_SSS_0002	Probably the same wreck as a late 20th century wreck registered in Fund og Fortidsminder as system number 179445. Same as surveyor's contacts KFII_N_B02_SSS_GO6_0741 and KFII_N_B02_MBES_GO6_0440. Also probably related to MAG anomaly KFII_N_B02_MAG_G
VIR3050_N_B03_SSS_0015	Possible partially buried wreck. There are several surveyor's contacts located in the area. Also related to MAG anomaly KFII_N_B03_MAG_GO6_0026.
VIR3050_N_B04_SSS_0031	Wreck registered in Fund og Fortidsminder (system nr. 245391), described as possibly the fishing vessel MARIE K 974, wrecked 11-02-1944. Same as surveyor's contact KFII_N_B04_SSS_GO6_0252 and KFII_N_B04_MBES_GO5_0099, and associated with MAG anomaly
VIR3050_N_B05_SSS_0018	Difficult to see in the side-scan sonar images. Appears in the MBES data as a series of depressions. Registered in Fund og Fortidsminder (system number 245602). Originally observed ahead of the Baltic Pipeline project.

The closest record to VIR3050_N_B01_SSS_0122 is found within Vragguiden, an online wreck database for and by recreational divers, it has not been registered in the Fund og Fortidsminder database. Vragguiden describes the wreck as a wooden wreck with two large canons. Two nearby linear objects, VIR3050_N_B01_SSS_0124 and VIR3050_N_B01_SSS_0125 are therefore possibly canons. It is very likely that this wreck will have protected status.

VIR3050_N_B03_SSS_0015 was picked out as a mound in the Baltic Pipe project (labelled as PL112001-A1_DK_GAZ-945) and was later confirmed to be a wreck during ROV investigation (Jonsson & H. Thomsen, 2022). The wreck is registered in Fund og Fortidsminder as system number 245599.

VIR3050_N_B04_SSS_0031 was seen in the Baltic Pipe project, labelled as PL112001-A1_DK_GAZ-630 and BP06_VIRSSS0116 (Jonsson & H. Thomsen, 2022) and in the Bornholm Energiø Interconnector Transect , labelled as SSS_B3A_0074 (Howorth, 2023)

Table 3. Potentially previously unknown wrecks within Kriegers Flak II North.

VIR3050_N_B01_SSS_0019	Partially buried wooden looking wreck surrounded by several linear objects. Same as surveyor's contact KFII_N_B01_SSS_GO6_0913 and KFII_N_B01_MBES_GO6_0028.
VIR3050_N_B01_SSS_0079	Broken down wreck, possibly wooden. Same as surveyor's contacts KFII_N_B01_SSS_GO6_0905 and KFII_N_B01_MBES_GO6_0027.
VIR3050_N_B01_SSS_0098	Area of a number of linear objects defined by Feature, VIR3050_N_B01_SSS_Feature0012. Measurements relate to the size of the area.
VIR3050_N_B02_SSS_0031	Partially buried wreck or ballast pile. Not close to any registered monuments. Same as surveyor's contact KFII_N_B02_SSS_GO6_0087 and KFII_N_B02_MBES_GO6_0453.
VIR3050_N_B04_SSS_0028	Well preserved intact wreck with possible masts and rigging. Appears to be previously unknown. Same as surveyor's contacts KFII_N_B04_SSS_GO6_0194 and KFII_N_B04_MBES_GO5_0104. Related to MAG anomalies KFII_N_B04_MAG_GO6_0009 and KFII_N_B04_MAG_GO6_
VIR3050_N_B05_SSS_0013	Large object causing a mound. Object looks square or is a tall linear object casting a large shadow. Possible partially buried wreck. Nearby linear object VIR3050_N_B05_SSS_0014 could be an associated mast or other wreck part.

VIR3050_N_B01_SSS_0079 was seen in the Kriegers Flak I project (labelled as SSS35) where it was given a 200 m exclusion buffer but was not investigated any further (H. Thomsen, 2018). The same wreck was also seen in the Bornholm Energiø Interconnector Transect (labelled as SSS_B3A_0058) (Howorth, 2023). It is not currently in the Fund og Fortidsminder database.

Target number VIR3050_N_B05_SSS_0013 is located approximately 78 m outside the southern extent of Kriegers Flak II – North, however, if the target is deemed to be a protected wreck, the resulting protection buffer could encroach into working areas.

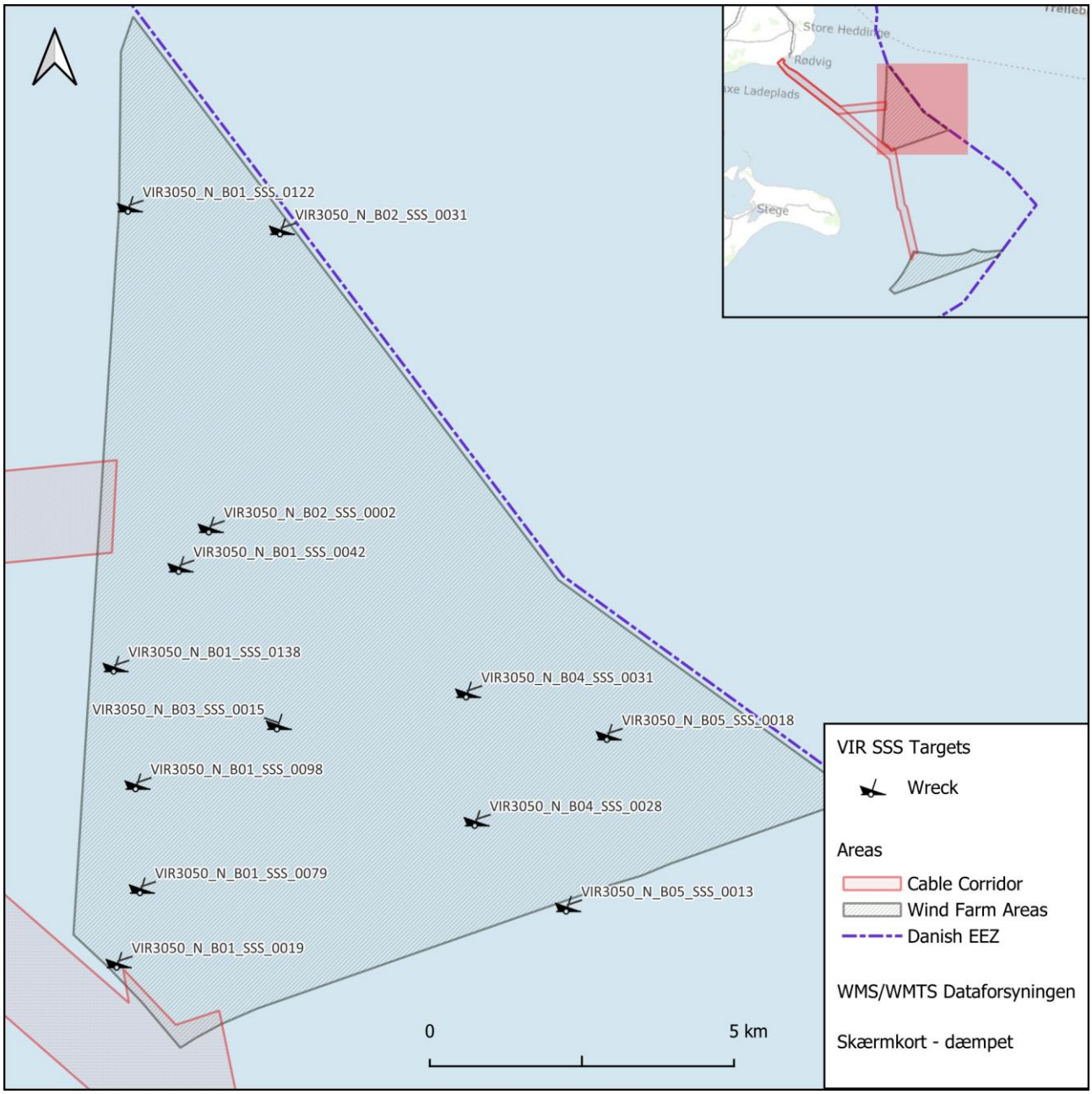

Figure 7. Location of potential wrecks within Kriegers Flak II North. Illustration: John Howorth ©Vikingeskibsmuseet. (CC BY 4.0) Contains data from Klimadatastyrelsen.

Anchors

Targets categorised as *anchor* not only include clear definite anchors but also anomalies which appear to be attached to chains/ropes, have a shape or shadow like an anchor, appear to have disturbance in the surrounding seabed, or are close to a MAG anomaly.

There is a total of 15 targets categorised as anchor within Kriegers Flak II North (Table 4 and Figure 8).

VIR3050_N_B03_SSS_0013 lies approximately 70 m outside of the eastern extent of the planned wind farm area, however, if it is found to have protected status or there are other wreck parts nearby, a resulting protective buffer zone could encroach into working areas.

Table 4. List of potential anchors within Kriegers Flak II North.

VIR3050_N_B01_SSS_0003	Object attached to one end of a rope or chain VIR3050_N_B01_SSS_0005. It is potentially an anchor.
VIR3050_N_B01_SSS_0004	Object within slight depression. Interpreted as potential anchor due to its attachment to VIR3050_N_B01_SSS_0005. Same as surveyor's contact KFII_N_B01_SSS_GO6_3876.
VIR3050_N_B01_SSS_0026	Potential anchor same as MAG anomaly KFII_N_B01_MAG_GO6_0148 and surveyor's contact KFII_N_B01_SSS_GO6_3674.
VIR3050_N_B01_SSS_0183	Anchor shaped anomaly. Same as surveyor's contact KFII_N_B01_SSS_GO6_3956.
VIR3050_N_B02_SSS_0003	Potential anchor attached to a long rope or chain, VIR3050_N_B02_SSS_0004. Same as KFII_N_B02_SSS_GO6_1098.
VIR3050_N_B02_SSS_0005	Potential anchor attached to rope, VIR3050_N_B02_SSS_0004.
VIR3050_N_B02_SSS_0006	Potential anchor attached to rope or chain VIR3050_N_B02_SSS_0007. Same as surveyor's contacts KFII_N_B02_SSS_GO6_2509 and KFII_N_B02_MBES_GO6_0401.
VIR3050_N_B02_SSS_0010	Potential anchor attached to rope or chain, VIR3050_N_B02_SSS_0011. Same as surveyor's contact KFII_N_B02_SSS_GO6_0777.
VIR3050_N_B02_SSS_0025	Potential anchor. Same as surveyor's contacts KFII_N_B02_SSS_GO6_0092 and KFII_N_B02_MBES_GO6_0100. Same as MAG anomaly KFII_N_B02_MAG_GO6_0100.
VIR3050_N_B02_SSS_0043	Potential large anchor. Same as surveyor's contact KFII_N_B02_SSS_GO6_2346.
VIR3050_N_B02_SSS_0045	Same as surveyor's contact KFII_N_B02_SSS_GO6_1011.
VIR3050_N_B02_SSS_0076	Potential anchor attached to a length of rope or chain. Same as surveyor's contact KFII_N_B02_SSS_GO6_1119. Related to MAG anomaly KFII_N_B02_MAG_GO6_0074.
VIR3050_N_B03_SSS_0013	Anchor shaped anomaly.
VIR3050_N_B04_SSS_0013	Potential anchor with attached rope/chain. Same as surveyor's contacts KFII_N_B04_SSS_GO6_0388 and KFII_N_B04_MBES_GO5_0049.
VIR3050_N_B04_SSS_0014	Potential anchor attached to rope/chain. Same as surveyor's contacts KFII_N_B04_SSS_GO6_0226 and KFII_N_B04_MBES_GO5_0047.

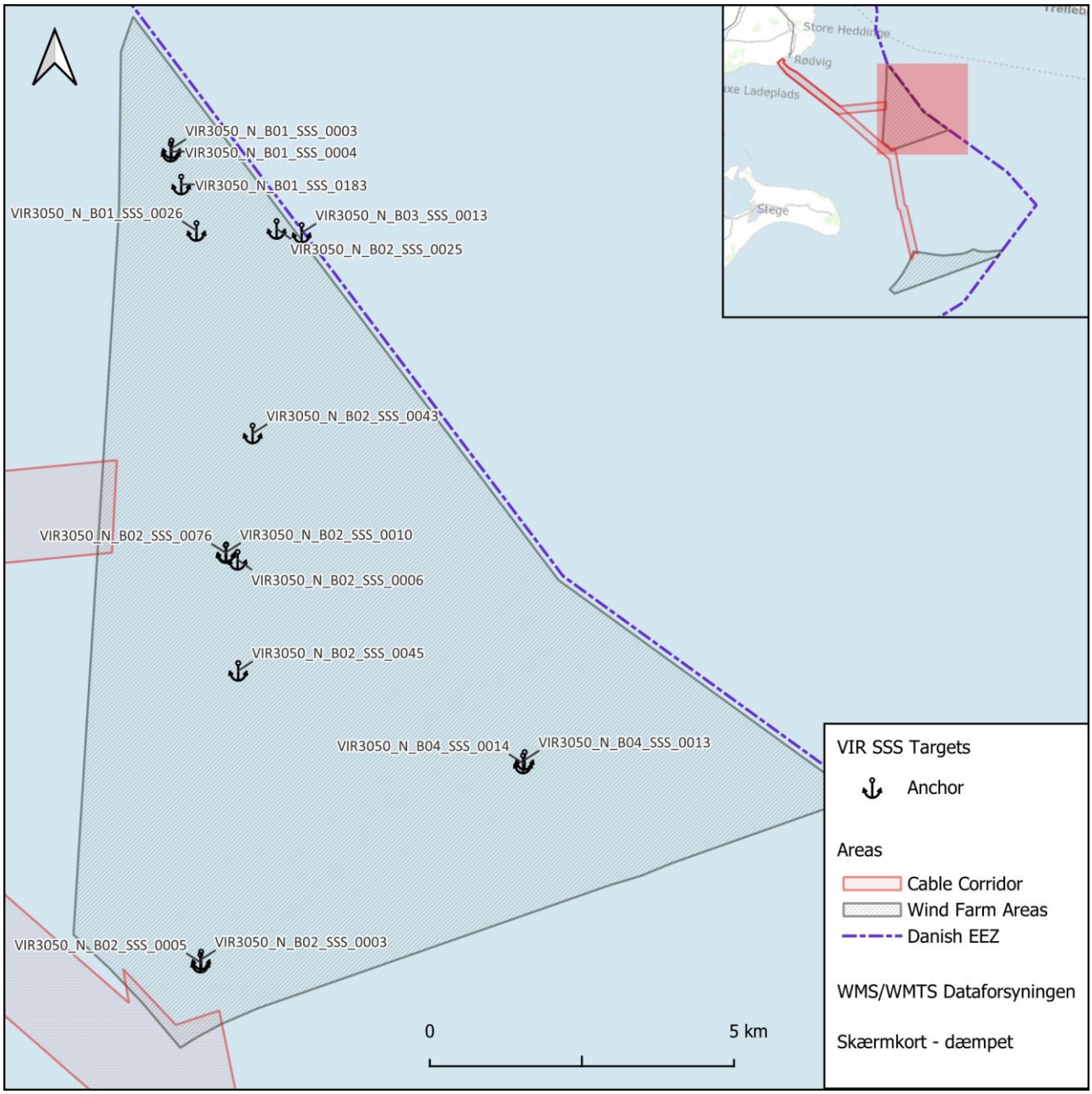

Figure 8. Location of potential anchors within Kriegers Flak II North. Illustration: John Howorth ©Vikingeskibsmuseet. (CC BY 4.0) Contains data from Klimadatastyrelsen.

