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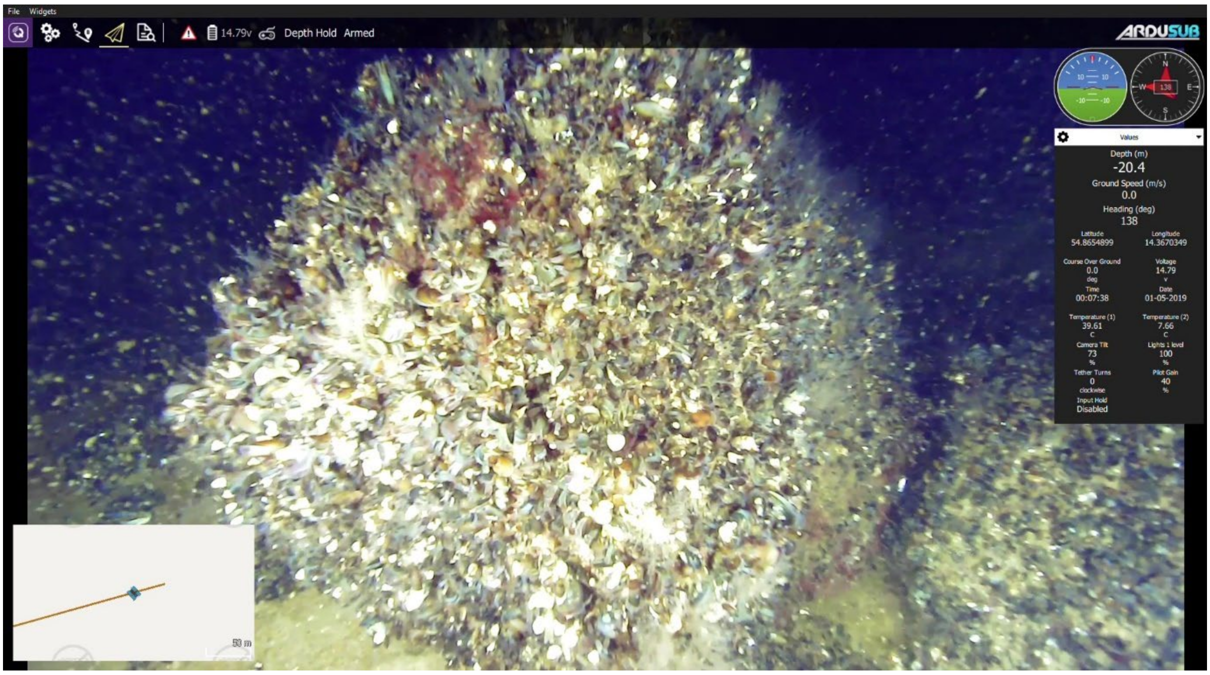
ENERGY ISLAND BORNHOLM

ENVIRONMENTAL BASELINE NOTE WP-E BENTHIC FLORA AND FAUNA

30-06-2022



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ENVIRONMENTAL BASELINE NOTE
WP-E BENTHIC FLORA AND FAUNA

ENERGINET

Project name	**Energy Island Bornholm**
Project no.	**3622100110**
Recipient	**Energinet.dk**
Document type	**Note**
Version	**FINAL**
Date	**2022-06-30**
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Description	**Environmental Baseline Note for WP-E Benthic fauna and flora**

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CONTENTS

Abbreviation	Explanation
AFDW	Ash free dry weight
Bird SPA	New bird SPA (Rønne Banke F129) for long-tailed duck located between the two wind farm areas.
Bornholm I nord	Bornholm I is divided into two subsections i.e. Bornholm I nord and Bornholm I syd. Both areas are offshore wind farm areas.
Bornholm I syd	Bornholm I is divided into two subsections i.e. Bornholm I nord and Bornholm I syd. Both areas are offshore wind farm areas.
CC	Cable Corridors
CC area	Area where cable corridors for CC1 and CC2 overlap close to the coast
CC1	Cable corridor from Bornholm I wind farm area to Bornholm
CC2	Cable corridor from Bornholm II wind farm area to Bornholm
Client	Energinet
CTDO	Conductivity-Temperature-Depth-Optical
D50	Average grain size
DEA	Danish Energy Agency
DKI	The Danish index for benthic infauna used for assessment of infauna condition
DW	Dry weight
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
HAPS	Sediment core sampler. Samples a cylinder of sediment in soft to loose seabed sediments
LOI	Loss of ignition (measure for organic content)
NSP2	Nord Stream 2 project
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
OWF	Offshore Wind Farm
OWF1	Bornholm I, Offshore Wind Farm Area 1, is now divided into two subsections: Bornholm I nord and Bornholm I syd
OWF2	Bornholm II, Offshore Wind Farm Area 2
Pre-investigation area	Gross area for the benthic survey including the three wind farm areas (Bornholm I nord, Bornholm I syd and Bornholm II) and the area in between in Danish waters
ROV	Remotely Operated Underwater Vehicle
SEA	Strategic Environmental Assessment
TOC	Total Organic Carbon
VO	Variation order
WW	Wet weight

1 INTRODUCTION

The energy islands mark the beginning of a new era for the generation of energy from offshore wind, aimed at creating a green energy supply for Danish and foreign electricity grids. Operating as green power plants at sea, the islands are expected to play a major role in the phasing-out of fossil fuel energy sources in Denmark and Europe.

After political agreement on the energy islands has been reached, the Danish Energy Agency plays a key role in leading the project that will transform the two energy islands from a vision to reality. The energy island projects are pioneer projects that will necessitate the deployment of existing knowledge into an entirely new context.

In the Baltic Sea, the electrotechnical equipment will be placed on the island of Bornholm, where electricity from offshore wind farms (OWF) will be routed to electricity grids on Zealand and neighbouring countries. The offshore wind farms will be constructed approximately 15 km south-southwest of the coast of Bornholm and have a capacity of 3 GW.

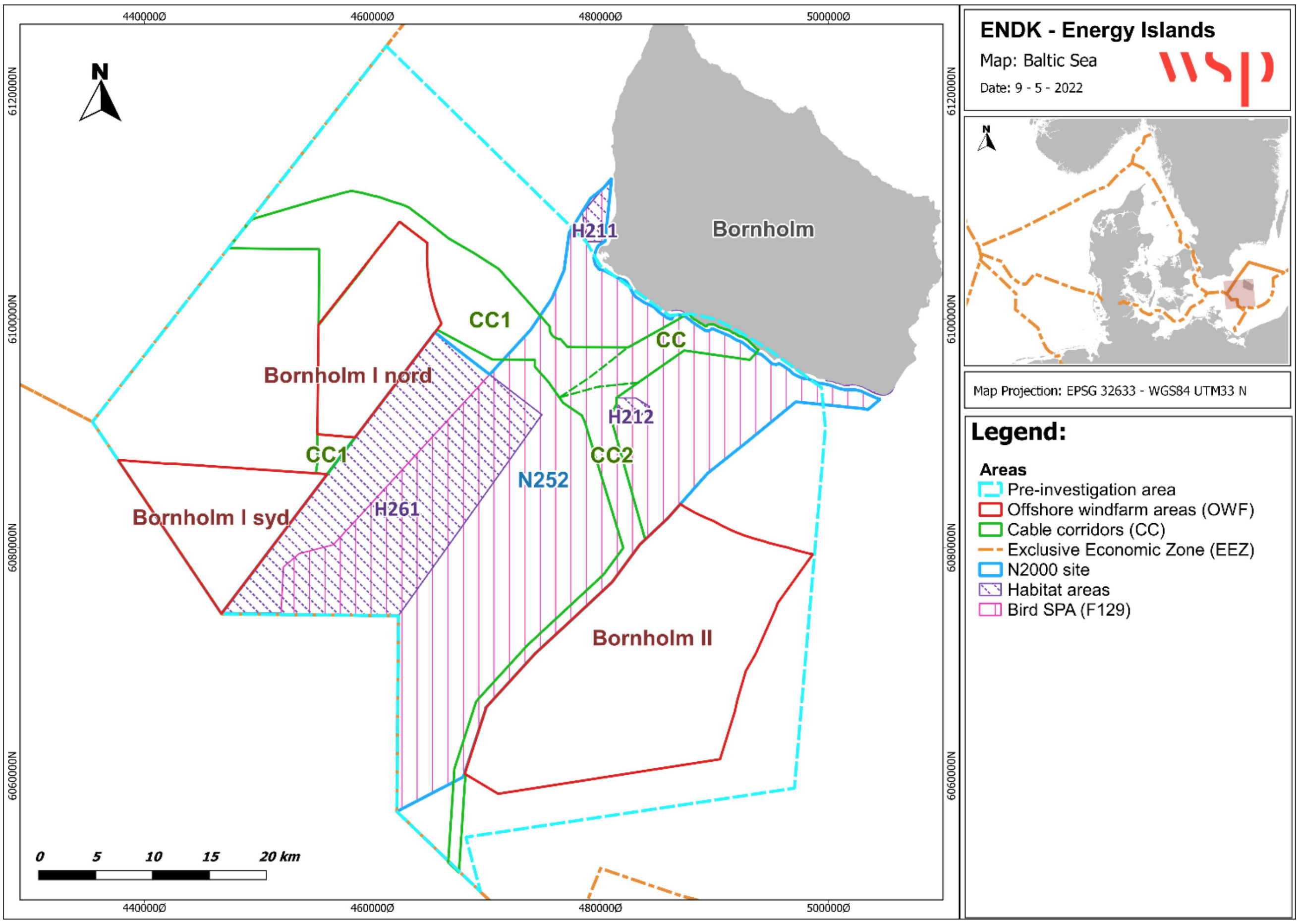

Figure 1-1. Energy Island Bornholm.

The environmental baseline note concerns the pre-investigation area, including the two planned windfarm areas (Bornholm I nord and syd and Bornholm II) and the cable corridors from the wind farm areas to Bornholm (CC, CC1 and CC2) (Figure 1-1). Furthermore, the Natura 2000 site “Adler Grund og Rønne Banke” (N252), habitat areas within the N252 (H261, H212, H211) and the new bird SPA (Rønne Banke F129) between the wind farm areas are shown. Cable corridors to Zealand and neighbouring countries are not included in this environmental baseline note but shown in Figure 1-1.

This document provides a description of existing data of the following parameters:

- Abiotic parameters
- Seabed sediment characteristics
- Benthic flora
- Benthic fauna

2 METHODOLOGY

Methodology used to map and describe existing data for abiotic data, seabed characteristics, benthic flora and – fauna in the pre-investigation area for Energy Island Bornholm are presented below.

2.1 EXISTING DATA SOURCES

Existing data are collected from different projects and studies in the pre-investigation area. The projects were chosen, as they provided relatively new existing data from the pre-investigation area, which were sampled and analyzed by comparable methods as is being done for Energy Island Bornholm in 2022 (*these results will be available at a later stage*). Stations within the pre-investigation area were chosen for description of existing data in this Environmental Baseline Note and are listed in Table 2-1 and shown in Figure 2-1. Nord Stream 2 AG (NSP2) has given permission for use of unpublished data and reports from the Northern route in this report. Other relevant existing data such as HELCOM and OSPAR references for pollutants and the HELCOM red list of macroalgae and benthic fauna species are included where relevant.

Existing data from the pre-investigation area are summarized based on the following projects:

- Nord Stream 2 – Final Route (Southeastern route)
- Nord Stream 2 – Northern Route - baseline study for sediment and infauna in Danish EEZ
- Nord Stream 2 – Northern Route - monitoring in Natura 2000 site N252/H261
- Baltic Pipe
- NOVANA data for benthic flora from two stations: Franks Rev (BRK_5065000), Bakkegrund (MCR310004) and Sose 2 (BOR310016) (Odaforalle.dk, 2022).
- Natura 2000 Basisanalyse 2022-2027 for N252/H261 "Adler Grund og Rønne Banke" (Miljøstyrelsen, 2021a)
- Natura 2000 Basisanalyse 2022-2027 for N251/H212 "Bakkebrændt og Bakkegrund" (Miljøstyrelsen, 2021b)

Table 2-1. Projects and stations used for description of existing data.

Projects	Sampling date	Selected stations	Reference
Nord Stream 2 – Final Route (Southeastern route)			
NSP2 - Final	August and September 2018	SS-13, -14, -15 and -16	(Nord Stream 2, 2019)
Nord Stream 2 – Northern Route baseline study for sediment and infauna in Danish EEZ			
NSP2 – Northern, baseline	November and December 2017	D_EEZ_22, _24, _26, _28, _29, _30, _31, _34, _35, _36, _37, _38, _39, _41	*Sediment*: (Nord Stream 2, 2018a), *Infauna*: (Nord Stream 2, 2018b)
Nord Stream 2 – Northern Route monitoring in Natura 2000 site N252/H261			
NSP2 – Northern, monitoring	November and December 2017 Sediment mapping in 2017/2018 ROV April/May 2019	N1_1, N1_2, N1_3, N2_1, N2_2, N2_3, N3_1, N3_2, N3_3	(Orbicon, 2019)
Baltic Pipe			
Baltic Pipe	February and March 2018	GCH32, _38, _41, _45, _48, _50, _51, _53; HCH_20, _24, _26, _27	(Baltic Pipe, 2019)
NOVANA data for benthic flora			
NOVANA stations	2008-2020 (no data from 2010)	Franks Rev (BRK_5065000) Bakkegrund (MCR310004) Sose 2 (BOR310016)	(Odaforalle.dk, 2022)

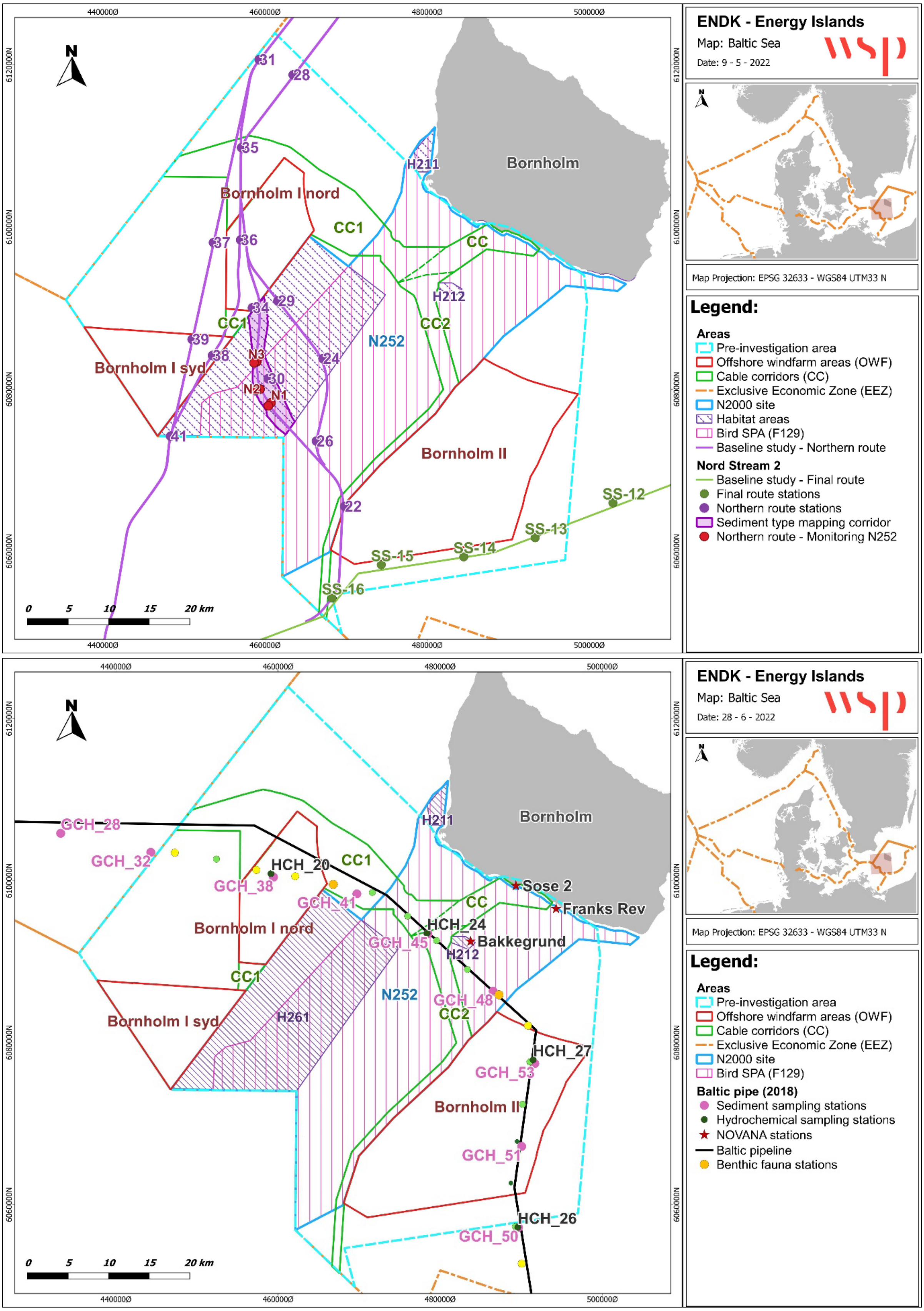

Figure 2-1. Existing data used for the Environmental baseline note from different projects in the area. Upper panel: Nord Stream 2 stations (Final Route and Northern Route incl. N252 monitoring stations). Lower panel: Baltic Pipe stations, NOVANA stations and Natura 2000 site, Habitat sites and Bird SPA site F129.

