ESPOO-report

Triton Wind Farm

10/02/2023

Administrative information

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Marine area concerned:	Swedish economic zone, south-west Baltic Sea
Permitting authority:	Swedish Government (Ministry of the Environment)

The report has been prepared as part of the consultation process according to the Espoo Convention. The report has been prepared by: Katarina Helmersson, Petra Adrup, Structor Miljöbyrån with contributions from Alva Jacobsson, Carina Lundgren, Kajsa Andersson, Structor Miljöpartner, Mathilda Karlsson, AquaBiota

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About the applicant

Tritonia Vindpark AB is a subsidiary of the OX2 AB (publ) Group. OX2 AB develops and sells wind farms and solar power plants. OX2 has developed and implemented large scale wind power plants of around 2.5 GW in Europe, and the company currently holds a strong project portfolio. OX2's project development portfolio amounts to more than 17 GW this year (2022) and consists of on- and offshore wind and solar power facilities. OX2 operates in Sweden, Finland, Poland, France, Lithuania, Norway, Spain, Italy and Romania, and its head office is located in Stockholm. Sales revenue in 2021 amounted to SEK 5 billion. OX2 has been listed on Nasdaq Stockholm's main market since spring 2022.

OX2's business objective is to contribute to the transition toward a renewable energy system with a net positive impact on natural capital by 2030. The aim is therefore that the wind farms and solar parks that the company develop, and build should create as much climate benefit as possible while protecting or strengthening biodiversity throughout the projects.

In line with its business objective, OX2 has developed a biodiversity strategy. In this, OX2 has worked on the goal of nature-positive wind and solar facilities by 2030. Despite the target being set at 2030, work has already begun. Contributing to biodiversity is an important part of the development of all OX2 wind and solar power projects.

Reader's guide

All underlying reports produced within the project framework are reference reports to this Espoo report and are referred to as R.1, R.2, R.3, etc. continuously in the text. Reference reports can be made available on request. A list of reference reports produced within the project framework is presented in connection with the appendix to this Espoo report, see page 14. The non-technical summary has also been translated into German and Polish, see Annex B.4.

Non-technical summary

Applicant company

Tritonia Vindpark AB, a subsidiary in the OX2 AB group (the applicant is referred to in this EIA as "OX2"), is planning a large-scale offshore wind farm within the Swedish economic zone in the south-west section of the Baltic Sea, off the coast of the Skåne region, known as Triton. The wind farm is planned to encompass up to 129 wind turbines with a total height of maximum 370 metres, and an estimated maximum delivered power of approximately 1,700–1,900 MW. The overall aim of the wind farm is to produce renewable electricity and thus contribute to the achievement of Sweden's energy and climate goals, and to provide society and industry, especially in southern Sweden, with competitive electricity.

This Espoo Report forms part of the consultation held by OX2 on the potential transboundary effects of the planned activities, in accordance with the Convention on Environmental Impact

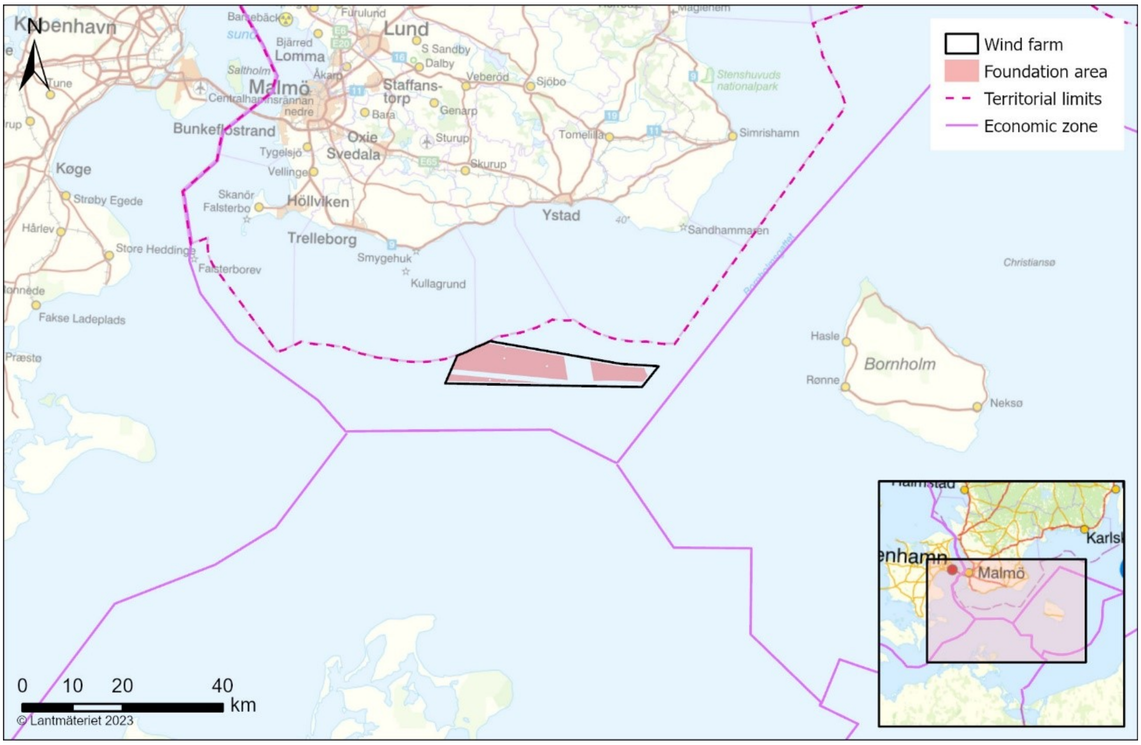
Assessment in a Transboundary context ("The Espoo Convention"). This report thus describes the estimated transboundary impact of the Triton wind farm.

Offshore wind power is evolving rapidly and there is continuous technical development, which means that more cost and environmental effective technologies gradually become available. The final design of the wind farm will therefore be determined on the basis of the most appropriate technology that is available at the time of procurement and construction, as well as on the basis of optimisation of energy production. The design of the wind farm, including the positioning of inter-array cables and transformer stations will be adapted to the site's conditions, including wind, climate, waves, water currents and geological properties.

Location and area description

The area for the planned Triton wind farm consists of open sea with no islands. The farm site is located about 30 kilometres south of Ystad. The distance to the German island of Rügen is 47 kilometres and to the German mainland is 80 kilometres, to Poland it is 130 kilometres and to Bornholm and to Zealand it is 37 and 66 kilometres respectively. The area is about 250 km^2 in size and the depth of water varies between 43 and 47 metres. The farm area consists almost exclusively of deep soft bottoms with mud and mud elements. The seabed that may be permanently affected by surface substrate changes in the wind farm is about 0.2% of the total surface area of the wind farm.

According to the Swedish marine spatial plan, the Triton wind farm is located in the outer offshore area of Bornholmsgattet, Ö267 with the designation "general use" (G). In the west, the farm borders to the Natura 2000 area Sydvästskånes utsjövatten (SE0430187), which are designated under the Species and Habitats Directive and are also of national interest. In the north and east the Triton wind farm borders to shipping lanes and national interest areas for shipping. The ferry route between Ystad and Germany and Poland runs through the eastern part of the farm area. The farm area partly overlaps with national interest area for two airports (so-called MSA areas for Malmö Airport and Bornholm Airport). A bit north of the planned wind farm lies the national interest area for commercial fishing in the form of fishing grounds. Two areas in the immediate vicinity are identified as national interest areas for energy extraction. The Triton wind farm does not adjoin any openly designated national defence areas, but the southern part of the wind farm adjoins an area used by NATO for military exercises.



Knowledge and investigations

Information from authorities, scientific literature and research results, environmental investigations, technical reports and site-specific inventory data has been used as a basis for descriptions and assessments in the Espoo report. Within the framework of the project, inventories have been made of, among other things, sea birds, porpoises and fish. Modelling and analysis have been conducted for propagation of the bottom fauna, sediment dispersion, sound propagation (under and above water), shadows and hydrography. Photo montage and graphic depictions have been created to visualise what the wind turbines will look like in the seascape. The results from the inventories and models conducted are in good agreement with the results from previous inventories and data. The knowledge base is considered to be robust and scientifically based and is of sufficient extent for qualified and reliable assessments of the influences and impacts of operations to be made.

Planned operations

Impact assessments have been conducted for all phases of the operation: Construction, operation and decommissioning. Assessment of the environmental impact on each environmental aspect has been made through a combined assessment of the sensitivity/value of the recipient and the extent of the assessed impact that may arise as a result of the activities.

Relevant impact factors assessed regarding transboundary impacts include effects of sedimentation, underwater noise impact, the spread of contaminants, barrier effects and displacement, shade and visual impact. In addition, risks and safety aspects have been assessed as well as the impact on shipping, national defence interests and commercial fishing.

The impact assessments in this Espoo Report have been based on a “worst-case scenario“. This means that the assessments of the impact of the planned activities on the environmental aspects have been based on the greatest possible impact. In reality, the influence and impacts are considered to be less than in the assessment.

Climate impact and climate benefit

The operation itself will lead to emission of greenhouse gases in the construction, operation and decommissioning phases, mainly from plant machinery, vessels and the manufacture of components. However, this climate impact is insignificant in relation to the emission reductions that wind power will bring during the operating period due to replacement of generation of electricity from fossil fuels. It is estimated that the Triton wind farm will provide 1.5 million households with renewable and fossil-free electricity. The wind farm is expected to form an important part of Sweden's and Europe's process of switching to renewable energy sources and contributing to the achievement of Sweden's and the EU's environmental and climate goals. In terms of the individual wind farm, the global impact is only slightly positive and with regard to the regional and national impact, the Triton wind farm will have a significantly positive influence with a very large positive impact for the climate in terms of replacing fossil electricity production and thus large-scale reduction of greenhouse gas emissions.

Bottom flora and bottom fauna

The seabed at the wind farm consists exclusively of deep soft bottoms and no bottom flora is expected to be found in the area. The bottom fauna of the area is dominated by animals that live buried in the sediment. The impact on the bottom fauna occurs mainly during the construction phase and is caused by sediment spreading and physical impact on the seabed when installing foundations and the inter-array cables. There may also be an impact from hydrographic changes, substrate changes and electromagnetic fields that can occur during the operating phase. Sediment spread arising from the installation of foundations and inter-array cables is limited in extent and time. The impacts of all influence factors are deemed to be negligible. The wind farm can also have a positive impact through the formation of artificial reefs and restriction of bottom trawling. The wind farm causes hard-seabed surfaces in the form of foundations and erosion protection to be created in a soft seabed area. Such structures are well known to attract a rich fauna, as they create the conditions for so-called artificial reefs where hard-bottom species can establish themselves.

No physical intrusion is made into Danish, German or Polish waters. The transboundary impact that can occur on bottom fauna and flora occurs mainly during the construction phase from sediment spread during installation of foundations, but the distances to Danish, German and Polish waters are great. Sediment spread that occurs when installing foundations is limited in extent, time and is very local. The transboundary impact is therefore considered to be insignificant and the impact negligible. The wind farm can also have a positive impact through reef effects and restriction of bottom trawling.

Fish

The most common species in the park are herring, sprat, cod, flounder, plaice, dab and whiting. Cod spawning takes place in the Arkona basin, but the farm site is not part of the main spawning grounds for cod. The impact on fish occurs mainly during the construction phase and is caused by sediment spread and subsea noise when installing foundations and the inter-array cables. Silencing and other mitigatory measures will be used to protect fish during impact piling for foundations. During the operating phase, the electromagnetic field from the cables may affect fish. During the operating phase, the electromagnetic field from the cables may affect fish.

The transboundary impact on fish can occur mainly during the construction phase from sedimentation and subsea noise from installation of foundations. The impact on fish is considered to be very local and there is no transboundary negative impact. The wind farm can also have a positive impact through reef effects and restriction of bottom trawling.

Marine mammals

Three species of marine mammals are present in the wind farm area; porpoises, common seals and grey seals. The farm area is not considered to be an important habitat or spawning ground for porpoises, which mainly consists of the Danish Straits population. The farm area is of low/moderate importance to common and grey seals because neither of the species use the area as a particular foraging area. The transboundary impact on marine mammals is expected to occur mainly during the construction phase as a result of subsea noise during geophysical surveys and foundation impact piling. In addition to this, there may be some impact from displacement and sedimentation. Far-reaching safeguards will be taken in the case of impact piling and seismic investigations to avoid injury or disturbance, including acoustic methods, soft start-up and sound-damping equipment (double bubble curtain and *Hydro Sound Damper*, or equipment with equivalent effect). No significant impact is expected to occur on marine mammals during the operational phase. All in all, the activities are assessed to have negligible to little impact for porpoises and seals.

Bats

Bats are not expected to use the farm area as a foraging area, because of the long distance to the closest coast (between 20 and 30 kilometres). Bats migrate across the Baltic Sea during spring and late summer/early autumn, usually in calm weather. In the case of the Triton wind farm, it is mainly migratory bats that can potentially be affected by increased risk of collision with the wind turbines. Once the wind farm is established, the bats' activity in the wind farm will be investigated and, if necessary, measures will be taken in the form of operational regulation in the event of significant migration to minimise the risk of collision. Taking into account the fact that these safeguards are being applied, the transboundary impact of the activity on bats is deemed to be insignificant, with negligible impacts.

Birds

The Triton wind farm area is not an important habitat for seabirds and few species of birds forage in the area. Nor is the wind farm on a route that birds frequently travel. The transboundary impact of the wind farm in the form of displacement and barrier effects is assessed to be insignificant, with negligible impacts on birds. A significant migration of birds takes place across the sea between the south coast of the Skåne region and the German Baltic coast, which may present a risk of collision with the wind turbines. However, most of the birds passing the Triton wind farm fly higher than the overall height of the wind farm and will avoid collision. Raptors fly over the sea in the Arkona Basin in relatively low numbers because the migration is concentrated on the Falsterbo peninsula and further north in the narrowest part of Öresund. A majority of the Swedish-Norwegian population of cranes overfly the Arkona basin during migration in spring and autumn. The collision risk modelling conducted shows that the impact of collision risk is small for cranes, and overall negligible for other bird species flying through or within the farm area. In order to minimise the impact on migrant cranes, the wind farm will be equipped with monitoring and operational control equipment to allow operation of the turbines during periods of intensive migration. These safeguards will reduce the risk of collision for the cranes and the impact is then deemed negligible.

Landscape and cultural environment

The distance between Sweden's coast and the Triton wind farm is relatively large, between 20 and 30 kilometres, and the visual impact and negative consequences for the landscape and heritage environment on the Swedish coast are assessed to be largely negligible or small, but moderate from a couple of the more sensitive environments. From a transboundary perspective, it is primarily Bornholm that is deemed to be at such a distance that the landscape can be significantly affected by the Triton wind farm, coastal distances from Germany and Poland are assessed to be at such distances that the wind farm does not affect the landscape.

Three viewpoints from Bornholm, at Rønne, Hasle and Hammershus, have been chosen to visualise the change that future wind power expansion will bring to the seascape. From Rønne, the wind farm will be seen in a relatively narrow sector on the horizon and will be seen as a single group. Port facilities and ship traffic to and from the port of Rønne create both static and moving elements in the seascape to which the eye is drawn. All in all, the influence on Rønne is estimated to be insignificant and the impacts for the seascape and the heritage environment negligible.

At Hasle the Triton wind farm will be visible over the horizon in the west. The Triton wind farm will be perceived as a group and is assessed to be subordinate to the seascape. All in all, the influence is deemed to be small and the impacts for the seascape and heritage environment are very small.

A slightly larger part of the wind farm will be visible from Hammershus as the viewer is over 70 metres above sea level compared to views from viewpoints at similar horizontal distances with an eye level only a few metres above sea level. The fortress ruins dominate while the wind turbines are seen in the background along the horizon. However, wind turbines as a group within a limited sector are still deemed to be minuscule in the vast seascape. All in all, the influence on the area's high heritage values and landscapes is assessed to be only slightly negative and the impacts moderate.

Residential environment and recreation

The wind farm is located far from the coast and residential areas, and in an area without any high value for outdoor activities and recreation. Recreational boat traffic, recreational fishing and diving may, however, occur in the area, albeit to a limited extent. During the construction and decommissioning phase, recreational fishing and divers will not, for safety reasons, be allowed to use certain areas in which work is taking place. This has only a temporary influence and will not involve the whole farm area at the same time, so the impacts are deemed to be small. During the operational phase, the area will be available for recreational fishing and diving, and the reef effect can then have a positive impact on these interests.

The transboundary impact is expected to arise mainly during the construction phase in the form of limited access for boat traffic within the wind farm area. Recreational fishing and recreational boat traffic can continue as usual during the operational phase. The wind farm is not located in an area of high value for outdoor activities and recreation, and recreational fishing within the wind farm area is limited. The transboundary impact on recreation and outdoor activities is assessed to be insignificant, with negligible impacts.

Commercial fishing

The farm area houses some valuable fish resources, in particular herring, sprat and cod. Fishing in the area has declined sharply in recent years, and there is also a ban on fishing for both cod and herring. Transboundary fishing from Poland, Denmark and Germany may be affected by the fact that a reduced catch area is created in the area of activity when the wind farm is established. The main type of fishing that could be affected by the Triton wind farm is considered to be bottom trawling for flatfish. However, this type of fishing represents a very small part of total fish catches and is also deemed to be capable of relocation. The local impact caused by the wind farm in the form of reduced surface area available for bottom trawling is currently considered to have very little impact on the commercial fishing industry. In addition, additional reef effects and reduced fishing pressure could, in the long term, improve the status of stocks of commercially important fish species, which in the long term also benefits the fishing industry.

The Danish, German, Polish and Swedish fishing industries will be affected locally by the wind farm in the form of longer transport routes and fewer or reduced fishing areas. The overall assessment is that there is little transboundary impact on the fishing industry, with slight negative impacts, as there are, among other things, good opportunities for redistributing fishing.

Maritime activities

The farm area is surrounded by shipping routes with international traffic to the north, east and south of the area. A ferry route between Ystad and Poland passes through the farm area. These shipping routes are also areas of national interest for shipping. There will be a certain risk of conflict with installation vessels and other vessel traffic during the construction phase and of incorrect entry into the working area. During the operational phase, wind farms may increase the risk of collisions between vessels and allisions with the wind turbines, which is considered to have moderate adverse consequences for shipping. Wind turbines can also cause radar interference. The wind farm can facilitate emergency response in the event of an accident due to the continuous monitoring of the farm and improved access to rescue equipment and personnel within the area. OX2 will take a number of measures to maintain safe navigation and reduce risks, including the monitoring of maritime traffic by a project-bound marine coordinator, a construction protection zone and the observance of safety distances between wind turbines and shipping routes. With the planned mitigation measures, the increase in the probability of accidents is expected to be significantly reduced. The final design and implementation of the necessary safety measures to ensure good maritime safety will be conducted after consultation with the maritime authorities.

As can be seen above, the wind farm will affect shipping, and also international traffic, with a transboundary impact. With various measures being introduced during both the construction and operational phases, the risks will be reduced to a level that can be defined as ALARP, *as low as reasonably possible*. The sensitivity of maritime traffic to vessel accidents may be seen as high, but the influence is deemed to be Insignificant, which implies negligible impacts.

Aviation

The farm area overlaps with areas that make up areas in which restrictions apply due to obstacles (so-called MSA areas) for Malmö Airport and Rønne/Bornholm Airport, respectively. The company is engaged in a dialogue with the airports concerned on the modification of the

MSA areas in order to avoid any impact on air transport. Marker beacons will be designed and installed according to current guidelines.

Defence interests

The design of the Triton wind farm has been adapted in order to avoid any impact on the military exercise area managed by NATO, located directly to the south of the farm area. OX2's intention is that a continued dialogue with the Armed Forces can generate consensus on suitable solutions to enable construction of the wind farm while maintaining the interests of the Swedish Defence Forces. Possible measures to protect military interests in a state of co-existence with the wind farm may include, for example, the installation of signal detection equipment and radar equipment.

The Danish Ministry of Defence considers that the Triton wind farm could affect their radar system on the Danish island of Bornholm. OX2 has, therefore, commissioned independent consultants to conduct technical analyses to assess the impact in accordance with the wishes of the Danish Ministry of Defence in the context of the Espoo consultation. The review will examine, in dialogue with the Danish Ministry of Defence, the necessary measures that may be necessary to avoid interference on radar systems.

Risk and safety

In addition to risks to maritime transport, operations may cause unplanned incidents and risks. The risks can consist of environmental risks (e.g. oil discharges), accident risks (e.g. part of turbine blades falling), health and safety risks (e.g. work at heights) and risks from external events (e.g. extreme weather and unexploded ammunition). Risks that could be caused by the operations will be continuously managed and minimised through risk analyses, preparation of rescue and emergency plans, working environment plans and mitigatory measures and procedures. The activity is not considered to give rise to any unacceptable risk. Risks caused by external events such as geological hazards, unexploded munitions and climate adaptation are managed through adaptation (e.g. through the design of a wind farm that can withstand extreme weather) and risk-aware planning of the activity.

Natura 2000

The farm area borders, to the west, the Swedish Natura 2000 area Sydvästskånes utsjövatten. This area is designated, according to the Species and Habitats Directive, for the protection of the nature types sandbanks and reefs, as well as the species porpoises, grey seals and common seals. The Triton wind farm does not physically intrude into the area, and is not considered to have any impact of importance on the nature types and species identified and their conservation status.

Natura 2000 sites belonging to the countries around the Baltic Sea are located both offshore and along the coasts of the various countries. The Danish Natura 2000 site closest to the planned wind farm, Adler Grund and Rønne Banke (Danish Natura 2000 sites), is about 24 kilometres south-east of the wind farm. Adler Grund and the Westliche Rönnebank (German Natura 2000 sites) are around 34 kilometres and 36 kilometres south-east of Triton wind farm area. Other Natura 2000 sites belonging to the Baltic Sea countries are located at a greater distance from the wind farm. The construction of the Triton wind farm does not involve any physical intrusion or the use of any seabed surfaces in any Natura 2000 site. Identified species in nearby Natura 2000 sites are not considered to be affected. Therefore, no Natura 2000 sites are assessed to be affected by the Triton wind farm.

