Consultation Documentation

In preparation for the application of a permit to construct, operate and decommission the Kapheira wind farm, along with its associated internal cable network, hydrogen production, and the installation of pipelines within the operational area.

WindFarm Kapheira, Zephyr Baltic Offshore AB

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1 Introduction

1.1 Background

Zephyr Baltic Offshore AB are planning to build an offshore wind farm in the Swedish Economic Zone between Gotland and the Swedish mainland.

Zephyr Baltic Offshore AB that are developing the offshore wind farm Kapheira, is a fully owned subsidiary of Zephyr Renewable AB, which in turn is owned by the Norwegian company Zephyr AS. Zephyr develops, establishes, and manages renewable electricity production and operates in Norway, Iceland, and Sweden, where the office is in Gothenburg. Since the start in Norway in 2006, the company has developed and established close to 800 MW and currently manages a total of 125 wind turbines. Zephyr AS is owned by the Norwegian energy companies Østfold Energi and Vardar, which in turn are owned by many municipalities and county councils in southern Norway. These two energy companies for example own hydropower, wind power, solar energy, and district heating in Norway and Sweden.

Two other offshore wind power projects are also being pursued in Kattegat and Skagerrak: Poseidon and Vidar. The application for the Poseidon wind farm was submitted in the beginning of 2023, and the government is expected to decide on the establishment during 2024. Both the Vidar and Poseidon projects are led by the company KonTiki Vind AB, which is co-owned by Vattenfall.

1.2 Planned Operations

The project involves the construction, operation, and decommissioning of a group station for wind power with associated internal cable network and internal grid. The wind farm is planned to have a maximum of 143 wind turbines with a maximum total height of 370 meters above sea level. The annual electricity production is estimated to approximately 9.5 TWh.

The offshore wind farm will be located outside off Swedish territorial waters but within the Swedish economic zone. As a starting point, Swedish law is not applicable in the economic zone. Sweden has, however, with support from the UN Convention on the Law of the Sea, implemented the law on Sweden's economic zone. According to this law, parts of the Swedish environmental assessment legislation become applicable, such as requirements for the establishment of an Environmental Impact Assessment with preceding consultation.

In addition to the production of electricity, the operation may also include the production and storage of hydrogen. Hydrogen is listed as a hazardous substance in Annex 2 of the Swedish Environmental Code (2015:236) regarding measures to prevent and limit the consequences of serious chemical accidents. Therefore, the facility will, according to the Seveso Act, be classified as a Seveso facility after it has been constructed. If hydrogen production becomes relevant, the expected amount of handled hydrogen within the operational area determines whether the operation is covered by the lower or higher requirement level (more than 50 tons of storage) according to the Seveso Act.

Permits for the export cable network and/or export pipeline as well as land connections will be evaluated in a separate permit process (including preceding consultation) and are therefore not covered by the planned permit application to which this consultation refers.

1.3 Scope and Legislation

Overall Scope

This consultation document has been created as a foundation for the scoping consultation according to Chapter 6, Sections 29–32 of the Environmental Code (1998:808) (EC). A Survey Consultation according to Chapter 6, Sections 23–25 EC has not been carried out, as wind farms are generally considered to have a significant environmental impact.

The project area is located within Sweden's Exclusive Economic Zone (EEZ). As mentioned above, the applicable legislation when applying for a permit is the Act on Sweden's Exclusive Economic Zone (1992:1140). Permits are handled by the Swedish government as well as permits for the wind farm's internal cable network/internal pipelines in accordance with the Continental Shelf Act (1966:314).

The purpose of a scoping consultation is to inform authorities, individuals, and the public about the location and execution of the planned project as well as to provide the overall potential environmental effects that the planned operations could cause.

The Seveso Directive

The company has made the assessment that the current project area is not covered by the Act (1999:381) on measures to prevent and limit the consequences of serious chemical accidents ("Seveso Directive") since the location is within the economic zone. The Seveso Directive is however considered applicable if the potential facility for hydrogen production is established in the same zone.

The purpose of the Seveso Directive is to prevent serious chemical accidents and to limit the consequences of such accidents for human health and the environment. This is of high priority for the company.

The company is therefore conducting the current consultation in accordance with the Seveso Directive to investigate if the safety of the operation can be affected by any surrounding factors and to identify what these are, as well as to gather information on preventive measures to avert and limit serious chemical accidents.

The Espoo Convention

Since the wind power project will be located in the Baltic Sea, which is used by several states, a transboundary impact could possibly occur. A consultation will therefore be carried out in accordance with Chapter 6, Section 33 EC to meet the requirements for transboundary consultation in Directive 2011/92/EU ("EIA Directive") and the Convention on Environmental Impact Assessment in a Transboundary Context ("Espoo Convention").

The Scope of the Consultation

The consultation is limited to the construction, operation, and decommissioning of the wind farm and includes potential hydrogen production/storage and associated infrastructure, such as wind turbines with foundations, platforms, measuring masts, internal cable networks, pipelines, and substations.

Permits for the export cable network and/or export pipeline as well as land connection will be carried out in separate permitting processes and are therefore not included in this consultation document.

The consultation will take place during the first quarter of 2024, and a complete environmental impact assessment will subsequently be prepared in accordance with Chapter 6 EC as a foundation for the above-mentioned applications.

1.4 The National Need for Renewable Energy through Wind Power

Zephyr aims to be a driving force in the development of renewable electricity production and thereby contributing to the necessary energy transition and electrification of society. The Swedish Energy Agency has stated that there will be an increased need for electricity since the electricity demand will double by 2035 compared to current consumption (Swedish Energy Agency, 2022). The demand for renewable electricity from businesses, the transport sector, and industries is already very high since all segments of the business community are planning for, or undergoing, a transition to more sustainable energy sources. Such a transition is hindered when the supply of renewable electricity production cannot be secured. To strengthen the competitiveness in Sweden, there is an urgent need for large scale expansion of electricity production , where for instance, hydrogen technology can enable efficient application of electricity production from wind power within industry and the transport sector.

The planned wind farm Kapheira can provide a significant addition of electricity to the SE3 and SE4 electricity areas. This becomes an important contributor to meet the industry's fast increasing need for electricity, since the transmission capacity from north to south currently is insufficient. Facilitating the establishment of offshore wind power, such as the Kapheira wind farm, is also important for Sweden in continuing the ongoing electrification in society and to fulfil international commitments.

2 Location and Project Description

2.1 Location

The Kapheira wind farm is planned to be located between Gotland and the Swedish mainland, within the Swedish exclusive economic zone. The project area covers 486 km^2 and closest distance is 24 km from the north-western coastline of Gotland (Figure 1). The area is assessed to have good conditions for offshore wind power on floating foundations. The wind resources are satisfactory, and the water depth varies between 65 and 205 meters.

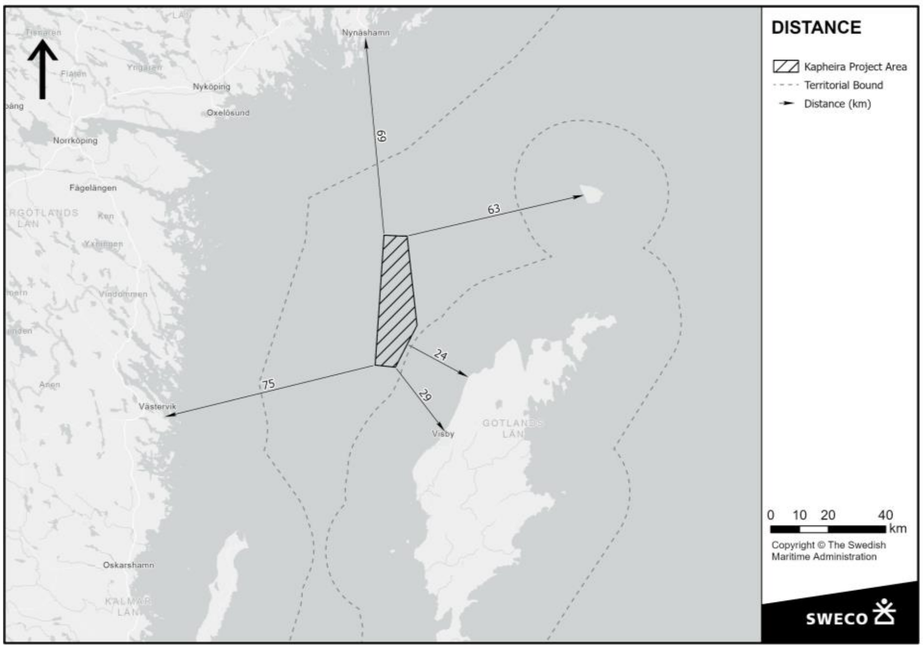

Figure 1. The project area for the Kapheira wind farm and its distance to land. The shortest distance is approximately 24 km to the north-western coastline of Gotland. Visby is located just about 30 km from Kapheira.

The preliminary location of the wind turbines is shown in Figure 2, with an internal distance of approximately 1.5–2 kilometres between the individual turbines.

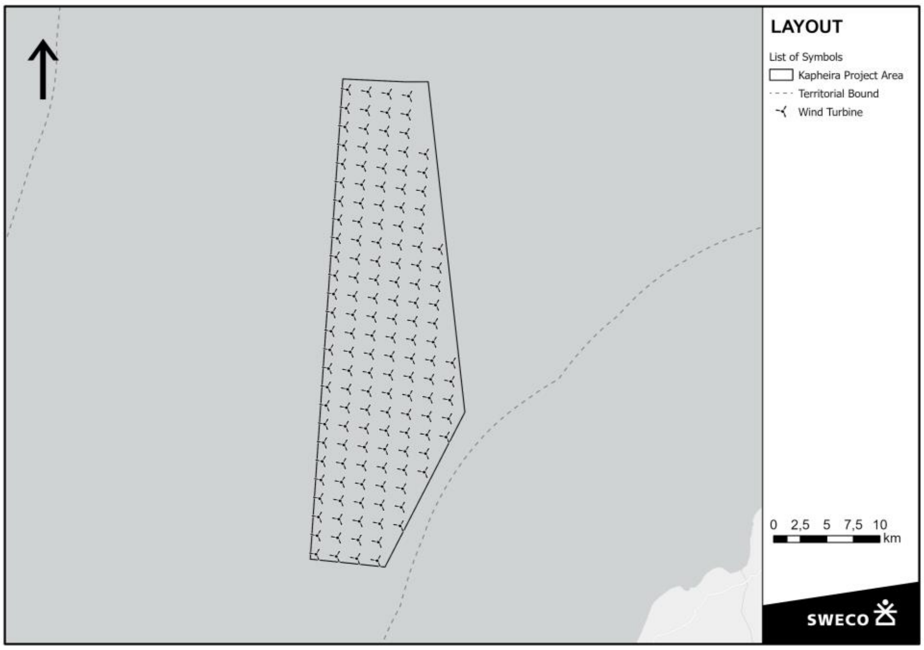

Figure 2. Kapheira with a layout example of 143 wind turbines.

To identify the best conditions for the establishment of offshore wind power, the company has conducted an extensive site investigation, evaluating various aspects such as nearby interests and the possibility of connection to the electrical grid as well as favourable wind conditions. The project area for Kapheira has been selected since the conditions in the area are favourable for wind power, including a suitable depth for floating wind turbines, good wind conditions, and a location with fewer sensitive ecological environments in comparison with a coastal location.

Since the wind farm is planned to be established far from land, any impact on the landscape and cultural environment is limited, and the company has noted good opportunities for coexistence between different interests within the sea area in question.

The fact that the current project area has been identified as suitable for energy extraction in proposals for amended marine spatial plans (consultation 2023) has also played a significant role in the assessment of an appropriate location.

2.2 Kapheira

The planned wind farm consists of 143 wind turbines at the most with a total height of up to 370 meters. The installed total capacity is estimated to be approximately 2,700 MW with an estimated annual electricity production of about 9.5 TWh. All wind turbines will have floating foundations. In addition to these, floating or fixed-bottom foundations are planned for 2–4 substations and 2–6 electrolysis plants for hydrogen production.

Technical data for the wind farm has been compiled in Table 1 below.

Table 1. Technical data for the wind farm Kapheira.

Number of turbines	143
Total height	370 m
Capacity per wind turbine	ca 20 MW
Yearly electricity production	ca 9,5 TWh
Maximal yearly hydrogen production	ca 250 000 tonnes
Project location area	486 m^2
Water depth	65 – 205 m
Wind resource (150 msl)	9,5 m/s
Foundation for wind turbine	Floating
Foundation for other site components	Floating or bottom-fixed

3 The Layout of The Wind Farm

3.1 Introduction

The following chapter aims to describe the site components and the technology that may be used for the construction of the Kapheira wind farm. Given that the project is currently in the consultation phase and that normal timelines for the development of offshore wind power extend over several years, a decision on the final design of the wind farm has not yet been made. The reason for deciding on the final design at a later stage is that rapid technological development in the field may enable the use of even more efficient methods and technologies when the final design process starts. Therefore, the following descriptions are general and comprehensive. Further description of the technologies will be provided in the permit application for environmentally impacting operations, including a technical description and an environmental impact assessment. Since permits for export cables and land connections will be conducted in a separate permitting process, these parts are only briefly described.

3.2 Wind Turbines

A wind turbine consists of primarily a tower, a nacelle (machine house), and a rotor. In addition to these parts, auxiliary equipment such as hydraulics, control equipment, and electronics are included.

The tower is usually comprises steel and the nacelle is often made from steel and/or fiberglass and contains a drivetrain and a generator. The rotor is typically three-bladed and usually made of a combination of fiberglass and carbon fibre.

The rotor and nacelle rotate to adjust to the wind direction, and the angle of the three rotor blades is adjusted to optimize production and function. With today's design and configuration, operation is normally allowed up to wind speeds of about 25–30 m/s, at which point the wind turbines shut down to avoid overloading the components.

The technological development of wind turbines is rapid, and manufacturers are continuously introducing larger models. A typical offshore wind turbine being built today has a total height of about 250 meters and a rotor diameter of about 200 meters. The trend for taller and larger wind turbines is however expected to continue, which is why Kapheira is planning for a maximal total height of 370 meters and a maximal rotor diameter of about 340 meters. The development of taller and more powerful wind turbines between the years 1995 and 2022 is illustrated in Figure 3 below.

Figure 3. The development of wind turbine size and capacity between the years 1995 and 2022 (DNV). In 2023, the installed wind turbine capacity was 15 MW.

3.3 Offshore Substations (OSS)

One or more substations (Offshore Substations, OSS) are normally required in connection to a wind farm where the alternating current (AC) generated by the wind turbines is transformed to a higher voltage (High Voltage Alternating Current, HVAC). For long distances to land connection, it is common to convert the alternating current to high voltage direct current (High Voltage Direct Current, HVDC) to reduce power losses during the transmission of electricity to land via export cable. Substations are normally constructed on one of the foundation types described below. Schematic examples of substations and various foundation types are shown in Figure 4.

There is a current development towards placing substations, or solutions with the same purpose, on the seabed. Such a solution may become relevant depending on local conditions and if the technology is available when the final design stage starts.

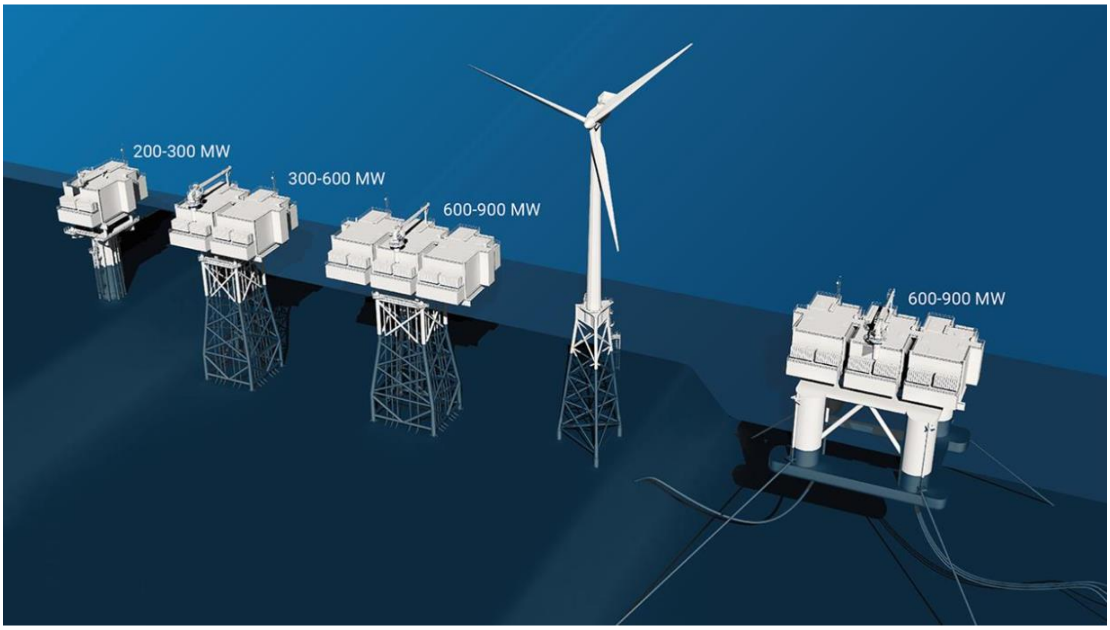

Figure 4. Schematic examples of substations and foundation types (Dodd, 2017).

3.4 Foundations

Wind turbines, substations, hydrogen production facilities, and monitoring poles that are required above the water surface are placed on foundations; dimensioned based on parameters such as the size of the wind turbine and the forces affecting the structure. There are both bottom-fixed and floating foundations, each in several different designs. An overview of the most common types of foundations is provided in Figure 5 and in the following sections below. As the industry is developing rapidly, additional types of foundations are likely to be developed over time.

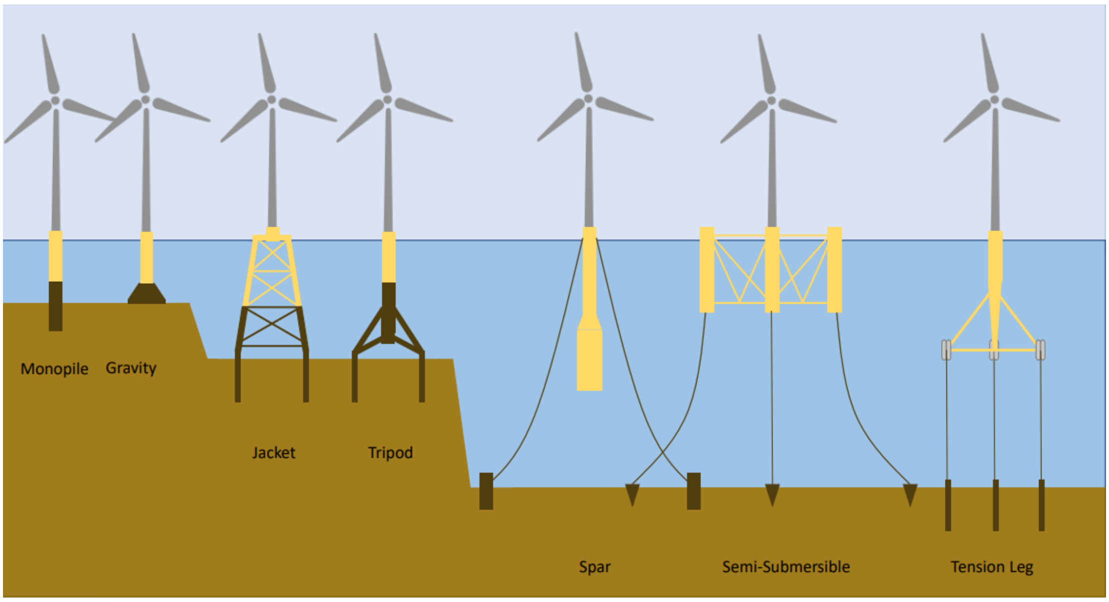

Figure 5. Common types of foundation for offshore wind power sites (Dornhelm 2019).

3.4.1 Floating foundations

Floating foundations will be used for the wind turbines and may, depending on technological developments, be used for OSS (Offshore Substations) and hydrogen production facilities, as well as for additional equipment.

Floating foundations can be made from steel or concrete.

There are various designs of floating foundations, primarily based on three principles (Spar, Semi-submersible, and Tension Leg) as shown in Figure 5, as well as Barge (pontoon construction).

The Spar technology consists of a deep cylinder with ballast at the bottom, providing the stability necessary to handle both statically and dynamically loads from the wind turbine, wind, and currents. A Spar construction requires an installation depth of about 100–150 m, hence they can only be used in deeper waters. The installation of wind turbines can only be done at sea.

