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ENERGY ISLAND BORNHOLM – TRANSMISSION CABLE

Navigational Safety – Technical Report

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Navigational Safety – Technical Report

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Description	**The report presents an assessment of potential impacts to the vessel traffic during the construction, operation, and decommissioning of the offshore cable from Energy Island Bornholm through Danish EEZ as input to the Environmental Impact Assessment.**

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ABBREVIATIONS

AIS	Automatic Identification System
CLT	Cable Lay in Trench
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
OWF	Offshore Wind Farm
PT	Pre-Trenching
TSS	Traffic Separation Scheme

1. INTRODUCTION

Energinet is planning to construct an offshore cable connection to connect Energy Island Bornholm with Zealand (Figure 1.1). The power cable connection is a central part of the Danish Energy Island Bornholm project, that will significantly contribute to The Danish Government's ambitious commitment to a 70 % reduction in Greenhouse Gas Emissions (GHG) by 2030, and to EU's political commitment to be climate neutral by 2050, ref. /3/.

This report serves as a technical background report for the environmental impact assessment (EIA) for Transmission Facilities Supporting Connection of Wind Energy to Bornholm Energy Island including the installation of the offshore cable connection. This report presents a navigational safety assessment for the two sections of the cable corridor, which are placed within Danish waters. The two sections include the section from landfall on Bornholm to the Swedish EEZ (Bornholm section) and the section between the Swedish EEZ and landfalls on Zealand in Køge Bugt (Øresund section). The cable located in Swedish international waters is not included as part of this assessment and is approved according to Swedish law.

The aim of the technical navigational safety impact assessment is, in relation to the Environmental Impact Assessment (EIA) application for the project, to provide as the background for the assessment of navigational hazards in the EIA. The report address the navigational safety related to the construction, operation, and decommissioning phases of the offshore cables. The assessment is based on historical vessel traffic (AIS data) in areas in the vicinity of the cable within Danish national and international waters.

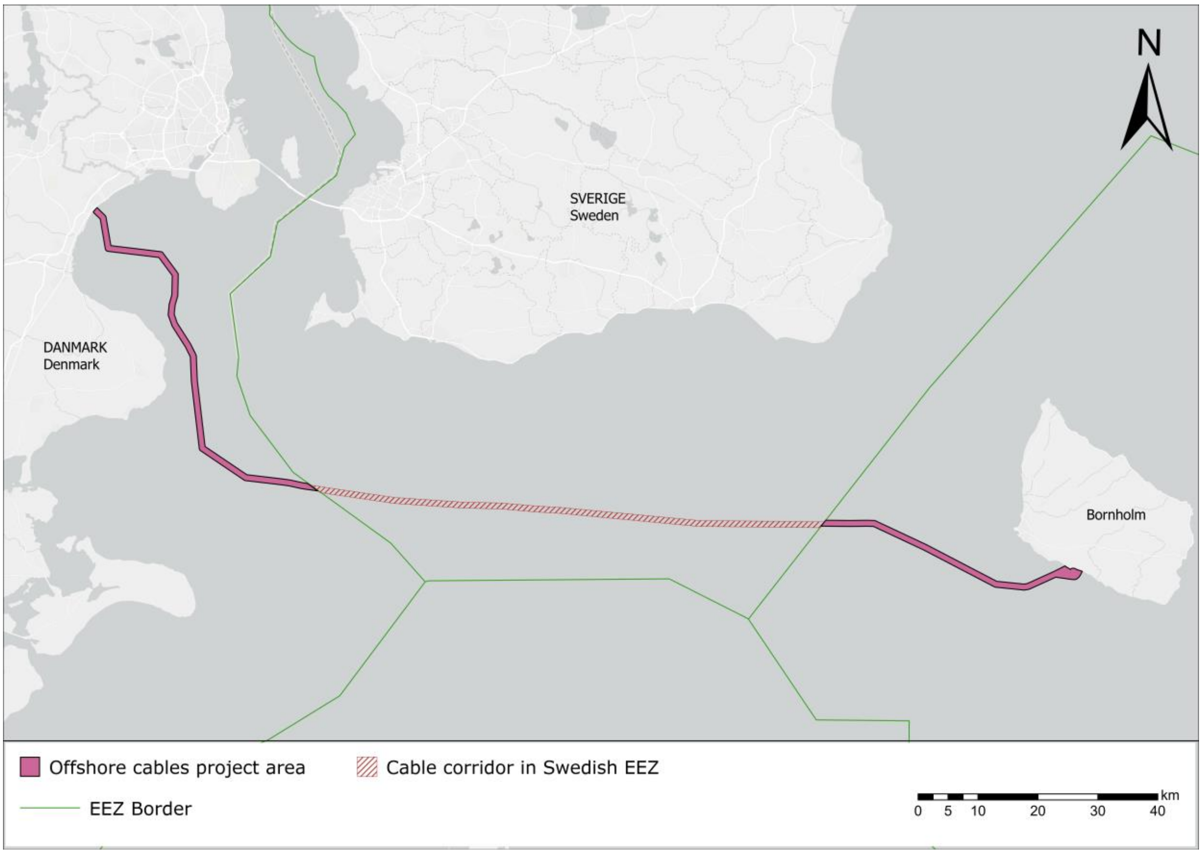

Figure 1-1 Overview of the offshore cable corridor in Danish and Swedish waters.

1.1 Cable corridor for the offshore power cable

The cable corridor for the offshore power cable consists of areas near Bornholm and Zealand which are from 1,000 to 4,000 metres wide, see Figure 1-1. The cable will be buried in the seabed at a depth of 1-3 meters within the cable corridor. Burial depths of 2-3 meters will be used when the cable is crossing the TSS's or at exposed landfalls.

The cable corridor between Bornholm and Zealand will pass through both Danish and Swedish territorial waters.

2. THE PROJECT

This section presents a brief description of interests for the project within the area. Figure 2-1 show the location of the project, the cable corridor, and the nearby Traffic Separation Schemes (TSSs). The following sections also presents relevant parts of the project description with respect to the cable corridor, systems and offshore activities during construction and operational phases.

2.1 Cable corridor

The cable corridor runs from Bornholm and to the Baltic Pipe gas pipeline, from here the cable corridor is parallel with the gas pipeline within a 500-meter-wide corridor on the northern side until the Swedish EEZ is reached. In the Swedish EEZ, the cable corridor continues parallel to the gas pipeline. When entering the Danish EEZ in the western end, the cable corridor divert north in Øresund, away from the gas pipeline, and the cable corridor then runs into Køge Bugt and to the landfall area at Karlstrup Strand.

The cable corridor, the energy Island Bornholm and the TSSs are shown in Figure 2-1.

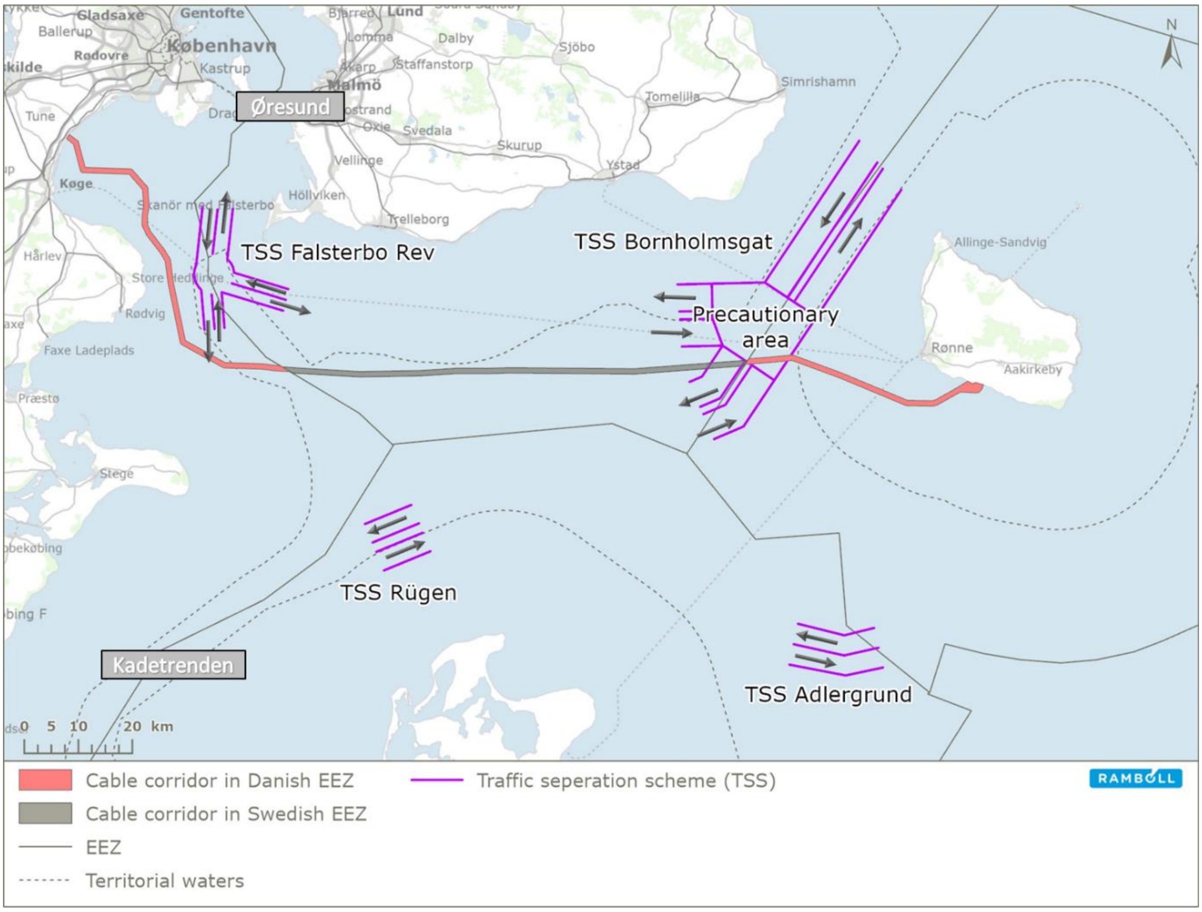

Figure 2-1. The Baltic Sea south of Sweden highlighted with the cable corridor and TSS's.

Four TSSs are marked in purple in Figure 2-1. They have been established to organize the commercial vessel traffic navigating through the area of the Baltic Sea south of Sweden. The traffic separation schemes help to avoid dangerous situations and/or collisions with the large vessels since an increased navigational safety is achieved by obtaining a higher predictability of the vessels' behaviour and therefore preventing collisions at sea.

The TSSs in the Baltic Sea south of Sweden, near the cable corridor, are:

- Falsterbo Rev, located at the lighthouse, east of the planned alignment of the cable corridor close to Zealand.
- The TSS Bornholmsgat, located west of Bornholm, where the traffic is routed from the north-eastern Baltic Sea around Bornholm to the western Baltic Sea.
- The TSS Rügen, located north of Rügen.
- TSS Adlergrund, located south of Bornholm.

The TSS at Falsterbo Rev has routes going north towards Øresund, south towards Gedser and Germany at Kadetrenden, as well as towards east in the direction along the south coast of Sweden. The eastern direction of this TSS is heading towards the TSS Bornholmsgat and further into the Baltic Sea. TSS Bornholmsgat is where the west bound vessel traffic split between routes either towards Øresund or further south to Kadetrenden through TSS Rügen. The TSS Rügen have eastern and western routes towards Kadetrenden and Bornholmsgat. Finally, TSS Adlergrund guides vessel traffic from Øresund or Kadetrenden into the south-eastern Baltic Sea, east and south of Bornholm.

Wind farm near the cable corridor

Near the western part of the cable corridor alignment close to Zealand several different wind farms are located. These are in different stages; operational, under construction, and planned. The wind farm Kriegers Flak is already in operation. This wind farm is split into an eastern and western part located about 6 km (3.25 nm) southeast of the cable corridor. Several other wind farms are in the early planning phase, located along the cable corridor, close to Zealand. In the area close to Bornholm no offshore wind farms are located near the alignment of the cable corridor. The specific locations of the wind farms in the area are shown in Figure 2-2.