Mitigation measures

During the construction phase, a number of mitigatory measures related to reducing the impact of subsea noise will be taken, partly during seismic surveys and partly in impact piling during installation of foundations. When impact piling foundations, the use of acoustic methods, soft start-up and sound damping equipment (such as double bubble curtains and *Hydro Sound Damper* or equivalent) will be used to protect primarily porpoises, but are also positive for other marine mammals and fish.

A number of mitigatory measures will also be taken for marine transport. For example, no wind turbines with foundations will be erected in part of the wind farm area and safety distances will be kept to shipping routes. During construction work, the operator will have to comply with the instructions given by the Swedish Maritime Administration and the Transport Agency so that vessel traffic to and from the area where construction is being conducted does not pose a risk to other shipping. During the construction phase, the area will be monitored from the operations centre. In particular, the operator will monitor a temporary protection zone of at least 500 metres from installation vessels when construction and maintenance work by installation vessels is conducted. Ships that are at risk of navigating incorrectly in relation to the wind farm will be warned.

Bats and birds will be protected by controlling the operation of the turbines. A special study will investigate the presence of bats. A special study will also investigate the impact of the wind farm on migratory cranes.

Cumulative effects

Cumulative effects may arise in connection with other existing or permitted activities in the relevant part of the Baltic Sea. Possible cumulative effects with other wind power installations and activities, including the Baltic Pipe gas pipeline, fisheries, shipping and the Bornholm energy island, have been taken into account and assessed in the EIA.

It is not considered likely that the Triton wind farm will be built at the same time as another wind farm in the immediate vicinity, but if this happens, cumulative effects may arise from sedimentation and subsea noise. During the operational phase, there may be cumulative effects with other wind farms for birds in the form of barrier effect, collision risk and displacement. However, with proposed protection measures for the Triton wind farm, the cumulative effect of the wind farm on birds is deemed to be insignificant, with negligible impacts. Cumulative effects during the operational phase related to additional vessel transport and fishing activities are expected to be limited. Reduction of bottom trawling in a wider area of the Baltic Sea would be positive for bottom flora and fauna, which could further benefit biodiversity and the recovery of herring and cod stocks in the southern Baltic.

Alternatives and the zero alternative

The chosen location for the planned operations has been assessed as appropriate on the basis of a comprehensive study of available alternatives, taking into account technical, environmental and financial conditions. Other alternatives in southern Sweden and in the south-west Baltic have been studied in addition to this area. The wind and seabed conditions and the depth of the sea at the Triton wind farm are favourable for an offshore wind farm. The area has also been adjusted to the surrounding interests, such as adjacent Natura 2000 sites, shipping and defence interests. The chosen location is one of the few contiguous areas in the relevant part of the Baltic Sea that do not coincide with protected areas or areas of importance for other interests. The area is also far from the coast, which means less impact on the landscape and no impact on individual interests.

The zero alternative means that the wind farm will not be established and therefore does not have any environmental impact due to construction work and the physical presence of the wind farm during the operational phase, for example on birds and landscapes. However, the zero alternative also means that the significant amount of electricity potentially produced by the Triton wind farm would not be produced, which would also result in a lack of contribution to the solution to the electricity production deficit in southern Sweden. Electricity production would then need to come from other sources, such as imports, onshore wind and solar installations or nuclear energy. The zero alternative would also mean that the contribution of the activity to climate change mitigation through the transition to renewable energy would not be made.

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Appendix

Appendix B.1 Acoustic calculation of noise from wind power – Triton wind farm Danish model. OX2 AB, 08/08/2022

Appendix B.2 Photo montage, cumulative, Triton. OX2, 2022

Appendix B.3 Consultation points and responses ESPOO, OX2, 2022.

Appendix B.4 Non-technical summary

Reference reports

R.1 Triton's climate benefit and impact, Structor Miljöpartner, 2022.

R.2 Seabed environment and offshore wind in the Baltic Sea south of Skåne, AquaBiota Consulting, 2022.

R.3 Fish and offshore wind power in the Baltic Sea south of Skåne, AquaBiota Consulting, 2022.

R.4.A Marine mammals and offshore wind farms in the Southwestern Baltic, 2022.

R.4.B Triton offshore wind farm, Impact of new seismic survey SSV on underwater noise prognosis OX2 AB, NIRAS, 2022.

R.5 assessment of the impact on bats at the projected Triton offshore wind farm, south of Ystad, Enviroplanning, 2021.

R.6 Birds and offshore wind power in the Baltic Sea south of Skåne, Triton wind farm, Ottvall Consulting and AquaBiota Consulting, 2022.

R.7 Triton wind farm. A marine archaeological feasibility study. The Baltic Sea, Swedish Economic Zone, Bohuslän Museum, 2021.

R.8 Commercial and recreational fishing in the south-west Baltic Sea – Triton Wind Farm, AquaBiota Consulting, 2022.

R.9 Seismic interpretation at Triton, offshore Sweden. Interpretation of sub-bottom-profiler single and multi-channel seismic data, Geo Subsurface Expertise, 2020.

R.10 Triton OWF. Sediment dispersal, seabed preparation, NIRAS, 2021.

R.11.A OX2 Seismic survey Triton. Underwater noise modelling, NIRAS, 2021.

R.11.B Screening of underwater noise from geotechnical investigations, NIRAS, 2021.

R.11.C Offshore Wind Farm Triton. Underwater noise technical report, NIRAS, 2021.

R.12 Triton OWF. Hydrodynamic Impacts, NIRAS, 2021.

R.13 eDNA-inventory of fish and marine mammals – Triton Wind Farm, AquaBiota Water Research 2021.

R.14 Acoustic calculation of noise from wind power, Triton wind farm, OX2, 2022.

R.15 Shadow extent, Triton Wind Farm, OX2, 2022.

R.16 Biodiversity Strategy. Nature-positive wind and solar farms to 2030, OX2, 2021.

R.17 Guidelines for Distances between Offshore Wind Farms and Shipping Lanes, Marico Marine, 2022.

R.18 Sampling and examination of sediments – Triton wind farm, NIRAS, 2022.

R.19 Alternative installation options using piling - Triton, OX2, 2022.

R.20 Triton Offshore Wind Farm. Note on mitigation effect of HSD-DBBC NAS, NIRAS, 2022.

R.21 Technical Description – Decommissioning of an offshore wind farm, OX2, 2022.

R.22 Triton Offshore Wind Farm – Underwater noise prognosis for seismic survey activities inside the offshore wind farm, NIRAS, 2022.

R.23 Benthic and hydrographic studies at Triton, AquaBiota, 2022

1 Introduction

1.1 Background and purpose

Tritonia Vindpark AB is planning a large-scale offshore wind farm in the south-west Baltic Sea off the coast of the Skåne region with the Swedish economic zone, called Triton, see Figure 1. The wind farm is expected to generate about 7.5 TWh of electricity per year, which corresponds to electricity consumption for more than 1.5 million households[1].

The wind farm will form an important part of Sweden's and Europe's process of switching to renewable energy sources and contributing to the achievement of Sweden's energy policy objectives, which include 100% fossil-free electricity production in Sweden by 2040 and zero net greenhouse gas emissions to the atmosphere by 2045. In order to achieve Sweden's climate target, Swedish society needs to transition and the demand for electricity will increase sharply in Sweden as a result of this change. In order to contribute to meeting Sweden's climate targets, large-scale electricity production will therefore be required to be built out within the near future.

The project also contributes to meeting the EU's climate targets, which include a 55% reduction in the EU's overall emissions by 2030 compared to 1990 and that the EU's will achieve climate neutrality by 2050.

The overall aim of the Triton wind farm is to produce renewable electricity and thus contribute to the achievement of Sweden's energy and climate goals, and to provide society and industry, especially in southern Sweden, with competitive electricity.

In view of the possible transboundary impact of the operation, a consultation procedure with the relevant neighbouring countries has been initiated under the Espoo Convention. This report forms part of the Espoo consultation and deals with the activities and their potential transboundary effects.

The general influence and impacts for the respective environmental aspects are described in Chapter 7. The transboundary effects and impacts are described last for each environmental aspect.

1Approx. 5000 kWh per household

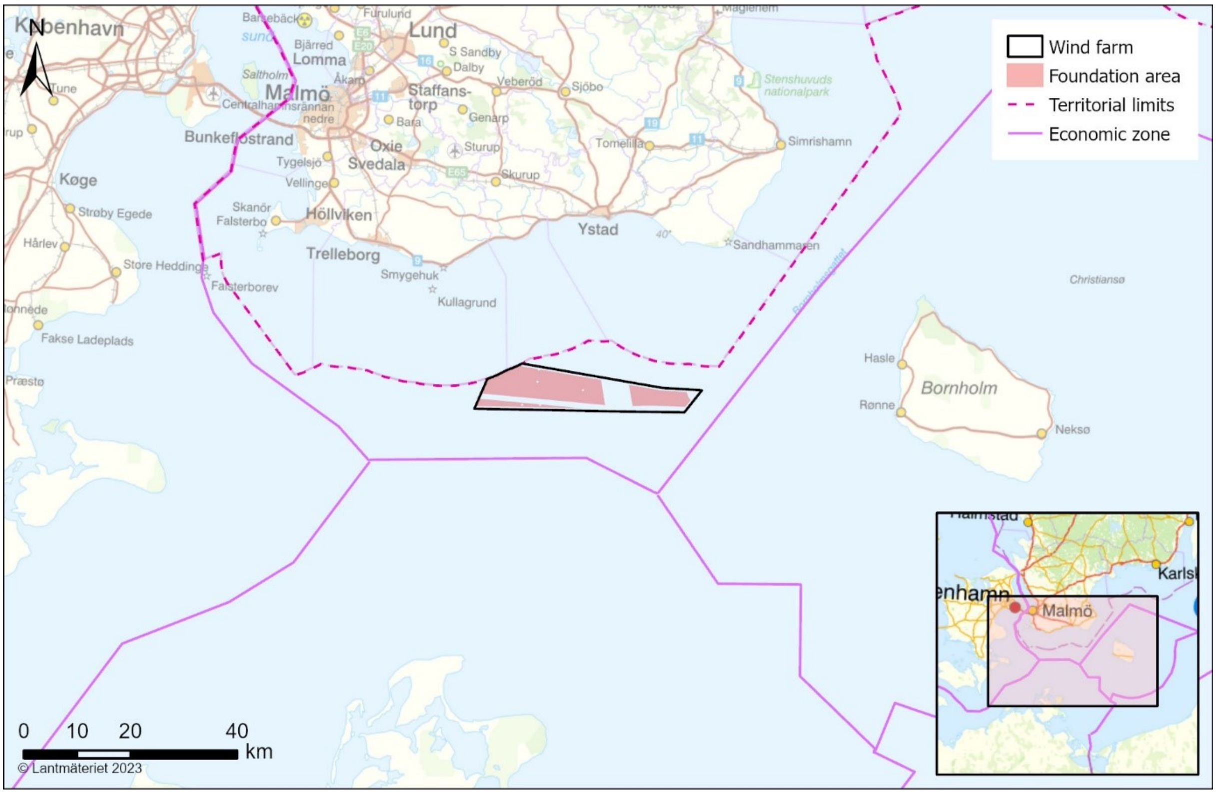


Figure 1. Overview chart of the wind farm and the area in which foundations will be built.

1.2 The need for offshore wind power

In 2017, Sweden adopted a climate policy framework. The framework consists of climate legislation, climate goals and a climate policy council. Its long-term goal means that Sweden will not have any net greenhouse gas emissions by 2045. The expansion of wind power for electricity generation contributes to the achievement of climate goals. Sweden's good conditions for renewable power generation also enable export to other countries which contributes to emission reductions in other markets when electricity production from coal and gas power plants can be replaced by fossil-free Swedish electricity.

The EU is working on a review of its climate, energy and transport legislation within the framework of the so-called Fit for 55 package to bring existing legislation into line with EU climate goals by 2050. The plan includes reducing overall EU emissions by 55% by 2030 compared to 1990 and achieving climate neutrality by 2050. The plan also aims to raise the EU goal for the overall energy mix to be made up of renewable energy sources from 32% to at least 40% by 2030.

The European Commission presented the EU strategy for offshore renewable energy at the end of 2020. The strategy proposes to expand Europe's offshore wind power from the current 12 GW to at least 60 GW by 2030 and to 300 GW by 2050. In order to increase capacity to 300 GW offshore renewable energy, with the greatest possible benefit to the EU economy, the offshore renewable energy supply chain must be able to increase its capacity and maintain a higher rate of installation.

In addition to the above, the Baltic Sea countries agreed, on 30 August 2022, to cooperate in various ways to promote, among other things, the massive expansion of offshore wind power in the Baltic Sea region by 2030 and to drive faster permitting processes. According to the declaration, the potential for offshore wind power is 93 GW and the target by 2030 is at least 19.6 TWh, which is a seven-fold increase from today's level[2].

Changes need to be made to Swedish society if its climate goals are to be achieved. A central part of the transition to a fossil-free society is the electrification of transport and of industry. Many initiatives have entered the start-up phase and investment is being made in large-scale fossil-free technology and production facilities with high demand for both renewable electricity and hydrogen that is produced using renewable electricity. According to a forecast produced by the Confederation of Swedish Enterprise, electricity consumption will increase to 200 TWh in 2045 and Swedenergy's *Road map for fossil-free electricity* assumes that electricity consumption will amount to 180 TWh in the same year According to a new analysis of the high-level scenario[3] presented by Swedenergy, electricity consumption in Sweden could reach 310 TWh in 2045, an increase of 120% from the current 140 TWh. In parallel with the above, many electricity generation plants, including the existing nuclear power plants, which account for about 40% of current electricity generation, will reach end of life and will be phased out. For this reason, Sweden will need a lot of new electricity generation in the near future.

Wind power has undergone major technological developments, with reductions in production costs and increases in electricity production from each wind turbine. Offshore wind power produces the highest yield per wind turbine, both because of the ability to build larger wind turbines than at onshore sites, and because of stronger and more stable winds at sea. Offshore wind power produces the highest yield per wind turbine, both because of the ability to build larger wind turbines than at onshore sites, and because of stronger and more stable winds at sea.

1.3 Consultation under the Espoo Convention

The Espoo Convention on Environmental impact assessment in a transboundary context is an environmental protection convention for Europe, Canada and the United States concerning cooperation to prevent transboundary environmental effects. Sweden ratified the Espoo Convention in 1991[4].

Under the Espoo Convention, the party of origin for an activity with a potential significant transboundary impact is required to inform and invite interested parties (i.e. other states) likely to be affected by the activity to participate in the environmental impact assessment procedure[5]. The consultation process under Articles 3 to 6 of the Espoo Convention is coordinated by a responsible authority in the respective state concerned. The Swedish Environmental Protection Agency is the competent agency responsible[6]. The Espoo procedure can be summarised briefly in the following horizontal steps:

2 The Marienborg Declaration, 2022

3 In the high-level scenario, all announced investments in electrification are realized (Swedenergy, Sweden, 2021).

4 Sweden's international agreements SÖ 1992:1.

5 See also Chapter 6, Section 33 of the Environmental Code.

6 See Section 21 Environmental Assessment Regulation (2017:966).

- Notification (Article 3) - Any planned activity likely to have a significant (harmful) transboundary impact must, through the competent authority, inform potential interested parties.
- Preparation of the environmental impact assessment (Article 4) – To the extent that interested parties continue to participate in consultations under the Espoo Convention, an environmental impact assessment (so-called ESPOO report/EIA) is established.
- Consultation on the basis of the environmental impact assessment (Article 5) – The Espoo report/EIA shall be submitted by the competent authority to the parties concerned who continue their intention to participate in the procedure. The consultation may include, inter alia, alternative locations or alternative implementation and mitigatory measures and precautions for the operation.
- Final decision (Article 6) – After consultation, a final decision on the proposed activities shall ensure that due account is taken of both the results of the environmental impact assessment and the comments received. In the case of permitting processes for offshore wind farms situated within the Swedish Exclusive economic zone, the government's decision to grant an authorisation under SEZ may be considered to be the final decision, which concludes the Espoo consultation.

The Espoo Convention consultation process for the Triton wind farm was initiated in autumn 2021, when a notification was sent via the Swedish Environmental Protection Agency to Denmark, Germany and Poland. The notification included a consultation paper setting out the planned project and the potential transboundary impact of the activities. The consultation was held between 2 November and 8 December 2021. Comments were received from all the above states, and all confirmed continued participation in the environmental assessment process under the Espoo Convention, including the opportunity to read the current Espoo Report. A total of 17 responses were received, seven of them from Denmark, three from Poland and seven from Germany.

The current report describes the activities and their potential transboundary impact, inter alia in the light of the comments received. The comments received were mainly concerned with:

- Risks/impacts for shipping
- Effects on migratory birds
- Influence on porpoises
- Impact on fish/commercial fishing
- Cumulative effects of other wind farms

The consultation points and responses to the comments (including references to the main document) can be found in Appendix B.3.

1.4 Permitting processes

1.4.1 Ongoing permit processes

The national permitting processes for the Triton wind park are continuing in parallel with the present Espoo consultation. OX2 submitted permit applications during autumn/winter 2021/22 as follows:

- A permit according to Chapter 7, Section 28 a of the Environmental Code (Natura 2000 permit) for the impact of the activities on the Natura 2000 area Sydvästskånes utsjövatten (SE0430187).

  The application for the Natura 2000 permit is issued by the Skåne County Administrative Board

- Permit under the Act (1992:1140) on the Swedish Economic Zone concerning the construction and operation of the wind farm and associated transformer and inverter stations, platforms and measuring masts.

  The application for a permit for the wind farm is issued by the Swedish Government (the application is processed by the Ministry of the Environment).

- Permit under the Continental Shelf Act (1966:314) ("KSL”) for the laying and maintenance of electrical cables for the inter-array and carrying out of surveys of the continental shelf.

  The application for a permit for laying of undersea cables is issued by the Swedish Government (the application is processed by the Ministry of Enterprise and Innovation).

1.4.2 Additional permit processes

In addition to the above-mentioned permits, the laying and operation of connection lines between the wind farm and the Swedish coast will require permits pursuant to KSL (to be granted by the Government), permits for water activities pursuant to the Environmental Code (to be granted by the Land and Environment Court at the Växjö District Court) and the grid concession pursuant to the Electricity Act (to be granted by the Swedish Energy Markets Inspectorate). Permits for further surveys of the seabed will also be applied for.

2 Limitations

2.1 The planned operations

This report covers the transboundary effects and impacts of the Triton wind farm, and its associated activities and installations.

Consequential activities to the wind farm consist mainly of shore connection lines and ship traffic to and from the wind farm. The connection lines are not considered to have a transboundary impact due to their location further away from neighbouring countries and their limited environmental impact, so their impact is not assessed in this Espoo report.

Furthermore, the following operational principles apply:

- The wind farm will comprise up to 129 wind turbines with a maximum overall height of 370 metres. They are located in the area based on foundation and technical requirements and taking into account other interests and site-specific seabed conditions.
- Technical developments, including to wind turbines and foundations, have been very rapid and it is not possible today to determine which technical solution will be most effective when constructing the wind farm, in terms of production, installation, environmental impact and electricity generation. In this context, the environmental impact that the activity can potentially have on the environment is described on the basis of a "worst-case". The worst-case is understood to mean that the described influence and assessed impacts in practice cannot be greater than that described in this EIA. The assessments are based on assumptions of a maximum design scenario that will significantly increase what could be the greatest impact on the environment. Different worst-cases are assessed for different impact factors. Section 5.3.1 discusses the worst-case for different impact factors linked to the affected recipients.

2.2 Geographical delimitation

The impact assessments cover the geographical area that may be affected by the activities and are deemed relevant for investigation. This includes both the direct impact area where the activities are conducted and where physical measures are taken, as well as the surrounding areas in which an impact can be detected, such as adjoining sea areas, nearby shipping lanes and the stretch of coast from which the wind farm can be seen. The geographical delimitation varies according to the aspect and interest studied. The geographical delimitation is based on the underlying investigations that have been developed for the respective impact factor and interest. Descriptions and assessments in this EIA focus mainly on impacts that may be transboundary.

2.3 Time periods

The environmental impacts are assessed in the following phases of the project:

- Construction phase:
- Operational phase
- Decommissioning phase

See Chapter 4, for the description of each phase.

2.4 Environmental aspects

The environmental aspects described and assessed in this Espoo-EIA are listed in Table 1. Environmental impacts are described for the construction phase, the operational phase and the decommissioning phase. The phases that have been assessed relevant for each aspect are shown in the table.

Table 1. Aspect and for which phase their impact has been assessed.

Aspect	Construction phase:	Operational phase	Decommissioning phase
Climate benefit and climate impact	x	x	x

Bottom flora and bottom fauna	x	x	x
Fish	x	x	x
Marine mammals	x	x	x
Bats		x	
Birds	x	x	x
Landscape and heritage environment		x	
Accommodation and recreation		x	
Commercial fishing	x	x	x
Maritime activities	x	x	x
Aviation		x	
Defence interests		x	
Risk and safety	x	x	x

3 Location and area description

3.1 Location

The planned Triton wind farm is located in the south-west Baltic Sea, within Sweden's economic zone and about 30 kilometres south of Ystad, Figure 1. The nearest urban areas are about 22 kilometres from the wind farm, at Beddingestrand and Smygehamn on the south coast of the Skåne region. The distance from the planned Triton wind farm to Bornholm (which is part of Denmark) is about 37 kilometres measured from the eastern end of the wind farm. The distance from the wind farm to the Danish island of Zealand is about 66 kilometres. The wind farm is about 47 kilometres from the German island of Rügen and about 80 kilometres from the German mainland. The distance from the wind farm to Poland is about 130 kilometres. The area is about 250 km^2 in size and the depth of water varies between 43 and 47 metres. The wind farm is planned to be connected to the Swedish grid.