2.2 CHEMICAL PARAMETERS

The description of existing data for chemical parameters in the pre-investigation area of Energy Island Bornholm follow legal requirements and assessment tools given as threshold values and core indicators provided by HELCOM, OSPAR, the Danish Environmental Protection Agency (EPA), the US EPA and the European commission (see 3.2.3 Chemical parameters/Pollutants). Standard parameters for this kind of investigation in Denmark were used and approved by the Danish EPA.

Chemical pollutants investigated:

- Total Organic Carbon (TOC), Total Nitrogen (TN) and Total Phosphorus (TP)
- Heavy metals (8): Arsenic (As), lead (Pb), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni) and zinc (Zn)
- Sum of PAH-compounds (9): Phenanthrene, anthracene, fluoranthene, pyrene, benz(a)anthracene, chrysene, benz(a)pyrene, indeno(1,2,3cd)pyrene and benzo(g,h,i)perylene
- Sum of PCB-compounds (7): 28, 52, 101, 118, 138, 153 and 180
- Tributyltin (TBT) and degradation products: Dibutyltin (DBT) and Monobutyltin (MBT)

Exceedances of threshold values for these pollutants have been analyzed and compiled for stations within the pre-investigation area.

2.3 BENTHIC FAUNA

The description of existing data for benthic fauna is based on sampling, where all animals were determined to species or lower taxonomic level. For species determined to a lower taxonomic level, only one representation of the taxonomic group, e.g. genus, is accounted for as sp. whereas several are given as spp. For the genus *Mytilus* both *M. edulis* and *M. trossulus* (or hybrid between these two species) are found in the region. Because these two species are very difficult to distinguish morphologically, specimens of *Mytilus* are denoted as *Mytilus* spp. and accounted as one species.

3 EXISTING DATA

Existing data for abiotic data, seabed characteristics, benthic flora and -fauna in the pre-investigation area for Energy Island Bornholm are presented below. These data will be included as existing data in the baseline report for WP-E - benthic fauna and flora. Existing data are used for comparison and verification of the data sampled by the Energy Island Bornholm project, and to increase the knowledge and data sum of the investigation area.

3.1 ABIOTIC DATA

Physical parameters such as depth, salinity and oxygen concentration are determining factors for the living conditions and habitat types available for benthic fauna and flora and are presented below. Salinity, temperature and oxygen profiles are measured in the water column by use of a CTDO.

3.1.1 DEPTH

Depth is an important factor for both benthic flora and fauna. Depth determines the light available for benthic flora. Benthic flora needs light for growth and therefore lives within the photic zone, where light is sufficient for plant growth (see section 3.3 - Benthic flora). For benthic fauna the importance of depth is mainly due to shifting sediment composition towards more soft sediment types at higher depths (>40-50 m, (Nord Stream 2, 2018a)) (see section 3.2.1 - Sediment types), higher salinity and lower oxygen concentrations below the halocline in the Baltic Sea (see section 3.1 – Abiotic data).

Depth in the pre-investigation area is presented in Table 3-1 and Figure 3-1 and ranges from 0 to 58 meters depth. The shallowest parts are found in Bird SPA F129 close to the coast and in the Rønne Banke area between the two wind farm areas (Bornholm I and Bornholm II). The deepest parts of the pre-investigation area are found northwest of Bornholm I nord and southeast of Bornholm II.

Table 3-1. Depth ranges in meters in the pre-investigation area, the wind farm areas (OWF), the two cable corridors (CC1 and CC2) from the OWFs to Bornholm and the Bird SPA in the middle of the pre-investigation area.

Depth ranges	Lowest (m)	Highest (m)
Pre-investigation area	0	58
Bornholm I nord	33.5	47.5
Bornholm I syd	28	45
Bornholm II	20	55
CC overlapping part near coast	0	20
CC1 (incl. CC area)	0	47
CC1 area between Bornholm I nord and Bornholm I syd	34.5	38
CC2 (incl. CC area)	0	36.5
Bird SPA F129	0	36.5

The depth range is 33.5 to 47.5 meters and 28 to 45 meters in Bornholm I nord and Bornholm I syd, respectively. The largest depth variation and depths of 20 to 55 meters are found in Bornholm II.

The overlapping part of the cable corridors (CC) close to the coast of Bornholm has depths between 0 and 20 meters. The cable corridor from Bornholm to Bornholm I nord (CC+CC1) has depths between 0 and 47 meters.

The small part of the small cable corridor (CC1) between Bornholm I nord and syd has depths between 34.5 - 38 meters. The cable corridor (CC+CC2) from Bornholm to Bornholm II is slightly shallower with depths between 0 and 36.5 meters.

The depth range in Bird SPA F129 is between 0 to 36.5 meters.

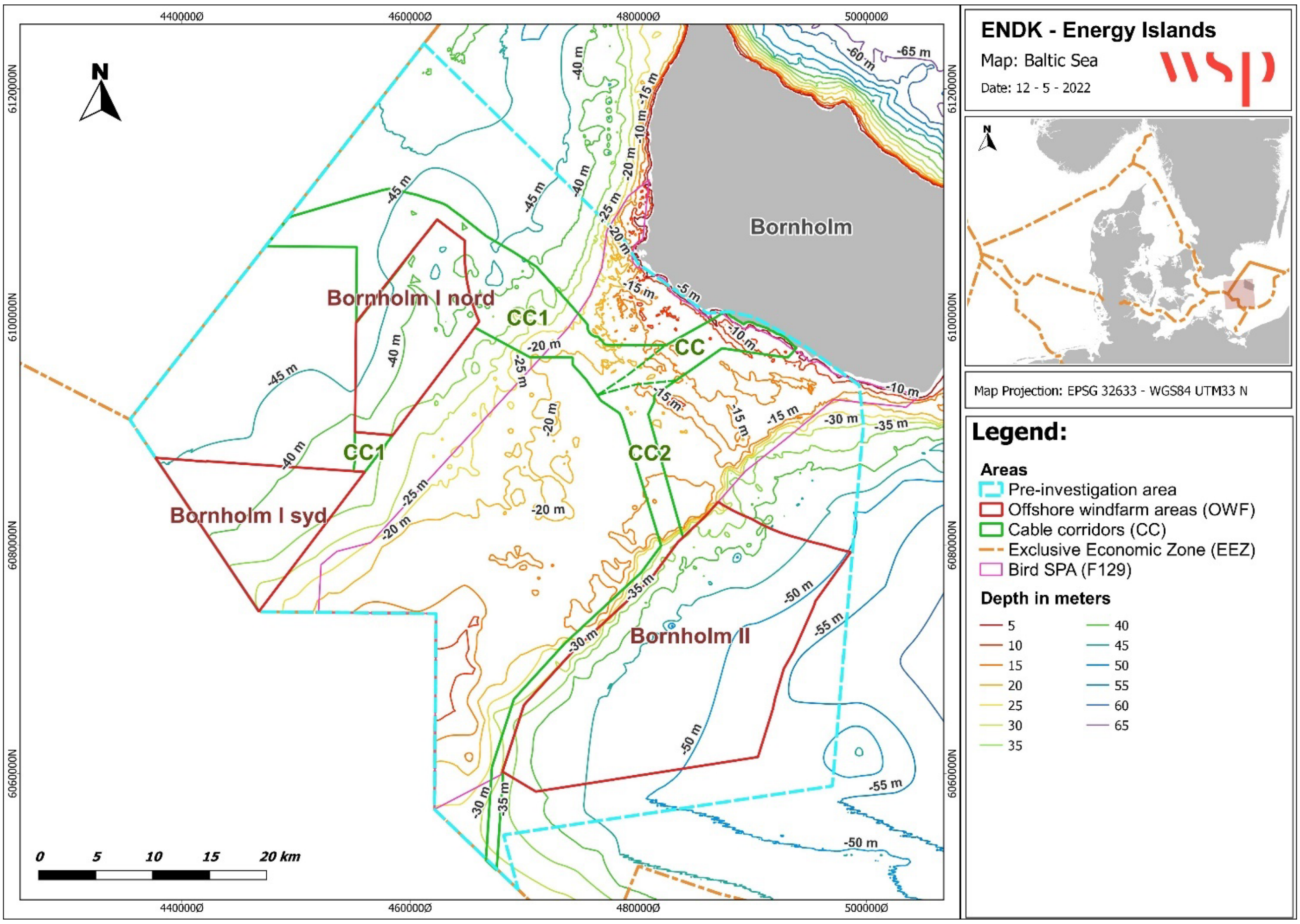

Figure 3-1. Depth map in the pre-investigation area. Source: (Sjöfartsverket, 2013).

3.1.2 SALINITY AND OXYGEN CONCENTRATION

Salinity is one of the main parameters that determines species diversity for both benthic flora and fauna in the Baltic Sea (Gogina et al, 2016; Køie & Kristansen, 2014). Species diversity for benthic flora and fauna is reduced from The Sound to the Bothnian Bay due to a general decline in the salinity of the bottom water from a salinity of approximately 20 psu in The Sound to 2-3 psu in the Bothnian Bay (Perttilä, 2007). Bottom water in the pre-investigation area south of Bornholm generally has salinities between 7.5 to 18 psu (Perttilä, 2007; Nord Stream 2, 2018a; Baltic Pipe, 2019).

The salinity in the Baltic is affected by surface freshwater from the many river outflows and from irregular inflow of high-saline deep water from the North Sea through the Danish Straits (Perttilä, 2007). The inflow of saline and oxygen rich seawater to the deep basins in the Baltic Sea is very important for the oxygenation of the deep parts of the Baltic Sea and for the ability of benthic fauna to survive at greater depth. Inflows of high saline water to the Baltic Sea have been relatively rare since the 1980ies but has had a slightly higher frequency from 2013 to 2016 resulting in recent improvements (HELCOM, 2018a). The most recent major Baltic inflow occurred in 2014, and moderate inflows were observed in 2018/19 (E.U. Copernicus Marine Service Information, 2020). Oxygen deficiency is of particular concern and is especially pronounced in the summer when the spring algae bloom sediments to the seabed and is degraded by bacteria consuming the available oxygen, near and in the seabed. In areas with a strong stratification (halocline and/or thermocline) (see Figure 3-2 A,B) there is no or little oxygen exchange between the surface water mass and the bottom water mass. Without inflow of new oxygen to the bottom water mass bacterial degradation of the spring bloom is able to use up most or all oxygen at the seabed, which in turn limits the growth of benthic flora and benthic fauna in deeper areas, where the oxygen depletion is most severe (HELCOM, 2018a). Shallower stations have more wind and current mixing of the water column and, thus, better oxygen concentrations above the seabed (see Figure 3-2C). Oxygen deficiency (<4 mgO_2 l^{-1}) is typically found in the period from late spring to late autumn in the pre-investigation area. Lowest oxygen levels are in general experienced at the end of summer, between August and October, due to decomposition of organic material on the seabed (HELCOM, 2018a).

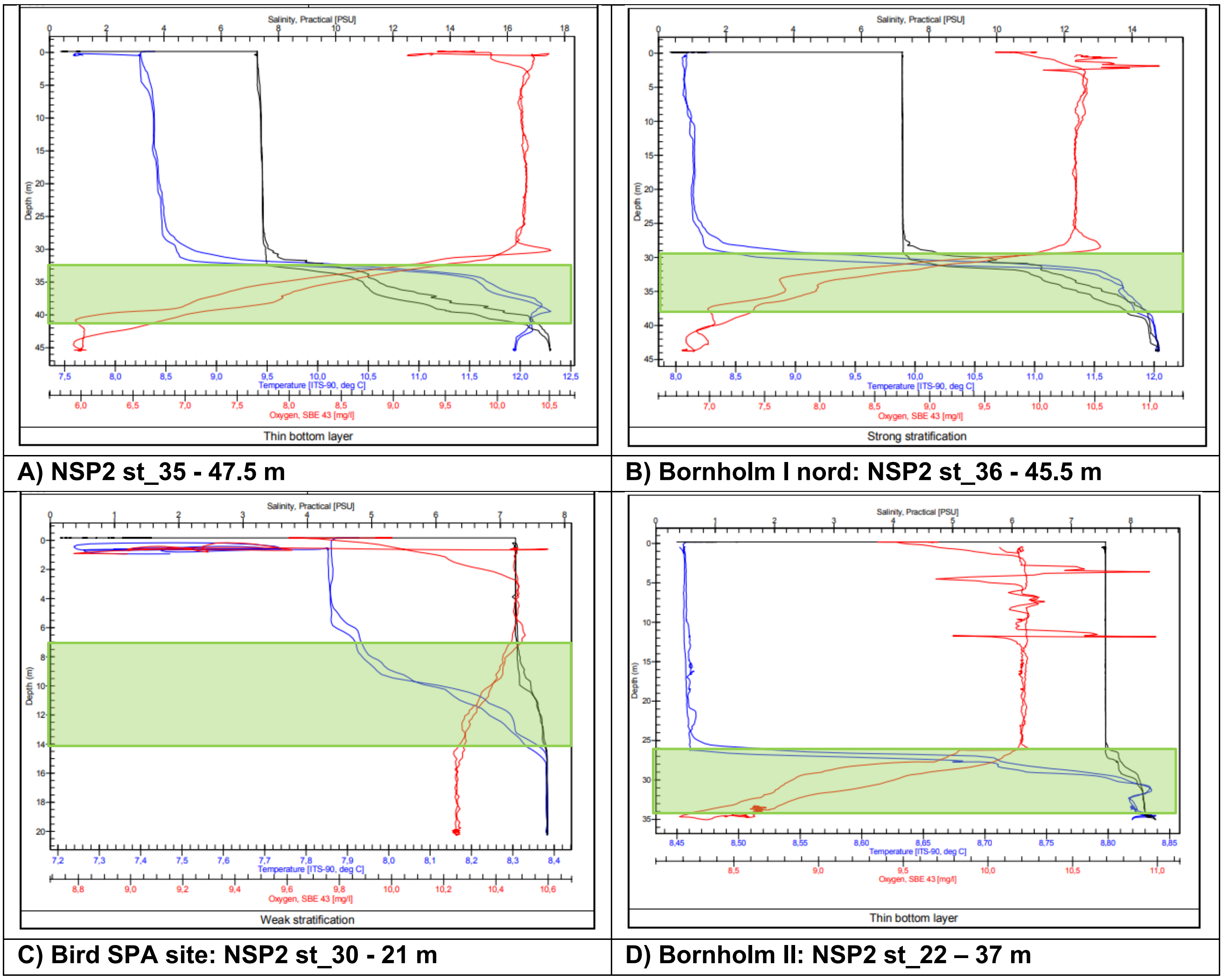

Figure 3-2. CTDO-profiles of salinity, temperature and oxygen concentrations from November 21st to December 4th 2017 crossing the pre-investigation area from north (st_35), to Bornholm I nord (st._36), south to the shallow Bird SPA area (st_30) and to the deeper Bornholm II area (st_22) (se stations in Figure 2-1). Green box illustrates the position of the halocline and/or thermocline (stratification) between an upper warmer, less-saline water mass and a water mass above the seabed characterized by a higher salinity, lower temperature and oxygen concentration. Source: (Nord Stream 2, 2018a; Orbicon, 2019).

