Galatea-Galene Wind Farm

Documentation for notification pursuant to Article 3 of the Espoo Convention

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1. Background

1.1 Introduction

OX2 AB (below referred to as “OX2”) plans to establish an offshore wind farm in Kattegat in Sweden’s exclusive economic zone off the coast of Halland (figure 1). The wind farm is called Galatea-Galene and consists of two subareas. Galatea-Galene is expected to generate an annual energy yield of about 5000 GWh. This corresponds to the annual consumption of electricity for about one million households.

According to the Espoo Convention, the party of origin of an activity with a transboundary impact must inform and invite parties (*i.e.* other countries) which can be assumed to be affected by the activity to participate in the environmental impact assessment procedure. This documentation has been prepared to provide an overall description of the project, the project area and a preliminary account of the scope and content of the forthcoming Espoo Environmental Impact Assessment (EIA), which specifically covers the expected transboundary impact.

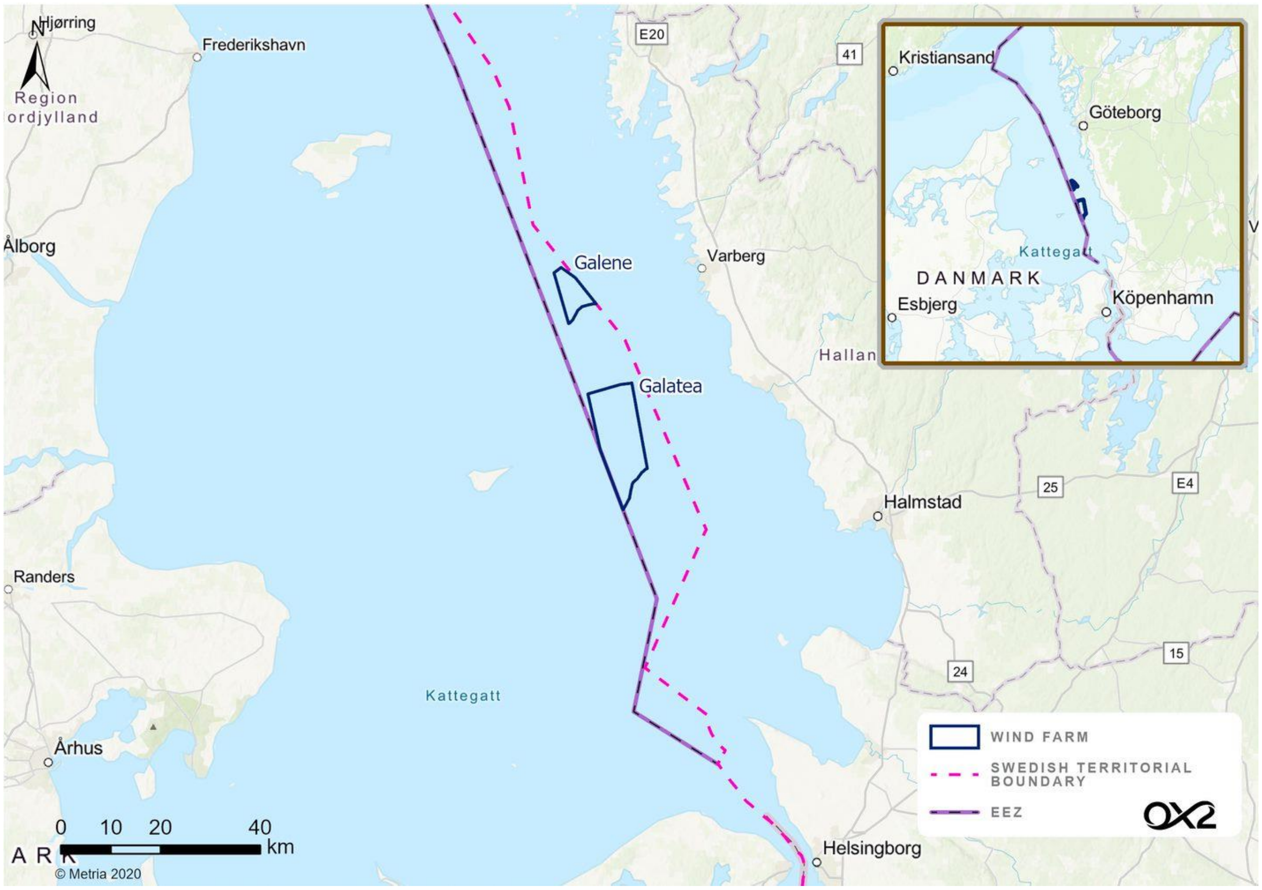

Figure 1. Overview of the location of the Galatea-Galene wind farm in Kattegat .

1.2 The need for offshore wind power

Sweden has set energy policy goals which, *inter alia*, aim for the country's electricity production to be 100 percent renewable by 2040, with no net emissions of greenhouse gases to the atmosphere by 2045. Expanding the share of wind power for electricity production is crucial in order to readjust the Swedish society to become fossil-free and achieve its climate goals. Good conditions for renewable power production in Sweden also facilitate electricity exports to other countries, which can reduce their emissions by replacing electricity production from coal and gas power plants with fossil-free Swedish electricity.

One of the current challenges in the Swedish electricity system is the limited capacity in the transmission grid. Most of the Swedish electricity is produced in the northern part of the country, while demand is highest in southern Sweden. The dominant source of electricity production in southern Sweden is nuclear power. As ageing nuclear power plants are gradually phased out, there is a risk that the geographical imbalance between electricity production and consumption in the Swedish power grid will worsen. Therefore, it is important that the phased-out capacity is replaced by new, large-scale renewable electricity production in the corresponding geographical area. On land, the potential for wind power that can be installed in southern Sweden is limited by a high population density and land use for other purposes, but favourable conditions for offshore wind power exist around the southern Swedish coast.

One of the great advantages of building offshore wind farms is that larger wind turbines with higher power ratings can be used. Offshore wind turbines can therefore generate significantly more power than their onshore cousins. Wind speeds are also higher and more consistent at sea, which means that an offshore wind farm can contribute to more efficient and stable electricity production.

1.3 About OX2

OX2 is one of Europe's leading large-scale wind power companies, with cutting-edge expertise in the entire value chain of wind power establishment. OX2 aims to offer investors the most profitable wind farms in the markets in which the company operates and is leading the transition to a renewable energy future. OX2 has developed and realized over 2 GW of wind power around Europe and has a strong project portfolio. The company currently has over 1.2 GW under construction and manages a total of 516 wind turbines. Of these, 365 are located in Sweden with an estimated energy yield of 4.1 TWh per year. This corresponds to one-fifth of the total wind power production in Sweden. OX2 has about 150 employees in Sweden, Finland, Norway, France, Lithuania and Poland, and is based in Stockholm. Turnover in 2019 came to SEK 4.9 billion.

2. Permit processes under Swedish law

The construction of wind turbines and associated facilities within Sweden's exclusive economic zone requires a permit from the Swedish Government in accordance with the Act (1992:1140) on Sweden's Exclusive Economic Zone ("SEZ"). A permit from the Government pursuant to Act (1966:314) on the Continental Shelf ("CSA") is also required to lay cables on the continental shelf for the grid that connects the wind turbines and for land connection. Prior to applying for a permit in accordance with SEZ and CSA (including the preparation of EIAs), public consultations will take place with authorities, organisations and other stakeholders.

For activities and measures within SEZ that can significantly affect Natura 2000 areas, a separate Natura 2000 permit is also required in accordance with Chapter 7, Section 28a-29b of the Swedish Environmental Code. The County Administrative Board in the county closest to the applied activity at sea is responsible for the review, *i.e*. in this case the County Administrative Board of Halland.

Furthermore, for the measures that are intended to be taken *within Swedish territory*, *i.e.* construction of cables to connect the wind farm to a point on land, the necessary permits according to the Swedish Environmental Code (including any Natura 2000 review regarding areas within Swedish territory), CSA and the Electricity Act (grid concession) will be applied for at a later stage.

With regard to any transboundary impact, information on the planned activities will also be provided to neighbouring countries and consultations will be held in accordance with the Espoo Convention.

3. Description of the activities

3.1 Location

The planned Galatea-Galene wind farm is located in Sweden's exclusive economic zone in the Kattegat (figure 2). The area is assessed to have favourable conditions for the establishment of wind power with an average wind speed of about 9.5 m/s (100 metres above sea level). There are no islands within the area, which consists entirely of open sea.

The Galatea subarea is located about 30 kilometres west of Falkenberg. It is about 17 km from the Danish island of Anholt, while Jutland and Zealand are about 70 and 62 km away respectively. The area covers around 176 km^2, with depths varying from 23 to 83 metres. The seabed is dominated by clay, except for the northwestern part of the wind farm, where there is more sand and gravel. Galatea borders the Swedish Natura 2000 areas of Stora Middelgrund and Röde bank (SE0510186) in the south, and Lilla Middelgrund (SE0510126) in the north.

The Galene subarea is located about 20 kilometres west of Varberg. It is about 30 and 45 km respectively from the Danish islands of Anholt and Læsø, while Jutland is about 80 km away. The area covers around 44 km², with depths varying from 22 to 93 metres. The seabed is dominated by clay with minor elements of sand and blocks in the outer areas of the wind farm. South of Galene the Swedish Natura 2000 area of Lilla Middelgrund (SE0510126), while to the north, Galene is adjacent to the Swedish Natura 2000 area of Fladen (SE0510127).

On the Danish side, west of Galatea-Galene, the Natura 2000 areas Kims top og den Kinesiske mur, Anholt og havet nord for, Farvandet nord for Anholt and Store Middelgrund are located.
Investigations are currently ongoing as to which point in the transmission grid is best suited for connection of the Galatea-Galene wind farm. One option is to connect east of Ringhals in Varberg municipality, another at Häradsbo in Hylte municipality. Four investigation corridors for the connection points will be examined and analysed in more detail to assess which corridor(s) constitute the most suitable route (figure 2). The investigation corridors are about four kilometres wide, but a cable on the seabed only requires a few metres.