Mounds

Mounds are picked out as they are potentially ballast from otherwise deteriorated wrecks. In some conditions, all that is left of a shipwreck are the ballast stones. Further investigations can sometimes find the remains of shipwrecks beneath the mounds.

There is a total of 24 targets categorised as *mound* plus a so-called *mound (no height)* (Table 5 and Figure 9).

One mound, VIR3050_N_B04_SSS_0042, is previously recorded in the Fund og Fortidsminder register as a wreck site. The mound is reportedly made up of a cargo of yellow bricks with the remains of a ship buried in the sediment. This target was seen in the Baltic Pipe project, labelled as PL112001-A1_DK_GAZ-612 where it was confirmed as a wreck site during ROV inspection

(Jonsson & H. Thomsen, 2022). The mound was also seen in the Bornholm Energiø Interconnector Transect, labelled as SSS_B3A_0046 (Howorth, 2023).

VIR3050_N_B05_SSS_0021, is located just under 200 m outside the eastern extent of Kriegers Flak II North and 100 m beyond the boundary of the Danish EEZ.

Table 5. List of mounds and mound (no height) within Kriegers Flak II North.

VIR3050_N_B01_SSS_0009	Potential ballast mound although possibly just a rocky reef.
VIR3050_N_B01_SSS_0011	Oval shaped mound, potential buried object.
VIR3050_N_B01_SSS_0029	Potential buried wreck or ballast pile contains MAG anomaly KFII_N_B01_MAG_GO6_0147. Possibly related to rope VIR3050_N_B01_SSS_0028 and VIR3050_N_B01_SSS_0030.
VIR3050_N_B01_SSS_0039	Mound with two regular shaped anomalies emerging from one side, possibly manmade.
VIR3050_N_B01_SSS_0078	Potential buried object.
VIR3050_N_B01_SSS_0160	Possibly two mounds next to one another. Possible buried object or objects.
VIR3050_N_B01_SSS_0163	Mound or area of boulders close to several possible linear anomalies grouped together. Also related to MAG anomaly KFII_N_B01_MAG_GO6_0052.
VIR3050_N_B01_SSS_0176	Mound made up of rough terrain. Possible buried object.
VIR3050_N_B02_SSS_0012	Faint mound feature. Possible buried object.
VIR3050_N_B02_SSS_0080	Shallow mound containing several rocks. Possible ballast mound.
VIR3050_N_B02_SSS_0101	Possible buried object.
VIR3050_N_B03_SSS_0010	Oval shaped area of rocks and slightly raised seabed. Possible buried object such as wreck or wreck parts. Same as surveyor's contacts, KFII_N_B03_MBES_GO6_0154, KFII_N_B03_MBES_GO6_0155, KFII_N_B03_MBES_GO6_0156, and KFII_N_B03_MBES_GO6_0157.
VIR3050_N_B04_SSS_0010	Oval shaped mound. Potential buried ballast pile or wreck.
VIR3050_N_B04_SSS_0018	Potential ballast mound.
VIR3050_N_B04_SSS_0026	Potential buried object.
VIR3050_N_B04_SSS_0027	Potential mound.
VIR3050_N_B04_SSS_0035	Oval shaped mound. Possible buried object or ballast pile.
VIR3050_N_B04_SSS_0042	Possible ballast pile. Same as surveyor's contacts KFII_N_B04_SSS_GO6_0234 and KFII_N_B04_MBES_GO5_0103.
VIR3050_N_B04_SSS_0043	Possible buried object or ballast mound.
VIR3050_N_B04_SSS_0047	Possible buried object or ballast pile.
VIR3050_N_B05_SSS_0004	Oval shaped mound. Potential buried object or ballast mound.
VIR3050_N_B05_SSS_0017	Large sub-rectangular mound. Possible buried object or ballast pile.
VIR3050_N_B05_SSS_0019	Possible ballast pile or buried object.
VIR3050_N_B05_SSS_0021	Possible buried object or ballast pile.
VIR3050_N_B05_SSS_0024	Oval mound. Possible partially buried wreck with nearby debris

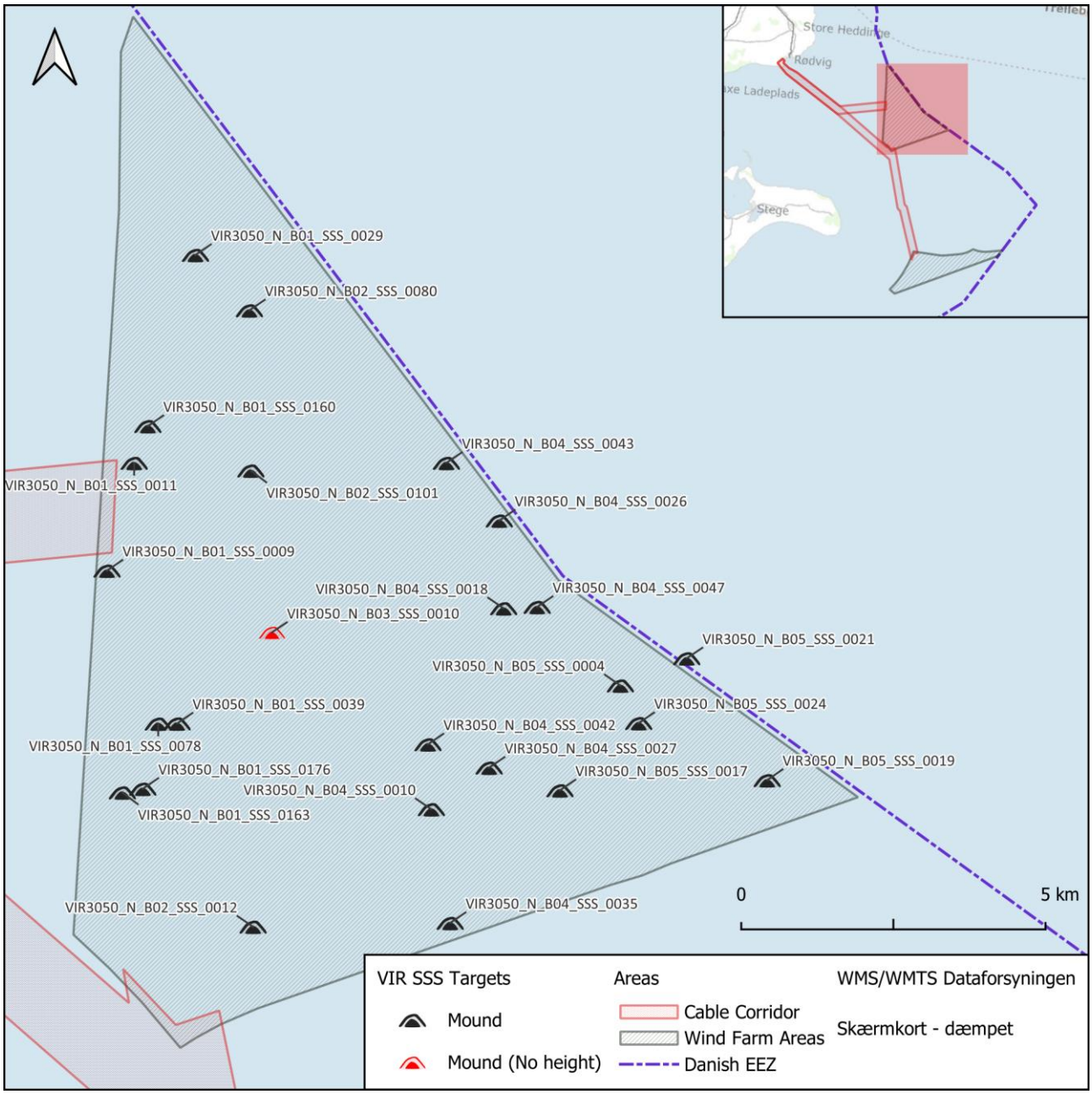

Figure 9. Location of targets categorised as mound and mound (no height) within Kriegers Flak II North. Illustration: John Howorth ©Vikingeskibsmuseet. (CC BY 4.0) Contains data from Klimadatastyrelsen.

Hollow Contours

There are two targets categorised as *Hollow Contour*. VIR3050_N_B03_SSS_0018 consists of several objects arranged in an oval shape and could be the remains of a wooden shipwreck emerging from the seabed sediment. VIR3050_N_B04_SSS_0034 is a dark oval shape on the seabed which may represent a wreck (Figure 10).

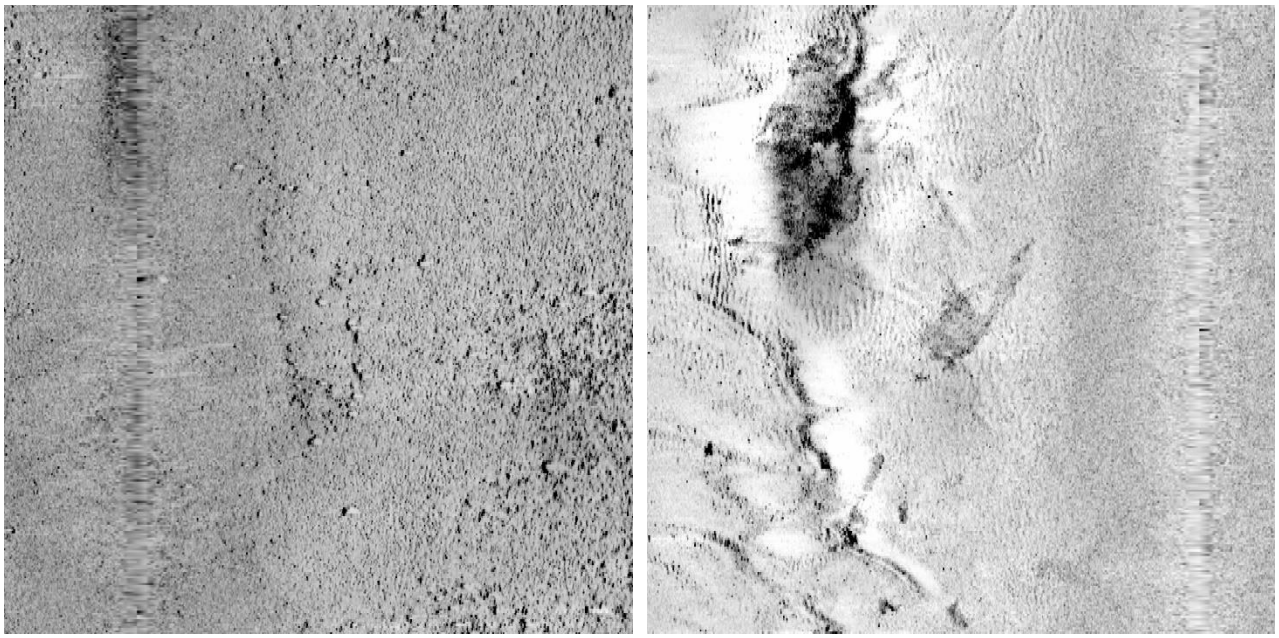

Figure 10. SSS images of the two targets categorised as *hollow contour*. VIR3050_N_B03_SSS_0018 (left) appears as an ellipse of rounded objects and VIR3050_N_B04_SSS_0034 (right) appears as a darker boat shaped area towards the centre.

Linear Objects

The largest target category is *linear object* (including *linear (angled)* and *linear (no height)*), it is important that any linear objects likely to be affected by construction work are investigated further to evaluate their significance.

Many objects that end up on the sea floor are linear, such as fishing stakes, spars and masts from the rigging on a sailing ship, timber and wreck parts. Even whole wrecks have started out as a single linear object during SSS screening. The reason for this, presumably, is that the initial survey has to be made over a wide enough area (resulting in low resolution data) to ensure that a large area can be covered in a feasible amount of time. Therefore, smaller objects do not appear in the resulting data. Large well-preserved wrecks are clearly visible, but deteriorated, partially buried wrecks will be hard to distinguish. Needless to say, the older and maybe archaeologically more interesting shipwrecks will be the most deteriorated and therefore harder to pinpoint.

Most linear objects require visual inspection in order to clarify what they are, and if they are protected by the museum act so, during the initial target picking, little or no description will be made of the anomaly other that giving its measurements. See appendix 4 for a full explanation for the importance of investigating linear objects.

Many of the targets categorised as *linear object* within Kriegers Flak II North were found close to wrecks and are likely to be wreck parts or debris.

MBES Anomalies and Targets from Previous Investigations

During the analysis phase of the report several extra anomalies were observed. These are anomalies that can be seen in the MBES data but not in the SSS data. Most of these are classed as *linear object* and were also targeted in the Bornholm Energiø project – Interconnector Transect, VIR2937 (Howorth, 2023).

One of the MBES anomalies, VIR3050_N_Extra_0001, was observed during the ROV investigation of SSS targets during the Baltic Pipe project and was found to be a wreck part, labelled as VIR_SSS_0354 (Jonsson & H. Thomsen, 2022), it was assigned the Fund og Fortidsminder system number 245618.

These targets should also be investigated further to ascertain whether they are CHOs. These targets are included in the main target summary (Appendix 2) but do not feature in the SonarWiz reports as they were not picked out at that phase of the investigation.

Kriegers Flak II – South

A total of 352 targets were identified and geolocated in Kriegers Flak II South, including 14 potential wrecks, 13 potential anchors, and 31 mounds (Figure 11).

