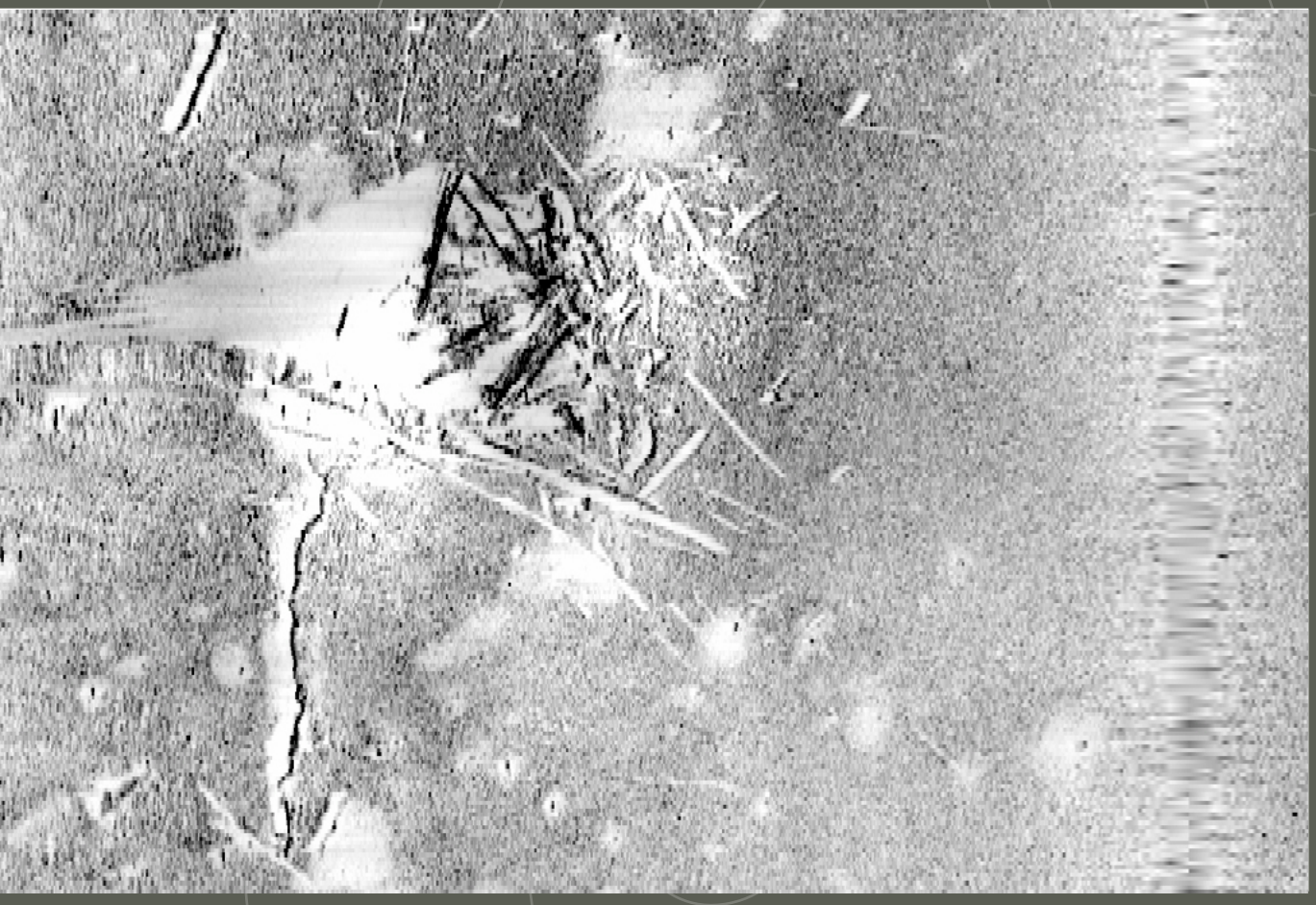
ENERGY ISLAND BORNHOLM

Geoarchaeological Analysis of Energy Island Bornholm Wind Farm Bornholm I

VIR 2937



John Howorth

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July 2023

Cover illustration: Sidescan sonar image SSS_BH1C_B05_0007. © Vikingeskibsmuseet.

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VIR 2937

ENERGY ISLAND BORNHOLM

WIND FARM BORNHOLM I (BH1)

STED- OG LOK. NR. 401751-142

Geoarchaeological Analysis of Energy Island Bornholm – Wind Farm Bornholm I (BH1)

Contents

List of Appendices

1. VIR SSS target reports
    a. Wrecks
    b. Anchors
    c. Mounds
2. VIR SSS target summary
3. Bornholm I Overview map
4. SLKS Marinarkæologisk process

Abstract

Energinet has requested that the Viking Ship Museum (VIR) identify potential cultural historical objects (CHOs) located at the planned wind farm sites and related cable routes of the Energy Island Bornholm. This report covers the western wind farm: Bornholm I, or BH1 for short.

The Viking Ship Museum has identified a number of possible CHOs on the seabed in the geophysical data, including 19 potential wrecks, 2 potential anchors and 24 mounds, plus one so-called "*mound-no-height*". Moreover, the paleo-terrain that best represents the terrain during the Late Palaeolithic and Early Mesolithic, between c. 9400 BC and 8400 BC, was analysed and a number of potential settlement 'hotspots' were highlighted.

Dansk resumé

Energinet har anmodet Vikingeskibsmuseet (VIR) om at identificere potentielle kulturhistoriske objekter (CHOs) i den planlagte Vindmøllepark *Bornholm Energiø* og dens kabelkorridorer i Østersøen. Nuværende rapport dækker den vestre vindmøllepark: Bornholm I eller BH1.

Vikingeskibsmuseet har identificeret et antal potentielle kulturhistoriske objekter, heraf 19 potentielle vrag, 2 potentielle ankre, 24 "mound" og en enkelt "mound with-no-height" (bunke, bunke uden højde). Desuden er et palæo-terræn, tolket som den bedste repræsentation af terrænoverfladen i sen Palæolitikum, tidlig Mesolitikum mellem ca. 9400 BC og 8400 BC, blevet analyseret og steder udpeget for sandsynlige bosættelses-"hotspots".