3.2 Natura 2000

In the west, the farm borders to the Natura 2000 area Sydvästskånes utsjövatten, which is listed under the Species and Habitats Directive. The potential impact of the planned wind farm on the Natura 2000 site depends on the distance from the wind farm and its associated facilities to the Natura 2000 site, the nature types and species that the site intends to protect and their sensitivity to the impact of the activities.

Another significant Natura 2000 site nearby that is not considered to be affected by the Triton wind farm is Falsterbo-Foteviken, which is located north-west of Triton at a distance of approximately 38 kilometres.

Nearby Natura 2000 sites in Danish waters are Adler Grund and Rønne Banke, that is about 24 kilometres south-east of the wind farm. The bird sanctuary F129 is close to Adler Grund and Rønne Banke. The nearest German Natura 2000 sites are Adler Grund (34 kilometres from the Triton wind farm) and Westliche Rönnebanke (36 kilometres from the Triton wind farm). These areas have been assessed not to be affected by the planned wind farm and associated inter-arrays, see Chapters 7.2, 7.4 7.6, and 11.2.

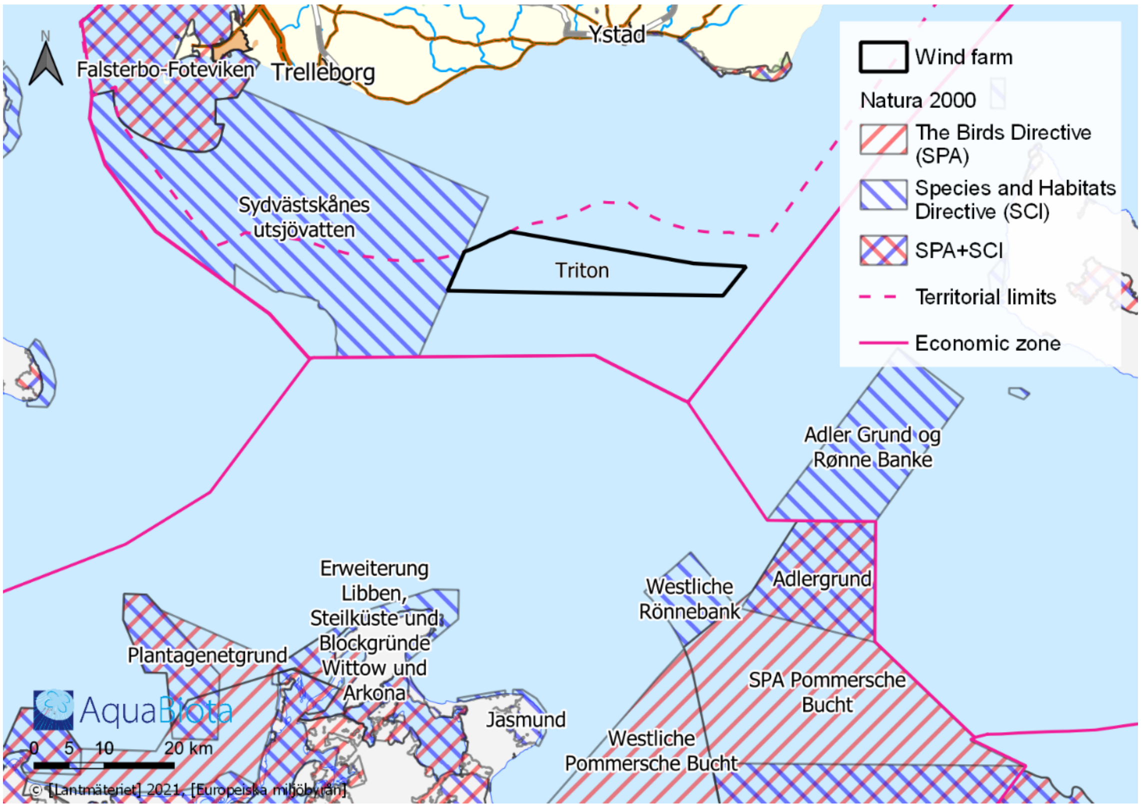


Figure 2. Overview of close Natura 2000 sites and nature reserves, areas designated SPA (red hatching) include areas under the Birds Directive and areas designated SCI (blue hatching) include areas under the Species and Habitats Directive. The map is produced by AquaBiota.

The potential impact of the planned wind farm on the Natura 2000 site depends on the distance from the wind farm and its associated facilities to the Natura 2000 site, the nature types and species that the site intends to protect and their sensitivity to the impact of the activities. The activities have been assessed to have a potential impact on the Natura 2000 Sydvästskånes utsjövatten, see the identified nature types and species in Table 2. The impact on the Swedish Natura 2000 area Sydvästskånes utsjövatten is evaluated in the framework of a separate permitting process pursuant to Chapter 7, Section 28 a of the Environmental Code (Natura 2000 permits). The Natura 2000 application has been submitted to the Skåne County Administrative Board in December 2021. The assessed impact on the Natura 2000 area is described in Chapter 11. The impact on identified bird species in the Natura 2000 site Falsterbo-Foteviken is described in the supplement (Appendix K and Appendix K.5) to the Natura 2000 application submitted in June 2022.

Table 2. The adjacent Swedish Natura 2000 area Sydvästskånes utsjövatten with designated nature types and species that are deemed to be affected by the Triton wind farm.

Natura 2000 area	Nature types identified	Identified species
Sydvästskånes utsjövatten (Swedish)	Reefs (1170) Sand banks (1110)	Porpoise (1351) Grey seal (1364) Common seal (1365)

3.3 Seabed conditions

The following chapters describe the seabed conditions at the Triton wind farm site. The description of the seabed conditions is limited to the water depth and seabed topography, seabed substrate and the deeper geology. The description includes a description of the current situation and the identified impact it may have on the activity.

We have a good knowledge of the seabed substrate, geology and depth conditions within the wind farm from surveys contucted by the Swedish Maritime Administration (surveyed in 2002–2004) and SGU (in 2004/2005). We also have knowledge of the surrounding area from existing offshore farms in the Arkona basin, such as Kriegers Flak (DK, S), Arkona (D), etc.

AquaBiota, on behalf of OX2, has counducted grab sampling which has confirmed the view of the bottom substrate in the area.

3.3.1 Water depth and seabed topography

The Baltic is a shallow sea characterised by shallow sounds and deep sea basins. Its average depth is 54 metres with the lowest point at 459 metres. The narrow Danish Straits link the Baltic Sea with the North Sea. The Triton wind farm will be built in the Arkona basin, whose borders are the thresholds in the north-east of Drogen (in Öresund) and Darss (in Fehmarn belt). The average water depth in the Arkona basin is 23 metres, with a maximum depth of 53 metres. One of the shallow areas in the Arkona basin is Kriegers Flak, where the waters are shallower than 20 metres.

The seabed within the wind farm area is relatively even and the level and depth of the water varies between 43–47 metres, with an average depth of 45 metres. The water depth within the wind farm area increases slightly in a south-easterly direction (in the south-east about 46 metres and in the north-west about 43 metres).

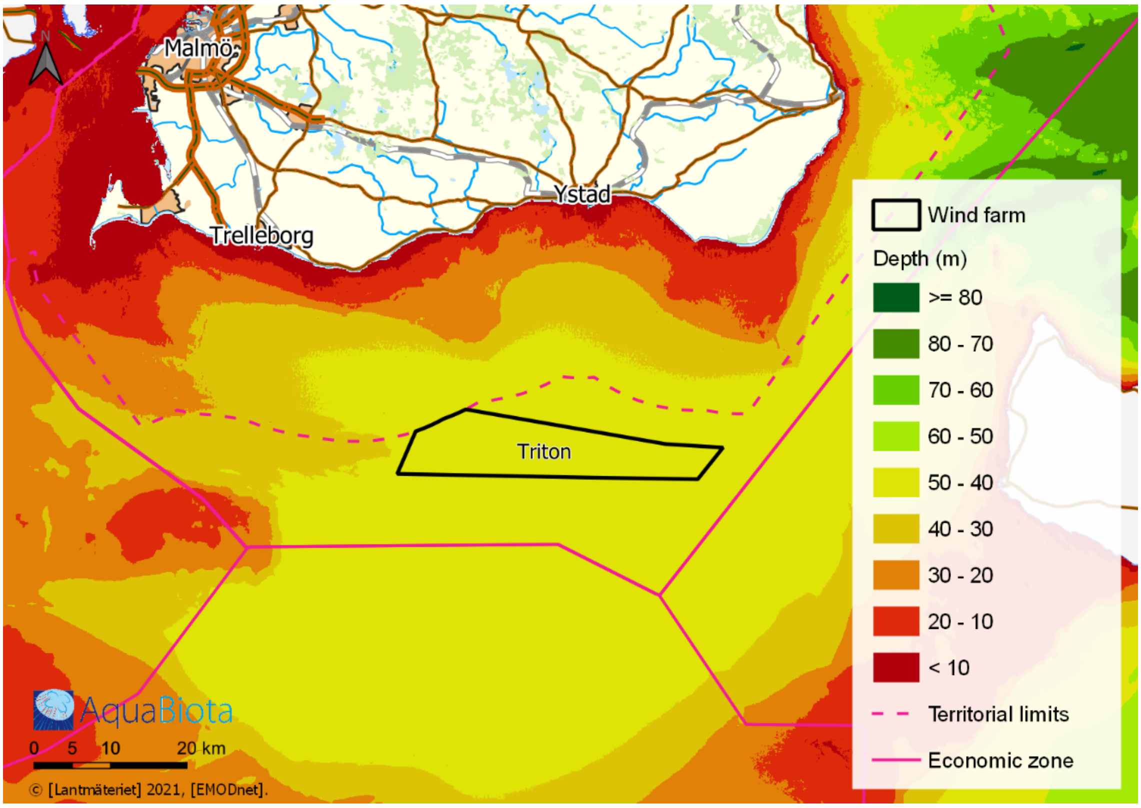


Figure 3. Map of the depth conditions in the wind farm and the surrounding area, where green indicates the deeper areas. The map is produced by AquaBiota.

3.3.2 Seabed substrate

SGU's Marine Geology Map 1:100 000 has been used to describe the bottom substrate within the wind farm area, see Figure 4. According to SGU's Marine Geology Map 1:100 000, the area covered by the Triton wind farm is almost entirely made up of soft seabeds with clay and silt elements, indicating that the wind farm area is mostly accumulated seabed (sedimentary areas). An accumulated seabed is a bed surface on which sedimentary material is laid and remains lying over time.

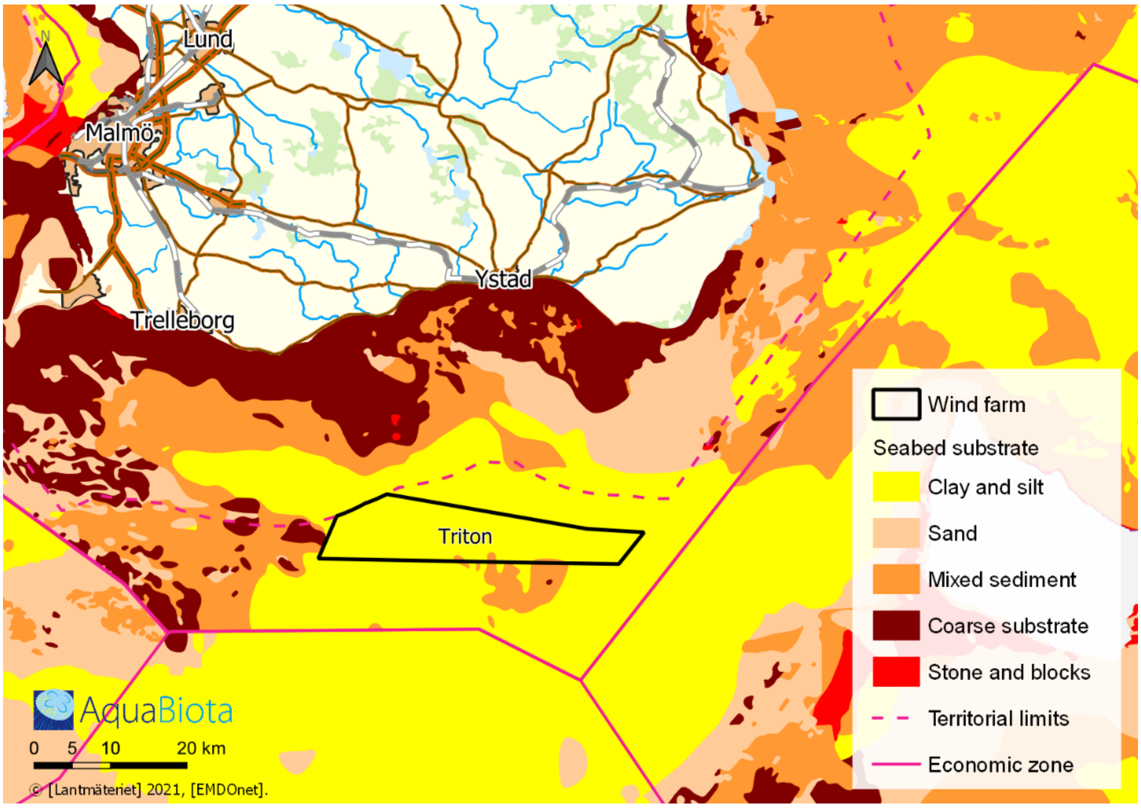


Figure 4. Map of the seabed substrate for Triton, where the darker colours indicate harder substrates. The map is produced by AquaBiota.

3.3.3 Sediment status

The seabed within the Triton site consists exclusively of accumulation beds, which means that sediment particles remain on the bottom as long as no disturbance occurs to the seabed. Most organic pollutants are bound to sediment particles and organic matter and can therefore accumulate in these areas. Environmental toxins in the bottom sediment can be released and spread in the water column and to new areas in connection with physical disturbance (e.g. bottom trawling or activities during the construction phase) of the seabed during the construction phase.

3.3.4 Geology

The Baltic Sea is an inland sea on the continental shelf of the Euro-Asian continent and contact with the oceans takes place only through the Danish Straits. Geodiversity is high in the Baltic, which means that the rock base, soil cover and geological processes and surface forms vary. The seabed is relatively smooth in southern parts of the Baltic, while broken and fragmented formations occur in the north and, above all, along the northern coast. In the southern parts of the

Baltic Sea, the bedrock is covered by younger sedimentary rocks. Höllviken Trough, Skurup platform and Bornholmsgat are the three main bedrock structures in the area south of Skåne.

The wind farm site is located on the Skurup platform, which is located within the Arkona basin. The Arkona basin has several established and planned wind farms.

Based on the marine geological maps and the analysis OX2 has commissioned of the geological profiles of SGU, we have found that the following soil types are present within the working area, see Table 3. The analysis is based on the studies SGU has conducted in the area of 19 Sparklines and 17 Sleev GUN lines within and directly adjacent to the wind farm area. The results are consistent with other knowledge about conditions in the Arkona basin. The wind farm area has variations in the distribution and thickness of the soil types present, so the table should not be interpreted as valid over the whole area, but for some selected points.

The top one to three metres below the seabed (in a few places even down to six metres below the seabed) is expected to be made up of silt and silty sand. The next layers are made up of quaternary deposits. The quaternary deposits within the wind farm area are expected to be sandy calcareous clay. The analysis conducted by OX2 shows that the thickness of the quaternary deposits varies over the wind farm area and can reach a thickness of approximately 40 metres. The deposits are thickest toward the north and east and thinnest in the western part of the farm. The deposits are about 16 metres thick in the central parts of Triton, which is also the average thickness (Geo, 2020).

Pre-quaternary deposits are expected to be Paleocene limestone, which is assumed to be found under the quaternary deposits. At least one shallow gas pocket has been noted in the interpreted material and we assume that additional gas pockets will be present at the wind farm site. Shallow gas pockets are easy to identify using seismic data and will be mapped before the construction phase to avoid accidents (Geo, 2020).

Table 3. Thickness of soil types within the wind farm area.

Unit	Lithology	Thickness
Silt/silty sand	Marine deposits consisting of clay and silt (organic sediments) Soft clay	1–6 metres
Sandy, calcareous clay	Rigid to hard clay	2–40 metres
Limestone	Soft limestone	-

3.4 Hydrography and wind conditions

3.4.1 Water depth and current conditions

Variations in water depth are mainly dependent upon the wind and by the inflow and outflow of water via the Danish Straits and Öresund. The influence of the moon and the sun is considered to be insignificant. Under normal circumstances, the area water level will vary between +1.5 and -1.5 metres from the mean water level, but may in extreme events exceed these values (R.12).

The wave climate is dominated by waves from western and southwestern directions between 225° and 285°. The average significant wave height is approximately 0.8 metres with an annual maximum value of 3.75 metres (Year 2016). Wind and waves predominately come from the west, which is likely to drive the currents that are generally dominated by flows of water from the west.

The current velocity is low. In a ten-year period (years 2008-2018) the current velocity was less than 0.1 m/s for more than 90% of the time. On a few occasions, 0.6% of the time during the same period, the current speed reached over 0.2 m/s, most often during the winter (R.12).

3.4.2 Salinity, temperature and oxygen content

In June and August 2021, AquaBiota conducted CTD (Conductivity, Temperature and Depth) surveys within the Triton site to measure salinity, temperature and oxygen content. In addition to the description, data are also used from SMHI's monitoring stations, BY1 and BY2 Arkona, located approximately 13 kilometres south-west and 15 kilometres south-east of the Triton wind farm, where all surveys are in progress.

The Triton CTD studies show that surface water temperature was similar in both surveys (June/August) with a temperature of 16-17°C. The deep water has a lower temperature that also differs between the surveys. In June, the deep water was colder with a temperature of about 6°C. In August, the temperature varied more through the water mass. The water was at its coldest at depths of between 20–30 metres, about 6–8°C, then rising up to 12–15°C at the greatest depths (>40 metres). This is probably due to the fact that more saline water, at a warmer temperature, flows in from the Kattegat via Öresund. A thermocline[7] was observed at depths of 20 to 30 metres.

The saline content throughout the water mass was similar in both studies. The June measurements show a salinity of 7–8 PSU[8] down to 30–40 metres. At this depth there is a halocline in which the salt content then increases significantly up to 15–16 PSU at the seabed. Measurements conducted in August found that the halocline was slightly higher in the water column at a depth of 20–30 metres. In the April 2021 SMHI measurement series, the halocline was found at about 30–40 metres depth and the salinity of the bottom water was between about 10–15 PSU (SMHI, 2021a), which is in accordance with CTD surveys conducted in the farm area.

Sea ice may occur during severely cold winters when the temperature is below -5°C to -10°C. over an extended period. However, SMHI's maximum ice spread maps show that the area has not been covered at any time in the last decade (SMHI, 2020).

The oxygenation was also similar in the two survey periods. The surface water had an oxygen saturation of 7 to 8 ml/l while the deep water had an oxygen saturation of about 4 to 5 ml/l. The study showed no anaerobic sea bottoms. SMHI's survey series show that the oxygen content is highest in the cold months of February–March and at its lowest in late summer of July–September (SMHI, 2021b).

3.4.3 Wind conditions

The average wind speed at the wind farm location is estimated to be about 9.5 m/s, at 100 metres above sea level. The wind direction[9] is dominated by winds from the west (ERA5, 2020), see Figure 5.

7 A layer in the sea or a lake where temperature changes very quickly within a small depth range.

8 Practical Salinity Unit. One PSU is equivalent to one part per mil (g/kg).

9 The wind direction is indicated from where the wind blows.

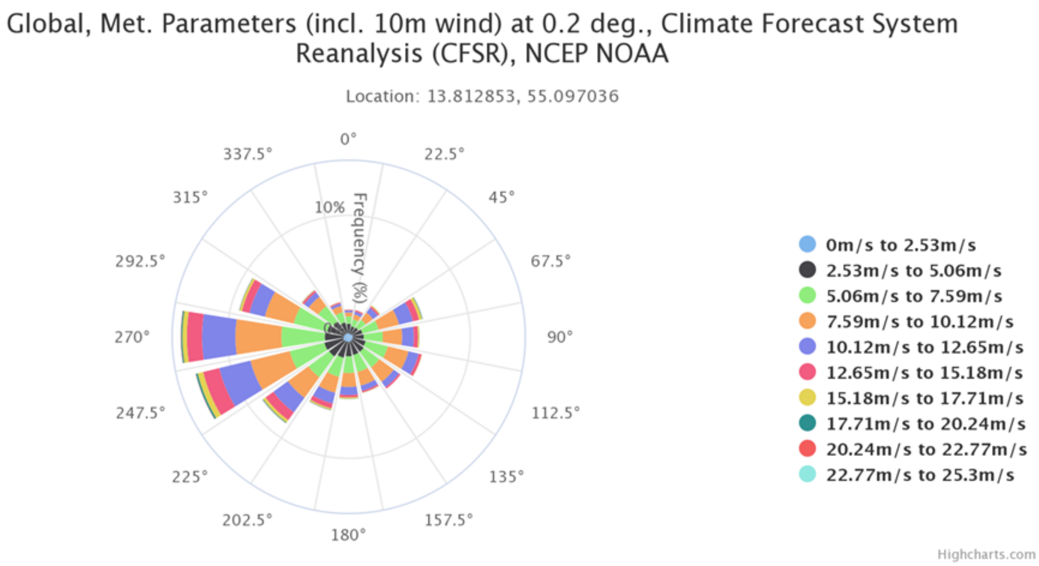


Figure 5. Wind rose based on wind data from 2000–2019 for the area around Triton (DHI, 2021).