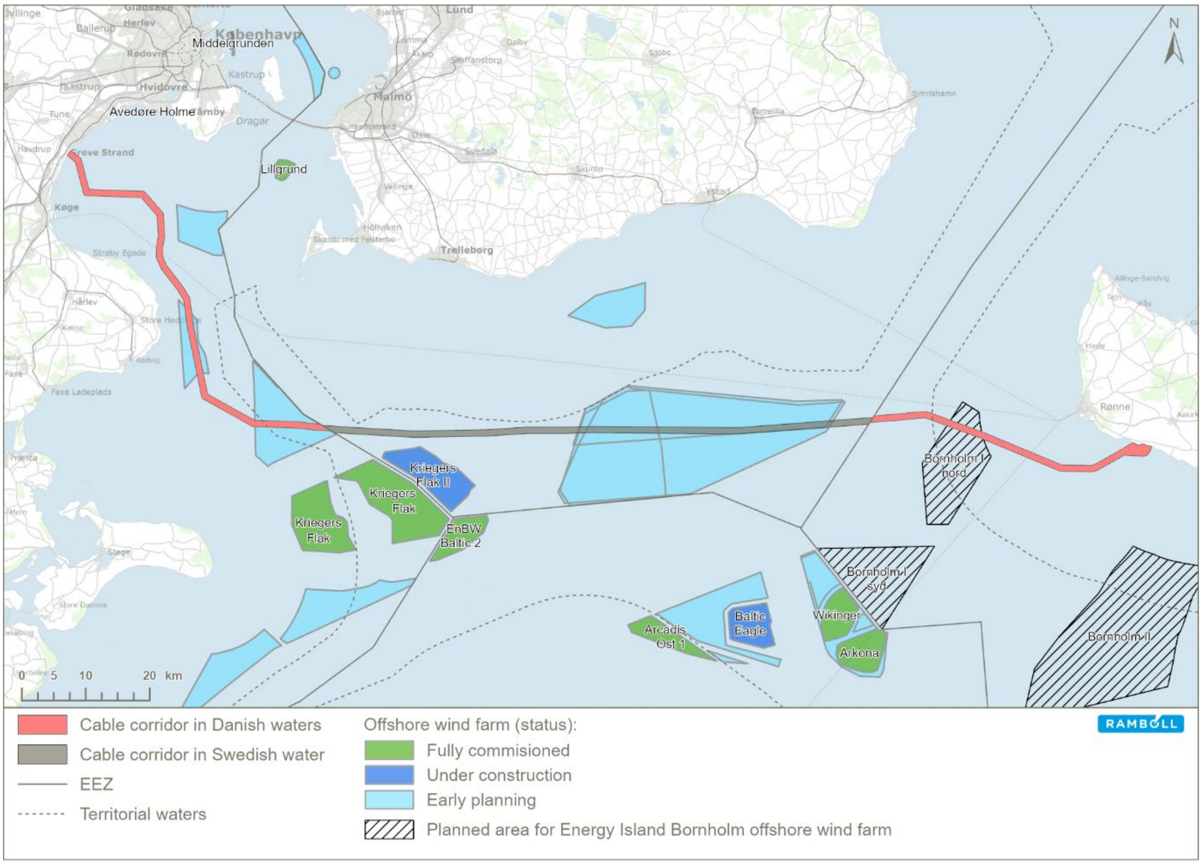

Figure 2-2. Wind farms in the area in operation and at various stages of planning or construction.

2.2 Cable systems

The project is described in the Technical Project Description (ref. /3/) and is briefly summarized in the following.

The cable will enable transmission of power between the offshore wind farms of Energy Island Bornholm and Zealand. Within the cable corridor one HVDC cable system will be installed: This cable system will have a maximum capacity of 1.2 GW. The cable system will transfer energy through a closed circuit of two high voltage conductors with opposite polarity. The HVDC cable system will therefore, have a configuration of four cables: Two HVDC (each with a maximal voltage of up to ± 525 kV); one metallic return; and one fibre optic cable. The HVDC offshore cable system will consist of a cobber or aluminium core surrounded by insulating material, as well as material to protect the cable from external damage, see Figure 2-3.

Figure 2-3. Left: An example of a configuration of the cable system (two HVDC offshore cables, one metallic return (MR) and one fibre optic cable (FO) for the 1.2 GW cable system. Right: Illustrates the configuration of the cable system in the seabed, see ref. /3/.

2.3 Near shore activities

Nearshore activities occur at water depths smaller than 10 m, and primarily in relation to the landfalls. In the areas where the cable will transit from sea to land; landfall in Køge Bugt, and landfall at Bornholm, the cable can be installed either in pre-installed tubes or via a direct trenching of the sea cables into a cable trench.

For trenching and laying of sea cables near the coast, special installation and digging equipment, installed on barges, are used. These are either able to work at very low water depths, or on uncovered sea floor (beach). In general, two installations methods for installation of sea cables in the transition from sea to land (landfall) exist:

1. Controlled subsurface drilling, Horizontal Directional Drilling (HDD).
2. Digged trench.

Both installation methods can be defined as a part of the pre-digging/trenching works.

The most suitable approach will, just as for the cable protection, be determined as part of the completion of the detailed technical design of the cable installation activities. However, the preferred method for the cable corridor near Zealand is a dug trench of roughly 3,800 meters leading towards the coast. As an alternative to a dug trench, a combination of HDD and dug trenches may be used for installation of the sea cables at the landfall in Køge Bugt. At the cable corridor near Bornholm, Horizontal Directional Drilling, (HDD) remains the preferred method. This is detailed in the technical Project Description, ref. /3/ in chapter 7, section 7.1.1.

The installation works near the coast for the cable laying are listed in bullets below to show that several options are available for the contractor.

Nearshore installation works

- Landfall
- Pulling of pipeline
- PT (Pre-Trenching) / CLT (Cable Lay in Trench)
    - Controlled subsurface drilling
        - Pipe laying
    - Digged trench
        - Pipe laying in open trench
            - Mechanical
            - Natural

- Cable attachment and protection
    - Stone protection (distribution of stones on the sea floor above the cable)
    - Concrete mattresses

The installations methods are described in more detail in ref. /3/.

2.4 Offshore activities

The offshore activities are related to both the construction phase, the operation phase, and the decommission phase of the project. The main activities addressed in the navigational safety impact assessment are described in the following. These activities are based on the Technical Project Description, ref./3/.

2.4.1 Construction phase

In the sections where the cable is laid parallel to the Baltic Pipe, the cable systems will be placed at the northern side of the pipeline within a distance of 500 metres. The exact location will depend on seabed conditions as well as proximity agreements with the gas pipeline owner.

To install the cable, the following construction activities must take place:

1. Pre-lay surveys (including UXO and removal).
2. Seabed preparation (including route clearance and boulder removal).
3. Cable lay (including pre-trenching, cable-lay, burial, and rock cover).
4. Crossings (protecting crossing cables).
5. Jointing (joining cable sections).
6. Post-lay surveys.

The pre-lay surveys (no. 1) and seabed preparation (no. 2) activities from the list of the construction phase are slightly different from the other construction activities because these activities will be part of the preparation phase. However, the preparation activities together with the installation activities listed above, are assessed as one during the construction phase.

Additional to the list of the construction phase, it is expected that the cable lay (no. 3) activity may also have a survey performed during cable lay. See ref. /3/ for detailed descriptions of each activity.

Pre-lay activities and seabed preparations consist of seabed clearance from UXO, debris, relocation of boulders etc. Seabed clearance typically involves a pre-lay grapnel run (PLGR), that is towed by a vessel along the planned burial section of the cable route to remove surface obstructions or shallow buried obstructions. Debris relocation or removal can be executed for example by remote operated grabs or a grab dredger. Boulders can be relocated by specialised tooling like rock grabs which can move the boulders clear from the cable route. An example of a construction vessel used for seabed preparation is shown in Figure 2-4 (left). An example of a construction vessel used for rock installation is shown in Figure 2-4 (right).

Figure 2-4 Example of a construction vessels used for seabed preparation (Grane R) (left), and a Fall Pipe Vessel (Braveness of Van Oord) (right).

The cable system will be buried in a 1-2-meter-wide trench in the seabed prepared during pre-trenching. The reason for the cable burial is to prevent external damage to the cable after installation. Despite the method used for cable burial, common for all installation methods is that the trenching machine is working on the seabed, towed behind a vessel. It is expected that the cable lay will be undertaken by specialised dynamically positioned cable lay vessel with adequate storage and facilities for installation of a cable system. Dynamically positioned vessels do not require anchors and are kept in position by thrusters that constantly counter act forces from the cables, waves, currents, and winds. Figure 2-5 show pictures of two modern cable lay vessels.

Figure 2-5. Examples of modern cable lay vessels: NKT Victoria (left) and Leonardo da Vinci (right).

The length of the entire offshore cable corridor is so long, that one vessel cannot transport the entire cable in on go. Therefore, the cables are installed in sections, which are joined together. However, the exact number of cables sections and position of joins cannot be determined in advance prior to selection of contractor. Jointing is performed on board the vessel and will take up to two weeks per joint. Meanwhile, the vessel will stay anchored at the specific location. After completing a jointing, construction will continue with the limited manoeuvrability.

Table 2-1 summarizes the construction activities and the associated vessel speeds and construction times as given in ref. /3/. The table has included a 20% buffer in the estimates, which makes some deviation in the estimates, however it will give a conservative estimate for the navigational safety.

Table 2-1. Assumptions regarding vessel speed and duration of construction activities, from ref. /7/.

Type	Activity	Speed [km/day]	Distance [km]	Duration [days]	Duration [months]
Survey	Pre-lay	48	115	3	0.1
	Post-lay	48	115	3	0.1
	Post-burial	14	115	10	0.3
	Unexploded Ordnance (UXO)	-	115	-	-
	UXO clearance	-	-	-	-
Preparatory works	Pre-lay grapnel run (PLGR)	36	115	4	0.1
	Moving stones - grab	-	-	-	-
	Moving stones - plough	9	98	13	0.4
	Sand wave removal	-	3	3	0.1
	crossings	-	-	52.8	1.8
Offshore construction works	Cable lay, surface lay, lay in trench	4	115	38	1.3
	Pre-Trenching and Cable Lay in Trench (PT/CLT)	10	115	14	0.5
	Simultaneous Lay and Burial (SLB)	7	105	18	0.6
	Post-Lay and Burial (PLB) - Soft seabed	7	74	12	0.4
	PLB - Medium seabed	4	21	7	0.2
	PLB - Hard seabed	1	20	17	0.6
	Joints	-	-	33.6	1.1
Coastal construction works	Moving stones - coastal	-	-	-	-
	Excavation - coastal	7	25	3.5	0.1
	Barge - Coastal	2	20	8.3	0.3
Miscellaneous	Guard vessels	-	115	50	1.7
	Restorative work/ remedial work	-	4.6	30	1.0

Table 2-2 summarizes the properties of the different vessel types that is assessed to be representative for vessels expected to be used in the construction phase.

Table 2-2. Assumptions regarding properties of vessels used in the construction phase.

Vessel	Length [m]	Width [m]	Draught [m]	Vessel type	Activity
Grane R	93.01	20.60	4.60	Construction	Pre- and post-lay survey, seabed preparation etc.
Braveness of Van Oord	154.40	28.00	6.00	Fall pipe	Crossing preparation and protection
NKT Victoria	140.00	29.60	7.20	Cable lay	Cable lay
Leonardo da Vinci	171.00	34.00	8.50	Cable lay	Cable lay

2.4.2 Operation phase

During the operation phase, occasional maintenance activities can occur due to cable failures. The most common cause of need of offshore cable repairs is due to damage that is caused by third parties, typically trawlers or anchors from vessels in the area. Damage can be local or cover longer sections due to something being pulled along the cable, or it may have been pulled up from the seabed. Repairs can be performed by a single vessel. Repairs at depths of more than 10 meters water depth will typically be carried out using a larger vessel. Vessels performing cable repairs have limited manoeuvrability and will therefore be equipped with the required navigation lights and signals. The specific details of cable repairs will depend on the type of repair being performed and the supplier's equipment.

Routine inspection is usually not necessary because offshore cables are designed to require a minimum of maintenance. Regular inspections of crossings can be required as part of the entered crossing agreements. If necessary, inspections on depths below 10 meters are performed from a survey vessel with side-scan sonar and a remote-controlled submarine.

2.4.3 Decommissioning phase

The decommissioning of the cable is assumed to be the reverse of the construction, hence removing the rock cover, digging up the cable from the seabed followed by a collection of the cable. In areas where no other cable or activity is ongoing, it may be without challenges to pull up the cable in shorter time, especially if recycling of the cable is out of scope or if the cable will immediately be cut into short pieces and stored in containers until later recycling on land. But opposite if other cables are later put on top, it may take longer time due to not only pulling the cable up from the seafloor.

The number of ships is expected to be comparable to the construction phase given the same construction activities. The vessels expected to be present during the decommissioning phase are expected to include barges, support tugs, jack-up vessels, supply/crew vessels (CTV) and cable vessels. Hence, approximately the same activities are needed as for the construction phase however in reverse order.

3. VESSEL TRAFFIC NEAR THE CABLE CORRIDOR

3.1 Existing conditions

The intensity of the ferry routes and all other types of vessel traffic is presented in the following sections for each of the two cable corridor sections; Zealand, and Bornholm. The two sections include the section from landfall on Bornholm to the Swedish EEZ (Bornholm section) and the section between the Swedish EEZ and landfalls on Zealand in Køge Bugt (Øresund section). The vessel traffic analysis is based on Automatic Identification System (AIS) data covering the entire year 2021. This data is considered as representative for the main vessel traffic in the area and comparable to pre-COVID-19 condition given the Danish Maritime Authority statistics, ref. /10/, where vessel traffic counts for vessel crossing specific passagelines near the cable corridor are shown for several years.

All vessels above 300 gross tons (GT) are required to have an AIS-transponder. Furthermore, all passenger vessels, and all fishing vessels over 15 meters in length (EU rules) must also have an AIS transponder, as mentioned in ref. /2/. For military vessels, there is no requirement to use AIS transponders. The same is the case for smaller vessels including primarily pleasure vessels. However, some of these have chosen to have an AIS transmitter to be more visible at sea and will therefore also be found in the data. As not all vessels state their vessel type in their AIS data, these will be represented as "other vessels". Often, it is military vessels, pleasure vessels or other smaller vessels that have not filled in their vessel information.

The vessel traffic for the two cable corridors; Zealand with the landfalls in Køge Bugt, and Bornholm with the landfalls at the southern coastline, are described in the following paragraphs where the existing conditions of the vessel traffic is detailed.