The baseline studies for Nord Stream 2's Northern route crossing the pre-investigation area (see Figure 2-1) found that low oxygen concentrations <4 $mgO_2\ l^{-1}$ were generally found at depths deeper than 60 m (see Figure 3-2). Moderate oxygen deficiency is defined as oxygen concentrations between 2-4 $mgO_2\ l^{-1}$ and severe oxygen deficiency as <2 $mgO_2\ l^{-1}$. Less than 2 $mgO_2\ l^{-1}$ occurred at most stations with a depth of more than 66 meters (Nord Stream 2, 2018a) and low numbers or no infauna (0-50 individuals m^{-2}) were found at these stations. The pre-investigation area for Energy Island Bornholm is maximally 58 meters deep and oxygen deficiency at the seabed is therefore possible but less likely.

CTDO-profiles from the deep and shallower part of the pre-investigation area are included to illustrate the profiles of salinity, temperature and oxygen concentration in the water column. The data are provided by the Nord Stream 2 – Northern route – Baseline study and were sampled in early winter (21st November to 4th December 2017) at four pipeline stations crossing the pre-investigation area from north to southeast (see Figure 2-1). The depth range is from 47.5 to 21 meters depth. More mixing of the water column at the shallow Rønne Banke station (NSP2st_30, 21 m depth) is evident from a weak stratification (see Figure 3-2C) and well oxygenated bottom water above the seabed.

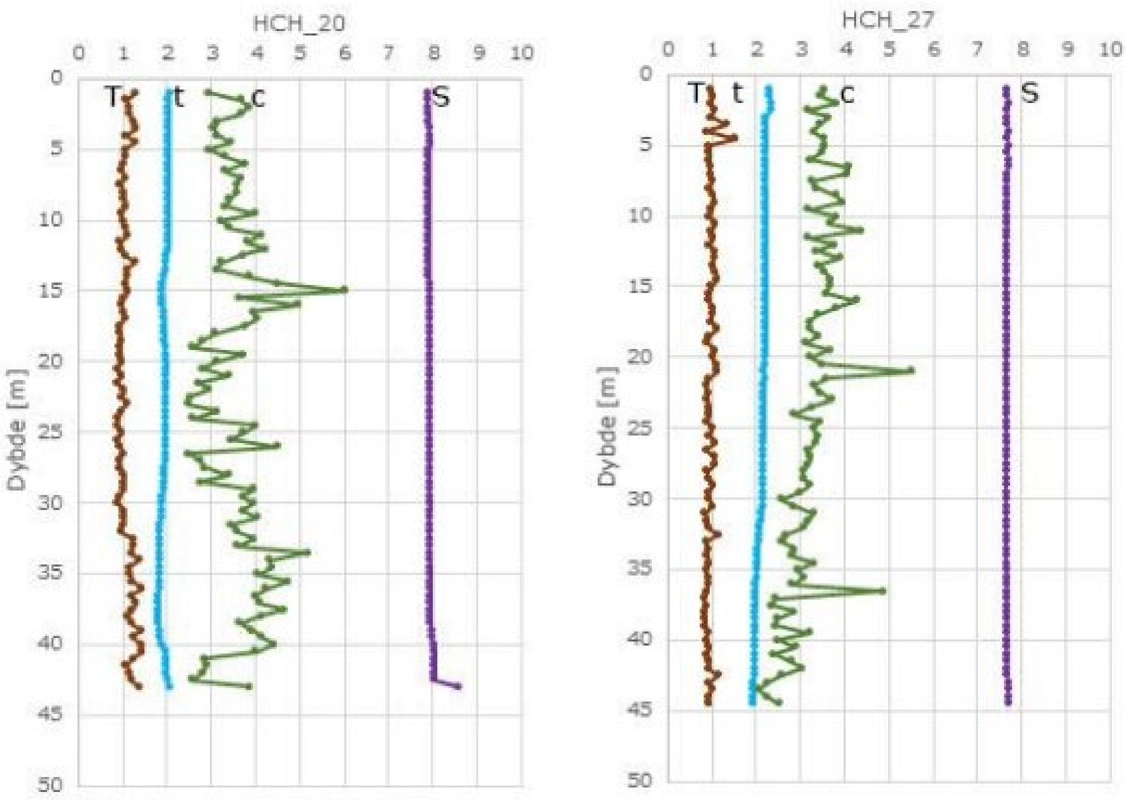

Figure 3-3. CTDO-profiles of temperature (t, °C), salinity (S, psu), turbidity (T, FTU) and chlorophyll-a (C, mg/m^3) in the water column, measured at station HCH_20 and HCH_27 within the pre-investigation area on the 24th to 26th of March 2018. Source: (Baltic Pipe, 2019).

For the Baltic Pipe project CTDO-profiles were taken in the period from 24th to 26th of March 2018, also crossing the pre-investigation area (see Figure 2-1). In this spring period salinities of 7.7 to 8.6 were found in the pre-investigation area and a more well-mixed water column with very little stratification. Oxygen concentrations at the two stations were 12.3 and 14.2 mg/l and no oxygen deficiency were found for any stations during that period ($mgO_2\ l^{-1}$) (Figure 3-3).

3.2 SEABED SEDIMENT CHARACTERISTICS

The seabed sediment types in an area determines the living conditions and habitats available for benthic fauna and flora in that area. Benthic flora lives attached to hard substrate such as larger stones (>10 cm), epifauna lives on hard substrate or on the surface of the seabed, whereas infauna lives buried in the seabed in soft/loose sediments such as silt, sand and gravel.

The physical and chemical sediment parameters are used as supporting parameters in the statistical analysis of infauna composition and distribution in the pre-investigation areas, wind farm areas, cable corridors and the Bird SPA site.

3.2.1 SEDIMENT TYPES

The overall distribution of seabed sediments in the pre-investigation area is presented below in Figure 3-4. The map is based on data from the national geophysical database provided by GEUS (Marta database, (GEUS, 2022)).

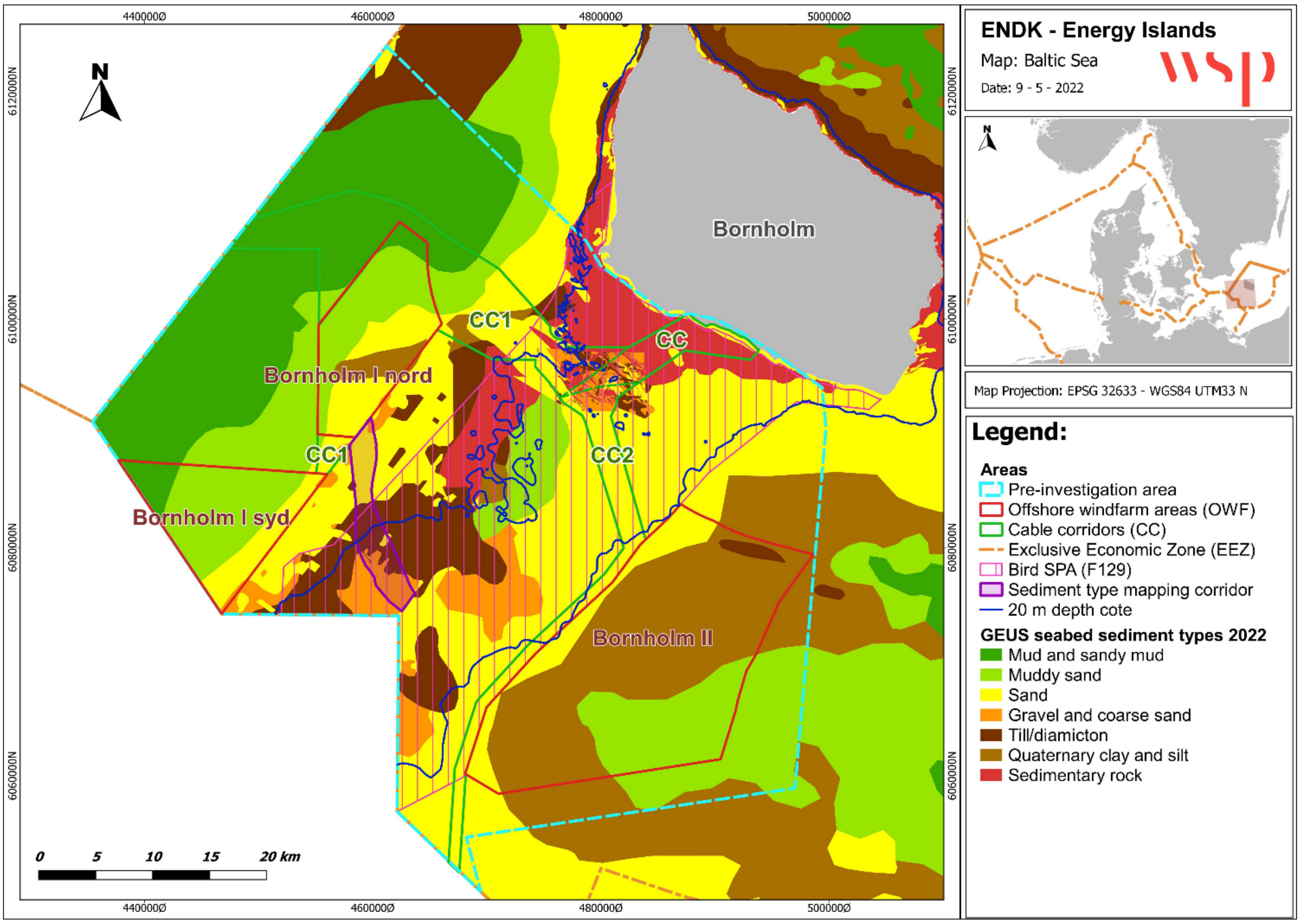

Figure 3-4. Seabed sediment types in the pre-investigation area based on GEUS´ sediment map. The sediment mapping corridor for the Nord Stream 2 project – Northern route – Monitoring in Natura 2000 site N252/H261 is included (purple line) and the fine-scale sediment mapping within part of this corridor is shown in (Figure 3-5) below. Sources: GEUS Marta database and (Orbicon, 2019).

The seabed sediment types in the pre-investigation area are highly variable with exposed bedrock ("Sedimentary rock", see Figure 3-4), glacial deposits (stony sediment types) and post-glacial sand and gravel deposits (finer sediments) (Figure 3-4). The deeper parts of the pre-investigation area (furthest east and west) are dominated by finer post-glacial sediments, i.e., "Mud and sandy mud" and "Muddy sand" dominates the sediment.

The largest variation in sediment types within the pre-investigation area is observed in the Rønne Banke area between the wind farm areas. This area is characterized by shallow depth and more till and rocky areas. "Stone reefs" (sediment type 4) are mainly found in the sediment types: "Till/diamicton" and "Sedimentary rock" and are mainly found in the Rønne Banke area between the wind farm areas.

The GEUS map of sediment types in the pre-investigation area is relatively broad-scale and does not illustrate the high natural variation in the pre-investigation area. The high variation in sediment types in the Rønne Banke area is illustrated from the fine scale-mapping of NSP2 - Northern route - Monitoring through the Natura 2000 site "Adler Grund og Rønne Banke (N252/H261)" in 2017/2018 as shown in Figure 3-5 below (Orbicon, 2019). This area is mapped as "Till diamicton" (substrate type 3 and 4), "Gravel and coarse sand" (substrate type 2) and small patches of "Sand" (Substrate type 1b).