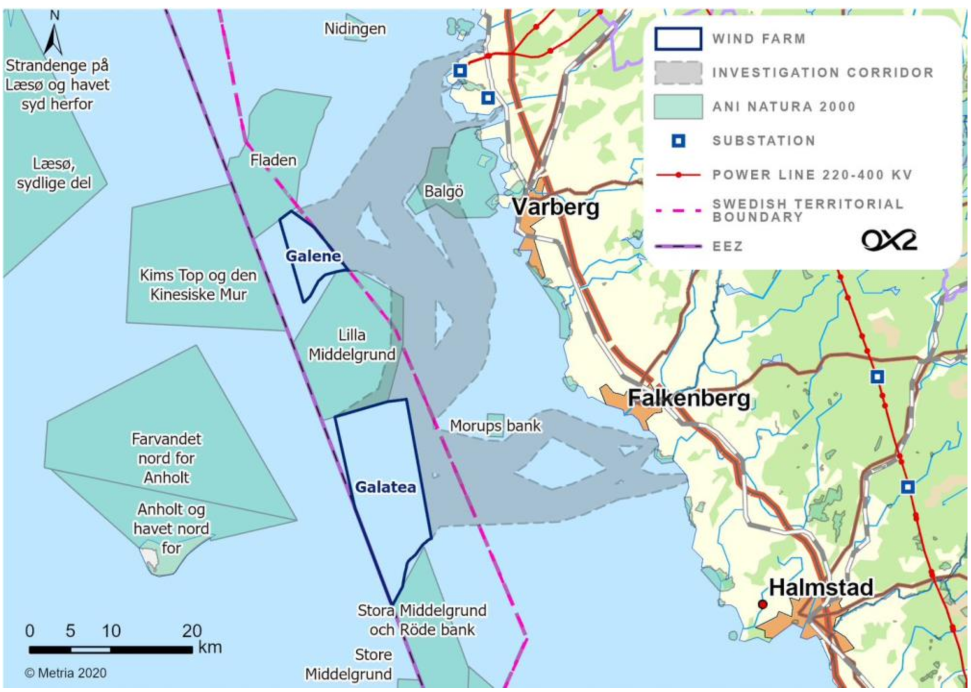

Figure 2. Overview of Natura 2000-areas and investigation corridors for connection cables (Source: The Swedish Environmental Protection Agency and Svenska Kraftnät (the Swedish TSO).

3.2 The wind farm layout

A wind turbine consists of a tower, nacelle, and rotor and is installed on a foundation that is anchored in the seabed. The electricity that each wind turbine produces is transmitted via an internal grid to one or more transformer/converter stations. The internal grid is located between the wind turbines on the seabed and also functions as a communication link to the wind turbines using fibre optic cable. After transformation to a higher AC voltage or conversion to a high DC voltage, the generated electricity is transmitted via connection cables to the connection point on the mainland (figure 3).

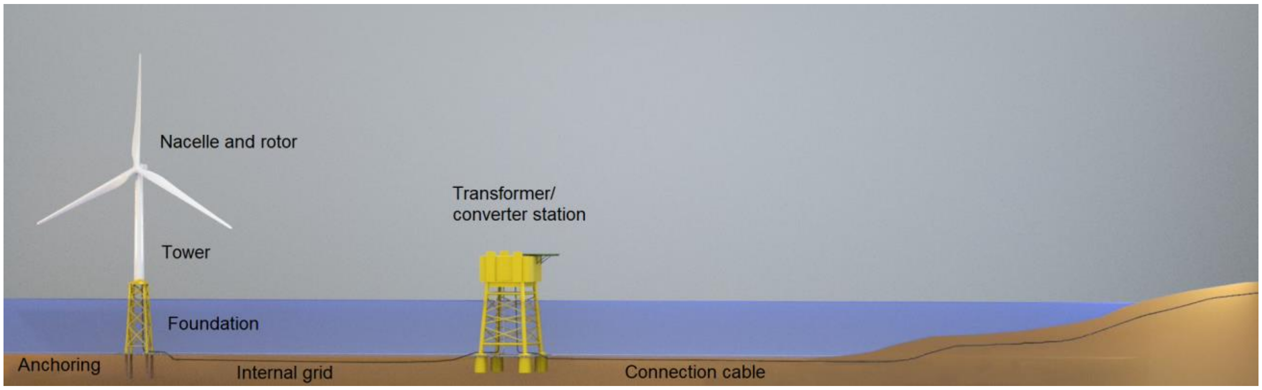

Figure 3. Example of the different parts of a wind farm.

The planning and construction of an offshore wind farm is a lengthy process (see preliminary time schedule in section 3.4). At the same time, rapid and continuous advancements in technology mean that more economical and environmentally efficient systems are becoming available. In recent years, wind turbines have become larger and more efficient, enabling greater energy yields. Wind turbine foundations are continuously being optimised, which also opens up new opportunities, as is the technology for the transmission of the electricity to the mainland. The design of the wind farm presented in this report should therefore be seen as an example, given that available technology may be changed prior to the start of construction.

The design of the wind farm, including the location of cables and transformer/converter stations, will be adapted to the site's conditions in terms of wind, climate, waves, currents, environmental impact, and geological properties. The final design of the wind farm will therefore be determined on the basis of the technology available at the time of procurement and construction, and with regard to optimised electricity production and production costs. The potential sizes and numbers of wind turbines provide alternatives that will be highlighted and evaluated based on the available wind resource in the area. An example of a wind farm layout for Galatea-Galene is shown in figure 4.

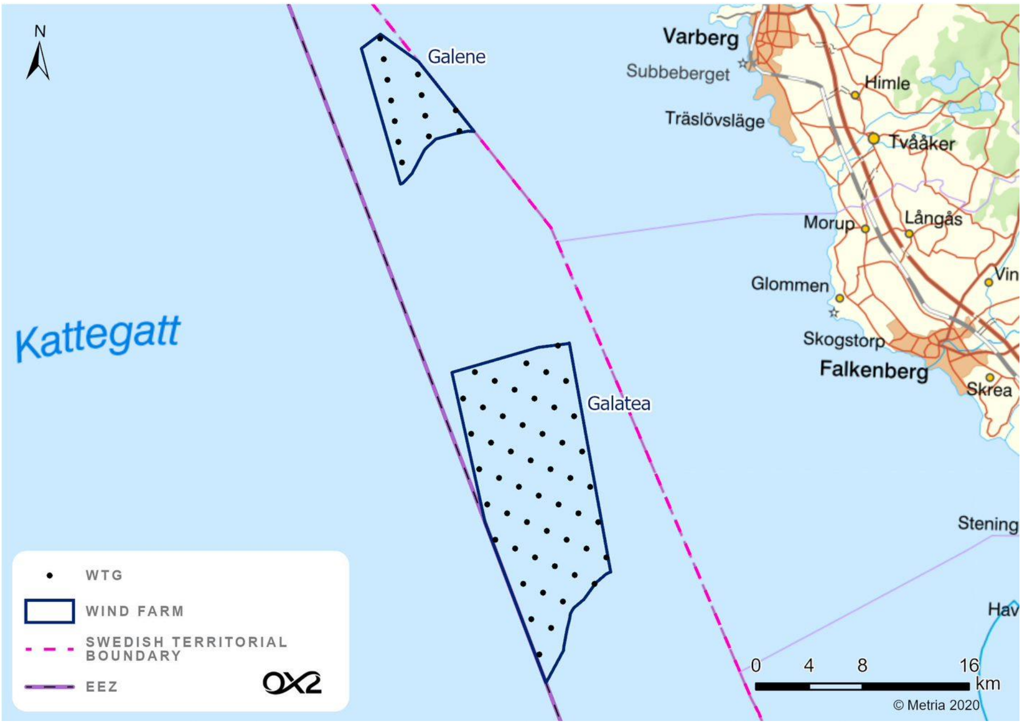

Figure 4. Example of layout with 63 wind turbines in the Galatea-Galene wind farm.

3.2.1 Wind turbines

Wind turbines can be either vertical-axis or horizontal-axis with two or three rotor blades. A horizontal-axis wind turbine has its rotor downwind or upwind. The type of wind turbines that have developed the fastest and to date been built the most often are three-bladed horizontal-axis wind turbines. Wind turbines generate electricity at wind speeds from about 3 m/s and achieve maximum production at wind speeds of between 10 and 14 m/s. They generate electricity up to wind speeds of about 30 m/s, after which they are designed to automatically shut off. It is expected that the available wind turbines at the time of procurement and construction will have a lifespan of at least 30 to 35 years. Figure 5 below shows an example of an offshore wind turbine.

The number, capacity, and size of wind turbines are determined by the speed of technical advancement. Based on developments to date and manufacturers forecasts, a wind turbine in 2025 is expected to have an output of approximately 20 MW. Examples of the numbers and sizes that may be relevant are shown in table 1 and figure 5 below. Figure 5 shows foundations for water depths of 70 metres (d1) and 30 metres (d2).

Table 1. Example of dimensions of wind turbines.

Power per wind turbine	**25 MW (1)**	**15 MW (2)**
Rotor diameter D (m)	305	240
Tip height H (m)	325	260
Clearance G (m)	20	20
Number of wind turbines	50	83

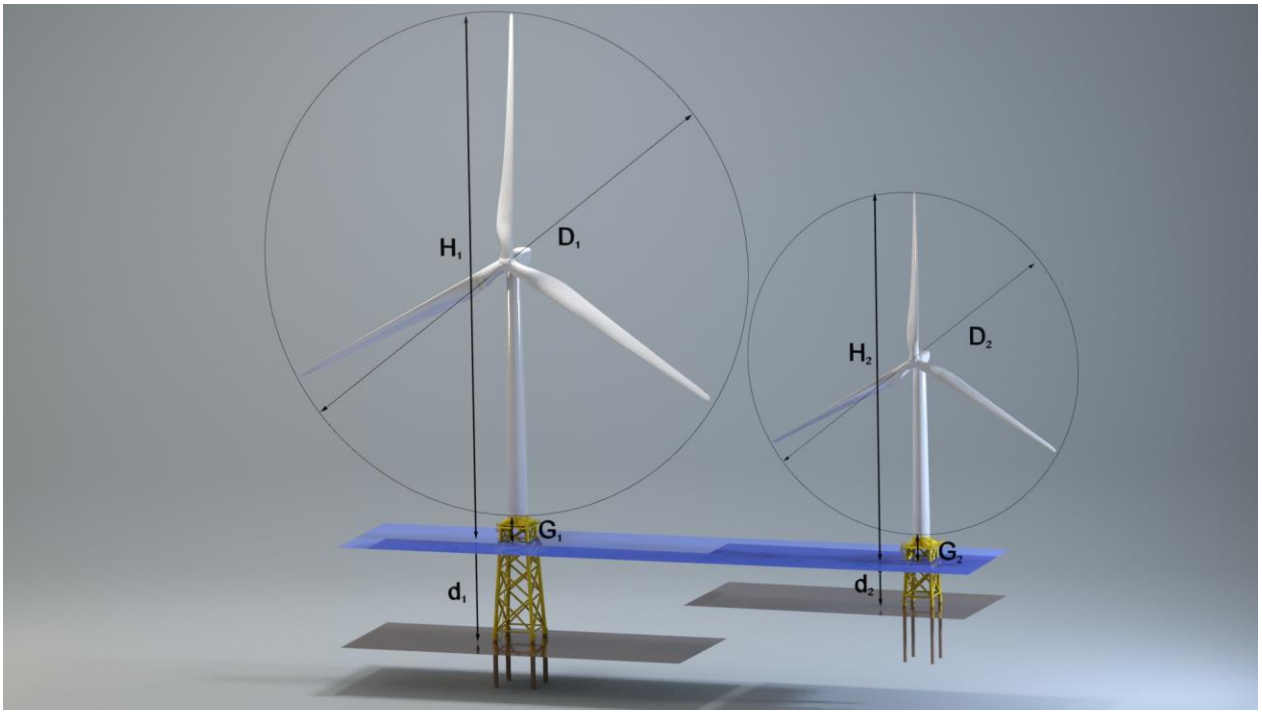

Figure 5. Example of wind turbine. D = rotor diameter, H = tip height, G = clearance, d = water depth.