A Semi-submersible consists of a floating semi-submerged platform where the displacement is mainly below the water surface, providing a stable platform less affected by weather loads. The design is well-suited for the installation of wind turbines along a pier.

The Tension Leg technology is based on a platform anchored to the seabed with rigid taut lines. The taut lines provide stability and require strong vertical anchoring in the seabed. If the installation of wind turbines is to take place at a dock, additional stability must be provided until the foundation is anchored in the park.

The Barge technology is based on a ship-like box structure and is well suited for concrete foundations. With its deep draft and foundational stability, it is suitable for the installation of wind turbines at a quayside.

3.4.2 Bottom-Fixed Foundations for Transformer Stations, Hydrogen Production Facilities and Other Equipment

Existing bottom-fixed foundations are primarily based on the four principles (Monopile, Gravity, Jacket, and Tripod) as shown in Figure 5 and described below. Bottom-fixed foundations are normally protected against erosion by placing stone or concrete formations on the seabed around the foundation.

Bottom-fixed foundations may be considered for substations or hydrogen production as well as for other equipment that cannot be placed on floating foundations.

Monopile foundations are to date the most common foundation type for offshore wind turbines. This type of foundation is normally used in shallow areas, down to water depths of about 30–40 meters. As technology advances, even deeper areas are becoming accessible for this method.

Gravity foundations consist of a ballast-filled concrete or steel structure placed on the seabed, the weight of the foundation provides its stability. This type of foundation is normally used in shallow water areas, down to water depths of about 30–40 meters. As technology advances, even deeper areas are becoming accessible for this method.

Jacket foundations are made of several metal parts joined together to form a truss structure. The foundation is typically anchored with several pre-installed mounting points in the seabed. How, and when, the mounting points are fixed into the seabed is determined by the type of seabed. There are different ways of mounting, for example piling. This type of foundation is mainly used in relatively shallow water but can also be adapted for use in deeper areas.

A tripod foundation consists of two three-legged structures joined together with a centrally placed vertical cylinder. The foundation has three attachments in the seabed which are normally piled down. Tripod foundations can be used in both shallow and relatively deep-water areas as well as on most types of seabeds.

3.5 Mooring and Attachment of Foundations

The type of mooring and attachment required, as well as dimensions, depends on parameters such as the height of the wind turbines, the type of foundation, water depth, the geology of the seabed, and the expected aerodynamic and hydrodynamic impact.

3.5.1 Mooring of Floating Foundations

All floating foundations need to be moored to the seabed by several lines/chains between the floating foundation and the seabed. The mooring can be done in different ways, for example, through suction anchors, drag anchors, or by driving a pile anchor into the seabed. The most common mooring methods are shown in Figure 6.

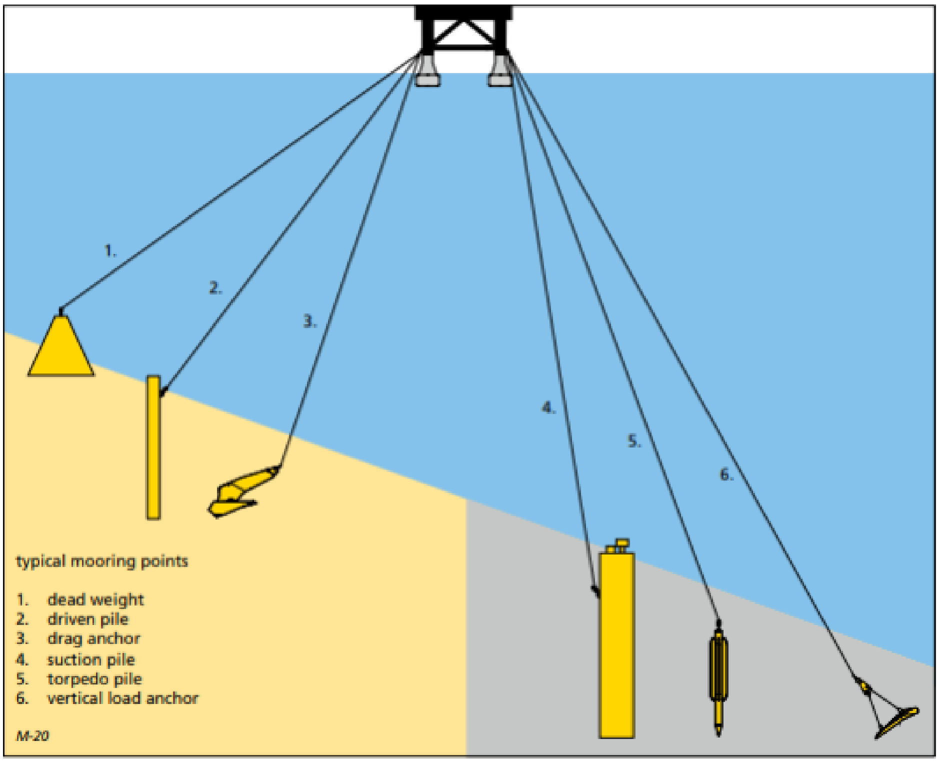

Figure 6. Illustration of the most common methods to moor floating foundations (X Castillo 2020).

3.5.2 Attachment of Bottom-Fixed Foundations

Many of the bottom-fixed foundation types need to be attached into the seabed in one or more locations per foundation.

A common method is to pile a homogeneous steel structure into the seabed in connection to the point where the foundation is in contact with the bottom surface. Another method is to secure anchoring points in the seabed by screwing. This method could be a suitable alternative when the seabed consists of rock.

An additional method involves using a bottomless cylinder with a sealed top, a so-called suction anchor, which is sucked into the seabed through a pump-generated vacuum inside the cylinder. This anchoring method is normally used in softer seabed, where the cylinder can sink into the sediment. The method is environmentally beneficial compared to, for example, piling, as it generates significantly lower noise levels, therefore impacting noise-sensitive marine fauna to a much lower extent. There are also combinations of the described attachment types, especially on seabed with a heterogeneous distribution of bottom materials where different techniques may be required for the same foundation. Examples of attachment through suction anchors and foundations with combinations of fastening types are presented in Figure 7.

Some foundation types do not need to be fixed, such as gravity foundations.

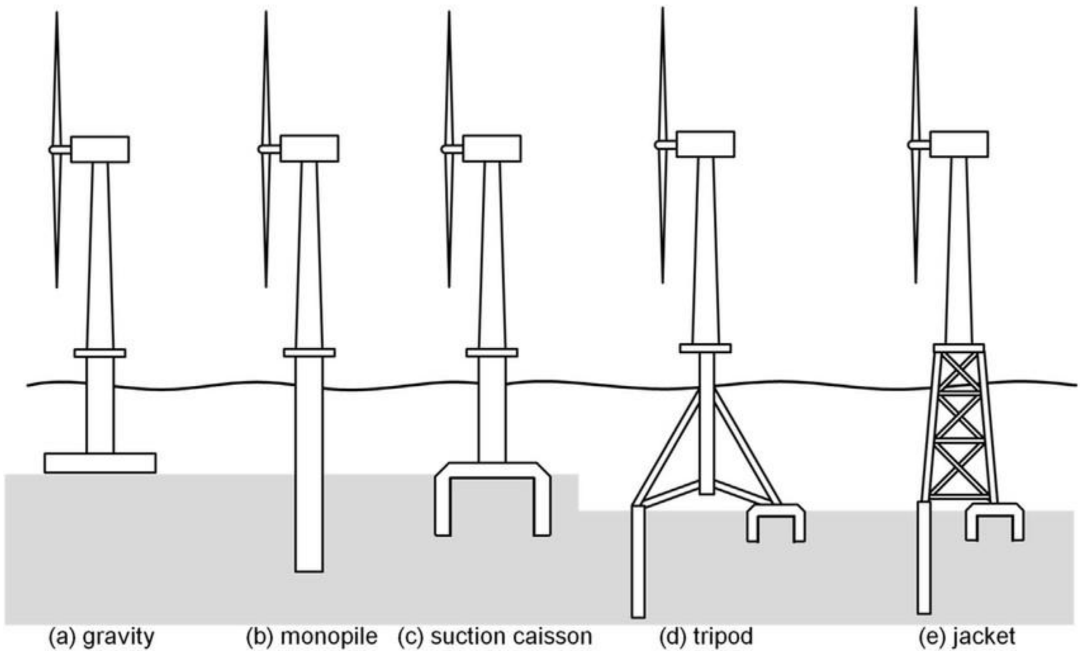

Figure 7. Examples of different foundation types, its attachment, and combinations of attachments (Oh et al. 2018).

3.6 Monitoring Masts

There is a steady development of methods for wind monitoring. Floating LIDAR units that use lasers may be used to measure wind conditions, or alternatively, wind monitoring can be conducted on shore. In some cases, it may be necessary to install a monitoring mast at sea within the park area.

One or more facilities for recording site-specific meteorological data, known as monitoring masts, can if needed be installed. The installation is usually done within the wind farm area. Monitoring masts are typically installed prior to the design of the wind farm but are often retained during the wind farm's operational period as well. Monitoring masts enable the collection of data for the dimensioning and design of the different parts of the facility. The masts also enable operational optimization during the operational phase. Monitoring masts can also be equipped with devices for other recordings, such as the presence of birds and other animals in the area. Equipment for recording oceanographic parameters such as currents, waves, chemical data, etc., can also be installed in connection with monitoring masts and provide information for the detailed project design. Monitoring masts typically have a height that is at the same level as, or slightly lower than, the planned wind turbines and are installed on one of the foundation types described above. An example of a monitoring mast is presented in Figure 8.

Different forms of radar technology for measuring wind conditions might be considered. SODAR or LiDAR (acoustic or laser radar) can be used for this purpose.

Figure 8. An example of a monitoring mast. (PowerPoint)

3.7 Hydrogen Production

3.7.1 Background

It has become increasingly common to consider and plan to produce hydrogen at offshore wind farms. The production of hydrogen in connection to wind-generated electricity provides an opportunity to supply the industry with raw materials or energy and the ability to store this energy for later use, as well as making the wind farm less dependent on power limitations and transmission capacity in the main grid. Hydrogen production also offers the possibility to regulate peaks and lows in both electricity generation and consumption, which benefits the electricity system by providing support when needed. A wind power facility can be designed so that either all, or parts, of the generated electricity is converted into hydrogen. For the Kapheira wind farm, the annual hydrogen production is estimated to approximately 250,000 tonnes, that is if all produced electricity is converted to hydrogen. A preliminary calculation shows that about 5-100 tonnes of hydrogen could be stored. If the momentarily maximum amount of handled hydrogen exceeds 50 tonnes, the operation must comply with the higher requirement level according to the Seveso Directive.

Hydrogen can be produced in the park area either centrally with a smaller number of electrolysis units of larger capacity or it can be produced decentralized at individual wind turbines.

Aa an alternative, the hydrogen facility can be located on land. If so, the hydrogen production will not be part of Kapheira's operations or the upcoming application.

3.7.2 The Technology

Hydrogen is produced through electrolysis and there are various technologies available, including alkaline electrolysis with, or without pressurization, electrolysis through a proton exchange membrane, and high-temperature electrolysis. The process at an offshore facility involves splitting the molecules in purified and desalinated seawater into hydrogen and oxygen. This is done by directing the wind-generated electricity through an electrolyzer where the water molecules are split into hydrogen and oxygen, after which the gases are separated from each other. The electrolyzer contains water and some type of electrolyte, such as sodium or potassium hydroxide.

3.7.3 The Need for Water

The electrolysis process requires large amounts of pure and desalinated seawater. To produce 1 kg of hydrogen, about 10 liters of desalinated seawater is needed, hence the annual need for desalinated water could amount to 2.5 million m³ if a maximum annual production of 250,000 tonnes of hydrogen is assumed.

Desalination usually takes place through reverse osmosis, where water is forced through a membrane that separates salts and water. The separated salts are normally returned to the sea. Heat is generated in the process and can be cooled by air or water. In the case of water-cooling, seawater will be used. Cooling water that is heated in the process is normally returned to sea.

3.7.4 Localization

Hydrogen production can either take place at each individual wind turbine (decentralized production) or on dedicated floating or fixed platforms within or close to the wind farm (centralized production). The project currently encompasses both alternatives.

3.7.5 Export and Storage

After hydrogen and oxygen is separated, the hydrogen is transported to land via export pipelines and/or to one or more storage locations within the wind farm area. In general, the gas is directed straight to the internal and external pipeline networks, not storage is necessary. Some storage of hydrogen may be needed as part of a back-up system to generate electricity at times when no other electricity supply is available. The oxygen that is formed in the process is normally released into the atmosphere. Alternatively, the oxygen can be introduced near the seabed to give a positive contribution to its oxygenation. There is also some technological development towards storage and shipping via ship-like units as the sole or complementary way to ship out produced hydrogen.

3.8 Internal Cable Network and Pipelines

Inter-array cables, within the park area, interconnect the wind turbines with each other and with one or more substations, monitoring masts, and any platforms for production and/or storage of hydrogen. A schematic overview of what an internal cable network might look like is shown in Figure 9.

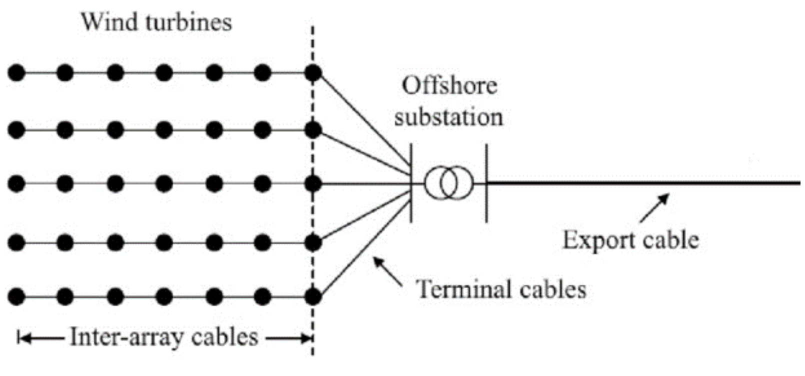

Figure 9. Schematic overview of the internal cable network, offshore substation, and the export cable. (Rentschler et al. 2020).

The internal cable network enables, not only the transmission of generated electricity, but also the power supply and control of the system's components. The cable network is primarily designed based on the number of wind turbines, their voltage level, and power. The voltage level in today's internal cable systems is usually 33 or 66 kV, but there is on-going development towards higher voltage levels such as 132 kV. Cables are normally partly placed on the seabed but can also be placed directly on the bottom.

In cases where hydrogen is produced and the production occurs at each individual wind turbine, pipelines must be placed on the seabed within the park area for the distribution of hydrogen to storage or to a connection point for a larger land-connected export pipeline. Pipelines are either placed in or directly on the seabed.

In addition to pipes, usually one or more manifolds are needed for the system to function. A manifold is a type of branch connection that receives and distributes/regulates the flow of gas on its way from the individual wind turbines to the platform for hydrogen production. A manifold with its associated equipment is normally installed on the seabed. An example of a manifold is seen in Figure 10.

Figure 10. An example of a manifold (Fishsafe).

Since there is usually a lot of internal cables and pipes within a wind farm area, there may be crossings where cables and pipes need to be arranged to minimize the risk of damage to the intersecting parts. Secure crossings are normally achieved by burying the parts on different depths or by placing some kind of support on both sides of a crossing. It is also common for cables and pipes to be insulated and reinforced, or covered with stone or concrete mattresses, at crossings to avoid interference and potential wear. An example of how a secure crossing between a cable and a pipe can be designed is shown in Figure 11.

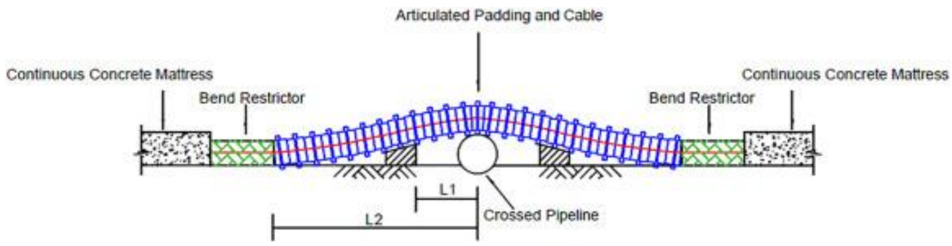

Figure 11. An example of the design of a secure crossing between pipes and cables (Reda et al. 2017).

3.9 Export-cables and Export-pipelines

Electricity that has been generated and transformed is transmitted to a connection point on or near land via one or more export cables that are adapted for the correct voltage level and technology.

In cases where hydrogen has been produced, it is transported to a land connection via export pipelines that have been adapted to the conditions of the route and dimensioned according to expected production parameters, such as expected flow volume and pressure.

Connection points for export cables are usually designated by the grid owner.

As previously mentioned, export cables and possible pipelines are not part of this consultation as the permitting process for these occur separately. A separate consultation will therefore take place regarding export cables and/or export pipelines.

3.10 Obstruction Lighting

According to *the Swedish Transport Agency's regulations and general advice (TSFS 2020:88) on marking objects that may pose a danger to aviation and on aviation obstruction notification*, wind turbines taller than 150 meters must be marked with white colour and with high-intensity white flashing obstruction lights on the nacelle (the machine house at the top of the tower on the wind turbine). The obstruction light must be placed in such a way that it is visible in all directions in case of an approaching aircraft. This applies to at least all turbines at the outer edge of the park. Annex 5 of the regulation describes a special method for marking the remaining turbines, see Figure 12.

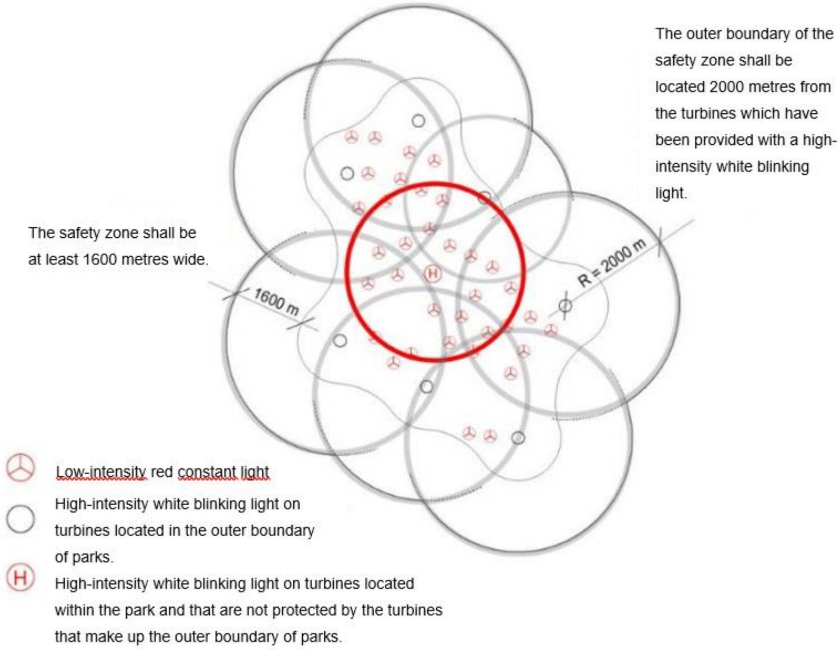

Figure 12. Method for marking wind turbines that, including the rotor in its highest position, have a height of over 150 meters above ground or the water surface (Swedish Transport Agency).

For the Kapheira wind farm, this regulation implies that most turbines will need white flashing obstruction lights. Due to the nacelle being more than 150 meters above the water surface, it must also be marked with at least three low-intensity lights halfway the height up to the nacelle, according to the same regulation. Additional marking requirements may be added since the total height that has been applied for is over 315 meters.

The possibility that exists in today's regulations to reduce potential impact on the landscape is to adjust the light intensity based on the ambient light. A future possibility is for example to control the obstruction lights based on transponder signals, meaning that they are lit when an aircraft is nearby. This is already technically feasible, but it is not permitted under current legislation. The final design of the obstruction lighting will be determined at a later stage and in accordance with the regulations and general advice of the Swedish Transport Agency.

4 The Wind Farm Stages

4.1 Introduction

After obtaining the permit for the facility, the company intends to carry out the following work in the comprehensive steps described below.

4.2 Investigations

To clarify and understand the conditions of the area, geophysical and geotechnical investigations as well as natural value assessments are intended to be conducted. The results of the investigations will, among other things, contribute to the selection of the most appropriate methods for construction and to ensure proper sizing, as well as to identify and manage any potential hazards and/or objects of conservation value within the area.