3.1.1 Zealand section

The sailing activities close to the cable corridor near Zealand consists of:

- Recreational vessel traffic in Køge Bugt between the marinas.
- Recreational sailing and minor commercial traffic between Amager and Stevns Klint.
- The primary commercial vessel traffic in north and southbound directions between Øresund and the traffic separation scheme Falsterbo.

In order to guide the commercial vessels in the waters east of Zealand, several beacons and sea markings have been set up to guide and help the traffic through the strait. These are shown in Figure 3-1, where the cable corridor is also shown.

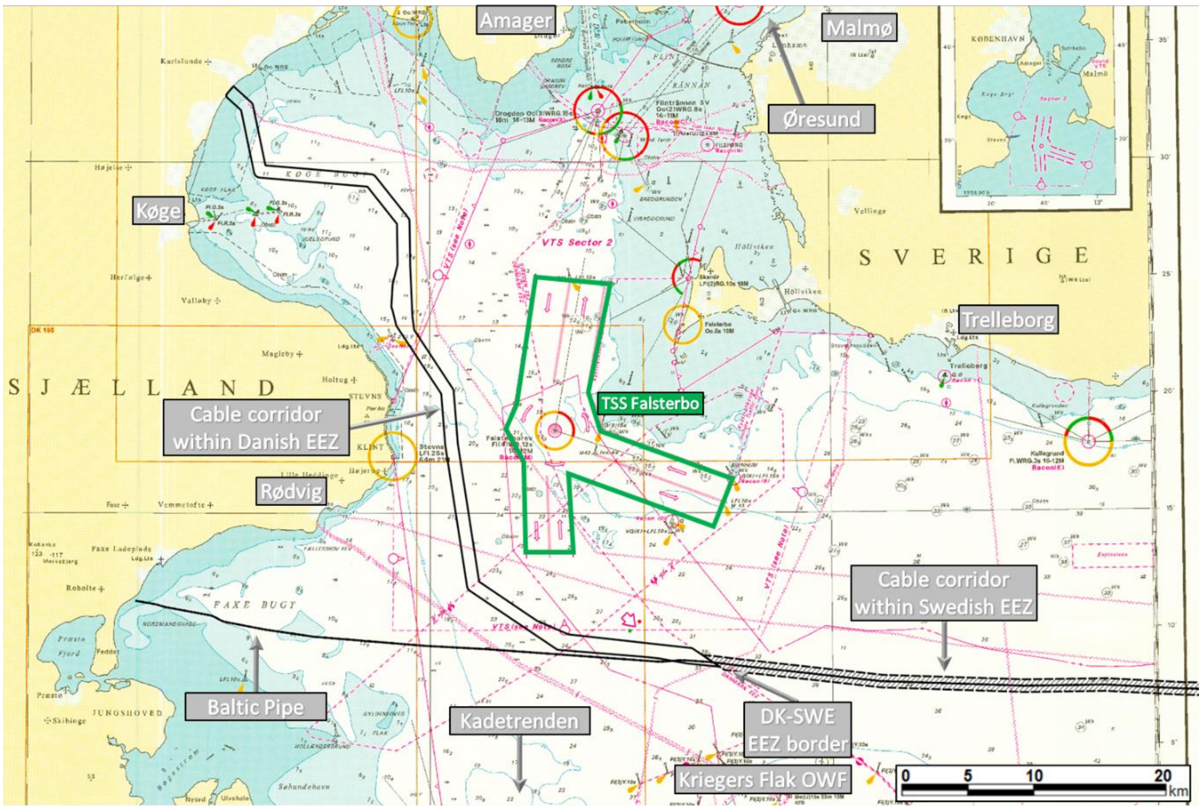

Figure 3-1 Navigational chart with indicative sea markings from which it appears that the commercial vessel traffic has fixed routes in the north and south direction at the cable corridor near Zealand. The cable corridor within Danish EEZ is also marked together with the TSS Falsterbo and relevant locations, ©Geodatastyrelsen – 320-0147.

Vessel intensity and routes

On the intensity map in Figure 3-2, the vessel traffic is illustrated using vessel registrations (AIS data) covering the entire year 2021. The intensity map shows the area around the cable corridor near Zealand and includes all types of vessels, i.e., commercial vessels, military vessels, passenger vessels, pleasure vessels, etc., as they are represented in the AIS data. A black colour indicates a high vessel traffic intensity; a red or orange colour indicates medium vessel traffic intensity; and a yellow colour represents a low vessel traffic intensity. Specific main traffic routes surrounding or crossing the cable corridor have been numbered for easier reference.

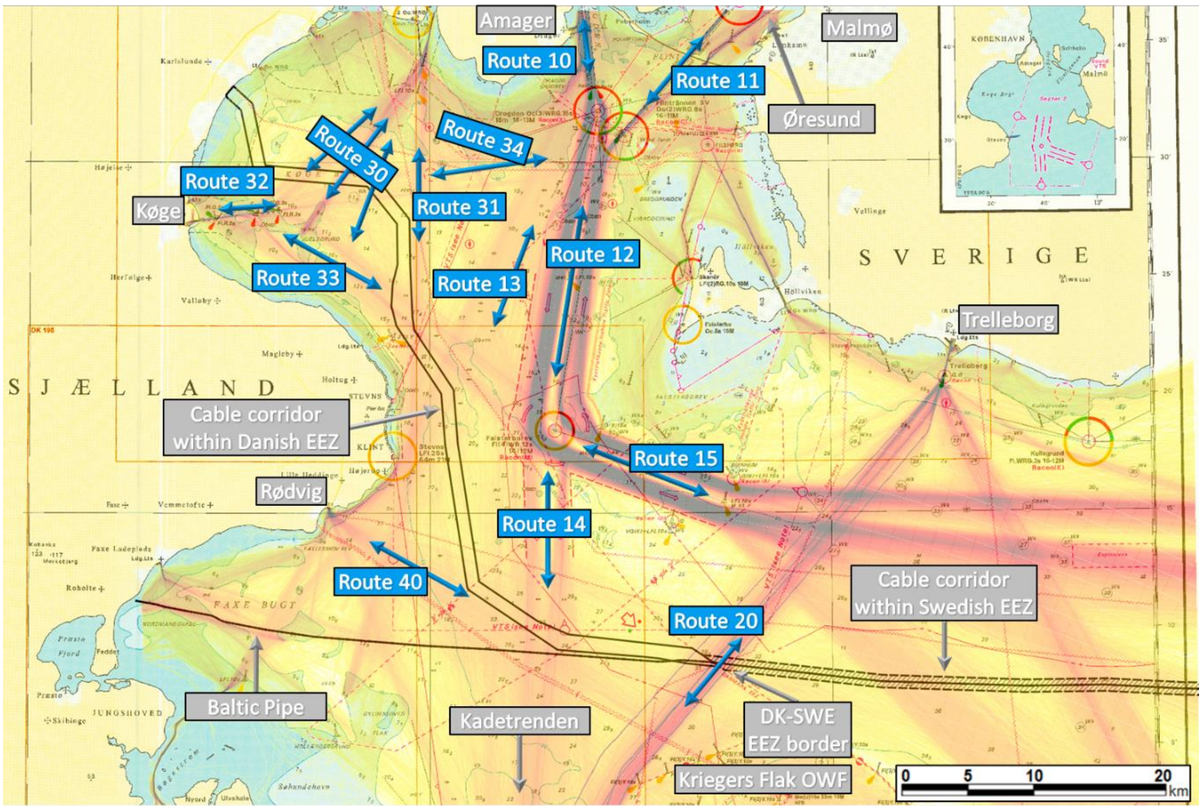

Figure 3-2. The intensity of the vessel traffic in the surroundings of the cable corridor at the western cable corridor close to Zealand for year 2021. The intensity map highlights patterns of the vessel traffic and where vessel traffic is most common together with route labels, the alignment of the cable corridor, relevant towns, navigational channels and nearby OWF.

Figure 3-2 shows that the vessel traffic generally follows the traffic separation schemes (Route 12, 14 and 15) and the extension of these (Route 10 and Route 11). In addition, there are other routes e.g., route 20 with moderate traffic intensity. Vessel traffic on this route is passing through the south-eastern part of the planned cable corridor, crossing the cable corridor south of the TSS Falsterbo within the Danish EEZ. Route 20 is mainly a route for the ferry traffic between Trelleborg and in direction towards Germany through the Kadetrenden.

The vessel traffic passing through the cable corridor includes routes passing in several directions within Køge Bugt. The vessel traffic within Køge Bugt is mainly routes from harbours heading out of Køge Bugt along the coastline or routes heading directly to another harbour within Køge Bugt. The vessel traffic routes within Køge Bugt are labelled Route 30-34. The vessel traffic in Køge Bugt consist of pleasure vessels of smaller sizes, vessel traffic to Avedøre Værket and Køge and the passenger ferry between Rønne (Bornholm) and Køge (Zealand). This ferry sails on route 33 and route 15.

The intensity map in Figure 3-2 shows all vessel types during year 2021. Two additional intensity maps are shown in Figure 3-3 to get a better understanding of the vessel traffic and the routes for the specific vessel types of pleasure vessels and fishing vessels.

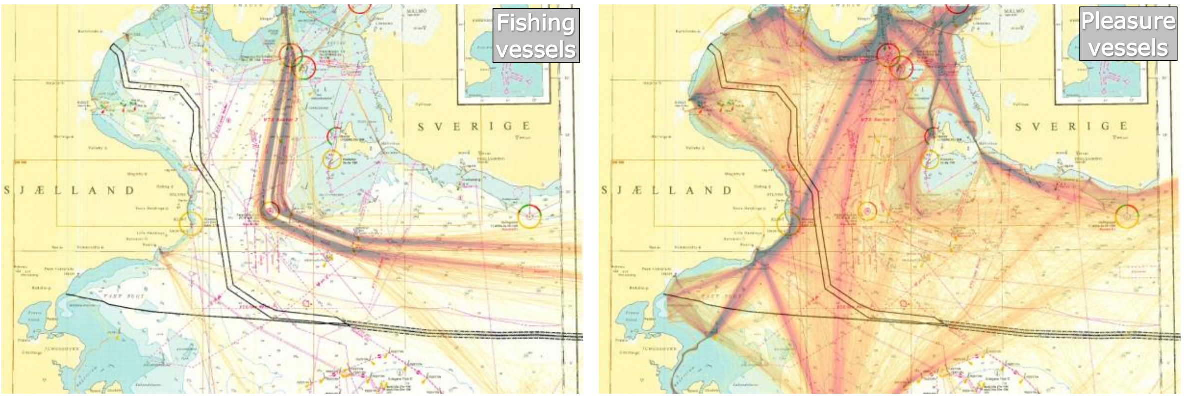

Figure 3-3. Intensity maps showing the movement of specific vessel types during year 2021. The intensity map highlights patterns of the vessel traffic and where vessel traffic is most common together with the cable corridor.

Fishing activities can move around from year to year depending on fish stocks and the location of good fishing spots. In Figure 3-3 it is seen that fishing vessels are primarily observed passing north and east of the cable corridor on the main shipping routes through the TSS Falsterbo sailing between Øresund and TSS Bornholmsgat. The fishing vessels are also seen elsewhere with a low intensity.

The intensity maps showing pleasure vessels, in Figure 3-3, show higher intensity in coastal areas than that of open waters. Most of the traffic are routes between harbours or shortcuts from one coast to another coast. Therefore, pleasure vessels are seen crossing or sailing near the cable corridor at several locations at the western cable corridor close to Zealand.

Passages

The traffic is further analysed by using passage lines (lines defined in the calculation software IWRAP MK2 v6_3_7 used to count vessel crossings), to show the frequency of vessels passing in the area. The passage lines are placed in the surroundings of the cable corridor at the western cable corridor close to Zealand and are shown on the intensity map in Figure 3-4. In the figure, each passage line is numbered for easier reference. Note that the histograms along the passage lines indicate the number of passages distributed along the line and not the angle of the sailing direction for the vessels. The histograms along the line on both sides are marked with different colors, which indicate the traffic crossing the line in each direction.