3.5 Neighbouring activities

3.5.1 Neighbouring wind farms and projects

Several wind farms are operating, permitted or under development in the area and near the wind farm and the Natura 2000 area Sydvästskånes utsjövatten (Figure 6 and Table 4). Of these, five wind farms are currently in operation: the Danish farm, Krieger's flak, EnBW Baltic 1, Wikinger, Arkona and Baltic 2 (Figure 6, Table 4). The operational wind farm that is closest to the Triton wind farm is the Danish farm, Krieger's flak, which lies within Danish waters and borders partly directly to Sydvästskånes utsjövatten and consists of 72 wind turbines. Baltic 2 is located 17 kilometres south of Sydvästskånes utsjövatten waters and consists of 88 wind turbines. Wikinger is located about 27 kilometres south-east of the Natura 2000 site and consists of 50 wind turbines. Arkona (Germany) is located about 34 kilometres south-east of the area and consists of 60 wind turbines. The operational wind farm that is furthest away from the area of those included in the assessment is EnBW Baltic 1, which is located approximately 71 kilometres south of the area and consists of 27 wind turbines.

The Arkadis Ost I and Baltic Eagle wind farms are under construction. In addition, there are two permitted farms in the neighbouring area: Krieger's flak II and Gennaker. A small part of Krieger's flak II is located in the Natura 2000 area Sydvästskånes utsjövatten (Figure 6, Table 4). The Baltic Pipe and Hansa PowerBridge infrastructure projects also partly affect the Triton wind farm. Baltic Pipe has received a permit, is scheduled and will be commissioned in 2022. A permit application has been submitted for Hansa PowerBridge and the planned start of construction was in 2024, but the start of the construction was postponed in the autumn of 2022 and no fixed start time has been decided.

The Wikinger Süd and O-1.3 wind farms have been purchased/are out for auction and are also estimated to be in place when construction for Triton begins. In addition, a number of projects are planned for the area, but these have not yet been granted permits, see Table 4. The closest location of these that could possibly have a cumulative effect is Sydkustens Vind, provided that it is granted a permit and can begin to be built according to schedule. As can be seen from Table 4, any wind farms that may be built in the area are not likely to be all built at the same time.

Ørsted is designing the Skåne Havsvindpark, which will partly occupy the same area as the Triton wind farm. The permit application for the project was submitted in late September 2021. Eolus Vind AB is also designing the Arkona wind farm, which also partly occupies the same area as the Triton wind farm. Consultations for the Arkona wind farm took place during the winter of 2021/2022.

An energy island is being planned on Bornholm south-east of the Triton wind farm that will become an offshore wind hub linking Denmark, Poland, Sweden and Germany. The project also supports large-scale production of green hydrogen.

Energinet is planning an export cable from Bornholm 1 that will be routed parallel to Baltic Pipe and will thus partially affect the Triton wind farm.

An artificial peninsula is planned for housing and companies to the north-west of the Triton wind farm, off Copenhagen.

Figure 6 also shows shipping routes and lanes. Ferries depart from Trelleborg, including to Sassnitz, past the western corner of the farm area. Ferries run from Ystad to Sassnitz and Swinoujscie through the farm. The shipping lanes through the farm will be kept open with a total width of about five kilometres, see Figure 1 and Figure 70 to see in which area foundations will be built. For more information about shipping see section 3.5.3, for impacts and assessment of shipping see section 7.10.

Refer to Figure 6 for location of planned wind farms and Table 4 for distances to nearby wind farms and projects.

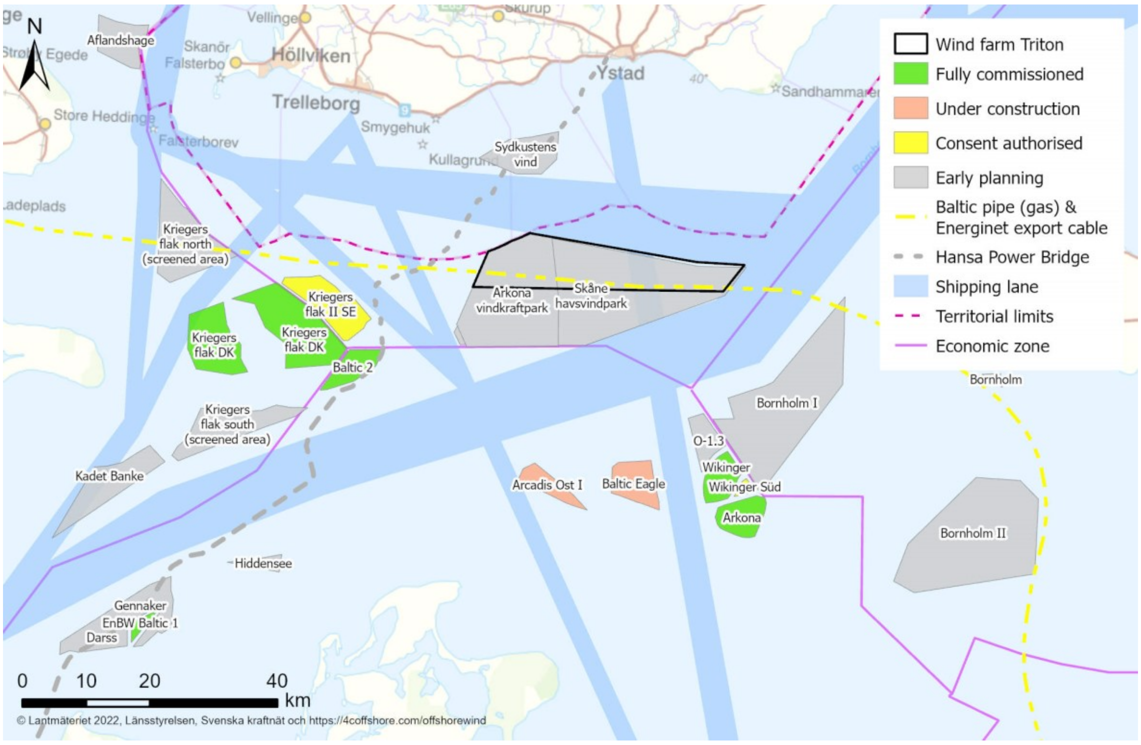


Figure 6. Wind farms and other facilities in the area.

Table 4. Neighbouring wind farms and activities.

Wind park/activity	Project status	Distance to Triton (kilometres)	Construction year
Aflandshage, Denmark	Permit granted	61	2025
Arcadis Ost I, Germany	Under construction	27	2023
Arkona, Germany	In operation since 2019	34	2019
Arkona wind farm, Sweden	Under development	0	2025–2027
Baltic Eagle, Germany	Under construction	27	2025
Baltic 1, Germany	In operation since 2012	71	2011
Baltic 2, Germany	In operation since 2015	17	2015
Baltic Pipe (Gas pipeline)	Constructed	0	2020–2022
Bornholm, Denmark	Under development	42	2030
Bornholm I, Denmark	Under development	16	2030
Bornholm II, Denmark	Under development	49	2030
Darss, Germany	Under development	66	
Energinet, export cable (Denmark)	Under development	0	2030
Energy Island, Bornholm (Denmark)	Under development	28	2030
Gennaker, Germany	Permit granted	66	2023
Hansa PowerBridge (power cable)	Permit application submitted	5.6	2024–2026
Hiddensee, Germany	Under development	52	
Kaden Banke, Germany	Under development	56	
Kriegers flak DK, Denmark	In operation since 2021	22	2019–2021
Kriegers flak II, Sweden	Permit granted	17	2026–2028
Kriegers flak north (screened area), Denmark	Under development	38	
Kriegers flak south (screened area), Denmark	Under development	32	
Lynetteholm, Denmark	Under development	80	
O-1.3, Germany	At auction	19	2026
Skåne havsvindpark, Sweden	Under development	0	2029
Sydkustens vind, Sweden	Under development	10	2025
Wikinger Süd, Germany	Procurement complete	31	2025
Wikinger, Germany	In operation since 2018	27	2018

3.5.2 Fishing

Commercial fishing in the Baltic Sea is mainly focused on a few species. Cod, herring and sprat have accounted for up to 95 % of total catches (ICES, 2018). Pelagic fishing (especially pelagic trawling) mainly concerns herring and sprat. The most important sea bottom fishing has been bottom trawling for cod and flatfish. Fishing quotas for cod and herring have been continuously reduced.

According to landing data reported to the International Council for the Exploration of the Sea (ICES, 2018), fishing around and in Triton's wind farm is conducted by Swedish, German, Polish and Danish fishermen. Commercial catch data from the Swedish Agency for Marine and Water Management and ICES landing data show that there has been a lot of fishing in both the Natura 2000 area Sydvästskånes utsjövatten and in the Arkona basin. ICES boxes 39G3/39G4/38G3/38G4, covering the Arkona basin and the area of activity, account for on average 41% of the total catches in the south-west Baltic Sea (ICES sub-area 27.3.D.24) between 2015 and 2019. For cod[10], the fishing intensity appears to be evenly distributed throughout ICES sub-area 27.3.D.24. Targeted fishing for eastern stocks ceased in 2019. In 2022, fishing bans were also introduced for western stocks. Only bycatch quotas are allowed. In ICES sub-area 24, which is the sub-area in which Triton is located, the fishing ban applies to fishing vessels of more than 12 metres in length. The total fishing pressure from Swedish fisheries is illustrated in Figure 7. AIS (Automatic Identification System) data on vessel density in 2020 from all European fishing vessels are reported in Figure 9.

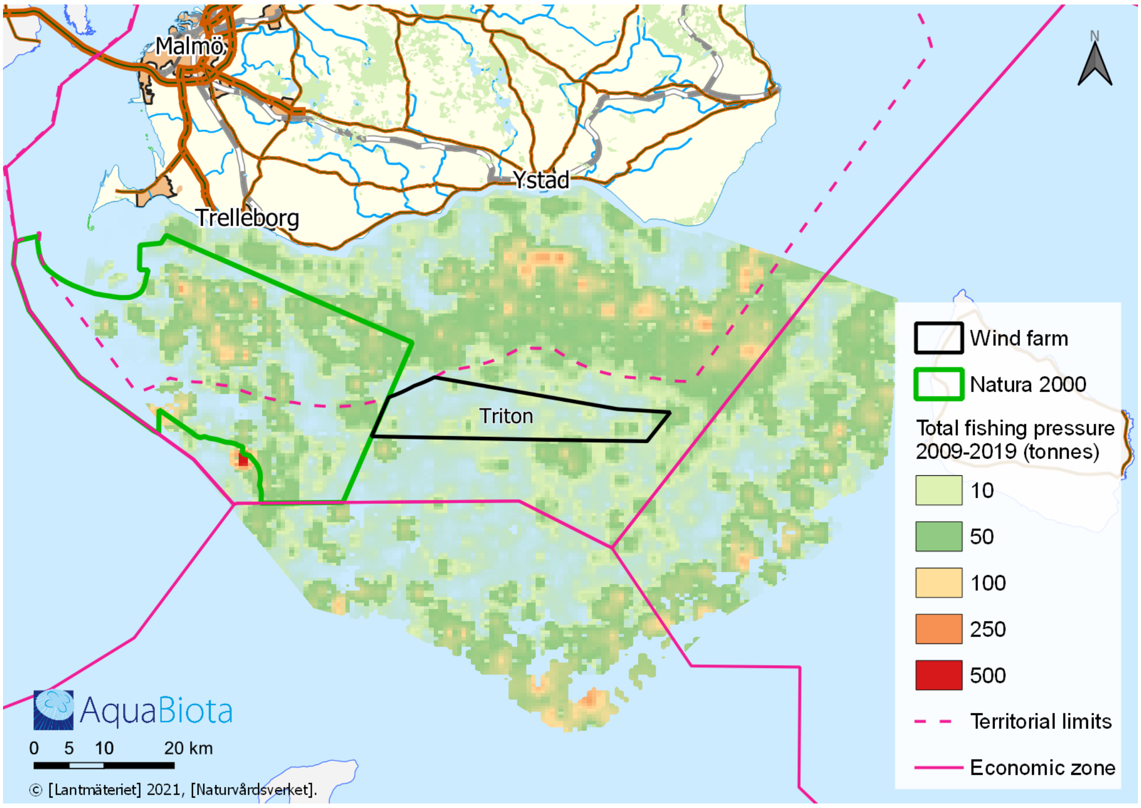


Figure 7. Aggregated Swedish fishing pressure in tonnes r the period 2009–2019. The values are based on the period's total catch value aggregated per reporting point. Values for each area were calculated by interpolation of all catch values within a two kilometre radius, creating an average catch value per two kilometre radius.

10 Targeted fishing for cod was stopped in sub-areas 24, 25-32 in 2022. For sub-area 24, vessels of less than 12 meters with passive fishing gear may continue to conduct targeted fishing for cod. This applies to areas with depths of less than 20 metres that are less than 6 nautical miles from the baseline (EU Regulation, EU 2020/1579).

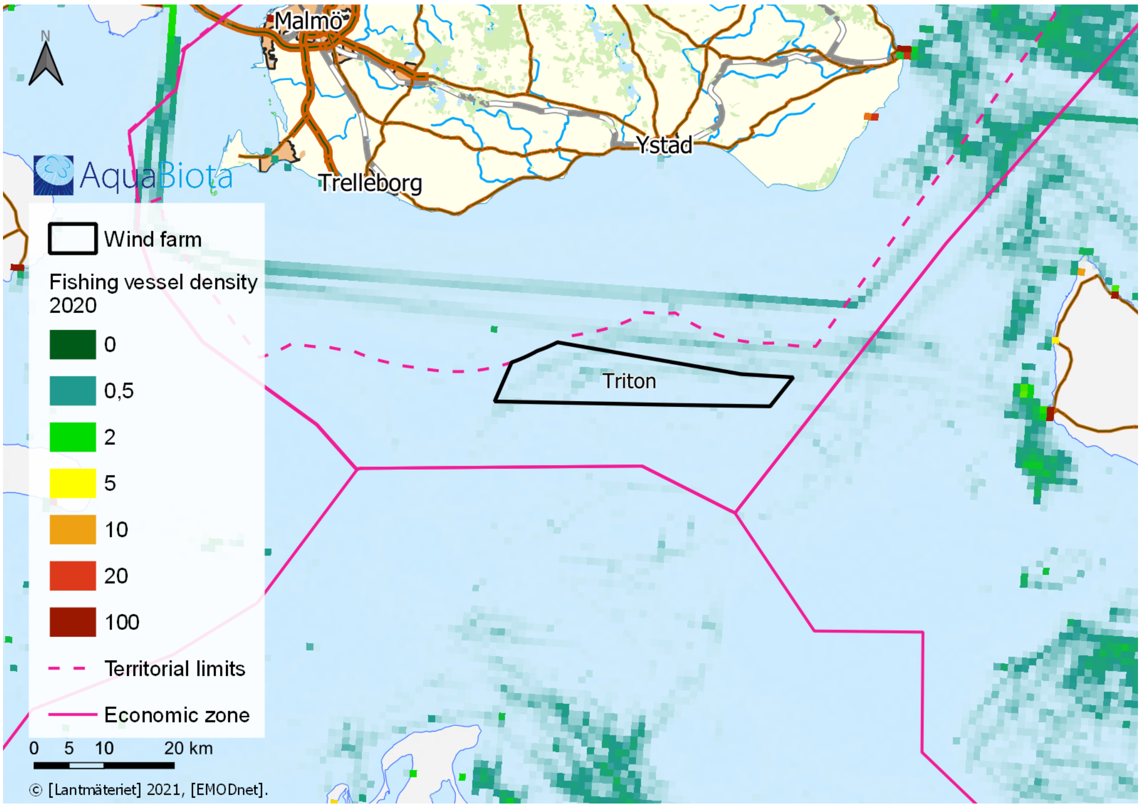


Figure 8. AIS data on vessel density in 2020 from all European fishing vessels in hours per 1x1 square per month.

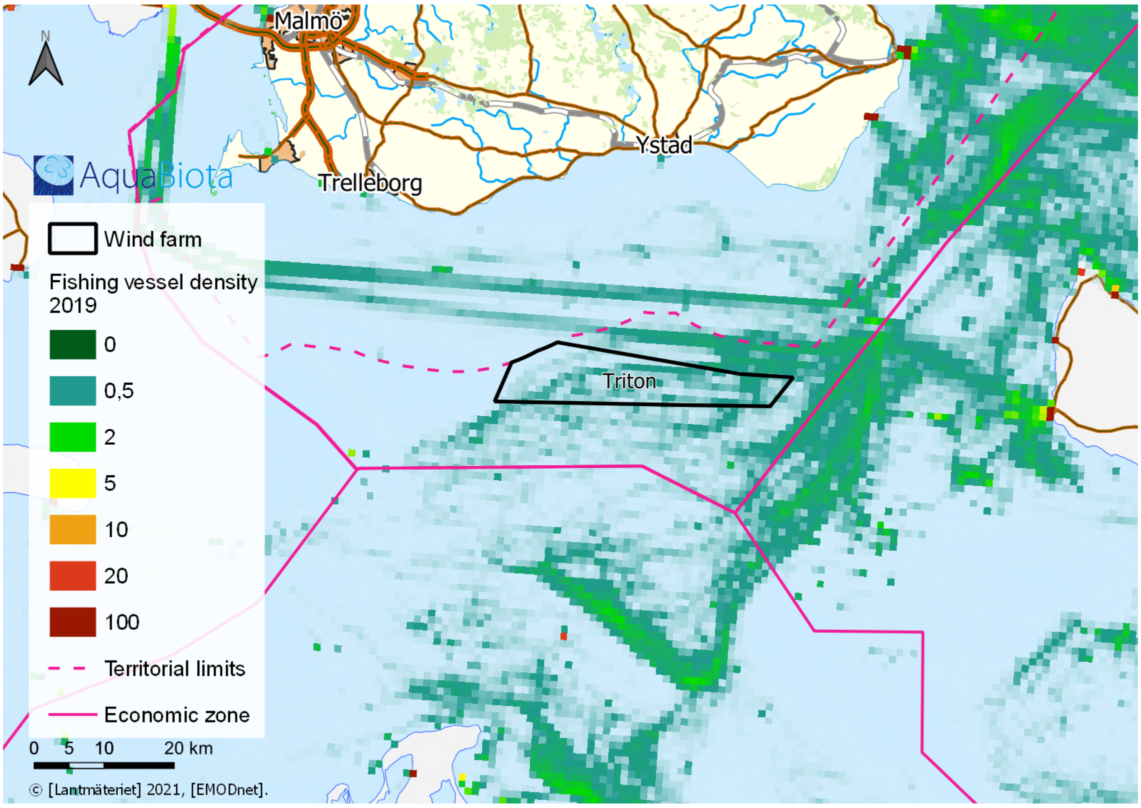


Figure 9. AIS data on vessel density in 2019 from all European fishing vessels in hours per 1x1 square per month.

3.5.3 Maritime activities

Shipping in this part of the southern Baltic Sea is largely constant with a slight seasonal variation. Statistics from the area show that approximately 19,200 vessels pass annually north of the farm area and about 24,200 vessels sail south of the farm area. The farm area has approximately 3,000–3,500 vessel passages annually. The vessels passing through consist of cargo, container, fishing, passenger, service and tanker vessels and more, which are tracked using AIS data. This shows that major shipping routes pass along the wind park farm on their way into and out of the Baltic Sea. Ferries depart from Trelleborg, including to Sassnitz, past the western corner of the farm area. Ferries run from Ystad to Sassnitz and Swinoujscie through the farm (Figure 10). The movement patterns of fishing vessels are more scattered as they usually move to and from different fishing areas that differ according to the target species and season. To the north-east of the wind farm is a precautionary area[11]. The intensive maritime traffic in the area means that there is a great deal of noise and movement from vessels.

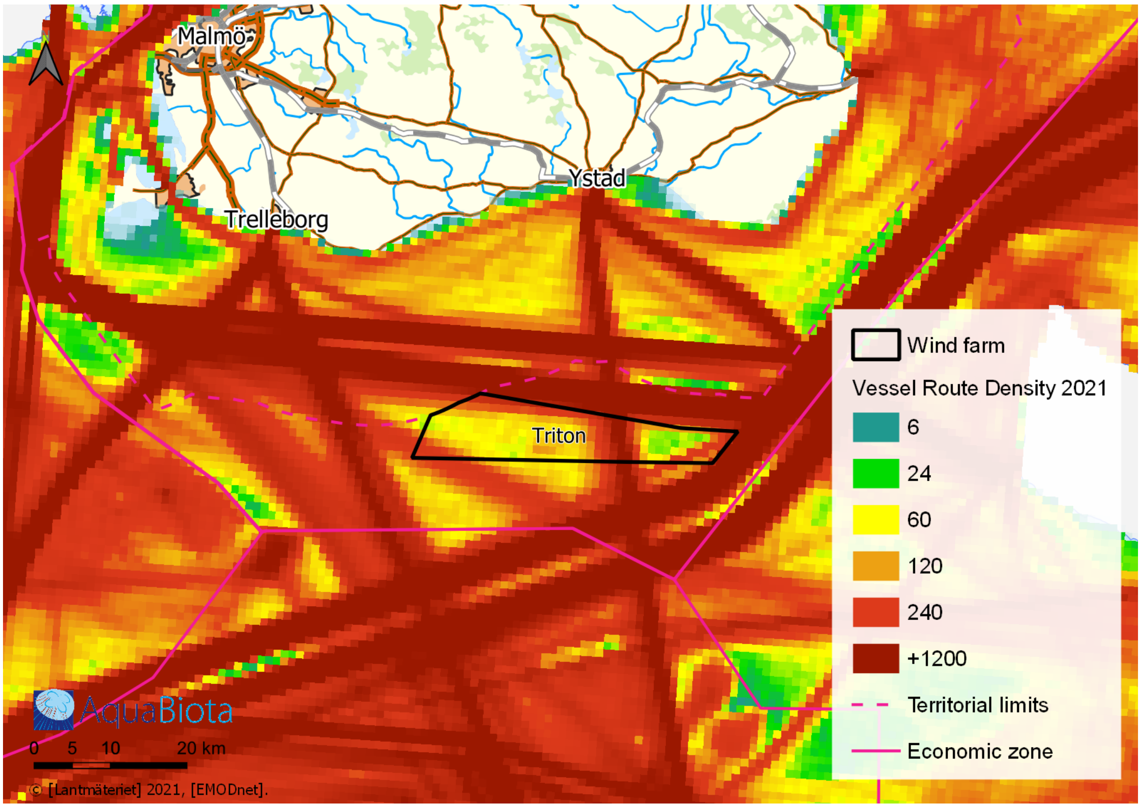


Figure 10. AIS data on the number of routes/passages per km^2 in 2020, and shipping lanes in the vicinity of the wind farm.