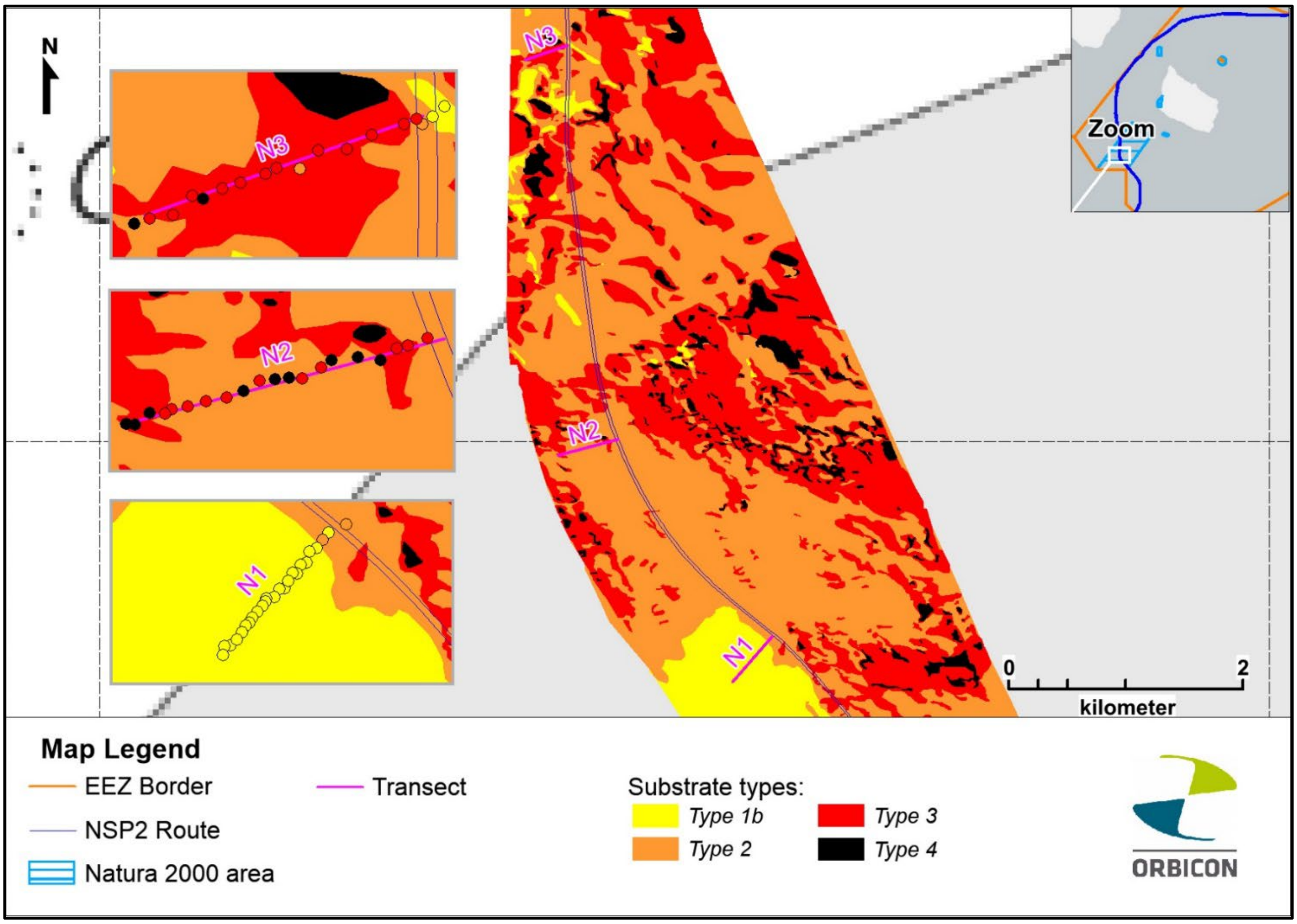

Figure 3-5. Small-scale variation in seabed sediment types in the Rønne Banke area. Fine-scale baseline mapping in the pipeline corridor for the Northern route through the Natura 2000 site "Adler Grund og Rønne Banke" (N252/H261) in 2017/2018 (Orbicon, 2019). Sediment type 1b is sand, Sediment type 2 is soft sediment, or gravel with up to 10% coverage of large stones (>10 cm). Sediment type 3 is soft sediment with 10-25% coverage of large stones (>10 cm) and finally sediment type 4 is stone reef with >25% coverage of large stones (>10 cm). Source: (Orbicon, 2019).

On GEUS broad scale map (Figure 3-4) the "sediment type mapping corridor" contains larger areas of "Sedimentary rock" (Substrate type 3 and 4), "Sand" and "Gravel and coarse sand" (sediment type 2 to 1b) (Figure 3-4). However, on the fine-scale map below the sediment types are shown as a highly varying mosaic of sediment types (Figure 3-5).

WIND FARM AREAS

Bornholm I nord is dominated by "Muddy sand", "Sand", and "Quarternary clay and silt" (Figure 3-4). Bornholm I syd is dominated by "Muddy sand", "Sand", and "Mud and sandy mud". Bornholm II is dominated by "Quarternary clay and silt", "Muddy sand" and a smaller area with "Sand". Bornholm II therefore has more "Quarternary clay and silt" compared to Bornholm I nord and syd with more sandy sediments. In general, the organic content of sediments in the area increases with depth (see section 3.2.2 below).

CABLE CORRIDORS

The cable corridors between the wind farm areas (OWFs) and Bornholm are shown in Figure 3-4 and Figure 3-6. In general, the sediment in the two cable corridors changes from "Sand" close to the coast, hard "Sedimentary rock" and at more than 20 meters depth finer substrate types such as mud and silt.

The cable corridor overlap (CC) from landfall on Bornholm and the first 10-15 km towards the OWFs is dominated by "Sand" in the landfall area closest to the coast and in the rest of the overlapping corridor by "Sedimentary rock", with smaller patches of "Gravel and coarse sand", "Sand" and finer sediments.

In the CC1 corridor connecting Bornholm and Bornholm I nord (OWF) at more than 20 meters depth the sediment changes from "Sedimentary rock" (CC1_01-05) to "Sand" (CC1_06 and CC1_09-11), a small area with "Till/diamicton" (CC1_07 and CC1_08) and closest to Bornholm I nord "Muddy sand" and "Mud and sandy mud" (CC1_12-15).

The small cable corridor CC1 area between Bornholm I nord and Bornholm syd consists mainly of "Sand" (see Figure 3-4)

The CC2 corridor connecting Bornholm II (OWF) and Bornholm is dominated by "Till/diamicton" (CC2_01-03) in the first part of the corridor (from landfall) and "Sand" (CC2_04-12) in the rest of the cable corridor towards Bornholm II.

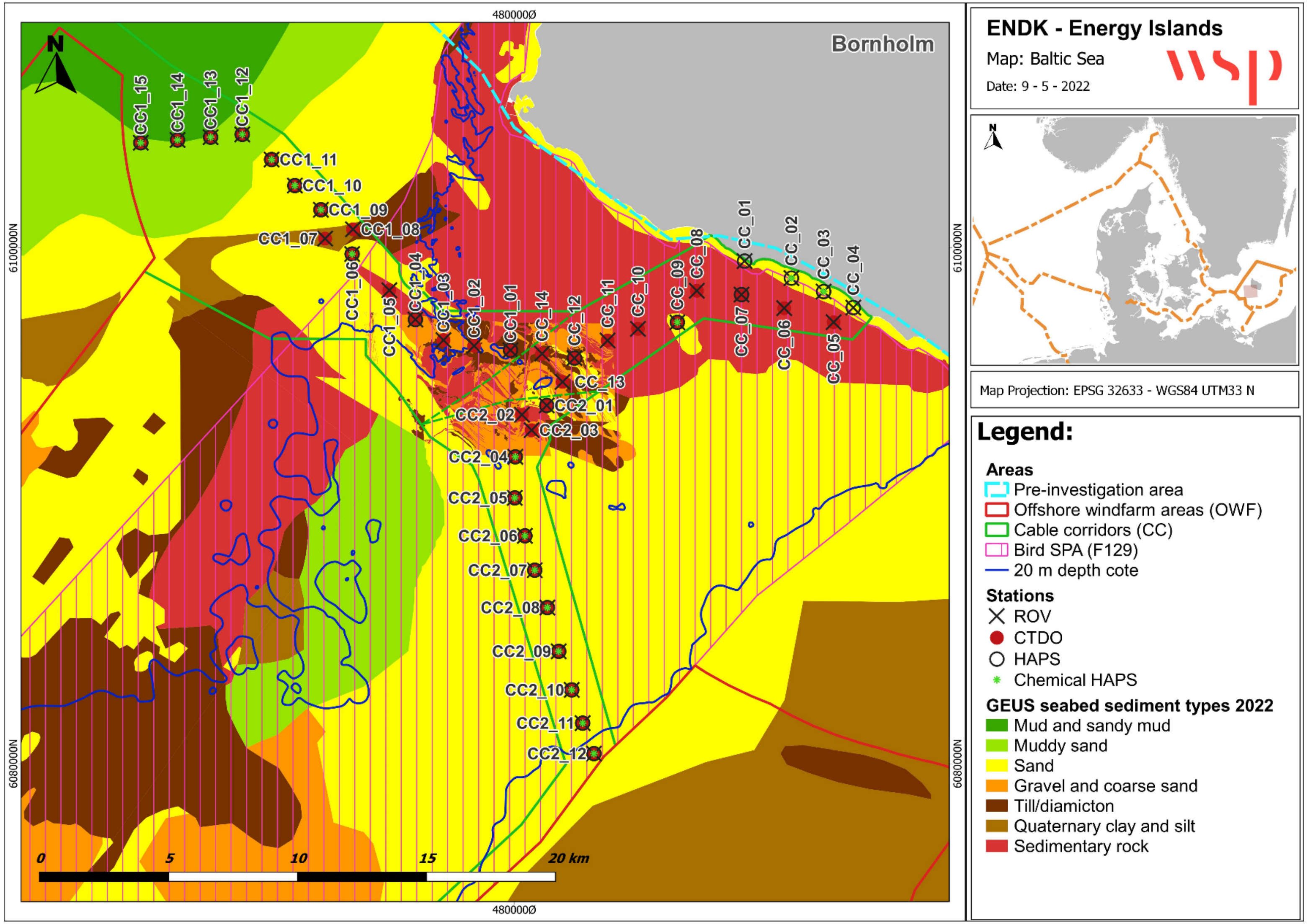

Figure 3-6. Seabed sediment types in the two cable corridors connecting the two OWFs to Bornholm (CC1 and CC2). Overlapping area of the cable corridors close to the coast are called CC. Sampling stations in the cable corridors are presented in the figure. Different sampling types are also shown i.e., ROV-video, Chemical samples, CTDO profiles and HAPS sediment core samples. Source: GEUS´ Marta database.

3.2.2 PHYSICAL PARAMETERS

Grain size and organic content is determining for the habitat available to the benthic flora and fauna and for oxygen conditions (see section 3.1.2).

Analyses of grain size and organic content along the NSP2 - Northern route showed that generally the organic content (TOC) and the silt and clay fraction increased with increasing water depth, whereas average grain size (D50) and dry weight (DW) decreased with depth. Thus, high organic content and fine grain size was found in the deep parts of the pre-investigation area along the NSP2 – Northern route (Nord Stream 2, 2019). Whereas, in the shallow part of the pre-investigation area in the Rønne Banke area, generally, high grain size and low organic content was found (Nord Stream 2, 2019) (Table 3-2).

Table 3-2. Standard physical conditions at the surface sediment stations in the pre-investigation area. TOC = total organic carbon, D50 = average grain size. – no data. *Read from graph (Figure 7-18) (Nord Stream 2, 2019). Stations within Bornholm I nord and Bornholm I syd are marked with blue and grey fill color, respectively. Bornholm II stations are marked with darker red fill color. Sources: (Baltic Pipe, 2019), (Nord Stream 2, 2019), (Nord Stream 2, 2018a).

Project and sample number	Depth [m]	TOC [% of DW]	D50 [mm]	Silt&Clay fraction [%]
Baltic Pipe, February/March 2018				
GCH38	44	-	-	88.9
GCH41	28	-	-	1.0
GCH45	15	-	-	0.8
GCH48	17	-	-	0.2
GCH53	44	-	-	90.8
GCH51	53	-	-	100
GCH50	51	-	-	98.7
Nord Stream 2 – Northern Route, Baseline study, November/December 2017				
D_EEZ_22	37.0	0.42	0.188	4
D_EEZ_24	21.0	0.07	1.250	0
D_EEZ_26	21.0	0.05	0.500	0
D_EEZ_28	45.0	1.80	0.052	52
D_EEZ_29	35.0	0.10	0.438	0
D_EEZ_30	21.0	0.12	0.440	4
D_EEZ_31	45.0	0.73	0.350	14
D_EEZ_34	38.0	0.24	0.210	3
D_EEZ_35	47.5	5.00	0.016	89
D_EEZ_36	45.5	3.90	0.024	70
D_EEZ_37	47.0	2.60	0.015	94
D_EEZ_38	37.0	0.56	5.000	1
D_EEZ_39	40.0	3.00	0.290	10
D_EEZ_41	27.0	0.08	0.800	0
Average (n=27)	51.8	1.9	0.7	51.1
Standard deviation (±)	20.1	1.7	1.9	43.3
Nord Stream 2 – Final Route, August/September 2018				
SS-13	55.6	0.4*	-	75*
SS-14	52	2.7*	-	62*
SS-15	46.1	0.7*	-	50*
SS-16	30.2	0.5*	-	42*

For stations located within Bornholm I nord and syd (D_EEZ_34, _36, _38, _39 and GCH38), there was a similar trend that the deepest stations had the lowest grain size and the highest amount of organic content (Table 3-2, Figure 2-1). Comparing stations within Bornholm I nord (D_EEZ_34, _36 and GCH38) and Bornholm I syd (D_EEZ_38, _39), both wind farm areas have very varying grain size and silt and clay fractions between stations within each wind farm area.

Two of the three stations within the Bornholm II (D_EZZ_22, GCH51, GCH53) were found at great depth (>98 m) with a very high silt and clay fraction (GCH51 and -53), whereas, the third, D_EEZ_22, bordering Rønne Banke, was a shallow station with a low silt and clay fraction (Table 3-2, Figure 2-1). Information on TOC and D50 was not available for comparison from Baltic Pipe stations. The silt and clay fraction differed to a great extend between stations in the wind farm areas (Bornholm I nord, Bornholm I syd and Bornholm II), and a further comparison of TOC and D50 would require more data.

There are no existing data available from the cable corridors leading from Bornholm to the wind farm areas.

3.2.3 CHEMICAL PARAMETERS

Sediment that is suspended in the water column due to digging or flushing activities during construction of the wind farms may cause release of nutrients, heavy metals and organic pollutants. Release of nutrients can increase phytoplankton concentration and epiphyte coverage and reduce light availability and growth for macroalgae on the seabed. High concentrations of pollutants in the seabed may be determining for the abundance and distribution of infauna in the seabed. The chemical sediment parameters are, therefore, used as supporting parameters in the statistical analysis of infauna composition and distribution in the wind farm areas and cable corridors.

NUTRIENTS

Existing data for total nitrogen (TN) and total phosphorus (TP) in and close to the pre-investigation area show highest concentrations at deep stations >40 meters depth corresponding to the presence of finer-grained and more organic-rich sediment dominated by silt and clay (Table 3-3). Station locations within the pre-investigation area are presented in Figure 2-1 and Figure 3-7 below.

There are no threshold concentrations for TN and TP in sediment in the Baltic Sea. Nord Stream 2 (NSP2) - Northern route – baseline study found concentrations between <100-5700 mg N/kg DW and 170-1100 mg P/kg DW for stations within the pre-investigation area (see Table 3-3).

Concentrations of sediment TN (150-5000 mg N/kg DW) and TP (110-820 mg P/kg DW) measured for NSP2 – Final route in 2018 along the southern rim of the pre-investigation area were within the range found at the same depths for the NSP2 - Northern route - baseline study in 2017 (Table 3-3).

For Baltic Pipe, measurements of TN (<200-6000 mg N/kg DW) and TP (240-1200 mg P/kg DW) in the sediment were within the same range as found in both NSP2 - Northern Route – baseline study and NSP2 - Final Route, however, most measurements of TN were <200 mg/kg DW, i.e. below detection range (Table 3-3).

Looking at the stations located within Bornholm I nord and syd (D_EEZ_34, _36, _38, _39 and GCH38), the concentration of TN ranged between 700-4900 mg N/kg DW, which is relatively high compared to the overall range in the pre-investigation area (<100-6000 mg N/kg DW). The range of TP in Bornholm I nord and syd (170-1100 mg P/kg DW) was similar to the overall range for all previous reports (110-1200 mg P/kg DW).

Within Bornholm II (D_EZZ_22, GCH51, GCH53), concentrations of TN and TP ranged between <200-6000 mg N/kg DW and 400-1200 mg P/kg DW, which is comparable to the overall ranges, although TP is in the higher end (Table 3-3, Figure 2-1).