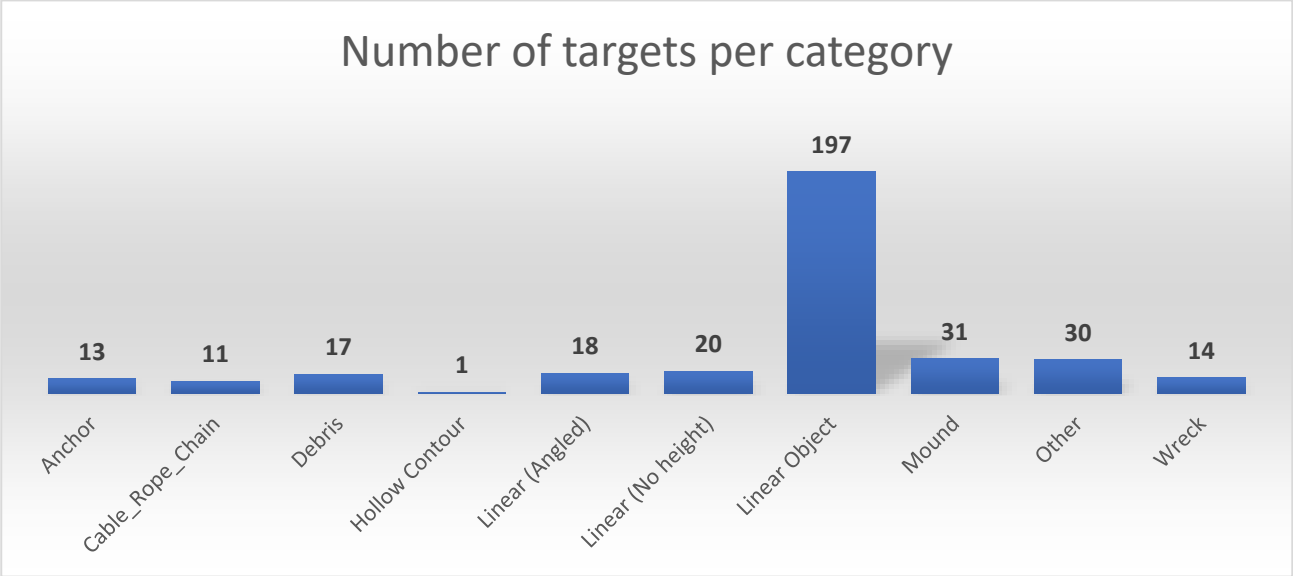

Figure 11. Target categories and number of occurrences within the surveyed area of Kriegers Flak II South.

Wrecks

There are 14 targets identified as potential wrecks within the surveyed area of Kriegers Flak II South Table 6 and Figure 12). None of the targets correlate with wrecks registered in any wreck databases. Two of the targets, VIR3050_B01_SSS_0045 and VIR3050_B04_SSS_0035, correlate with MAG anomalies, KFII_S_B02_MAG_G05_0009 and KFII_S_B04_MAG_G06_0014, respectively, which strengthens the case for these being previously unrecorded wrecks.

In the geophysical surveys for the windfarm areas (GEOxyz, 2024), VIR3050_B04_SSS_0013 (MMO ID – KFII_S_148 in the survey report) is labelled as a known wreck and named as the *Birgit Ehlers*. The source of this information is unknown to VIR and there are no records of a wreck within the vicinity of VIR3050_B04_SSS_0013. This report will therefore treat the wreck as previously unrecorded.

VIR3050_B02_SSS_0086 is over 300 m outside of the north-eastern extent of the wind farm area.

Table 6. List of potential wrecks within Kriegers Flak II South.

VIR3050_B01_SSS_0045	Possibly a partially buried deteriorated wooden shipwreck.
VIR3050_B02_SSS_0025	Possible wreck part or anchor. Possibly attached to a rope or chain. Same as surveyor's contacts KFII_S_B02_SSS_GO5_0056 and KFII_S_B02_MBES_GO5_0056.
VIR3050_B02_SSS_0027	Wreck shaped anomaly. Possible partially buried wreck or exposed rock outcrop.
VIR3050_B02_SSS_0028	Possible wreck part or rocky outcrop.
VIR3050_B02_SSS_0036	Potentially several linear objects running parallel to one another. Possible wreck or wreck parts.
VIR3050_B02_SSS_0086	Potential damaged/deteriorated wreck or other large buried object. There's a large amount of disturbance on the surrounding seabed possibly related to the target.
VIR3050_B03_SSS_0022	Potential partially buried deteriorated wooden wreck. Appears as a mound with several linear objects lying close by. Same as feature VIR3050_B03_SSS_Feature0005.
VIR3050_B03_SSS_0029	Area of several linear objects spread across a large area. Possible parts of a partially buried deteriorated wooden wreck. Includes surveyor's targets KFII_S_B03_SSS_GO5_0072 and KFII_S_B03_SSS_GO5_0074. Same as feature VIR3050_B03_SSS_Feature0006.
VIR3050_B03_SSS_0030	V-shaped object, possible partially buried wreck, anchor or other manmade object.
VIR3050_B03_SSS_0050	Possibly overturned vessel. Same as KFII_S_B03_SSS_GO5_0026.
VIR3050_B04_SSS_0013	Broken down wreck, potentially wooden. Surrounded by wreck parts and debris (VIR3050_B04_SSS_Feature0002). Same as surveyor's contacts KFII_S_B04_SSS_GO5_0105 and KFII_S_B04_MBES_GO5_0004.
VIR3050_B04_SSS_0023	Possible wreck in close vicinity to wreck VIR3050_B04_SSS_0013. Could be related or an entirely separate wreck.
VIR3050_B04_SSS_0035	Partially buried wreck or ballast pile surrounded by linear objects which are all potentially wreck parts. Related to feature VIR3050_B04_SSS_Feature0005 which represents the wreck and potential debris field. Also related to MAG anomaly KFII_S_B04_M
VIR3050_B04_SSS_0064	Potential upturned hull. Same as surveyor's contact KFII_S_B04_SSS_GO5_0006 and KFII_S_B04_MBES_GO5_0066.

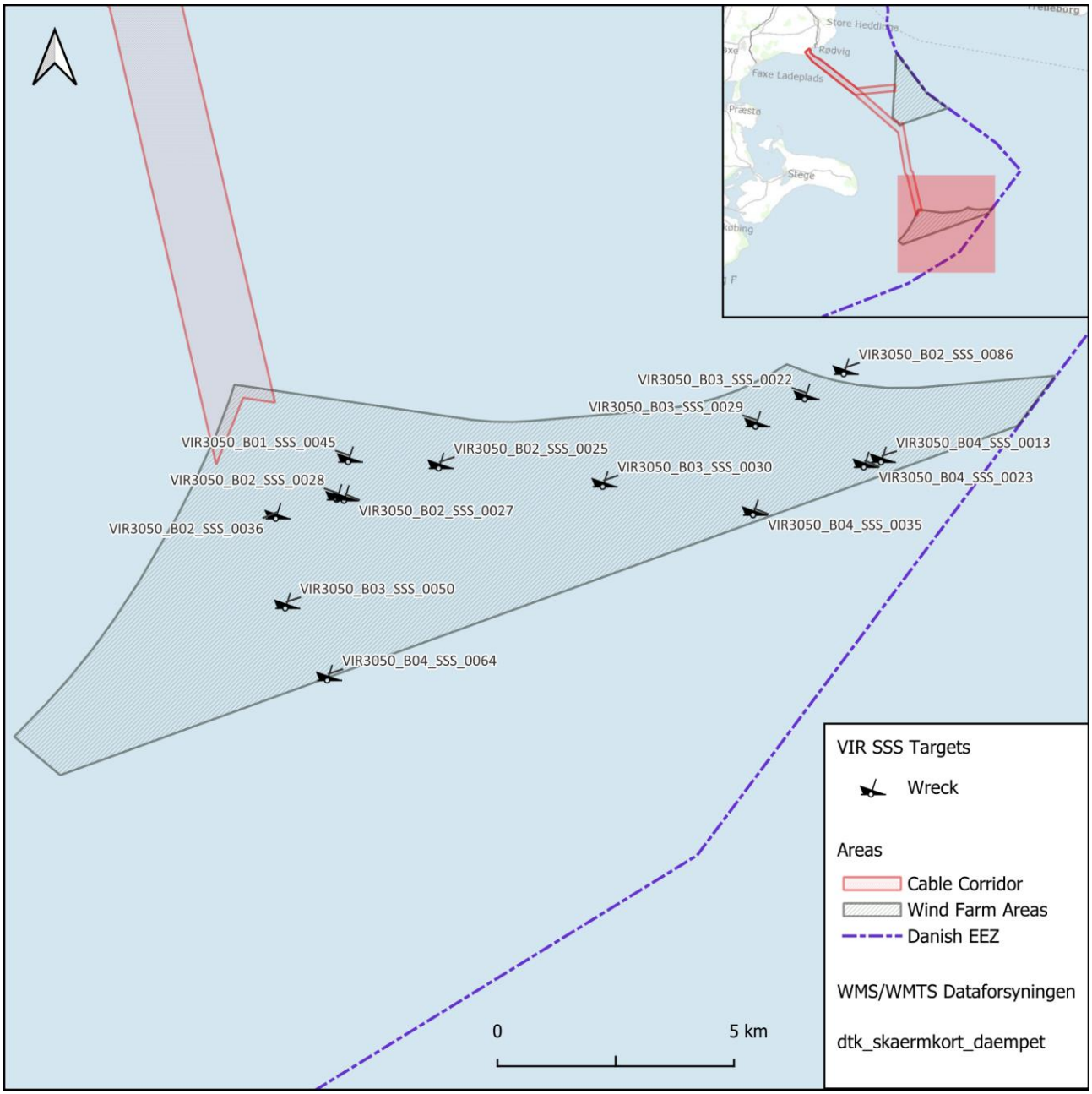

Figure 12. Location of potential wrecks within Kriegers Flak II South. Illustration: John Howorth ©Vikingeskibsmuseet. (CC BY 4.0) Contains data from Klimadatastyrelsen.

Anchors

There is a total of 13 targets categorised as anchor within Kriegers Flak II South Table 7 and Figure 13).

VIR3050_B04_SSS_0034 correlates with MAG anomaly, KFII_S_B04_MAG_G06_0016 and has a fairly distinct shape within the survey data.

VIR3050_B02_SSS_0098 is located approximately 150 m outside the northern extent of Kriegers Flak II South and might be unaffected by future work.

Table 7. List of potential anchors within Kriegers Flak II South.

VIR3050_B01_SSS_0022	Unusual shaped object, thought to be a possible anchor due to a possible rope (VIR3050_B01_SSS_0023).
VIR3050_B02_SSS_0059	Potential anchor. Same as surveyor's contacts KFII_S_B02_SSS_GO5_0080 and KFII_S_B02_MBES_GO5_0038.
VIR3050_B02_SSS_0061	Same as surveyor contact KFII_S_B02_SSS_GO5_0077. Possible anchor as there are marks on the seabed possibly made by ropes.
VIR3050_B02_SSS_0071	Interpreted as anchor due to the fact it appears to be attached to a rope/chain (VIR3050_B02_SSS_0072).
VIR3050_B02_SSS_0088	Potential anchor or debris. Same as surveyor's contact KFII_S_B02_SSS_GO5_0063.
VIR3050_B02_SSS_0098	Possible anchor. Object appears to be in a scar on the seabed.
VIR3050_B03_SSS_0072	Potential anchor. Same as surveyor's contact KFII_S_B03_SSS_GO5_0062.
VIR3050_B04_SSS_0009	Unusual shaped object, possible anchor. Same as surveyor's contacts KFII_S_B04_SSS_GO5_0038 and KFII_S_B04_MBES_GO5_0071.
VIR3050_B04_SSS_0010	Potential anchor attached to a rope/chain VIR3050_B04_SSS_0011. Same as surveyor's contacts KFII_S_B04_SSS_GO5_0047 and KFII_S_B04_MBES_GO5_0051.
VIR3050_B04_SSS_0034	Possible anchor located approximately 90 m from a probable wreck/ballast pile. Same as MAG anomaly KFII_S_B04_MAG_GO6_0016.
VIR3050_B04_SSS_0044	Possible wreck part or anchor. Round object attached to a long linear object or rope/chain. Same as surveyor's contacts KFII_S_B04_SSS_GO5_0028 and KFII_S_B04_SSS_GO5_0029.
VIR3050_B04_SSS_0065	Potential anchor attached to rope or chain, VIR3050_B04_SSS_0066. Same as surveyor's contacts KFII_S_B04_SSS_GO5_0003 and KFII_S_B04_MBES_GO5_0068.
VIR3050_B04_SSS_0088	Anchor shaped object.

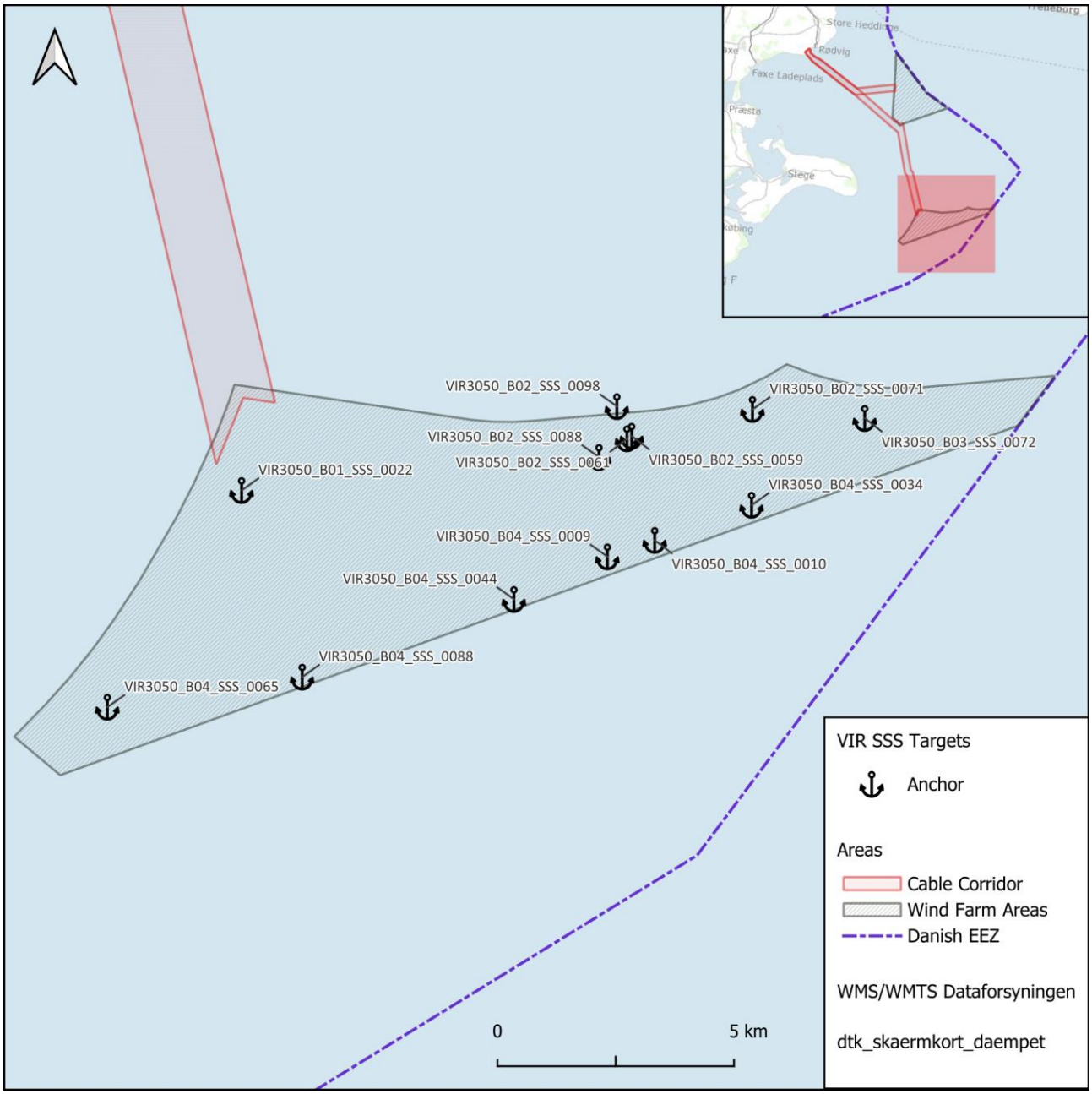

Figure 13. Location of potential anchors within Kriegers Flak II South. Illustration: John Howorth ©Vikingeskibsmuseet. (CC BY 4.0) Contains data from Klimadatastyrelsen.