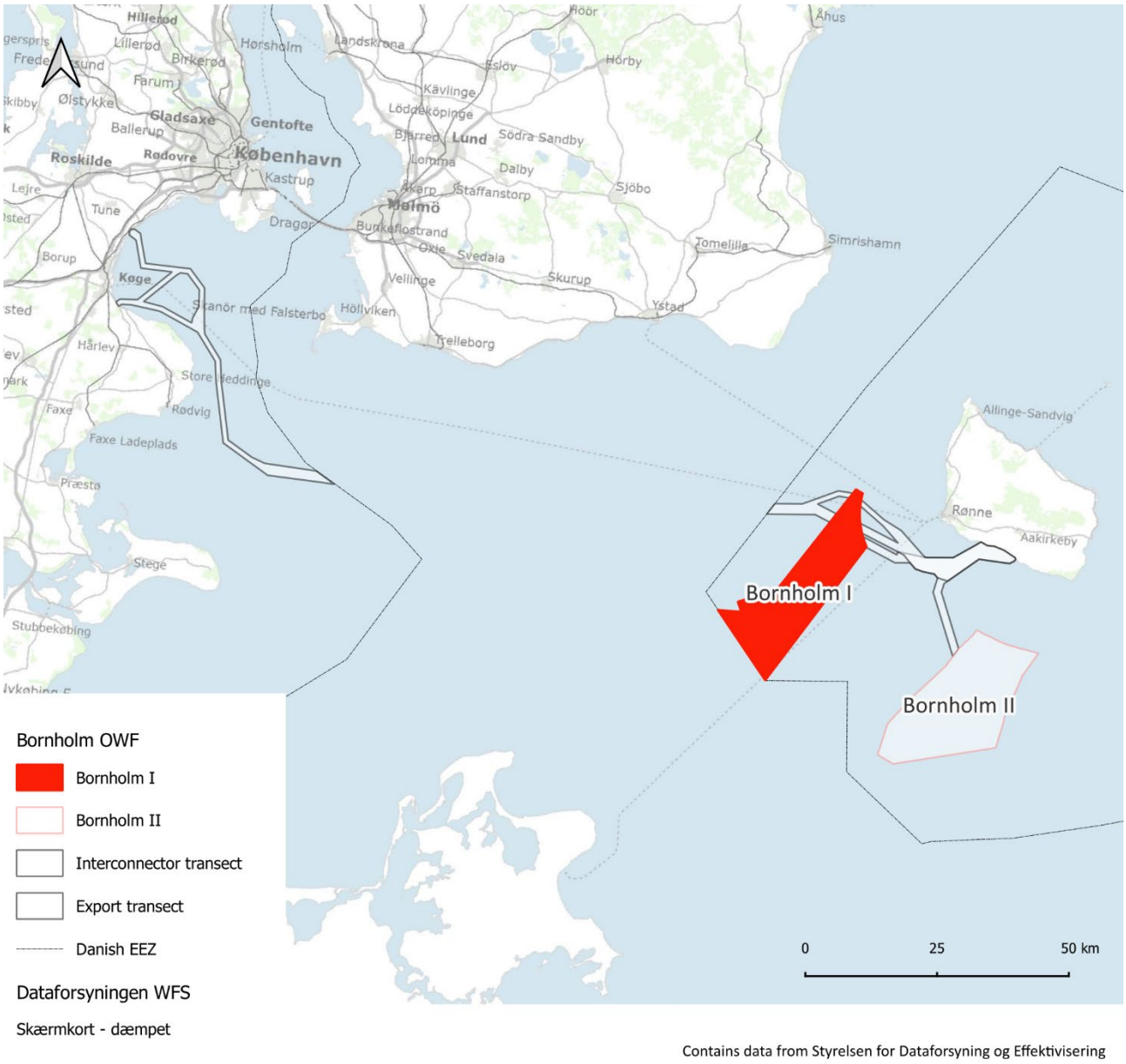

Figure 1. Map showing the areas included in the Energy Island Bornholm. Bornholm I in red. Illustration: Marie Jonsson © Vikingeskibsmuseet.

Introduction

Following a decision by the Danish Parliament in June 2020, Denmark is on the path to establishing offshore energy infrastructure in the Danish North Sea and the Danish Baltic Sea to connect offshore wind energy to the Danish mainland and to neighbouring countries via offshore energy hubs called *Energy Islands*. In the Baltic Sea, the Energy island is the existing island of Bornholm.

Table 1. Abbreviations used in the text

CHO	Cultural historical object	Kulturhistorisk objekt
DMA	Danish Maritime Authority	Søfartsstyrelsen
EEZ	Exclusive Economic Zone	Eksklusiv økonomisk zone
FF	Danish national registry of CHO finds	Fund og Fortidsminder
GIS	Geographical information system	Geografisk informationssystem
HF	High frequency	Højfrekvent
LF	Low frequency	Lavfrekvent
MAG	Magnetometer, magnetic	Magnetometer, magnetisk
MBES	Multibeam echo sounder	Flerstråleekkolod
MMO	Man-made object	Menneskeskabt objekt
ROV	Remotely operated vehicle	Fjernstyret undervandsfartøj
SBP	Sub-Bottom Profile	
SSS	Sidescan Sonar	Sideseende sonar
VIR	Viking Ship Museum, Roskilde	Vikingeskibsmuseet i Roskilde
WGS 84	World geodetic system 1984	

Project data

The BH1 Sidescan Sonar (SSS) data screening was completed at the Viking Ship Museum in Roskilde, Denmark by maritime archaeologists Marie Jonsson, Torben Malm, Staffan Lundblad, and John Howorth.

The entire Energy Island Bornholm project archive is filed at VIR under file no. 2937.

Topography, terrain and geology

The western wind farm, BH1 (Figure 1) lies in water at depths between around 28m to the south and around 47m to the north (Figure 7), with an average depth of around 41m (GEOxyz, 2023). The seabed substrate over the majority of the area is a mix of muddy sand and mud with an area of sand along the eastern edge. There is an area of quaternary clay and silt towards the north-eastern side and some relatively small areas of gravel and coarse sand on the very eastern limit (Figure 2).

Bornholm is in a part of the Baltic Sea that has been an important and busy shipping channel throughout history, so there is a likelihood of a high number of maritime CHOs in this area.

Parts of the Baltic Sea were dry land during the Mesolithic period. However, even at its lowest level at around 11700 years BP, the water was 40 to 45 metres below current levels meaning that large parts of the BH1 area will always have been submerged by the time human habitation began (Jensen

& Bennike, 2021). There was a relatively rapid rise after the lowstand water period and areas below 15m in depth were likely only dry land for a relatively short time. Gravel and coarse sand are found in some of the shallower areas towards the south and the east. From previous investigations, it has been found that these types of layers are the most likely to contain preserved evidence for Mesolithic human activity.