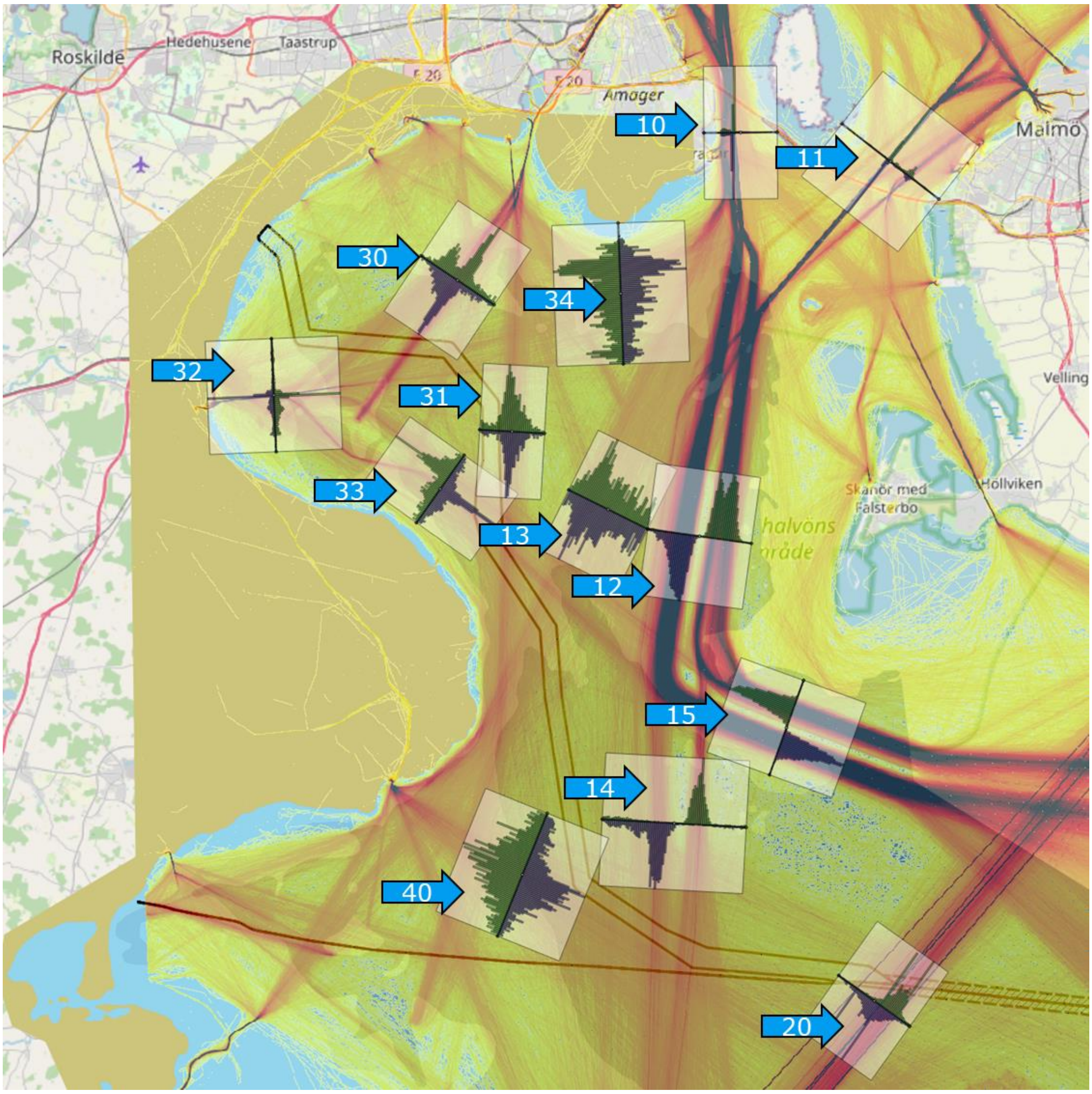

Figure 3-4. The intensity of the vessel traffic in 2021, for the surroundings of the cable corridor at the western cable corridor close to Zealand together with the passage line and histograms.

In the following the traffic for each of the passage lines are presented. For each passage line, the number of vessels per vessel type is counted, as represented in the AIS data. The total number of vessels that cross any part of the passage line has been summarised to get an overview of the vessel traffic. The number of crossings of the passage lines during year 2021 for all the vessel traffic are listed in Table 3-1 and Table 3-2.

The vessel traffic is counted for the different main navigation routes, shown in Table 3-1, and indicates a large amount of annual traffic along these routes (Route 10-15), especially for cargo vessels and oil tankers. These routes are located nearby the cable corridor until the TSS Falsterbo. In the intensity map in Figure 3-4, and in the vessel counts summarized in Table 3-1, it is shown that most of the vessel traffic at the western cable corridor close to Zealand uses route 10 instead of route 11 through Øresund.

The vessel traffic crossing the passage line (Route 14) represent vessels sailing at the TSS Falsterbo towards the south and continuing straight south across the planned cable corridor or in the opposite direction. The vessel traffic count on Route 14 sums up to 4,728 vessels, which results in an on average of 13 vessels crossing the cable corridor on a daily basis.

The intensity is much higher in the eastern direction of the TSS Falsterbo, where 22,381 vessels cross the passage line (Route 15) during 2021. The traffic sailing along route 13 are vessels sailing on a route parallel to route 12, which are not following the TSS Falsterbo. The vessels sailing here are sailing between the coast of Amager and Stevns near the cable corridor close to Zealand. Vessels sailing along route 13 are sailing across the planned cable corridor west of the TSS Falsterbo.

Table 3-1 The vessel traffic counts for each vessel type category in both directions for the main navigation routes in 2021.

	Numbered routes in cable corridor near Zealand					
Vessel types	**10**	**11**	**12**	**13**	**14**	**15**
Fast ferry	20	7	17	9	5	11
Fishing vessel	643	24	459	18	11	461
General cargo vessel	14,785	1,676	15,986	333	1,445	15,122
Oil products tanker	3,052	1,777	4,792	6	357	4,446
Passenger vessel	126	1,932	1,995	32	1,926	856
Pleasure vessel	3,915	2,284	462	1,003	599	194
Support vessel	1,085	1,621	523	171	88	581
Other vessel	1,854	660	832	210	297	710
Total	**25,480**	**9,981**	**25,066**	**1,782**	**4,728**	**22,381**

The additional routes in Køge Bugt, at the cable corridor near Zealand, and the respective vessel traffic counts are summarised for the less trafficked navigation routes per vessel type in Table 3-2. These routes all cross the cable corridor in Køge Bugt or at the cable corridor near Zealand. The cable corridor towards the landfall at Karlstrup Strand is crossing vessel traffic. The traffic on route 30-31 mainly consist of support vessels, whereas route 32-33 consists of more varying mix of vessel types like cargo vessels, passenger vessels, pleasure vessels etc. The vessel traffic on route 34 has in total 1,014 pleasure vessels and fewer support-, cargo- and other vessels sailing in and out of Køge Bugt.

Vessel traffic on route 20 are nearly only passenger vessel between Trelleborg in Sweden and Germany crossing the cable corridor at the border between the Danish and Swedish EEZ. On route 40 many fast ferries are observed sailing between the harbour at Rødvig and towards Kriegers Flak OWF. This is due to Rødvig being the support harbour during the construction phase of Kriegers Flak OWF in 2021, ref. /8/. However, also some cargo vessels, pleasure vessels and other vessels are sailing across the passage line on route 40. This route crosses the southern area of the planned cable corridor at the same area as the traffic from route 14.

Table 3-2 The vessel traffic counts for each vessel type category in both directions for the less trafficked navigation routes in 2021.

	Numbered routes in cable corridor near Zealand						
Vessel types	**30**	**31**	**32**	**33**	**34**	**20**	**40**
Fast ferry	0	0	10	7	0	14	1,135
Fishing vessel	8	2	25	12	14	2	23
General cargo vessel	34	43	923	367	476	67	335
Oil products tanker	0	2	44	1	33	56	0
Passenger vessel	1	1	760	752	5	5,507	1
Pleasure vessel	487	120	695	294	1,014	135	344
Support vessel	2,381	1,008	1,172	256	573	21	66
Other vessel	145	54	604	213	365	183	212
Total	**3,056**	**1,230**	**4,233**	**1,902**	**2,480**	**5,985**	**2,116**

3.1.2 Bornholm section

The sailing activities close to the cable corridor near Bornholm consists of:

- Recreational vessel traffic around Bornholm and between the marinas of Bornholm and Sweden and Germany.
- Intense commercial traffic through the TSS Bornholmsgat between Sweden and Bornholm, west of Bornholm, which also includes a precautionary area where merging and traffic splits.

TSS Bornholmsgat is a dense traffic route which is the only route to and from the Baltic Sea and therefore an important route for the industry and commercial vessel traffic. To guide the commercial vessels in the waters through the TSS Bornholmsgat, some beacons and markings have been set up at the coast to guide and help the traffic through the strait. Also, digital markings on the German offshore wind farms further southwest helps vessel to locate themselves with navigation and guidance. The markings are shown in Figure 3-5, where also the cable corridor is shown.

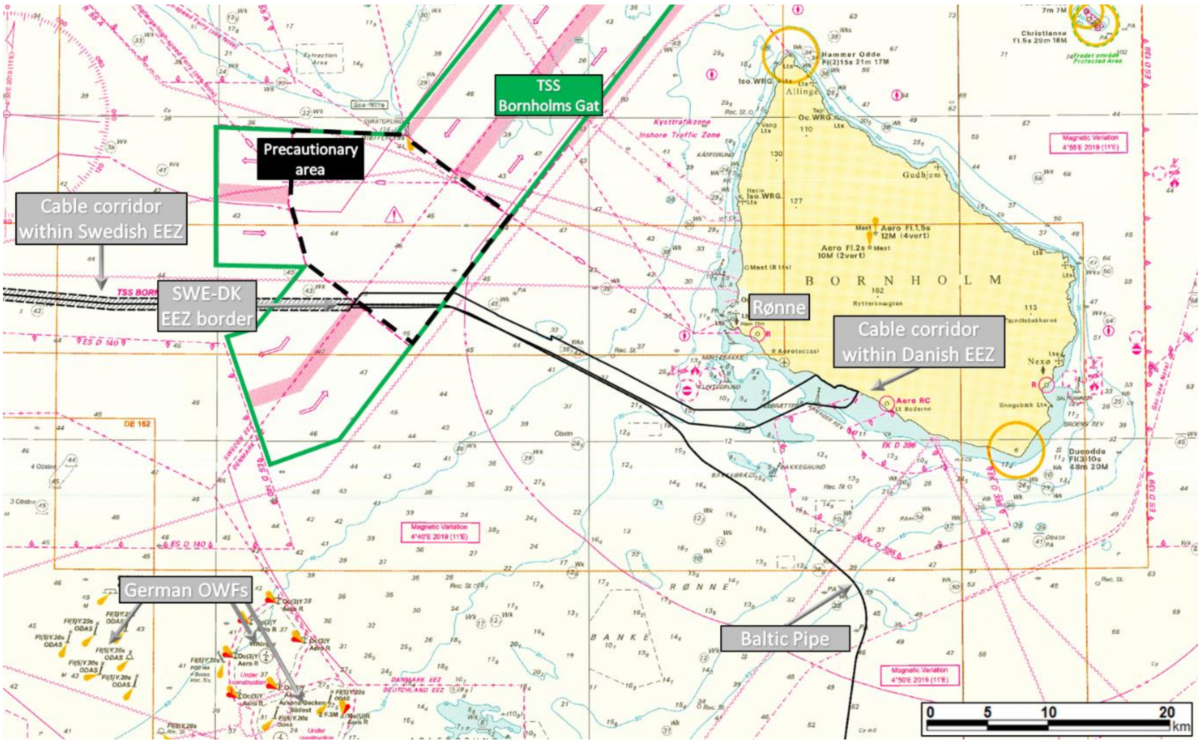

Figure 3-5 Navigational chart with indicative sea markings from which it appears that the commercial vessel traffic has fixed routes in the north and south direction off Bornholm. The cable corridor withing Danish EEZ, TSS Bornholmsgat and relevant locations are marked, ©Geodatastyrelsen – 320-0147.

Vessel intensity and routes

On the intensity map in Figure 3-6, the vessel traffic is illustrated using vessel registrations (AIS data) covering the entire year 2021. The intensity map in Figure 3-6 also shows the area around the cable corridor near Bornholm and includes all types of vessels, i.e., commercial vessels, military vessels, passenger vessels, pleasure vessels, etc., as they are represented in the AIS data. A black colour indicates a high vessel traffic intensity; a red or orange colour indicates medium vessel traffic intensity; and a yellow colour represent a low vessel traffic intensity. Specific main traffic routes surrounding or crossing the corridor have been numbered for easier reference.

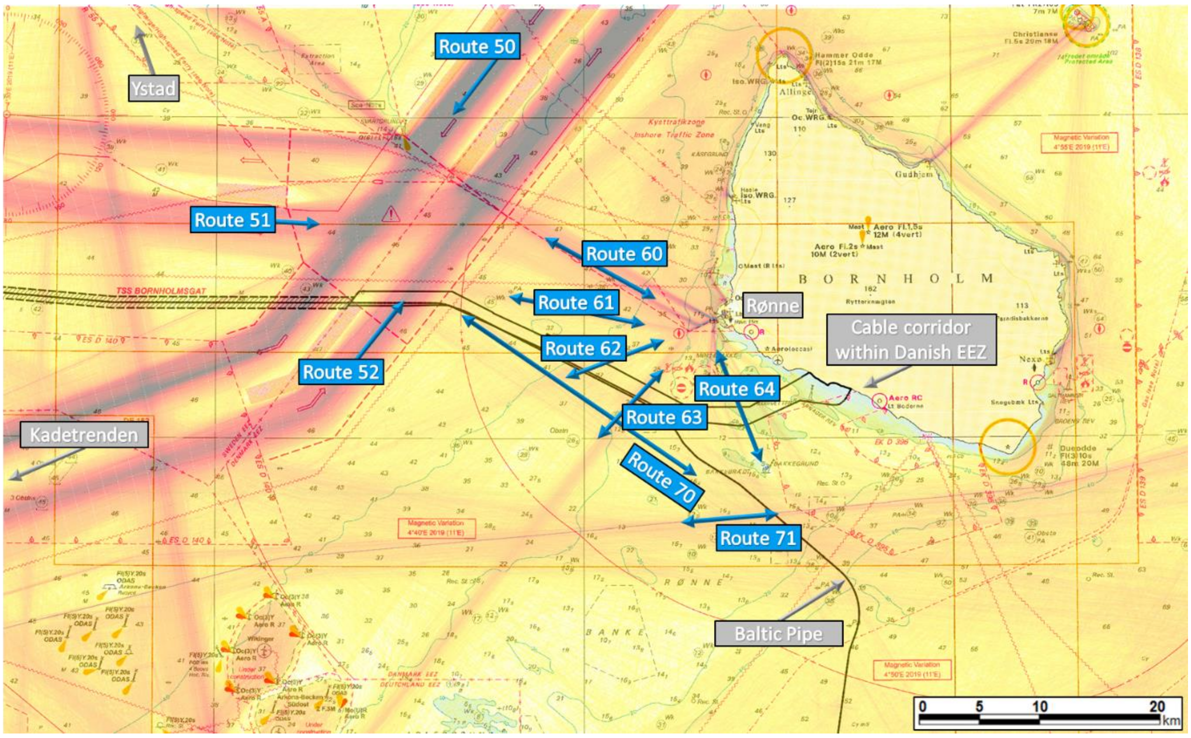

Figure 3-6. The intensity of the vessel traffic in the surroundings of the cable corridor at the eastern cable corridor close to Bornholm for the year 2021. The intensity map highlights patterns of the vessel traffic and where vessel traffic is most common together with route labels, the alignment of the cable corridor, relevant towns, navigational channels and nearby OWF.