Mounds

The seabed surface sediment in Kriegers Flak II South is very soft and some of the mounds may have been caused due to recent anchoring or trawling activity. It is however necessary to carry out further investigations to confirm this.

There is a total of 31 targets categorised as *mound* within Kriegers Flak II South (Table 8 and Figure 14).

Despite being observed in the Kriegers Flak II South SSS data,VIR3050_B01_SSS_0002 is actually located about 80 metres outside the wind farm site and within the southern end of the cable corridor.

VIR3050_B02_SSS_0014 is located over 210 m outside the western extent of the wind farm site, and VIR3050_B02_SSS_0049 and VIR3050_B02_SSS_0105 are located at around 100 m and 65 m respectively outside the northern extent of the wind farm site. Despite the anomalies being physically outside the planned working areas any potential buffer zones applied to them could encroach into the wind farm areas.

VIR3050_B03_SSS_0039 and VIR3050_B03_SSS_0040 look to possibly be fairly recent in date, possible anchoring positions that have disturbed the seabed sediment.

Table 8. List of targets categorised as mounds in Kriegers Flak II South.

VIR3050_B01_SSS_0002	Possible pile of stones. Difficult to see as close to edge of sonar file.
VIR3050_B01_SSS_0043	Very circular mound.
VIR3050_B02_SSS_0014	Possible small mound or large boulder.
VIR3050_B02_SSS_0017	
VIR3050_B02_SSS_0049	Oval shaped mound. Possible buried ballast mound.
VIR3050_B02_SSS_0054	Small oval shaped mound. Potential buried object.
VIR3050_B02_SSS_0076	Potential buried object causing disturbance on the seabed.
VIR3050_B02_SSS_0094	Faint image of possible mound.
VIR3050_B02_SSS_0096	Very circular mound.
VIR3050_B02_SSS_0097	
VIR3050_B02_SSS_0100	Potential buried ballast pile or wreck.
VIR3050_B02_SSS_0105	
VIR3050_B03_SSS_0039	Large object which appears to be partially buried. Potential wreck but could be something related to modern infrastructure, i.e. something related to a modern cable. There is a similar object approximately 75 m to the northeast and appears to have c
VIR3050_B03_SSS_0040	Large object which appears to be partially buried. Potential wreck but could be something related to modern infrastructure, i.e. something related to a modern cable. There is a similar object approximately 75 m to the southwest and appears to have c
VIR3050_B03_SSS_0041	Area of two or three mounds with a rope or cable like object towards the north. Possible buried wreck or could also be linked with modern infrastructure.
VIR3050_B03_SSS_0054	Possible buried object.
VIR3050_B03_SSS_0055	Potential buried object or disturbance caused by anchor.
VIR3050_B03_SSS_0056	Potential buried object, same as KFII_S_B03_SSS_GO5_0007.
VIR3050_B03_SSS_0057	Potential buried object or disturbance caused by an anchor.
VIR3050_B03_SSS_0058	Possible mound or disturbance caused by an anchor.
VIR3050_B03_SSS_0060	Oval shaped mound or disturbance caused by anchor.
VIR3050_B03_SSS_0063	Possible mound or disturbance caused by an anchor.
VIR3050_B03_SSS_0064	Possible mound or disturbance caused by an anchor.
VIR3050_B03_SSS_0065	Possible mound or disturbance caused by an anchor.
VIR3050_B03_SSS_0094	Shallow, oval-shaped mound.
VIR3050_B04_SSS_0024	Irregular shaped mound. Possible buried object.
VIR3050_B04_SSS_0030	Potentially a continuation of VIR3050_B04_SSS_0018 but buried in silt.
VIR3050_B04_SSS_0033	Potential buried object.
VIR3050_B04_SSS_0048	Mound, very faint in the SSS data and not visible in the MBES data.
VIR3050_B04_SSS_0051	Image distorted due to its proximity to the centre of SSS file.
VIR3050_B04_SSS_0084	Shallow mound, potential buried anomaly.

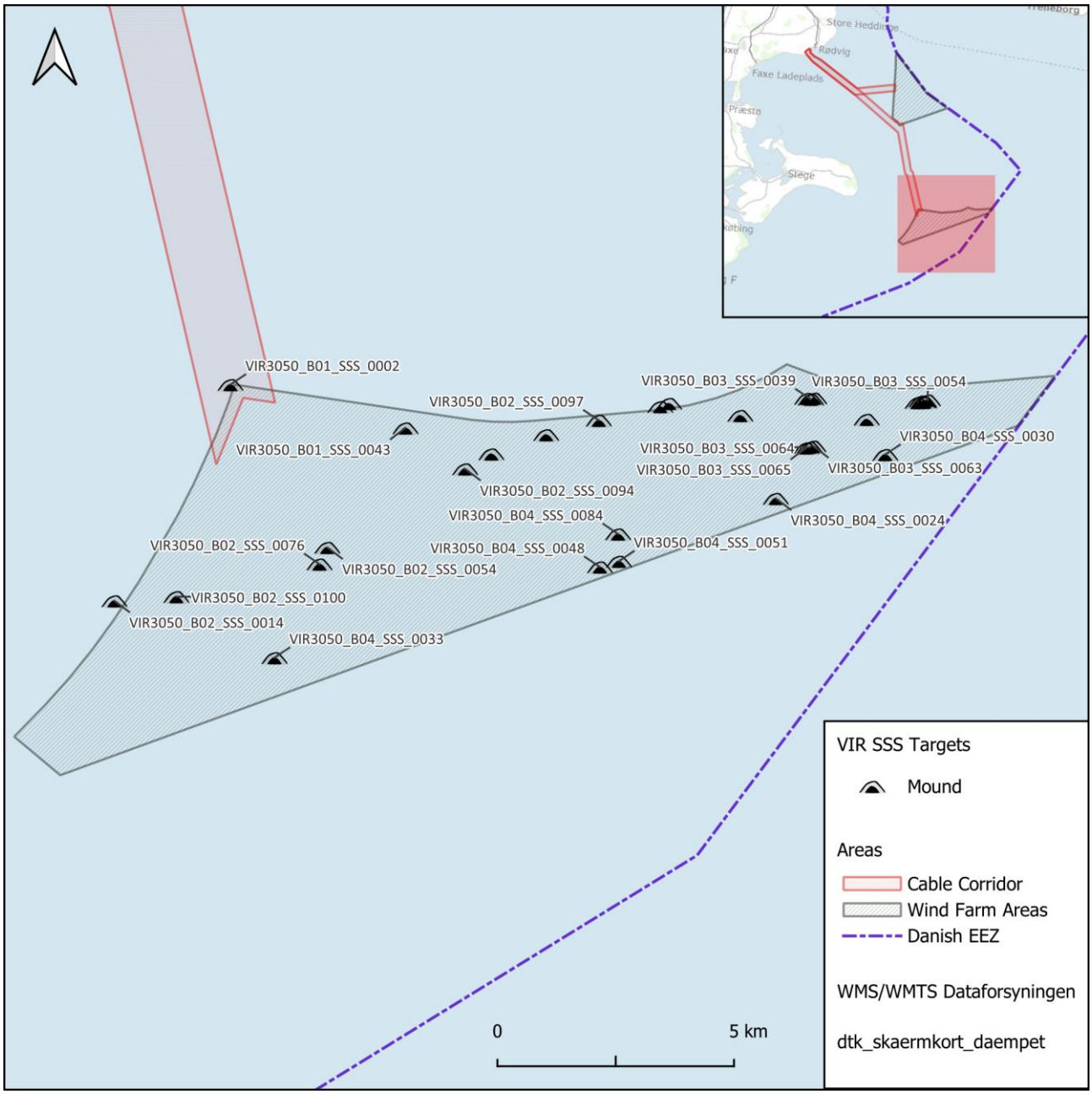

Figure 14. Location of targets categorised as mound within Kriegers Flak II South. Illustration: John Howorth ©Vikingeskibsmuseet. (CC BY 4.0) Contains data from Klimadatastyrelsen.

Debris

There are 17 targets categorised as debris. VIR3050_B02_SSS_0040 is an area of several anomalies rather than one specific object.

VIR3050_B04_SSS_0014, VIR3050_B04_SSS_0016, VIR3050_B04_SSS_0020, and VIR3050_B04_SSS_0022 are all possibly debris from potential wreck VIR3050_B04_SSS_0013.

VIR3050_B04_SSS_0036 is potentially debris from wreck, VIR3050_B04_SSS_0035.

Potential debris, VIR3050_B04_SSS_0041, correlates with MAG anomaly KFII_S_B04_MAG_G06_0010 and is maybe related to debris target VIR3050_B04_SSS_0042.

Other

The targets categorised as *other* are irregular shaped anomalies which are potentially manmade. VIR3050_B02_SSS_0093 correlates with a MAG anomaly KFII_S_B02_MAG_G05_0005 which could mean it is metallic.

VIR3050_B03_SSS_0059 and VIR3050_B03_SSS_0061 are possibly areas where objects have been disturbed by anchors dragging across the soft sediment.

VIR3050_B04_SSS_0021 is located close to wreck site VIR3050_B04_SSS_0013 and could be related.

Hollow Contour

There is just one target categorised as *hollow contour* in Kriegers Flak II South, VIR3050_B02_SSS_0034. It appears as a small boat shaped dark discolouration on the seafloor.

Linear Objects

The largest target category is *linear object* (including *linear (angled)* and *linear (no height)*), it is important that any linear objects likely to be affected by construction work are investigated further to evaluate their significance. The importance of investigating linear objects has been discussed in the section for Kriegers Flak II North and can be found in Appendix 4.

MBES Anomalies

One extra target, VIR3050_S_Extra_0001, a linear anomaly, was observed during the analysis of the MBES data. It lies approximately 13 m to the south west of a potential anchor VIR3050_B04_SSS_0088.

This target should also be investigated further to ascertain whether it is a CHO. It is included in the main target summary (Appendix 2) but does not feature in the SonarWiz reports as it was not picked out at that phase of the investigation.

Kriegers Flak II – Cable Corridor

A total of 471 targets were identified and geolocated in the Kriegers Flak II Cable Corridor, including 13 potential wrecks, 11 potential anchors, and 8 mounds (Figure 15).

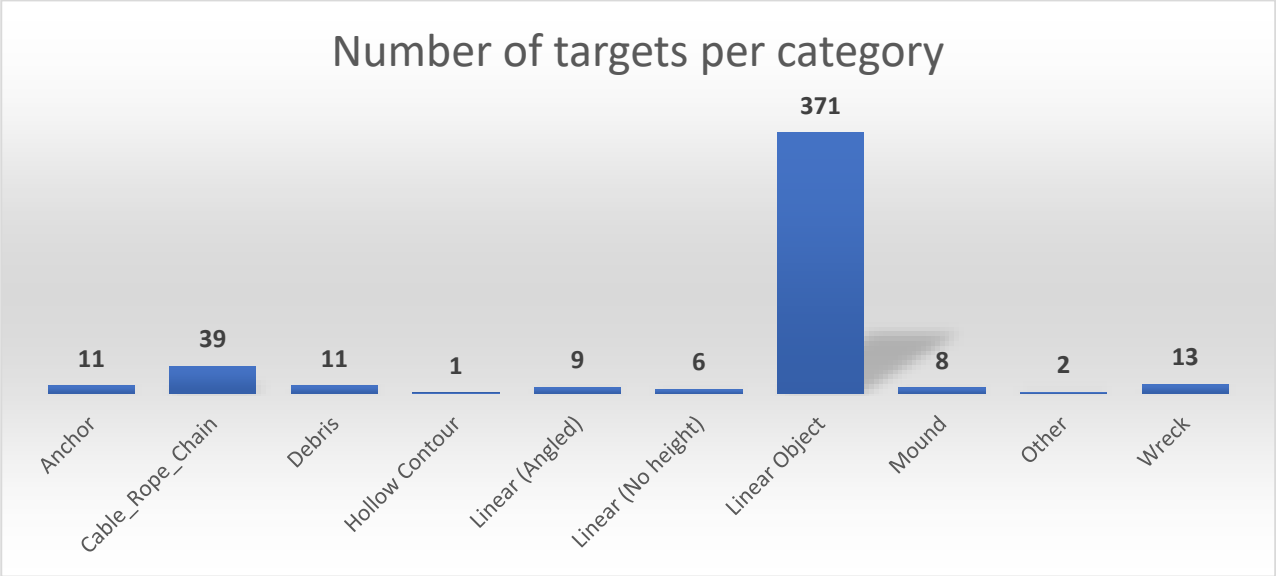

Figure 15. Target categories and number of occurrences within the surveyed area of the Kriegers Flak II Cable Corridor.

Wrecks

As well as potential whole wrecks, the targets can represent partial shipwrecks and areas of potential wreck parts.

There are 13 targets identified as potential wrecks within the surveyed area of the Kriegers Flak II Cable Corridor (Table 9 and Figure 16).

VIR3050_Cable_N_SSS_0176 is a distinct wooden wreck which appears to have split into two main parts. A smaller part of the same wreck, VIR3050_Cable_N_SSS_0177, lies a short distance to the south. The wreck correlates with MAG anomaly, KFII_ECR-B_MAG_GO4_0021 and survey target ECR_MMO_PTS_0350. This target does not correlate with any previous records and is therefore potentially a new find.

VIR3050_Cable_N_SSS_0183 is another wooden wreck which does not correlate with any previous records. This wreck is heavily deteriorated and consists of several linear objects scattered over a small area. A MAG anomaly, KFII_ECR-B_MAG_GO4_0309, is located nearby and could indicate an anchor or a metal fitting for the ship. The target area is surrounded by pock marks in the seabed sediment which could indicate further wreck parts or debris.

VIR3050_Cable_N_SSS_0250 is an area covered with a large number of linear objects, the concentration of these objects could indicate a wreck site. There are no previous records of wrecks associated with this area.

VIR3050_Cable_S_SSS_0039 is a large pear-shaped object which is presumably a large leeboard. There are no known previous records associated with this object.

VIR3050_Cable_N_SSS_0036 is potentially part of a wreck or a partially buried wreck within a large depression. The depression contains 5 MAG anomalies, KFII_ECR-A_MAG_GS17_0016 to KFII_ECR-A_MAG_GS17_0020, with KFII_ECR-A_MAG_GS17_0018 correlating with the target itself.