3.5.4 Military areas

The Triton wind farm does not adjoin any of the Defence Forces' openly designated military areas (Försvarsmakten, 2019), but the southern part of the wind farm adjoins an area used by NATO for military exercises, see Figure 11.

11 An area within defined limits where ships must navigate with particular caution and within which the direction of flow of traffic may be recommended.

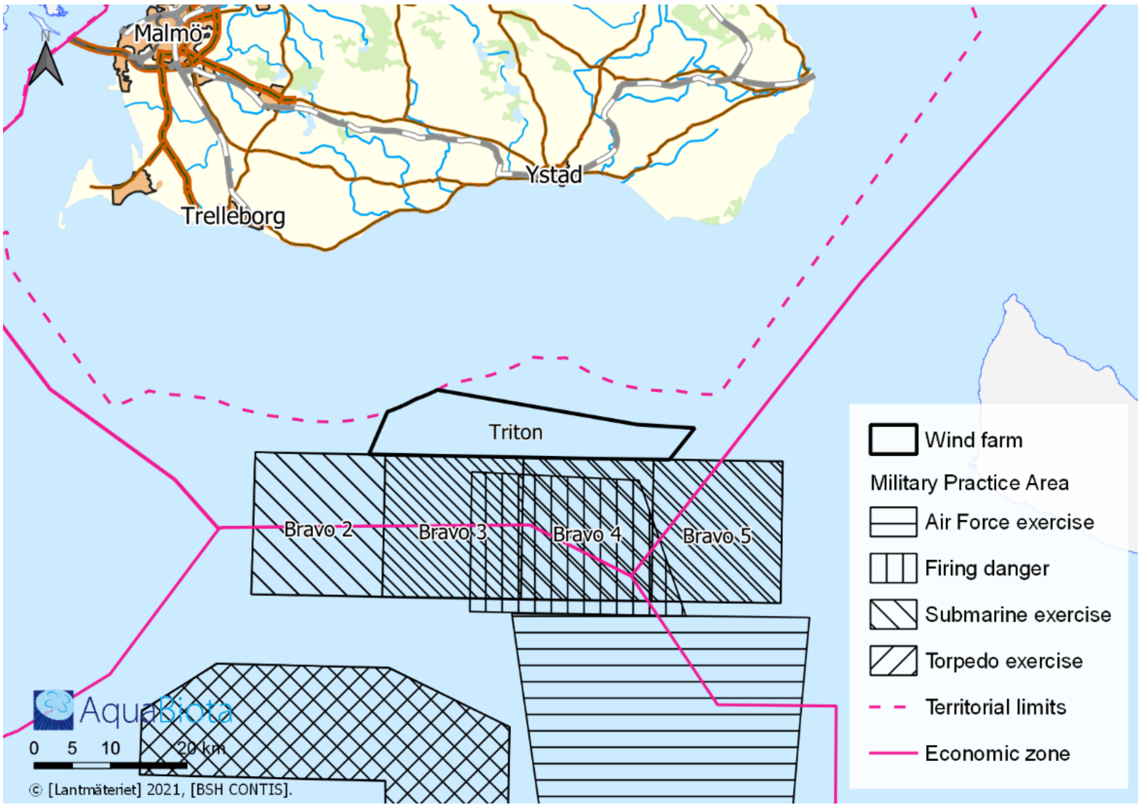


Figure 11. NATO maritime exercise area.

3.5.5 Environmentally hazardous objects and dumping areas

There are several extremely environmentally hazardous wrecks[12] north of the park area. No known dumping areas exist within the Triton wind farm site and HELCOM classifies the area as having a low risk of sea mines.

4 Description of the project

This chapter describes the planned operations and its main components.

Technology is being developed rapidly and continually in the wind power industry, which means that more cost and environmentally effective technologies are becoming gradually available. The detailed design of the wind farm, including final location of the turbines, choice of foundations and installation techniques, will be decided in before construction of the wind farm to enable the use of the best possible technology. On that basis, the following are descriptions of examples of wind farm layout design, design of foundations and wind turbines, and installation methods.

4.1 Overview

The wind farm consists mainly of wind turbines erected on foundations that are anchored to the seabed, and inter-array cables connecting the wind turbines to one or more substations (or inverter stations), see example in Figure 12. Erosion protection is installed around the

12 Wrecks containing large quantities of oil that may leak out in an uncontrolled fashion (Swedish Agency for Marine and Water Management, 2019d)

foundations. In addition, connector cables are needed to lead the electricity produced to land. However, these are not included in this study.

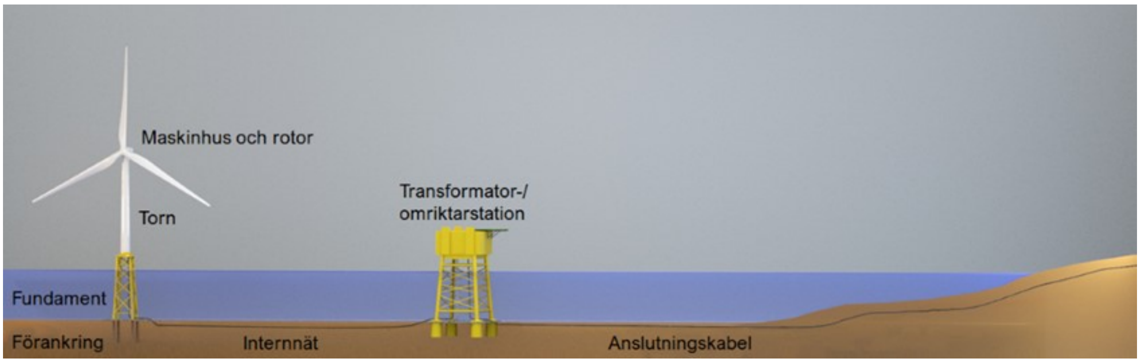


Figure 12. Example of the various components of a wind farm, OX2 AB, 2021.

An offshore wind farm comprises the following main components:

- Offshore wind turbines
- Foundations for the wind turbines
- Undersea cables for the inter-array and communication between turbines
- Foundations for offshore transformer or inverter stations, and related superstructures (platforms)
- Erosion protection for foundations
- Met mast
- Undersea cables for connecting the wind farm to land

4.2 Planned design

The planned windfarm has an estimated total nameplate capacity of about 1700–1900 MW and will consist of a maximum of 129 wind turbines.

The final design of the wind farm will be determined from, among other things:

- Site-specific conditions including geology, wind measurements, waves and currents.
- The technology available at the time of procurement and construction.
- Optimisation of electricity production and costs.
- Limitations set by the licence regarding dimensions, conditions and environmental impacts linked to, e.g., natural values, sound, sediment spread and visual impressions.

Varying sizes of wind turbines lead to different numbers and different designs for a wind farm layout. Figure 13 and Figure 14 present two examples of farm layouts for the Triton wind farm, using smaller (15 MW) and larger (25 MW) wind turbines. The output of the wind turbine is not a controlling factor but is used to obtain a reasonable size of future turbines. The layout examples below show how wind turbines could be placed within the wind farm. No wind turbines are placed on the shipping lane for ferries from Ystad to Sassnitz and Swinoujscie. The minimum distance between the turbines will be five rotor diameters. Table 5 shows basic information for the two different examples.

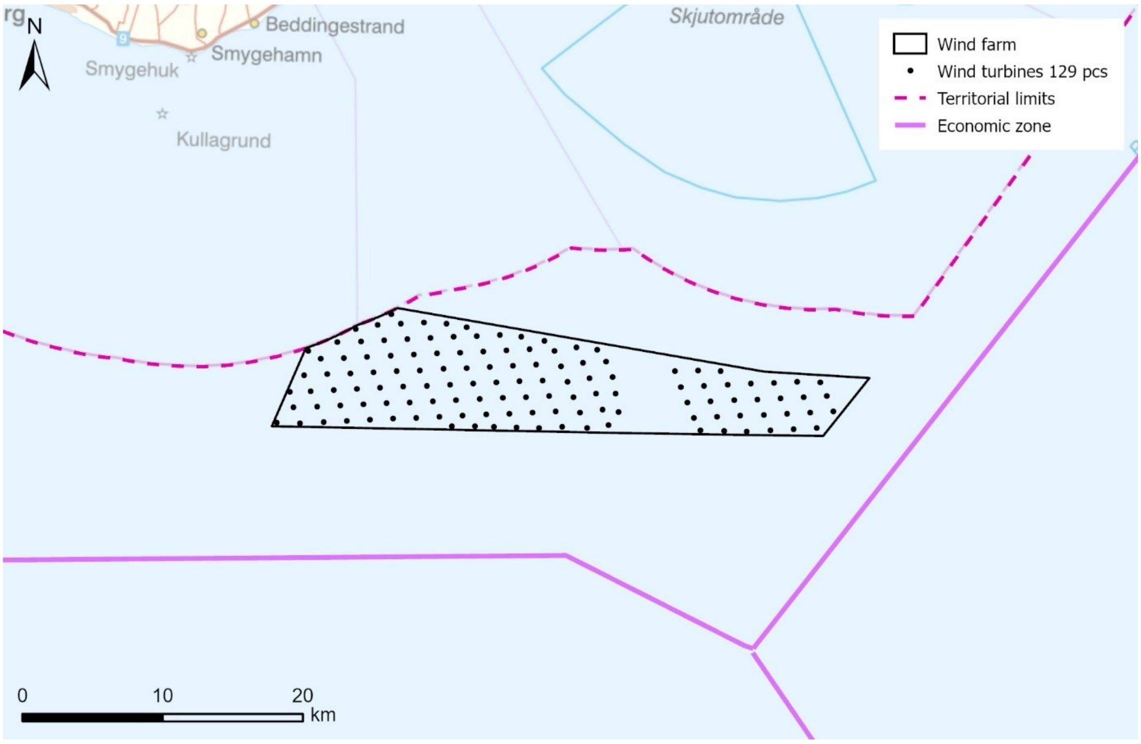


Figure 13. Example of layout with 129 15 MW turbines. No wind turbines will be placed where ferries from Ystad to Sassnitz and Swinoujscie pass. (Source: Lantmäteriet (the Swedish mapping, cadastral and land registration authority)

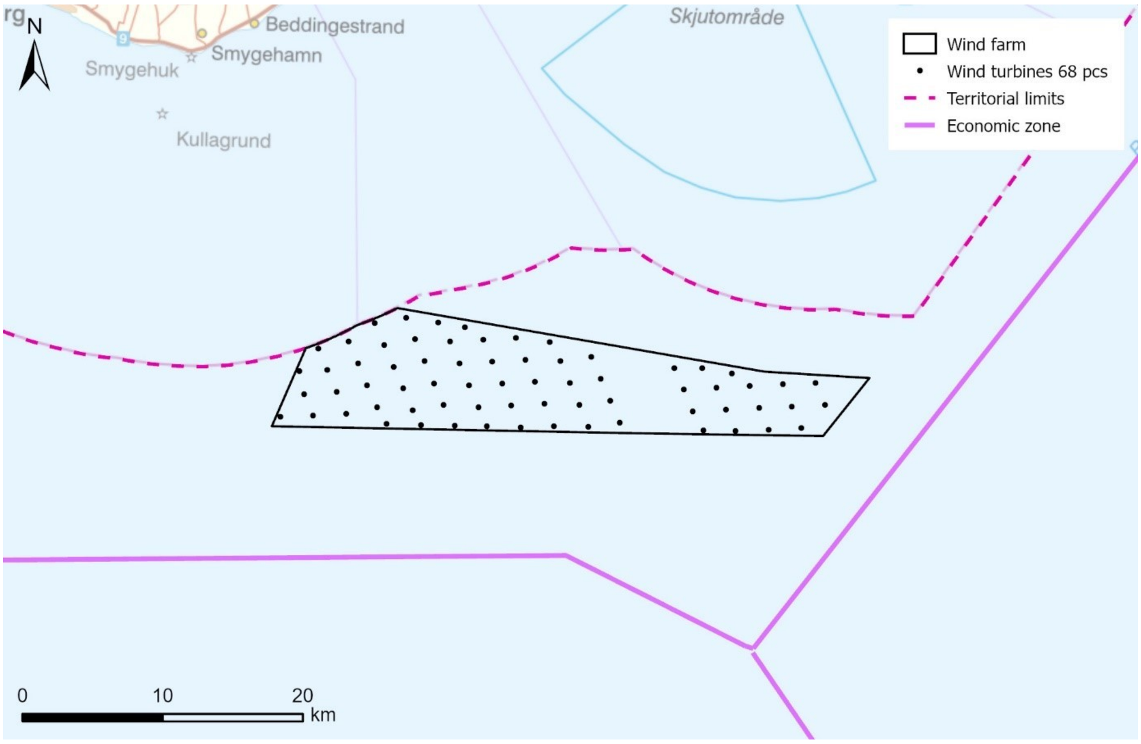


Figure 14. Example of layout with 68 25 MW turbines. No wind turbines located in the shipping lanes where ferries from Ystad to Sassnitz and Swinoujscie pass. (Source: Lantmäteriet (the Swedish mapping, cadastral and land registration authority)

Table 5. Example layout with 129 15 MW turbines. The height above the surface of the water is relative to the average water level (MSL).

Maximum number of turbines	**129 turbines**
The maximum overall height of the wind turbines	370 metres
The maximum rotor diameter of the wind turbines	340 metres
Expected minimum distance between turbines	5 rotor diameters
Clearance (minimum height of blade tip above water surface)	30 metres
Estimated cable length of the inter-array	300 kilometres
Number of transformer substations/platforms	Up to 6 stations
Estimated number of shore export cables	2- 6 cables
The farm area	250 km^2 (including shipping lanes for the Ystad-Sassnitz and Ystad-Swinoujscie ferries)
Water depth	43–47 metres
Estimated total nameplate capacity	1700–1900 MW
Estimated annual electricity generation	7.5 TWh

4.3 Description of the components of the the wind farm

4.3.1 Wind turbines

In principle, a wind turbine consists of three parts: A tower, a nacelle and a bladed rotor. Wind turbines can have either vertical or horizontal shafts with two or three rotor blades. The type of wind turbines that have been developed most rapidly and mostly installed are of three-blade horizontally shafted turbines (see Figure 15). Vertical-axis wind turbines are not currently commercially viable.

Wind turbines are expected to produce electricity at wind speeds from about three m/s and achieve maximum production at wind speeds between 10 and 14 m/s. When the wind (on rare occasions) exceeds about 30 m/s, the turbine is switched off to restart automatically when the wind speed is lower.

Examples of the number and size of turbines that may be considered at Triton are given in Figure 15 and Table 6. In the examples, the turbines have an output of 25 MW and 15 MW, respectively. The turbines that are relevant at the time of procurement and construction of the Triton wind farm are expected to have a useful life of approximately 40–45 years.

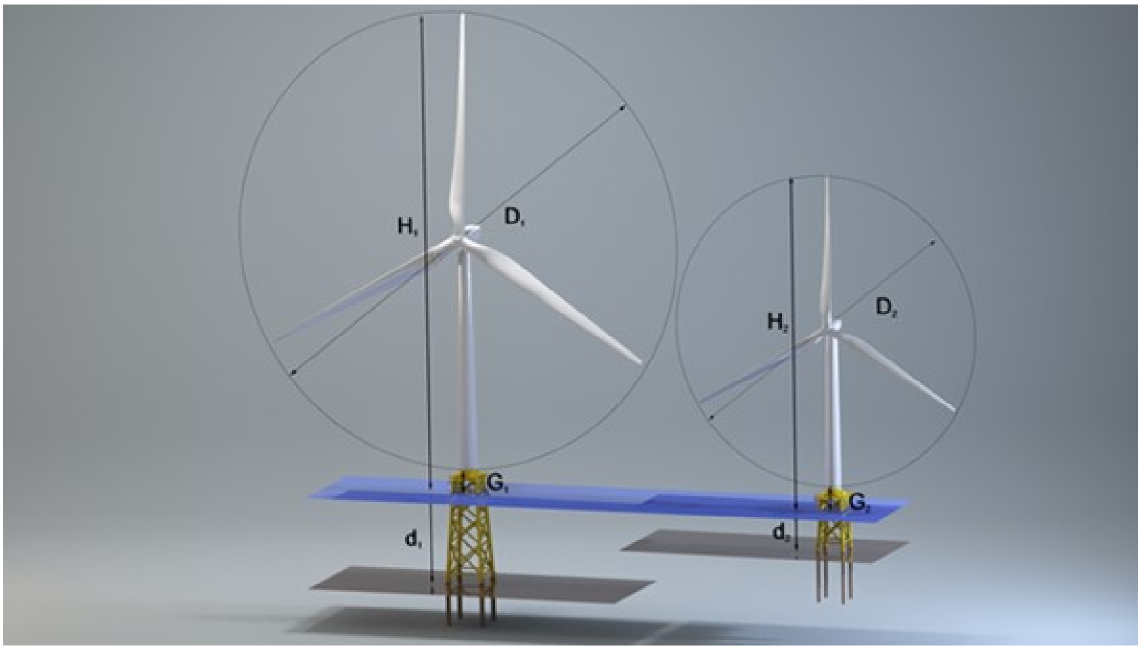


Figure 15. Examples of wind turbines. D = rotor diameter, H = overall height, G = clearance, d = water depth. The illustration applies to two different depths of water, but the selection of wind turbines is not dependent on the water depth, OX2 AB, 2021.

Table 6. Examples of the dimensions of wind turbines that could be considered for use at Triton.

	Example 1	**Example 2**
Turbine output	25 MW	15 MW
Rotor diameter D (metres)	340	240
Overall height H (metres)	370	270
Clearance (G) (metres)	30	30
Hub height (metres)	200	150

4.3.2 Foundation

The function of the foundation is to support the turbines. Fixed foundations are firmly anchored to the seabed, and technical developments have led to the construction of fixed foundations in ever deeper waters. Floating foundations, which are also under development but not yet commercialised, are primarily intended for depths of water over 60–70 metres and have therefore been excluded for Triton. This section describes the different types of foundations that may be applicable to Triton.

Fixed foundations consist of three main parts: A part that secures the foundation in or on the seabed, a part to elevate above the surface of the water and a part (*transition piece*) that forms the transition between the foundation and the tower to ensure that the tower stands vertically. The most common types of fixed foundations are:

- Monopile – a steel cylinder, usually driven into the seabed
- Monobucket – a monopile with a *suction bucket* (a steel cylinder with a suction cup)
- Gravity foundations made from concrete or other materials
- Jacket foundation, a framed structure that is supported on three or four legs and is anchored by *suction caissons*
- Jacket foundations anchored by *pinpiles*; small steel piles driven down into the seabed.

Examples of the different alternative foundation types are shown in Figure 16.

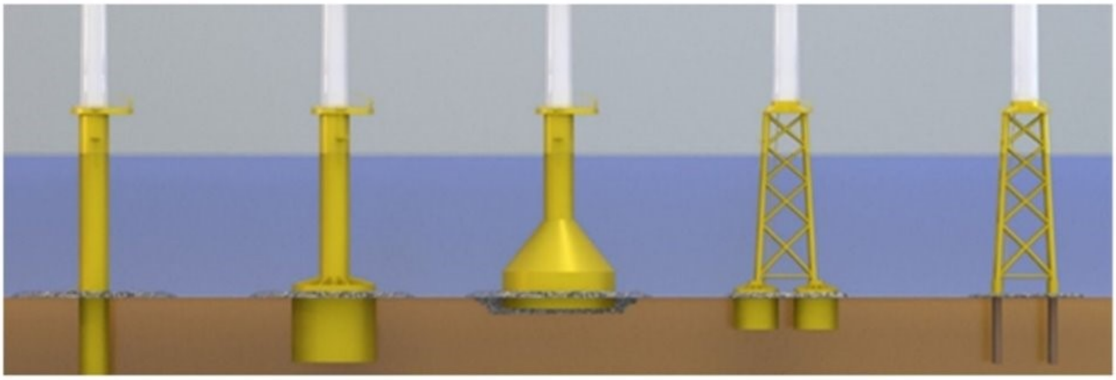


Figure 16. Example of the various foundation types, OX2 AB, 2021.

Based on the geological conditions at the site (see section 3.3) and the technology available today, three different types of foundations are considered to be relevant for Triton: Gravity foundations, monopile foundations and jacket foundations. Jacket foundations can be anchored using pinpiles or suction caissons, also known as *suction buckets*. The technology is developing rapidly, which also makes it possible that other types of foundations, or hybrids of the foundations presented, could be taken into consideration at the time of construction.

Erosion protection is fitted around the foundations on the seabed to protect foundations from occurrence of erosion scour. The quantity and need for erosion protection vary depending on the foundation type, waves, currents and bottom substrate and will be finally determined at a later stage. The most common type of erosion protection consists of layers of rock, gravel and sand in varying sizes that are laid around the base of the foundations.

For a description of which foundations have been used as basis for assessment in the EIA, see section 5.3.