There are no existing data from the cable corridors leading from Bornholm to the wind farm areas.

Table 3-3. Existing data for total nitrogen (TN) and phosphorus (TP) measured in sediment samples within the pre-investigation area. Data included from Nord Stream 2 – Northern route (Nord Stream 2, 2018a), Nord Stream 2 – Final Route (Nord Stream 2, 2019) and Baltic Pipe (Baltic Pipe, 2019). Stations within Bornholm I nord and Bornholm I syd are marked with blue and grey fill color, respectively. Bornholm II stations are marked with darker red fill color. For station location see Figure 3-7.

Location ID shortcut	Total nitrogen (mg/kg DW)	Total phosphorus (mg/kg DW)	Depth (m)	Sediment type
Nord Stream 2 – Northern Route, November/December 2017				
D_EEZ_22	600	400	37	Fine sand and silt
D_EEZ_24	110	300	21	Sand
D_EEZ_26	<100	180	21	Sand
D_EEZ_28	2900	670	45	Silt on top of clay
D_EEZ_29	<100	180	35	Sand
D_EEZ_30	140	340	21	Sand
D_EEZ_31	520	580	45	Silt, sand and gravel on top of clay
D_EEZ_34	700	170	38	Sand and silt
D_EEZ_35	5700	1100	47.5	Silt
D_EEZ_36	4900	1100	45.5	Silt
D_EEZ_37	2900	290	47	Silt
D_EEZ_38	1000	260	37	Sand and silt
D_EEZ_39	2300	820	40	Silt and sand
D_EEZ_41	<100	260	27	Sand
Nord Stream 2 – Final Route, August/September 2018				
SS-13	5000	820	55.6	Grey and dark clay
SS-14	3600	740	52	Clay and some sand
SS-15	1000	490	46.1	Sand and dark clay
SS-16	150	110	30.2	Sandy
Baltic Pipe, February/ March 2018				
GCH38	1.000	640	44	Silt/clay (88.9 %), sand
GCH41	<200	240	28	Sand (98.8 %)
GCH45	<200	810	15	Sand (96.9 %), gravel
GCH48	<200	470	17	Sand (99,7 %)
GCH53	<200	550	44	Silt/clay (90,8 %), sand
GCH51	6000	1200	53	Silt/clay (100 %)
GCH50	1400	630	51	Silt/clay (98,7 %)

POLLUTANTS

Existing data for chemical pollutants found in the pre-investigation area are presented below (see section 2.2 for list of included pollutant parameters). Station locations within the pre-investigation area are presented in Figure 2-1.

CORE INDICATORS AND THRESHOLD VALUES:

HELCOM uses core indicators with quantitative threshold values to evaluate progress towards the goal of achieving good environmental status in the Baltic Sea. Core-indicator evaluations are regularly updated and published as core indicator reports (HELCOM, 2018b).

The environmental quality standards (EQS) are threshold values used by HELCOM countries that are also EU Member States for the classification of chemical status of water bodies under the Water Framework Directive. At concentrations below this level, it is assumed that no harm will be caused to the marine environment.

The Danish EPA has determined national environmental quality standards (NEQS) for specific hazardous substances (Miljø- og Fødevareministeriet, 2017). NEQS are specified to secure good chemical status in Danish waters. The EQS and NEQS threshold values are both legal requirements based on risk assessments.

The ecotoxicological assessment criteria (EAC) is based on a similar risk assessment but is an assessment tool and not a legal requirement. The EAC threshold values are defined for each hazardous substance, as the concentration below which no chronic effect is expected to occur in the most sensitive marine species (OSPAR, 2009). The OSPAR standards are, however, not applicable to the Baltic Sea, but since no specific threshold values for the Baltic Sea exists, HELCOM uses the OSPAR standards for assessment of xenobiota (chemicals foreign to a biological system) in the Baltic Sea (HELCOM, 2010).

The Effect-Range – low (ERL) threshold value has been developed by the US EPA (see (OSPAR, 2009; Nyberg et al., 2013)), and similarly to the EAC, the ERL is not a legal requirement. The ERL-values represent a lower boundary above which impacts on the benthic invertebrate community can be expected. For comparison, existing data from the pre-investigation area of the baseline studies of Baltic Pipe (data sampled in February and March 2018), Nord Stream 2 – Northern Route – baseline study (data sampled in November/December 2017) and Nord Stream – Final Route (data sampled in August/September 2018) have been compiled and checked for exceedances of threshold concentrations.

The Lower Action Level (LAL) for specified chemical substances is defined in “the Danish guideline for disposal of dredged material” (klapvejledningen) (Miljøstyrelsen, 2005). This standard is a legal requirement, but only applies to sediment dumping, and therefore does not directly relate to the concentration of hazardous substances in normal sea-floor sediment. Therefore, this threshold should only be used in the absence of the quality standards and threshold values mentioned above.

Observed exceedances of pollutants in the sediment are shown in Table 3-4 below and station location is shown in Figure 2-1. Pollutants are evaluated based on the available quality standards and threshold values, prioritized according to recommendations from the Danish Centre for Environment and Energy, Aarhus University (DCE) (Strand & Larsen, 2013) in the following order:

1) EQS (HELCOM, 2017)
2) NEQS (Miljø- og Fødevareministeriet, 2017)
3) EAC (OSPAR, 2009)
4) ERL (OSPAR, 2009)
5) LAL (Miljøstyrelsen, 2005)

POLLUTANTS FROM EXISTING DATA:

The majority of the analyzed sediment samples at stations within the pre-investigation area had concentrations of pollutants below threshold values, corresponding to background levels, which are considered to be harmless to marine life. 11 out of a total of 26 selected stations had exceedances of pollutants. All exceedances are listed in Table 3-4 below and stations where exceedances are found are shown in Figure 3-7.

The environmental quality standards EQS and NEQS are legal requirements when performing an environmental assessment. However, of the chemical compounds investigated for Energy Island Bornholm, threshold values only exist for the heavy metal lead (Pb), the PAH-compound anthracene and the organotin-compound TBT (Table 3-4). The concentration of Pb did not exceed the EQS or the NEQS in any previous investigation. The PAH, anthracene, exceeded the NEQS threshold at all stations, except for one, and TBT exceeded the EQS threshold at several stations in all previous investigations.

Looking at the ERL-values, however, exceedances of the heavy metals Pb (Lead) and Cu (Cobber), and four PAH-compounds (all except anthracene) were found (see Table 3-4).

The EAC- threshold is the only tool for assessing concentrations of PCB-compounds, apart from the LAL-value, which is higher. Of the seven included compounds exceedances were found only for CB118 at one station from Baltic Pipe (GCH41) and one station from NSP2 – Northern (D_EEZ_35) (Table 3-4).

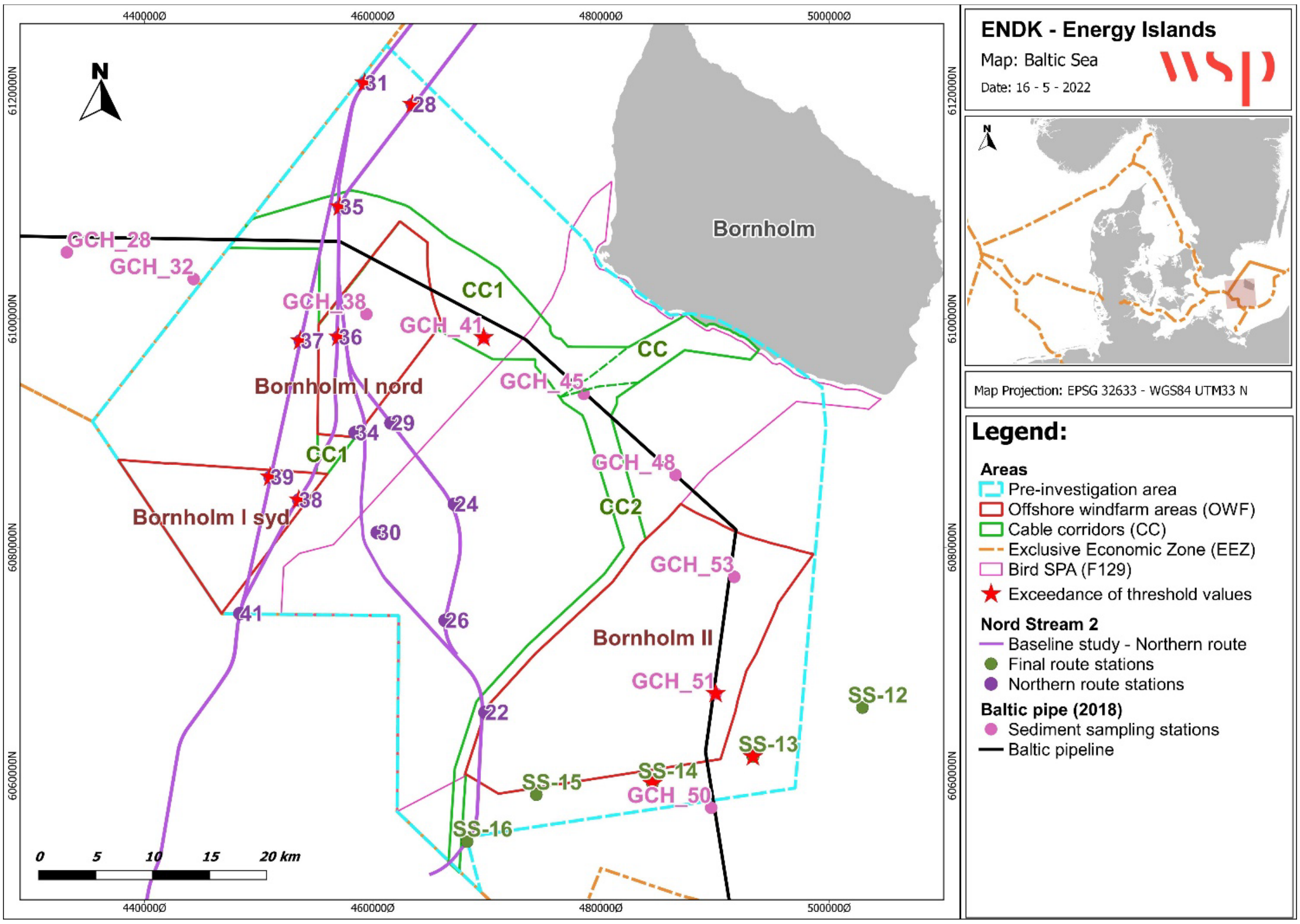

Figure 3-7. Stations with exceedances of threshold values for pollutants within the pre-investigation area, marked with red star symbol. Data based on existing data. Data and data sources are shown in Table 3-4.

The exceedances of threshold values were generally found at stations deeper than 37 m, often characterized by fine-grained, organic-rich sediment consisting primarily of silt and clay (Table 3-4). This was expected since pollutants tend to adsorb to fine-grained, organic-rich material and accumulate with depth.

Only one shallow water station (Baltic Pipe station GCH41) with less than 37 m depth (-28 m) and a primarily sandy substrate showed exceedance of the EAC threshold for PCB-compound CB118 (Table 3-4).

Depths between 37-55 m were found in the deepest parts of the pre-investigation area and the wind farm areas (see Figure 3-1). Stations situated within the wind farm areas where concentrations of pollutants exceeded threshold values were (see Figure 3-7 and Table 3-4):

- Bornholm I nord: D_EEZ_36 (NSP2 – Northern route)
- Bornholm I syd: D_EEZ_38 and _39 (NSP2 – Northern route)
- Bornholm II: GCH51 (Baltic Pipe)

In Bornholm I syd and nord exceedances of five pollutants were found: Pb (D_EEZ_39), the PAHs anthracene (all), fluorene (all), benzo(g,h,i)perylene (D_EEZ_36 and _39) and TBT (D_EEZ_36, and _39) (Table 3-4).

Within Bornholm II exceedances of six pollutants were found, but only at one station (GCH51): Pb, Cu, the PAHs anthracene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene and indeno(1,2,3cd)pyrene and TBT (Table 3-4).

The remaining stations found within the wind farm areas did not have pollutants that exceeded threshold values.

There are no existing data from the cable corridors leading from Bornholm to the wind farm areas.

Table 3-4. Concentrations and available threshold values for pollutants exceeding threshold values (µg/kg DW) from three existing reports: Baltic Pipe, Nord Stream – Final Route and Nord Stream – Northern Route – baseline study. Baltic Pipe: 2 out of 8 stations within the pre-investigation area exceeded threshold values; NSP2 – Final route: 2 out of 4 stations exceeded threshold values within the pre-investigation area; NSP2 – Northern route: 7 out of 14 stations exceeded threshold values within the pre-investigation area. Stations within Bornholm I nord and Bornholm I syd are marked with blue and grey fill color, respectively. Bornholm II stations are marked with darker red fill color. For station locations see Figure 3-7.

		Heavy metals		PAH-compounds					PCB-compounds	Organotin-compounds	Depth (m)	Sediment Type
		Pb	Cu	Anthracene	Benzo-(g,h,i)-perylene	Dibenzo-(a,h)-anthracene	Fluorene	Indeno-(1,2,3cd)-pyrene	CB118	TBT		
	Threshold values											
	EQS	120 000								1.6		
	NEQS	163 000		4.8								
	ERL	47 000	34 000	85	85	63	19	240				
	EAC			78					0.6			
	LAL	40 000	20 000							7		
Baltic Pipe	**GCH41**								3.6		28	Sand 98.8%
	GCH51	57 000	41 000	9.0	300	69		480		10	53	Silt/clay
NSP2 – Final route	**SS-13**			16	230			320		2.9	55.6	Grey and dark clay
	SS-14				110					2.3	52	Primarily clay (sand)
NSP2 – Northern route	**D_EEZ_28**			16	86		85				45	Silt on top of clay
	D_EEZ_31			8.6			22				45	Silt, sand and gravel on top of clay
	D_EEZ_35	78 000	44 000	50	420	89	76	520	0.93	4.2	47.5	Soft silt/mud
	D_EEZ_36			34	190		91			3	45.5	Soft silt/mud
	D_EEZ_37			14			140			1.7	47	Silt
	D_EEZ_38			12			81				37	Coarse sand, gravel and cobbles
	D_EEZ_39	54 000		15	92		35			2.9	40	Silt and sand

3.3 BENTHIC FLORA

Benthic flora in the Baltic Sea consists mainly of seagrasses and macroalgae. Seagrasses grow in sandy sediment types down to 2-4 meters depth along the southern coast of Bornholm (NOVANA-station Franks Rev, Figure 2-1). Macroalgae live attached to hard substrate within the photic zone. The photic zone is generally defined as depths, where more than 1% of surface irradiance is present and typically encompasses the upper 0-20 m of the water column in the Baltic Sea. Monitoring of Nord Stream 2 in the Natura 2000 site N252/H261 in the pre-investigation area found macroalgae down to 24.5 m depth in 2017 (Orbicon, 2019). At greater depths benthic flora, generally, cannot exist due to light limitation (Olsonen, 2006).

Depths within the photic zone (light green) and with hard substrate (dark green) for macroalgae attachment in the pre-investigation area are shown in Figure 3-8 below. The figure illustrates that benthic flora is potentially present along the coast of Bornholm and in the shallow Rønne Banke area south of Bornholm between the wind farm areas where depths are 0-24.5 meters.