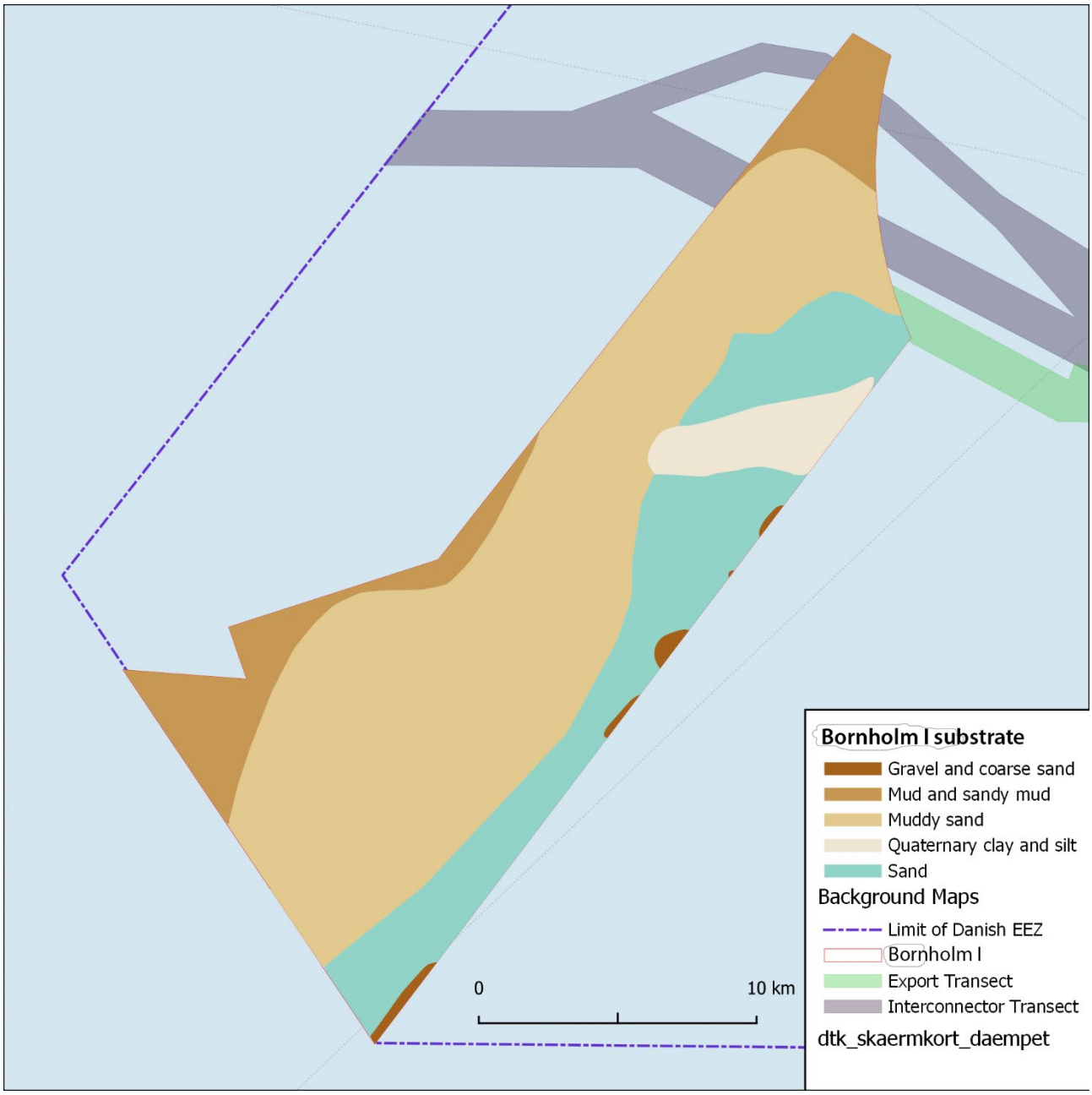

Figure 2. Seabed substrate in the western wind farm area, BH1. Illustration: John Howorth ©Vikingeskibsmuseet. Contains data from Styrelsen for Dataforsyning og Effektivisering (dtk_skærmkort_dæmpet) and data from EMODnet © European Union, 2022. Data collated by GEUS.

Coordinate system

The present report and associated digital files archived at VIR use the coordinate system: UTM zone 33N, WGS 84, unless otherwise specified.

Methodology

Using Sonarwiz (v.7.10) software, all the High Frequency (HF) SSS data for the BH1 wind farm site was screened and potential archaeological targets were selected based on their shape and size, and the potential for being a CHO. The target was then checked for matching anomalies in other datasets:

- The surveyor's SSS targets.
- The surveyor's Magnetic (MAG) anomalies.
- Danish national registry of CHO finds *Fund og Fortidsminder* (FF) (https://www.kulturarv.dk/ffreg/).

Targets were then exported to a mapping project in QGIS (v.3.28.4 – Firenze), where further matches were made from the following records:

- Søfartsstyrelsens vragregister – The Danish Maritime Authority's Register for Wrecks.
- 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.
- Vragguiden – Denmark's largest online wreck database for and by recreational divers.
- Nord Stream 1 and 2 – information from the museum's archives, VIR 2545 and VIR 2740.
- Baltic Pipe - information from own archives, VIR 2813.

Furthermore, extra attention has been paid towards any targets that are found within 500 metres of a registered CHO as they may be related which means that the registration can help identify and/or date the target.

Within this report, references made to objects registered with *Fund og Fortidsminder* are preceded with FF followed by the unique *system number*.

Results

A total of 512 targets were identified and geolocated within BH1. Each target was assigned a category, a list of the categories used can be seen below. The vast majority of these are so-called *linear objects*. There is a total of 19 *wrecks*, 2 *anchors* and 25 mounds, which includes 1 *mound with no height* (Figure 3). For more details on locations etc. see appendix 1a-1c.

All targets are potentially CHOs. The different *linear objects* can be wreck parts or cargo. *Debris* can be remains of cargo or broken up wrecks. *Cables* is used collectively for cables, wires and ropes, all of which can be part of wrecks or anchors. These categories are not presented in full below in the same manner as *wrecks*, *anchors* and *mounds*, as this would make a too detailed report. However, all targets are covered in Appendix 2, and should be considered as CHOs until investigated.

List of target categories

Each target category is described below:

Anchor	Anchor/potential anchor
Cable	Cable, chain etc.
Debris	Manmade object, debris
Hollow contour no height	Ship-shaped object without shadow
Linear object	Linear object of certain size and with shadow
Linear angled	Angled linear object, with or without shadow
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
Unknown	Unknown object of noteworthy size and or shape
Wire	Wire or rope
Wreck	Wreck/potential wreck

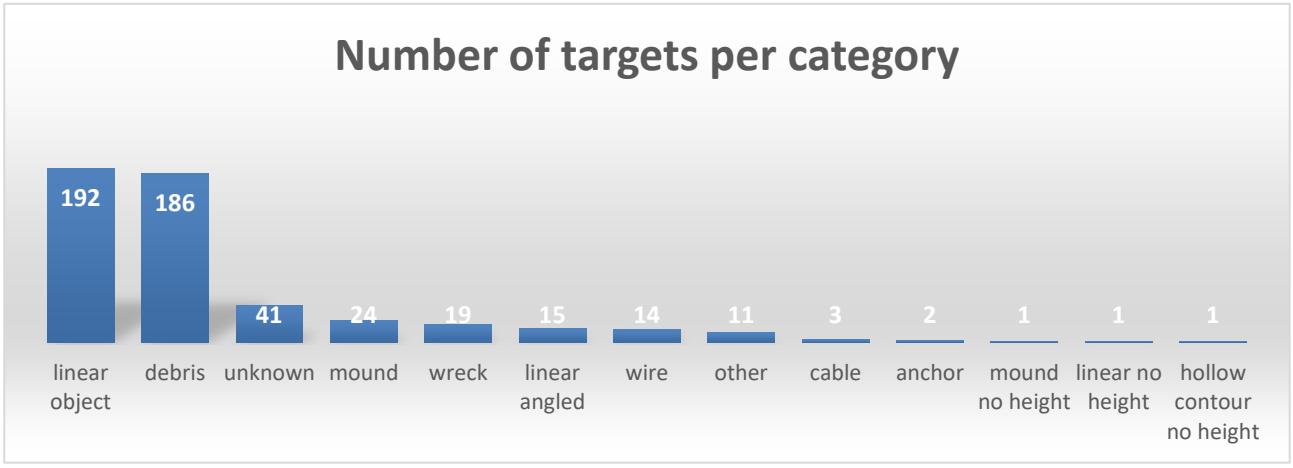

Figure 3. Target categories and number of occurrences.

Wrecks

In total, there are nineteen targets which have been assigned the category of *wreck* (Table 2). As well as potential whole wrecks, the targets represent partial shipwrecks and wreck parts, therefore, when several targets lie in very close proximity to one another, they could be parts of the same wreck. This is illustrated in Figure 4, where there are two areas with three targets each separated by less than 10 metres. One group includes SSS_BH1_BLOCK05_0028, SSS_BH1_BLOCK06_0021 and SSS_BH1_CROSSLINES_0007, and the second group includes SSS_BH1_BLOCK06_0051, SSS_BH1_BLOCK07_0007 and SSS_BH1C_B05_0007.