4.3.3 Offshore transformer and inverter stations

One to three platforms are planned at the wind farm site to house transformer or inverter stations. The exact design and number depend on the choice of technology and design of the wind farm and the connection technology. If the superstructure of the platforms results in the need for more foundations or a division into a larger number of platforms, the assessments will allow for six platforms. Transformer stations connect the inter-array cables and transform voltage from lower to higher to reduce electrical losses when transferring to land. A number of export cables are connected from the transformer station and conduct the electricity on to the connection point on land. Transformer stations/platforms consist of one or more foundations and a superstructure. If the transfer to land is made with high-voltage direct current (DC) instead of high-voltage alternating current (AC), inverters are included as part of the electrical equipment, this station is then usually referred to as an inverter station. The inverter station converts the AC current generated at the turbines to direct current. An inverter station can be placed on a separate platform. An inverter station can be used alone or in combination with transformer substations.

The foundation types that are available for offshore transformer substations/platforms are essentially the same as those for wind turbines but dimensioned with respect to the loads resulting from the design of the stations. See Figure 17 for some examples of how platforms and foundations can be designed. They may contain a helicopter landing pad.

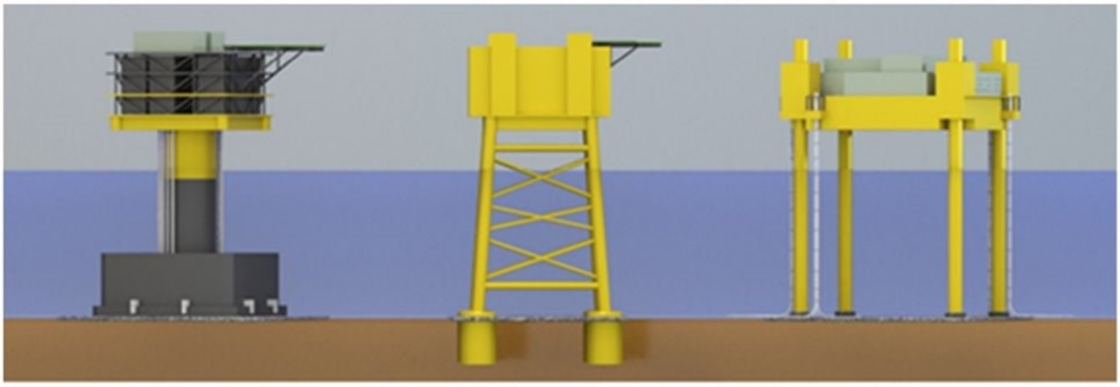


Figure 17. Example of foundations and design of offshore substations/platforms, OX2 AB, 2021.

The number, design and location of the transformer substations/platforms and/or inverter substations/platforms will be determined during the wind farm's detailed engineering, based on the size and number of turbines, seabed conditions and optimal cable routing. At present, alternative locations for transformer stations are being investigated in order to optimise the length of the inter-array cables and export cables. It is most likely that the substations are placed in the central parts of the wind farm site.

4.3.4 Inter-array cables

The inter-array cables form the connection between the wind turbines and the offshore substations by connecting individual wind turbines in groups (radials) which are then connected to the substation.

The total length of the inter-array cables depends on the wind turbines' voltage level, output and numbers. Other factors, such as the nature of the seabed, can also affect the length of the cable array. That is because longer cables are required if the seabed is very uneven, or if there are areas that must be avoided. For example, based on the cabling technology available today the inter-array can consist of 66 kV cables, which can transmit a combined power of around 80– 90 MW per radial. This means that six 15 MW turbines or four 25 MW turbines can be connected along the same radial. In view of developments in the technology, the voltage level of the inter-array cables is expected to increase to approximately 170 kV or even higher over the next five to ten years. This would increase the total transmission capacity of each cable, thus reducing the number of radials and thereby the total length of cable. See Figure 18 and Figure 19 for examples of two alternative farm designs and their inter-array, which consists of 66 kV cables. The cables are laid on the seabed and are buried either by jetting or ploughing to a depth of one and two metres below the seabed to protect the cables from damage from fishing gear, anchors, etc. Transboundary impacts are not expected to arise as a result of the inter-array cables.

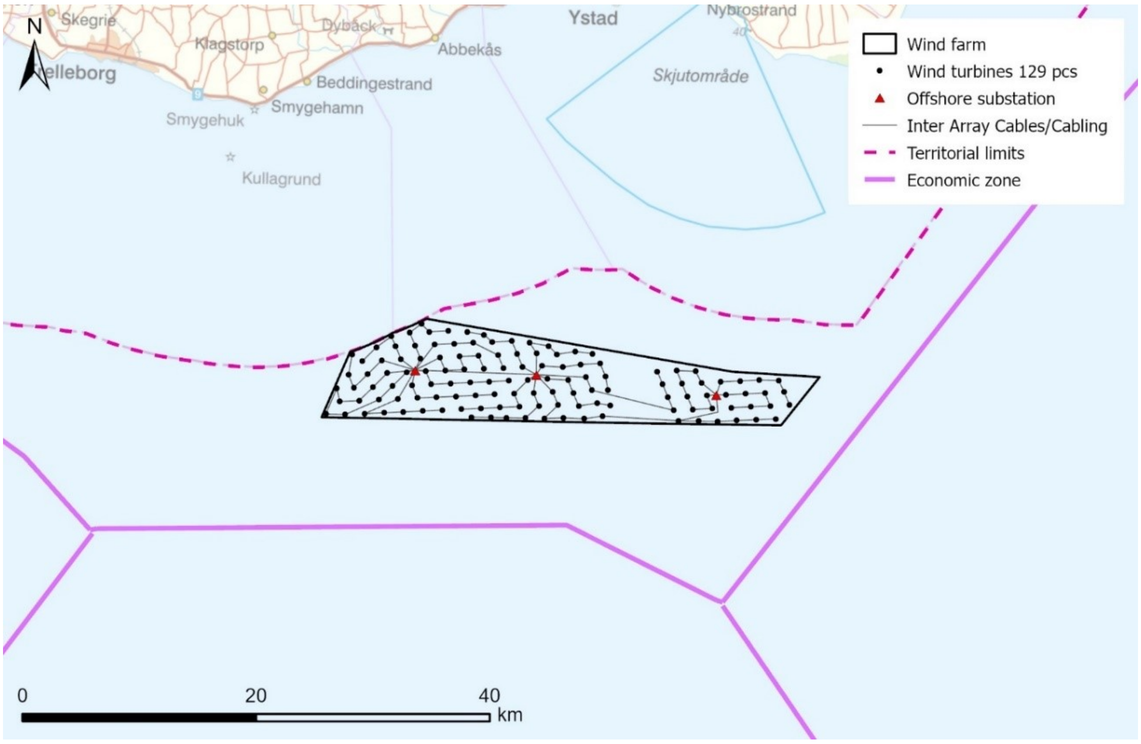


Figure 18. Example of the inter-array within the wind farm with 129 wind turbines. (Source: Lantmäteriet (the Swedish mapping, cadastral and land registration authority).

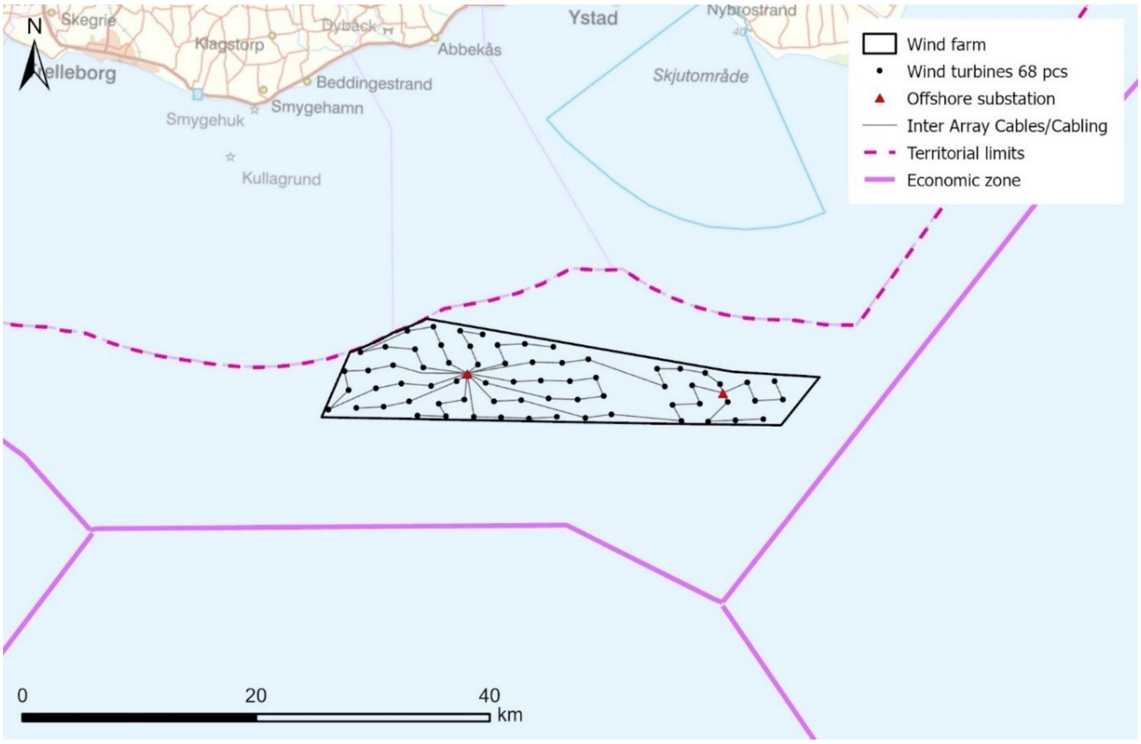


Figure 19. Example of the inter-array within the wind farm with 68 wind turbines. (Source: Lantmäteriet (the Swedish mapping, cadastral and land registration authority).

4.3.5 Export cables

When the electricity is transformed and possibly converted, it is transferred via one or more export cables to an onshore connection point. The number and design of the cables depends, among other things, on the technology (HVAC–High Voltage alternating current or HVDC–High Voltage Direct current) used and the voltage level.

The number of cable connections for the Triton wind farm will be determined on the basis of the final capacity of the wind farm and the level of voltage at which the electricity can be transmitted and whether the transmission is direct current or alternating current. Triton survey corridors are shown in Figure 20.

It may also be appropriate to route one or more cables directly to shore from the wind farm without transforming the voltage at a substation.

For an AC connection, each offshore cable connection has a diameter of approximately 30 centimetres (approximately 1,000 mm^2 conductor area) and is a high-voltage AC (HVAC) transmission system. A voltage level of up to 220 kV is currently the most common, but there are also developments by cable manufacturers to further increase voltage on subsea cables.

DC transmission is usually used for transfers between countries and over longer distances, as the losses are smaller than for alternating current. Transmission with DC connections uses two-pole cables (+ and -) with an approximate conductor size of approximately 1,000–2,500 mm^2 and an external diameter of 15–20 centimetres. The cable voltage can be up to 525 kV HVDC.

Export cables are usually installed using the same methods as for the inter-array cables. The position of the export cables is shown on nautical charts and marked by signs at the onshore landing site. The export cables are a consequential activity for the wind farm but are not deemed to have any transboundary impact.

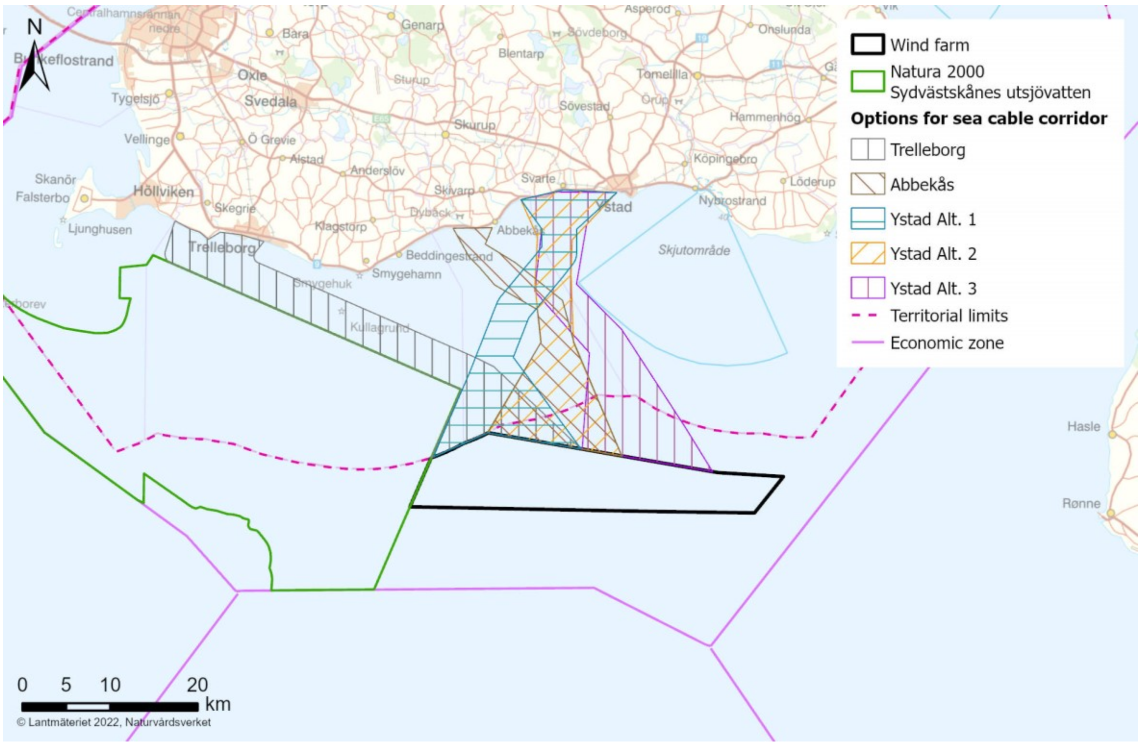


Figure 20. Cable routing for export cables. At the end of the corridor, the cable continues on land.

4.3.6 Met masts

One or more met masts may be installed to supplement the available wind data from the area. A met mast usually has a height corresponding to the hub height of the wind turbine and is installed in the same way as a wind turbine, with a foundation anchored to the bottom. However, the foundation for a met mast is considerably smaller than for a wind turbine.

A technology that is rapidly developing and has the potential to replace met masts is called Lidar. Lidar devices use lasers to measure wind speed. The equipment can be placed either on a fixed foundation or on a floating platform. At present, this measurement technique has not been certified to provide a basis for load determination, but this is expected to be possible in the future. Masts for communication equipment may also be erected in the farm area.

4.4 The various phases of the operation

The wind farm will be established in different phases. The operation is currently in the permittingphase, followed by the construction, operation and decommissioning phases. The section describes the activities of the phases in broad terms.

Figure 21. Schematic diagram of the various phases of the operation.

4.4.1 Construction phase:

The construction phase includes detailed engineering, manufacturing and installation. The construction phase also includes survey activities that are needed before and during the construction of the operation.

The detailed engineering of the wind farm produces the final design. The components are adapted to technical requirements and to site-specific conditions such as geology, hydrology and metrology. The components are dimensioned to cope with extreme temperature, wind speeds, wave height, etc., according to current standards. In addition, potential impacts from ongoing climate change are taken into account, such as changes in sea surface level, temperature and wind climate, as well as the average wind speed and the strength of extreme wind events. The final design should also ensure minimal environmental impact.

During the detailed engineering and installation of the wind farm, surveys of the farm area (construction surveys) are conducted to obtain detailed information for detailed engineering, final design documents and for the control of the construction work.

The typical survey methods may include:

- Geophysical surveys to map seabed conditions, which may include side scan sonar (SSS), multibeam echo sounder (MBES, multibeam sonar that maps the seabed), and seismic surveys (2D, 3D).
- Geotechnical investigations involving geotechnical drilling and sedimentation studies (e.g., rotary pressure sounding and vibrocorer).

- Magnetometry that is used to examine the seabed for, in particular, artificial objects such as wrecks, dumped objects and abandoned unexploded ordnance (UXO).
- Wave measurement, which involves laying a buoy out to get high resolution information about wave and current conditions at the site.
- Wind measurements can be made either by establishing a met tower (see section 4.3.6) or by using floating buoys, usually known as Floating LiDAR, FLIDAR.
- Seabed grab sampling, filming
- Surveys using ROV (remotely operated vehicle) or equivalent

Methods other than the above may be used, but their environmental impact will never be greater than described in this EIA.

Once the final design of the wind farm has been defined and components have been procured and manufactured, construction of the farm can begin. The entire installation would preferably conduct during a single season, because work at sea is preferably limited during the winter period, although spread over multiple seasons is possible. For example, foundations and cables can be installed during an initial season and the turbines during the following season. Alternatively, half of the wind farm can be installed and commissioned during a first season, after which the remaining part of the wind farm will be installed and commissioned during the next season.

Installation at sea takes place by first installing the foundations, substations and export cables. The inter-array cables are then installed. Finally, all wind turbines are installed with towers, nacelle (including hub) and rotor blades. Once the turbines have been fully installed, commissioning and operational trials take place before it is handed over to the operating organisation after approved trials. The installation of the wind farm is completed with the commissioning of the turbines, which includes trial operations.

Installation of land cables normally starts before work at sea. This part is not as weather-dependent as installation at sea. The entire system should be ready when the turbines are installed so that they can be energised.

During the installation of the wind farm, many installation vessels and working platforms of various kinds will be located in the area for installation of components and for transport to and from the site. Usually, several installation stages occur in parallel with each other but in different parts of the wind farm. For example, installation of a transformer substation can take place at the same time as installation of foundations for wind turbines and cable laying can take place at the same time as installation of foundations or wind turbines at a different location.

The preliminary number *of crew transfer vessels* (CTV) that will work in the wind farm is about three to four that sail to and from ports during the construction phase. A range of vessels and barges will be used for the delivery of foundations, cables and wind turbines and make trips to one or more of the final assembly or manufacturing ports. A Guard vessel will be used during the construction phase for safety monitoring, round trips and return trips to ports.

Proposals for safety measures

A number of safety measures have been proposed for the construction phase, including for the surveys that need to be conducted and for the installation of foundations. Chapter 10 describes the safety measures, the impact of the various safety measures and which safety measures have formed the basis for the impact assessments that have been conducted.

4.4.2 Operational phase

During the operational phase, regular maintenance and maintenance of the wind farm will be performed throughout its lifetime. The wind farm is expected to operate for 40–45 years.

Service and maintenance

The final operating and maintenance strategy will be established as part of the detailed planning of the wind farm. Both wind turbines and substations are remotely monitored 24 hours a day and unattended during normal operation. However, continual maintenance takes place at the wind farm, which requires wind farm personnel and materials to be transported there by small supply vessels, ship or helicopter. Installation vessels may also be used if repair or replacement of major components are necessary. Seabed surveys may also take place to inspect the status of the facility.

The preliminary number of CTVs that will work in the wind farm is about three to four, with up to about 300 trips to and from port per year per CTV. Maintenance using jack-up vessels or similar will also be used as well as service operation vessels for larger jobs. During the operational phase, seabed surveys may be carried out to inspect the status of the facility, to prepare for major maintenance operations with jack-up vessels, or to meet the requirements of an inspection programme. The type of surveys is similar to those described in the construction phase but of a more superficial nature and to a limited or local extent.

Electromagnetic fields

Power through cables generates a magnetic field, which varies according to the momentary power load in the cable, and on the construction of the cable. Both AC and DC power cables generate electromagnetic fields. Alternating current generates an alternating magnetic field, while direct current generates a static magnetic field.

The strongest magnetic field in the inter-array is generated directly above the cable. The magnetic field then decays rapidly and about four metres from the centre line the magnetic field is less than 1 µT. When the inter-array is made up of AC power cables, an alternating magnetic field is generated from the array cables.

4.4.3 Decommissioning phase

The section is a summary of reference report R.21 "*Technical Description – Decommissioning of an offshore wind farm".*

When the wind farm is decommissioned, wind turbines, foundations and substations will be dismantled and the site of the foundation restored to the required extent. A decommissioning plan will be drawn up about two years before the start of decommissioning. The purpose of the decommissioning plan is to describe how the decommissioning is to be conducted and to define what re-establishment work is to be conducted. The decommissioning method will be applied in accordance with the practice and legislation in force at the time of decommissioning.

According to current levels of knowledge, the construction parts that are above the seabed are generally removed. For example, decommissioning can be achieved by dismantling wind turbines and substations using a crane vessel. Pile foundations can be cut off just below the seabed and then lifted away from the site. For subsea structures (foundation components and cables) and erosion protection, an assessment will be made as to whether the environmental damage caused by the removal of structures is greater than the environmental benefit. This assessment will be conducted in consultation with the authorities closer to the time of decommissioning.

Some components in a wind turbine may be rebuilt or resold, depending on the lifetime of the component and how long it has been used. There is, therefore, a potential for reusing blades, yaw mechanisms, gearboxes, generators, nacelles, brakes and towers after overhaul. Several companies are currently also offering component conversion services. If the components cannot be reused, most parts of a turbine are recyclable. Components in a wind turbine are mainly made of steel, aluminium, composites and fibreglass.