In accordance with the Swedish Continental Shelf Act, an application for a permit to carry out the above investigations was submitted to the Geological Survey of Sweden (SGU) in November 2023.

4.3 Site

4.3.1 In general

The wind farm will be constructed in a safe and environmentally correct manner by using the best available technology and equipment based on the work to be performed and the permit obtained. The construction phase includes both preparatory work on the seabed and the installation of the different parts of the wind farm.

4.3.2 Seabed Preparation

Depending on the characteristics and shape of the seabed as well as the choice of foundation and anchoring types, some levelling off the seabed may be required to create the correct conditions for a safe installation of the foundation or anchorage. In cases where fixed monopile foundations are to be installed, pre-drilling of installation holes may be necessary. Preparatory work on the seabed may also be needed to facilitate the placing of cables or pipelines.

4.3.3 Anchoring

For floating foundations, anchors, and other mooring equipment, such as lines/chains for anchoring points, will likely be installed before other site components are installed.

4.3.4 Production, Transport, and Installation

The different parts of the site, such as foundations, wind turbines, substations, monitoring masts, and any potential production and storage facilities for hydrogen, are normally manufactured and assembled on land, in proximity to the harbour. Construction parts for fixed foundations are transported to the wind farm area in parts, via ship or barge, to be assembled and installed at the site. Firstly, the foundation is put in place and secured, after which the respective construction part is assembled with its intended foundation.

The construction parts for the floating foundations are usually assembled into one unit in the harbour. Thereafter they are towed out to the wind farm area where they are connected to the pre-installed anchors. Figure 13 shows an example of a towing of wind turbines with floating foundations.

The transport and installation are normally carried out from tugboats, barges, and larger custom-designed vessels with equipment adapted for the purpose, such as cranes and lifting devices. Helicopters can also be used in certain stages.

Figure 13. Towing of a wind turbine with a floating foundation (Tomic, Bartolomej 2020).

4.3.5 Laying of Cables and Pipelines

The laying of cables and pipes is carried out from appropriate vessels, see example in Figure 14. The laying can be done directly on the seabed surface, or somewhat into the bottom by plowing, jetting, or burying the cable/pipe. The selection of method and approach depends on factors such as the extent to which the cable or pipe needs to be protected from, for example, anchoring and bottom trawling, as well as the geological characteristics of the seabed. Larger variations in seabed elevation are usually levelled out, mainly before the laying of pipelines. Cables and pipes are often protected by covering with materials such as stone or concrete mats. Pipeline installations are typically anchored to the seabed through anchoring lines and/or by covering with sandbags, gravel, or similar materials.

Figure 14. Laying of pipelines from a specially equipped vessel (Allseas).

4.4 Operation

Once the wind farm is in operation, electricity is generated continuously (except at low wind speeds) and is transformed and transmitted to the mainland connection via the export cable.

The site is managed and monitored from a land-based control centre. A service facility is planned along the coastal stretch, in proximity to the wind farm.

Inspection, service, and maintenance of the different parts of the site will occur continuously during the operation of the farm. The work is performed according to established programs and normally includes both visual inspection and inspections carried out via remote underwater systems for video and hydroacoustic surveys of, for example, pipelines and erosion protection.

Service, maintenance, and inspections are normally performed from smaller boats and vessels or alternatively by helicopter. When necessary, larger cranes and vessels may be required to perform heavier and more complex operations.

4.5 Decommissioning

The current estimated lifespan of the wind farm is approximately 45 years. During decommissioning, the parts of the site will be dismantled and removed for recycling. Installations on the seabed will be removed if it is deemed to be the most appropriate action at the time of decommissioning. It is possible that some parts of the facility may be left behind after decommissioning, such as cables, pipes, foundations, anchors, and covers on the seabed. Restoration and potential leaving of parts will be carried out in consultation with the responsible authorities.

5 Area Description

5.1 Marine Planning

5.1.1 Marine Spatial Plans

Marine spatial plans are decided on and adopted by the Swedish government and aim to provide guidance on the most appropriate use of the sea. The use or uses specified in the plans should take precedence over other uses in the relevant area. The marine plans also provide guidance on possible needed adjustments where different uses can coexist with each other (Swedish Agency for Marine and Water Management 2022). In 2023, consultations concerning proposals for amended marine spatial plans were held, thus changes to current plans may be relevant further on.

Regarding the current marine spatial plan, the project area of Kapheira is located within the marine planning area of the Baltic Sea and the Central Baltic Sea area. The project area is located within the so called Ö226 area where the marine plan indicates general use, i.e., an area where no specific use has precedence. However, uses delimited by their own geographical markings have precedence where they are indicated (Figure 15). Within the marine spatial planning area, possible uses include recreation, shipping, investigation area for shipping, and commercial fishing. The current marine plan does not indicate any specifically designated areas of use within the corresponding location for the Kapheira project area.

In the Central Baltic Sea area, defence matters are given precedence over energy extraction according to Chapter 3, Section 10 of the Environmental Code, as they are not considered to be able to coexist (Swedish Agency for Marine and Water Management 2022).

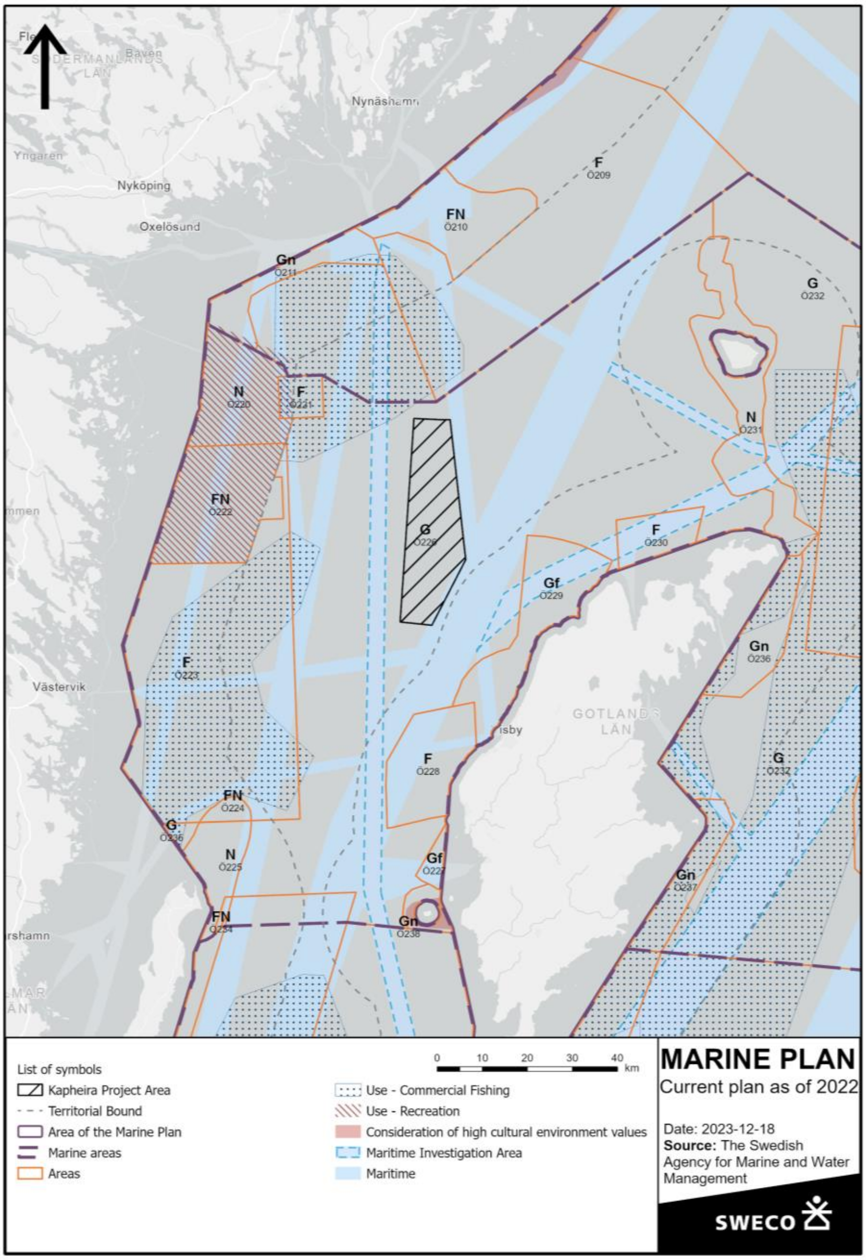

Figure 15. Current marine plans within and around the planned project area for Kapheira. (Swedish Agency for Marine and Water Management 2022).

During the coming revision of the marine plans, conditions for offshore wind power are to be examined and updated. In proposals from the Swedish Energy Agency (2023) regarding areas suitable for energy extraction, the area where Kapheira is planned (EÖ16) is mentioned as having "good conditions for the establishment of offshore wind power in regard to wind conditions, distance to land, electricity demand, and conditions for grid connection." Coexistence with defence matters has not been examined for this consultation.

In the marine spatial plans, that have been part of the consultation conducted by the Swedish Agency for Marine and Water Management during 2023, the area EÖ16 is incorporated as an investigation area for energy extraction with special consideration for defence interests, E(utr)f Ö276, see Figure 16. The area overlaps entirely with the project area for Kapheira.

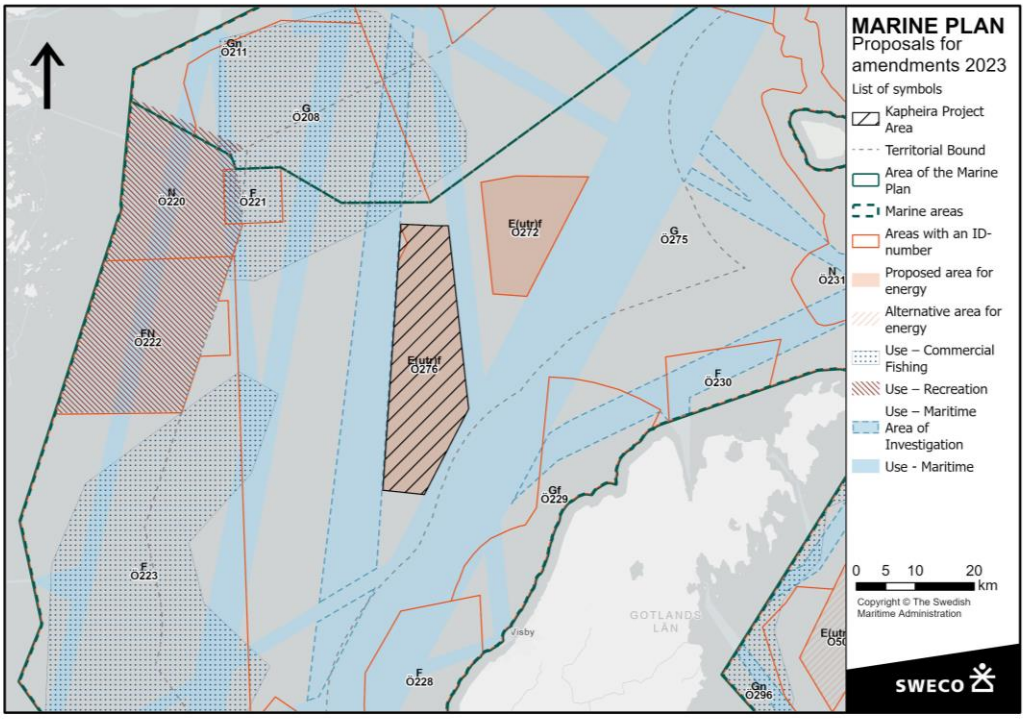

Figure 16. Suggestions for new areas of energy extraction, from the consultation version for proposals of new marine spatial plans (the Swedish Agency for Marine and Water Management).

5.1.2 Existing and Planned Wind Power Projects in the Surrounding Area

There are several planned wind farms in the vicinity, but none of these have yet been granted permits, see Figure 17.

The nearest planned wind farm, Dyning, is located west of Kapheira and overlaps with the north-western corner of the project area. The permit application for the Dyning wind farm was submitted in October 2023.

Approximately 6 kilometers east of Kapheira's project area is the Baltic Offshore Alpha, for which a consultation process has been carried out.

Additional planned wind farms are located northwest of the project area within Swedish territorial waters, Långgrund 1 and 2.

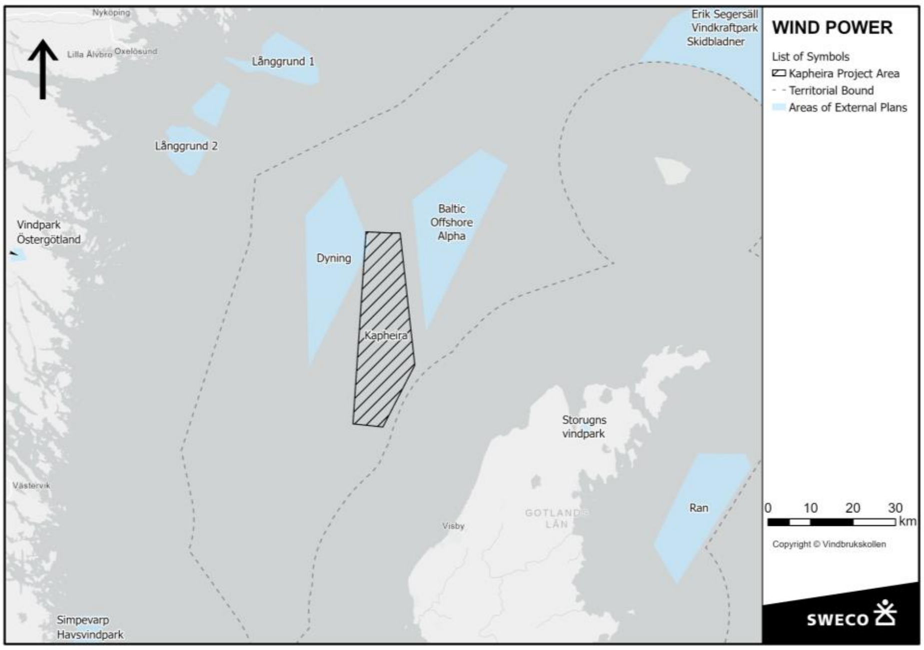

Figure 17. Known planned wind farms in the vicinity. Dyning and Kapheira overlap in the north-western corner of Kapheira. (Vindbrukskollen, the Swedish Energy Agency)

5.2 National Interests and Protected Areas

5.2.1 In general

National interest areas have been identified to have values of national significance. There are two types of national interests. Areas decided on by the government according to Chapter 4 of the Environmental Code, are large areas with significant values for nature, culture, or outdoor life. Other areas according to Chapter 3 of the Environmental Code are decided on by national authorities such as the Swedish Environmental Protection Agency, the Swedish Agency for Marine and Water Management, the Swedish Transport Administration, and the Swedish Armed Forces. These are areas of national interest for different sectors, for example nature conservation, shipping, or commercial fishing.

5.2.2 National Interest for the Swedish Defence

The southern part of the project area overlaps with an MSA area (Minimum Sector Altitude) designated to the Swedish Armed Forces. The purpose of the area is to ensure aircraft have sufficient obstacle clearance to fly at the lowest specified altitude for the sector. This MSA area is connected to Visby Airport with a radius of 46 km, which applies to military procedures (Swedish Armed Forces 2023, Swedish Transport Administration 2014).

An area indicated as a national interest area for naval exercises is located about 4 km north of the project area, see Figure 18.

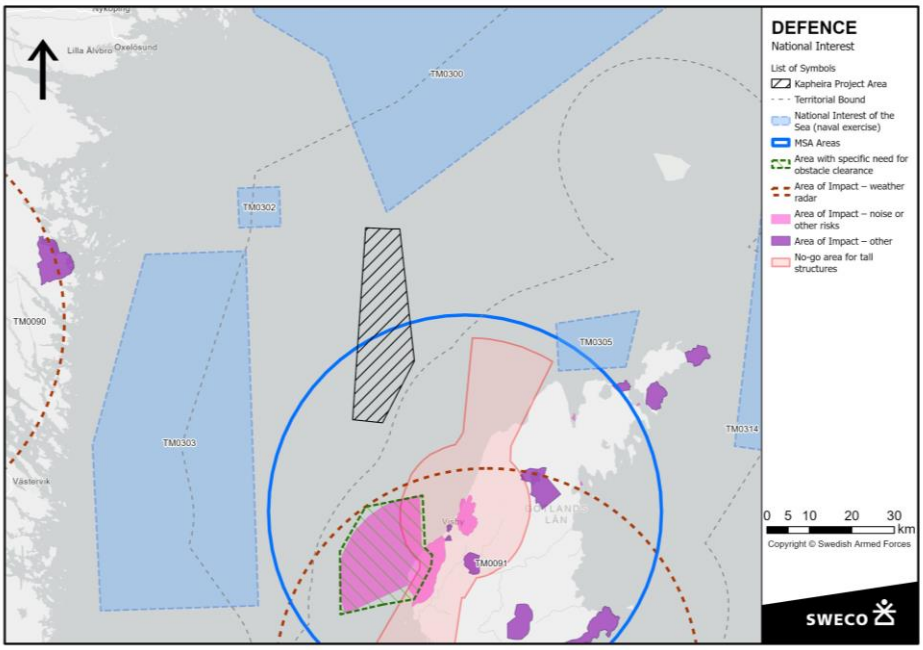

Figure 18. The national interests of the Swedish Armed Forces, thereof an MSA area which overlaps about half of the project area (the Swedish Armed Forces, 2023a).

5.2.3 National Interests for Shipping and Aviation

Approximately half of the project area is encompassed by the MSA area for Visby Airport, a national interest for aviation designated by the Swedish Transport Administration, see Figure 19. The MSA area has a radius of 55 km from the airport and is a requirement for civil operations.

The project area does not overlap with any area indicated as a national interest for shipping. However, the western, eastern, and south-eastern parts of the area are adjacent to such national interests. The western fairway of national interest runs between Nynäshamn and Gdansk, the eastern runs between Visby and Nynäshamn, and the south-eastern between the southern shoal of Öland and the lighthouse Svenska Björn.

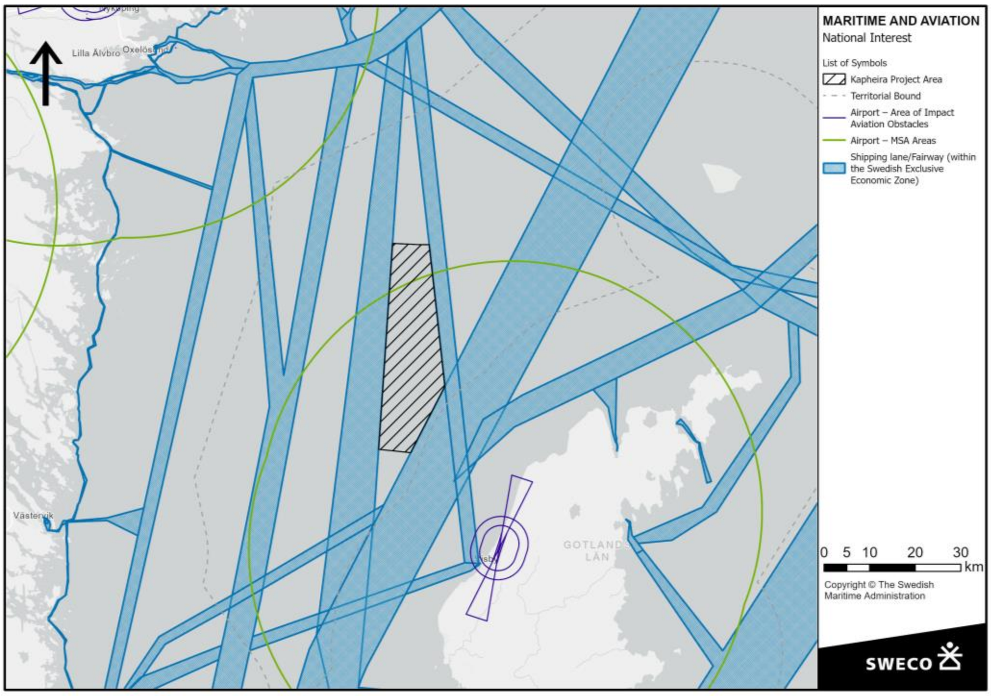

Figure 19. National interest for shipping and aviation designated by the Swedish Transport Administration. MSA area for civil activities for Visby Airport overlaps with a larger part of the project area. (Swedish Transport Administration 2023)

5.2.4 National Interest for Commercial Fishing

A national interest area for commercial sea fishing is located approximately 2.5 km northwest and about 20 km southwest of the project area. (Figure 20).