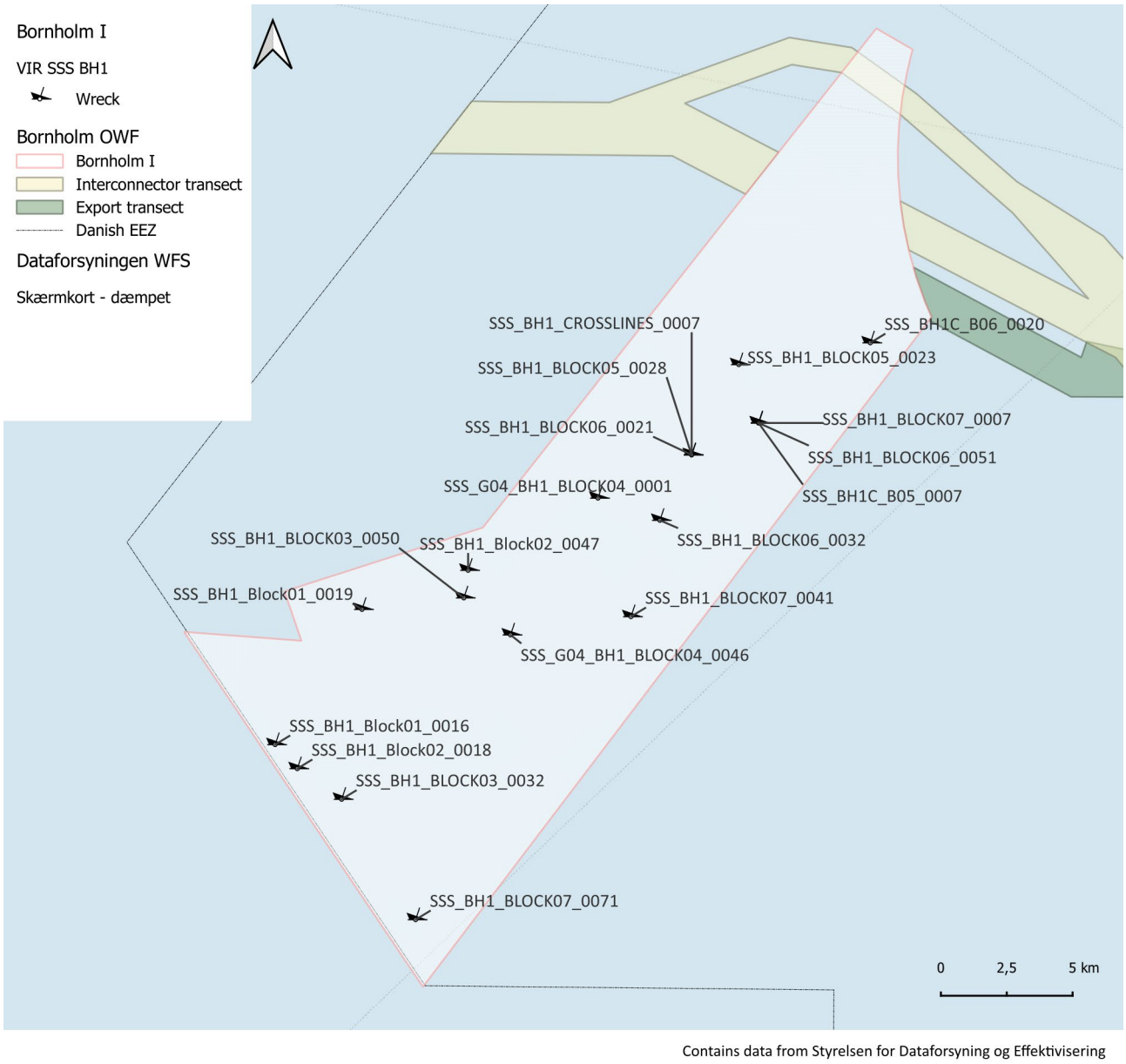

Figure 4. Overview of the location of possible wrecks. Illustration: John Howorth © Vikingeskibsmuseet.

The latter group is described as a shipwreck surrounded by scattered debris and correlates closely with an entry into the *Fund og Fortidsminder*, FF195583 which is an undated wreck, most likely of a wooden ship. Most of the debris is categorised as *linear objects* except for SSS_BH1_BLOCK07_0012 which is a possible rope, and SSS_BH1C_B05_0010 which is a possible anchor cable/chain/rope.

The former group is described as a well-preserved shipwreck and was also observed in the scanning for the Nord Stream project, target ID SD-DK37-0727 (H. Thomsen, 2019). The wreck is surrounded by at least nine pieces of *debris* and *linear objects*.

Table 2 List of potential wrecks

SSS_BH1_Block01_0016	Wreck	Looks man made, possible wreck that is partially buried. Same as SSS_B01_2020
SSS_BH1_Block01_0019	Wreck	Debris from wooden wreck. Most likely demolished by trawler. Possible feature from mast.
SSS_BH1_Block02_0018	Wreck	Likely man-made
SSS_BH1_Block02_0047	Wreck	Same as SS_BH1_B02_0251
SSS_BH1_BLOCK03_0032	Wreck	Fragmented shipwreck
SSS_BH1_BLOCK03_0050	Wreck	Uncertain, possibly ballast
SSS_BH1_BLOCK05_0023	Wreck	Possibly shipwreck damaged by trawling
SSS_BH1_BLOCK05_0028	Wreck	Shipwreck, end of range
SSS_BH1_BLOCK06_0021	Wreck	Well preserved shipwreck. Same as SSS_B06_3080
SSS_BH1_BLOCK06_0032	Wreck	shipwreck with debris scattered around it. Same as SSS_B06_2258
SSS_BH1_BLOCK06_0051	Wreck	Possibly shipwreck with scattered debris. Anomaly at the end of range.
SSS_BH1_BLOCK07_0007	Wreck	Shipwreck, damaged with debris scattered around it. Same as SSS_GO4_BHI_B7_3406
SSS_BH1_BLOCK07_0041	Wreck	Likely damaged shipwreck with semi-buried debris covering a large area. Possibly of old age. Same as SSS_BO4_BHI_B7_2452
SSS_BH1_BLOCK07_0071	Wreck	Likely natural but possibly buried shipwreck considering measurement/shape
SSS_BH1_CROSSLINES_0007	Wreck	Shipwreck
SSS_BH1C_B05_0007	Wreck	Fragmented shipwreck with debris scattered around it
SSS_BH1C_B06_0020	Wreck	Same as BH1C_B06_2694 and MMO 569. Large shipwreck with surrounding debris.
SSS_G04_BH1_BLOCK04_0001	Wreck	Shipwreck with debris scattered around it. Same as SSS_B04_1906
SSS_G04_BH1_BLOCK04_0046	Wreck	Possibly ballast from shipwreck. Same as SSS_B04_1208

The final thirteen potential wrecks are not located close to any previously identified CHOs. Six of these have been specifically described as shipwrecks:

SSS_BH1_BLOCK07_0041 lies just to the west of twelve targets identified in the current project. They all lie to the east and categorised as *linear objects* or *debris* originating from the wreck.