3.2.2 Foundation

The choice of foundation depends on a number of factors – primarily water depth, geology, wind, and wave conditions – as well as environmental considerations and costs. Since both water depth and geological conditions vary within the wind farm, different types of foundations may be used. Based on the technology available today, there are essentially three different types of foundation that are considered relevant: gravity base foundations, monopile foundations and jacket foundations. These three basic types can also be combined to form hybrid foundations. The foundations can be anchored to the seabed with suction buckets or piles. Examples of the different foundations are shown in figure 6. The indicative dimensions of the foundations will be described in the EIA after the area's site conditions have been investigated to the required extent.

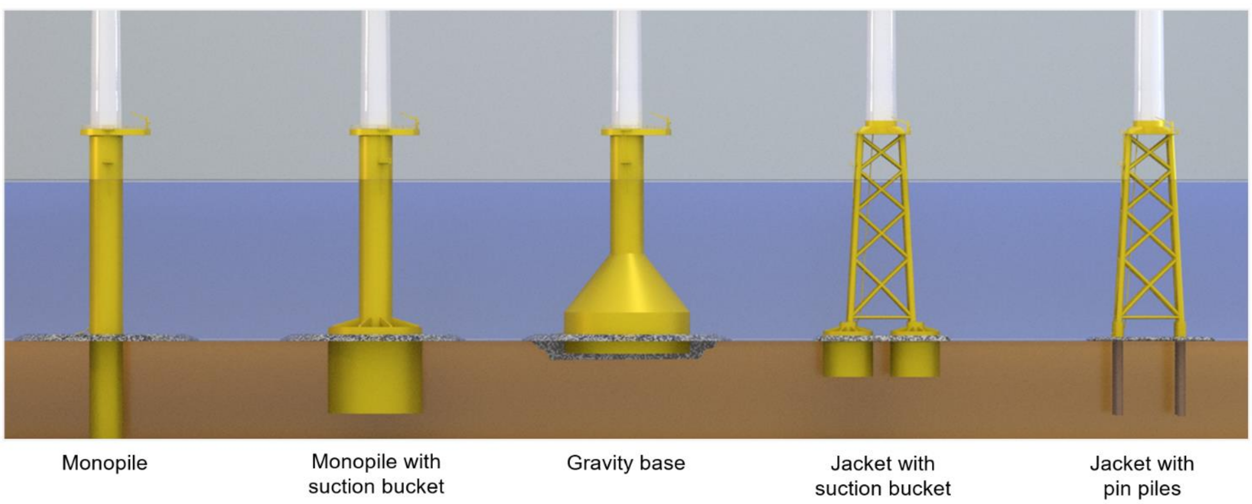

Figure 6. Example of different foundations.

3.2.3 Internal grid

The internal grid can be designed in different ways depending on the choice of technology. The number of cables, cable type, voltage level and the number of wind turbines connected via the same radial will depend on the rated power of the wind turbines. The internal grid cable technology available today consists of, for example, 66 kV cables, which can transmit a total power of around 80 MW per cable. This means that four 20 MW wind turbines can be connected along the same radial. The rated voltage level of internal grids is expected to rise to 99 kV or even higher over the next 5 to 10 years, which would increase the total transmission capacity for each cable and thus reduce the number of radials and the total length of cables. Figure 7 shows an example of an internal grid layout.

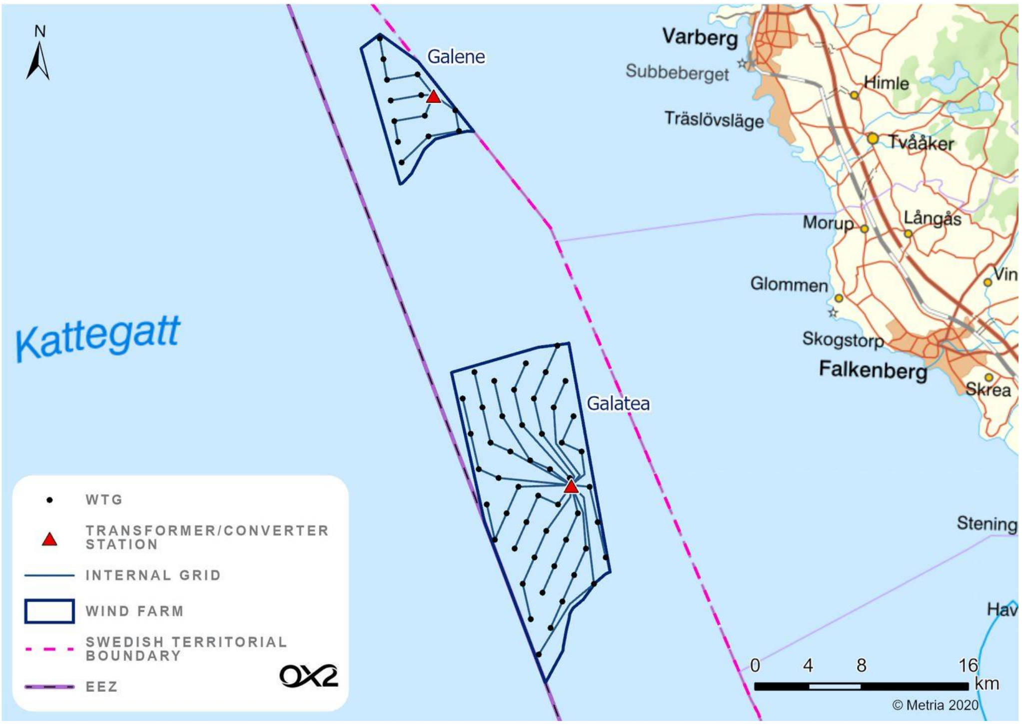

Figure 7. Example of the wind farm's internal grid layout. The example shows 50 (Galatea) and 13 (Galene) wind turbines, with 66 kV cables and a central offshore transformer/converter station in each subarea.

3.2.4 Connection cable and transformer/converter station

The transmission of electricity from the wind farm to the connection point on land takes place via either high-voltage alternating current (HVAC) or high-voltage direct current (HVDC). The route and length of the connection cables depend on the final connection point and area conditions (*e.g*. geology, other activities, and the environment).

Transformation to higher voltage and possible conversion to high-voltage direct current requires one or more transformer (HVAC) or converter stations (HVDC). The foundation types available for the transformer/converter stations are largely the same as for the wind turbines, but are dimensioned with regard to the station loads. The transformer/converter stations can also be placed on jack-up barges. Depending on the choice of technology, it may also be possible to place equipment for transformation to higher voltage on the same foundation as a wind turbine. Below are a few examples on how transformer/converter stations can generally be designed (figure 8).

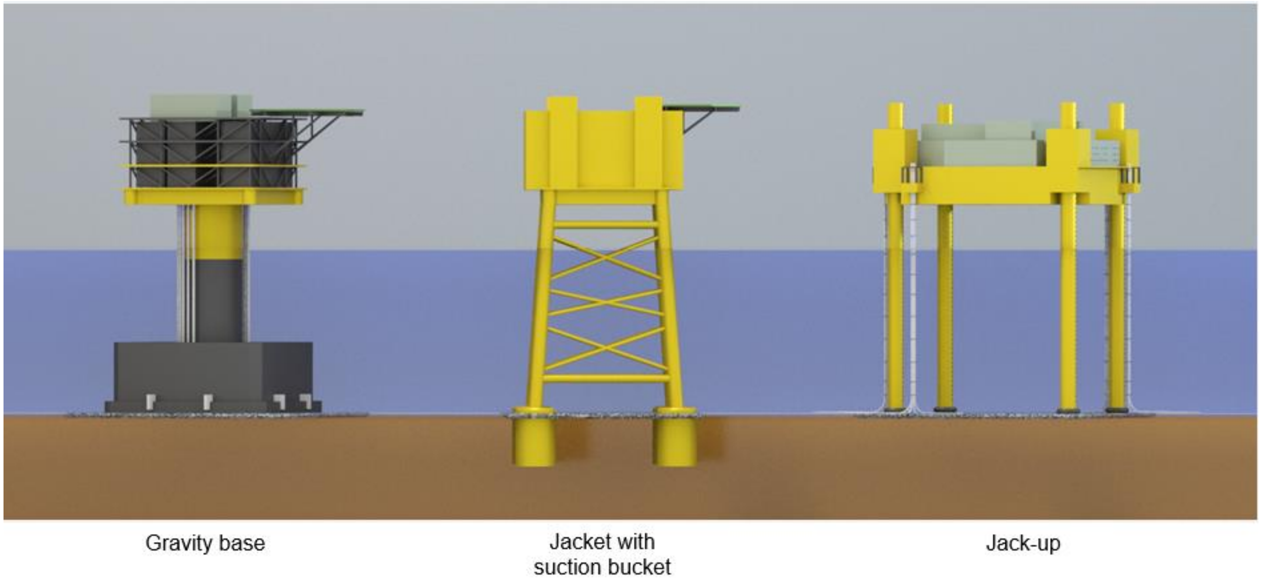

Figure 8. Example of offshore transformer/converter stations.

3.3 Activities in the different phases of the project

This section provides a summary of the activities that take place during construction, operation, and decommissioning of the wind farm and connecting cables. The expected impact from these activities is set out with regard to environmental impact in section 5 and with regard to the expected transboundary impact in section 6.

3.3.1 Preparatory investigations

Prior to the construction of the wind farm and cable, investigations of the seabed will be carried out to further investigate the geology and sediments. This will form the basis for the final choice of foundation type(s) as well as the detailed design of the wind farm and cabling. The investigations will also ensure that the construction work can be carried out without risk of, for example, encountering any unexploded ordnance.

3.3.2 Construction phase

The construction phase includes steps related to preparations for (*e.g*. investigations of the seabed) and installation of the wind farm. The installation takes place in several phases, normally covering the anchoring, foundation, wind turbines, cables and transformer/converter station.

Anchoring and foundations

When installing a gravity base foundation, the seabed is prepared where the foundation is to be placed by replacing existing material in the top layer of the seabed with a homogeneous and even layer of gravel. The foundations are then transported out (floating) to the site by means of tugs or on a barge or a ship. The foundations are then lowered onto the gravel bed with winches/taps or by carefully filling them with water, after which, once in place, they are filled with ballast material.