VIR3050_Cable_N_SSS_0109 correlates with the Fund og Fortidsminder record system number 245387, which has been identified as the tugboat, *Stella Mojac,* which foundered in 1976. It is the same as survey target KFII_ECR_MMO_PTS_0390. Three MAG anomalies are associated with this wreck; KFII_ECR-B_MAG_GO4_0228, KFII_ECR-B_MAG_GO4_0231, and KFII_ECR-B_MAG_GO4_0233. This wreck was observed in the Kriegers Flak I project, labelled as SSS2 (H. Thomsen, 2018) and also seen in the Baltic Pipe project, labelled as BP06_VIRSSS0076 (H. Thomsen, 2020).

VIR3050_Cable_N_SSS_0121 is a long lattice type structure which correlates with MAG anomaly KFII_ECR-B_MAG_GO4_0034. The target has the look of a lattice tower/mast or crane. A nearby linear object, VIR3050_Cable_N_SSS_0240, resembles a possible lifting hook attached to a long cable or chain.

Table 9. List of potential wrecks within the Kriegers Flak II Cable Corridor.

VIR3050_Cable_N_SSS_0024	Ship shaped feature raised from the seabed. Visible in the MBES data.
VIR3050_Cable_N_SSS_0036	Boat shaped feature made up of apparent linear objects within a large depression in the seabed.
VIR3050_Cable_N_SSS_0071	Long linear with possible perpendicular linear anomalies.
VIR3050_Cable_N_SSS_0109	Wreck of tugboat STELLA MOJAC, foundered 20-11-1976, positively identified during the Baltic Pipe project. Registered in Fund og Fortidsminder (system number 245387).
VIR3050_Cable_N_SSS_0121	Large gridded structure. Possible large wreck piece or debris.
VIR3050_Cable_N_SSS_0176	Potentially fairly well-preserved wooden wreck with exposed frame and possible mast running alongside part of the hull. The wreck appears to be mainly be in two large pieces. There are no previously recorded shipwrecks within the immediate vicinity.
VIR3050_Cable_N_SSS_0177	Probably part of the nearby wreck VIR3050_Cable_N_SSS_0176. Appears to be 2 large planks.
VIR3050_Cable_N_SSS_0183	Heavily broken up wooden wreck, there are no previously registered cultural historical objects in close proximity.
VIR3050_Cable_N_SSS_0214	Oval shaped area with several potential linear objects. There is a possibility that these could be the remains of a ship. Measurements were taken for the area of possible debris.
VIR3050_Cable_N_SSS_0250	Potential wreck site, an area containing a large number of linear objects (VIR3050_Cable_N_SSS_0137 to VIR3050_Cable_N_SSS_0149). Area is bounded by VIR3050_Cable_N_SSS_Feature0004. Measurements relate to size of area.
VIR3050_Cable_N_SSS_0340	Group of linear objects in the base of a small depression. Possible wreck.
VIR3050_Cable_S_SSS_0026	Lozenge shaped anomaly. Possible hull of a shipwreck. Hard to see within area of rocky seabed. The anomaly can be more clearly seen in the MBES data.
VIR3050_Cable_S_SSS_0039	Pear shaped object. Possibly a wreck part, potentially a leeboard or a partially buried wreck. Not currently registered in Fund og Fortidsminder.

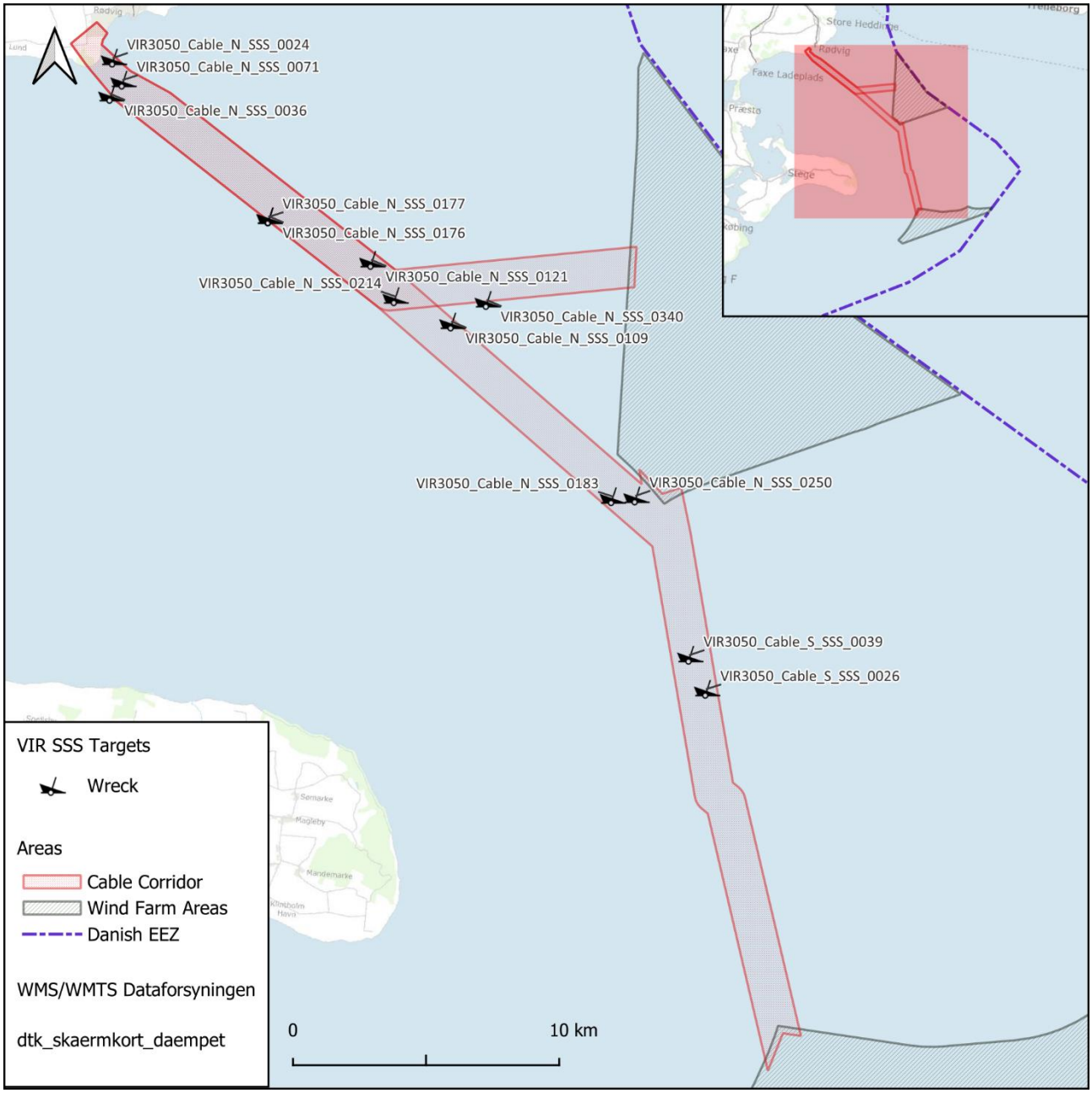

Figure 16. Location of potential wrecks within the Kriegers Flak II Cable Corridor. Illustration: John Howorth ©Vikingeskibsmuseet. (CC BY 4.0) Contains data from Klimadatastyrelsen.

Anchors

There is a total of 11 targets categorised as anchor within the Kriegers Flak II Cable Corridor (Table 10 and Figure 17).

Two of the anchors were discovered during the Baltic Pipe project and are recorded in Fund og Fortidsminder. VIR3050_Cable_N_SSS_0119 (correlating with MAG anomaly KFII_ECR-B_MAG_GO4_0263), and VIR3050_Cable_N_SSS_0192, are recorded as Fund og Fortidsminder system numbers 245611 and 245609 respectively.

Seven of the targets are previously unrecorded and have strong potential to be CHOs; VIR3050_Cable_N_SSS_0098, VIR3050_Cable_N_SSS_0180, VIR3050_Cable_N_SSS_0268 (correlates with MAG anomaly KFII_ECR-B_MAG_GO4_0318), VIR3050_Cable_N_SSS_0291 (correlates with MAG anomaly KFII_ECR-C_MAG_GO4_0080, this target is about 5 m to the east of the anomaly seen in MBES and might indicate a discrepancy in the SSS data), VIR3050_Cable_S_SSS_0025, VIR3050_Cable_S_SSS_0065, and VIR3050_Cable_S_SSS_0077

The remaining two targets are less distinct and are based on their relation to other anomalies or shapes in the MBES data. These are: VIR3050_Cable_S_SSS_0066 which cannot be seen in the SSS data but there is a potentially anchor shaped object in the MBES data which is attached to a possible chain or rope; and VIR3050_Cable_S_SSS_0047 which has been picked out on the basis that a chain or rope is possibly attached to something buried in the sediment.

A target classified as *other*, VIR3050_Cable_N_SSS_0224, is also potentially an anchor. It consists of two linear objects perpendicular to one another.

Table 10. List of potential anchors within the Kriegers Flak II Cable Corridor.

VIR3050_Cable_N_SSS_0098	Anchor shaped anomaly.
VIR3050_Cable_N_SSS_0119	Anchor already registered in Fund og Fortidsminder (system number 245611). Well preserved with wooden stock and wide spade shaped flukes. Observed during the Baltic Pipe project.
VIR3050_Cable_N_SSS_0180	Anchor shaped anomaly, difficult to see clearly as it is located in a slight depression. The ring, stock and shank are visible but the flukes cannot be seen. There appears to be no previously known cultural historical objects within close proximity.
VIR3050_Cable_N_SSS_0192	Well preserved stock anchor. Previously observed in the Baltic Pipe project and registered with Fund og Fortidsminder (system number 245609)
VIR3050_Cable_N_SSS_0268	Possibly previously large unknown anchor or two perpendicular linear objects.
VIR3050_Cable_N_SSS_0291	Possible anchor. Anchor shaped anomaly but not much distinction.
VIR3050_Cable_S_SSS_0025	Possible anchor, with hoop towards the southern end and possible arms to the north.
VIR3050_Cable_S_SSS_0047	Not visible in the SSS or MBES data but there is a chain or rope leading from this point which has the characteristics of being attached to an anchor.
VIR3050_Cable_S_SSS_0065	Distinct anchor shaped anomaly. Not related to any known CHOs.
VIR3050_Cable_S_SSS_0066	Possible anchor, not visible in the SSS data but an anchor shaped anomaly appears in the MBES data and there appears to be a chain or rope related to this object (VIR3050_Cable_S_SSS_0067).
VIR3050_Cable_S_SSS_0077	Anchor, possibly standing at a slight angle on the seabed. Not related to any previously known CHOs.

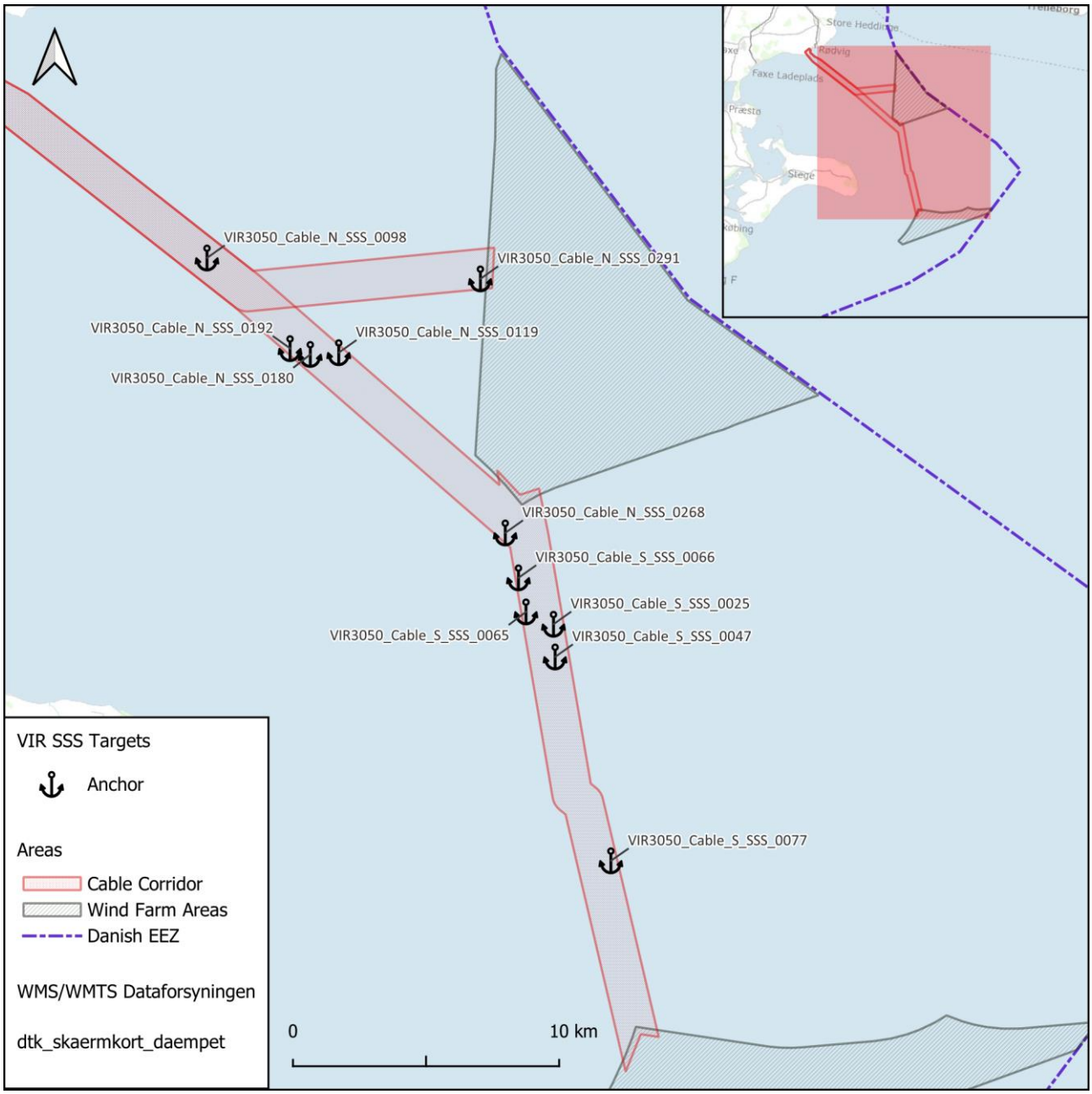

Figure 17. Location of potential anchors within the Kriegers Flak II Cable Corridor. Illustration: John Howorth ©Vikingeskibsmuseet. (CC BY 4.0) Contains data from Klimadatastyrelsen.

Mounds

There is a total of 8 targets categorised as *mound* within the Kriegers Flak II Cable Corridor (Table 11 and Figure 18). None of the mounds correlate with any previous records of wrecks or MAG anomalies. VIR3050_Cable_N_SSS_0320 is located around 300 m outside the eastern extent of the northern branch of the cable corridor which leads to KFII North, it is however within the KFII North wind farm area.