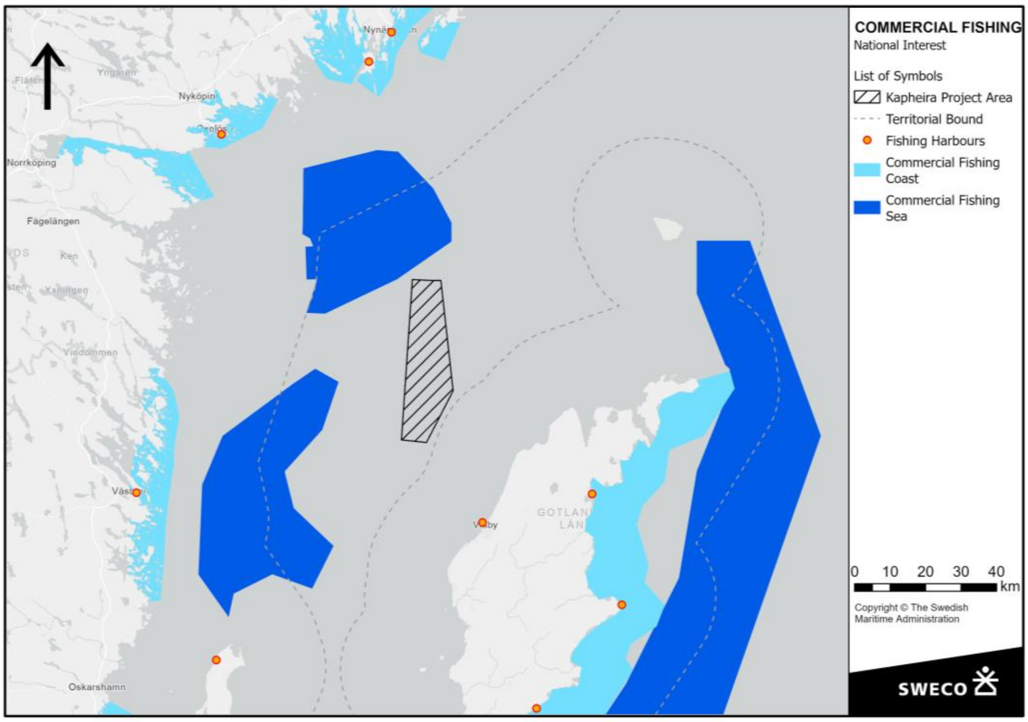

Figure 20. Areas of national interest for commercial fishing.

5.2.5 National Interest for Outdoor Recreation and Nature Conservation

The national interest area for outdoor recreation, which encompasses the entire island of Gotland including the territorial waters around Gotland, is located approximately 2 km from the project area. Along the coastline, the closest being about 25 km from the project area, there is a national interest area for nature conservation, outdoor recreation, and highly exploited coast (Figure 21).

On the mainland, there is a national interest area for undisturbed coast, the nearest point being approximately 30 km west of the project area.

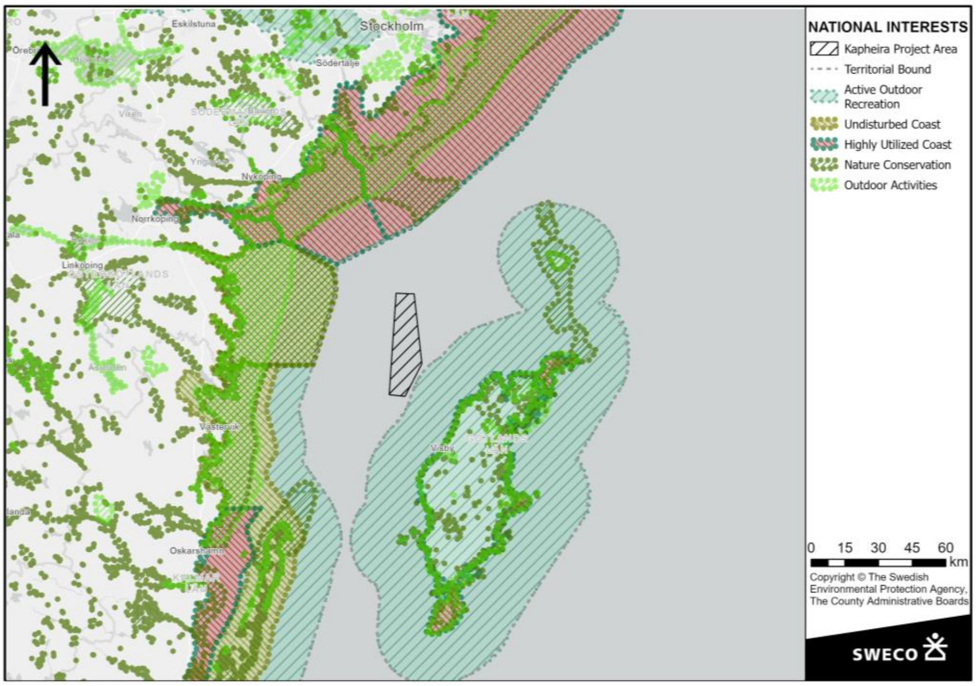

Figure 21. The project area and nearby national interests for active outdoor recreation, nature conservation, highly utilized coast, undisturbed coast, and outdoor activities. Data from the County Administrative Boards' Geodata Catalogue (2023).

5.2.6 National Interest for Conservation of Cultural Environment

Gotland has several areas that are indicated as national interests for conservation of cultural environment. All are located on land, at least thirty kilometres from the planned wind farm, see Figure 22.

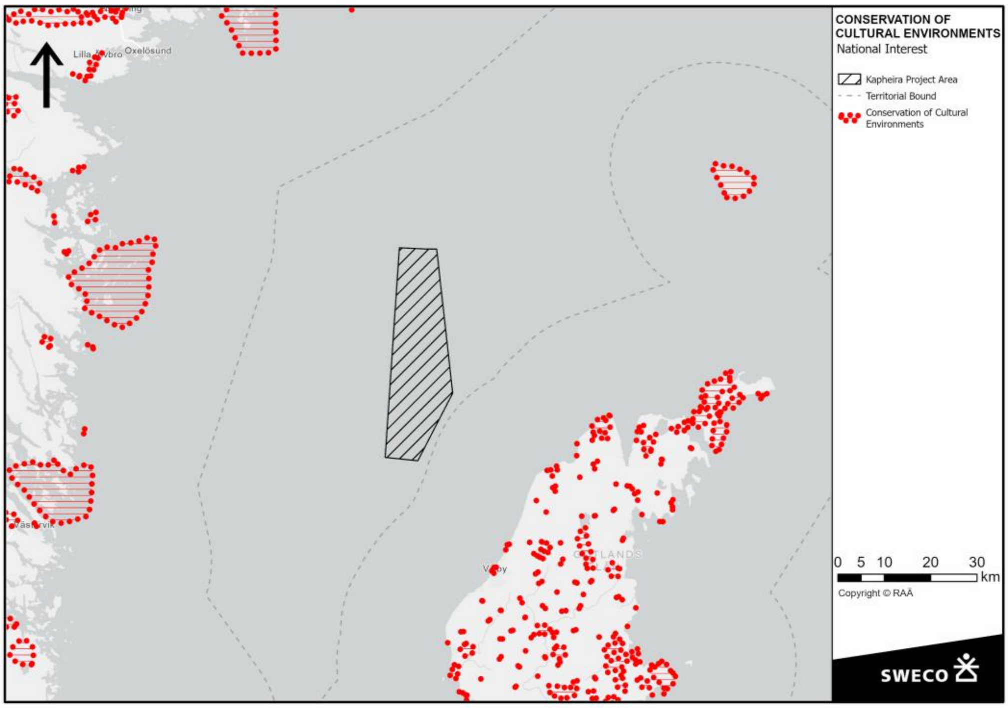

Figure 22. Areas with national interests for conservation of cultural environments.

5.2.7 Protected Areas and Natura 2000

5.2.7.1 Terrestrial Natural Habitats

There are no protected areas within or adjacent to the project area. The nearest protected area, *Björkume (SE0340076/2000135)*, is located on the coast of Gotland approximately 24 km from the project area (Figure 23) and is designated as a Natura 2000 site as well as a nature reserve. The area aims to preserve natural habitats such as stone and gravel ridges, alvars (limestone plains), and wet meadows, along with the area's hydrology, which is an important condition for the conservation of other values. Several Natura 2000 sites and nature reserves can be found along the north-western coast of Gotland at similar distances, for example, *Hall-Hangvar (SE0340090/2000452)* and *Klinthagen (SE0340107).* These are also primarily protected with respect to terrestrial values.

5.2.7.2 Marine Natural Habitats

The nearest Natura 2000 areas that include marine natural habitats are *Gotska Sandön-Salvorev*, *Sankt Anna* and *the Archipelagos of Gryt (SE0230055)*, *Hävringe Källskären (SE0220028)*, and *Skärgårdsreservaten (SE0220129)*, all at distances of about 50 km or more from the project area to the east, west, and northwest (Figure 23).

Sankt Anna and the Archipelagos of Gryt

The EU Habitats Directive and the Birds Directive both apply to the area. Among the natural habitats that must be conserved, according to the conservation plan for the area, are lagoons, large bays and straits, reefs, as well as sea cliffs and islands in the Baltic Sea. Species mentioned in the conservation plan include the grey seal, osprey, three species of terns, black woodpecker, and red-backed shrike.

Skärgårdsreservaten

The area consists of an archipelago and the Habitats Directive and the Birds Directive both apply to the area. The conservation plan mentions natural habitats such as sandbanks, lagoons, large bays, and straits. Noted species include the bluethroat, common tern, grey seal, barred warbler, nightjar, smew, arctic tern, red-throated diver, black woodpecker, black-throated diver, wood lark, red-backed shrike, and barnacle goose.

Hävringe Källskären

The Habitats Directive and the Birds Directive both apply to the area. Indicated natural habitats include sandbanks, reefs, skerries, and small islands in the Baltic Sea. Species in the conservation plan include the common tern, grey seal, bar-tailed godwit, arctic tern, caspian tern, and barnacle goose.

Gotska Sandön-Salvorev

The Habitats Directive apply to the area. Among the indicated natural habitats are sandbanks, reefs, and sandy beaches of the Baltic Sea. The grey seal is among the noted species. The entire island of Gotska Sandön is also a national park.

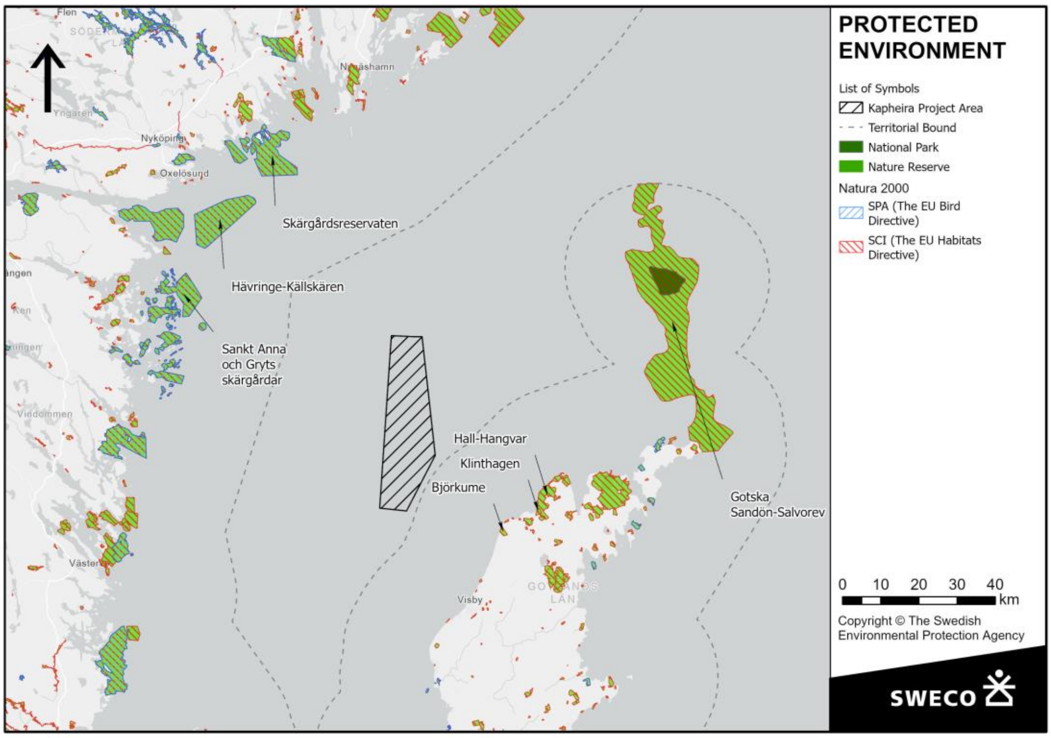

Figure 23. Natura 2000 sites, national parks, and nature reserves near the project area. Data from the County Administrative Boards' Geodata Catalogue (2023).

5.2.8 UNESCO World Heritage

The Hanseatic town of Visby (Figure 24) is listed among UNESCO's World Heritage Sites due to its universally recognized historical value. The town has preserved old buildings and is a typical example of a walled Hanseatic town.

The UNESCO World Heritage status implies protection through cultural heritage and planning legislation.

Figure 24. The Hanseatic town of Visby. Photo: Sara Appelgren 2015 © Region Gotland/Gotlands Museum.

5.3 Water Depth and Seabed Conditions

5.3.1 Bathymetry

Bathymetric surveys indicate depths ranging from approximately 65 to 205 meters within the project area, where the deeper parts are mainly located in the western and northern sections, while the water becomes somewhat shallower in the southeast (Figure 25).

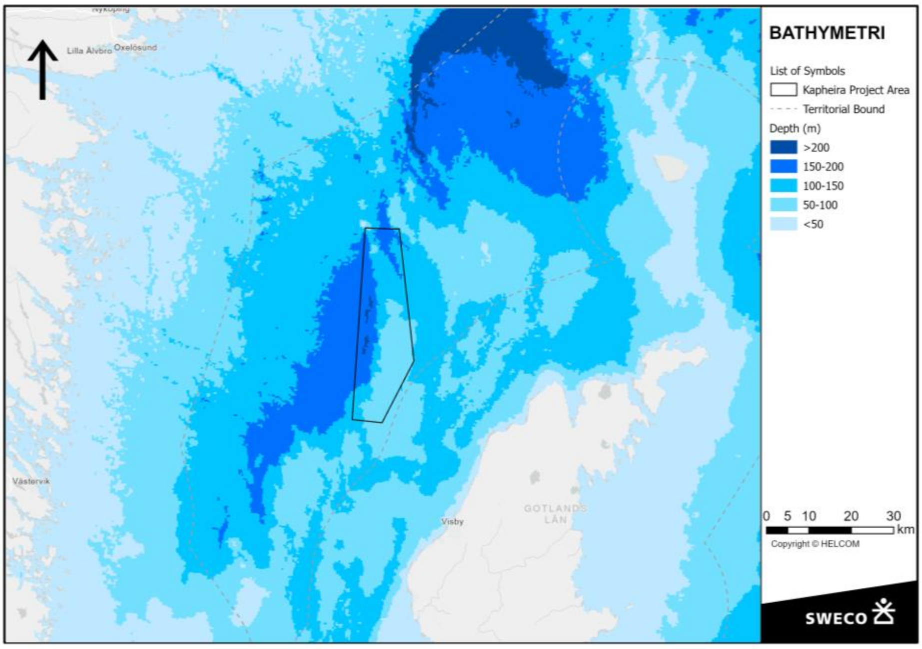

Figure 25. Bathymetry over the area surrounding Kapheira.

5.3.2 Geology and Seabed Conditions

According to data from the Geological Survey of Sweden (SGU), the dominant bedrock in the area is sedimentary rock, and the seabed mainly consists of substrates such as sand, coarse sand, gravel, and stone. There are also larger areas of clay and smaller areas with harder substrates of stone and boulders (Figure 26). The seabed slopes to the west and mainly consists of a mixed soft bottom with coarser material, indicating erosion bottoms. In the deeper parts to the west, the bottom consists of clay and is likely of accumulation type.

Accumulation bottoms are surfaces where material continuously settles and accumulates. In such areas, environmental toxins and pollutants can also accumulate over time. The SGU performs regular sampling of metals and organic environmental toxins in sediment as part of national and regional environmental monitoring. Samples are taken from accumulation bottoms throughout Sweden. One of the included stations is called Norrköpingsdjupet and is located near the western boundary of the project area. Another station where the SGU conducts sampling, most recently in 2005, is in the north-eastern part of the project area (Figure 26).

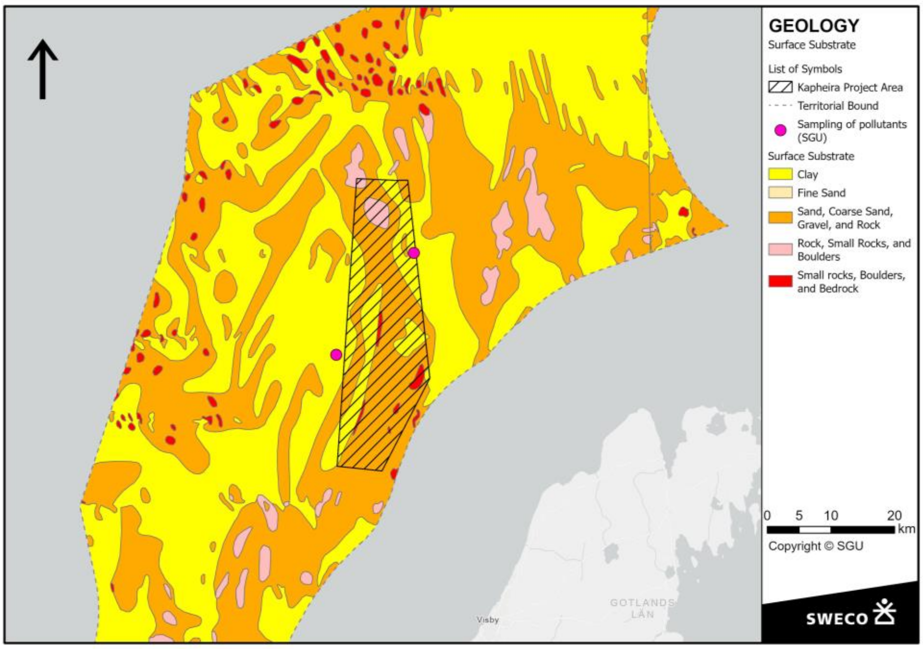

Figure 26. The map shows the project area of Kapheira with expected bottom substrate classified by SGU. It also marks two of SGU's sampling stations for metals and organic pollutants. Data has been collected from Hallberg et al. (2010) and Swedish Environmental Monitoring, data host SGU (2023a and 2023b)

The Baltic Proper is strained with both metals and organic pollutants. With respect to metals, especially cadmium, copper, and zinc occur in high concentrations. Several organic pollutants such as PAH, PCB, and DDT are also present in elevated levels (Josefsson 2022). The area where the park is planned is part of a larger area which status is classified as poor with respect to the presence of metals and pollutants (HELCOM 2023a). During the sampling of metals in the north-eastern subarea of the park in 2005, copper was measured at very high levels and cadmium at high levels. The sampling of environmental pollutants showed very high levels of HCH and high levels of DDT, HCB, chlordanes, and PCB (Swedish Environmental Monitoring, data host SGU 2023a). During a sampling of Norrköpingsdjupet in 2020 and 2021, very high levels of cadmium, copper, and zinc were found. High levels of HCH, chlordanes, and PAH were found (Swedish Environmental Monitoring, data host SGU 2023b). The classification, that is the categorization of levels into classes 1 to 5 corresponding to very low up to very high levels, however, does not indicate ecotoxicological effects and only describes how the levels relate to other areas or benchmark values (Josefsson 2017; Swedish Environmental Protection Agency 1999).

In summary, it can be concluded that the deep seabeds of clay within the project area likely are of the accumulation type, where. elevated levels of cadmium, copper, and zinc can be expected, as well as some organic pollutants. However, this does not apply to the larger part of the project area, which is assessed to be of erosion type.

5.3.3 Seismic Activity

The area has a very low seismic activity. There have been no registered earthquakes within the project area. According to the Swedish National Seismic Network, there has been very little activity in the area over more than the last 100 years, see Figure 27 which shows the occurrence of quakes with a magnitude over 1.