Figure 3-6 shows that the vessel traffic generally follows the traffic separation schemes (Route 50-52) where the traffic is most dense. In addition, other routes with lower intensity are marked with numbered labels sailing to and from Rønne Harbour (Route 60-64) and finally, also two routes south of Bornholm (route 70-71).

The vessel traffic passing through the cable corridor includes routes passing in several directions southwest of Rønne, as well as the intense traffic through TSS Bornholmsgat.

The intensity map in Figure 3-6 shows all vessel types during year 2021. Two additional intensity maps are shown in Figure 3-7 to get a better understanding of the vessel traffic and the routes for the specific vessel types of pleasure and fishing vessels.

Figure 3-7. Intensity maps showing specific vessel types during the year of 2021. The intensity map highlights patterns of the vessel traffic and where vessel traffic is most common together with the cable corridor.

Fishing activities can move around from year to year depending on fish stocks and the location of good fishing spots. In Figure 3-7 it is seen that fishing vessels are primarily observed sailing through Bornholmsgat or sailing to and from Nexø, the eastern harbour of Bornholm. In other areas, the activities are of medium intensity (orange-red color) e.g., west of Bornholm crossing the cable corridor near the main routes through the TSS Bornholmsgat. The fishing vessels are also observed elsewhere with a lower intensity.

The intensity map showing pleasure vessels, in Figure 3-7, shows the highest intensity in the coastal areas of Bornholm, compared to the open waters. Most of the traffic are routes to and from harbours on Bornholm, which are marked as coastal traffic, but also routes from Bornholm northwest towards Sweden or southwest towards Germany are observed. Hence, pleasure vessels are seen crossing or sailing near the cable corridor at several locations at the eastern cable corridor close to Bornholm.

Passages

The traffic is further analysed by using passage lines (lines defined in the calculation software IWRAP MK2 v6_3_7 used to count vessel crossings), to show the frequency of vessels passing in the area. The passage lines are drawn in the surroundings of the cable corridor at the eastern cable corridor close to Bornholm and are shown on the intensity map in Figure 3-8. In the figure, each passage line is numbered for easier reference. Note that the histograms along the passage lines indicate the number of passages distributed along the line and not the angle of the sailing direction for the vessels. The histograms along the line on both sides are marked with different colors, which indicate the traffic crossing the line in each direction.

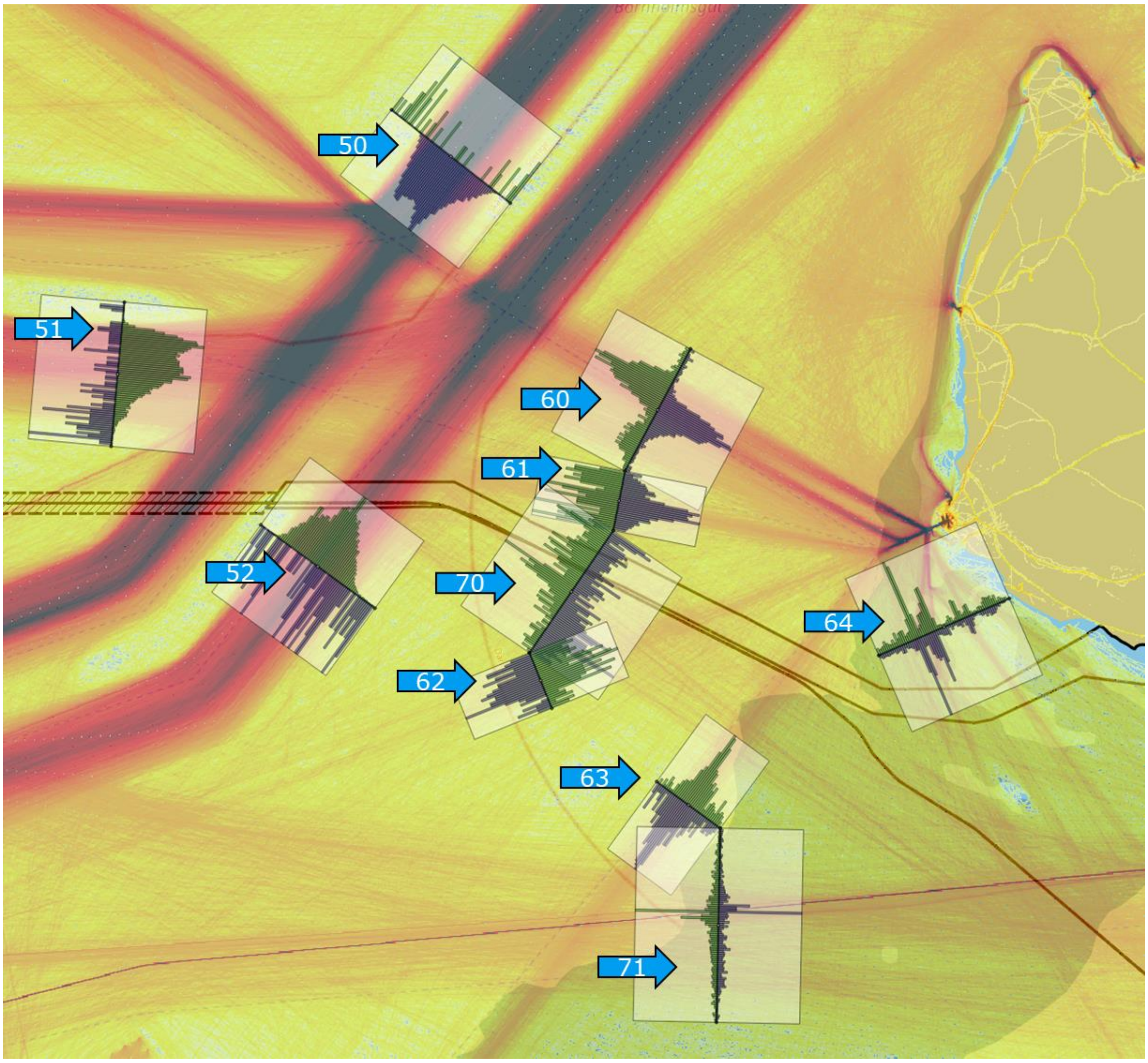

Figure 3-8. The intensity of the vessel traffic next to the cable corridor in the Baltic Sea south of Sweden representing the whole year 2021 together with the passage line and histograms along the line. Note that the histograms along the passage lines indicate the number of passages distributed along the line and not the angle of the sailing direction for the vessels.

In the following the traffic for each of the passage lines are presented. For each passage line, the number of vessels per vessel type is counted, as represented in the AIS data. The total number of vessels that cross any part of the passage line has been summarised to get an overview of the vessel traffic. The number of crossings of the passage lines during year 2021 for all the vessel traffic is listed in Table 3-3 and Table 3-4.

The vessel traffic is counted for the different main navigation routes, shown in Table 3-3, and indicates a large amount of annual data along these routes (Route 50-52), especially for cargo vessels and oil tankers. These routes are located nearby or crossing the cable corridor at the precautionary area within the TSS Bornholmsgat west of Bornholm. In the intensity map in Figure 3-8, and in the vessel traffic counts summarized in Table 3-3, it is shown that most of the vessel traffic at the eastern cable corridor at Bornholm sails through TSS Bornholmsgat further into the Baltic Sea north of Bornholm. Lower intensity is seen elsewhere in this area.

The vessel traffic crossing the passage line (Route 52) represent vessels sailing at the TSS Bornholmsgat towards north, crossing the cable corridor within the Danish EEZ. The vessels count on Route 52 sums up to 11,657 vessels, which results in an average of 32 vessels crossing the cable corridor on a daily basis. A similar amount of vessel traffic is expected going south in the opposite direction, crossing the cable corridor alignment in the Swedish EEZ (continuation of Route 50 towards south).

The vessel traffic counts presented in Table 3-3 also includes Routes 70 and 71, which are vessel traffic routes for traffic sailing south of Bornholm, hence, sailing along and crossing the cable corridor. These routes are less trafficked than the others and had a total of 942, and 2,615 vessels, respectively, during year 2021.

Table 3-3 The vessel traffic counts for each vessel type category in both directions for the main navigation routes in 2021.

	Numbered routes in cable corridor near Bornholm				
Vessel types	**50**	**51**	**52**	**70**	**71**
Fast ferry	17	8	0	5	1
Fishing vessel	169	196	105	30	30
General cargo vessel	15,319	6,918	8,012	488	1,523
Oil products tanker	4,341	2,523	2,206	42	110
Passenger vessel	1,066	658	802	27	678
Pleasure vessel	86	97	82	145	84
Support vessel	215	229	68	74	63
Other vessel	598	288	382	131	126
Total	**21,811**	**10,917**	**11,657**	**942**	**2,615**

The additional routes close to the cable corridor near Bornholm, and the respective vessel traffic counts are summarised for the less trafficked navigation routes per vessel type in Table 3-4. This table also includes Route 60; the fast ferry between Rønne and Ystad, which is not crossing the planned cable corridor. The less trafficked routes (Route 61-64) all cross the cable corridor at different locations. The traffic counts for these routes are consisting of a varying mix of vessel types of cargo vessel, passenger vessels, pleasure vessels etc.

The vessel traffic counted on Route 61 are dominantly cargo vessels, passenger vessels or pleasure vessels, sailing to or from Rønne harbour from the west. The passenger vessel traffic on Route 61 are ferries sailing back and forth between Køge at Zealand and Rønne at Bornholm on a daily basis. Route 63 is used by another ferry sailing from Rønne and southwest towards Sassnitz in Germany.

The vessel traffic on Route 64 contains mainly support vessels due to a raw material extraction area south of Bornholm.

Table 3-4 The vessel traffic counts for each vessel type category in both directions for the less trafficked navigation routes in 2021.

	Numbered routes in cable corridor near Bornholm				
Vessel types	**60**	**61**	**62**	**63**	**64**
Fast ferry	3,216	16	2	1	12
Fishing vessel	68	10	12	7	131
General cargo vessel	78	122	102	47	29
Oil products tanker	25	17	1	1	2
Other vessel	65	94	109	54	123
Passenger vessel	426	362	4	319	4
Pleasure vessel	307	105	86	159	584
Support vessel	28	24	20	12	793
Other vessel	65	94	109	54	123

3.2 Future conditions

The above analysis is based on AIS data from year 2021. However, current, and future changes to the traffic patterns may occur.

The historic development of vessel traffic in the Baltic Sea is indicated by HELCOM in ref. /4/, Figure 3 as adopted below in Figure 3-9. A significant effect of the economic crisis in 2007-2009 is seen to have reduced the number of vessel crossings north of Bornholm in the years following 2007. However, since then the number of vessels in the area has been relatively stable, with only a slight increase in cargo traffic from a low-point in 2010. Furthermore, both cargo vessels, tankers and other vessels show a slight decline in numbers from 2017 to 2018 followed by an increase after the COVID-19 pandemic (start 2020). Vessel traffic through Øresund ("Sunset Syd" in Figure 3-9) have been relatively stable with only smaller changes over the years. A future increase in vessel traffic may occur, however, the tendency for using larger vessels may counteract the increase in vessel traffic numbers.