Table 11. List of targets categorised as mounds in the Kriegers Flak II Cable Corridor.

VIR3050_Cable_N_SSS_0077	Boat shaped mound. Possible wreck.
VIR3050_Cable_N_SSS_0086	Potential ballast mound or buried object.
VIR3050_Cable_N_SSS_0134	Potential ballast mound.
VIR3050_Cable_N_SSS_0151	Potential ballast mound.
VIR3050_Cable_N_SSS_0159	Potential ballast mound.
VIR3050_Cable_N_SSS_0284	Sub-rectangular mound. Possible ballast mound or buried wreck.
VIR3050_Cable_N_SSS_0320	Possible buried ballast pile or wreck.
VIR3050_Cable_S_SSS_0126	Small mound, possible buried object or ballast pile, close to linear object VIR3050_Cable_S_SSS_0125.

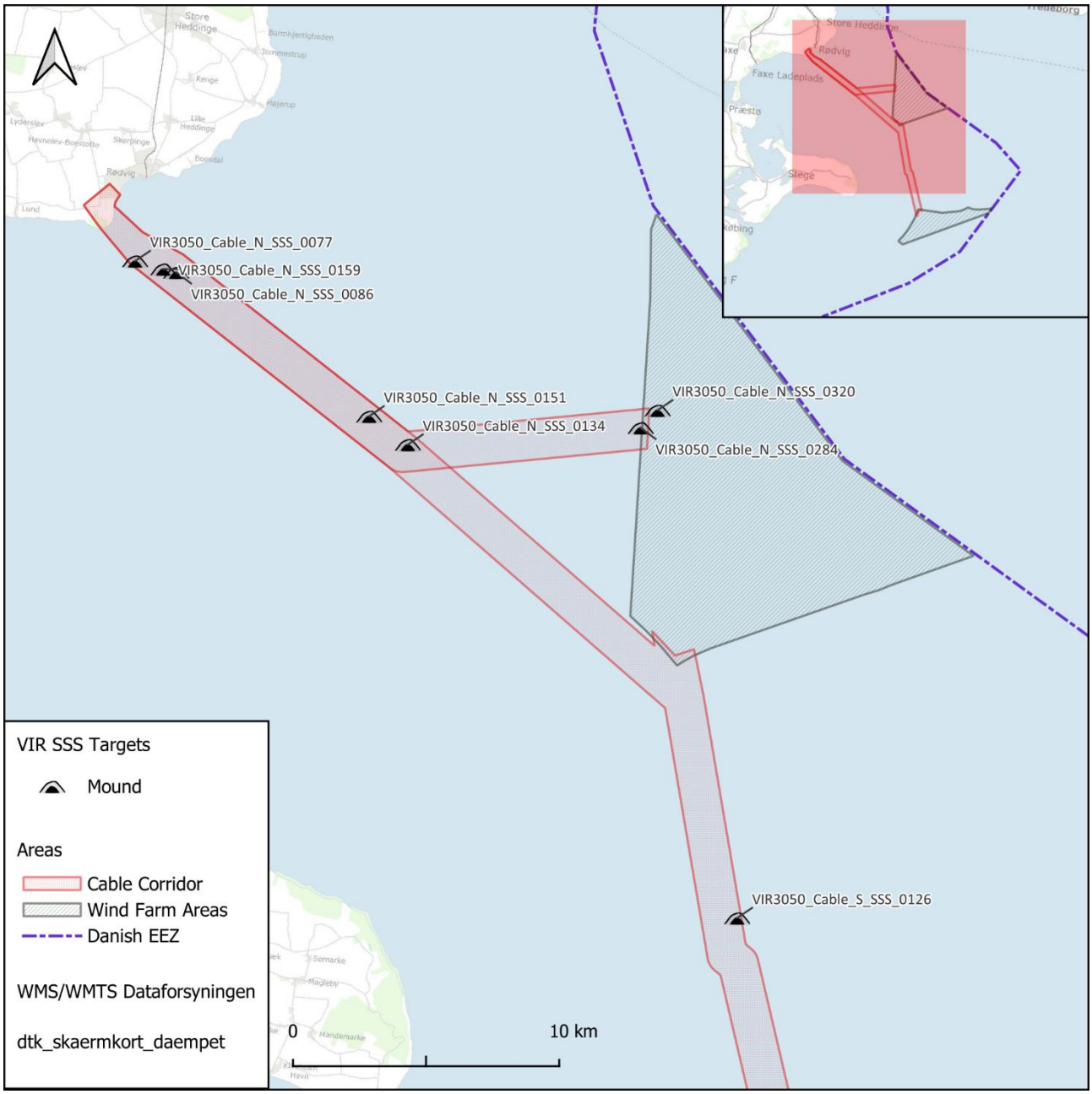

Figure 18. Location of targets categorised as mound within the Kriegers Flak II Cable Corridor. Illustration: John Howorth ©Vikingeskibsmuseet. (CC BY 4.0) Contains data from Klimadatastyrelsen.

Hollow Contour

There is one target categorised as *hollow contour* within the cable corridor, VIR3050_Cable_N_SSS_0238. This appears as a large oval shaped disturbance on the seabed and is potentially the remains of a partially buried shipwreck.

Linear Objects

The largest target category is *linear object* (including *linear (angled)* and *linear (no height)*), it is important that any linear objects likely to be affected by construction work are investigated further to evaluate their significance. The importance of investigating linear objects has been discussed in the section for Kriegers Flak II North and can be found in Appendix 4.

Several linear objects from Kriegers Flak II correspond with targets which were found to be wooden posts used in pound net fishing in the Kriegers Flak I project (SSS7, SSS15, SSS16, SSS17) (Figure 19). These linear objects can be seen in Table 12.

Table 12. Linear objects which are likely to be poles from pound net fishing.

Name	UClass1	Easting	Northing	MapProj	Kriegers Flak I Number
VIR3050_Cable_N_SSS_0003	Linear Object	332976,81	6124213,77	EPSG:25833	SSS16
VIR3050_Cable_N_SSS_0005	Linear Object	332926,51	6124227,05	EPSG:25833	SSS16
VIR3050_Cable_N_SSS_0015	Linear Object	332884,81	6124233,06	EPSG:25833	SSS16
VIR3050_Cable_N_SSS_0016	Linear Object	332891,34	6124229,33	EPSG:25833	SSS16
VIR3050_Cable_N_SSS_0017	Linear Object	332889,53	6124232,6	EPSG:25833	SSS16
VIR3050_Cable_N_SSS_0018	Linear Object	332879,97	6124204,44	EPSG:25833	SSS16
VIR3050_Cable_N_SSS_0072	Linear Object	333194,71	6124007,82	EPSG:25833	SSS15
VIR3050_Cable_N_SSS_0075	Linear Object	333048,74	6123993,26	EPSG:25833	SSS7
VIR3050_Cable_N_SSS_0084	Linear Object	333061,02	6124014,74	EPSG:25833	SSS7

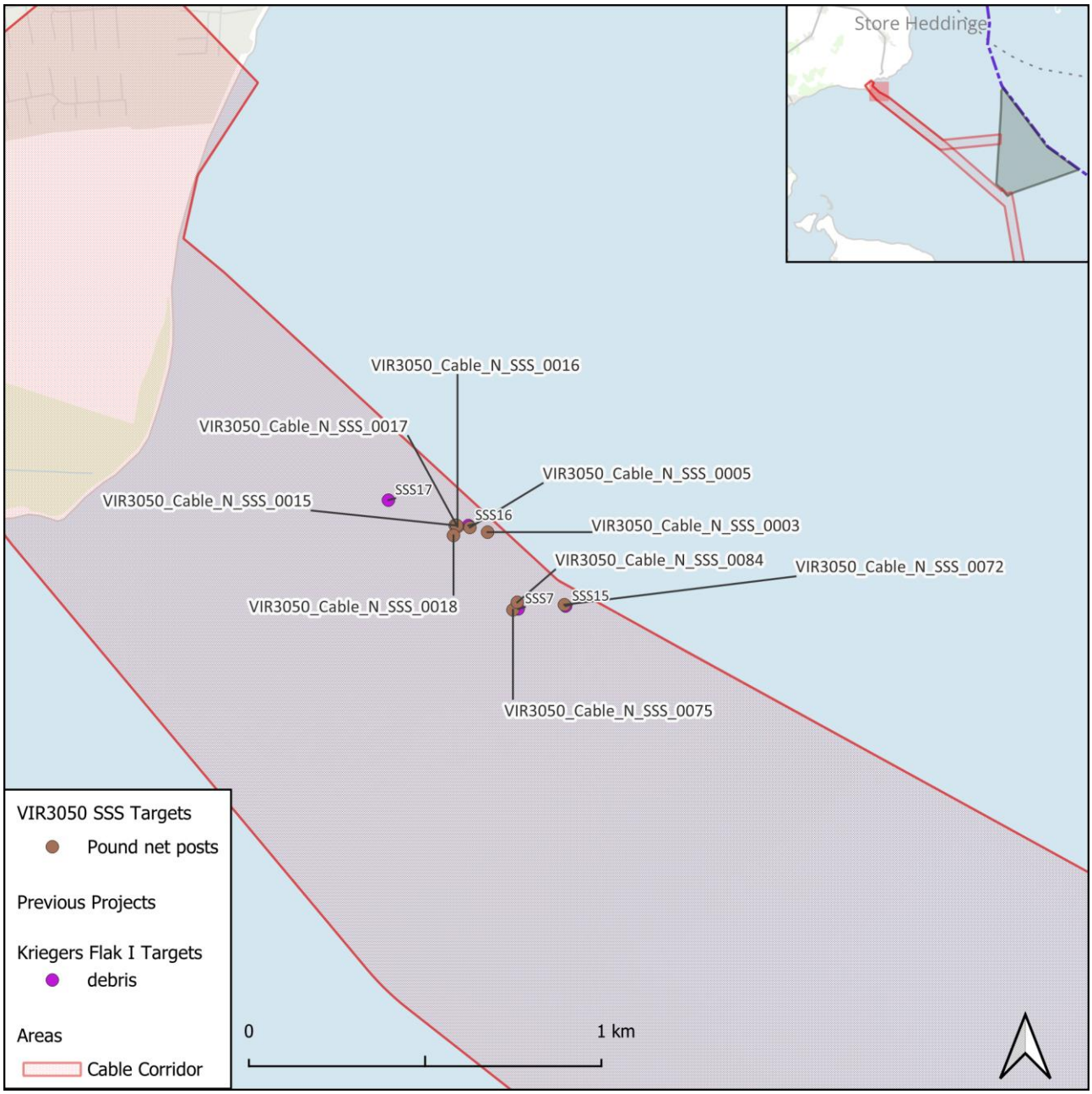

Figure 19. Linear objects from the current survey which correspond with areas of debris found to be wooden posts used for pound net fishing in the Kriegers Flak I cable corridor. Illustration: John Howorth © Vikingeskibsmuseet. (CC BY 4.0) Contains data from Klimadatastyrelsen.

Stone-Age Potential

The potential to find stone-age human activity within the windfarm areas and cable corridor depends on two factors: the depth of the seabed and conditions for preservation.

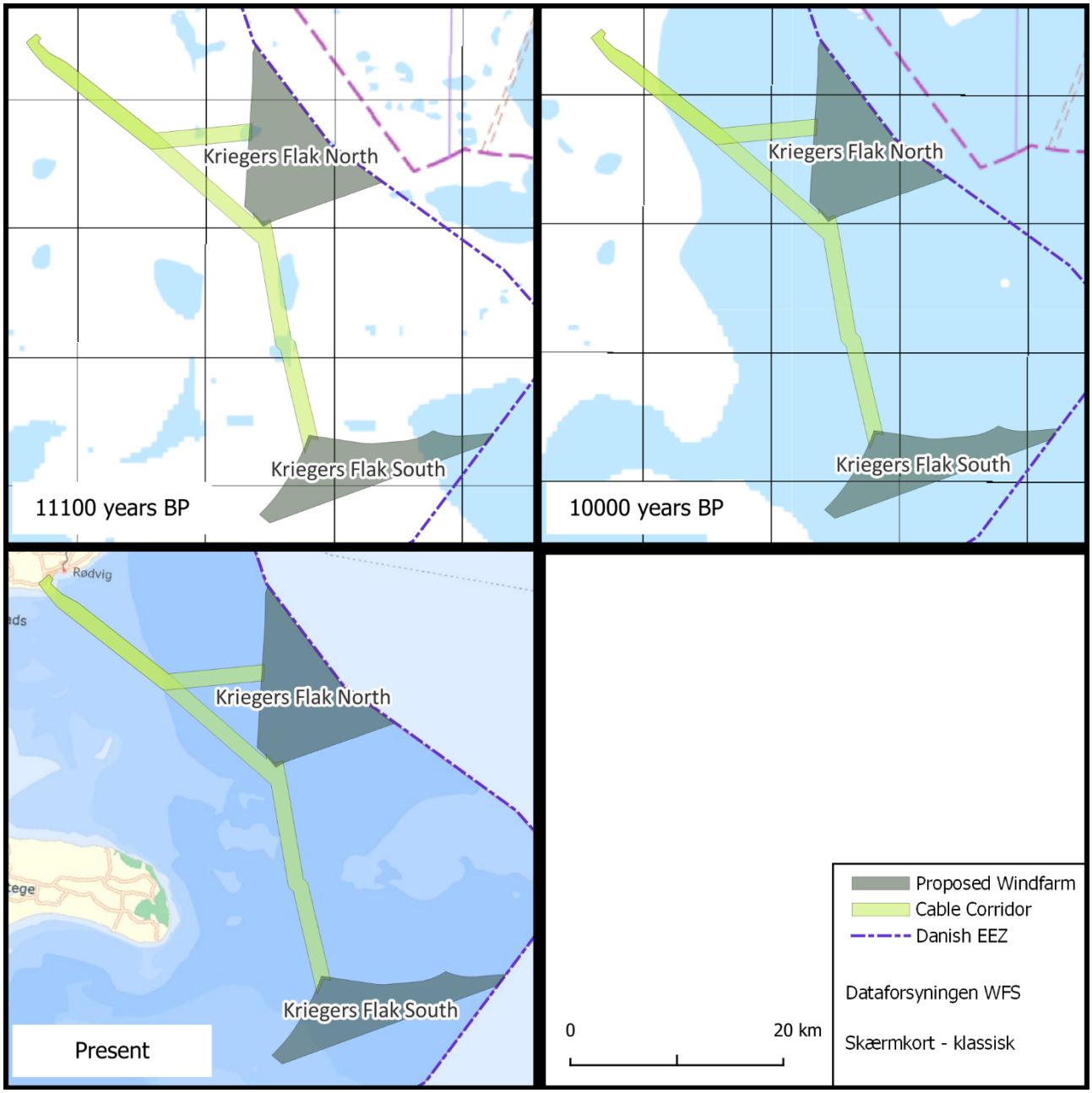

Figure 20. Shore displacement from 11100 years BP to 10000 years BP and present shoreline. The white areas in the first two images represent dry land. The images use data acquired from the Geological Survey of Sweden's (SGU) shore displacement model. It should be noted that he model is designed for the Swedish coastline and therefore this is for illustrative purposes rather than an accurate representation. (See Methodology earlier in this report.) Illustration: John Howorth © Vikingeskibsmuseet. (CC BY 4.0) Contains data from Klimadatastyrelsen.