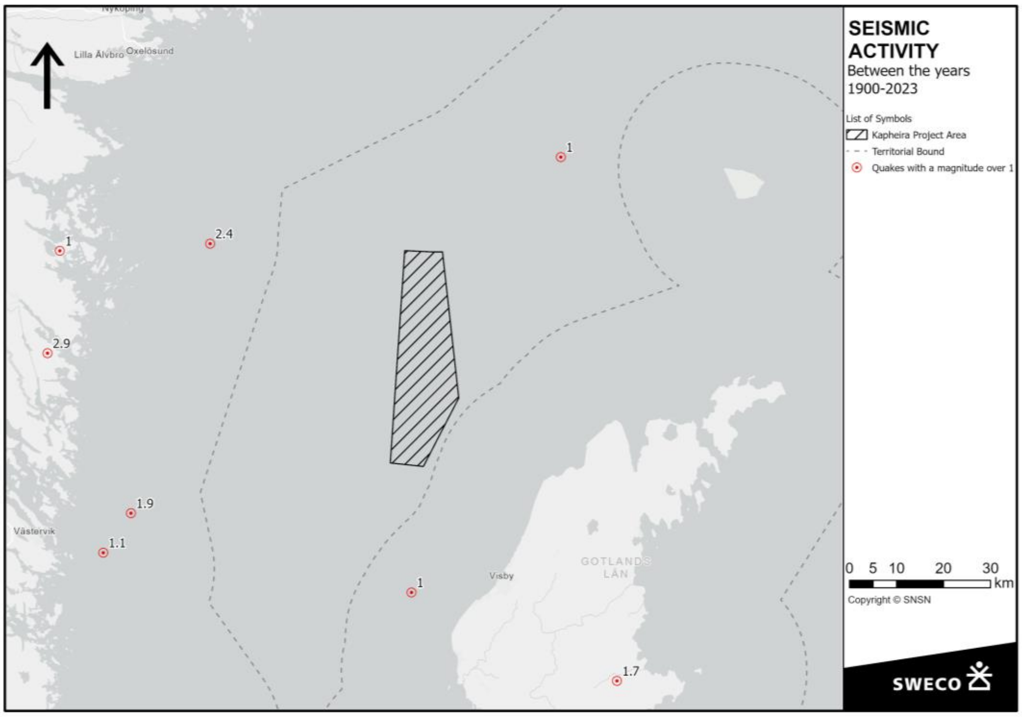

Figure 27. All earthquakes with a magnitude of at least 1, in and around the project area, which have been recorded from year 1900 until today (SNSN).

5.4 Hydrography and Oxygen Conditions

The currents in the Baltic Sea are weak and not permanent in comparison to the currents in Skagerrak and Kattegat. Generally, the surface currents weakly move counterclockwise due to the Coriolis force and freshwater runoff from land. The surface water layer thus forms a current heading out of the Baltic Sea along the coast (SMHI 2011). In the open sea, the currents depend on wind and water levels, making the currents irregular (SMHI 2023a).

In the Baltic Sea, the water level primarily depends on winds and air pressure, but long- term, climate changes may cause higher water levels. The water level adjusted for land elevation is shown in Figure 28. Over the past 40 years, there has been a rise of the sea level of 10 cm outside of Visby. The tidal range in the Baltic Sea is a few centimetres with no practical significance (SMHI, 2023b).

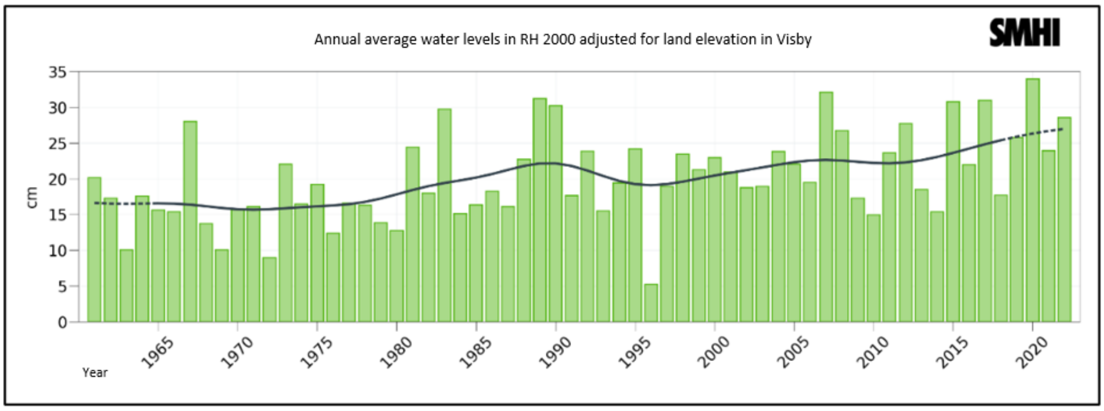

Figure 28. Water levels in Visby, SMHI (2023c). The bars show the annual average values of water levels in RH 2000 adjusted for land elevation in Visby. The grey line represents a moving average calculated over approximately ten years. The dashed section of the line indicates that the average is calculated over fewer years.

The Baltic Sea is a brackish sea, with a large freshwater inflow from rivers and saline water inflow from the North Sea. Since freshwater is less dense than saltwater, it floats on top of the denser, deeper saline water, and the salinity can thus vary greatly with depth. Within the project area, the salinity in the surface water is about 6–8 ‰, while the bottom water has a salinity of about 11–14 ‰. This difference creates a halocline, which means that the different layers of water do not mix easily. This halocline is found at about 80 meters depth in the Baltic Proper.

The lack of mixing means that the water below the halocline is rarely replaced. In addition, the Baltic Proper has several deep basins with shallower sills in between. In the Danish straits in the Belt Sea, there are also shallow thresholds. Due to the large freshwater outflow, the currents in the Baltic Sea are generally directed out of these thresholds. It is only under certain specific conditions of weather, wind, and sea level that the currents reverse, and salt and oxygen-rich water can flow into the Baltic Sea. How the inflow of water would occur is illustrated in Figure 29. However, these inflows must be large or frequent for the new water to be able to cross the thresholds into all the deep basins in the Baltic Sea. Therefore, this happens very rarely; the last time a major inflow occurred was in 2014 – 2016 (Hansson and Viktorsson 2023).

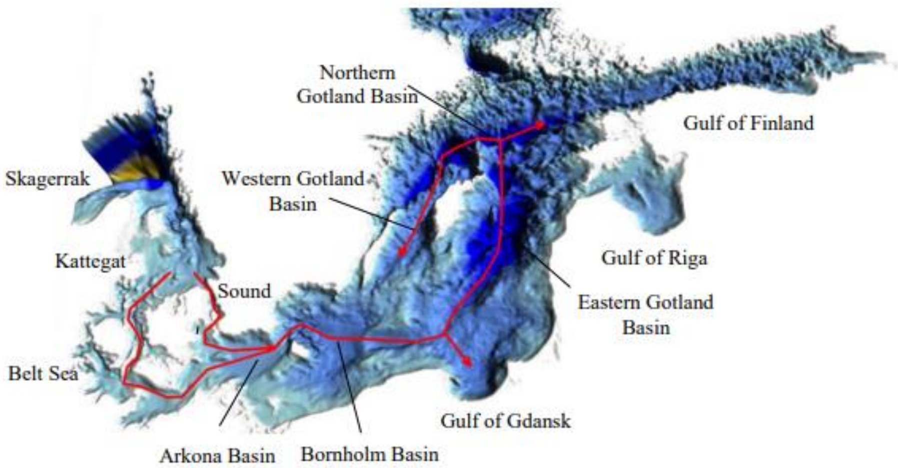

Figure 29. Bathymetric map of the southern Baltic Sea and the path of water flow during inflows from Öresund and the Belt Sea through the Baltic Sea (red arrows). The figure is sourced from Hansson and Viktorsson 2023.

The lack of mixing of the water layers and the limited inflow of new, oxygen-rich saltwater may cause oxygen deficiency in the bottom water as the decomposition of organic material on the seabed consumes oxygen. The increased nutrient input and eutrophication that has occurred since the 1950s also result in an increased amount of organic material on the seabeds, which exacerbates the problem. Large areas of the Baltic Sea's deep seabeds are therefore affected by oxygen depletion or are completely anoxic. The extent of oxygen depletion from the monitoring in 2022, shown in Figure 30, indicates anoxic seabeds throughout the project area during autumn and has been the case ever since 2003 (Hansson and Viktorsson 2023).

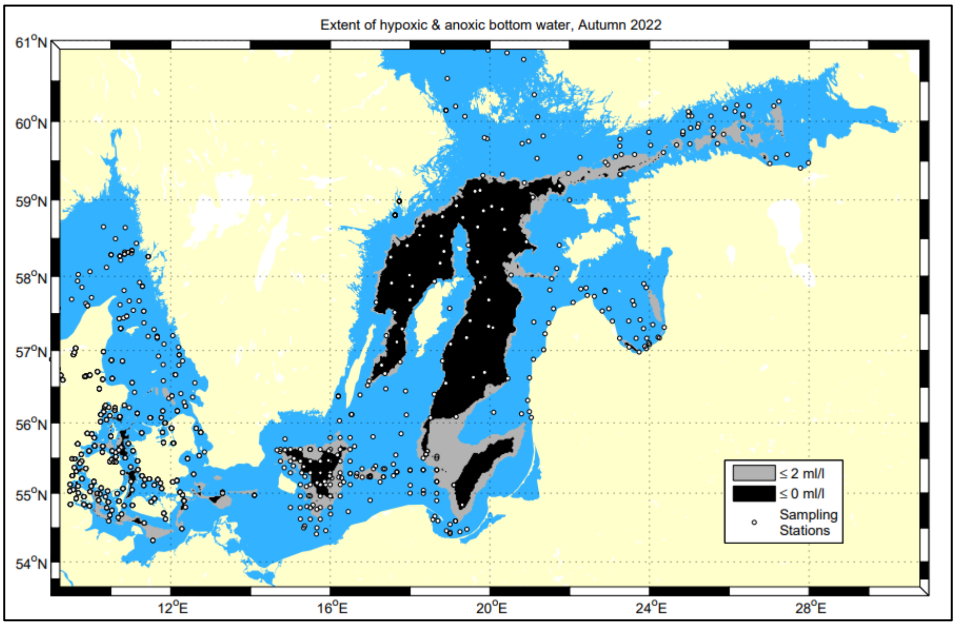

Figure 30. Oxygen deficiency in the bottom waters layers of the Baltic Sea during the autumn of 2022 (Hansson and Viktorsson 2023)

Around the project area, there is also a permanent oxygen deficiency over large areas, hence formation of hydrogen sulphide occurs, making areas near the bottom permanently inaccessible for organisms that depend on oxygen. It is mainly the northern and western parts of the project area where permanent oxygen deficiency is expected. In the south-eastern parts, the oxygen levels are somewhat better, which also correlates with a shallower depth.

5.5 Natural Environment

5.5.1 Birds

The groups of birds that live at sea and which could mainly be affected by offshore wind farms are the common scoter and velvet scoter, long-tailed duck and common eider, as well as gulls and terns. Additional species that exist in the sea or along the coasts within a few miles of the planned park, are mainly geese, swans, cranes, and birds of prey. Small birds can also be found across the Baltic Sea.

Many ornithological observing stations and ornithological societies have long-term experience in studying bird migration and nesting of species around the Baltic Sea. However, as these observations have primarily been made from land, there are knowledge gaps regarding how birds behave at sea. Migration routes and behaviours have been extrapolated from land observations and, to a lesser extent, followed with the help of satellite transmitters or light loggers mounted on individual birds.

Mortality and avoidance have been studied to a greater extent around individual wind turbines on or near land. It has been observed that flocks of geese, swans, and cranes avoid the turbines, as well as wading birds. Small birds and birds of prey are at a greater risk of being killed. At sea, it has been noted that loons, common scoters, long-tailed ducks, and auks largely avoid wind turbines when foraging in such an area. (Dierschke et al. 2016).

Birds that tend to be attracted to marine wind farms are gulls and cormorants, which may benefit from reduced fishing in the area and more scouting spots in the form of the turbine foundations. When it comes to foraging, terns do not seem to be affected by the presence of turbines, which is also the case for eiders. However, migratory routes of eiders may cross the open sea through the planned area for the wind park. (Gotland Ornithological Society)

Most bird species migrating over the Baltic Sea stick to coastlines and take the shortest route across the open sea. This means that relatively few species migrate directly over the project area. However, species that do so to a greater extent include the brant goose and the greater white-fronted goose, and to some extent the greater tundra bean goose and whooper swan. Birds of prey may also cross the open sea during their migration, including the osprey, hen harrier, rough-legged hawk, and honey buzzard. (Bird Migration Atlas)

5.5.2 Bats

Bats typically do not move further than 8 kilometers from land to forage. However, several migrating species can fly longer distances to reach hibernation sites on the continent or other parts of Sweden. Species that migrate regionally include the common and soprano pipistrelle. The group of long-distance migratory species includes the Nathusius' pipistrelle, parti-colored bat, and the greater and lesser noctule. The latter can migrate up to 4,000 kilometers (Ahlén 2011).

Knowledge about bats in the area is relatively small, but the presence of migrating bats cannot be ruled out. In Sweden, autumn migration occurs during August and early October, with the highest activity at the end of August. During migration, bats are weather-dependent, and 90 % of the observations made were as the wind speed was less than 5.8 meters per second and the temperature was above 14.6 °C (Rydell et al. 2017). Research conducted in Germany shows that bats do not migrate in clear paths but rather broadly across the front (Seebens-Hoyer et al. 2021).

5.5.3 Fish

Within the Baltic Sea, which is a brackish sea, both marine and freshwater fish species are found. The distribution of the different species typically depends on the salinity of the water, with marine species dominating further south and freshwater species further north. In the current area, the salinity level means that both freshwater and marine species can be found. Since the water is neither fully salt nor fully fresh, an environment many species cannot tolerate, there are relatively few fish species in the Baltic Sea, in total about 80 species.

From the BITS (Baltic International Trawl Survey), the species sprat, herring, three-spined stickleback, European flounder, shorthorn sculpin, cod, European plaice, eelpout, lumpsucker, ten-spined stickleback, four-bearded rockling, fourhorn sculpin, and one species of goby have been caught in trawling in the open sea south of the project area (DATRAS 2023). Among these, cod and four-bearded rockling are red-listed as vulnerable (VU) and near threatened (NT), respectively.

These species are thus present in the offshore area around Kapheira, but the permanent oxygen deficiency on the bottom and in the deep water means that bottom-dwelling species such as European flounder, shorthorn sculpin, European plaice, eelpout, lumpsucker, four-bearded rockling, fourhorn sculpin, and goby are unlikely to reside within these areas. Possibly, the south-eastern parts of the project area are accessible to these species during certain parts of the year. The species that are likely to occur within the entire project area throughout the year are probably only sprat, herring, stickleback, and cod based on the trawl study and the oxygen availability in the bottom waters.

However, the area's suitability as a spawning ground for the above fish species is considered low. The occurrence of oxygen deficiency in the bottom water limits the possibility of spawning for species that spawn and lay their eggs on the bottom. Moreover, several of the occurring species prefer to spawn in significantly shallower waters.

Salmon and trout are expected to be able to migrate through the area on their way to their spawning grounds in rivers. Likewise, eels can migrate through the area.

5.5.4 Sea Bed Ecosystems

The seabed within the project area is dominated by soft substrates such as sand, gravel, or clay. Therefore, the dominant type of animals found on these bottoms are expected to be species associated with softer substrates, either living on top of or buried in the sediment. The depth of the area precludes the presence of any bottom flora.

In the Baltic Proper near Gotland, there are a total of about 20 different species of benthic fauna (Cederwall et al. 2011). However, the current project area is clearly affected by oxygen deficiency, and the number of species in these types of environments averages between 4 and 7 species, with the scale worm *(Bylgides sarsi)*, the amphipod *(Pontoporeia femorata),* and species of polychaete worms within the genus *Marenzelleria* being common. In areas with a lack of oxygen, mats of the sulphur bacteria *Beggiatoa* also occur (Gogina et al. 2016). The benthic habitat within the area does not reach good status, with a Benthic Quality Ratio (BQR) of 0.2 – 0.4 (HELCOM 2023).

Some sampling has been conducted in the open sea relatively close to the project area, and the findings from these samples are summarized in Table 2. Station C10, located about 25 km north of the project area, has been found to have no benthic fauna during investigations. Station 4001, about 20 km east of the project area, had occurrences of the *Monoporeia affinis* in samplings conducted in 2005. Station 4006, about 43 km southwest of the project area, found a total of five species. These species are the Baltic tellin *(Macoma balthica)*, the scale worm, and the polychaete worms *Halicryptus spinulosus, Pygospio elegans*, and *Marenzelleria spp*. (SMHI SHARKweb, 2023). All these species, except for *Marenzelleria spp*., are typical in the deeper soft bottoms of the Baltic Proper (Nordic Council of Ministers 2001). Worms of the genus *Marenzelleria* are invasive in Swedish waters (Strand et al. 2018).

Table 2. Findings of benthic fauna in the open sea around the planned project area Kapheira. Data sourced from SMHI SHARKweb 2023.

Station	N Sweref TM	E Sweref TM	Year	Depth	Species
4001	6461922	702080	2005	77	Monoporeia affinis
4006	6383451	646261	2000, 2005, 2006	66	Halicryptus spinulosus Baltic tellin (Macoma balthica) Pygospio elegans Scale worm (Bylgides sarsi) Marenzelleria
C10	6487945	681667	2000, 2002, 2003, 2004, 2005, 2006	126	No bottom fauna

Within large parts of the project area, there is permanent oxygen deficiency with presence of hydrogen sulphide. Within these areas, no benthic fauna is expected to occur.

5.5.5 The Pelagic Zone

The pelagic habitat is the environment that accounts for the primary production in the Baltic Sea. Phytoplankton living here form the foundation of the food chain as they provide food for bottom-dwelling animals and zooplankton, which in turn become food for fish, among others.

In the pelagic zone of the Baltic Sea, aside from fish, larvae of various fish and benthic fauna species, there are mainly different types of plankton. The types of plankton that dominate are various species of diatoms, dinoflagellates, and cyanobacteria, as well as zooplankton.

However, a recent trend caused by eutrophication and increased temperatures is an increased proportion of cyanobacteria and a decrease in the number of diatoms (Hamrén 2022). A high level of eutrophication also leads to an increase in algal blooms, which in turn cause decreased water transparency (turbidity) and increased oxygen consumption in the bottom water. Even in the pelagic zone, the availability of oxygen plays a role; the open water below the halocline becomes inaccessible to species during oxygen-deficient or anoxic conditions. At a depth of about 200 meters and a halocline at about 80 meters, this means that 60 % of the water column becomes inaccessible during oxygen depletion.

In the project area, there are surfaces where there is almost permanent oxygen deficiency, which limits the use of the deeper parts of the water column. Especially the northern and western parts of the project area have low accessibility for biota in the deep water. However, in the south-eastern parts of the project area, there are accessible deep-water habitats (Figure 31). The part of the Baltic Sea where Kapheira is located is situated within an area classified as unsatisfactory regarding pelagic habitats (HELCOM 2023a).

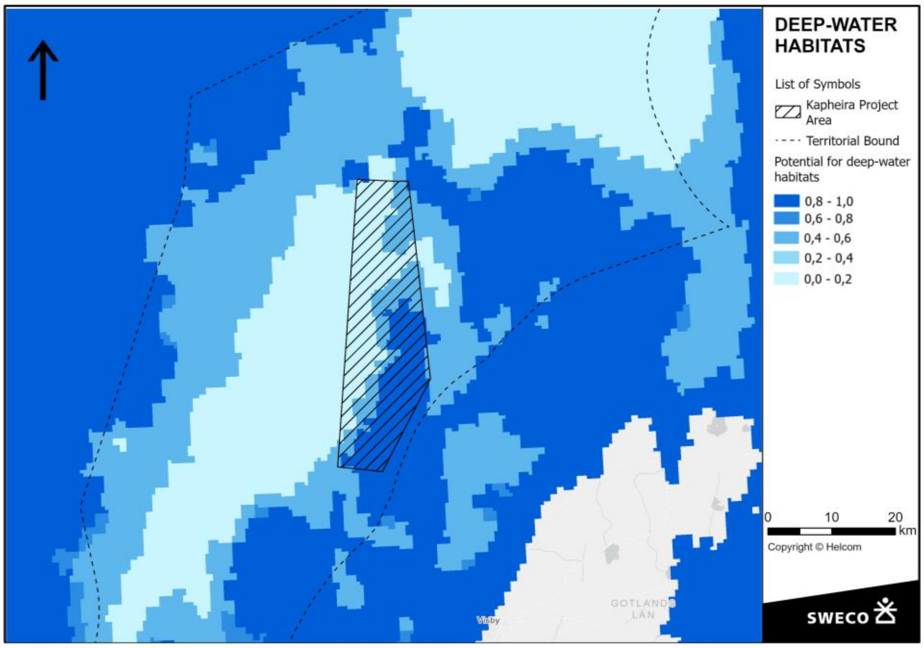

Figure 31. The availability of deep-water habitats for biota in the sea area around the project area Kapheira. The availability has been calculated based on oxygen conditions and the presence of hydrogen sulphide. The lower the value (brighter colour), the more the deep-water habitats are affected by oxygen deficiency and hydrogen sulphide. Darker colours indicate habitats with a better oxygen availability. Data from HELCOM (2023f)

5.5.6 Marine Mammals

The marine mammals that regularly occur in the Baltic Sea are the harbour porpoise, ringed seal, grey seal, and harbour seal.