Monopile foundations are transported out to the wind farm floating in the water or on board an installation vessel. The monopile foundation is placed on the seabed, either using a jack-up barge or a floating crane vessel. It is then driven into the seabed by piling, vibration or drilling. Depending on the conditions, installation may involve a combination of these methods.

Jacket foundations require that the seabed is relatively flat, which means that levelling may be required before installation. The foundation is transported to the site on a barge or an installation vessel and placed on the seabed using a jack-up barge or crane vessel. If pin piles are used, steel pipes are piled, vibrated or drilled into the seabed at the respective corners of the foundation. The pin piles are then joined to the foundation by casting or by mechanical anchoring.

If the geology and other site conditions permit, monopile foundations and jacket foundations can be anchored in the seabed using a suction bucket, which is a steel or concrete cylinder that is sucked into the seabed.

After installing the foundation, protection is applied to prevent the seabed around the foundation from eroding and undermining the anchorage. Erosion protection usually consists of a lower layer of gravel and an upper layer of mixed-size stone.

Wind turbines

To install the wind turbines, towers, nacelles, and rotors are transported to the wind farm on a barge or an installation vessel (for example a jack-up barge). The various components are then installed using a crane, usually within a day if the weather conditions are favourable.

Transformer/converter stations

A transformer/converter station is normally installed on its foundation using a crane vessel. Depending on how the transformer/converter station and its foundation are designed, they can also be moved out or installed with other lifting methods, for example with their own support legs.

Internal grid and connection cables

The wind farm’s internal grid and connection cables are laid from cable vessels. When needed for protection from anchors, for example, cables can be coiled, furrowed or alternatively buried in the seabed, normally to a depth of approximately 1.5 metres. In the event that the geological conditions do not allow for cables to be laid in the seabed, they can be protected by a cover of stone or in pipes. In the event that a cable has to cross another cable, the cables are usually protected by concrete mats or stone.

3.3.3 Operational phase

Both the wind turbines and the transformer/converter stations are subject to remote and unmanned monitoring during normal operation. Maintenance of the wind farm, however, requires that personnel and material is transported there using smaller service vessels, ships or helicopters. Cables are inspected when needed, for example to ensure that their protection by the foundation of each wind turbine is intact. In the event of damage to a cable, it will be repaired using a cable vessel which lifts the damaged cable section for repair and then places the cable back on the seabed using the same method as during the construction phase. To protect the cables from damage, bottom trawling should not take place within the wind farm or over the route of the connection cables.

3.3.4 Decommissioning phase

The wind farm will be decomissioned when it has reached its lifespan (at least 30 to 35 years). Wind turbines, foundations and transformer/converter stations are dismantled and the site of the foundation(s) is restored to the extent necessary. Some minor parts may remain in place after decommissioning.

3.4 Preliminary time schedule

The time schedule for the project is set out below (figure 9), and should be regarded as general and preliminary. Several parameters can affect the time schedule during the course of the project.

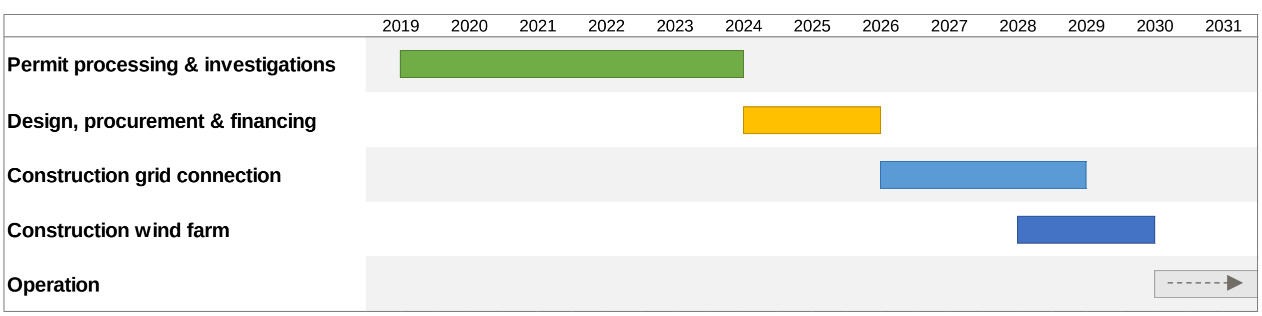

Figure 9. Preliminary time schedule for the project.

4. Area description

4.1 *General*

As noted above, the subareas for Galatea-Galene are located in an open sea area without islands. The Swedish coast is approximately 30 kilometres from Galatea and around 20 kilometres from Galene. The distance to Denmark is around 72 km and 85 km respectively. The Danish islands of Laeso and Anholt are situated at a distance of 45 and 17 km respectively.

Water depths within Galatea vary from 21 to 84 metres, the north-east and the central-west area being the deepest, from where a shallower plateau extends approximately 15 kilometres from the coast. For Galene, the water depth varies from 20 to 70 metres, most shallow in the south and deepest towards the north. Towards land from Galene, the depth continues to be around 40 metres up until approximately the last five kilometres, where the depth rapidly declines.

4.1.1 Natura 2000 areas

The Natura 2000 area of Fladen is adjacent to the Galene subarea in the very north. The Natura 2000 area of Lilla Middelgrund is located between the two subareas and the Natura 2000 area of Stora Middelgrund and Röde bank are in the south adjacent to the Galatea subarea (figure 10).
Other closely located Natura 2000 areas in Sweden are Morups bank, approximately nine kilometres east of the Galatea subarea, and Balgö, approximately eleven kilometres east of Galene subarea.

On the Danish side, the Natura 2000 area of Kims Top og den Kinesiske Mur is located approximately three kilometres west of the Galene subarea, Farvandet nord for Anholt and Anholt og havet nord for approximately seven kilometres west of the Galatea subarea. The Natura 2000 area Store Middelgrund is located south of Galatea on the Danish side.

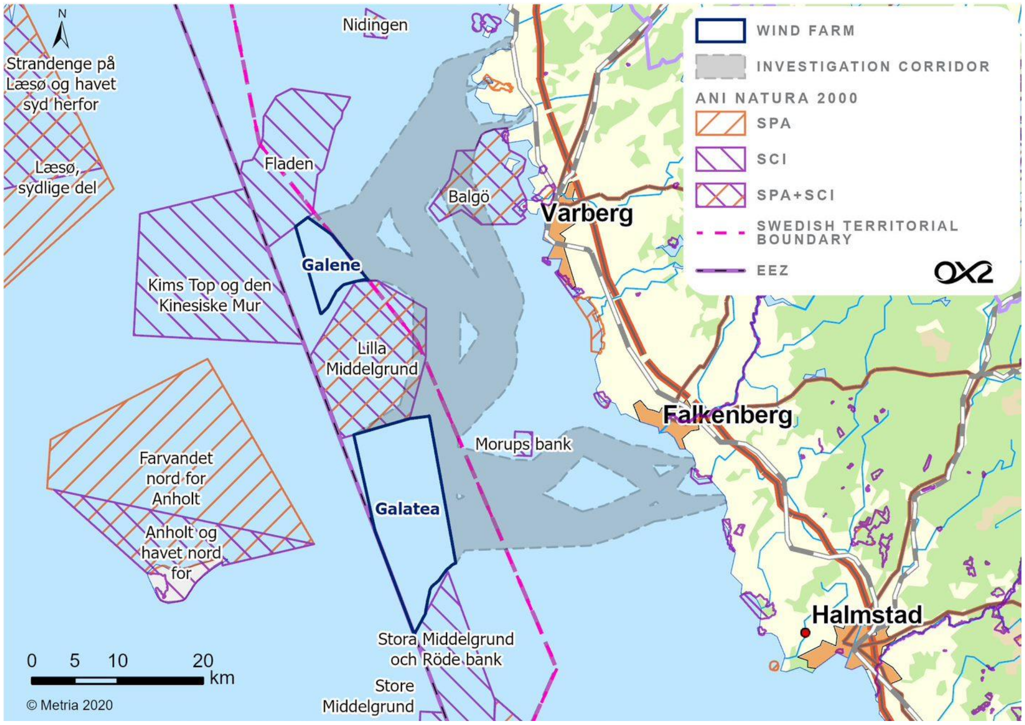

Figure 10. Natura 2000 areas (source: European Environment Agency).

Table 2 below lists designated species and natural habitat types for the Swedish Natura 2000 areas that are most likely to be affected by the project activities.

Natura 2000	Habitat type	Species
Fladen (SCI)	Reefs (1170), sandbanks (1110), Submarine structures made by leaking gases (1180)	Harbour porpoise (1351)
Lilla Middelgrund (SCI/SPA)	Reefs (1170), sandbanks (1110)	Common murre (A119), razorbill (A200), black-legged kittiwake (A188), harbour porpoise (1351)
Stora Middelgrund och Röde bank (SCI)	Reefs (1170), sandbanks (1110), Submarine structures made by leaking gases (1180)	Common murre (A199), razorbill (A200), harbour porpoise (1351)

Table 2. Designated species and natural habitat types in the Swedish Natura 2000 areas.

Table 3 below lists the designated species and natural habitat types in the Danish Natura 2000 areas located closest to Galatea-Galene.

Natura 2000	Habitat types	Species
Anholt og havet nord for	Sandbanks (1110), lagoons (1150), embryonic shifting dunes (2110), white dunes (2120), grey dunes (2130), decalcified fixed dunes with Empetrum nigrum (2140), dunes with Salix repens ssp. argentea (2170), wooded dune (2180), humid dune slacks (2190), coastal dunes with Juniperus spp. and bog woodland (91D0)	Grey seal (1364) and harbour seal (1365)
Farvandet nord for Anholt		Common eider (A063), common scoter (A065), velvet scoter (A066)
Store Middelgrund	Sandbanks (1110), reefs (1170), submarine structures made by leaking gases (1180)	Harbour porpoise (1351)
Kims top og den kinesiske mur	Reefs (1170), submarine structures made by leaking gases (1180)	

Table 3. Designated species and natural habitat types in the Danish Natura 2000 areas (from Natura 2000-planer 2016–2021 Miljøstyrelsen).

4.1.2 Fish

Galatea-Galene is situated in a recruiting area for commercially valuable species, among them cod. Galene overlaps a spawning ground for cod, while Galatea only overlaps marginally in its eastern section. The area mostly consists of soft seabed which is reflected in the occurrence of several species of flatfish. Other common species are the greater weever, Atlantic herring and European sprat.

4.1.3 Birds

The Kattegat is a famous wintering area for, *inter alia*, common murre and razorbill, which outside their breeding season live a pelagic life where they gather on shallow areas to forage during the winter months. Both species are classified as “least concern” (LC) in the Swedish red list (2020) (Sw. *Artdatabanken*), and populations are increasing in number. The nearby shallow sea areas of Lilla Middelgrund, Stora Middelgrund, and Röde bank are used as halting and wintering areas for several species, among them common murre and razorbill, which, moreover, are designated as especially worthy of protection for these areas.