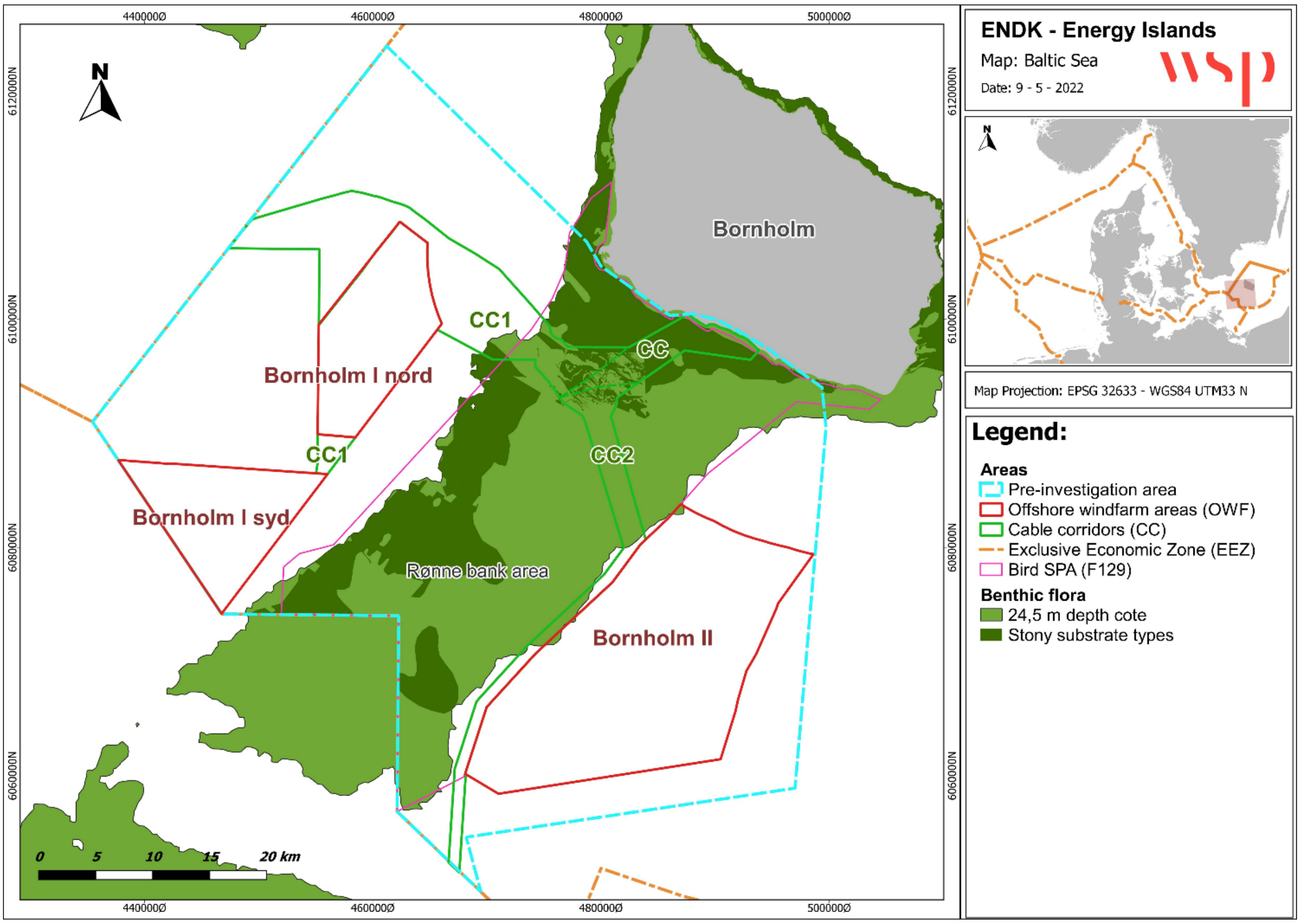

Figure 3-8. The map shows the photic zone (light green) and stony areas (dark green) where attachment is available for macroalgae in the pre-investigation area at depths from 0 to 24.5 meters, the wind farm areas and in the cable corridors.

Apart from hard substrate and light availability, macroalgae growth is limited by oxygen deficiency and low salinity (Olsonen, 2006; Køie & Kristansen, 2014). In general, species richness decreases with decreasing salinity concentration from the Danish Sound towards the northeastern part of the Baltic (Olsonen, 2006; Køie & Kristansen, 2014). Macroalga species composition varies with succession during the year, from year to year, and can, therefore, vary between sampling years (Køie & Kristansen, 2014). Macroalgae compete with blue mussels (*Mytilus edulis*) for the hard substrate in the area, and in large parts blue mussels dominate the coverage of stones in the pre-investigation area creating biogenic reefs (Orbicon, 2019; Miljøstyrelsen, 2021b).

Benthic flora in the shallow-water, sandy seabed along the southern coast of Bornholm consists mainly of macroalgae on hard substrate and some seagrass (*Zostera marina*) in sandy substate.

Zostera marina is found at 2-4 meters depth along the southern coast of Bornholm (NOVANA-station Franks Rev, Figure 2-1) and in very thin populations with an area coverage of generally 0% and in a few spots up to 10% area coverage (NOVANA-station Sose 2, BOR310016 station in 2017, Figure 2-1) (Odaforalle.dk, 2022).

Macroalgae are divided into three groups including red algae (Rhodophyta), brown algae (Phaeophyta) and green algae (Chlorophyta). All three groups can be found along the coast of Bornholm (Table 3-5). Green algae are most common in shallower water, with higher nutrient load. Red algae are generally able to live at the highest depth, the crust forms being found at greatest depth.

Table 3-5. Macroalgae species found in the pre-investigation area. [1]: NOVANA-station Franks Rev 2008-2020 (Odaforalle.dk, 2022), [2]: Nord Stream 2 – Northern route - monitoring in N2000 site N252/H261 (Orbicon, 2019), [3]Baseline analysis Natura 2000 site N252/H261 (Miljøstyrelsen, 2021a). No benthic flora stations from Baltic Pipe were located within the pre-investigation area.

Macroaalgae taxa	Red algae (Rhodophyta)	Brown algae (Phaeophyta)	Green algae (Chlorophyta)
NOVANA st Franks Rev close to the coast[1] 2008-2020 **0-100% coverage** **0-14 m depth**	<u>Crusts:</u> *Red crust (Hildenbrandia rubra)* *Red calcified crust* <u>Red algae bushes:</u> *Aglaothamnion roseum* *Callithamnion sp.* *C. corymbosum* *Ceramium spp.* *C. diaphanum* *C. rubrum* *C. strictum* *C. tenuicorne* *C. virgatum* *Coccotylus truncates* *Cystoclonium purpureum* *Delesseria sanguinea* *Furcellaria lumbricalis* *Phyllophora pseudoceranoides* *Polysiphonia spp.* *P. fibrillose* *P. fucoides* *P. nigrescens* *P. stricta* *Rhodomela confervoides*	<u>Crusts:</u> *Brown crust* *Scytosiphon lomentaria crust* <u>Brown algae bushes:</u> *Chorda filum* *Desmarestia viridis* *Dictyosiphon foeniculaceus* *Ectocarpus sp.* *Eudesme virescens* *Fucus sp.* *Fucus serratus* *Halosiphon tomentosus* *Leathesia difformis* *Pylaiella littoralis* *Stictyosiphon tortilis*	*Cladophora sp.* *C. glomerata* *C. rupestris*
Nord stream 2 - N2000 monitoring in N252/H261 in 2019[2] **18-24.4 m depth** **0-10% coverage**	<u>Crusts:</u> *Red crust (Hildenbrandia sp.)* *Coralline red algae (Phymatolithon sp.)* <u>Red algae bushes:</u> *Callithamnion corymbosum* *Polysiphonia spp.*	<u>Crusts:</u> *Brown crust algae* <u>Brown algae bushes:</u> *Sugar kelp (Saccharina latissima)*	

Macroaalgae taxa	Red algae (Rhodophyta)	Brown algae (Phaeophyta)	Green algae (Chlorophyta)
	Ceramium spp. *Coccotylus truncatus*		
Natura 2000 site N252/H261[3] 2016-2021	*Red algae bushes*	*Sugar kelp (Saccharina latissima)*	

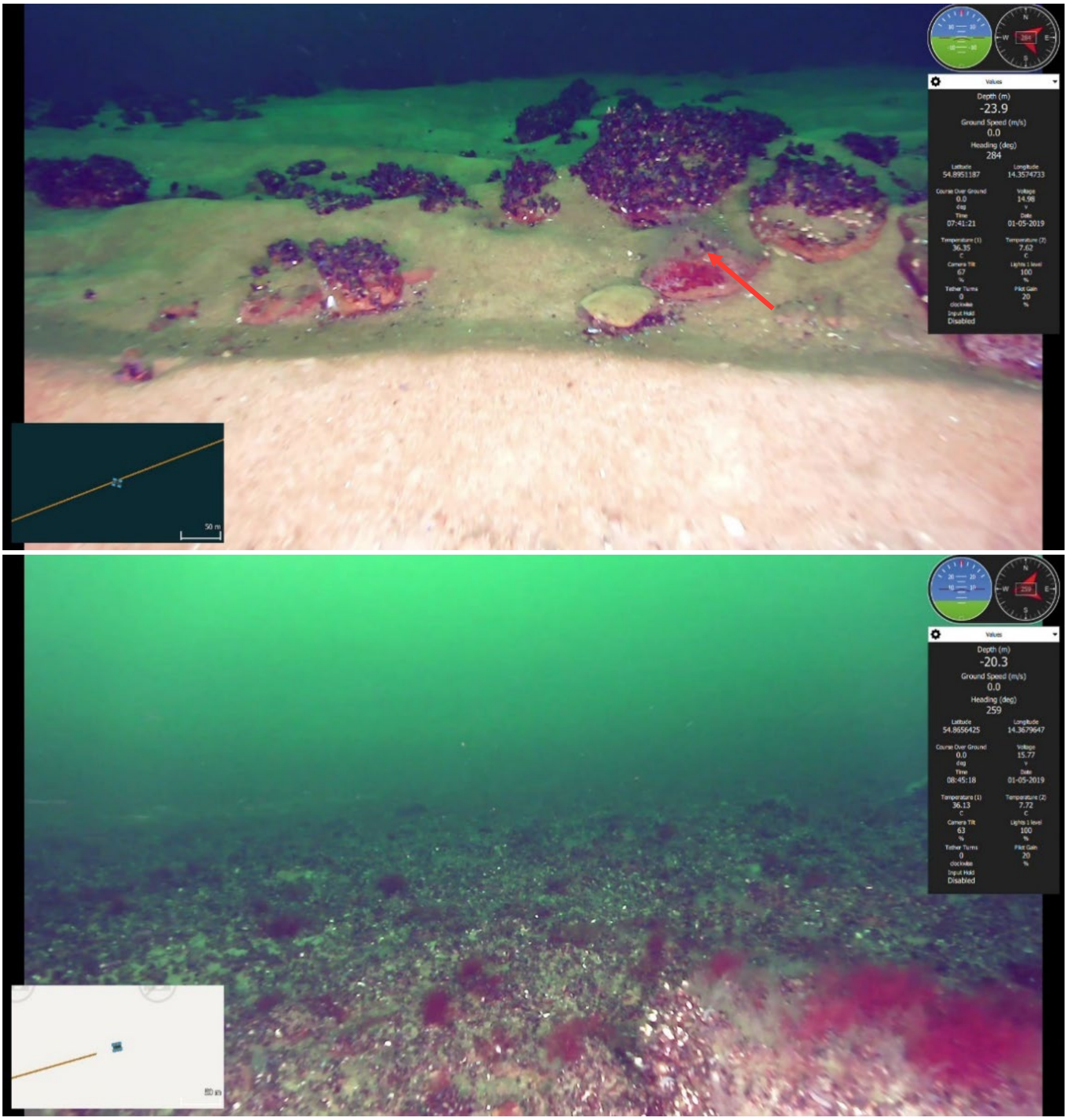

Figure 3-9. The dominating macroalgae species observed in the NSP2 – monitoring study in the habitat site N252/H261 in 2017 within the pre-investigation area. Upper panel: red crust alga *(Hildenbrandia* sp.) (red arrow). Lower panel: Red alga bush *Callithamnion corymbosum*. The panel in the lower left corner shows the ROV positions in relation to the NSP2 pipeline. Source: (Orbicon, 2019).

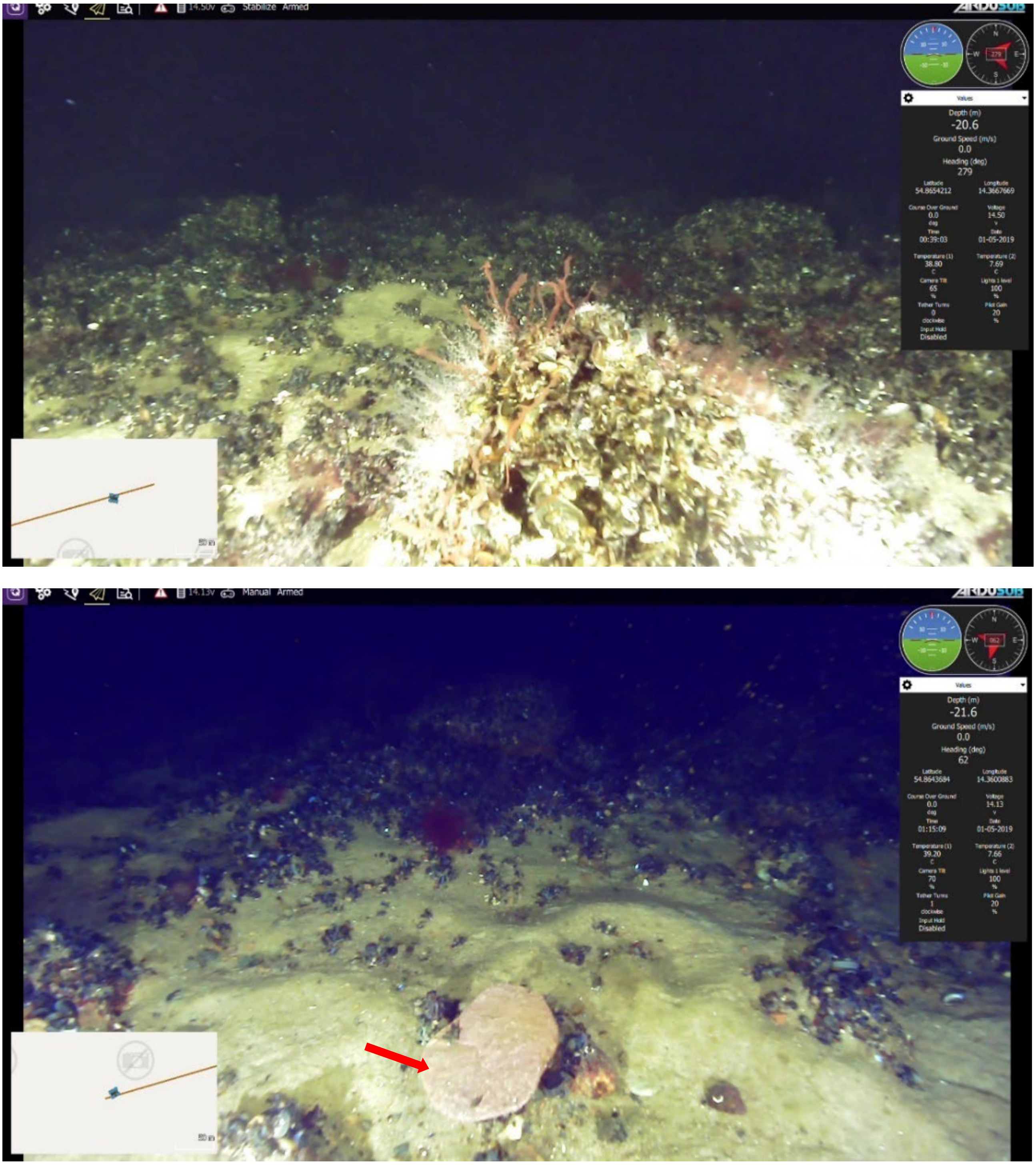

Figure 3-10. Other important macroalgae species observed in the NSP2 – monitoring study in the habitat site N252/H261 in 2017 within the pre-investigation area. Upper panel: red alga bush likely *Coccotylus truncatus* (coarser filaments). Lower panel: Coraline red algae (red arrow, *Phymatolithon* sp.). The panel in the lower left corner shows the ROV positions in relation to the NSP2 pipeline. Source: (Orbicon, 2019).