Harbour Porpoise

The harbour porpoise is protected according to the Swedish Species Protection Ordinance (2007:845) and is also included in Annexes II and IV of the EU Habitats Directive (92/43 EEC). Species in the EU Habitats Directive are of conservation value from a European perspective. These are divided into three categories: species in Annex II are those whose habitats should be protected, for which special areas of conservation should be designated and included in the Natura 2000 network. Species in Annex IV require strict protection, and species in Annex V may require special management measures (SLU Species Information Centre 2023). Harbour porpoises occur along the entire Swedish coast all the way up to Åland. However, there are three distinct populations: the North Sea population, the Belt Sea population, and the Baltic Sea population. The Baltic Sea population, which can occur in the Kapheira marine area, today consist of about 500 individuals and is classified as critically endangered (CR) (Swedish Agency for Marine and Water Management 2021).

However, the Baltic Sea harbour porpoise is deemed to have a low probability of occurrence around the project area throughout the year (SAMBAH 2017). There are no areas in the project area or nearby that are considered particularly valuable for the conservation of the Baltic Sea harbour porpoise. Instead, valuable areas are mainly found south of Gotland and around Öland, see Figure 32 (Carlström and Carlén 2016, SAMBAH).

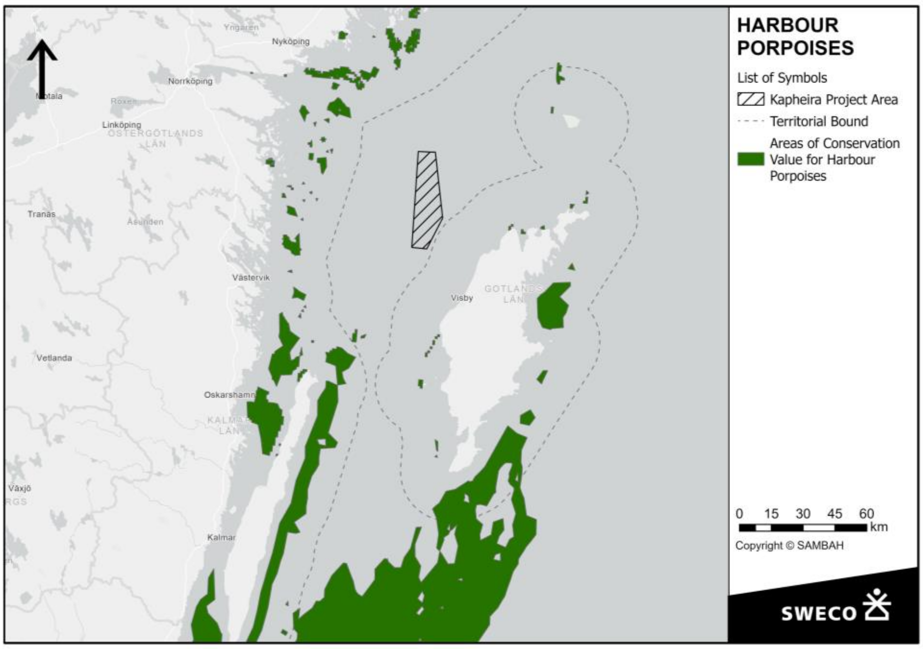

Figure 32. Areas of conservation value for harbour porpoises in the Baltic Sea.

However, it should be noted that there is a limited amount of data regarding the presence of the harbour porpoise in a larger area around Kapheira. The reason is that the devices used by SAMBAH for porpoise monitoring were not placed comprehensively and are missing in certain areas (SAMBAH 2017), possibly due to the greater depths. The nearest Natura 2000 area with harbour porpoises as a target species are *Hoburgs bank* and *Midsjöbankarna,* located south of Gotland.

Ringed Seal

The Baltic Sea population of the ringed seal is covered by Annexes II and V of the EU Habitats Directive. The distribution of the ringed seal is concentrated to the Bothnian Bay, parts of the Bothnian Sea, the Gulf of Finland, and the Gulf of Riga. They only occur occasionally in and around the Baltic Sea area where Kapheira is located (HELCOM 2023a).

Harbour Seal

The harbour seal is covered by Annexes II and V of the EU Habitats Directive. The main distribution of the harbour seal is along the west coast, with a smaller isolated population in the Kalmarsund area. The population in Kalmarsund is genetically isolated from the rest of the Swedish harbour seal population and is classified as vulnerable (VU) (SLU Species Information Centre 2020). Individuals from this population of harbour seals may occasionally be found around the project area, but there are no haul-out sites or other areas of significance for them within the project area (HELCOM 2023a; HELCOM 2018).

Grey Seal

The grey seal is covered by Annexes II and V of the EU Habitats Directive. The species is common along the entire Baltic Sea coast and is expected to occur regularly within the project area (HELCOM 2023a). The species reproduces in the Baltic Sea, but the nearest haul-out sites for reproduction and moulting are found along the coast and at Gotska Sandön (HELCOM 2018). It is also where the nearest Natura 2000 areas with grey seals as a target species are found, namely St: Anna and the archipelagos of Gryt, Hävringe-Källskären, Skärgårdsreservaten, and Gotska Sandön (Figure 23). All these places are located about 50 km from the project area. Therefore, there are no places in or around Kapheira where grey seals gather and stay during sensitive periods. Grey seals can swim long distances and are expected to pass through the area regularly. However, they generally prefer water depths shallower than 50 m for foraging and hunting (Sjöberg and Ball 2000). Therefore, regular use of the project area for hunting by grey seals is not expected.

5.6 Environmental Quality Standards

The Marine Strategy Framework Directive aims to achieve or maintain good environmental status in the European seas. According to the fundamental statutes in the directive, good environmental status should be achieved through ecosystem-based management. Ecosystem-based management should be characterized by a holistic approach to the conservation and sustainable use of ecosystems, which, among other things, means that the holistic view should consider that different species in an ecosystem affect each other and that the interaction between humans and the environment often spans across several societal sectors. The Marine Strategy Framework Directive (2008/56/EC) has been implemented in Swedish legislation through Chapter 5 of the Environmental Code and the Marine Environment Ordinance (2010:1341), as well as through HVMFS 2012:18.

Environmental quality standards are a legal control mechanism regulated in the Environmental Code and used to achieve or maintain good environmental status. The environmental quality standards should be based on scientific criteria and reflect the lowest acceptable environmental quality or the desired environmental condition, authorities and municipalities are responsible for ensuring standards compliance on a general level. The standards are in practice impacting individual operators after they have been converted into some form of requirement, for example through permit or supervisory decisions. The Swedish Agency for Marine and Water Management has developed 11 descriptors (3) to measure four main strains on the marine environment. These pressures consist of the input of nutrients, the input of hazardous substances, biological disturbances, and physical disturbances.

To practically assess the state of the environment, each descriptor has several associated criteria and indicators. The criteria specify what should be included in the assessment of environmental status, and the indicators are more specific tools to measure the condition of the environment.

The Kapheira wind farm area is located within the Western Gotland Basin. Every sixth year, the Swedish Agency for Marine and Water Management assesses load and impact in the area in question. The latest assessment was made in 2018 (Swedish Agency for Marine and Water Management, 2018). Most descriptors were assessed as not achieving good status, hence the current environmental status assessment for the Western Gotland Basin.

Table 3. Descriptors for environmental status.

Descriptor		Good environmental status
Descriptor 1	Biodiversity	Not achieved
Descriptor 2	No-indigenous species	Not achieved
Descriptor 3	Populations of commercial fish and shellfish	Not achieved
Descriptor 4	Marine food webs	No assessment
Descriptor 5	Eutrophication	Not achieved
Descriptor 6	Sea floor integrity	No assessment
Descriptor 7	Permanent alteration of hydrographical conditions	No assessment
Descriptor 8	Concentrations and effect of contaminants	Not achieved
Descriptor 9	Contaminant in seafood	Not achieved
Descriptor 10	Marine litter	Not achieved
Descriptor 11	Underwater noise	No assessment

5.7 Cultural Environment and Marine Archaeology

5.7.1 Cultural Environment

Gotland has a significant number of areas with interest from a cultural environment perspective. All these areas are on land, at least 30 km away from the planned wind farm.

5.7.2 Marine Archaeology

According to the Swedish National Heritage Board, there are three registered remains on the seabed within the project area (Figure 33). One of them (L1934:3894) is a shipwreck, and the other two (L1934:3987, L1934:3985) are referred to as other remains, one of which is denoted as a mine and the other as scrap iron.

Two additional remains are registered just outside the project area, L1934:3893 and L1934:4171. Both are ship remains but have not been confirmed by field visits. They are located approximately 1 and 2 kilometres respectively from the project area boundary. It cannot be ruled out that there are other objects of archaeological interest in the area.

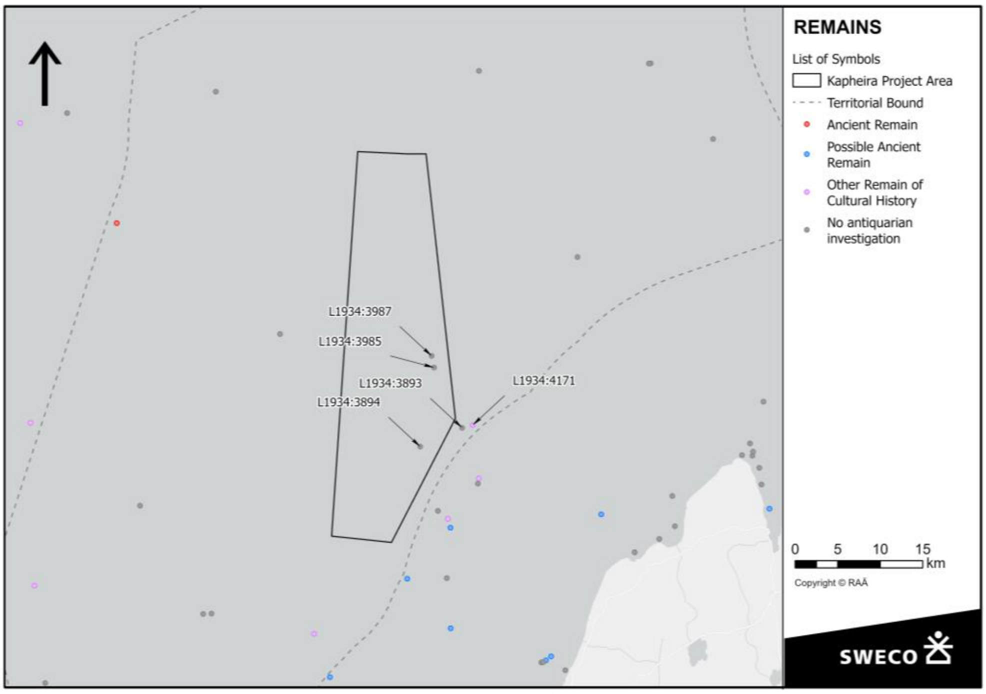

Figure 33. Different types of remains in and around the Kapheira project area. Three of the remains are within the project area, and two are located just outside, at distances of 1 and 2 kilometres respectively.

5.7.3 Landscape View

Offshore wind farms located off the coast are elements in the landscape that break the previously untouched horizon line. However, good visibility is required for these, at more than 20 to 30 km, to constitute a dominating element in the view during daylight hours.

Photomontages will made developed to provide an impression of how the future wind farm will be visible and look from land and how the view might affect areas of cultural-historic interest and areas for recreation and outdoor activities.

5.8 Recreation and Outdoor Activities

Many of the coastal areas are popular and frequently visited areas for outdoor recreation. In and around the project area, it can be expected that sailing boats will pass by as well as small scale recreational fishing takes place.

5.9 Shipping Fairways and Maritime Traffic

The project area is surrounded by three fairways, the busiest being the one in the southeast.

With the help of an Automatic Identification System (AIS), a density map can be created to show the traffic pattern in a certain area. Figure 34 shows the traffic pattern for all types of vessels near the project area in 2022 (EMODnet).

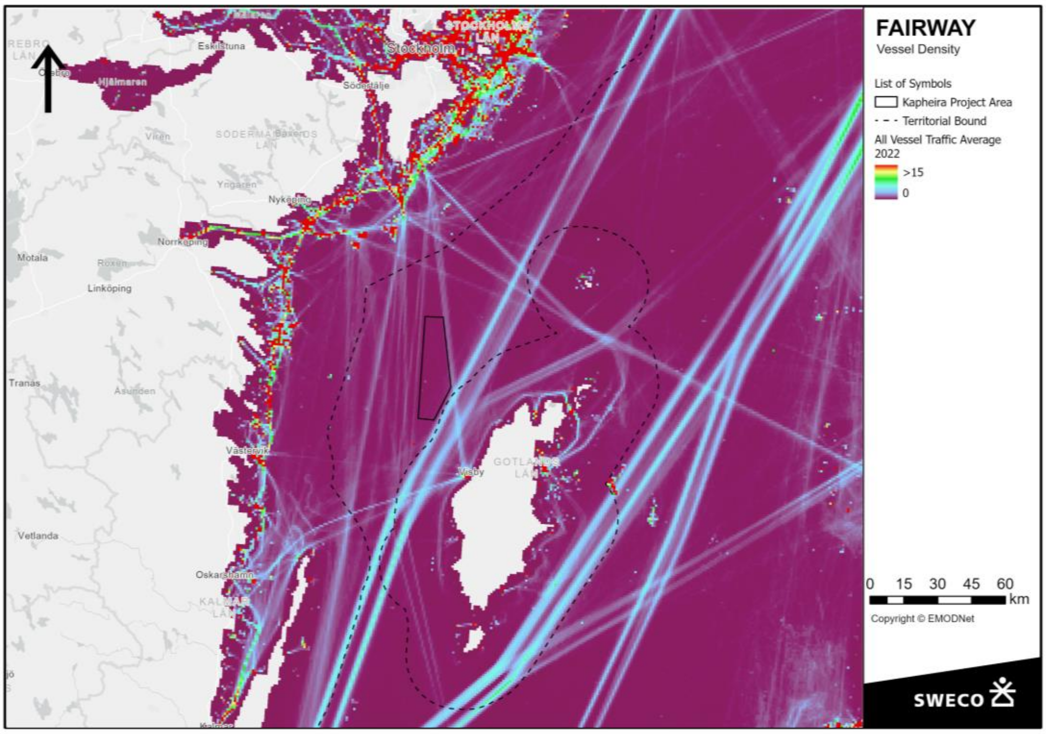

Figure 34. Vessel density for all vessels.

5.10 Aviation

The airspace northwest of Gotland is partly used by the Visby Airport, located 30 km from the Kapheira project area. The project area overlaps horizontally with the airport's terminal areas: Visby TMA A and Visby TMA B (Figure 35).

As previously described, the project area is also overlapped by the MSA (Minimum Sector Altitude) area for Visby Airport, with established maximum heights for obstacles around the airport that may affect aircraft landing and departure systems.

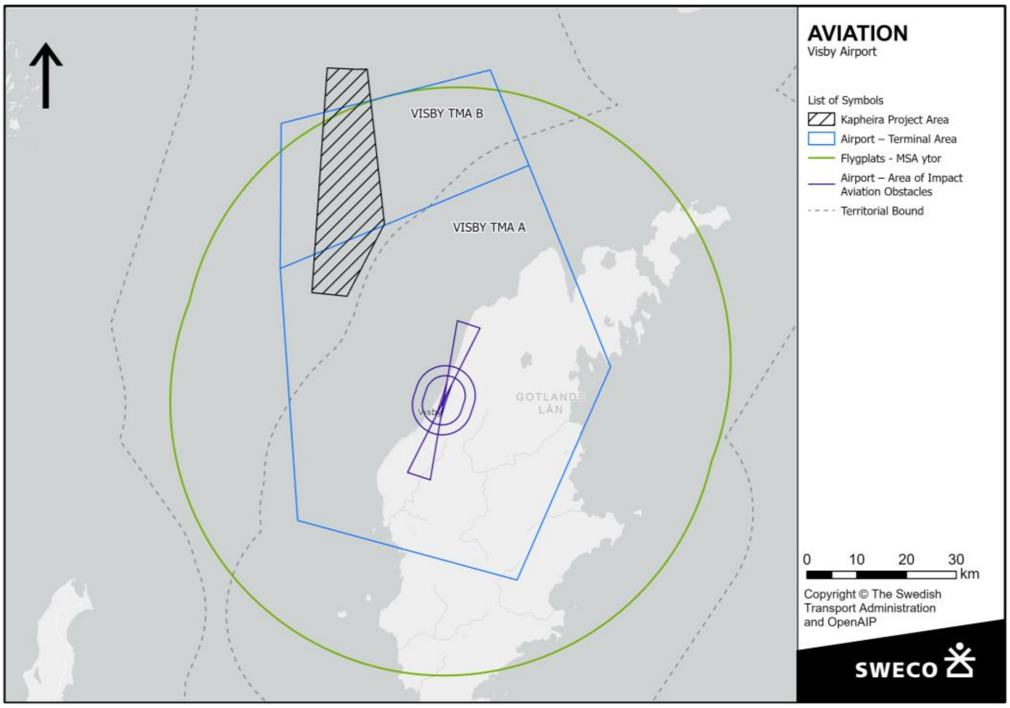

Figure 35. Areas with restrictions around Visby Airport.

5.11 Commercial Fishing

The Kapheira project area is located within the Baltic Proper in ICES subdivision 27. ICES further divides the subdivision into smaller areas; statistical rectangles of approximately 56 x 56 km, where commercial fishing is controlled to provide statistics. Kapheira is located within four such rectangles: 45G7, 45G8, 44G7, and 44G8. Several of these rectangles also extend into coastal areas and therefore the statistics do not solely cover fishing in the open sea.

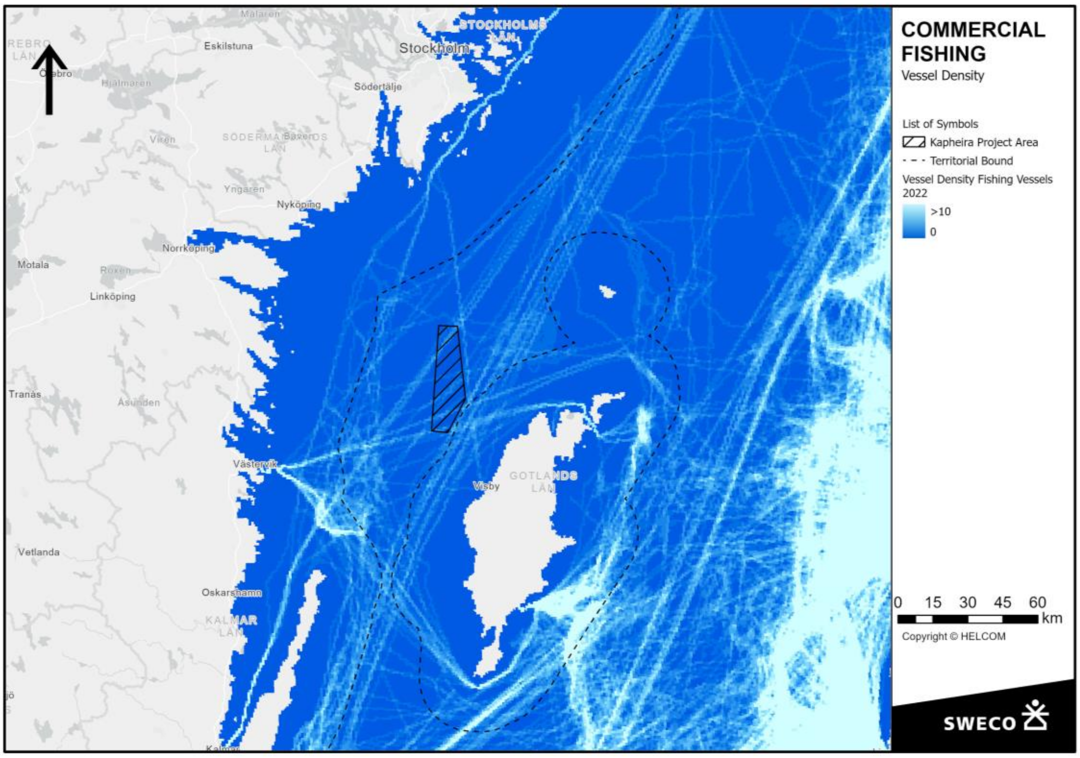

Figure 36. Vessel density concerning fishing vessels, 2022.