4.1.4 Marine mammals

Harbour porpoises are found in the area all year round and are a designated species in all adjacent Swedish Natura 2000 areas as well as in the Danish Natura 2000 area of Store Middelgrund. There are three genetically divergent populations in Swedish waters – the Skagerrak population, the Belt Sea population, and the Baltic Sea population, of which the Skagerrak and the Belt Sea population occur in the area. In the Swedish red list (2020) the harbour porpoise is classified as “least concern” (LC) . The biggest threats for the harbour porpoises are by-catches in fishing, environmental toxins, underwater noise and a reduced availability of prey. The Belt Sea population has been estimated to be approximately 42,000 individuals and the Skagerrak population approximately 32,000 individuals(Hammond et.al., 2017).

Studies of satellite tracked harbour porpoises show that the distribution of the high-density areas in Kattegat has changed to some extent over time. Harbour porpoises belonging to the Belt Sea population showed higher relative densities in the deeper part of Kattegat (from Stora Middelgrund, east of Anholt and north of Anholt) during year 2007-2016 than year 1997-2006 (figure 11, Svegaard mfl., 2018).

Corresponding studies of harbour porpoises from the Skagerrak population show that they also use the northern parts of Kattegat (figure 12).

Two seal species occur in the Kattegat, the grey seal and the harbour seal. The grey seal occurs above all along the Swedish east coast and is rare in the Kattegat, where the harbour seal is significantly more common. Both species are classified as “least concern” in the Swedish red list (2020). One of the region’s largest colonies of harbour seals can be found on the Danish island of Anholt, approximately 17 kilometres west of Galatea, and both Lilla Middelgrund and Fladen are significant foraging areas for the seals. In both the Swedish Natura 2000 area Balgö, 21 kilometres east of Galene, and in the Danish Natura 2000 area Anholt og havet nord for, grey seal and harbour seal are designated species in the area’s preservation plans.

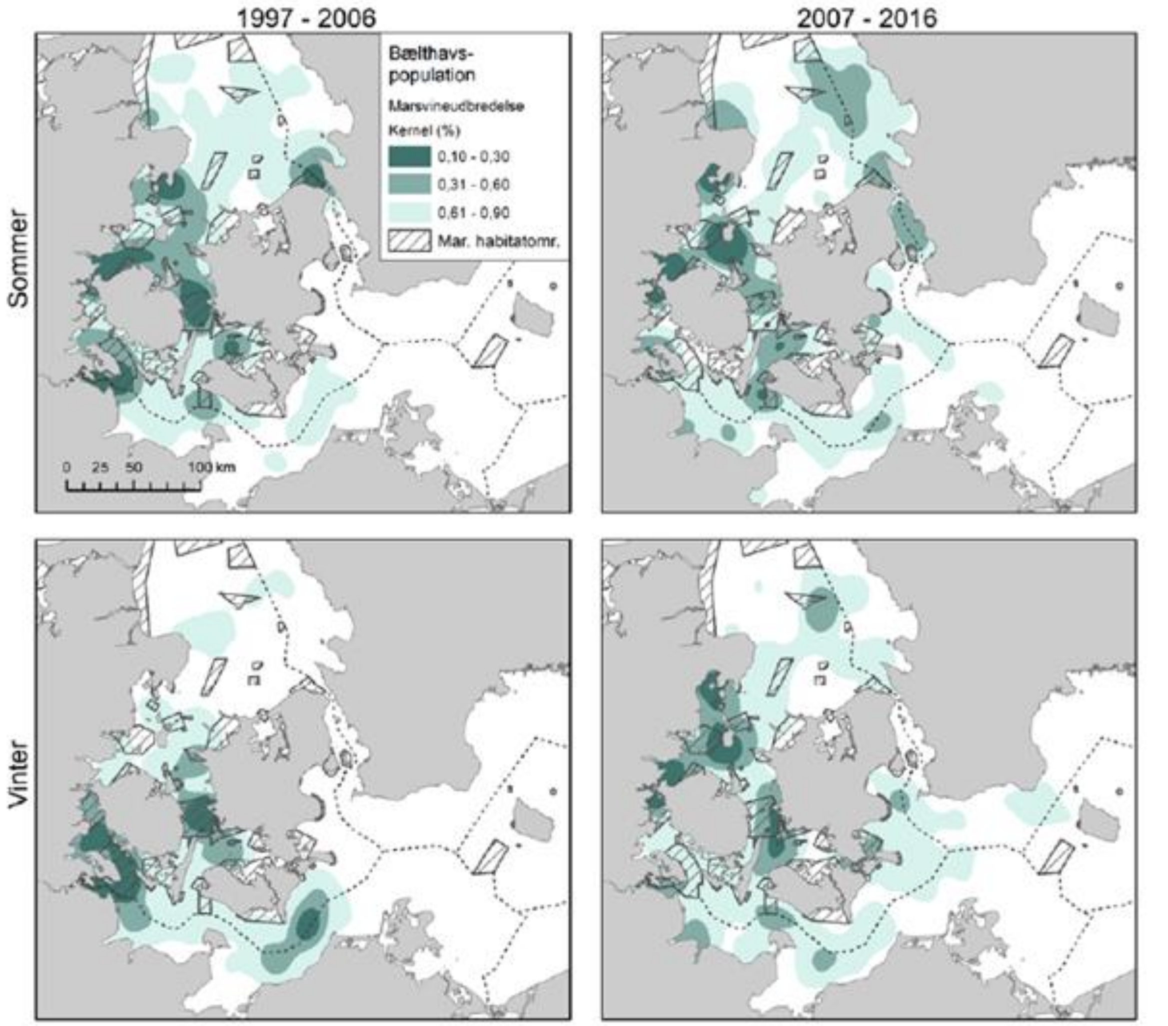

Figure 11. Distribution of satellite tracked harbour porpoises in the Belt Sea administrative area analysed as Kernel densities (the darker colour, the higher densities) for ten-year periods over seasons (from Svegaard et.al., 2018)

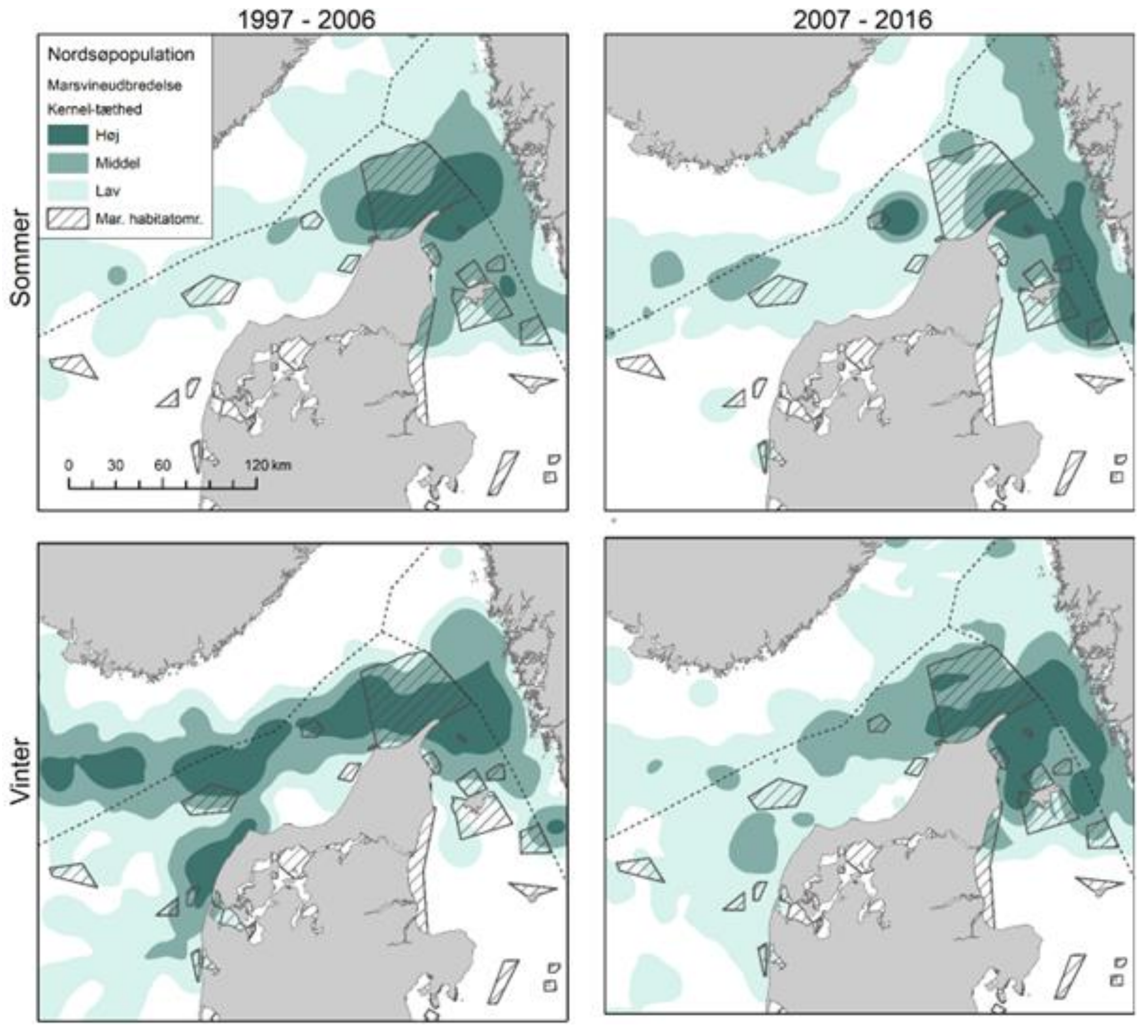

Figure 12. Distribution of satellite tracked harbour porpoises in the North Sea and Skagerrak analysed as Kernel densities (the darker colour, the higher densities) for ten-year periods over seasons (from Svegaard et.al., 2018)

4.1.5 Bats

Due to Galatea-Galene's location far out at sea and the absence of land, there are no reported observations of bats in the area. A search for bats in the Swedish species observation system (Sw. *Artportalen)*, conducted between the years 2000 and 2020 in Halland County, shows that the northern bat is the most commonly observed species in coastal areas. This species is presumed to be Sweden's and northern Eurasia's most common bat (IUCN 2018) and has also been shown to be a bat species that is believed to be attracted by wind turbines (Rydell et al. 2017). Bats may fly far out to sea during their seasonal migration and have been observed foraging up to 14 kilometres from the coast (Ahlén et al. 2009), but never as far out as the location of Galatea-Galene.