SSS_BH1C_B06_0020 is described in the SSS data as a large shipwreck and there are at least seven *linear objects* located in close proximity, all are lying to the west of the wreck and all are probable wreck parts; SSS_BH1_BLOCK05_0023 is a shipwreck damaged by trawling, there are no other targets nearby; SSS_BH1_BLOCK06_0032, shipwreck surrounded by at least ten pieces of debris the majority of which lie to the northeast, there is a rope or cable, SSS_BH1_BLOCK06_0015, which lies approximately 220 metres to the south; SSS_BH1_BLOCK03_0032 is described as a fragmented shipwreck, all seven pieces of debris associated with this wreck lie to the northeast; SSS_G04_BH1_BLOCK04_0001 is wreck with scattered debris which lies almost exclusively towards the west side.

SSS_BH1_Block01_0019 is described in the SSS data as debris from a wooden wreck which has most likely been extensively damaged due to trawling activities, it is possibly a feature in the SSS image is a mast. The object is surrounded by a tightly packed debris field with eight other targets within a 100-metre radius.

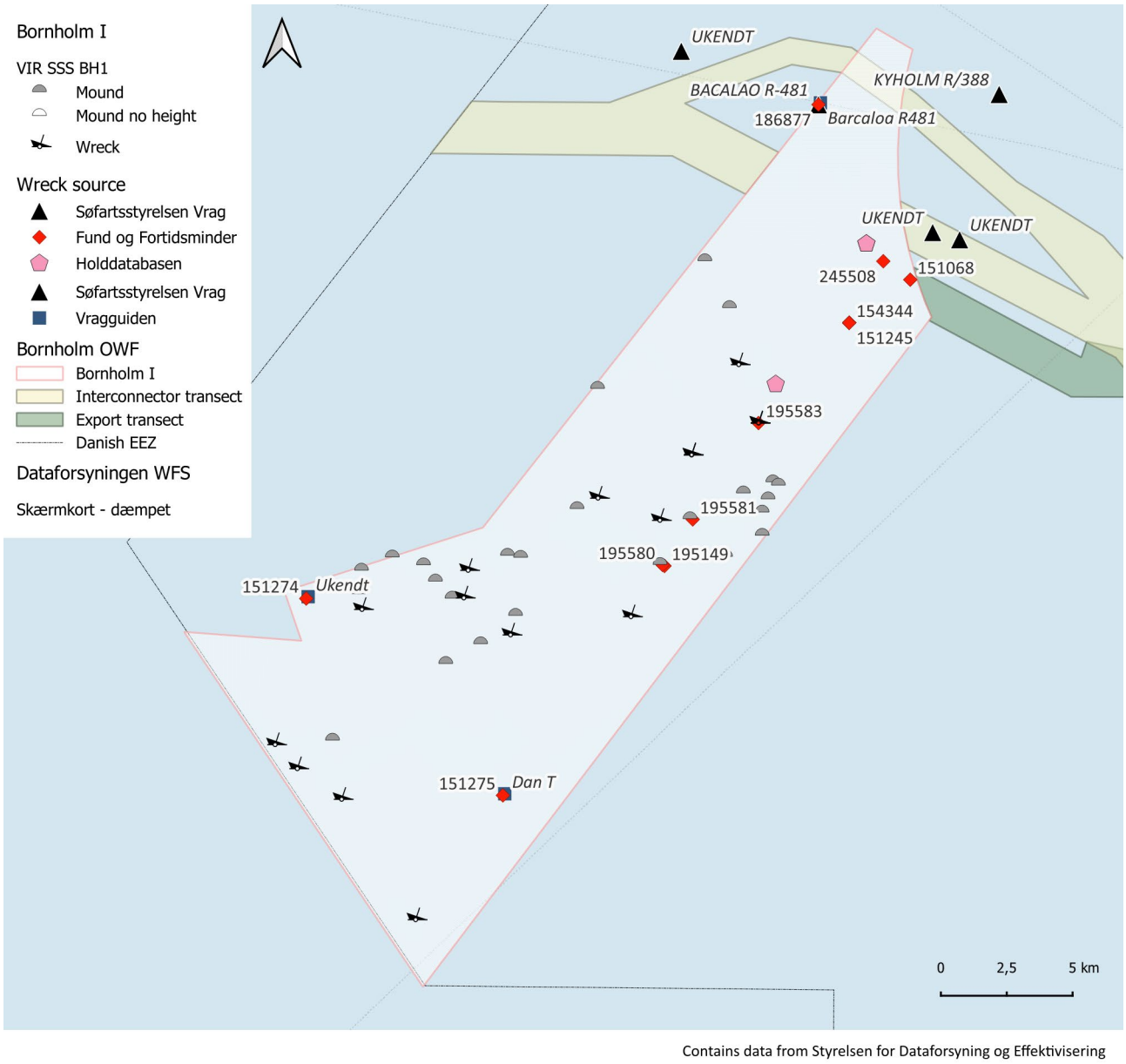

Figure 5. Overview of the location of *wrecks* and *mounds* in relation to information from other sources. Illustration: John Howorth © Vikingeskibsmuseet.

Two of the potential *wrecks* have been described as possible ballast, SSS_BH1_BLOCK03_0050 and SSS_G04_BH1_BLOCK04_0046. A *linear object* possibly with a rope attached, SSS_G04_BH1_BLOCK04_0047, lies about 200 metres to the north-northeast of the latter. This could possibly be an anchor.

Two potential *wrecks* are described as manmade objects, SSS_BH1_Block01_0016, and SSS_BH1_Block02_0018. The former lies next to what has been described as an 'interesting circular object', SSS_BH1_Block01_0017.

One of the final two, SSS_BH1_Block02_0047, is a rectangular object surrounded by four objects which could be debris, and the final target, SSS_BH1_BLOCK07_0071, is described as a possible buried object.

Anchors

Only two potential anchors have been identified in the SSS data (Figure 7 and Table 3). Neither are close to any previously recorded CHOs. SSS_G04_BH1_BLOCK04_0034 is approximately 400 metres from a target categorised as *debris*.

SSS_BH1C_B06_0059 appears to sit isolated from any previously identified CHOs or other targets identified in the current project.