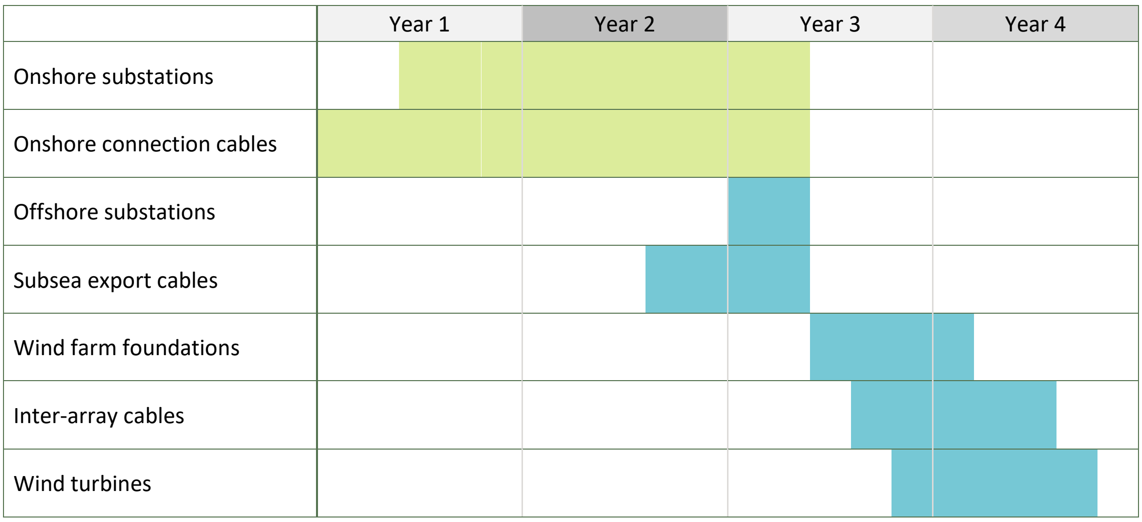
The development of blades, which usually consist of a fibreglass composite, is taking place with greater use of other materials that will allow more parts of the blades to be recycled in the future, for example in insulation. Foundations and offshore platforms are mostly made of steel that can be recycled when disassembled. In the unlikely event of the dismantling of gravity foundations (that used concrete as ballast), the concrete can be used as aggregate for other structures.

4.5 Preliminary installation plan

An overall schedule describing the principles for the construction works for the wind farm is shown in Table 7. In order to provide a holistic understanding of the project, the schedule also describes parts of the construction that takes place on land. The schedule shows the order of construction and when the different parts of the plant are planned in relation to each other.

The wind farm is intended to be taken into operation as soon as possible. The commissioning of the wind farm is dependent, among other things, on obtaining the relevant licences and the allocation of an access point to allow the wind farm to be connected to the grid. The installation time depends on the choice of technology, any requirements and conditions laid down in the licences and the availability of installation vessels. Commissioning of the wind farm, given current lead times for licences, is expected around the year 2030, with construction work for the wind farm taking place in the latter part of the 2020s. The possibility of electrical connection and coordination with Svenska kraftnät's timetable is also included in the estimate. Installation work at sea can generally take place all year round, even if it is affected by weather conditions, in the form of wind forces and wave climates. During the winter months the weather is generally more challenging, which requires longer installation times, with longer periods of standstill.

Table 7. Triton Preliminary Installation Plan.



5 Methodology for impact assessments

5.1 Data and methods for describing the prevailing conditions

Descriptions of the current situation are based on information from authorities, scientific literature, environmental and technical reports, modelling of nature types and habitats, and existing conditions regarding sediment spread and noise propagation.

In addition to this, several surveys, inventories and calculations have been conducted to establish a basis for impact assessments, see Table 8.

Table 8. Surveys conducted.

Study/survey	Dated	Method	Dated
Sediment modelling	July 2021	Modelling	NIRAS
Hydrographic modelling	November 2021	Modelling	NIRAS
Modelling subsea noise from impact piling and seismic surveys	October 2021	Modelling	NIRAS
Oxygen content, salinity and temperature	June and August 2021, June 2022	CTD surveys	Aquabiota
Bird inventories	March and April 2021, and January and April 2022	Aviation inventory. observers	Ottvall Consulting
Porpoise counts	June 2021-ongoing	Acoustic porpoise detectors, F-pods	Aquabiota
Counts of marine mammals and fish	June and August 2021, June 2022	eDNA counting	Aquabiota
Modelling of bottom fauna	October 2021	Modelling	Aquabiota
Bottom flora and fauna	June 2022	Video survey, grab sampling	Aquabiota
Environmental toxins	June 2022	Sediment sampling	Aquabiota
Environmental toxins	June 2022	Modelling	NIRAS
Noise propagation air	November 2021	Modelling	OX2
Shading	November 2021	Modelling	OX2
Marine archaeological pre-study.	September 2021	Desktop study	Bohuslän Museum
Visualisations, photo montage and visibility analysis	November 2021	Photo montage, animations	Norconsult, OX2
Landscape analysis	February 2022	Report	Rejlers
Exploratory fishing	June and August 2021	Trawl exploratory fishing	Aquabiota
Bat counts	August and September 2021	Bat counts	EnviroPlanning

The knowledge base (existing data such as scientific studies, literature, counts and modelling and the data produced in the work on the licence application) is deemed to be of the extent to which dependable, robust and scientifically substantiated descriptions of the current situation and assessments of the effects and impacts of the operation can be made. The results of counts and modelling performed regarding, for example, seabirds, porpoises, fish and nature types are well in line with the results of previous counts and the data collected and analysed from authorities, scientific literature and research.

The report describes in detail the methods, modelling, surveys, etc. used for descriptions of the current situation and impact assessments. All supporting documentary reports make up reference reports to this Espoo report and are referred to as R.1, R.2, R.3, etc. continuously in the text.

5.2 Impact assessment methodology

A systematic approach has been used to identify and assess the potential influences, effects and impacts of the activity on various environmental aspects and to describe mitigatory measures to avoid, minimise or reduce impacts. The methodology below is used for the planned operations that is included in the permitting process, whereas the impact assessment is more general for consequential activities.

The EIA uses the terms sensitivity, influence, effect and impact.

- **Sensitivity** or **value** – what is the sensitivity of the recipient? The value can be objects and/or areas and connections.
- **Influence** - the physical measure itself.
- **Effect** – the change that occurs in the environment as a result of the influence. The effect is the extent or degree of influence. If possible, it is described quantitatively.
- **Impact**– the significance of the change that arises.

The sensitivity or value of an environmental aspect is described according to the site's existing conditions and can be performed by objects and/or areas and their connections within or between them. Sensitivity/value depends, among other things, on such properties as size, robustness and connection to the environment.

When value/sensitivity is developed, a delimitation of the influence is made, which type of influence can be caused by the activity. The degree of influence (impact) on the recipient is then assessed as a result of the activity. Assessment of the environmental impact on each environmental aspect has been made through a combined assessment of the recipient's sensitivity/value and the extent of the influence (effect).

5.2.1 Description of potential influence factors

The influence factors of the activities have been identified in the form of when, where and how the activities can give rise to an influence on the identified environmental aspects.

In Chapter 6 we describe the influence factors that influence each recipient and the phase (construction, operation, decommissioning) during which the influence occurs.

5.2.2 Assessment of the sensitivity/value of the recipient

In a second step, the sensitivity, or value, of the recipient is assessed and described. Recipients in this case are those who may be affected by the activity and may refer, for example, to a species group, nature type or other interests such as fishing or scenic values. The biological values use the sensitivity of the recipient and other interests use sensitivity/value.

- The status of the recipient (e.g. population trends, occurrence, the significance of the region to the recipient)
- Sensitivity and adaptability of the recipient to the influence factor concerned (e.g. sedimentation or subsea noise)
- The sensitivity of the recipient during different periods of the year, for example, the recipient may be more sensitive during the mating season or migration periods
- The recipient's protection value

The sensitivity of the recipient is evaluated for relevant influence factors during each phase of the operation such as construction, operation and decommissioning on a three-degree scale: Low, moderate, high.

5.2.3 Size and extent of the influence (effect)

The size and extent of the influence (effect) are assessed from: Geographic spread, duration in time, size (magnitude) of the influence factor and likelihood of the influence occurring. The influence is evaluated for relevant influence factors during each phase of the business on the following scale: none/insignificant, small, moderate or large. An influence is stated as positive or negative.

Table 9. Description of the levels of importance of the influence for the recipient.

Size and extent of the influence (effect)	Description
None/insignificant	Forces do not produce any or minor effects that have limited propagation, are less complex, short-term
Small	The forces give rise to effects with some extent and complexity and of a certain duration
Moderate	The forces give rise to effects of either a relatively large extent or that are long-term (e.g. lasting throughout the lifetime of the wind farm)
Large	The forces give rise to effects of that are large in extent and/or are long-term, frequent effects

5.2.4 Impact assessment

For the assessment of the impact of the activity, the value of the sensitivity to the recipient is weighed against the value of the size and extent of the influence (effect), resulting in a total assessment of the impact. The significance of the impact is assessed on the scale of none/negligible, very small, small, moderate, large or very large positive or negative impacts, Table 10.

It should be noted that the assessment scales do not constitute a precise assessment template. In each case, a more detailed assessment is made of the specific circumstances and the type of influence assessed. In order to make a value assessment as objective as possible, the basis on which the influence has been motivated/evaluated is presented for each nature type and species.

Table 10. Description of the levels of impact significance for the recipient.

The significance of the impact	Description
None/negligible	No or negligible impact on the recipient. No/minor disturbance on areas and/or functions/populations.
Very small	Negative impact for the recipient. Very small areas and/or functions and very small part of the population are disturbed. Without irreversible effects.
Small	Low impact for the recipient. Small areas and/or functions and small parts of the population are disturbed, without irreversible effects.
Moderate	Moderate impact for the recipient. Areas, structures and/or functions and/or part of population are harmed. May cause local irreversible effects, such as loss of conservation values. Impacts that may require mitigatory measures.
Large	Large impact for the recipient. A large area, a large part of structures and/or functions or a large part of the population is significantly harmed, with the possibility of causing significant irreversible impacts. Impacts are classified as serious, which means that changes to operations or the application of mitigatory measures must be considered in order to minimise the impact.
Very large	Very large impact for the recipient. Impacts are classified as very serious, which means that changes to operations or the application of mitigatory measures must be applied in order to reduce the impact.

Table 11 shows the total scale for sensitivity/value and the forces and their impact are presented.

Table 11. Evaluation matrix of the importance of the impacts.

Impact's significance		**Size and extent of the influence**						
		Extremely negative	Moderately negative	Slightly negative	Insignificant	Slightly positive	Moderately positive	Extremely positive
Recipient Sensitivity	Small	Moderate	Small	Very small	Negligible	Very small	Small	Moderate
	Moderate	Large	Moderate	Small	Negligible	Small	Moderate	Large
	High	Very large	Large	Moderate	Negligible	Moderate	Large	Very large

It is less appropriate to apply the assessment methodology as described above to some environmental aspects because what is relevant is whether or not a negative impact occurs. The environmental aspects for which the assessment methodology is not fully followed are aviation, risk and security, and military interests.

5.3 Conditions for impact assessments

5.3.1 Assessment based on a worst-case scenario

Offshore wind technology is undergoing rapid development, which makes it difficult to predict exactly which technology will be the most suitable and available at the time of construction of the wind farm. This requires application of a worst-case approach to impact assessments to cover the maximum impact that the Triton wind farm could result in. In order to allow for future technology development, the final design of the wind farm will be determined before procurement and construction commences. The worst-case approach means that the final environmental impact of the plant could be less extensive but never more extensive than described in this EIA and its related reports. This approach makes it possible to assess the mitigatory measures and the considerations that need to be taken to protect the environment.

OX2 has drawn up two representative examples of potential wind farm designs. These are based on turbines with a nameplate capacity of 15 MW (based on 129 turbines) and 25 MW (based on 68 turbines). When output is increased per turbine, the rotor diameter usually also increases. The output of the wind turbine is not a controlling factor but is used to obtain a realistic size for future turbines, Figure 13 and Figure 14.

One challenge is that both example designs lead to different effects for different influence factors. In reality, the design and thus the influence from a future wind farm may land between these examples. It can also mean that some forces, when combined, may be greater than in the design examples; for example, turbine size may allow a number of turbines that is in the mid-range of numbers in the design examples, but that the foundations selected for that option may cause higher sediment spread than in any of the design examples. So, two design examples do not necessarily describe a worst-case.

Therefore, in order not to underestimate the influence and at the same time define relevant conditions for the operation, the maximum influence has been assessed by applying 25 MW turbines and their foundations to the 15 MW design; in other words, 129 wind turbines with 340 metre blades and a 14 metre monopile foundation being constructed in the wind farm, thereby creating a worst-case scenario. In practice, this would not be an optimal scenario because it would be inefficient and unprofitable to build the wind farm in such a way, but it means that the assessed environmental impact is based on very conservative assumptions.

The construction of the Triton wind farm with 129 25 MW turbines also means that the entire installation must be practically assessed on the basis of a worst-case scenario. The starting point is therefore that 15% of all foundations are drilled, which is higher than the 10% used in similar projects in recent years. Because the assessments should not underestimate the impact and no locations should be excluded for drilling, the sediment modelling also assumes that all foundations adjacent to the Natura 2000 site are drilled to 100%, i.e. maximum sedimentation exposure.

The worst-case scenario regarding the impact on the identified nature types and species on which the assessments have been based is shown below. The worst case scenario (in the form of, for example, design, choice of foundations, etc.) is in all cases the same for the recipients, although they may be affected in different ways.

Table 12. Worst-case assumptions used in modelling/calculations for each influence factor connected to nature types/species.

Influence factor	Worst case definition for each influence factor	Recipients

Subsea noise, see section 6.1	The most subsea noise occurs when driving monopile foundations.
	• Impact assessments have been conducted for the month of March, in which sound dispersion is highest in the water.
	• Installation of 14 metre diameter monopiles (the largest monopile foundations) by impact piling.
	• The foundation positions have been chosen where highest noise levels are expected to occur and closest to the Natura 2000 area Sydvästskånes utsjövatten in order not to underestimate the influence on the Natura 2000 area.
	• Sound suppression:
	  o Initially, the prerequisite for assessing noise propagation when impact piling monopiles was use of a simple bubble curtain as a sound-damping measure and smooth start-up.
	  o Additional mitigatory measures to ensure minimal influence on both marine mammals and fish will involve used of double bubble curtains and Hydro Sound Damper or equivalent, and soft start-up will also be used.
		Marine mammals, fish

Sediment spread, see section 6.2	The most sediment spread is caused by the construction of monopile foundations when they are drilled instead of being impact driven. Both sedimentation suspension and sedimentation have been considered.
	• The baseline assumption is that 15% of 14 metre diameter foundations are drilled to full anchor depth (60 metres)
	• Two scenarios for release of sediments during drilling have been assessed:
	  o Sediment is discharged two metres above the seabed and suspended material is reported as an average of the lowest ten metres above the seabed for assessment of the effects on the benthic community.
	  o Sediment is discharged two metres below surface level and measured as an average of the top ten metres of the water column, as well as the lowest ten metres, to assess the effects on fish and larvae
	• When cables are laid, we have estimated that the cables are jetted down to the seabed, as this method causes more sediment spread than other methods.
		Bottom flora and bottom fauna, fish, marine mammals

Environmental toxins/ pollution spread, see section 6.3	See "Sediment spread". Furthermore, we have made the assumption that any pollution that can dissolve in water will also do so.	Bottom flora and bottom fauna, fish
Physical influence, see section 6.4	The total surface of the seabed affected at the facility includes, among other things • gravity foundation, 50 metres in diameter • erosion protection, 70 metres in diameter • substations on jacket foundations • Inter-array cabling • temporary forces from jack-up vessels	Bottom flora and bottom fauna
Substrate changes and reef effect, see sections 6.5 and 6.6	Assessment of substrate changes is based on constructing the most (129) and largest foundations (gravity foundation) including erosion protection, and substations with erosion protection. The reef effect is not assessed on the basis of a worst-case scenario because no adverse effects are expected to occur as a result of the reef effect.	Bottom flora, bottom fauna, fish, marine mammals

Electromagnetic fields, see section 6.7	The worst-case scenario for the inter-array cable network is a maximum magnetic field just above the cables of approximately 23 µT[1]. The magnetic field then decays rapidly side and about four metres from the centre line the magnetic field is less than 1 µT. At locations where the cable has not reached a depth of 1 meter or is covered with cable shields, the magnetic field may be locally larger. The calculations are made at a laid depth of one metre and 1,200 amps.	Fish, marine mammals
Displacement, see section 6.8	Wind farm design: • Maximum number of turbines (129 turbines) • Choice of turbines with the largest rotor (340 metres in diameter) and the highest overall height (370 metres) Bird behaviour in relation to the wind farm: • Birds avoid the entire wind farm and not just specific wind turbines.	Birds
Barrier effects, see section 6.8	Wind farm design: • Maximum number of turbines (129 turbines) • Choice of turbines with the largest rotor (340 metres in diameter) and the highest overall height (370 metres) Bird behaviour in relation to the wind farm: • Birds avoid the entire wind farm and not just specific wind turbines.	Birds
Collision risk, see section 6.9	Wind farm design: • Maximum number of turbines (129 turbines) • Choice of turbines with the largest rotor (340 metres in diameter) and the highest overall height (370 metres) • The clearance between the sea surface and the lowest tip of the rotor blade is 30 metres	Birds, bats
Visual changes, see section 6.10	Wind farm design: • Maximum number of turbines (129 turbines) • Choice of turbines with the largest rotor (340 metres in diameter) and the highest overall height (370 metres) • Marker beacons at a hub height of 200 metres	Landscape scenery
Airborne noise, see section 6.11	Wind farm design: • Maximum number of turbines (129 turbines) • Choice of turbines with an output of 25 MW with the largest rotor (340 metres in diameter) and the highest overall height (370 metres)	Residents, marine mammals
Shadowing, see section 6.12	Wind farm design: • Maximum number of turbines (129 turbines) • Choice of turbines with the largest rotor (340 metres in diameter) and the highest overall height (370 metres)	Marine mammals, fish, benthic community
Nautical hazards, see section 6.13	Scenario design: • Dimensions of the risk of allision of a vessel with a wind turbine o Influence radius of 50 metres from the turbine o vessels are 30 metres high • Maximum number of turbines (129 turbines)	Maritime activities

5.3.2 Mitigatory measures

A number of mitigatory measures will be applied to reduce the effects and impacts of the planned operations. The mitigatory measures to be taken are laid out in Chapter 10 and include, inter alia, the following protective measures, which have formed the basis for impact assessments:

- Geophysical surveys using side-scanning sonar and multi-beam sonar methods will operate at frequencies greater than 200 kHz to be outside the hearing range of porpoises.
- For seismic surveys, mitigatory measures applied will include soft-start, passive acoustic monitoring and observers.

- Techniques that reduce sound dispersion such as double bubble curtains and Hydro Sound Damper or equivalent will be used during impact piling.
- Impact piling will begin with soft start, after which the strength of the hammer impacts is gradually stepped up (ramp-up). Acoustic methods should also be used to discourage fish and marine mammals before soft-start and ramp-up begin.
- The clearance between the water surface and the rotor has been set at 30 metres, which is important for the area's seabirds and any migratory bats. Most birds in the area fly low, which means that a high clearance will reduce the risk of collision.
- Marking of the wind farm will be in accordance with current guidelines.
- The spread of the wind farm must be clearly shown on charts.

In addition to the above, mitigatory measures that have been taken as a result of the impact assessments will also be taken in the framework of planned activities. These are, together with the above, described in Chapter 10.

5.3.3 Cumulative effects

Cumulative effects have been assessed for such forces from the Triton wind farm that coincide with, or can be added to, forces from other projects and activities. Assessment of cumulative effects includes the forces from other activities that may lead to effects on the environment during the construction, operation or decommissioning phases of the wind farm. Projects that have been planned and are in the engineering stage and/or the permitting process are rarely sufficiently defined to be able to make a cumulative assessment with a sufficient degree of certainty and relevance, but are taken into account as far as possible. In addition to other wind farms, such activities as the Baltic Pipe (gas pipeline), fisheries and shipping are also included in the cumulative effects assessment. The related projects are presented in section 3.5.

5.4 Uncertainties

The EIA is based on information gathered from authorities, scientific literature, environmental and technical reports, studies and modelling for sediment and sound propagation. Calculations and modelling are based on estimates of a worst-case scenario. The estimated environmental influence is based on conservative assumptions and the environmental influence is therefore not underestimated. The environmental influence will be of less scope than we have assumed but not more comprehensive than described.

The respective sub-assessments (which all constitute reference reports to this EIA), provide more specific information about assumptions in documentation and estimates, but are summarised in this EIA.

6 Impact factors

This chapter describes the environmental effects that the planned activities may produce, and which influence factors and conditions have been used as the basis for the impact assessment. It is stated under each influence factor whether it creates a transboundary effect and so will be described further in this EIA. Chapter 7 describes how the changes that planned activities may cause affect the environment and businesses.

The influence factors have been assessed as relevant to describe and that are included in the impact assessment are described in 6.1 to 6.13.

6.1 Subsea noise

Subsea noise resulting from planned operations can arise in the construction phase, the operational phase and the decommissioning phase. During the construction phase, noise may occur during the construction of foundations. Subsea noise may also occur in connection with installation surveys, for example during geophysical and geotechnical surveys.

Subsea noise may affect marine mammals and fish, depending on the volume and duration of the noise, either in the form of changing behaviour[13] or temporary or permanent hearing loss. Changes to behaviour would mainly involve avoidance behaviour that can vary from a small change, for example short disturbance in foraging to flight behaviour. The different levels of influences from behavioural change to permanent hearing loss can be sorted as levels of influence.

The levels of influence used as the basis for assessment for porpoises, seals and fish are shown in Table 13, Table 14 and Table 15.

Table 13. Weighted noise limit values that may cause avoidance behaviour, TTS and PTS for porpoises, from Tougaard et al. 2015, National Marine Fisheries Service 2018 and Southall et al. 2019.

Influence	Limit value
Avoidance behaviour	100 dB re 1µPa (SPLRMS fixed)
Temporary hearing loss, Temporary threshold shift (TTS)	140 dB re 1µPa2s (SELcum)
Permanent hearing loss, Permanent Threshold Shift (PTS)	155 dB re 1µPa2s (SELcum)

Table 14. Weighted noise level limits that may produce TTS and PTS for seals (common seals and grey seals), National Marine Fisheries Service 2018 and Southall et al. 2019.

Influence	Limit value
Temporary hearing loss, Temporary threshold shift (TTS)	170 dB re 1µPa2s (SELcum)
Permanent hearing loss, Permanent Threshold Shift (PTS)	185 dB re 1µPa2s (SELcum)

Table 15. Non-weighted noise level limits that may give rise to TTS and PTS in fish (Andersson et al., 2017). Herring and cod have been used to represent all species since they are among the most sensitive to noise.