4.1.6 Ecosystem/green infrastructure

An ecosystem service refers to a product or service that the nature's ecosystem provides to humans and which contributes to our welfare and quality of life. Examples include natural water regulation, natural recreation and natural resources. Green infrastructure is defined as ecologically functional networks of habitats, structures and nature areas, as well as those elements that help to provide different ecosystem services. Both the wind farm and its cable corridors affect ecosystem services that contribute to recreational values such as outdoor life, bird-watching and recreational fishing. Natural resources are also exploited in the area in the form of commercial fishery.

4.1.7 Marine archaeology

Galatea-Galene is located far out at sea and is completely devoid of cultural environments typical of land areas. No known ancient remains are registered in the location. In the Swedish National Heritage Board's (Sw. *Riksantikvarieämbetet*) Fornsök database, which contains information on all known and registered historical remains and other cultural history remains, wrecks are registered in the proposed cable corridors (figure 13).

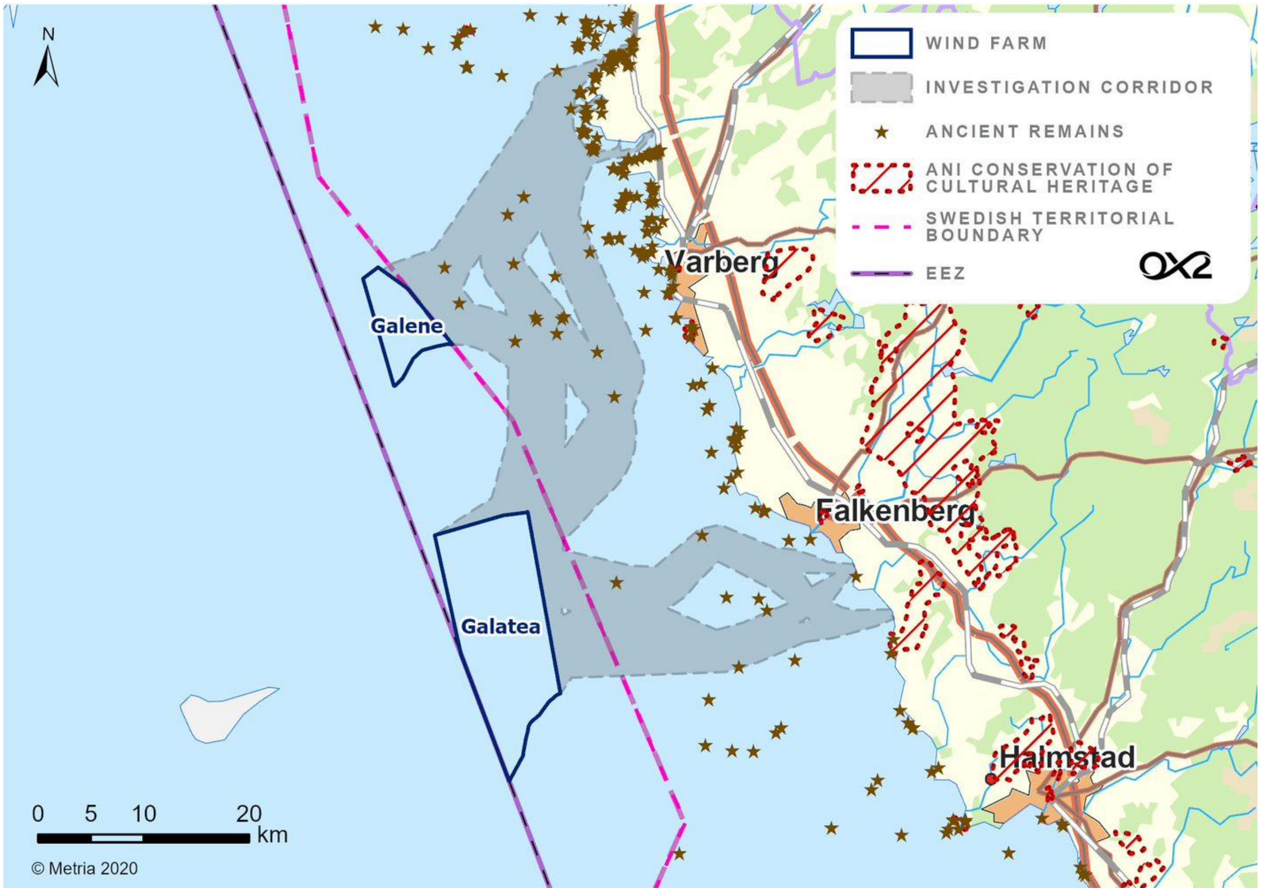

Figure 13. Areas of significance for heritage protection and existing historical remains in the immediate area.

4.2 Infrastructure and planning situation

4.2.1 Shipping

There is intensive ship traffic in the region, including both heavy shipping and fishing vessels. No shipping lane of significance or area designated for navigation by the marine spatial plan overlaps with Galatea-Galene’s wind farm area. Two larger shipping lanes are, however, located adjacent in the east and the west, see figure 14. The proposed cable corridors also cross existing shipping lanes. AIS data from 2017 and 2018 indicates that the highest concentration of traffic is located in the shipping lanes, but also that ship traffic occurs in the whole immediate area, including the planned wind farm area.

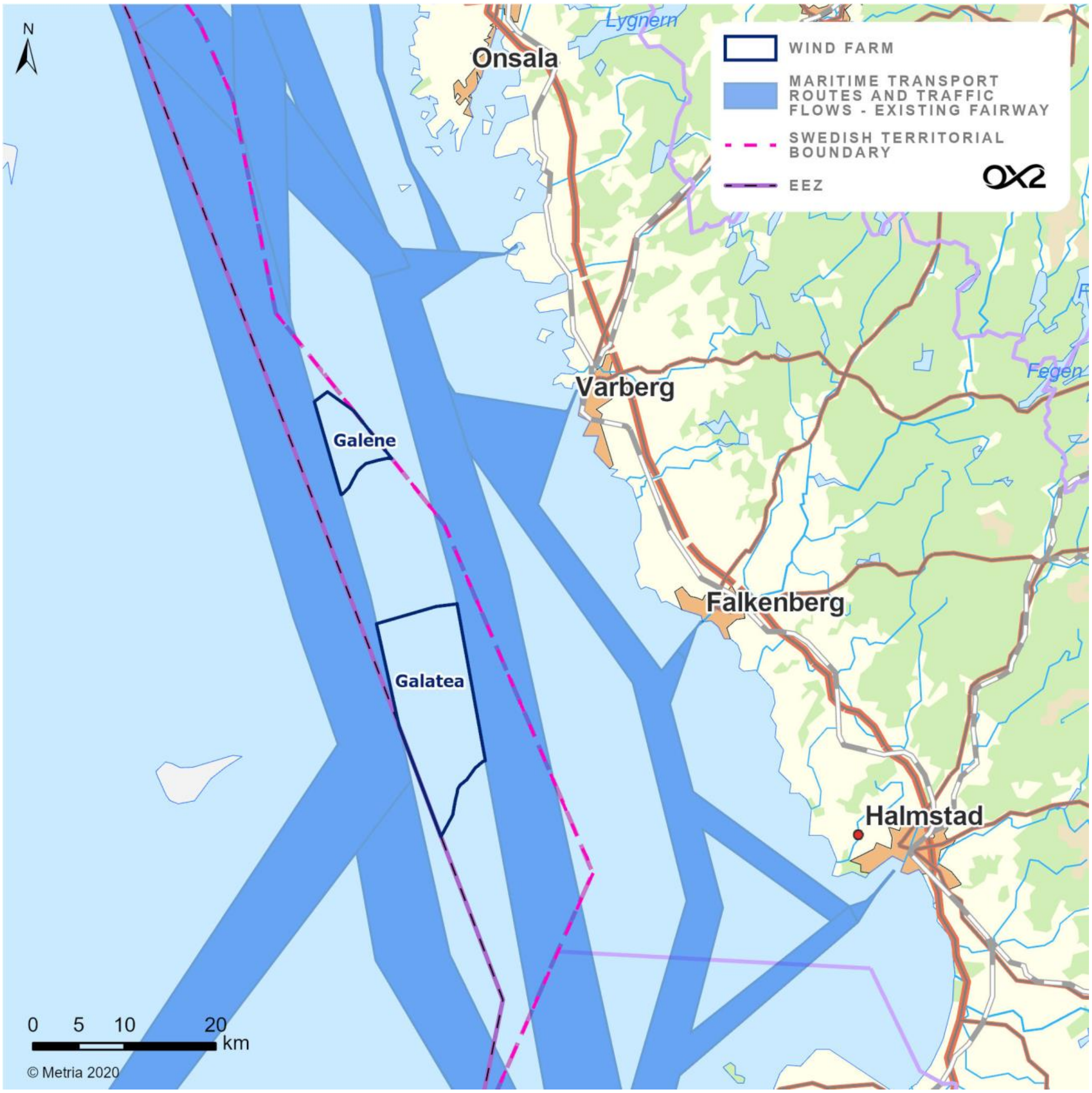

Figure 14. Fairways.

4.2.2 Aviation

Galatea-Galene is situated in the peripheral part of Halmstad airport's MSA area (Minimum Sector Altitude) (figure 15). The MSA area consists of a circle with a diameter of 55 kilometres and the airport in the centre. The MSA circle is further divided into four sections, where the lowest permitted flight altitude is 300 metres above each section's highest physical point. Airplanes have, in other words, a safety margin of 300 metres above the highest object in each section.