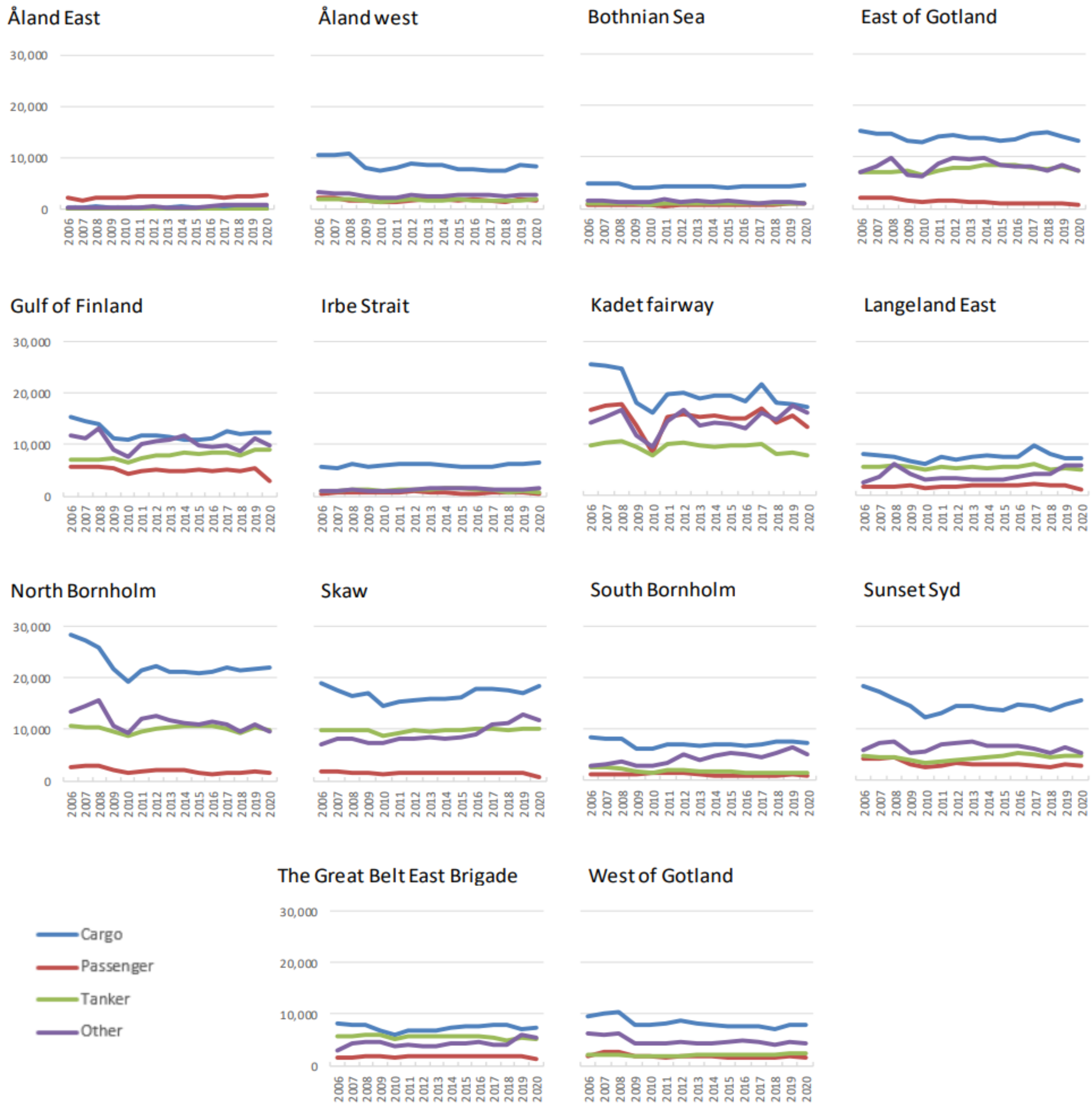

Figure 3-9. Historic development of the vessel traffic in the Baltic region. Adopted from HELCOM, ref. /4/, Figure 3.

In general, the passenger traffic across the Baltic Sea as presented in Figure 3-9 is also seen to be stable and in some areas – including the area north of Bornholm and Øresund (Sunset Syd) – to show a slight decline. However, local changes to ferry routes and timetables for ferry routes may occur. For this reason, the future development in commercial vessel traffic in the area is assumed to follow the trend observed during the last years. Hence, no significant increase in vessel traffic numbers is assumed.

4. NAVIGATIONAL SAFETY IMPACT ASSESSMENT

The impact assessment for the navigational safety is conducted separately for each phase (construction, operation and decommissioning) for the cable alignment.

4.1 Construction phase

4.1.1 Method and assumptions

In the navigational safety impact assessment for the construction phase of the cable connection, we assume a total of four different vessels to carry out the entire construction works:

- Pre-lay surveys (including UXO and removal).
- Seabed preparation (including route clearance and boulder removal).
- Cable lay (including pre-trenching, cable-lay, burial, and rock cover).
- Crossings (protecting crossing cables).
- Jointing (joining cable sections).
- Post-lay surveys.

Pre- and post-lay surveys and seabed preparations works sum up to 6.5 months of work (Table 2-1) and are assumed to be performed with a vessel type similar to Grane R (Table 2-2).

The cable lay and burial is performed using a cable lay vessel. For this activity two vessels are assumed utilized: one for the eastern and one for the western section, each vessel will be operated for up to one to three months each (Table 2-1). This part of the construction work is assumed to be performed with a vessel type similar to Leonardo da Vinci (Table 2-2). Finally, the cable is planned to be protected post-lay by rock cover or buried deeper to avoid reducing the depth in areas where the cable crosses other seabed installations, or in areas with high intensity vessel traffic, to reduce the risk of damage due to an anchor drag or anchor drop. This part of the construction works is assumed to be performed with a vessel type similar to Braveness of Van Oord (Table 2-2), and to last for five to six and a half months (Table 2-1).

The cable corridor crosses several existing cables within the Danish EEZ, see ref. /7/. Crossing of existing cables involve localized activities with preparation and protection layer near these crossings. These construction activities are assumed covered by the above, as post-lay by rock cover is assumed for crossing of other cables along the entire cable corridor. The use of rock cover at areas where the installation of the cable cross other cables will affect the water column. The water depth is assumed to be worsened locally above cable crossings after installation.

Jointing cable sections also involve presence of stationary construction vessels for the duration of the jointing. These activities are assumed to be performed away from main vessel traffic corridors and hence contribute only insignificantly to the risk.

The order in which the different activities are performed, and whether cable lay is performed before/after trenching, is irrelevant for the risk modelling. The reason for this is, that it does not have an influence on the total number of vessels used and the presence of the stationary equipment blocking for the surrounding vessel traffic.

In the calculations we conservatively assume one vessel type (size and draught) for all construction works, and conservatively base our model vessel on the largest vessel listed in Table 2-2.

It is assumed that all installation vessels will sail along the entire cable corridor shown in Figure 2-1, and that four, large vessels will operate along the corridor within a year performing operations such as route clearance, pre-trenching, cable laying and rock protection. The total construction time extends for more than one year, and pre- and post-lay activities may (partly) occur before and after the period with most intense construction activities. The cable corridor within the Danish EEZ is 62 nautical miles (115 km) long. A vessel speed of 0.016 knots is assumed for all vessels operating along the cable corridor. This is in line with assumptions done for other cable laying activities and corresponds to an average cable laying speed of about 0.7 km per day. However, according to the project description (ref. /7/), an average cable laying speed for the current project is assumed to be 1 to 10 km per day. The low speed assumed in the present study is therefore considered very conservative and assumed to also cover possible situations where the activities are almost stationary along the alignment.

The risk calculation is performed as a comparative study, where the baseline (no construction vessels) is compared to the situation where construction vessels are present. For both the baseline and the scenario with the cable laying activities, the risk is estimated within the cable corridor. That is, vessel collisions occurring for the main traffic outside the cable corridor are not included, as the vessel traffic in these areas are not affected by the cable lay operation. Therefore, the first step is modelling the collision frequencies in a normal situation and evaluate the collision frequency along the cable corridor.

In the case of the construction phase, four vessels are added into the model. In this model, the collision frequencies in each crossing point of the known shipping routes with the construction vessels are calculated. Comparing the baseline with the construction scenario results in a risk-increase for the construction year.

The baseline scenario is calculated based on the vessel traffic data from 2021. The construction scenario is calculated based on the baseline scenario, though added the construction vessels, as described in Table 4-1.

Table 4-1. Modelling parameters used for the construction situation.

Modelling parameter	Cable laying vessel
Vessel length	171.00 m
Vessel width	34.00 m
Vessel draught	8.50 m
Vessel speed	0.016 knots
Number of vessels	4

4.1.2 Risk results

The risk results, given as return periods (average time between events), for all collision types in an ordinary year and in the year of construction, are given in Table 4-2. In general, the return period for collisions during overtaking, head on and merging collisions (collisions where vessels are merging into the same route) are only slightly changed in the construction year. The merging collisions mainly cover interactions on the crossing routes which are unaffected in the installation year, compared to the baseline. However, the return period for collisions in crossings is changed from app. 580 years to app. 180 years. While the return period for collisions in the route bends are changed from 23,000 years to app. 8,700 years. These changes also affect the annual return period for any kind of collision from app. 330 years to 140 years. The change in the return period for collisions is due to the introduction of construction vessels (long and slow moving), sailing perpendicular to the established routes crossing the cable corridor.

Table 4-2. Collision return periods (average time between events) for the different types of collisions in a year without construction and during the construction year.

	Collision return period	
	Ordinary year	**Construction year**
Overtaking	928	869
Head on	7,505	6,272
Crossing	576	178
Merging	61,709	61,645
Bend	23,315	8,743
All collisions	**333**	**142**

Table 4-3 shows the return periods for crossing collisions for the routes identified in Figure 3-2 and Figure 3-6. All return periods in each crossing are well above 1,000 years, except for the crossing with route 52 (TSS Bornholmsgat). This is the most problematic crossing of the cable corridor, where the return period for a crossing collision in the construction year is found to be app. 500 years, whereas in an ordinary year it is found to be app. 2,900 years specifically within this part of the cable corridor. However, due to this area already being very busy, and the area being declared as a precautionary area, extra attention from vessels crossing this area is also expected.

Table 4-3. Collision return periods (average time between events) for the different route crossings during a year without construction and during the construction year.

Crossings with cable corridor		**Collision return periods**	
		Ordinary year	**Construction year**
Route 13		92,926	4,874
Route 14		20,751	4,836
Route 20		10,605	2,597
Route 30		50,110	2,654
Route 31		35,009	4,799
Route 32		26,130	10,973
Route 33		68,917	10,001
Route 40		1,465,866	152,676
Route 52	TSS Bornholmsgat	2,896	501
Route 62		66,836	20,018
Route 63		38,233	16,095
Route 64		1,541,673	18,109
Route 70		8,837	1,573
All collisions with routes		**1,324**	**228**

The return period for a crossing collision anywhere along the cable corridor is given in the bottom of Table 4-3. The return period for a collision anywhere along the cable corridor in an ordinary year is found to be app. 1,300 years, while during the construction period it is found to be app. 230 years.

It is noted that the return periods only cover the area within the cable corridor, and that the risk for incidents and collisions is generally higher in the area, which will be further described in section 4.1.3 'Reported accidents in the area'.

Near shore installation activities

The increased risk for third party related to the near shore installation activities is not calculated in a similar manner as for the cable corridor in open waters. As described in paragraph 2.3, the installation method near shore on shallow water will be performed differently, compared to the installation in locations with larger water depths and further from land.

As seen in Figure 3-2, the vessel traffic density near the landfall in Køge Bugt is low, and only the named route 30 crosses the cable alignment in the middle of Køge Bugt where the water depth has increased to more than 10m. Hence no main routes and larger vessels are foreseen to navigate in the area relevant for nearshore installation activities in Køge Bugt.

For the area south of Bornholm, see Figure 3-6, only the named route 64 crosses the cable alignment relatively close to the shore. This route mainly carries pleasure traffic and support vessels and pass over an area with water depths below 10m. However, the water depth is larger than 10m closer to the shore, and offshore installation activities are therefore assumed for the crossing of route 64. Hence, the estimated collisions frequencies involving route 64 are already included in Table 4-3 assuming potential impacts with slow-moving offshore cable-laying activities.

Based on the above, vessel traffic closer to the shore is assessed to consist mainly of smaller pleasure boats. As the vessels which can be affected by the installation works close to the shore are smaller vessels, and that the installation works near shore will be visible for the users of the waters, it is expected that the majority of the traffic will stay in safe distance to the installation works. The collision risk related to the installation works near shore is therefore evaluated to be low, and not significantly adding to the overall risk assessed above.

4.1.3 Reported accidents in the area

To compare the risk results with the general reported accidents in the wider area, accidents reported during 2020 and in the Baltic marine environment protection commission (Helsinki Commission, HELCOM) are described in the following.

In the accident report from 2020, ref. /4/, two accidents with pollution were registered in the Baltic Sea in total, but these accidents were both in harbours. The only vessel accidents near the cable corridor from the accident report is three situations next to Bornholm categorised as "Other" in the TSS Bornholmsgat. These are shown with their location in Figure 4-1, were the accident report also states the following: "(if no accidents are displayed in certain national waters, the reason can be either no accident occurrence during 2020, or lack of data)."

Figure 4-1. Collision and contact accidents in the Baltic Sea in 2020 from the report, ref. /4/.

The result from HELCOM only covers accidents within year 2020. To compare with other years, data from the Danish maritime authority accident statistics are shown in Figure 4-2. This show the latest 12 years of accidents in the Baltic Sea between Bornholm and Zealand covering the area south of Sweden and the area of the cable corridor between Bornholm and Zealand.