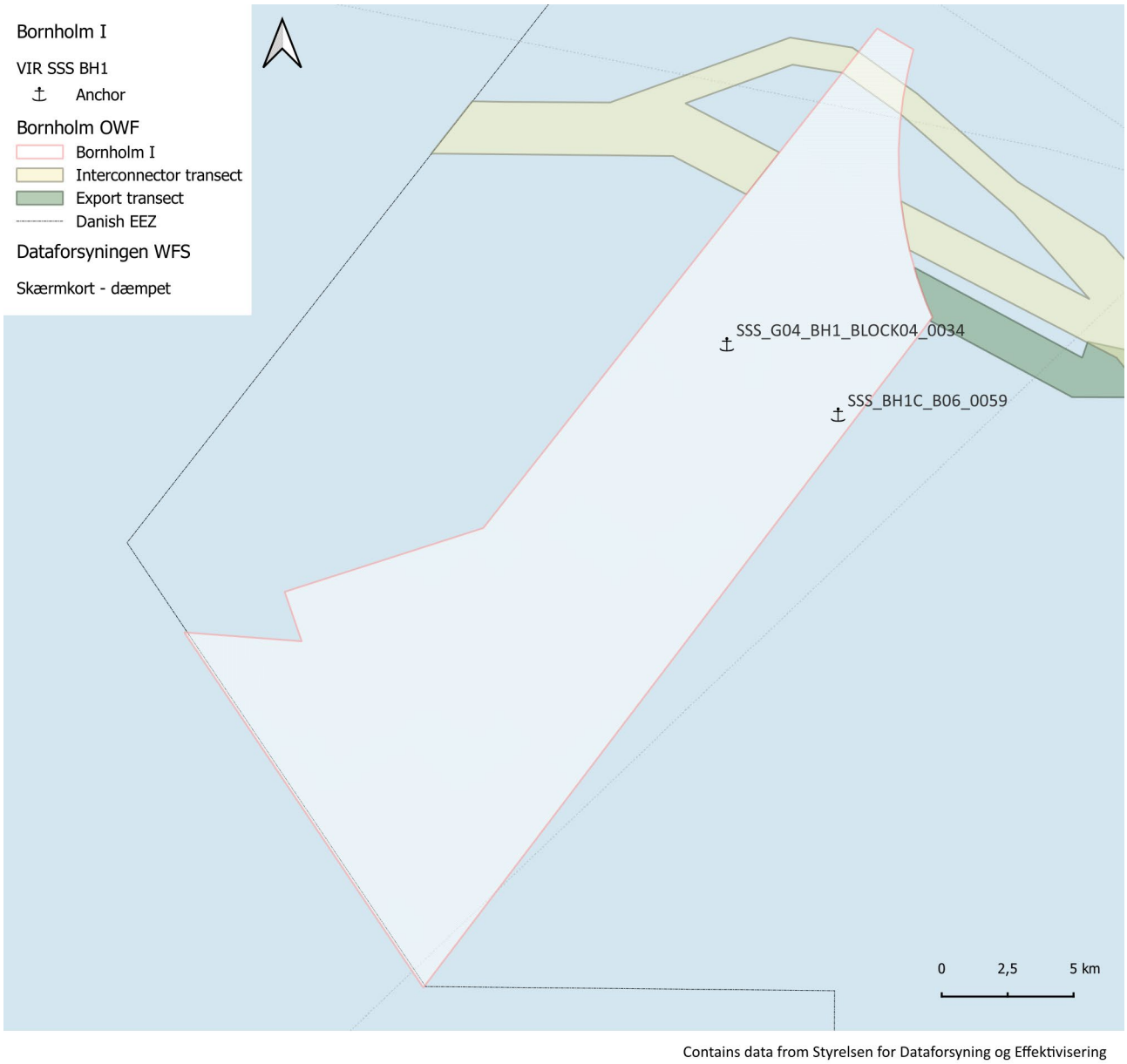

Figure 6. Overview of the location of possible anchors. Illustration: John Howorth © Vikingeskibsmuseet.

Table 3 List of potential anchors

SSS_BH1C_B06_0059	Anchor	Two parts to this feature. The first part is the same as BHC_B06_1745 and MMO 533 and is possibly a rope or cable attached to the second part. The second part is the same as BH1C_1739 and MMO 532, it is also mag anomaly E_BH1C_MAG_0488 which may ind
SSS_G04_BH1_BLOCK04_0034	Anchor	Anchor or other man-made object. Same as SSS_B04_2813

Mounds

There is a total of twenty-four mounds and one so-called "mound with no height" identified in the SSS data (Figure 5). 'Mounds' are targets that may be cargo or ballast from more or less completely disintegrated (wooden) shipwrecks, characterised by being boat-shaped or rectangular, usually also a bathymetric high (relative to surrounding seabed).

Two of these mounds, SSS_BH1_BLOCK07_0024 and SSS_BH1_BLOCK07_0027, are located close to objects on the *Fund og Fortidsminder* register

The former is close to FF 195581, interpreted as a possible wreck due to its rectangular shape and well-defined edges. Additionally, there are seven targets, possibly debris, immediately to the east of this target.

The latter, SSS_BH1_BLOCK07_0027, is close to FF 195580, a pointed oval shape and possible wreck, which, in turn, is in close proximity to FF 195149, which is possibly the keel from a medieval ship.

The remaining mounds, and mound with no height, were not situated close to any previously identified CHOs. Although it is necessary to keep in mind that this does not make them any less likely to be of archaeological significance.

SSS_BH1_Block02_0046 is approximately 100 metres from SSS_BH1_Block02_0054, an area of debris. SSS_G04_BH1_BLOCK04_0042 is described as an interesting partially buried object. There are three pieces of potential debris to the north. Alternatively, all these objects could be part of an extended debris field associated with wreck SSS_G04_BH1_BLOCK04_0001.

Nine of the mounds, including the mound with no height, SSS_BH1_Block01_0003, SSS_BH1_Block01_0006, SSS_BH1_Block01_0014, SSS_BH1_Block01_0029, SSS_BH1_Block02_0010, SSS_BH1_Block02_0033, SSS_BH1_Block02_0042, SSS_G04_BH1_BLOCK04_0009, and SSS_G04_BH1_BLOCK04_0026, are found towards the southwest portion of the BH1 wind farm area. Although these features are not situated close to any CHOs, there are many targets categorised as *unknown* or *other* in the area, which could be wreck debris. It appears that there are a large number of unusual anomalies on the seabed which could be a result of natural formations or some type of activity in the area.

There are a further three mounds, SSS_BH1_BLOCK03_0024, SSS_BH1_BLOCK03_0044, and SSS_BH1_BLOCK03_0029, which are situated just to the north of the nine mounds mentioned above. These three have been described as possible ballast but were not found close to any CHOs.

Towards the east side of the area, there are seven mounds, SSS_BH1C_B06_0015, SSS_BH1C_B06_0062, SSS_BH1_BLOCK07_0003, SSS_BH1C_B06_0060, SSS_BH1C_B06_0058, SSS_BH1C_B06_0035, and SSS_BH1_BLOCK08_0006, which are not close to any CHOs but several are situated within 100 metres of MAG anomalies.

Finally, there is one mound, SSS_G04_BH1_BLOCK04_0010, which appears to be completely isolated, situated away from CHOs and targets identified during the current project.

Table 4 List of mounds

SSS_BH1_Block01_0003	Mound no height	Not obvious but interesting
SSS_BH1_Block01_0006	Mound	Possible ballast, same as SSS_B01_0485
SSS_BH1_Block01_0014	Mound	Possible ballast, same as SSS_B01_0392
SSS_BH1_Block01_0029	Mound	Interesting mound like object, could also be a large boulder. Same as SSS_B01_0419
SSS_BH1_Block02_0010	Mound	Possibly ballast
SSS_BH1_Block02_0022	Mound	Possibly ballast
SSS_BH1_Block02_0033	Mound	Possibly ballast
SSS_BH1_Block02_0042	Mound	Likely geologic but possibly ballast, Same as SSS_BH1_B02_0084
SSS_BH1_Block02_0046	Mound	Possibly ballast
SSS_BH1_BLOCK03_0024	Mound	Possibly ballast
SSS_BH1_BLOCK03_0029	Mound	Possibly ballast
SSS_BH1_BLOCK03_0044	Mound	Possibly ballast
SSS_BH1_BLOCK07_0003	Mound	Possibly ballast
SSS_BH1_BLOCK07_0024	Mound	Gravel, possibly ballast. Same as SSS_GO4_BHI_B7_1247
SSS_BH1_BLOCK07_0027	Mound	Possibly ballast
SSS_BH1_BLOCK08_0006	Mound	Gravel mound. Possibly ballast
SSS_BH1C_B06_0015	Mound	Possible ballast mound. Interpretation based on shape and size of feature
SSS_BH1C_B06_0035	Mound	Potential ballast mound. Interpretation based on size and shape of the feature and that there are no other significant formations of rock in the near vicinity.
SSS_BH1C_B06_0058	Mound	Oval shaped area of rocks in an area devoid of concentrations of rock. Possible ballast mound. Interpretation based on size and shape of feature.
SSS_BH1C_B06_0060	Mound	Possible ballast mound based in size and shape of feature.
SSS_BH1C_B06_0062	Mound	Large oval shaped stone mound or natural feature.
SSS_G04_BH1_BLOCK04_0009	Mound	Possibly ballast. SSS_B04_1311
SSS_G04_BH1_BLOCK04_0010	Mound	Interesting anomaly
SSS_G04_BH1_BLOCK04_0026	Mound	Possibly ballast. Same as SSS_B04_1189
SSS_G04_BH1_BLOCK04_0042	Mound	Interesting feature, possibly man-made object partially buried in sediment. Same as SSS_B04_187