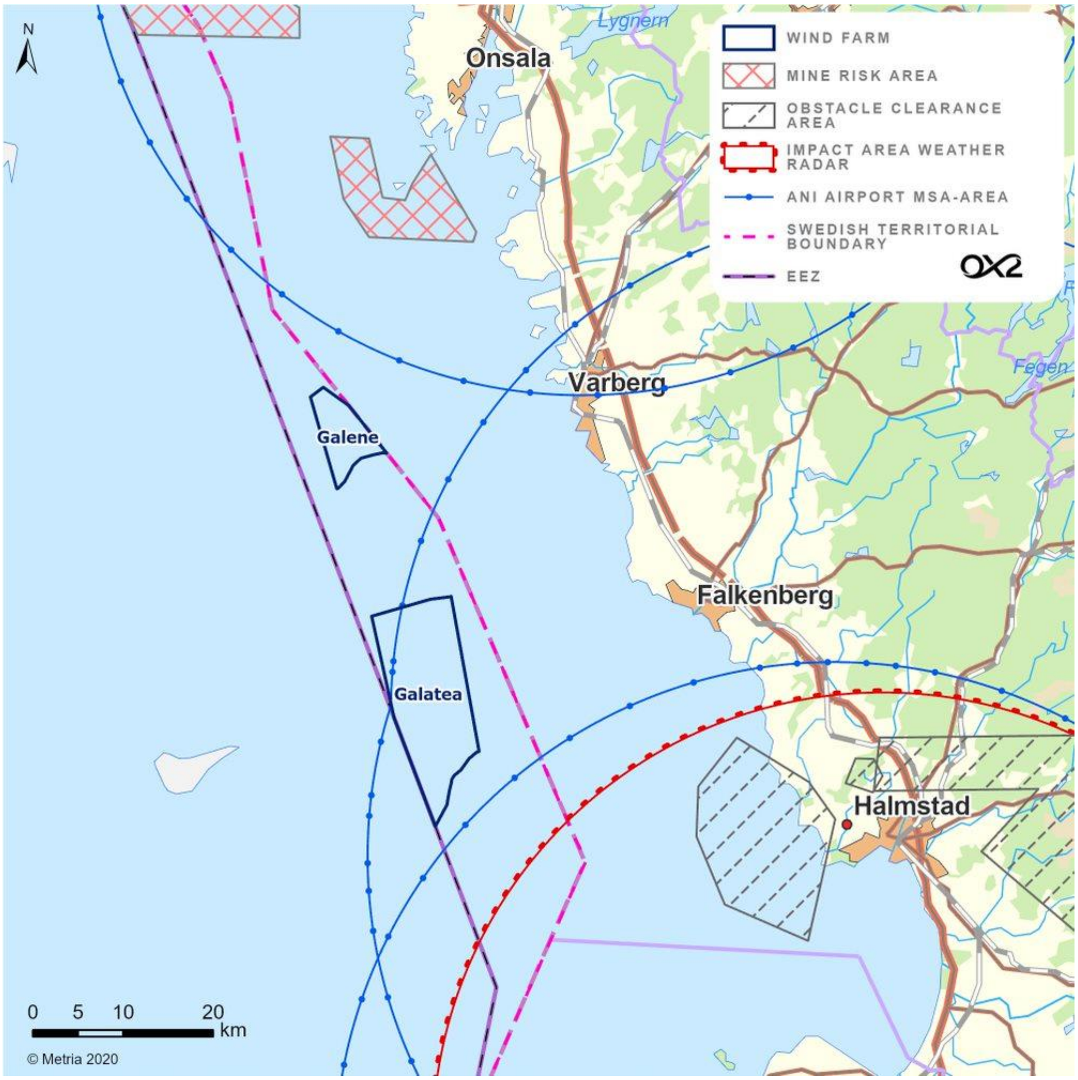

Figure 15. The Swedish Armed Forces' areas of significance, as well as the MSA areas of civil airports and existing/ planned wind farms.

4.2.3 Military areas

Galatea-Galene does not overlap with any designated military areas. By Ringenäs, approximately 30 km south-east of Galatea, there is a military area in the form of a marine training area.

4.2.4 Environmentally hazardous objects and dumping areas (mine risk areas)

There are a large number of shipwrecks along the Swedish coast. Most of these do not constitute any threat towards humans, flora or fauna but some are classified as environmentally hazardous as they contain environmentally hazardous substances. In the central parts of the Galatea subarea, there is a wreck that has been classified as environmentally hazardous by the Swedish Maritime Administration (Sw. *Sjöfartsverket*) due to its content of oil and petrocoal, a substance used in the production of aluminium. The vessel sank in 1998 and its position on the seabed is well known. There are no other known environmentally hazardous objects or dumping areas in the wind farm area or the proposed cable corridors. HELCOM classifies the area as a low risk area for naval mines, which is representative for the Kattegat in general.

4.3 Wind farms in the region

An existing offshore wind farm, Anholt, is located in Danish waters approximately 45 kilometres west of the Galatea-Galene area. The wind farm by Anholt consists of 111 wind turbines and has been in operation since 2012. Two other existing wind farms in the Kattegat are the Danish Frederikshavn Offshore (three wind turbines), approximately 80 km south west of the Galene subarea, and Tuno Knob (ten wind turbines), approximately 130 km south-west of the Galatea subarea.

Furthermore, two additional wind farms are planned in the Kattegat. Kattegatt Offshore is being developed by Favonius AB and is planned to be located approximately 15 kilometres east of the Galatea subarea. Stora Middelgrund is being developed by Vattenfall AB and is located directly south of the Galatea subarea (figure 16).

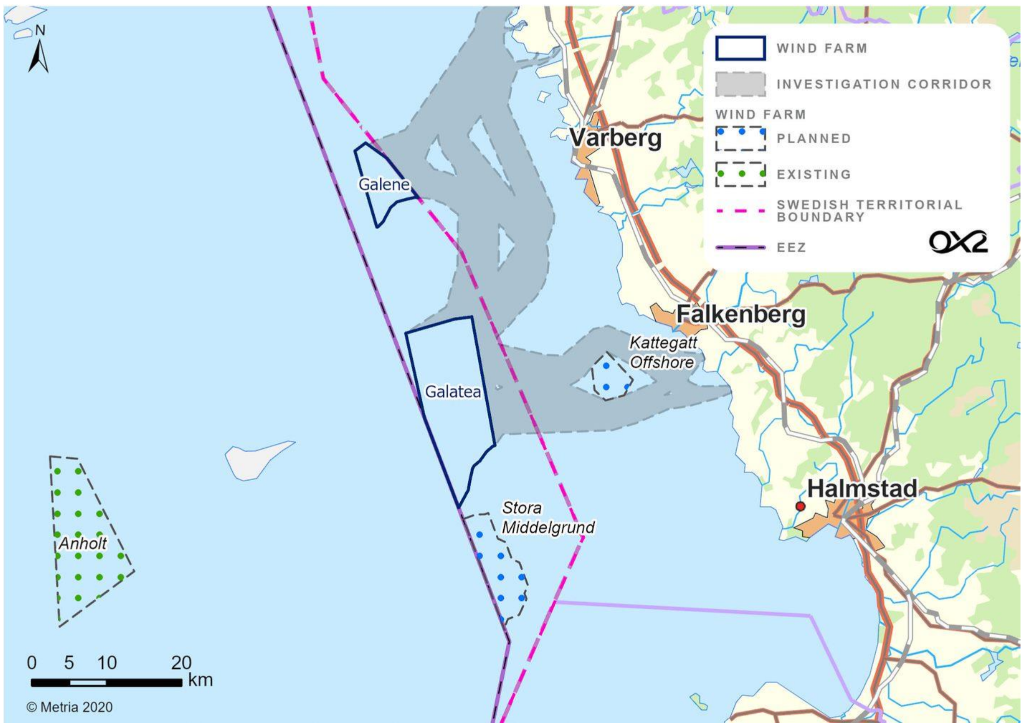

Figure 16. Existing and planned wind farms in the vicinity of Galatea-Galene (source: EMODnet).

5. Anticipated environmental impact

5.1 General

The impact of offshore wind power can be divided into three phases: the construction phase, the operational phase and the decommissioning phase. Under the construction phase, the impact on marine life is in general the greatest since construction work can cause underwater noise, spread sediment and introduce new habitats. This section addresses the anticipated significant environmental impacts which the Galatea-Galene wind farm may entail.

5.2 Natural environment

5.2.1 Natura 2000 areas

Galatea-Galene is adjacent to the Swedish Natura 2000 areas of Fladen, Lilla Middelgrund, and Stora Middelgrund and Röde bank. The closest located Natura 2000 areas on the Danish side are Kims Top og den Kinesiske Mur, Farvandet nord for Anholt, Anholt og havet nord for and Store Middelgrund. Potential impacts are primarily linked to the construction and decommissioning phases in the form of sediment spreading and underwater noise. During the operational phase, no impact is anticipated since the wind farm is located outside all the Natura 2000 areas. Protective measures will be applied during the construction and decommissioning phases to ensure no significant impacts on the adjacent Natura 2000 areas. The most appropriate protective measures will be investigated and assessed during the drafting of the environmental impact assessment.

5.2.2 Seabed flora and fauna

Flora and fauna living in and on the seabed can be affected by various elements associated with the establishment of wind power. Arguably the most apparent example is the spreading of suspended particles during the construction phase, which can cause algae, plants and animals to be covered by sediment. The spread of sediment is largely dependent on the seabed substrate, water currents and the type of foundation that is used. Hardbottom species of algae and filter feeding animals can be negatively affected by overlay of large amounts of suspended particles. In general, sedimentation is considered to have a limited impact on softbottom invertebrates as suspended particles occur naturally in areas characterised by sand and mud. Animals that have adapted to live buried under the seabed (infauna) manage better than organisms that live on the seabed (epifauna) (Bergström et al. 2012).

Video investigations have shown that the area is heavily affected by bottom trawling. Since many benthic organisms are sensitive to this, the establishment of a wind farm can have a preservation effect if fishing is regulated in the areas. The foundations may, however, bring about a change in natural habitats and therethrough locally displace some species. Since the total area affected by this is very small, this risk is estimated as low and can furthermore be counterbalanced by the positive effect of reduced bottom trawling. Once the foundations are installed, they also offer access to hard substrates which are underrepresented in these areas. The foundations thus create conditions for the establishment of hard substrate species and by doing so potentially contribute to a reef effect.

Seabed flora and fauna in the area will be further described in the upcoming environmental impact assessment. Modelling of the sedimentation will also be run to estimate the patterns of the sediment spreading in relation to the construction of the wind turbine foundations.

5.2.3 Fish

Galatea-Galene is a potential spawning area for several fish species. During the construction phase, there is above all the risk of impact on fish egg, juvenile fish and larval stages as sedimentation may result in mortality if suspended particles are caught on gills or cover eggs.
During the drafting of the environmental impact assessment, noise analyses and models of sedimentation will be conducted to further investigate potential environmental impacts on fish and to examine suitable protective measures.

5.2.4 Birds

The impact of wind power on birds is usually considered on the basis of three factors. The first is the risk of collision, whereby birds are at risk of injury or impact if they accidentally fly into one of the wind turbines' rotor blades. The second is the loss of habitat, whereby a species is driven away from its habitat because of changed conditions in the area. The third factor is the barrier effect, whereby the wind farm poses an obstacle to passing birds. This impact is greatest if the wind farm is built close to an existing bird colony, but decreases significantly further out to sea, where there are fewer birds.

The impacts of these three factors vary considerably between different wind farms and different groups of species. Some species of bird have a strong evasion for offshore windfarms such as loons, northern gannets *Sula bassana*, great crested grebe *Podiceps cristatus* and northern fulmar *Fulmarus glacialis*. For other species, avoidance have been observed to varying degrees and not as consistently, *e.g.* common scoter *Melanitta nigra*, long-tailed duck *Clangula hyemalis*, manx shearwater *Puffinus puffinus*, razorbill *Alca torda*, common murre *Uria aalge*, little gull *Larus minutus* and sandwich tern *Thalasseus sandvicensis*. Some species have been found to be barely affected at all by offshore windfarms or where the number of studies showing avoidance or attraction is roughly the same *e.g.* common eider *Somateria mollissima*, black-legged kittiwake *Rissa tridactyla*, common tern *Sterna hirundo* and artic tern *Sterna paradisaea* (Dierschke et.al., 2016). There are also species that show an attraction of offshore wind farms *e.g.* the red-breasted merganser *Mergus serrator*, several gull species and above all cormorants that are probably drawn to the foundations for seating space. Improved food availability, due to artificial reef effects and that commercial fishing is usually not taking place within wind farms, is also believed to be relevant to why mainly fish-eating birds are attracted to offshore wind farms (Dierschke et.al., 2016).