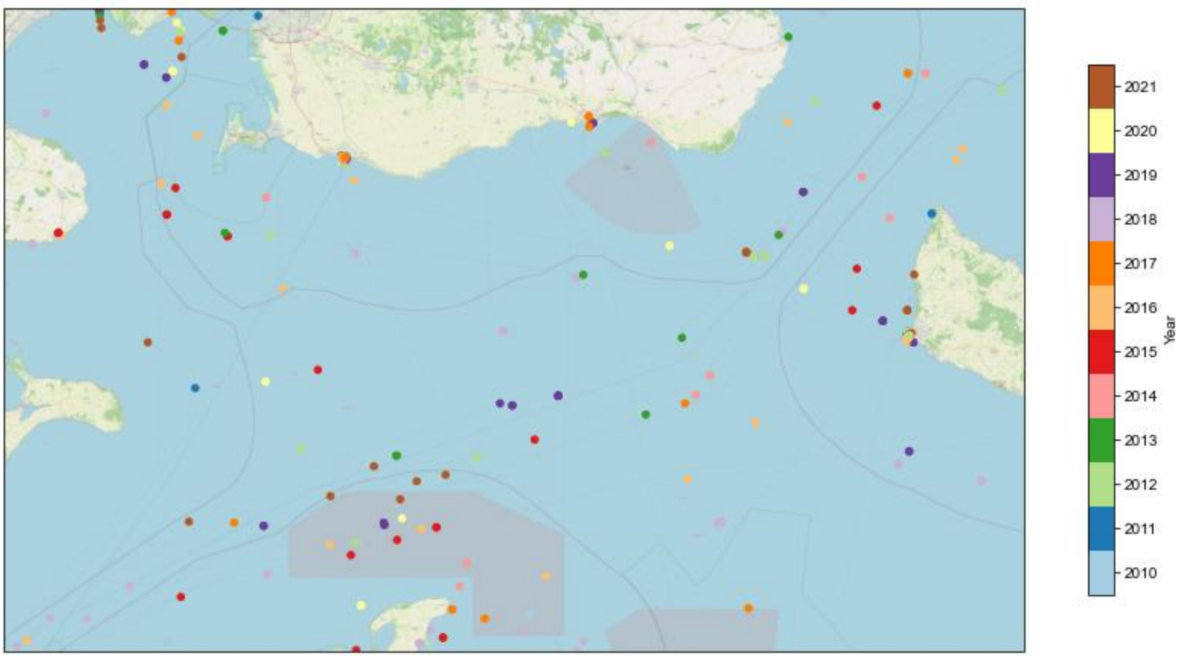

Figure 4-2. Vessel traffic accidents in the last 12 years in the Baltic Sea south of Sweden. The data set is received from DMAIB: https://dmaib.dk/.

Vessel traffic accidents in the Baltic Sea between Bornholm and Zealand covering the area south of Sweden and the area of the cable corridor between Bornholm and Zealand (Figure 4-2) are most frequent in the areas of TSS Rügen and TSS Bornholmsgat where the traffic is sailing closer to stay within the TSS. The same tendency is not seen at TSS Falsterbo and TSS Adlergrund. Further, several reported accidents are found near the cable corridor at Bornholm next to Rønne harbour and the TSS Bornholmsgat in the Danish EEZ. Towards Zealand in the Danish EEZ, fewer accidents are reported near the coastline and in Køge Bugt where the cable corridor is located.

Overall, incidents and accidents in the area in general are seen to occur quite frequently in relation to the intensely trafficked vessel corridors.

4.1.4 Summary of the risk and risk reducing measures

From the above, the construction phase of the project will mostly affect the vessel traffic safety while the construction vessels are present near the TSS Bornholmsgat. Given that this is the area with most reported incidents and accidents, the captains of the vessels passing this area are already extra vigilant; especially in the precautionary area where commercial traffic merge and split.

The navigational safety shall therefore be ensured by risk reducing measures in general and specifically at route crossings. In general, information on construction work and location of the construction vessels will be available in Notice to Mariners. This ensures that other vessels will be informed appropriately about the ongoing work and the presence of vessels with restricted manoeuvrability according to COLREGS rule 3, ref. /6/. Furthermore, a safety distance around the construction vessel of 500 meters will be defined, and relevant navigation lights shall be used. The safety zone is not specifically included in the modelling of the return periods above, and hence such safety zones together with information on the construction works will reduce the risk.

Lastly, use of guard vessels and dedicated lookout posts on the construction vessels to maintain focus on third-party traffic may be decided as part of detailed planning together with the authorities to further lower the collision risk.

Based on the risk calculations, the evaluation of risk for near shore areas, and the planned risk reducing measures, which will lower the annual risk, the navigational safety during the construction phase is evaluated as acceptable.

Depending on the construction year, some wind farm development may be ongoing in the area near the cable construction works, and vessel traffic on the main vessel routes may have been relocated slightly to accommodate such other construction activities (see Figure 2-2). Hence, the exact location of the crossing routes of vessel traffic may have changed, but the overall assessment of the collision frequencies is assessed to be covered by the above analysis. Care must be taken to perform cable joints away from crossing routes.

The space for navigating through any of the proposed OWFs (see Figure 2-2) shall be considered with respect to cumulative effects in detail when planning the construction works within or next to the wind farm areas, especially if a corridor is planned with dense traffic through.

Finally, construction activities shall be coordinated with other cables in the area and be performed with adequate safety distance to the Baltic Pipe.

4.1.5 Evaluation of the navigational safety at sea

The Danish Maritime Authority requires, as part of marine construction works, to perform a risk assessment after having launched preventive measures, ref. /9/. A risk scoring framework is defined where the consequence and probability of identified incidents shall be scored according to given index values resulting in a risk score being the sum of the probability and consequence index. The risk assessment framework is presented in Table 4-4.

Consequence categories range from 0 (limited) to 4 (catastrophic) whereas probability categories range from 0 (improbably seldom; once every 1.000.000 years) to 7 (often; about once per month). As the sum of the frequency and consequence score, the risk index will therefore range between 0 (limited consequence; improbably seldom) and 11 (catastrophic event occurring about once per month). A risk score of 5 or less is normally assessed to be acceptable.

Table 4-4 Risk assessment framework from the Danish Maritime Authority, section 19. The "consequence figure" index added to the "probability" index gives the "Risk" located in column 5 (R (C+P)).

Incident **(What could go wrong?** **"brainstorm")**	**Consequence figure** (total amount for environmental cleaning, loss of values, loss of lives/injuries per year): 0 in the amount of DKK 20,000 (limited) 1 in the amount of DKK 200,000 (minor) 2 in the amount of DKK 2,000,000 (considerable) 3 in the amount of DKK 20,000,000 (serious) 4 in the amount of DKK 200,000,000 and above (catastrophic)	**Probability** 7=10 accidents/year (often) – about once a month 6=1 accidents/year (relatively often) – once a year 5=0.1 accident/year (probable) – once every 10. year 4=0.01 accident/year (possible) – once every 100. year 3=0.001 accident/year (seldom) – once every 1000. year 2=0.0001 accident/year (very seldom) – once every 10,000. year 1=0.00001 accident/year (extremely seldom) – once every 100,000. year 0=0.000001 accident/year (improbably seldom) – once every 1,000,000. year	**M**	**R** **(C+P)** <5>

Figure 4-3. Risk assessment framework from the Danish Maritime Authority, section 19. The "consequence figure" index added to the "probability" index gives the "Risk" located in column 5 (R (C+P)). The column M is for listing mitigations for the identified risks.

The collision frequencies presented in paragraph 4.1.2 are estimated without considering risk reducing measures. The risk assessment, following the form of the Danish Maritime Authority, focuses on a qualitative assessment of the risk based on potential hazards identified from the consultation of the users of the water as well as from the basic information on vessel traffic in the area.

The purpose of the risk assessment is to identify potential risks for further elaboration in a future phase, as well as to perform an initial and overall qualitative evaluation of the risk imposed by the installation of the cable from the Energy Island Bornholm and to shore, either at Bornholm or Zealand. In this evaluation risk reducing measures are considered, which is why the estimated collision frequencies are not equal to those found in paragraph 4.1.2.

The risk reducing measures considered in the following risk assessment are:

- Information on construction work and location of the construction vessels will be available in Notice to Mariners.
- Safety distance around the construction vessel of 500 meters.
- Use of relevant navigation lights.
- Guard vessels and dedicated lookouts on the construction vessels to maintain focus on third-party traffic.
- Weather requirements for safe installation.

Table 4-5. Evaluation of risk index during installation of the offshore cable.

Incident	Consequence index	Probability index	Risk index
Passenger vessel/ferry collision with installation vessel	3	2-3	5-6
Cargo/tanker vessel collision with installation vessel	3	3-4	6-7
Pleasure vessel collision with installation vessel	2	2-3	4-5
Fishing vessel collision with installation vessel	2	1-2	3-4
Grounding of installation vessel, drifting	1	0	1
Grounding of installation vessel, full speed	2	3-4	5-6

The installation vessels will only be in the areas for crossing routes in shorter intervals, and the largest risk of the installation vessel for grounding is in the periods of time, where it is situated close to shore, where the near shore installation activities is applied. Given that the installation of offshore cable cannot be performed in harsh weather, this will also limit the grounding frequency.

All together the installation of the offshore cable is evaluated to be feasible and only result in a limited decrease in the overall navigational safety. However, the area around the TSS Bornholmsgat is an area with especially dense traffic, and the navigational risk in this area will be increased during the installation. Of this reason marking of the construction area and guard vessels will be of large importance in this area.

4.2 Operation phase

4.2.1 Changes of sea depths at cable crossings

As described in paragraph 2.4.1 the offshore cable will cross several other cables, both close to Zealand and to close to Bornholm. At cable crossings, a mat will be placed above the existing cable, before the offshore cable will be placed, and finally the offshore cable will be covered with protection. Hence, at cable crossings, the offshore cable will not be trenched into the seabed, and the mat between the two cables, as well as the protection placed on top of the offshore cable will cause a local change of water depth for each cable crossing.

While changes in water depth in open waters, where the water depth is already large will have no effect on the navigational safety with respect to grounding, changes in water depth in shallow waters can cause groundings, if the water depth suddenly is not sufficient for the vessel traffic in the area.

In total the offshore cable will have 15 crossings in the Danish EEZ, an overview of cable crossings and estimated change in water depth is summarized in Table 4-6.

Table 4-6. Cable crossings and planned changes in water depth.

Cable	Seabed	Seabed hardness	Planned change in water depth [m]
DK-PL 1	Sedimentary rock	Hard	2
The Digital Highway	Sand	Soft	1
Unknown_03	Muddy sand	Soft	1
Falster-Rønne	Muddy sand	Soft	1
C-Lion1	Muddy sand	Soft	1
Unknown_04	Muddy sand	Soft	1
Unknown_05	Muddy sand	Soft	1
Malmö-Stralsund 1930	Muddy sand	Soft	1
Unknown_08	Muddy sand	Soft	1
Rødvig-Rønne	Muddy sand	Soft	1
Unknown_09	Muddy sand/clay silt	Soft	1
Unknown_10	Sand/quartenary clay/silt	Soft	1
Unknown_11	Sand/quartenary clay/silt	Soft	1
Unknown_12	Sand/quartenary clay/silt	Soft	1
Unknown_13	Muddy sand/Sand/quartenary clay/silt	Soft	1

The 15 cable crossings in the Danish EEZ are shown in Figure 4-4 for the Bornholm section and Figure 4-5 for the Zealand section. The figures show the locations of the cable crossings together with a navigational chart. Naming of the crossings can be related to the information given in Table 4-6

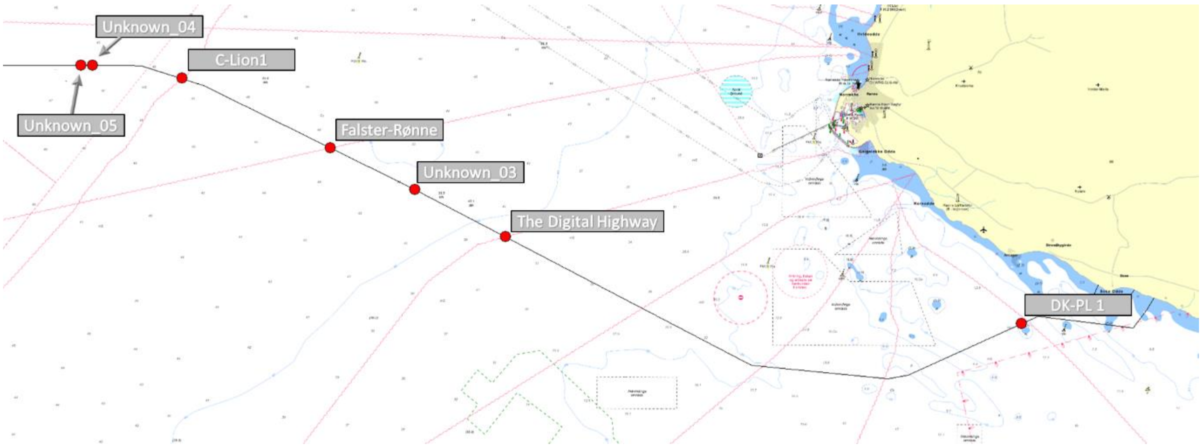

Figure 4-4 Cable crossings locations showed on a navigation chart for Bornholm section.