The geological history of the Baltic Sea is complex and the water levels in the area fluctuated after the initial deglaciation of the area approximately 16000 to 15000 years BP due to a combination of rising water levels, isostatic rebound, and periodic damming of the lake by ice (Jensen & Bennike,

2022). There were two periods of lowstand water levels following deglaciation. The water levels were at their lowest in the second of these periods at around 11000 years BP, which correlates with the end of the Palaeolithic and beginning of the Mesolithic period. At this time, the water levels were between 35 and 40 m below current sea level. This would mean that most of the wind farm areas and associated cable corridor would have been dry land at this time, only the deepest areas towards the eastern side of Kriegers Flak II South may have remained submerged (Figure 20). It is possible that settlements may have been present along the coastline and at the edge of lakes during this period. The period of lowstand did not last long until water levels rose rapidly again and, by 10000 years BP, the areas for the windfarms and most of the cable route would have been inundated (Figure 20).

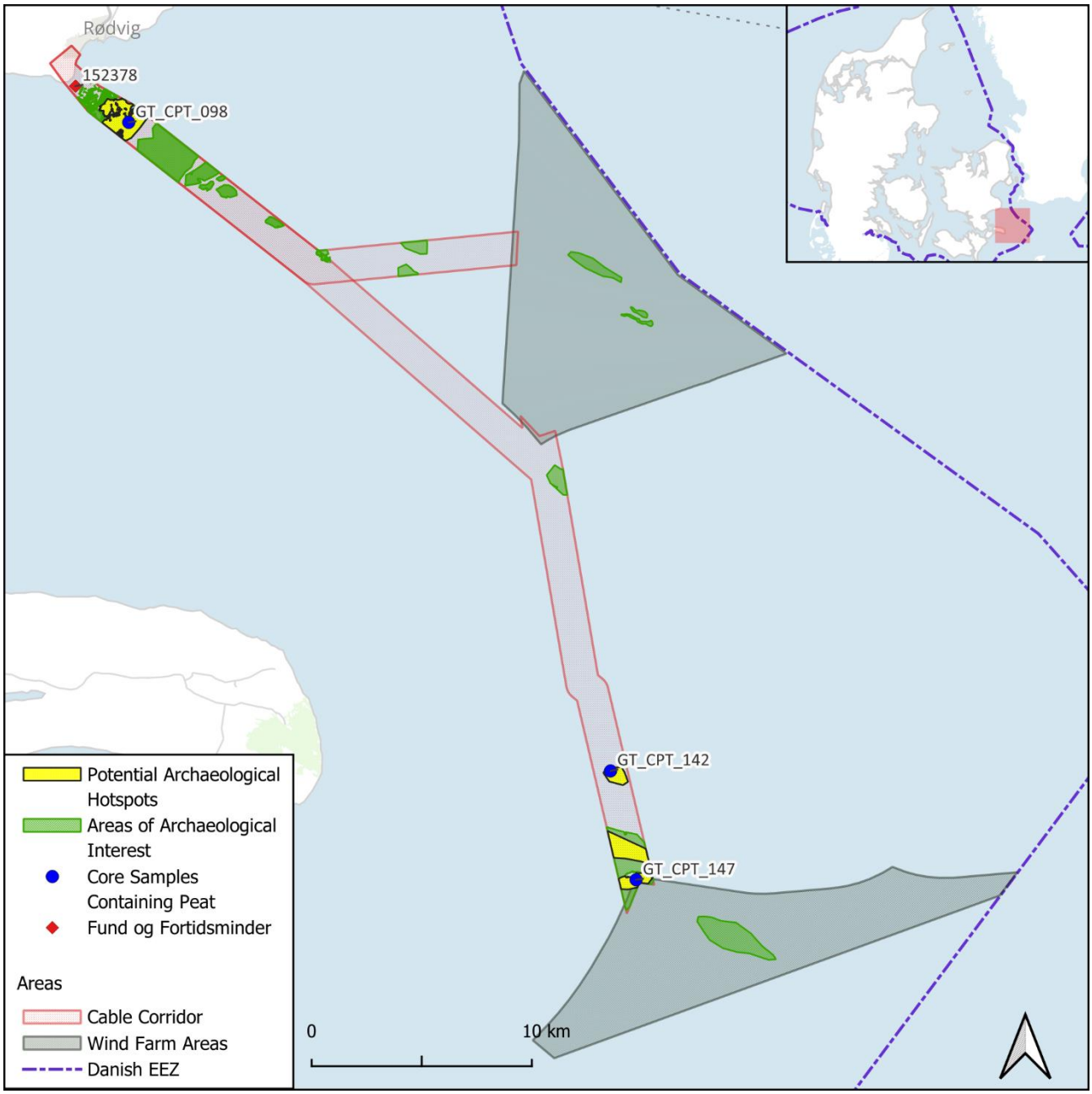

Figure 21. Areas of archaeological interest, potential hotspots and location of three core samples containing peat layers. Illustration: John Howorth © Vikingeskibsmuseet. (CC BY 4.0) Contains data from Klimadatastyrelsen.

Areas of stone age potential have been chosen on the basis of the thickness of post-glacial deposits and their depth below sea level. Any part of the seabed which is interpreted as exposed till/diamicton or quaternary clay has been omitted from areas of stone age potential, due to a lack of a protective covering for potential prehistoric remains. Two classifications have been used for areas of stone age potential; Areas of Archaeological Interest and Potential Archaeological Hotspots.

Areas of Archaeological Interest are broad areas based on the available sub-bottom profile data and seabed sediment mapping. Due to the resolution and accuracy of this data, these boundaries could change if/when further physical investigations are carried out such as machine dug test pits and/or diver inspection.

Potential Archaeological Hotspots lie within the Areas of Archaeological Interest. These areas have very thick post-glacial deposits and/or core samples containing layers of peat and have a higher likelihood for surviving archaeological layers (Figure 21). The boundaries of these 'hotspots' could also change if/when physical investigations are carried out due to the accuracy and resolution of the available seismic data.

Wind farm areas

Preservation of possible Mesolithic sites in the wind farm areas is not expected to be good. The wind farm sites and the parts of the cable corridor farthest from land are exposed to a long fetch and high energy environment (Jensen & Bennike, 2022) which will disturb and redeposit any possible archaeology. The depth of the seabed below current sea level at both sites limits the possibility of finding remains of human settlement as the land areas would have been flooded relatively soon after the retreat of the ice field.

Both wind farm sites have areas of post glacial deposits which reach a thickness of 2 m and over (Figure 22). In KFII South, the thickest deposits are located towards the east which is an area that is deeper than the expected limit for finding evidence for prehistoric settlement therefore these have been omitted from archaeological areas of interest. A second area of thick sediment is located towards the centre of the site and it may be possible that these deposits cover archaeological layers.

In KFII North, the thickest deposits are found towards the centre of the site and appear to have formed on the eastern side of a shallow dip in the post-glacial topography, there is a possibility that these sediments are covering archaeological layers. To the southeast of these layers are the remains of possible submerged paleochannels which also contain thick post-glacial deposits. These have also been included in the areas of archaeological interest due to the potential for the siting of Mesolithic settlement along the edges of bodies of water.

A potential stone "structure" type anomaly was observed in the SSS data in Kriegers Flak II North (VIR3050_N_B02_SSS_0029) which consists of two almost parallel lines of boulders which eventually taper to a point towards the west and open out towards the east (Figure 25). The seabed at this point is very exposed with only an approximately 20 cm thick sediment above the glacial deposits and there are therefore no other related features. It is difficult to see in the SSS data whether these boulders are purposefully placed or are a result of trawling. Further investigation may provide clarification.

Cable Corridor

The northwesternmost part of the cable corridor is expected to have the most potential for preserved stone-age archaeology. This area is in the shallowest water and was therefore dry land for a longer

period and the shorelines were not as rapidly inundated by rising sea levels. The northwesternmost parts are also sheltered from the long fetch and high energy environment to which the wind farm areas are subjected, this means that the preservation of archaeological layers is likely to be better. During the Baltic Pipe archaeological investigation (Jonsson & H. Thomsen, 2022), preserved tree stumps and evidence for a more extensive forest environment was found on the seabed in Faxe Bay suggesting good conditions for the preservation of archaeological material. It is possible that some of the SSS targets in the north-western parts of the cable corridors could also be prehistoric tree remains. Furthermore, a record in Fund og Fortidsminder, system number 152378, refers to a number of flint tools which were recovered close to Rødvig during aggregate extraction work over two decades between 1955 and 1975 (Figure 21). Although there is no specific location attached to these finds, their presence is evidence for prehistoric human activity in the area close to the current coastline.

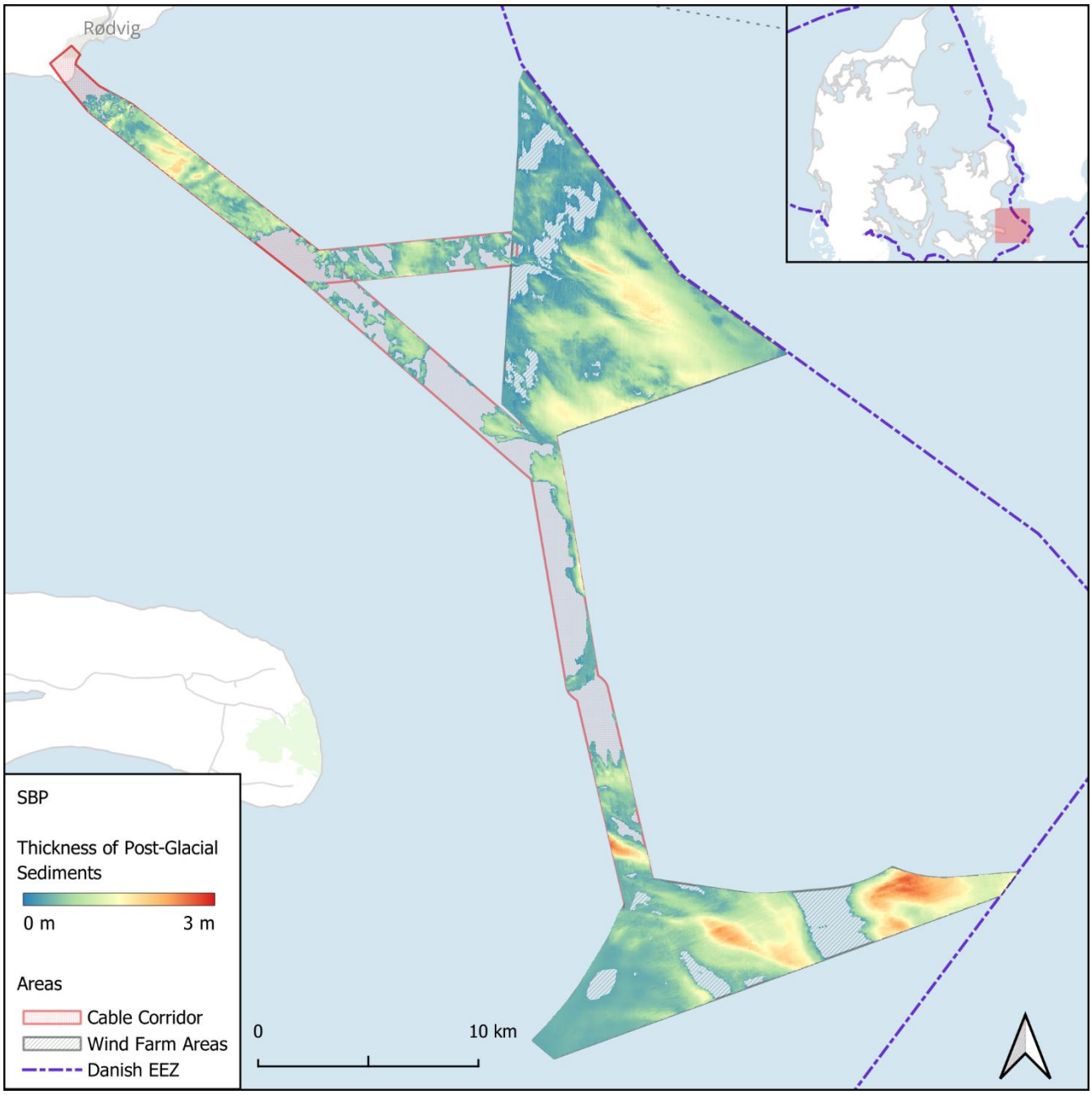

Figure 22. Thickness of post-glacial sediments in Kriegers Flak II North and South and associated cable corridor. Illustration: John Howorth © Vikingeskibsmuseet. (CC BY 4.0) Contains data from Klimadatastyrelsen.

For the first kilometre along the cable corridor from landfall, there is no available SBP data. According to the report (Screening of seabed geological conditions for the offshore wind farm areas Kriegers Flak II North and Kriegers Flak II South (Jensen, Bennike, & Leth, 2023)), there is an outcropping of Upper Cretaceous chalk close to landfall. In the Danish Offshore Wind 2030 Cable Route Survey (GEOxyz, 2024), this outcrop is shown to be within the first kilometre from land (Figure 23). This area is therefore unlikely to yield any prehistoric archaeology. The seabed geology for the remainder of this area, is mainly made up of glacial till with smaller areas of post-glacial sand and gravel. The areas of till have been excluded from the areas of archaeological interest.