The short-term effects of offshore wind farms on shallow offshore banks are fairly well understood as many species are being displaced from their foraging areas. The effects of wind farms in deeper areas are less obvious. The risk of accidents for bird species passing the offshore wind farms is difficult to assess as data on offshore wind farm related mortality are deficient and can only be estimated with visual observations, radar studies and theoretical collision risk models. Species that avoid wind farms should reasonably have low accident rates, while species that do not avoid the wind farms may be killed in higher numbers (Rydell et.al., 2017).

During the drafting of the environmental impact assessment, a bird inventory will be conducted in the area in order to investigate the significance of the area for birds, the wind farm’s potential impacts on these and the most appropriate protective measures.

5.2.5 Marine mammals

During the construction phase, noise emissions may arise from several different sources, including *inter alia*, vessels and construction work. The noise level generated during the construction work depends on the type and dimension of the foundations being installed.

The impact of noise on marine mammals depends on several different factors, among them the intensity of the sound and frequency, whether the source of the noise is impulsive or continuous, the salinity of the water, the seabed conditions, the type of foundation that is to be installed, the distance to the noise source and the organism’s hearing range and sensitivity. The harbour porpoise has a well-developed auditory sense which makes it very sensitive to noise disturbance.

Seals are not as sensitive to noise and no considerable long-lasting impact has been shown in connection with the establishment of wind power. Noise during the construction phase can, however, also disturb seals, primarily during critical periods such as mating.

The occurrence of harbour porpoises in Galatea-Galene will be further investigated through acoustic monitoring prior to completion of the environmental impact assessment.

5.2.6 Bats

Since Galatea-Galene is located over 20 km from the coast, the probability of bats using the area for foraging is estimated as low. Offshore wind turbines may constitute a collision risk for bats during the *operational phase,* but there is a lack of data for this. Bats migrate during short periods twice a year (spring and fall) during calmer wind conditions when most wind turbines are not in use. Many migrating species also fly lower than the expected clearance of the wind turbines There is therefore no expectation that the operational phase will have an impact on bats. Unlike birds, however, observations indicate that bats migrate in broader transects with a low density of individuals. The potential impact on bats will be described in further detail in the environmental impact assessment.

5.3 Ecosystem/green infrastructure

Several different types of ecosystem services can be expected to develop around the wind farm, the extent depending on different factors such as the type of foundation, currents and depth. Reef formation around the foundations leads to the settlement of filtering organisms which creates a potential *regulating ecosystem service* in the form of improved water quality (McLaughlan and Aldridge 2013). Protection against erosion around the foundations form cavities for crabs and lobsters, which becomes a providing ecosystem service for the fishery (Hammar et al. 2008). The increase in filtering and photosynthetic organisms around the foundation contributes to an enrichment and aggregation of fish, which is a method used by the commercial fishery (Grove et al. 1989). The enrichment of fish then becomes a providing ecosystem service for the area. Improved habitats for commercial species in combination with reduced trawling would favour the coastal fishery, which could also constitute an important cultural ecosystem service for the local area.

5.4 Residential environment and landscape view

Residents close to a wind farm can be negatively impacted through the changed view of the landscape, the noise emitted by rotor blades or other reasons that lead to the wind farm being experienced as a negative element in the environment by some people. Galatea-Galene is, however, offshore, far away from residential areas and other buildings. Neighbours, visitors and tourists in the harbours used during construction and operation of the wind farm may temporarily be affected by an increased traffic flow and additional noise.

The impact an object has on the landscape view is primarily determined by the size of the object, its design and its distance from the viewer. For offshore wind power, it is therefore the design, size, location, colour, lighting, and distance from the coast that are relevant for the impact on the landscape view. Increased distance means a smaller impact. At a great distance, wind turbines constitute an insignificant part of the landscape view. Further, rapid rotation of the rotor blades can be perceived as disturbing, but this effect declines with an increased size of the wind turbines.

Galatea-Galene is located far out at sea, over 20 km from the Swedish mainland and more than 17 km from the Danish island of Anholt. The establishment of wind power is therefore estimated to have an insignificant impact on the landscape view, even though the wind turbines will be visible in clear conditions.

During the drafting of the environmental impact assessment, a photomontage will be developed to more thoroughly evaluate the potential impact on the landscape view.

5.5 Cultural environment

5.5.1 Marine archaeology

Investigations of the seabed will be conducted to search for potential obstacles, wrecks and historical remains. The collected information from the investigations will be analysed by marine archaeological experts to identify potentially important marine archaeological objects. Identified objects will then be more closely investigated, through *inter alia*, underwater video to avoid potential impacts in connection with construction and decommissioning. The operational phase is not anticipated to have any impact on potential marine archaeological findings.

If previously unknown wrecks or other cultural heritage remains are found in connection with the investigations, the Swedish authorities will be notified in accordance with the Swedish Heritage Conservation Act (Sw. *kulturmiljölagen (1988:950)*).

5.6 Recreation and outdoor life

Recreation and outdoor life at sea may be impacted during construction and decommissioning due to increased vessel traffic, noise and barriers. During construction and decommissioning, recreational crafts may have to take detours because of the barriers, but since the wind farms do not overlap with any designated shipping lanes, this impact is also deemed to be limited. The distance to the coast will further limit the wind farm's negative impact on outdoor life. During the operational phase, the wind farm may contribute to favourable recreational fishing as the foundations can attract fish from areas close by and because regulation of bottom trawling within the wind farm area decreases large-scale fishing pressure.

5.7 Natural resource management

5.7.1 Fishing

The Galatea-Galene area is used by commercial fishing vessels. During operation, bottom trawling will likely be restricted to within the farm area, which may have an impact on the fishing industry. During the construction and decommissioning phases, vessel traffic is expected to increase temporarily, which may also influence commercial fishing in the area.

5.8 Environmental quality standards

The establishment of the Galatea-Galene wind farm is not expected to negatively influence the environmental quality standards of the surrounding bodies of water. Neither are the activities expected to make it more difficult to improve the status of the environmental quality standards. A closer description and evaluation of potential impacts will be included in the upcoming environmental impact assessment.

5.9 Climate

The construction of a wind farm, involving the production of wind turbines and other equipment, transport of material and installation means that some emission of greenhouse gases cannot be avoided. During decommissioning, the project will again have some impact related to decommissioning vehicles etc., but these activities are limited in time and extent. During the operational phase, however, Galatea-Galene will contribute to achieving Sweden's climate target of zero net emissions by 2045. The wind farm's annual energy yield is calculated to be approximately 5,000 GWh, which corresponds to the annual consumption of approximately one million households. In other words, wind power is a central part of the national strategy to limit climate change and ensure a shift to a renewable energy future.

5.10 Infrastructure and planning situation

5.10.1 Shipping

During the construction phase, shipping within the areas may potentially be affected due to increased vessel traffic and some barriers within the construction area. The disturbances will, however, be temporary and limited to the time of the construction work. Measures to minimise the impact will be scrutinised. Since Galatea-Galene is outside of any designated shipping lanes, the impact during the operational phase is anticipated to be limited.

5.10.2 Aviation

Wind turbines can in general impact airports' MSA areas.

An obstacle analysis will be commissioned from the Swedish Civil Aviation Administration (Sw. *Luftfartsverket)* to analyse how the planned wind farm may affect Halmstad airport. Other impacts on aviation will be analysed more closely during the drafting of the environmental impact assessment.

5.10.3 Military areas

No military exercise areas are located in the vicinity of the wind farm. Tall objects can in general have an impact on the Swedish armed forces' national interests, which will be scrutinised during the drafting of the environmental impact assessment.

5.11 Cumulative effects

Potential cumulative effects from other wind farms and other activities in the area concerning anticipated environmental impacts will be accounted for in the environmental impact assessment.

6. Potential transboundary impact

The anticipated transboundary impact will be evaluated and specified in the environmental impact assessment, which is drafted in accordance with article 4 of the Espoo convention. The main transboundary impacts that may potentially apply are set out below.

6.1 Shipping

The potential impacts raised in section 5.10.1 above may also have a potential transboundary impact, primarily in the form of a potential temporary impact on shipping in the area as a consequence of the increased vessel traffic and temporary barriers during the construction phase. As described above, Galatea-Galene is, however, located outside any designated shipping lanes, hence the anticipated impact during the operational phase will probably be limited.

6.2 Birds

There is a risk of birds being temporarily displaced from the area during the construction phase due to increased vessel traffic and noisy construction work. Further, there is a general risk of collision during the operational and decommissioning phases, as well as a risk of habitat loss and barrier effects. The impacts described in section 5.2.4 may extend beyond Swedish borders, considering that, *inter alia*, some designated bird species move over a larger area in the Kattegat.

Bird inventories will be conducted in the area to investigate the occurrence of birds and the area's significance for birds, the wind farm's potential effects on these, and the most appropriate protective measures to minimise the impact on birds.

6.3 Bats

The activities’ anticipated impact on bats are set out in section 5.2.6 above, and these effects may potentially also be relevant beyond Swedish borders. However, as concluded above, the probability that the area is used by foraging bats is estimated as low since Galatea-Galene is located over 20 km from the coast. Moreover, offshore wind turbines may constitute a collision risk during the operational phase, even if there is no evidence for this.

6.4 Marine mammals

Harbous porpoises are designated species in both the Swedish and Danish Natura 2000 areas. In addition, the grey seal and the harbour seal are designated species in the Danish Natura 2000 area of Anholt og havet nord for. Harbour porpoises and seals may be disturbed by noise emissions from different sources (*e.g.* vessels and other construction work) that can occur during the construction phase. The sound levels will depend on, *inter alia*, the choice of foundation. The impact on marine mammals depends on several different factors, set out in section 5.2.5, which are also expected to be relevant beyond the Swedish border.

6.5 Fishing

The area of the Kattegat where Galatea-Galene is located is subject to commercial fishing, which constitutes a potential impact on commercial fishery from neighbouring countries.

6.6 The landscape view

Galatea-Galene is located offshore, more than 20 km from the Swedish cost and 17 km from the Danish island of Anholt. As described in section 5.4 above, the establishment is anticipated to have an insignificant impact on the landscape view, even if the wind turbines will be visible in clear conditions. During the drafting of the environmental impact assessment, a photomontage will be produced to more thoroughly evaluate the potential impact on the landscape view.

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