Targets within 500 metres of a *Fund of Fortidsminder* object

There is a total of 32 targets found within 500 metres of sites registered with the *Fund and Fortidsminder*. Some of these are wrecks and mounds and have been discussed above. However, the remainder of the targets are classed as debris or linear objects. Their close proximity to registered sites of archaeological interest could be significant as wreck parts and cargo could drift from the main wreck area.

Twenty of the targets lie within 500 metres of FF 195583 described in the register as a wooden shipwreck disturbed by trawling activity and surrounded by smaller objects (Table 5). Three of the targets are categorised as *wreck* and discussed with the other objects identified as wrecks above. The remaining targets are three *linear objects* and fourteen categorised as *debris*.

Table 5 List of targets found with 500 metres of FF 195583

SSS_BH1_BLOCK06_0051	Wreck	Possibly shipwreck with scattered debris. Anomaly at the end of range.
SSS_BH1_BLOCK07_0007	Wreck	Shipwreck, damaged with debris scattered around it. Same as SSS_GO4_BHI_B7_3406
SSS_BH1C_B05_0007	Wreck	Fragmented shipwreck with debris scattered around it
SSS_BH1_BLOCK07_0021	Linear object	Possibly linear debris
SSS_BH1C_B05_0021	Linear object	Possibly debris. Same as BH1C_B05_0175
SSS_BH1C_B06_0082	linear object	
SSS_BH1_BLOCK07_0008	Debris	Possibly linear debris from nearby shipwreck
SSS_BH1_BLOCK07_0009	Debris	Debris from nearby shipwreck
SSS_BH1_BLOCK07_0010	Debris	Possibly linear debris from nearby shipwreck
SSS_BH1_BLOCK07_0011	Debris	Debris from nearby shipwreck
SSS_BH1_BLOCK07_0012	Debris	Debris from shipwreck, possibly rope
SSS_BH1_BLOCK07_0015	Debris	Linear debris, likely from nearby shipwreck
SSS_BH1_BLOCK07_0016	Debris	Linear debris, likely from nearby shipwreck
SSS_BH1_BLOCK07_0017	Debris	Possibly debris from nearby shipwreck
SSS_BH1_BLOCK07_0018	Debris	Linear debris, likely from nearby shipwreck
SSS_BH1_BLOCK07_0019	Debris	Linear debris, likely from nearby shipwreck
SSS_BH1_BLOCK07_0020	Debris	Linear debris, likely from nearby shipwreck
SSS_BH1C_B05_0008	Debris	Linear debris related to nearby shipwreck
SSS_BH1C_B05_0009	Debris	Linear debris related to nearby shipwreck
SSS_BH1C_B05_0010	Debris	Possibly anchor cable related to shipwreck

Two FFs, 195580 and 195149, an undated possible wreck and a possible keel from a medieval ship respectively, are located less than 100 metres apart. There are eight targets associated with these two CHOs. One of the targets, SSS_BH1_BLOCK07_0027, is a mound and has already been discussed above. The remaining seven objects are all *linear objects* or *debris* and could possibly be related to one or both of the CHOs.

Table 6 List of targets found with 500 metres of 195580 and 195149

SSS_BH1_BLOCK07_0027	Mound	Possibly ballast
SSS_BH1_BLOCK07_0028	Debris	Uncertain. Same as SSS_GO4_BHI_B7_2938
SSS_BH1_BLOCK07_0029	Linear object	Likely linear debris. Same as SSS_GO4_BHI_B08_0236
SSS_BH1_BLOCK07_0030	Linear object	Possibly linear debris. Same as SSS_GO4_BHI_B7_0939
SSS_BH1_BLOCK07_0031	Linear object	Possibly linear debris. Same as SSS_GO4_BHI_B7_2789
SSS_BH1_BLOCK07_0061	Linear object	Possibly debris
SSS_BH1_BLOCK07_0064	Linear object	Possibly debris
SSS_BH1_CROSSLINES_0005	Linear object	Possibly linear debris

There are two objects found within 500 metres of an undated wreck, FF 195581. One of the objects is a mound which is discussed above. The other is a piece of debris described as likely to be manmade and it lies almost 500 metres from the wreck.

One linear object, SSS_BH1C_B05_0012, correlates exactly with FF 245508 which is described as part of a wreck. The registry entry describes the object as a wooden pole which is squared off at one end and worn at the other. The description of the target from the current project is that SSS_BH1C_B05_0012 is a semi buried possible linear object. It is highly likely that the object in the SSS data is the same as the object in the FF register.

Barcaloa R-481

As well as being on the *Fund og Fortidsminder* register, FF 186877, the *Barcaloa* R-481, in the northwest corner of BH1, is also in the DMA's Register for Wrecks and *Vragguiden*. Its position is reportedly confirmed so it is unusual that there has been no sighting of any targets in the vicinity. Three MAG anomalies were detected within 500 metres of the wreck's location point, the closest at around 100 metres away. It may be possible that it has been buried by sediment transport.

Stone-Age Potential

The area of BH1 lies just to the west of Rønne Banke in water depths between 28 and 41 metres below sea level. Large parts of the seabed in the Baltic Sea were above sea level during the prehistoric period due to glaciation. The last period of lowstand water occurred approximately 11700 years BP when the water levels were between 40 to 45m below the current levels (Jensen & Bennike, 2021). Therefore, anything around this depth and below are very unlikely to contain evidence for human activity from the Mesolithic period. The water level then rose relatively quickly.

The sub-bottom profile data shows a seabed mainly made up of lake sediments and sediments laid down in marine environments (GEOxyz, 2023), there does not appear to be thick deposits of peat or other heavily organic layers that would suggest a preserved Mesolithic land surface. The most likely areas to find evidence for Mesolithic human activity are on the edge of Rønne Banke where it slopes down into BH1 from the east. The highest points may have been dry land for a long enough period for settlement areas to be established in the Mesolithic period. In Figure 7, the shallowest areas are coloured red. It is also more probable that evidence for Mesolithic human activity will be located within gravel and coarse sand. In the most southern corner of BH1 and in parts along the eastern edge where the water is at its shallowest, there are areas of gravel and coarse sand. These

are the areas where evidence for Mesolithic human activity is the most likely to be found and any investigations into stone-age archaeology should be focussed here.