Macroalgae found on larger stones along the coast are dominated by the brown alga genus *Fucus* spp., green algae such as *Cladophora* spp., and red alga bushes such as *Ceramium* spp., *Polysiphonia* spp. and *Furcellaria lumbricalis*. At greater depth red algae bushes, crust algae and coralline red algae dominate (Figure 3-9 and Figure 3-10). At even greater depths of 14-30 m blue mussels (*Mytilus edulis*, up to 100% coverage) was found to dominate the benthic communities in the NOVANA baseline study from 2011 in the Natura 2000 site N252/H261 (Miljøstyrelsen, 2021a).

In the shallow Rønne Banke area NSP2 - monitoring in Natura 2000 site “Adler Grund og Rønne Banke (N252/H261)” in 2017 at depths from 18-24.4 m, showed dominance of blue mussels on the hard substrate and low coverage of macroalgae (0-10%) (Orbicon, 2019). The most common red algae species was the red bush *Callithamnion corymbosum* and red crust algae *Hildenbrandia* sp., which were observed at all but one station (Figure 3-9). Very few brown algae were observed. Most common was brown crust (Orbicon, 2019).

There are no benthic flora species on the Danish red list (Den danske rødliste, 2022). None of the observed species in the pre-investigation area (Table 3-5) are considered threatened (Critically Endangered, Endangered or Vulnerable) according to the HELCOM red list (HELCOM redlist, 2022). The two brown algae species *Fucus serratus*, *Fucus vesiculosus* and the red algae species *Furcellaria lumbricalis* are listed as Least Concern (LC).

3.3.1 WIND FARM AREAS

Bornholm I nord and syd are too deep to have benthic flora communities (28-47.5 meters depth) (Table 3-1) according to the existing data from the pre-investigation area.

Bornholm II has depths between 20 to 55 meters and macroalgae communities are potentially present at depths between 20-24.5 meters along the westernmost rim of Bornholm II along the shallow Rønne Banke area (Figure 3-1). Most likely single crust algae and red algae bushes grow with low coverage in this area within Bornholm II, since the available depths are close to the depth limit of macroalgae in the area (Figure 3-8).

3.3.2 CABLE CORRIDORS

The overlapping part (CC) of the two cable corridors closest to the coast of Bornholm has depth limits of 0-20 meters (Table 3-1), and is therefore appropriate for seagrass growth in the sandy part close to the coast down to approximately 4 meters depth and for macroalgae on hard substrate in the entire length of the corridor. Most of this part of the corridor is dominated by hard substrate such as “Sedimentary rock” and “Till/diamicton” and therefore optimal for macroalgae growth and may have dense coverage of macroalgae in parts along the corridor consisting mainly of red algae bushes.

In the CC1 cable corridor connecting Bornholm I with Bornholm, macroalgae can potentially grow in the part from the CC corridor to the edge of the Bird SPA at depths between 13 to 24.5 meters on available hard substrate (Figure 3-4). The small part of the corridor between Bornholm I nord and south is 34.5-38 meters deep and generally too deep for macroalgae growth.

In the CC2 cable corridor connecting Bornholm II with Bornholm most of the cable corridor is below 24.5 meters depth (14-36 m) except for the part nearest the Bornholm II wind farm area (Figure 3-1). Macroalgae can therefore potentially grow on larger stones (> 10 cm) in the sandbed if present (Figure 3-4).

3.4 BENTHIC FAUNA

Benthic fauna refers to invertebrates associated with the seabed surface (epifauna) or living buried in the seabed (infauna).

Benthic fauna in the open Baltic Sea is mainly determined by substrate type, salinity and oxygen concentration. The number of species which can be found, strongly depends on the ambient salt concentration, resulting in a generally higher species numbers in the south-western part of the Baltic Sea compared to the north-eastern part of the Baltic Sea in the Bothnian Bay. Oxygen deficiency (<4 $mgO_2\ l^{-1}$) results in a reduced number of benthic fauna species and abundance and is observed mainly at depths below 60 meters in the area (see section 3.1.2). Oxygen concentrations below 2 $mgO_2\ l^{-1}$ are critical for benthic organisms and will typically result in death of most organisms depending on species resilience (Rambøll, 2019; Hansen og Høgslund, 2021). The pre-investigation area for Energy Island Bornholm is maximally 58 meters deep and oxygen deficiency at the seabed is therefore possible but likely rare.

In general, benthic fauna in the Baltic Sea belong to the so-called Macoma-community and are characterized by the bivalve *Limecola balthica* (formerly known as *Macoma balthica*) and a few other species, such as the common mussel *Mytilus* spp. (Figure 3-12). The small, amphibian crustacean white Baltic pole flea *Pontoporeia (Monoporeia) affinis* living in brackish water, the isopoda crustacean *Saduria entomon* and the invasive bristleworm *Marenzellaria* are also characteristic species in the Baltic Sea. Furthermore, the benthic populations in the open waters of the central Baltic Sea are often characterized by the amphipod *Pontoporeia femorata* and the scale-worm *Bylgides sarsi* (Gogina et al, 2016), which are considered ice-age relics in the Baltic Sea.

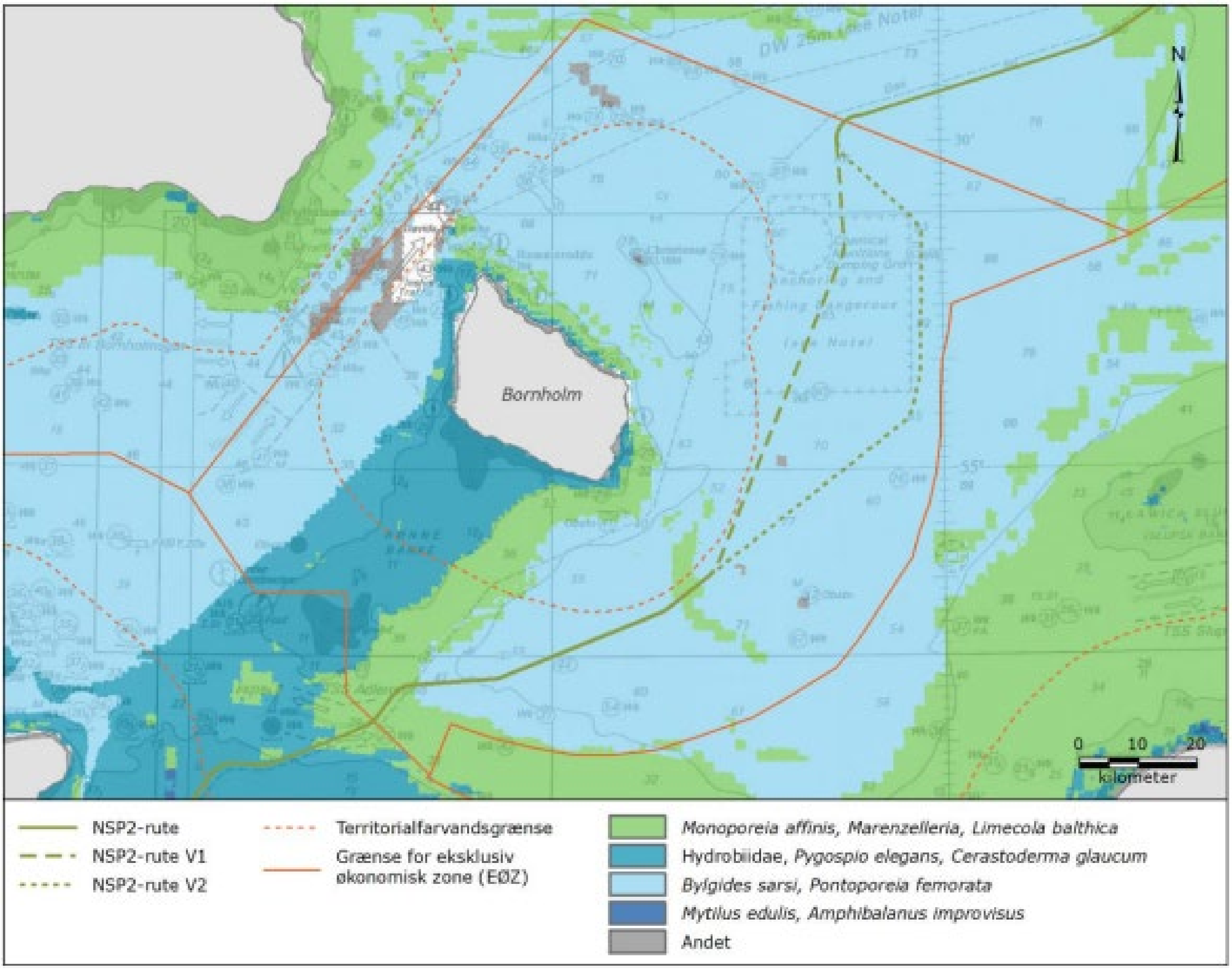

Figure 3-11. Benthic fauna communities in the southwestern Baltic Sea, based on abundance data from the period 2000-2013, showing the most abundant or characteristic species in the Baltic Sea (*Macoma baltica* = *Limecola balthica*). Source: (Rambøll, 2019) based on (Gogina et al, 2016).

3.4.1 EPIFAUNA

Epifauna observed by ROV is generally dominated by blue mussel (*Mytilus* spp.), both measured as individual numbers and biomass in the pre-investigation area (Nord Stream 2, 2018b; Orbicon, 2019; Miljøstyrelsen, 2021a; Miljøstyrelsen, 2021b). Nord Stream 2 (NSP2) - Northern route - Baseline studies and NSP2 - Northern route - Monitoring in Natura 2000 site N252 found highly variating blue mussel coverage of 0-100% (Orbicon, 2019). Blue mussels dominated reef areas, and blue mussels and the small mud snail *Peringia ulvae* (*Hydrobiidae*) dominated sand areas (Orbicon, 2019). Hydrobiidae was observed as dominating in the sandbank and reef areas on sand in 2019 on the ROV-videos (Orbicon, 2019). In reef areas blue mussels are attached to larger stones. On sand banks blue mussels can be found as small ballistic (moving) balls consisting of blue mussel communities that are moved along the sandbed with the current (Figure 3-12).

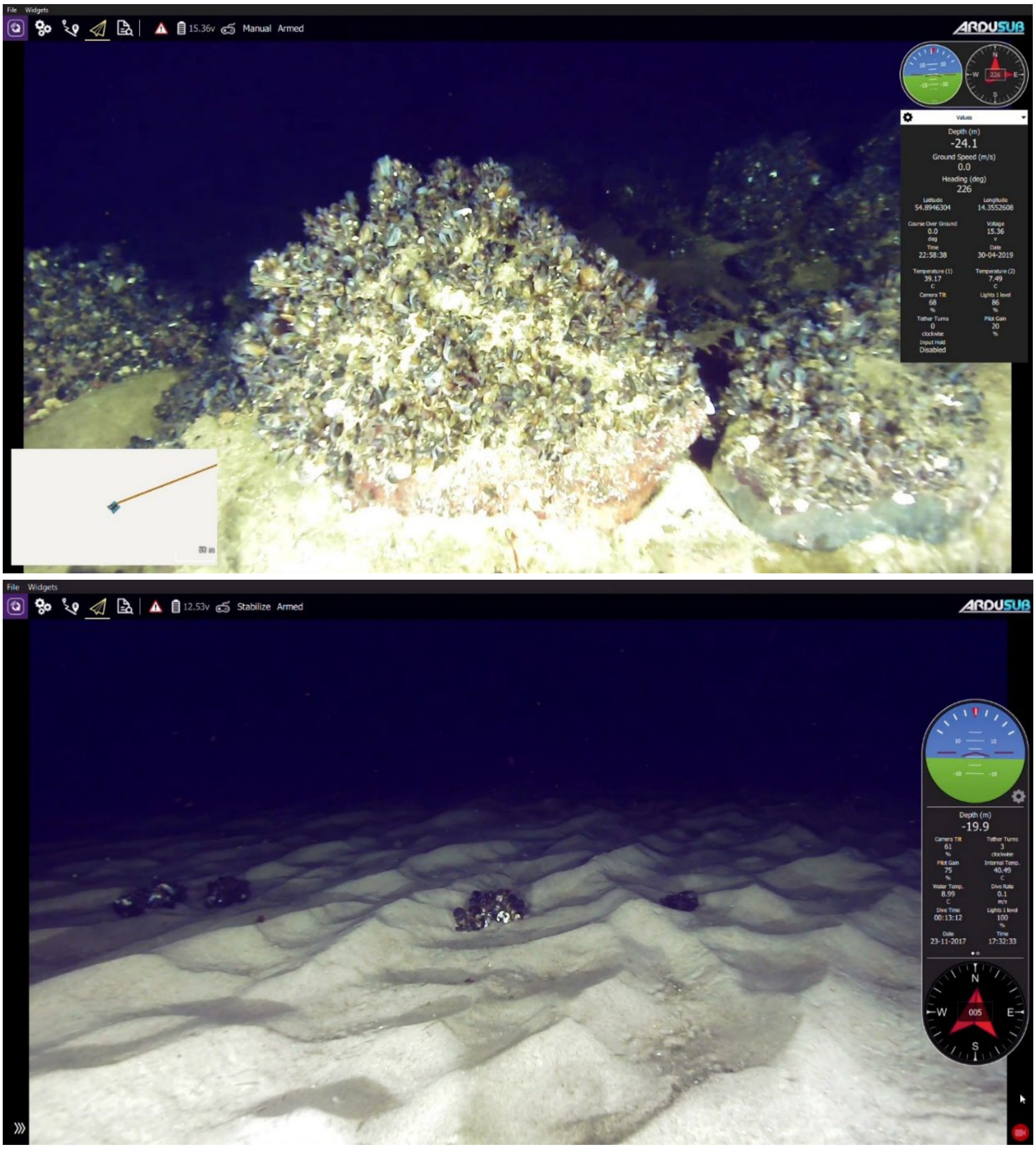

Figure 3-12. Blue mussel communities in the pre-investigation area. Upper panel: Blue mussels on large stones at station N3_3, NSP2 - monitoring in N252 in 2019. Source: (Orbicon, 2019). Lower panel: Mussels as small ballistic balls on the sandbed, that are moved along the seabed by the current at station D_EEZ_26, NSP2 - Northern route - Baseline study in 2018. Source: (Nord Stream 2, 2018a).