Commercial fishing in the project area concern mainly sprat and herring through pelagic trawling. Combined, these two species account for 98 % of the landed weight and 97 % of the landed value within the Swedish commercial fishing in the relevant rectangles over the last four years (2019 - 2022). However, the catch of herring has decreased over these years, from constituting of over 50 % of both the landed weight and the landed value in 2019, to only making up 12 % of both weight and value in 2022 (SLU 2023). Nevertheless, fishing efforts are quite low in the open sea west of Gotland, where the project area is located (Figure 36). The bulk of fishing is carried out closer to the mainland coast, which correlates with the areas of national interest for commercial fishing. Trawling conducted within the project area is mainly in the northern and eastern parts (Figure 37).

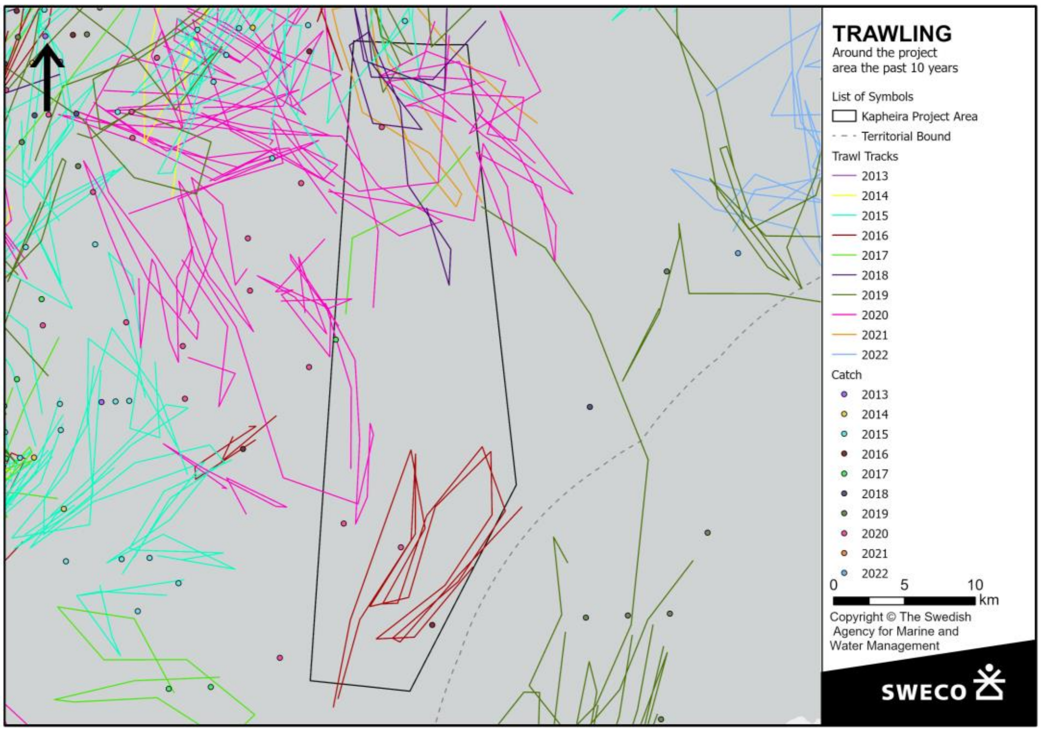

Figure 37. Trawling with Swedish vessels from 2013 to 2022. Data from the Swedish Agency for Marine and Water Management (2023b).

5.12 Risk Areas for Mines

The Baltic Sea is likely the sea with the highest concentration of old mines, ammunition, and chemical warfare agents on the seabed. Many originate from the time during and after the world wars, and it is still a hazard to touch objects found on the seabed or in the water column.

There is a minefield more than 30 km east of the planned area, see Figure 38. According to the Swedish Maritime Administration, it is an area where German mines of the EMA/EMB type from World War I are dumped. There is an elevated risk associated with anchoring, trawling, and other bottom activities in this area. (Swedish Maritime Administration)

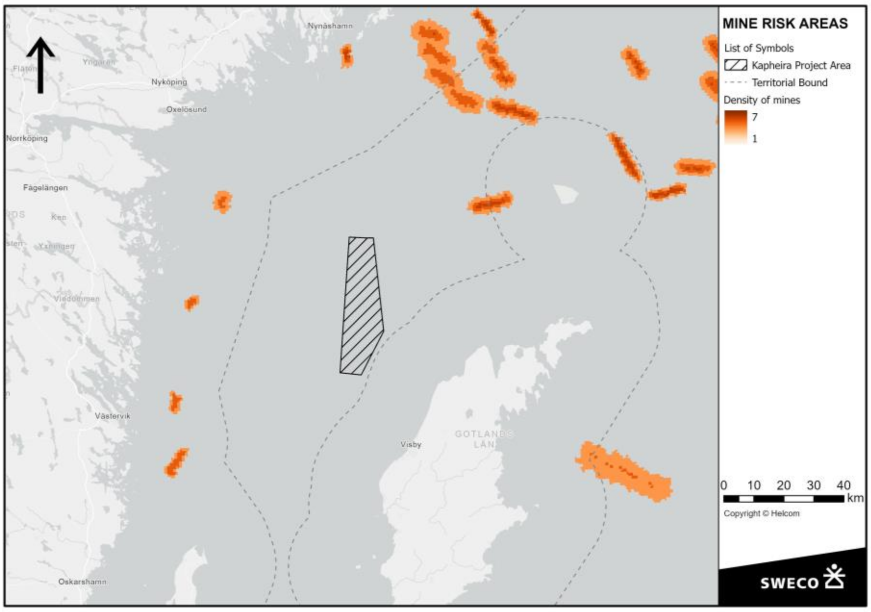

Figure 38. Areas with potential risk of mines.

5.13 Cables and Pipelines

No cables or pipelines are crossing the project area. Cables and pipelines that have been identified in proximity of the area of the wind farm are shown in Figure 39. North of the project area is a power cable that extends between north-western part of Gotland and the Stockholm archipelago.

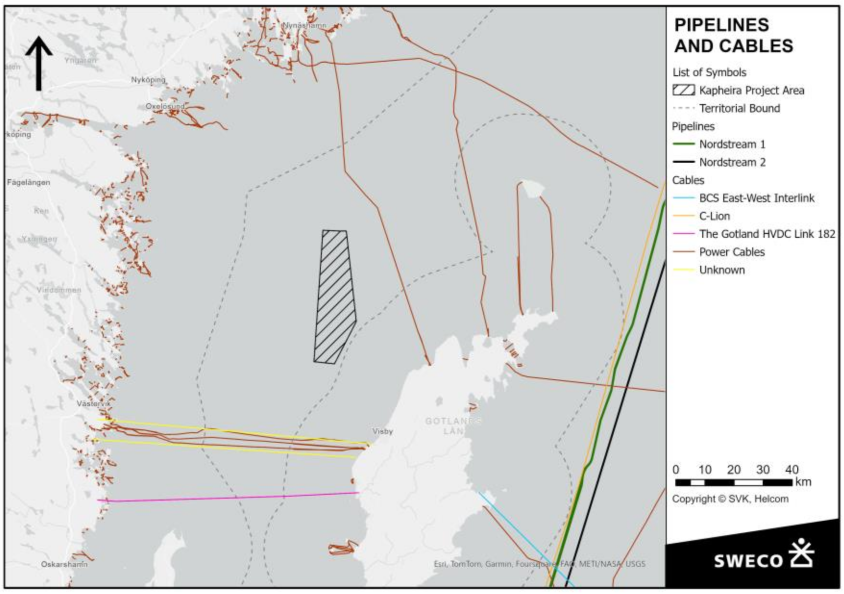

Figure 39. Pipelines and cables within and around the Kapheira area.

6 Possible Environmental Impact

6.1 National Interests and Protected Areas

6.1.1 National Interest Swedish Armed Forces

Only publicly published national interests for the Swedish Armed Forces are known; however, there are other national interests in relation to defence matters that are classified. Therefore, these have not been considered in the documentation, nor in proposals for new areas of energy extraction.

In addition to tall objects posing an obstacle to aviation within the MSA area around Visby Airport, there may be other obstacles and interests that are currently unknown. The defence authority is a stakeholder and will hence be involved in the current permit process.

6.1.2 National Interest Shipping and Aviation

The project area overlaps with the MSA area for Visby Airport. In the MSA Area there are established heights for obstacles around the airport that may impact the system in relation to landing and departure.

Consultations will be held with LFV (the Swedish Aviation Authority) and the Visby Airport to examine the conditions in detail and any impact from the project on the relevant areas and the airport's operations. The establishment of the wind farm will be preceded by a notification of flight obstacles according to Chapter 6, Section 25 of the Swedish Aviation Regulations.

The project area borders the national interest for shipping. For shipping, the nautical risks will be evaluated in consultation with the concerned authorities, and the potential impact on the national interest will be described further in the environmental impact assessment (EIA).

6.1.3 National Interest Commercial Fishing

Areas designated as national interests for commercial fishing are located outside the project area and are therefore not expected to be impacted by a future establishment.

6.1.4 National Interest Outdoor Recreation and Nature Conservation

National interest areas for nature conservation are located along the coast more than 30 km from the planned project area, therefore not expected to be impacted by the establishment.

The national interest area for outdoor recreation includes both land and sea and is at its closest about 2 km away from the project area. Recreational fishing and sailing may occur near the project area to a small extent and maybe impacted by the establishment, which will further be described in the environmental impact assessment.

6.1.5 Natura 2000

The protected areas closest to Kapheira are located about 24 km from the nearest outer boundary of the project area. However, these areas are not expected to be impacted as their values are due to ecological values on land. Protected areas with sea-based values are located at least 50 km from the nearest outer boundary of the project area. The distances imply that no impact is expected, neither during construction nor operation of the planned wind power park.

6.1.6 UNESCO World Heritage

The Hanseatic Town of Visby is located about 30 km from the nearest wind turbine within the planned project area. Under weather conditions with clear visibility, the wind turbines will be visible from this distance, but due to the great distance, they will not constitute a significant element in the landscape. Therefore, the visual impact on the Hanseatic Town is assessed to be limited.

6.2 Geology and Seabed Conditions

Within the project area, soft seabeds of various types dominate, primarily erosion bottoms but also deeper clay bottoms of the accumulation type. The installation of offshore wind turbines involves the addition of new, hard material to the seabed which may result in some loss of habitat. The degree of habitat loss depends on the type of foundation used, as well as if erosion protection is utilized. However, the loss is usually quite small in relation to the size of the area (Bergström et al. 2022). Kapheira is planned to consist of floating wind turbines, which means that the foundation will not be placed on the seabed. The possible habitat loss will therefore only happen at the anchoring arrangements used to secure the foundations, which means that the impact on geology and seabed conditions is not expected to be significant.

The impact on geology and seabed conditions will be further described and assessed in the environmental impact assessment.

6.3 Hydrography

The construction of offshore wind turbines may cause some changes in hydrographic conditions, both locally around individual foundations and on a larger scale. The foundations themselves may cause changes in water currents, waves, and the mixing of water. Calculations, however, only show that currents and mixing will be impacted locally within the park and to a low degree (Hammar et al. 2008). These calculations have been based on a monopile construction.

The impact of wind turbines on wind conditions may also impact on a larger scale through so-called wake effects, a phenomenon where the wind speed is locally reduced downwind of a wind turbine but also on a larger scale downwind of a wind park. In the Baltic Sea, this can occur within approximately 4 – 7 km from a wind park. In the edge zones of the reduced wind, upwelling or downwelling effects can occur, which may impact the mixing and transport nutrients in the water to the photic zone. Overall, the impact on ecosystems from the resulted changes in hydrography is however considered to be on the same scale as naturally occurring variations (van Berkel et al. 2020). Although a construction with floating foundations in deeper waters is expected to cause less disturbance on currents and waves than fixed foundations in shallower waters, local impact like for instance on water mixing may occur (Farr et al. 2021).

The impact on hydrography from the planned wind park will be further described and assessed in the environmental impact assessment.

6.4 Natural Environment

6.4.1 Birds

During the operational phase, offshore wind power may impact birds that forage within the project area as well as the birds that migrate across the region. Section 5.5.1 describes the occurrence of species in, or in proximity to, the project area that are particularly important to investigate further. Generally, the species which are attracted to the turbines, such as gulls and cormorants, are at greatest risk of being impacted. Cumulative effects from multiple future wind farms may occur for species that avoid turbine areas due to significant limitations in their foraging grounds. Birds that migrate across the area where the wind farm is planned may adjust their flight paths, potentially leading to reduced survival if the routes become less optimal. The non-migrating birds in the area, that are attracted to, and forage around wind farms may be killed by the rotor blades. Studies of bird fatalities caused by onshore wind turbines have found that small birds constitute the majority. Investigation has shown that approximately 60 % of the birds killed have been passerines. How these birds move over the open sea and to what extent offshore wind turbines impact them has not been studied.

To assess the impact on birdlife during the construction and operational phases of the planned wind farm, further investigations and assessments are needed.

The planned wind farm's impact on birds will be described and evaluated in more detail in the environmental impact assessment.

6.4.2 Bats

Given that the planned project area is approximately 30 km from the nearest point on Gotland and about 45–50 km from the islands south of Nynäshamn, the occurrence of foraging bats is likely to be low within the area. The risk of bats dying due to collisions with wind turbines is therefore assessed to primarily occur in combination with migration during spring and autumn. The knowledge about bats in the area is fairly limited, but the presence of migrating bats cannot be ruled out. An investigation of how bats move in relation to the placement of the wind farm is necessary to assess any potential impact.

The planned wind farm's impact on bats will be described and evaluated in more detail in the environmental impact assessment.

6.4.3 Fish

Construction Phase
During the construction phase, factors expected to affect fish in and around the project area include underwater noise from vessels and construction activities, as well as water turbidity.

Fish can perceive sound in two different ways: through their lateral line organ and through their inner ear. Different species have varying sensitivity to sound. Most species are categorized as hearing generalists**,** species with swim bladders being more sensitive to sound than those without. There are also hearing specialists**,** such as herring, which have a connection between the swim bladder and the inner ear, making them particularly sensitive to sound (Thomsen m.fl. 2006). Like marine mammals, fish can experience damage when exposed to high levels of noise, such as tissue damage as well as permanent or temporary hearing impairment. Elevated noise levels can also cause fish to flee or avoid certain areas (Andersson m.fl. 2016). The distances where damage or avoidance can occur depend on for example type of species, noise level, frequency, and distance to the sound source. Protective measures, such as using bubble curtains during construction work, can reduce the risk of harm and limit the areas where fish behaviour is affected (Bergström m.fl. 2022).

Increased water turbidity may cause fish avoiding the area and with prolonged exposure, cause harm. Fish generally tolerate turbidity levels up to 100 mg/L for two weeks (Karlsson m.fl. 2020). When water becomes cloudy, there is a risk that sediment particles will attach to floating eggs, potentially weighing them down and causing them to sink (Westerberg m.fl. 1996). This negatively impacts the survival, especially if the bottom water is oxygen-depleted[1].

Operational Phase
During the operational phase, factors expected to influence fish in the project area primarily include reef effects, operational noise, and electromagnetic fields.

Reef effects occur when new hard materials are introduced, such as floating devices, anchor lines, anchors, as well as potential erosion protection. These structures provide a habitat for marine organisms to colonize, which means increased access to food and protection for various species. Studies have shown that this attracts a diverse range of fish from different groups (Farr m.fl. 2021)

Fish can perceive operational noise, but the risk of disturbance or avoidance is estimated to occur within a maximum distance of 100 meters from a foundation during strong winds (Andersson m.fl 2011).

It is possible that several species of fish, including salmon and eels, can perceive electromagnetic fields from underwater cables within an offshore wind farm. However, these fields do not appear to act as a barrier to migration, and the observed effects are mostly minimal. Electromagnetic fields from sea cables likely do not pose a significant threat (Öhman 2023; Farr m.fl. 2021).

The impact on the seabed is not considered significant within the planned project area during the operational phase due to the current oxygen conditions.

The impact on fish will be further investigated, described, and assessed in the environmental impact assessment.

6.4.4 Benthic environment

Since benthic flora is not expected to occur within the area, the impact will only be associated with benthic fauna.

During the construction phase, the impact will partly consist of direct physical impact, such as the establishment of foundations for structures or cable flushing. Partly, there will be an impact from turbidity and sedimentation as a result from the mentioned activities, both during construction and decommissioning. The benthic environment in the area is expected to consist of a limited number of species, or to be entirely devoid of species, due to a large part of the area being affected by permanent lack of oxygen, and the entire area being expected to experience lack of oxygen the entire year. In areas where a permanent lack of oxygen does not prevail, any species that may occur should be those capable of rapidly colonizing a new area after significant disturbance. Long-lived, reef-forming organisms are therefore not expected to occur within the project area. Consequently, the impact during the construction phase is unlikely to affect species that are particularly sensitive to disturbances. Generally, benthic fauna is not negatively affected by short-term turbidity, and mobile species can emerge from sedimentation of up to approximately 10 cm (Hammar et al., 2009).

During the operational phase, the impact is expected to occur through the introduction of new hard substrates, both on the seabed and in the water column. Additionally, there may be an impact from electromagnetic fields generated by cables. Depending on how the floating foundations are attached, the seabed may be affected by movements of chains or other fastening devices, which can periodically cause both direct impact and minor turbidity and sedimentation. The introduction of anchoring devices and floating foundations provides new surfaces for species to attach to throughout the water column, both for benthic fauna and flora (Karlsson et al., 2022; Farr et al., 2021). These changes are not expected to affect the occurrence of benthic fauna in deeper waters where lack of oxygen prevails, but they may lead to more individuals and species higher up in the water column. The impact on invertebrates from electromagnetic fields has not been assessed to be of significance on a population level (Bergström m.fl. 2022).

The occurrence of benthic fauna will be further investigated in the environmental impact assessment, as well as the description and assessment of consequences for existing species.

6.4.5 Marine Mammals

The marine mammals expected to be found within and around the project area are primarily grey seals and harbour porpoises. These species are sensitive to underwater noise, which will occur within the wind farm, primarily during the construction phase, but also during the operational phase. Harbour porpoises are generally more sensitive to underwater noise than seals since they use their hearing for foraging through echolocation as well as for communication (Bergström et al. 2022).

The noise levels generated during the construction phase are higher than those produced during operation and decommissioning (Mooney et al. 2020). However, the exact types and levels that occur depend on the construction methodology, where construction involving piling or blasting is associated with the highest noise levels. Vessel traffic from construction vessels also contributes to noise during construction and decommissioning (Bergström et al. 2022). How far the sound spreads from the source depends on factors such as the frequency of the sound, water depth, bottom substrate, salinity, and water temperature (Andersson et al. 2016). High noise levels can cause damage to marine mammals, such as temporary or permanent hearing loss, but can also affect the animals' behaviour in the form of flight, avoidance, or masking of echolocation and communication (Andersson et al. 2016). In construction involving piling, several measures can be taken if there is a risk of damage to marine mammals. For example, noise-reducing measures such as bubble curtains, or the use of acoustic deterrents before starting the work (Bergström et al. 2022).

The project area is not located within an area that is currently considered to be important for any species of marine mammals. During operation, the sound from wind turbines is not powerful enough to cause hearing damage to or frighten marine mammals (Bergström et al. 2022), and it is not likely that the sound will risk masking the animals' communication (Farr et al. 2021).

The impact on marine mammals will be investigated, described, and assessed further in the environmental impact assessment.

6.5 Environmental Quality Standards

Any impact on the Marine Environmental Quality Standards (EQS) and descriptors will be assessed in the environmental impact assessment.

6.6 Emissions to Water

During hydrogen production, the operation will result in emissions of enriched salt from the deionization process as well as discharge of heated cooling water. This will create a mixing zone in the water. It may be possible to utilize this mixing zone when reintroducing the enriched salt to facilitate its dissolution. Additional chemicals may become necessary for water purification.

The impact of the emissions will be investigated and described in the environmental impact assessment.