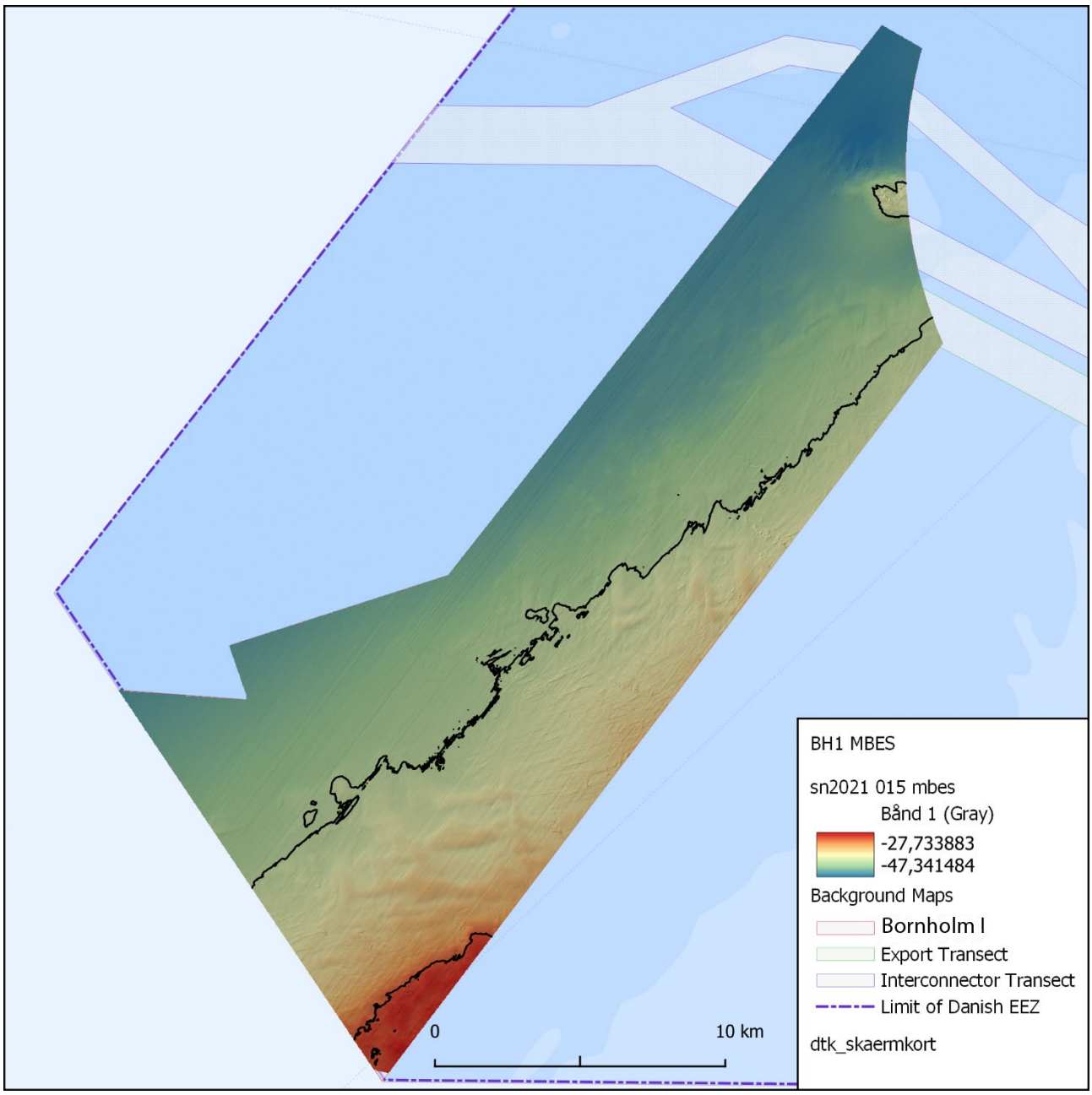

Figure 7. Contoured MBES data showing the depths of the current seabed. The contour lines are at 10 metre intervals with the shallowest at 30 metres and the deepest at 40 metres. MBES data provided by GEOxyz. Illustration: John Howorth © Vikingeskibsmuseet. Contains data from Styrelsen for Dataforsyning og Effektivisering (dtk_skærmkort).

Past investigations during the Baltic Pipe project, which ran across BH1, found evidence for submerged prehistoric forest on Rønne Banke as well as non-rooted prehistoric tree trunks in deep waters down to 35 metres just off the underwater ridge (Jonsson & H. Thomsen, 2022). BH1 lies exclusively in an area of deeper water, but some of the unidentified linear objects could be remains of uprooted prehistoric tree trunks. Any evidence for submerged forests could increase the likelihood that there are surviving Mesolithic layers in the area and therefore a higher probability of finding evidence of human activity.

In conclusion, a large part of BH1 is at such a depth that it was probably already submerged by the time human settlement began in this region and some parts would have only been land for a relatively short period of time. It is very unlikely that evidence for Mesolithic human activity will be found in these deeper areas. The southern corner and the south-eastern edge are much shallower and there are areas of gravel and coarse sand on the seabed. It is these areas that are the most likely to yield evidence for Mesolithic human activity, if any is to be found at all.

Future Work

Within the current BH1 area (OWF_Bornholm_3GW), all the SSS targets from the separate survey blocks have been merged into a single GIS file:

VIR_SSS_BH1

The GIS file corresponds to Appendix 2 in this report.

In previous projects, it was common practice to create so-called first-generation exclusion zones around potential CHOs depending on the nature and size of the object. An assessment was then made on whether these zones intersected the future work areas. The targets with buffer zones which intersected the work areas were then more closely studied in the side scan and multibeam sonar and the buffer zone was reassessed based on the type, shape, and extent of object. However, more recent guidelines from the Danish Agency for Culture and Palaces urge against the use of these preliminary exclusion zones before visual inspection (Appendix 4).

All targets which are within, and in close proximity to, the proposed work areas should be visually inspected by ROV and the footage screened by archaeologists from VIR in order to further assess their significance. Targets which, through this process, 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.

The same goes for potential stone age sites, an initial area in the southern corner and along the south-eastern edge has been highlighted, but in order to conclude any positively identified sites, further investigation is needed. Such investigations could include dive and/or machine test pit excavations.

If the client's work cannot be carried out due to an exclusion zone or altered to avoid it, 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.

Bibliography

GEOxyz. (2023). *SN2021_015 - Geophysical Survey For Offshore Wind Farms And Energy Island BORHOLM I - Revision 4.0.*

H. Thomsen, M. (2019). *Nord Stream 2 Pipeline - North-Western Route: Cultural heritage target assessment and exclusion zone recommendations.* Roskilde: Vikingeskibsmuseet.

Jensen, J. B., & Bennike, O. (2021). *Geological desk study Bornholm Windfarm cable transects. Geological seabed screening in relation to possible location of cable transects. Client Energinet. (Danmarks og Grønlands Geologiske Undersøgelse Rapport; Vol. 2021, No. 63).* GEUS.

Jonsson, M., & H. Thomsen, M. (2022). *Baltic Pipe, Danish Baltic Sector: Screening of geophysical data and target inspections for the proposed Baltic Pipe gas pipeline - Anchor corridor.* Roskilde: Vikingeskibsmuseet.