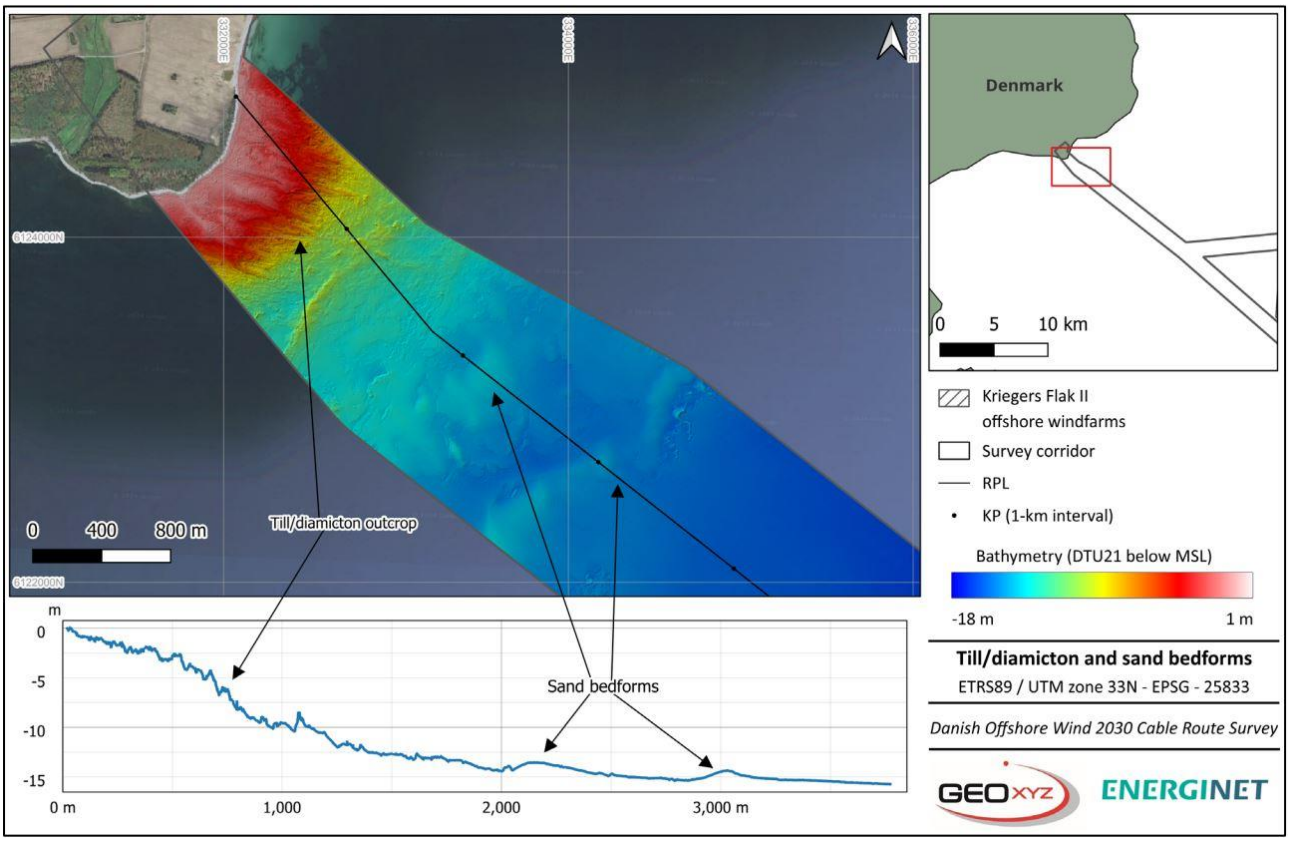

Figure 23. Image showing the areas of rock outcrop and till/diamicton in the first 1 km from landfall. Illustration taken from Danish Offshore Wind 2030 Cable Route Survey: Kriegers Flak II - Cable Route Integrated Report (GEOxyz, 2024).

During the Kriegers Flak I investigations, several test pits were excavated within the first 3.5 km of the coastline. The sediments in these test pits were found to be very thin due to erosion of the seabed (H. Thomsen, 2018). As can be seen in Figure 24, the test pits from Kriegers Flak I are mostly located outside the areas of archaeological interest highlighted in this report. The thicker deposits highlighted as ‘hotspots’ and ‘interest areas’ away from the former test pits may contain archaeological material.

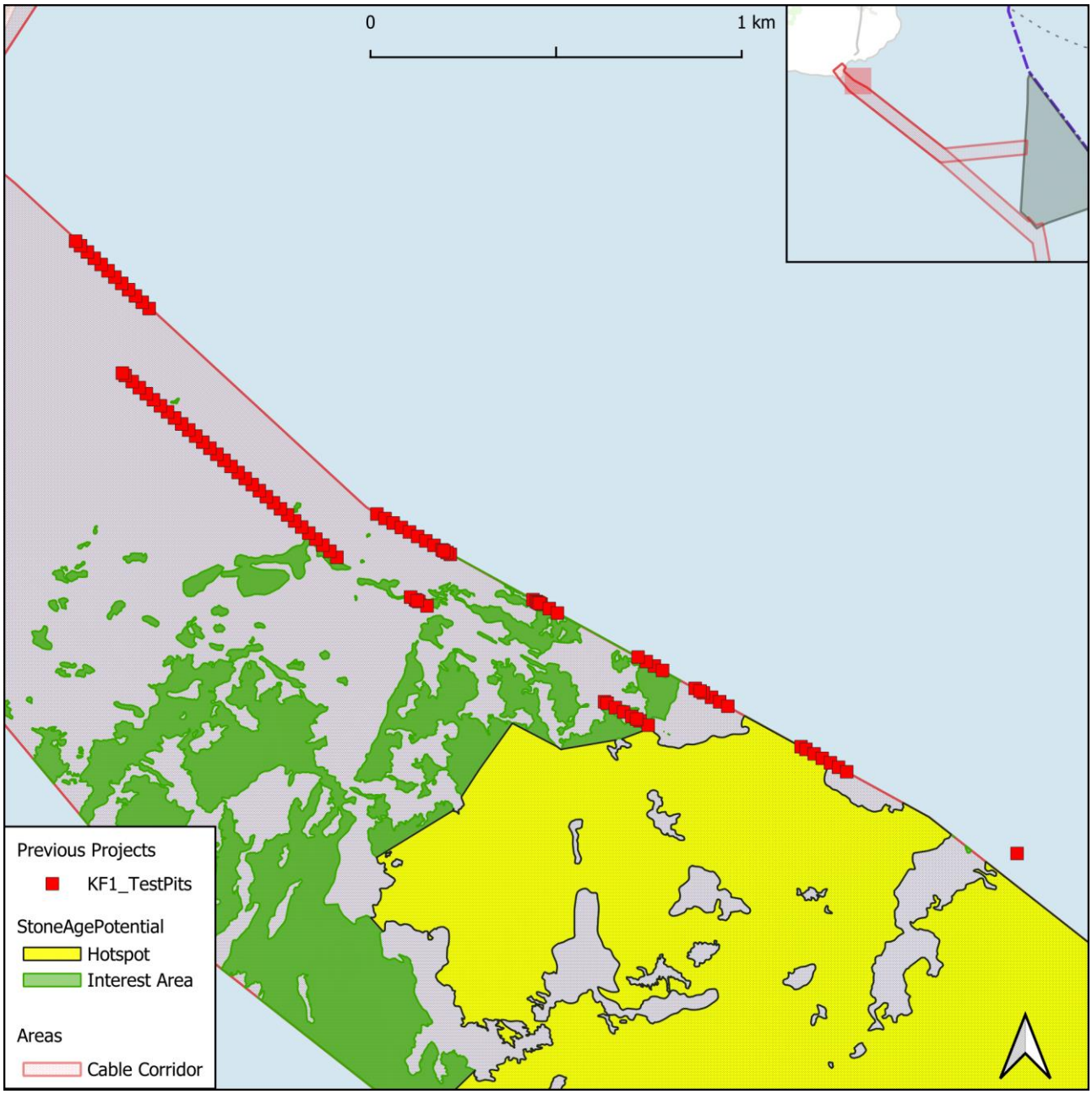

Figure 24. Archaeological test pits from the Kriegers Flak I cable corridor. The vast majority of these are outside the areas highlighted as areas of archaeological interest

Several organic/peat layers culminating in a mixture of peat and gravel were found lying just above the glacial sediments within a vibrocore sample (GT_VC_098a) taken approximately 3 km from the current coastline (Figure 26). The gravel was found to contain several pieces of flint but none could be definitively identified as manmade. A well-preserved pine cone was also recovered from this layer, further evidence for the forest which once covered the area within Faxe Bay. These types of layers are often indicative of buried beach deposits or material washed out from former shorelines. Radiocarbon dating analyses on plant material from this sample have given dates of 10586 – 10405 BP for the upper subsample and 11251 – 11190 BP for a subsample approximately 0.5 m lower. These dates would potentially place these deposits close to the shoreline at the time. The SBP data only shows a thin covering of post-glacial deposits around GT_VC_098a, however, there are over 3 metres of post-glacial sediments within the sample itself. Samples are a more accurate and reliable source for sub-bottom sediments and the area around the sample has therefore been included in the areas of archaeological interest and is a possible hotspot.

Several areas along the cable corridor have been highlighted as areas of interest due to thick post-glacial deposits. The thickest deposits appear at the southernmost part of the cable corridor (Figure 22) and a core sample close to this area (GT_VC_147) contained a thin organic layer and layers of gravel which may indicate washed out material. This area has therefore also been highlighted as an area of interest and possible hotspot (Figure 21).

A further sample, GT_VC_142, also contained a thin layer of peat and was taken from an area with thick post-glacial sediments (Figure 21). Radiocarbon dating dates the deposit as c. 11000 BP – 10500 BP, around the time that this area was in transition from dry land to water. This area has also been highlighted as a possible hotspot.

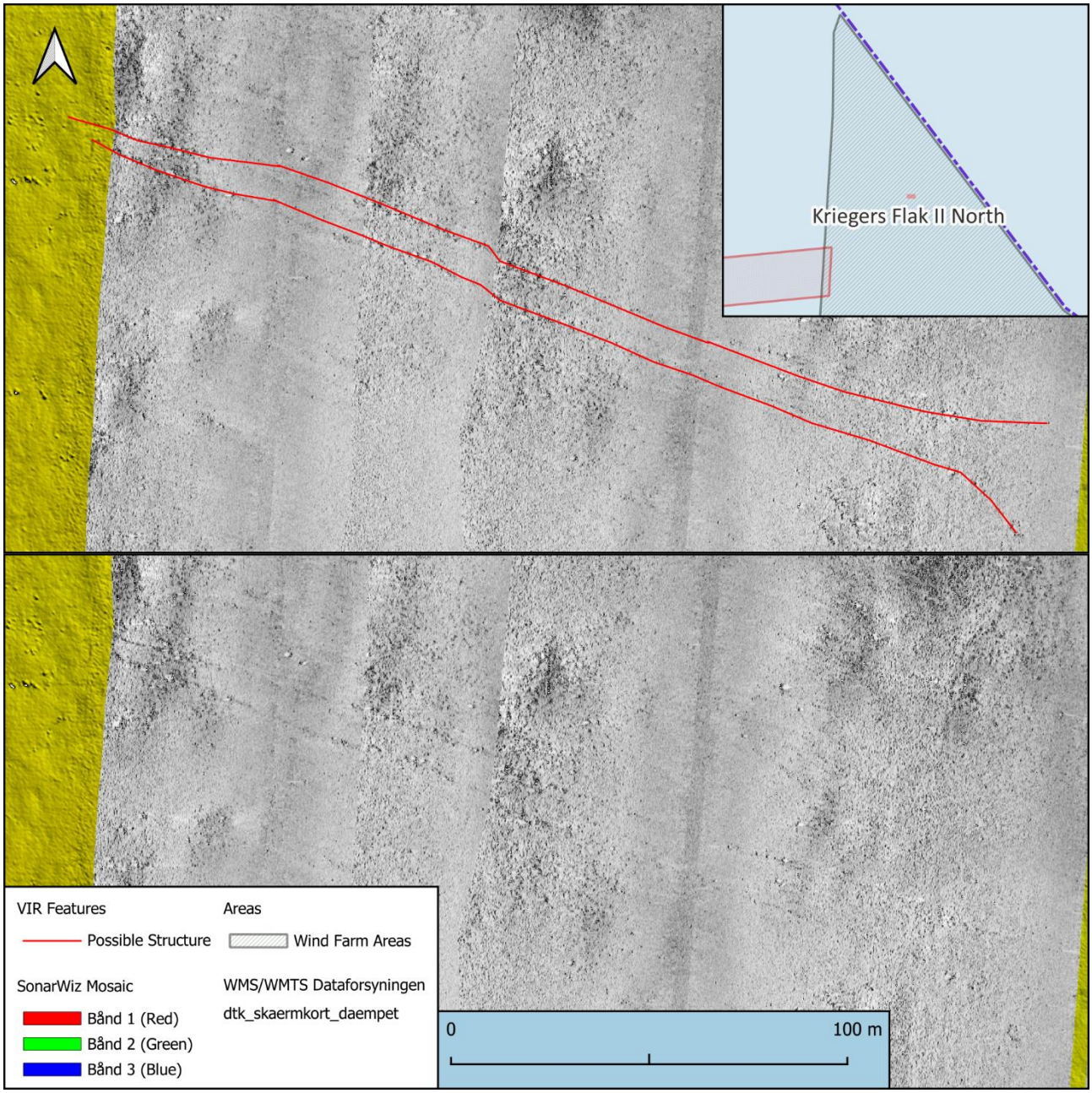

Figure 25. Possible structure formed from two almost parallel lines of boulders on the seabed. Comparison of image with (above) and without (below) highlights. Illustration: John Howorth © Vikingeskibsmuseet. (CC BY 4.0) Contains data from Klimadatastyrelsen.

Figure 26. Vibrocore sample, GT_VC_098a. An image of a very organic and gravel layer located just above the glacial deposits. Image: John Howorth © Vikingeskibsmuseet.

Future Work

All the SSS and MBES targets for the Kriegers Flak II wind farm areas and associated corridor cable are filed in a single GIS file:

VIR_SSS _KriegersFlakII

The GIS file corresponds to Appendix 2 in this report.

In accordance with the most recent guidelines from the Danish Agency for Culture and Palaces (*Slots- og Kulturstyrelsen*), no initial exclusion zones have been created around any of the targets as it is unclear as to whether they are culturally significant.

All SSS targets mentioned in this report which are within, and in close proximity to, the proposed wind farm areas and cable corridor should be visually inspected by ROV and the footage screened by archaeologists from VIR in order to further assess their significance. Targets which, through further investigation, are positively identified as CHOs, will be reported to the National Sites and Monuments register (*Fund og Fortidsminder*). A definitive exclusion zone can then be created around any protected archaeological objects. Future construction work can then be planned around these exclusion zones. A full description of the methods and motives for picking out potential CHOs from SSS data can be seen in Appendix 4.

Despite best efforts to account for all possible CHOs within the SSS data, it is possible that some objects may have been obscured, especially in areas with extensive vegetation or a high percentage

of boulders on the seabed. Likewise, the assessment of stone age potential was carried out based on SBP data to highlight areas of thick post-glacial sediments and core samples to locate areas containing peat, these methods only give a probability of finding archaeology, it is still possible that stone age archaeology could be encountered elsewhere within the Kriegers Flak II wind farm areas and associated cable corridor. It is therefore possible that archaeological objects could be unexpectedly encountered during future work. If this occurs, work should cease and the findings must be immediately reported to the Danish Agency for Culture and Palaces (Slots- og Kulturstyrelsen).

Where any planned construction work crosses into the areas of archaeological interest (Figure 21), further archaeological investigations should be carried out. These investigations could consist of machine dug test pits and/or diver inspection in order to pinpoint any potential evidence for human activity such as settlements or constructions.

If the client's work cannot be carried out due to an exclusion zone or altered to avoid CHOs, special dispensation can be sought. This dispensation would typically state that a marine archaeological survey or excavation would need to be carried out on the site.

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Appendices available on request from The Viking Ship Museum

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