6.7 Cultural Environment and Marine Archaeology

According to the Swedish National Heritage Board, there are three identified remains in the project area that may be affected by the construction of foundations and other seabed activities. Protective distances will be maintained to avoid impact. Prior to the permit process, seabed investigation will be conducted within the project area to prevent damage to any remains. Since it cannot be ruled out that additional remains exist in the area, a marine archaeologist will be hired to assess the results from the seabed examination.

The company will, if permission for investigation is granted, conduct seabed examinations from which the result can be used for an archaeological investigation which will provide increased knowledge about the remains in the area. Any impact on the cultural environment and marine archaeological remains will be described in the environmental impact assessment.

6.8 Visual Impact

The visibility of an offshore wind farm from surrounding land depends on various parameters such as distance, turbine size, height above sea level at the observation point, current conditions for visibility, and weather conditions. There is also a difference in visibility depending on if the experience is related to the visibility of the aviation warning lights or just the wind turbines themselves.

Generally, the human eye can see an offshore wind farm at about 50 km during daytime provided good visibility, the contrast between the turbines and the sky is high, and that no haze is present. Visibility can also vary with the angle of the sun in relation to the wind turbines and the observer.

Kapheira is at its closest planned 25 km from Gotland and will be visible to the naked eye from several locations. A photomontage from Visby can be seen below in Figure 40. Photomontages from several other photo spots are available in Appendix 1. There are also exact instructions regarding how to view the images so they, as much as possible, correspond to the actual visibility.

In preparation for the environmental impact assessment, dark sky animation and photomontages from more locations will be added to better assess and describe the visual impact.

SWECO

Figure 40. Photomontage, picture taken from ”Klinten” above the Visby cathedral.

6.9 Noise

6.9.1 Airborne Noise

The company has conducted preliminary calculations of airborne operational noise from the planned activities. Since the planned wind farm is located far from the coast, the noise levels from the wind turbines at the nearest inhabited environments are expected to be fairly low. The Swedish Environmental Protection Agency's guidelines for noise at residential areas of 40 dB(A) as well as the Public Health Agency of Sweden's guideline values for low-frequency noise indoors are expected to be met with a good margin. More detailed calculations of airborne noise will be carried out in connection with the environmental impact assessment.

6.9.2 Underwater Noise

The greatest impact in the form of underwater noise occurs during the construction phase since certain foundation works, such as piling, may cause noise disturbances. The sound can travel over long distances and potentially impact marine life. It is important to distinguish between the anchoring piles of smaller diameter used for anchoring floating units or jacket structures, and the piling that occurs during the installation of larger diameter monopiles. To reduce the impact on wildlife, if piling or other noise-generating work is carried out, the level can gradually increase so that larger animals are scared and avoid the area before the piling is performed at full force. Alternative ways to dampen noise include, if necessary, the use of bubble curtains, air is pumped into tubes/pipes with valves releasing air bubbles and breaking up the sound waves. (Swedish Environmental Protection Agency 2020)

Low-frequency sound and infrasound generated by offshore wind power during the operational phase primarily risk affecting marine mammals and fish.

The impact and consequences of underwater noise and infrasound, as well as protective measures to limit such noise, will be reported in the environmental impact assessment.

6.10 Recreation and Outdoor Activities

Impacts on recreation and outdoor activities can be expected to occur during the construction phase due to for example the presence of work vessels within the work area which can disrupt activities such as fishing and sailing in the area. The impact is temporary and limited and is not considered to need further investigation.

6.11 Shipping Fairways and Maritime Traffic

The wind farm could pose a safety risk for maritime traffic in established shipping fairways. The expansion of offshore wind power may have an impact in the form of changed traffic patterns, obscured navigation marks for shipping, radar interference, or increased risks of collision and allision (collision between a ship and a fixed installation). To be able to assess the impact on shipping fairways, a risk analysis will be developed.

During the construction and decommissioning phases, extensive planning will be required to minimize the impact on shipping traffic in the area.

A detailed assessment of the impact and the need for any protective measures will be made in the environmental impact assessment.

6.12 Aviation

The project area overlaps with MSA areas, as well as TMA areas for Visby Airport.

Consultations will be held with Luftfartsverket and the airport in question to examine the conditions in detail and any potential impact from the project on the airport's operations. The establishment of the wind farm will be preceded by a notification of aerial obstacles in accordance with Chapter 6, Section 25 of the Swedish Aviation Regulations. Any impact on aviation will be described in the environmental impact assessment.

6.13 Commercial Fishing

The fishing activities within the area is pelagic trawling for herring and sprat. During the construction of a wind farm, the project area, or parts of it, will be closed off for fishing and vessel passage for safety reasons. During the operation of the wind farm, trawl fishing will not be possible within the project area.

Other parameters that may impact commercial fishing are effects on fish during the construction phase. High noise levels associated with piling as well as sediment dispersion may cause fish to avoid impacted areas during construction works. Any impact on fish outside the areas closed off for safety reasons depends on construction methods and the spread of noise and sediment.

The impact on commercial fishing will be described and assessed in more detail in the environmental impact assessment.

6.14 Mine Hazard Areas

The nearest dumping ground for mines from World War I is located more than 30 km east of the project area and is not considered to pose any risk to the operation.

During further seabed surveys, the area will be scanned for any unexploded mines and ammunition.

6.15 Risk and Safety

6.15.1 In General

Major incidents related to wind turbines are uncommon, although the risk must always be considered. Incidents that are deemed possible include allision (drifting or powered), tower failure, nacelle detachment, blade failure, fire, icing and ice throw, as well as falling parts. Wind turbines contain lubricant grease which, if spilled, can harm plant and animal life.

6.15.2 Shipping Fairways and Maritime Traffic

The planned wind farm is located near several shipping fairways, and there will therefore be maritime traffic in its vicinity. The construction of the wind farm will affect maritime traffic through a slight increase in the risk of collision (between two vessels) and other navigational risks such as allision (collision between a vessel and a fixed installation). It may also cause navigation impacts. The proximity of shipping fairways may impose safety distances to be maintained from the area of operation. Risks for maritime traffic can be reduced through traffic limitation in the project area, safety distances, and navigation lights. A traffic analysis and a nautical risk analysis will be undertaken as part of the environmental impact assessment.

6.15.3 Hydrogen

The biggest risk associated with handling hydrogen is the risk of fire and explosion. Hydrogen is prone to leakage and can cause embrittlement of steel, weakening steel equipment with subsequent leaks. This may be prevented at the design stage by selection of materials and equipment that meet the technical requirements.

If a gas leak occurs and there are ignition sources nearby, the gas can be ignited. The amount of gas that leaks out and the size of the area affected by ignition depends on how the leakage occurs.

Prior to the environmental impact assessment and permit application, a risk analysis regarding hydrogen handling risks will be made. In accordance to applicable Seveso legislation and the requirements, necessary documents will be prepared.

6.16 Pipelines and Cables

There are no known pipelines and cables within the project area. Consultations will be held with other ongoing and planned wind farm projects as a competitive situation may arise over future pipelines.

6.17 Cumulative Effects

Cumulative effects may arise from the interaction between multiple effects. For example, environmental impact from several parameters from a single activity or action, or if environmental impact arise due to the interaction between several different operations.

In assessing cumulative effects, the parameters that are relevant and possible to assess are analysed. For example, studies/investigations of birds, bats, marine mammals, conditions of currents, commercial fishing, shipping, and risks associated with hydrogen handling will include cumulative effects.

The company will investigate cumulative effects in the environmental impact assessment.

7 Continued Work

7.1 Environmental Impact Assessment

An Environmental Impact Assessment (EIA) will be prepared in accordance toChapter 6, Sections 35–36 of the Environmental Code and Sections 15–19 of the Environmental Assessment Ordinance. The purpose of the environmental assessment is to integrate environmental considerations into planning and decision-making to promote sustainable development.

An EIA should identify and describe the direct and indirect effects that a planned activity or action may entail, both on humans, animals, plants, soil, water, air, climate, landscape, and cultural environment, as well as on the management of land, water, and the physical environment in general. The purpose is also to enable a comprehensive assessment of the effects on human health and the environment. To summarize, the Environmental Impact Assessment will contain the following:

- Non-technical summary
- Undertaken consultations and outcome
- Presentation of the company and its operations
- Localization and description of surroundings
- Background and conditions for the operations
- Design of the operations
- Zero alternative, alternative localization, and design
- Environmental effects of the operations during construction, operation, and decommissioning, such as electricity production, noise, landscape and aviation warning lights, birds, marine mammals, fish, benthic fauna, shipping, marine archaeology, cumulative effects, and protective measures
- The operations' potential impact on environmental quality standards
- Risk and safety
- Comprehensive assessment
- Presentation of the expertise of those involved in the production of the environmental impact assessment
- Reference list.

Feedback on other issues that should be investigated in the Environmental Impact Assessment is welcomed during the present consultation process.

7.2 Preliminary Timeline

A preliminary timeline for the entire project can be seen in Table 4. The times are preliminary and may be adjusted. The company is planning for the park to be in operation in the early 2030s.

Table 4. Preliminary time schedule

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Permit processes											
Procurement, design and financing											
Construction											
Commissioning											

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Appendix 1 Photomontage

Photos have been taken from 8 places on Gotland and photomontages have been created in the WindPRO program to visualize the visibility from these points.

A brief description of the photo spots follows below, and their location can be seen in Figure 41.

- Photo Spot 1 – Högklint, a rocky beach that is a popular excursion destination southwest of Visby. Distance to the nearest wind turbine is 31 km.
- Photo Spot 2 – Södra Hällarna, a nature reserve just southwest of Visby, also a popular excursion destination. Distance to the nearest wind turbine is 30.5 km.
- Photo Spot 3 – Strandpromenaden, a walking and cycling path along the coast in northern Visby with the oldest tower of the city wall. Distance to the nearest wind turbine is 29.4 km.
- Photo Spot 4 – Klinten above the Visby Cathedral, a viewpoint overlooking Visby's inner city and the sea. Distance to the nearest wind turbine is 29.6 km.
- Photo Spot 5 – Lickershamn, a fishing village on the northwest coast of Gotland. Distance to the nearest wind turbine is 27 km.
- Photo Spot 6 – Hallshuk, Hall's fishing village. Distance to the nearest wind turbine is 36 km.
- Photo Spot 7 – Digerhuvud, a nature reserve on Fårö and a field of limestone sea stacks (raukar). Distance to the nearest wind turbine is 57 km.
- Photo Spot 8 – Langhammar, a well-visited nature reserve on Fårö with a beach area with limestone sea stacks (raukar). Distance to the nearest wind turbine is 60.6 km.

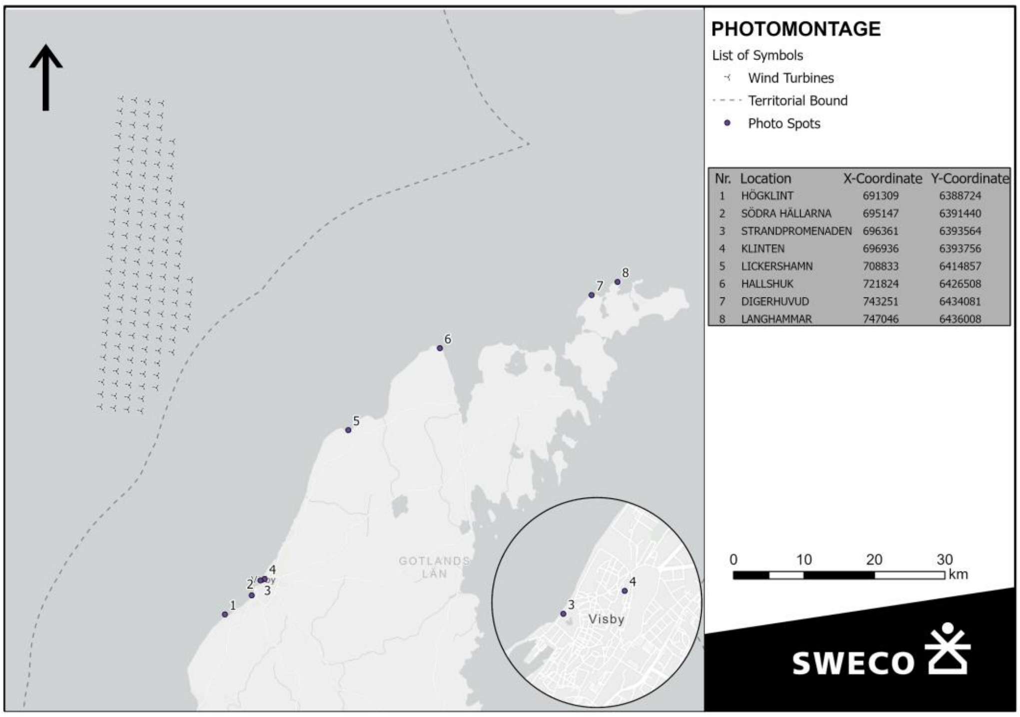
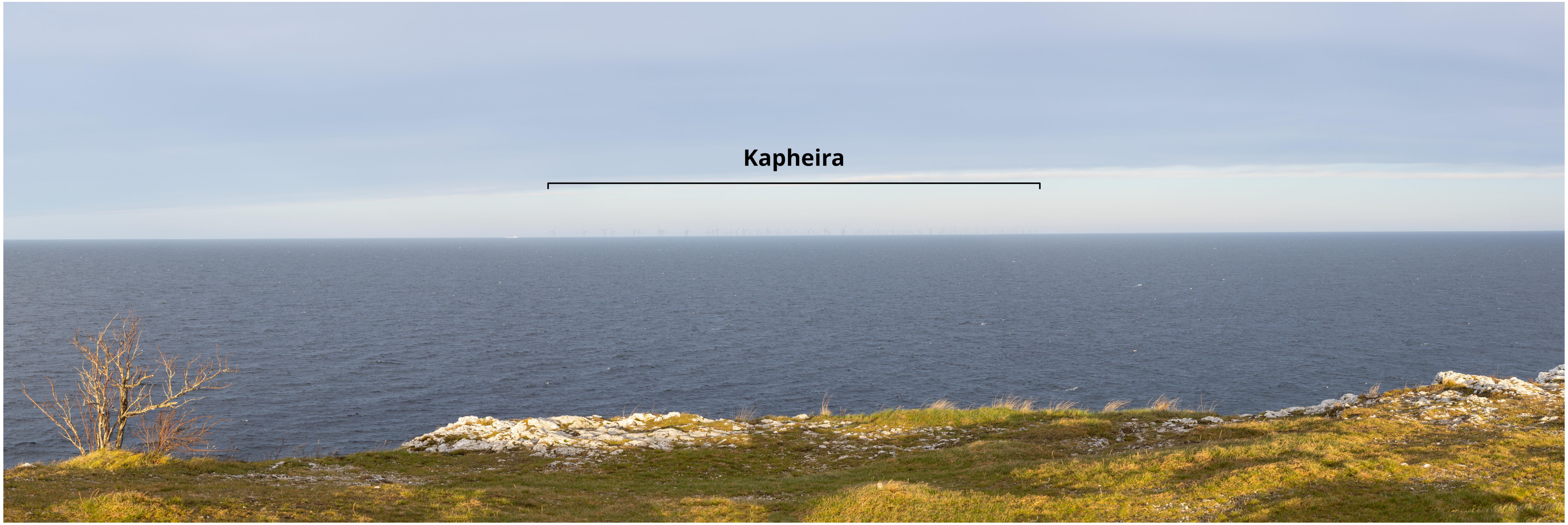
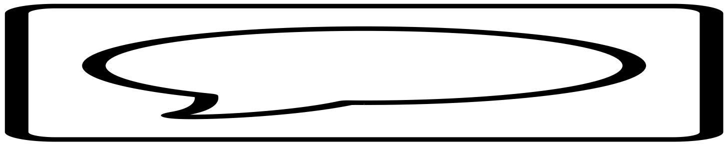


Figure 41. The planned wind park Kapheira and the photospots, from where the photomontages have been created.

Location: Högklint (SWEREF99 691309, 6388724), 50 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 31,2 km
Recommended observation distance: 2,1 times the height of the photo

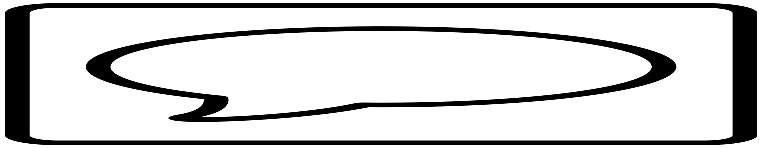


Location: Högklint (SWEREF99 691309, 6388724), 50 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 31,2 km
Recommended observation distance: 2,1 times the height of the photo



Location: Södra Hällarna (SWEREF99 695147, 6391440), 40 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 30,5 km
Recommended observation distance: 2 times the height of the photo

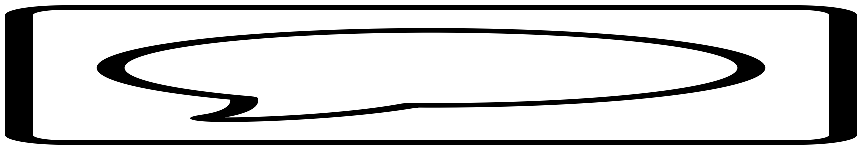
Location: Södra Hällarna (SWEREF99 695147, 6391440), 40 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 30,5 km
Recommended observation distance: 2 times the height of the photo



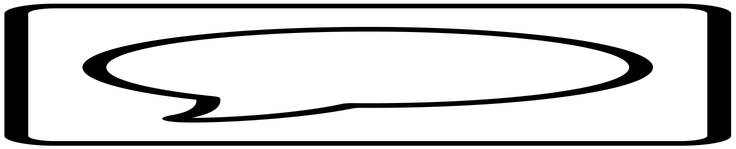
Location: The Beach Walk (SWEREF99 696361, 6393564), 2 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 29,4 km
Recommended observation distance: 2,2 times the height of the photo

Location: The Beach Walk (SWEREF99 696361, 6393564), 2 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 29,4 km
Recommended observation distance: 2,2 times the height of the photo

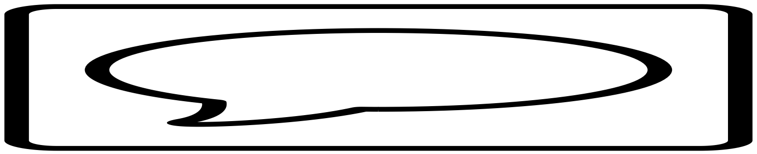
Location: Klinten over the Cathedral (SWEREF99 696936, 6393756), 33 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 29,6 km
Recommended observation distance: 2,3 times the height of the photo



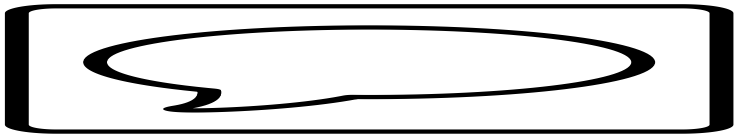
Location: Klinten over the Cathedral (SWEREF99 696936, 6393756), 33 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 29,6 km
Recommended observation distance: 2,3 times the height of the photo



Location: Lickershamn (SWEREF99 708833, 6414857), 0 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 27,1 km
Recommended observation distance: 2,2 times the height of the photo

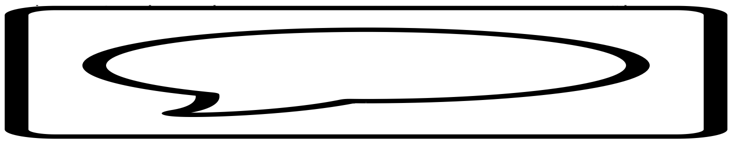


Location: Lickershamn (SWEREF99 708833, 6414857), 0 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 27,1 km
Recommended observation distance: 2,2 times the height of the photo



Location: Hallshuk (SWEREF99 721824, 6426508), 1 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 36 km
Recommended observation distance: 2,4 times the height of the photo

Location: Hallshuk (SWEREF99 721824, 6426508), 1 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 36 km
Recommended observation distance: 2,4 times the height of the photo



Location: Digerhuvud (SWEREF99 743251, 6434081), 0 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 57 km
Recommended observation distance: 2,7 times the height of the photo

Location: Digerhuvud (SWEREF99 743251, 6434081), 0 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 57 km
Recommended observation distance: 2,7 times the height of the photo

Location: Langhammar (SWEREF99 747046, 6436008), 0 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 60,6 km
Recommended observation distance: 2,3 times the height of the photo

Location: Langhammar (SWEREF99 747046, 6436008), 0 MSL
Wind turbines: 143, 370 m total height
Distance to nearest turbine: 60,6 km
Recommended observation distance: 2,3 times the height of the photo

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