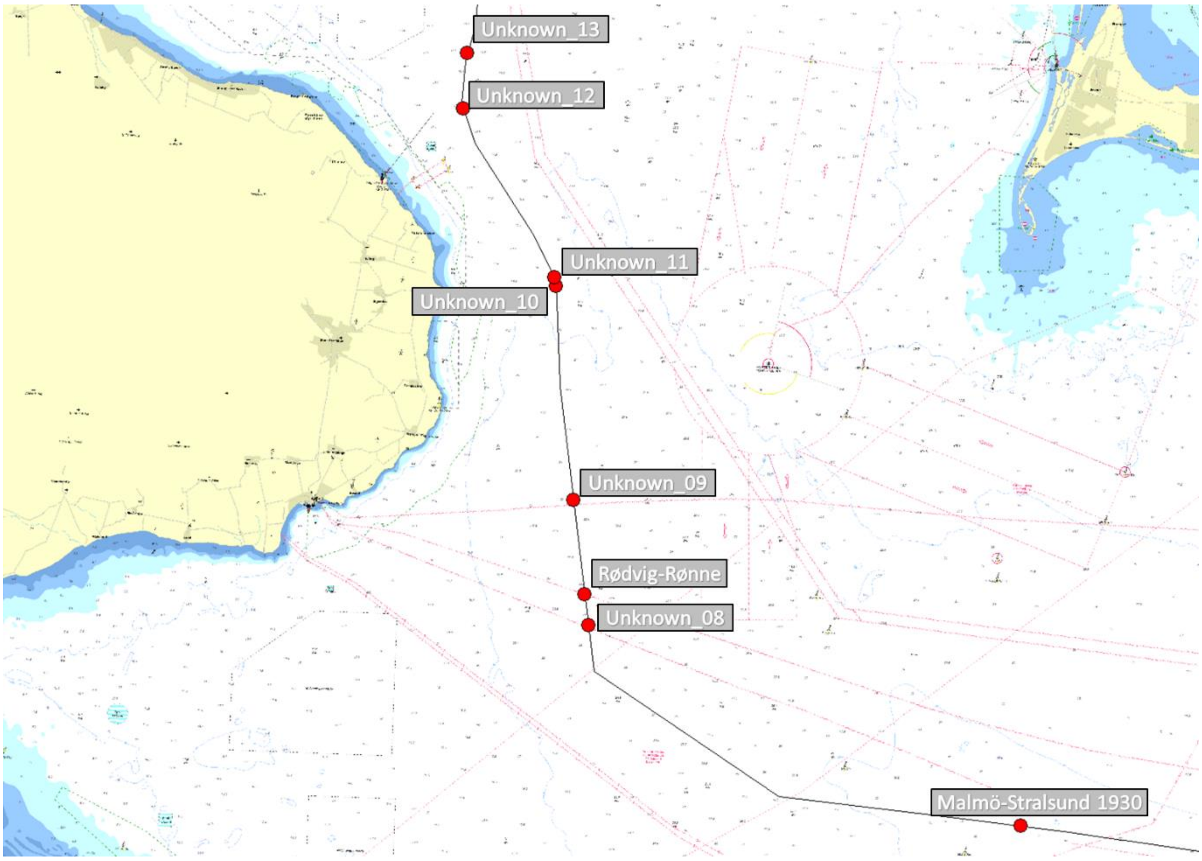

Figure 4-5 Cable crossings locations showed on a navigation chart for Zealand section.

The effect on the navigational safety (grounding risk) due to changing the water depth at cable crossings in the operational phase, is as for the construction phase, calculated as a comparative study. The baseline is the same used for the construction phase, which is compared to a scenario, where the water depths are changed at each of the cable crossings over an area of 50 m x 100 m. There is not made any changes to the vessel traffic in the model.

Risk results

The risk results, given as frequencies for all groundings with the 15 cable crossings where the water dept are reduced are given in Table 4-7.

The change in water depth affect the frequencies for vessel groundings at one cable crossing near Bornholm and seven near Zealand. The remaining cable crossings are at deeper waters not causing additional risk. For eight cases, are the additional risk increased by drifting groundings and only for the one at Bornholm and two a Zealand are also a risk contribution from powered groundings. Nearly all the increased grounding frequencies for the cable crossings are in the range of 1×10^{-8} to 1×10^{-12}, except at the cable crossing "Unknown_12", which has the increased grounding frequencies for the cable crossing of 1.3×10^{-5}.

Table 4-7 Grounding frequencies for the different cable crossings during the operational year.

Cable crossings	Section	Powered grounding	Drifting grounding	Total groundings
DK-PL 1	Bornholm	3.0E-12	1.1E-08	1.1E-08
The Digital Highway		0	0	0
Unknown_03		0	0	0
Falster-Rønne		0	0	0
C-Lion1		0	0	0
Unknown_04		0	0	0
Unknown_05		0	0	0
Malmö-Stralsund 1930		0	0	0
Unknown_08	Zealand	0	1.4E-09	1.4E-09
Rødvig-Rønne		0	7.6E-10	7.6E-10
Unknown_09		0	6.0E-11	6.0E-11
Unknown_10		0	3.1E-11	3.1E-11
Unknown_11		0	4.6E-10	4.6E-10
Unknown_12		1.3E-05	7.3E-09	1.3E-05
Unknown_13		5.1E-12	3.3E-10	3.4E-10
Total		**1.3E-05**	**2.2E-08**	**1.3E-05**

The total risk result induced by all the cable crossing is mainly affected by the powered grounding with “Unknown_12”, which equals a return period of app. 77,000 years between events. However, this is a rare event, and grounding due to local changes in the water depth at the other cable crossings is even more rare.

4.2.2 Regular maintenance activities

The amount of ordinary maintenance is expected to be minimal as routine inspections are usually not necessary. Possible use of survey vessels including vessels with remote-controlled submarines for checking the cable occur seldom, and the impact on the navigational safety is assessed to be insignificant compared to the risks related to other vessel traffic present in the area.

4.2.3 Cable damage

The cable alignment will often be crossed by vessels sailing on the crossing routes listed in Table 4-3. Damage to the cable can occur in case of fishing activities and due to anchor drops. Fishing activities will mainly occur outside the main shipping routes, and hence cable damage due to fishing activities is assessed mainly to occur in areas with lower vessel traffic intensity. Repair works in these areas will result in a slightly increased risk while a maintenance vessel is present in the area. The risk related to such repair works may be comparable to the construction phase risk in these areas, and the risk is assessed to be negligible compared to other risks in the area.

Anchor drops from commercial vessels can potentially damage the cable. Statistics for the cable at Bornholmsgat in ref. /5/ shows six times where the island Bornholm has been blacked out because the offshore cable between Bornholm and Sweden has been torn over by vessels with dragged anchors. The torn offshore cable with six events refers to events from year 2004 and latest in year 2022. However, this is also in the most trafficked part of the cable corridor section. It should be noted that the protection of existing Bornholm cable is also poor due to cable position in the seabed, and the offshore cable connecting the Energy Island Bornholm is planned to be better protected.

To assess the risk from vessel traffic anchoring and damaging the buried cables, the frequency for vessels uncontrolled anchor drops is qualitatively assessed. The frequency for uncontrolled anchor drops is extracted from the DNV ref. /1/ appendix E about "Unintentional Anchor Drops from Ships Under Way". The frequency is 2.7 x 10^{-8} for an accidental anchor drops per km.

The risk is most critical for the cable alignment within the precautionary area at the TSS Bornholmsgat due to the denser vessel traffic over this crossing. The risk is also due to commercial vessel traffic often using its anchor when waiting outside harbours or at other occasions, which give rise to a higher risk of unintentional anchor drops compared to ferries. The risk of anchor drops for ferries in operation on a regular basis is assessed to be lower due to no need for anchoring in general.

The highest risk of uncontrolled anchor drops is seen for Route 52, which holds the largest volume of traffic. Anchor drop is estimated to occur approximately every 70 years. The return period for anchor drops around Route 20 is found to approximately 130 years. At the other route crossings, the return period for anchor drops are above 200 years. Cable protection or burial into the seabed will reduce the risk of cable damage in case of an anchor drag event on top of the cable.

Cable damages must be repaired and may impose a smaller risk if repair works are to be carried out in an area with denser traffic. The repair works will be comparable to construction works involving a vessel with restricted manoeuvrability present in the area. Hence the local risk will be increased in years with cable damage, however to a level assessed as acceptable for the construction phase. Appropriate risk reducing measures shall be applied, as for the construction phase, especially when performing cable repairs at densely trafficked route crossings.

4.2.4 Compass disturbances

The cables are installed in a cable trench, and in case of crossings, protected by rock layers. Therefore, the potential resulting magnetic field is limited when positive and negative pole-cables are installed close together. Worst-case magnetic field disturbances have been estimated, ref. /3/, indicating far less than one-degree potential compass deviation. Moreover, most vessel traffic in the area will be commercial vessels not navigating solely on compasses. The effect of compass disturbances on the navigational safety induced by the HVDC offshore cable is therefore assessed to be negligible.

4.3 Decommissioning phase

Activities related to decommissioning are not yet detailed. However, in the event of picking up the cable, activities similar to construction activities are assumed along the entire stretch of the cable, see section 2.4.3. Hence the risks are similar. The amount of vessel traffic at the time of decommissioning is not assessed in detail as this may have developed into larger, but fewer, vessels, more vessels, etc. A brief discussion on the future vessel traffic is mentioned in section 3.2. Moreover, decommissioning may occur in an environment with additional wind farms or other obstacles located in the area.

The impact of cables in the decommissioning phase is expected to be the same or less than in the construction phase and can thus be compared with the estimated impact in the construction phase. This phase has therefore not been evaluated further.

5. SUMMARY AND CONCLUSION

The project is a HVDC offshore power cable connection between the Danish islands of Bornholm and Zealand. The cable connection consists of a bundled HVDC cable system that will enable transmission of power between Energy Island Bornholm and the electricity transmission system on Zealand. The cable corridor consists of a 1 km wide and 115 km long cable corridor within the Danish EEZ. Only the Danish part of the cable is included in the present assessment.

Activities related to the project can pose a risk for the vessel traffic in the area. The navigational safety impact assessment is divided into three main parts and assessed for:

- Construction phase
- Operation phase
- Decommissioning phase.

The risk is assessed in relation to impacts to the vessel traffic in the areas. The areas as such is densely trafficked carrying all the vessel traffic to and from the Baltic Sea, with many identified routes crossing the cable alignment.

5.1 Construction phase

The construction phase requires several vessels performing various activities across the area, including vessels with reduced manoeuvrability according to COLREGS rule 3. The impact of construction works is estimated and reported as changes in the return periods for vessel collision scenarios in an ordinary year, without construction works, and during the year of construction.

Most of the construction works occur within areas outside the main shipping routes. However, the cable corridor crosses several vessel routes, where construction activities potentially pose an increased risk for vessel-vessel collisions.

The return period for any type of collision in the area covered by the cable corridor is found to be app. 330 years in an ordinary year without construction works, and app. 140 years, during the construction year without considering specific risk reducing measures. The collisions during an ordinary year mainly count collisions in relation to overtaking vessels on the existing routes, and the crossing vessel traffic along the cable. During construction, the largest risk consists of crossing collisions between existing vessel traffic and the construction vessels moving slowly along the cable corridor, hence collisions in crossing situations.

The highest risk for the construction works is associated with the area close to the TSS Bornholmsgat, where the return period during the construction year on average will be app. 500 years for the cable alignment. This is in comparison to an ordinary year where the return period for collisions specifically within this part of the cable corridor is estimated to app. 2,900 years. Even though the risk is increased during the time of the cable lay, risk reducing measures will be able to partly control the risk in the construction phase.

The overall risk associated with the construction phase is assessed as acceptable with the proposed risk mitigating measures:

- Information on construction work and location of the construction vessels will be available in Notice to Mariners.
- Safety distance around the construction vessel of 500 meters.
- Use of relevant navigation lights.
- Guard vessels and dedicated lookouts on the construction vessels to maintain focus on third-party traffic.

- Weather requirements for safe installation.

5.2 Operational phase

The risk for the vessel traffic in the area during the operation phase is assessed for the following:

1. The effect of changing the water depth at cable crossings with the offshore cable.
2. Maintenance activities.
3. Repair work following cable damage due to dropped or dragged anchor.
4. Compass disturbances.

The effect of changing the water depth at 15 crossings is assessed by calculating the grounding risk in the baseline scenario (before cable installation) and calculating the grounding risk, where the water depths has been updated for each of the crossing locations. Only at location with already shallow water depth, the effect of lowering the water depth due to need of cable protection affects the risk for grounding. The total risk result induced by all the cable crossing is mainly affected by the powered grounding with "Unknown_12", which equals a return period of app. 77,000 years between events. However, this is a rare event, and all the other cable crossings are even more rare. The effect due to changed water dept at the cable crossings is not affecting the vessel traffic.

The risk related to maintenance activities is assumed to be small, as no regular maintenance activities are normally required. However, some repair activities may be foreseen following cable damage events.

Repair works following events where the cable is damaged due to an accidental dropped or dragged anchor or related to fishing activities with bottom trawl will require vessels present at the location of the damaged cable section. Trawling activities will take place outside the main shipping routes, and repair activities will therefore also most likely occur in less trafficked areas posing only a limited risk in relation to repair works. On the contrary, anchor drop events will most likely occur along the main shipping routes, and anchor drop events are regularly observed between Bornholm and Sweden. Repair works occurring at locations of crossing shipping lanes are assessed to be comparable to construction works involving a vessel with restricted manoeuvrability, and hence risk reducing measures as for construction works must be applied.

Finally, the compass disturbances are assessed to be negligible, as the cable consist of a positive and a negative pole-cable, as well as the cable being trenched into the seabed, hence lowering the magnetic disturbances at the sea surface.

5.3 Decommissioning phase

The decommissioning phase is assumed to be similar in risk to the construction phase. However, it must be noted that the amount of vessel traffic and the presence of wind farms and other obstacles in the area may have changed.

Overall, the construction, operation and decommissioning phases involve relatively well-known activities, and with adequate focus on route crossings as well as detailed risk reducing measures within these areas, the overall risk involved with the activities is assessed to be acceptable.

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