Other epifauna species observed in the Nord stream 2 monitoring of Natura 2000 site N252/H261 “Adler Grund og Rønne Banke” are listed in Table 3-6 below. In general, epifauna coverage was highly variable from 1% to 90-100%, *Mytilus* spp. comprised most of the coverage. Bristle worms as indicated by sand worm piles had a low coverage of 0-1%.

Table 3-6. Epifauna and infauna observed on the seabed in Natura 2000 site N252/H261 “Adler Grund og Rønne Banke” in 2019. Source: (Orbicon, 2019).

Taxonomic group	Taxa/species and common name
Porifera	*Marine fungi* spp.
Cnidaria	*Hydrozoans* spp.
	Sea anemone sp.
Polychaeta/ bristle worms	*Spirobranchus triqueter* (Tube worms)
	Pygospio elegans
	Fabriacia stellaris
	Sand worm piles (Polychaeta spp.)
Bivalvia/ mussels and cockles	*Mytilus edulis* (Blue mussel)
Only shells observed	*Mya arenaria*
	Cerastoderma spp./cockle sp.
	Limecola balthica (Baltic macoma)
Gastropoda	*Mud snail (Hydrobiidae)*
Crustacea	*Balanidae spp.* (Barnacle)
	Amphipoda sp.

The wind farm areas and the cable corridors are therefore expected to be dominated by the epifauna species *Mytilus* spp. and possible the small mud snail *Peringia ulvae* (*Hydrobiidae*) in areas with sand.

There are no existing data available from the cable corridors leading from Bornholm to the wind farm areas.

3.4.2 INFAUNA

Infauna was sampled in the pre-investigation area for Baltic Pipe in July 2018 and for the Nord Stream 2 baseline study in November/December 2017 and monitoring in the Natura 2000 site N252 in April/May 2019. Species numbers, abundance (individual numbers) and biomass are compared between the three studies in Table 3-7 below. Baltic Pipe generally found the highest biomass values in the pre-investigation area, whereas NSP2 found the highest individual numbers (Table 3-7).

The baseline study for Nord Stream 2 - Northern route in 2017 included extensive sampling and statistical analysis of infauna at the stations within the pre-investigation area. This study found that high species numbers were positively correlated to oxygen concentration, lower depth and lower salinity. Salinity in the bottom waters was negatively correlated with species numbers, likely, due to low oxygen concentrations correlated to a strong halocline i.e., high salinity at the seabed (see section 3.1.2). A strong halocline hinders oxygen exchange with the surface layers and can cause oxygen deficiency for infauna species in the seabed. Species numbers were highest in areas with coarse and varying sediment types and lowest on stations with high silt and clay content. The silt and clay fraction is positively correlated to depth, which again is negatively correlated to oxygen concentrations (Nord Stream 2, 2018b).

Table 3-7. Comparison of species numbers, abundance (individual numbers) and biomass in the baseline study for Baltic Pipe (Baltic Pipe, 2019), Nord Stream 2 - Northern route (Nord Stream 2, 2018b) and Nord Stream 2 - monitoring in Natura 2000 site N252/H261 (Orbicon, 2019) within the pre-investigation area of this study. **: range minimum and maximum, *: average for all samples. Indv. = individuals.

Previous studies	Sampling period	Species numbers pr. sample	Abundance (Individuals/sample) (individuals/m^2)	Biomass Wet weight (WW)/Dry weight (DW)
Baltic Pipe	July 2018	0-15	0-800 indv./sample	0-30 g WW/sample**
NSP2 – Northern route, - Baseline study	Nov-dec 2017	5-25	0-2200 indv./m^2	3.33 g WW/m^2 (incl. bivalves)* 0.28 g WW/m^2 (excl. bivalves)* 1.88 g DW/m^2 (incl. bivalves)* 0.11 g DW/m^2 (excl. bivalves)*
NSP2 – Northern route – monitoring N2000 site N252/H261	April-May 2019	5-20	107-347 indv./m^2	0.25-7.27 g WW/m^2** 0.15-6.67 g DW/m^2**

In the Natura 2000 site (N252/H261) southwest of Bornholm (depth range 24-38 m) the highest species numbers (10-22 species) and abundances (approx. 100-2110 individuals/m^2) of infauna were observed, particularly in the western part of the site (station D_EEZ_27, _29, _32, _33, _34, _40, _41) (see Figure 3-13 and Figure 3-14). These stations have a large variation in sediment composition and generally more sand, gravel, cobbles and stones compared to stations with lower species numbers and abundances. South of the Natura 2000 site (Rønne Banke) (depth range 21-38 m; st. D_EZZ_22, _26) the sediment was dominated by sand and silt and had lower species numbers (8-11 species) and abundances (approx. 300-600 individuals/m^2) of infauna than observed in the Natura 2000 site (Nord Stream 2, 2018b).

Generally, Infauna abundance showed the same pattern as described for species numbers and was highest in the Rønne Banke area (see Figure 3-13 and Figure 3-13). The dominating infauna species in the NSP2 - baseline study in 2017 was blue mussel (*Mytilus* spp.), Northern astarte (*Astarte borealis*) and Baltic macoma (*Limecola balthica*) (Nord Stream 2, 2018b). *Marenzelleria* sp., *Hediste diversicolour* and *Pygospio elegans* dominated in 2019 during NSP2's monitoring in the Natura 2000 site N252/H261 and approximately the same number of species were found pr sample in the two studies (Table 3-7) (Orbicon, 2019). In general, the most abundant infauna species in 2017 with more than 500 individuals in total (for all stations) were: blue mussel (*Mytilus edulis*), *Pygospio elegans*, *Scoloplos (Scoloplos) armiger*, Oligochaeta, mud snail (*Peringia ulvae*), Northern astarte (*Astarte borealis*), *Marenzelleria*, Baltic macoma (*Limecola balthica*,), *Tubificoides benedii* and ragworm (*Hediste diversicolor*) (Nord Stream 2, 2018b).

Species biomass was highest at station D_EEZ_31 on the northern edge of the pre-investigation area and generally high in the Natura 2000 site N252/H261. High biomass was related to the presence of bivalves. The highest average biomass was found for blue mussel (*Mytilus* spp.) (5.43 g AFDW/m^2), which was present at 73% of the stations (Nord Stream 2, 2018b).

Two HELCOM red listed species (HELCOM redlist, 2022) the amphipods *Monoporeia affinis* (LC) and *Pontoporeia femorata* (LC) were observed in one sample from station D_EEZ_22 south of Rønne Banke on the border of Bornholm II (see station in Figure 3-13) (Nord Stream 2, 2018b).

In the wind farm areas, species number and abundance generally increased with closeness to the shallower Rønne Banke area. The highest species numbers were found in Bornholm I syd. The highest infauna abundances were found in Bornholm I syd and Bornholm II closest to the Rønne Banke area (Figure 3-13 and Figure 3-13).

Stations were few and not equally distributed within the wind farm areas. It is, therefore, not possible to compare the wind farm areas in more detail based on the existing data.

There are no existing data available from the cable corridors leading from Bornholm to the wind farm areas.

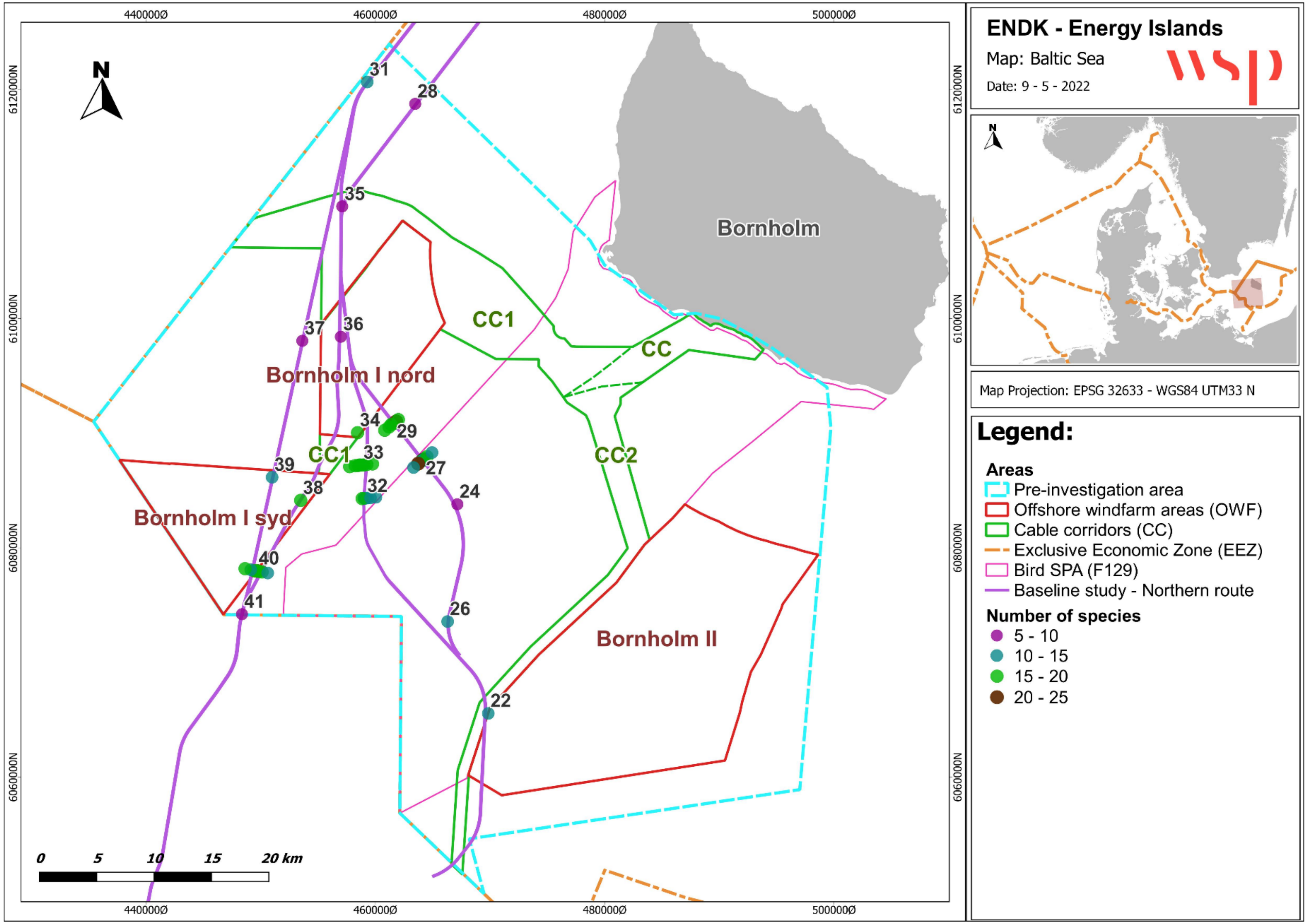

Figure 3-13. The number of infauna species found per station (sum of three replicates) from the baseline study for Nord Stream 2 – Northern route. Prefix for stations is D_EEZ_ Source: (Nord Stream 2, 2018b).

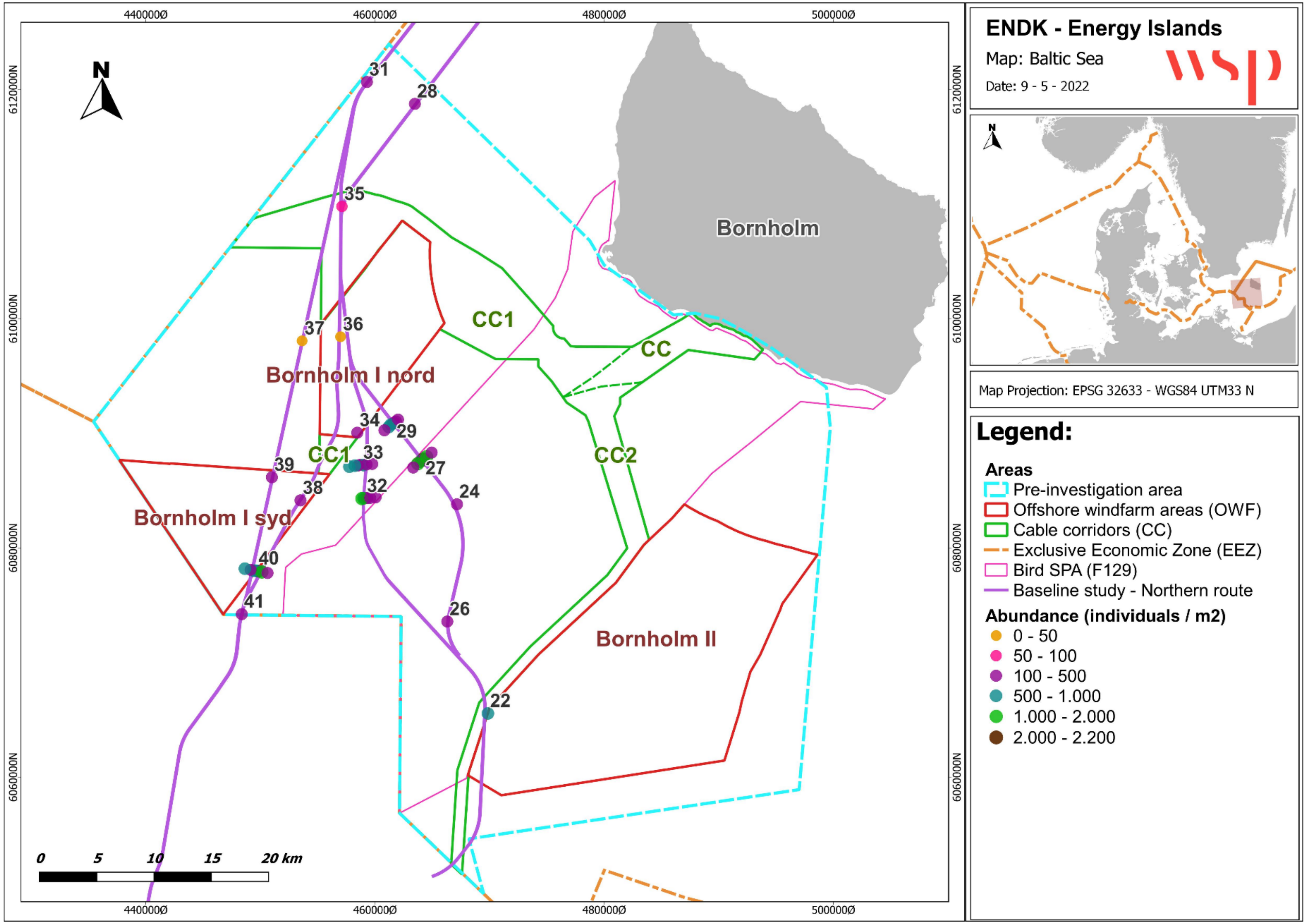

Figure 3-14. Infauna abundance (Individuals m^2) from the baseline study for Nord Stream 2 – Northern route. Prefix for stations is D_EEZ_ Source: (Nord Stream 2, 2018b).

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