Fish species	Limit value	
	Temporary hearing loss, Temporary threshold shift (TTS)	Permanent hearing loss, Permanent Threshold Shift (PTS)
Cod	185 dB SELC24h, unweighted	204 dB SELC24h, unweighted
Herring	185 dB SELC24h, unweighted	204 dB SELC24h, unweighted
Fish larvae and roe	-	207 dB SELC24h, unweighted

NIRAS has conducted modelling of subsea noise, on behalf of OX2, from impact piling and during seismic and geotechnical surveys (R.11.a, R.11.B, R.11.C and R.4.B) based on knowledge of site-specific environmental conditions (e.g. bathymetry and the sediment composition of the bottom) and with a well-known source model. Modelling of the propagation of subsea noise from impact piling and seismic surveys has been performed for four and three different locations respectively within planned wind farm, which represent worst-case scenarios in which the sound propagation is assessed to be greatest.

13 Behavioural change can also take place in nature, e.g. as a result of an attack by a predator.

The points are spread out within the wind farm to represent variations in environmental conditions, such as bathymetry and seabed sediments. One point is located in the south-west corner of the wind farm, adjoining the Natura 2000 area Sydvästskånes utsjövatten. The effects have been assessed partly by using a simple bubble curtain and soft start-up, partly by a double bubble curtain and Hydro Sound Damper and soft start-up.

In addition to work operations during installation, underwater noise occurs from vessels sailing to and from the wind farm during the construction phase. During the operational phase, noise from vessels is generated in connection with maintenance and service, as well as noise from the turbines themselves that may arise as a result of the planned activities. Noise from wind turbines comes from the aerodynamic noise (rotating blades) and mechanical noise. The transmission of noise from the air is limited as most of the sound is reflected by the sea surface (Richardson, et al. 1995). Vibrations from the turbine, mainly created in the gearbox if installed in the turbine, are carried via the tower into the foundation and spread from there as low frequency noise (Tougaard & Michaelsen, 2018).

The impact on fish and marine mammals resulting from underwater noise is assessed in sections 7.3 and 7.4.

6.2 Sediment spread

In the construction phase, planned operations will give rise to sediment suspension and sedimentation. This applies mainly to monopile foundations that may need to be drilled into the seabed. Sediment suspension is a measure of turbidity that indicates the amount of suspended material in the water. The suspended materials are small particles of organic and inorganic materials that can be transported in water. Sediment suspension is measured in mg/l. Over time, the suspended particles settle. Sedimentation is a measure of the number of particles that settle onto the seabed, overlaying the existing seabed surface.

For example, an increase in the turbidity may affect fish through behavioural changes due to impaired visibility and affect filtering animals by clogging their filtration mechanism. Sedimentation can mainly affect sessile organisms or animals with limited ability to dig out of the sediments if they are covered.

During the construction phase, geotechnical investigations will be conducted, including trial drilling and cone pressure testing, which may result in minor and extremely local sediment suspension and sedimentation. During installation of the wind farm, construction of foundations and platforms for wind turbines, transformer and inverter substations, as well as met masts, erosion protection, and cable networks (inter-array cables) give rise to sediment suspension and sedimentation.

NIRAS has performed a sedimentation modelling exercise (R.10) on behalf of OX2. Modelling was conducted for different scenarios, partly with different types, number and sizes of the foundations, and partly when sediments are discharged two metres above the seabed or two metres below the surface of the sea. Sediment spread calculations have also been based on a worst-case scenario, with monopiles anchored down to depths of 50–65 metres below the seabed and a large number of foundations needing to be drilled. Only particle sizes with a diameter <0.25 millimetres are included in the models, which is based on the relevant documentation for the area from SGU and the assumption that coarser particle sizes settle within a short distance of the source. Cables are assumed to be built by jetting down into the sediment. During the decommissioning phase, when the wind farm is dismantled, sediment suspension and sedimentation can also occur, although to a much smaller extent.

The estimated impact of sediment suspension and sedimentation is assessed for the relevant aspects of Chapter 7.

6.3 Pollution spread

The area within the planned wind park consists mainly of accumulation seabed. Most organic environmental pollutants are bound to sediment particles and organic matter that can accumulate in these areas. As long as no disturbance of the seabed occurs, sediment particles remain on the accumulation seabed, including the bound potential pollutants. When sedimentation occurs continuously, the pollutants are then overstored.

All the bed surface sediments in the waters off Sweden's coast contain environmental pollutants, but the content varies depending on the area. Higher concentrations are more common closer to the coast than further out. Environmental toxins in the bottom sediments can potentially spread in connection with physical disturbance of the seabed. Environmental toxins accumulate in thin layers and any spread is limited to locations where the physical disturbance occurs, but may spread to new areas depending on the sediment spread. Dilution then takes place in the water column. In order to assess the environmental impact of possible environmental toxins in sediment, we have used the limit values specified for organic pollutants and metals are used in the Agency for Marine and Water Management's statute book (2019a).

The impact of pollution spread is assessed for its relevant aspects in Chapter 7.

6.4 Physical impact on the seabed

Physical impact on the seabed refers to direct operations on the seabed, including the use of bed surface. The planned wind farm will make permanent use of the seabed surface. The size of the area used depends mainly on the type of foundation that is used, the number of wind turbines and the amount of erosion protection being built. There will also be temporary physical influence during the construction phase. The construction of the inter-array represents the largest part of the total physical impact of the wind farm establishment on the seabed, most of which is temporary. The maximum bed surface on which there is a physical impact at the Triton wind farm site is estimated to be approximately 3.75 km^2 (approximately 1.5 %) of the total wind farm area of 250 km^2.

Restructuring of the seabed may result in a change in hydrodynamics that can also lead to a change in the bed substrate at the site (Hammar et al., 2009). Studies in Denmark (DONG Energy et al., 2006) show that the hydrographic changes caused by an operative wind farm are minimal and very local due to the large distances between the turbines. This is also confirmed in the modelling of the current location (R.12) see the example from the modelling in Figure 22. The assessment and reasoning about hydrographic changes (such as salinity and current conditions), physical impact on the seabed and influence on relevant aspects are described in Chapter 7.

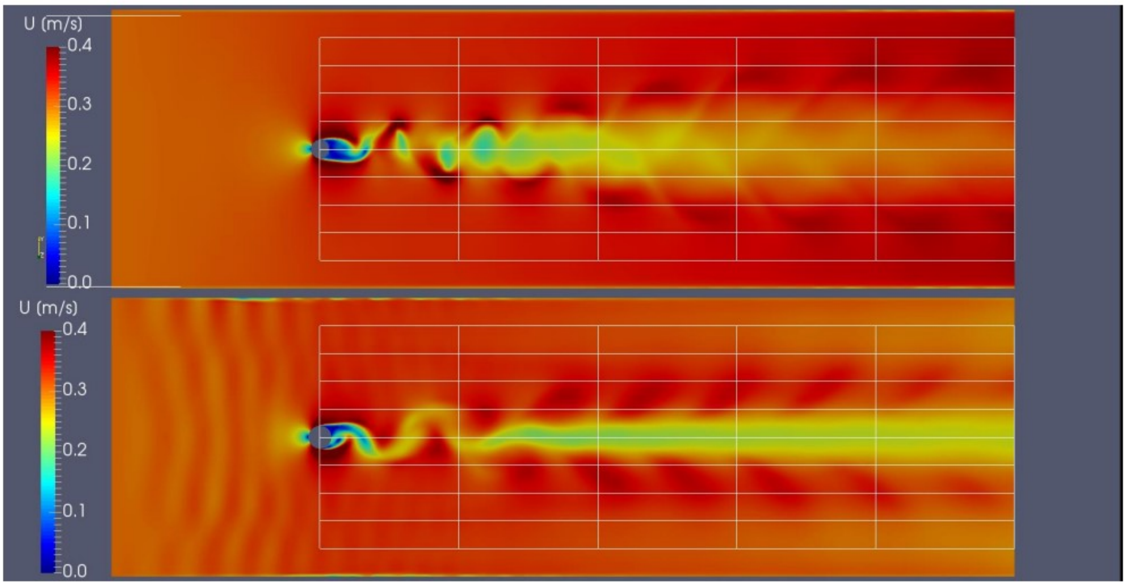


Figure 22. Modelling of hydrographic changes with monopiles.

Physical influence on the seabed mainly comes from the construction of foundations and the inter-array. Some physical influence may also occur during the operational phase when jack-up vessels are used in connection with maintenance of foundations and turbines. As physical influence during the operating phase is only negligible, the influence factor is only assessed during the construction phase of the wind farm.

6.5 Alien species

Hard seabed surfaces are built in connection with the wind farm construction in the form of foundations in an area that naturally consists of soft seabed. It is well known that such structures attract many aquatic animals and plants. In the southern Baltic Sea, common mussels and barnacles dominate hard seabed surface areas together with associated organisms, such as amphipods and polychaetes (Brzana and Janas, 2016). In addition to the positive effect of a rich fauna, there is also a risk that they can facilitate the establishment of alien species, which do not exist naturally in the area (Kerckhof et al., 2012). The impact of the planned wind farm for alien species is described in Chapter 7.

Installation and cargo vessels use water as ballast. For vessels that sail in international traffic, such ballast water may present a risk of alien species spreading. However, most components will be transported from a final assembly port in the Baltic Sea directly to the farm area, thus excluding any risk of spreading alien species in connection with the shipments. However, some components may be shipped from international manufacturers directly into the farm area. These vessels and all those engaged in international traffic are covered by the ballast convention set up to prevent the spread of alien organisms. Taking into account the ballast convention and the current regulatory framework, the size and extent of the impact is considered to be insignificant in the surrounding environment and is thus not further described in this EIA.

6.6 Reef effect

The establishment of wind turbines in the wind park area means that artificial reefs will be formed as a result of foundations that provide a hard seabed environment. Artificial reefs are often used to increase the number of fish in a marine area (Oman, 2006). The species that establish themselves on foundations vary depending on the natural conditions of the area (e.g. salinity, substrate and depth) and the construction of the foundation. What is unique with wind turbines, compared to many other reef types, is that the structure penetrates the entire water column from sea surface to seabed. This means that the influence is not only at the bottom, but also that a habitat is created where there would otherwise have been open water.

Common mussels and barnacles can be expected to colonise the shallower parts of the foundation. An establishment of algae found in the area can lead to higher biodiversity, because the presence of algae communities is otherwise limited in Triton, and the algae can also attract other species and function as a nursery for several fish species. The blocks and stones used for erosion protection around foundations are also expected to contribute with substrate and habitat for fish and crustaceans, among other things.

The new hard seabed environments are therefore of great importance for species at different trophic levels (levels in the food chain), from algal communities to molluscs, crustaceans and fish. The establishment of foundations and erosion protection can therefore be of importance from a wider ecosystem perspective. Figure 23 shows an overview of the possible establishment of species at the artificial reef of a sea-based wind turbine, as well as the ecosystem for which it creates conditions (Degraer et al., 2020). The relevant aspects for assessment and reasoning for the reef effect are described in Chapter 7.

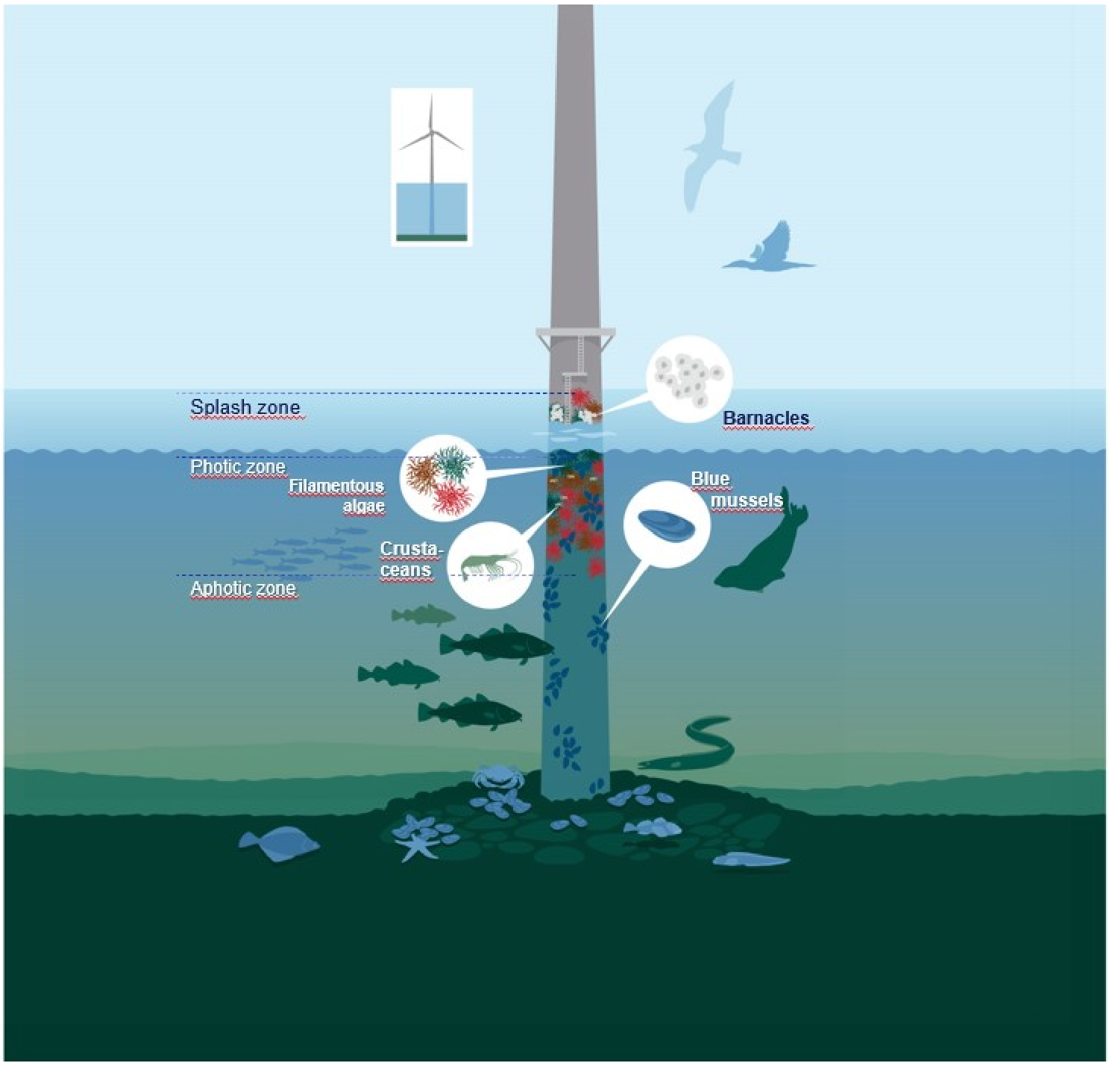


Figure 23. Overview of the reef effect of an offshore wind turbine distributed over the whole water column from bottom to surface. Illustration OX2, Illustrator Tobias Green.

6.7 Electromagnetic fields

Subsea cables (inter-array) will be laid within the Triton wind farm. Export cables to land from the wind farm will also be laid. Electrical cables form electrical and magnetic fields, collectively referred to as electromagnetic fields. Both AC and DC power cables generate electromagnetic fields. Alternating current generates an alternating magnetic field, while direct current generates a static magnetic field.

The electrical field is shielded by the insulation of the subsea export cables and by the depth the cable is laid. The strength of the magnetic field at a given point depends on several factors, such as the instantaneous current, how the conductors are relative to each other, and how deep the cable is buried in the seabed. The field decays in line with the distance from the cable.

The majority of fish species are able to sense magnetic fields (Öhman et al., 2007) and they use the earth's magnetic field to navigate (Putman et al. 2013; 2014; Naisbett-Jones et al., 2017). This is apparent physiologically because fish can have magnetic material in their body (Walker, 1984; Hanson, et all. 1984; Hanson and Westerberg, 1987).

The impacts of electromagnetic fields are assessed during the operational phase in Chapter 7 for the inter-array cables.

6.8 Displacement and barrier effect

Wind farms can cause birds to be affected through displacement, barrier effect, and collision (for collision risk see 6.9).

Displacement is caused by environmental disturbances such as wind turbines in operation (presence of wind turbines, noise and lighting) or vessels. Disturbances in bird's foraging areas, for example, can result in displacement because they must search for food elsewhere, which increases competition.

The barrier effect means that a disturbance occurs in birds' flight paths, with the result that the birds may have to change their navigation to alternative paths. This can lead to increase in their energy use, which can particularly affect birds that have to pass through a wind farm daily when flying between foraging areas and their nesting sites (Madsen m.fl., 2006).

Marine mammals that occupy the area on a permanent bases may also suffer displacement from wind farms, especially during the construction phase.

Chapter 7.4 and 7.6 describes the impact of planned activities on marine mammals and birds.

6.9 Risk of collision

The establishment of wind turbines that are in the way of natural movement patterns can also lead to a risk of collisions. Bird collision risk refers to the risk of birds colliding with, and being injured by, the blades of a wind turbine. The risk of collision for birds depends, among other things, on the design of the wind turbine, such as the sweep area and rotation speed, the height that bird flies, what avoidance behaviour the bird has, flight speed and the number of individuals who pass through. Behavioural studies have been conducted to find out to what degree birds avoid flying in the vicinity of wind farms (macro avoidance), in the vicinity of wind turbines within the wind farm (meso avoidance) and how the birds avoid being hit at the last moment by the rotor blades (micro avoidance).

Bats can also suffer collisions with wind farms if they are within the areas used by bats.

Chapter 7.5 and 7.6 describes the impact of planned activities on bats and birds.

6.10 Visual changes

The visual impact of a wind farm on a landscape depends on its character, scale and use. Landscapes that are built-up and in use are more changeable and resistant to impact than untouched nature where changes are few and slow. There is, therefore, a greater risk in unaffected natural areas that a large-scale change in the landscape will have an impact on the landscape compared to an already built-up and in-use landscape.

Valuable heritage environments and landscapes are protected mainly by the Environmental Code, the Historic Environment Act and the Planning and Building Act. However, not all values are equally sensitive to impact.

Sustainability is aimed at how heritage environments and landscapes are considered to be able to receive new elements without significantly affecting the nature and development potential of the area. Different landscapes have different ability to withstand change. Both heritage environments and landscapes can contain

- knowledge values (documentary, scientific and educational values) consisting, inter alia, of biotopes, antiquities or buildings;
- experience values that give rise to feelings of admiration and recognition, and
- utility values relating to how the area is used or could be used (agriculture, tourism, etc.).

Chapter 7.7 describes the impact of planned activities on the landscape.

6.11 Airborne noise

Wind turbines in operation emit two types of noise; mechanical and aerodynamic. The mechanical noise is generated by the alternator, fan system and. occasionally, the gearbox. In modern wind turbines, mechanical noise has been largely eliminated by insulating the nacelle and mounting the gearbox on elastic fittings. Turbines without a gearbox do not this noise. The aerodynamic noise makes up the dominant part of the sound from a wind turbine and is caused by the passage of the rotor blades through the air. At close range, this is usually perceived as hissing or sparking sound, while at larger distances it changes its character, and the noise becomes more muffled. The aerodynamic sound is determined by the velocity of the blade tip, the blade shape and the turbulence in the air. For this reason, each wind turbine model has a specific sound output level (source noise). The noise distribution from different wind turbines and suppliers is thus not the same at the same wind speed.

Noise levels decay in line with the distance from the turbines. The audibility and spread of the noise depends on meteorological conditions, mainly wind speed, humidity and air temperature. In addition, sound propagation is affected by soil properties in the form of ground damping. Water is acoustically speaking hard, which means that the sound waves have a good reflectance, and their damping is less over the sea compared to over land.

An example layout of the planned wind park has been developed and used as a basis for calculation of noise The field consists of 129 25 MW turbines and rotor diameter 340 metres.

Calculation of A-weighted equivalent sound level outside has been performed by OX2 using the model Nord2000 according to offshore wind power practice Figure 24. For this calculation, a fictitious 25 MW turbine has been used as reference with a hub height of 200 metres (i.e., 340 metre rotor diameter and 370 meters total height). Actual noise data has not been available as this type of wind turbine is not currently on the market. OX2 has therefore estimated sound output levels and the corresponding frequency spectrum of the fictitious turbine based on the data available from existing turbines.

The results show that the current guidelines for housing (40 dBA outdoors) and outdoor areas (35 dBA) from the Swedish Environmental Protection Agency are not exceeded at the coast. For Triton, the level of 30 dBA is far off the coast, which also indicates that low frequency sound will not pose a risk to nearby residents (R.14).

Additional sound calculations have been made on the basis of the so-called Danish model (Appendix B.1), which is a model for calculating wind noise recommended in the Danish Environment Control Regulation "Bekendtgørelse on støj fra vindmøller, Bekendtgørelse No 135 af 07/02/2019" [*Regulation governing noise from wind turbines. Regulation no. 135 of 07/2019*] Figure 25 shows the results of this calculation. The result shows that the A-weighted equivalent sound level guideline values, 39 dB(a) and 37 dB(a) respectively, do not reach any coast. Thus, all homes and areas where low noise levels should be sought are not affected by noise levels above the guideline values. According to the Danish regulatory framework, the maximum permissible sound level is as follows:

Table 16. Maximum permissible sound level according to Danish regulations.

	6 m/s	**8 m/s**
Open land	42 dB(A)	44 dB(A)
Residential areas	37 dB(A)	39 dB(A)

The length of the distance to the coast, about 30 kilometres, means that the sound is attenuated, and a preliminary investigation of low frequency indoor noise between 31.5–200 Hz has been conducted. The result of the calculation of low frequency noise also indicates that low frequency indoor noise will not exceed the 20 dB target for coastal residents. The distance to the coasts from the wind farm causes the noise to be attenuated due to a certain density of air with reflective and absorbent properties.

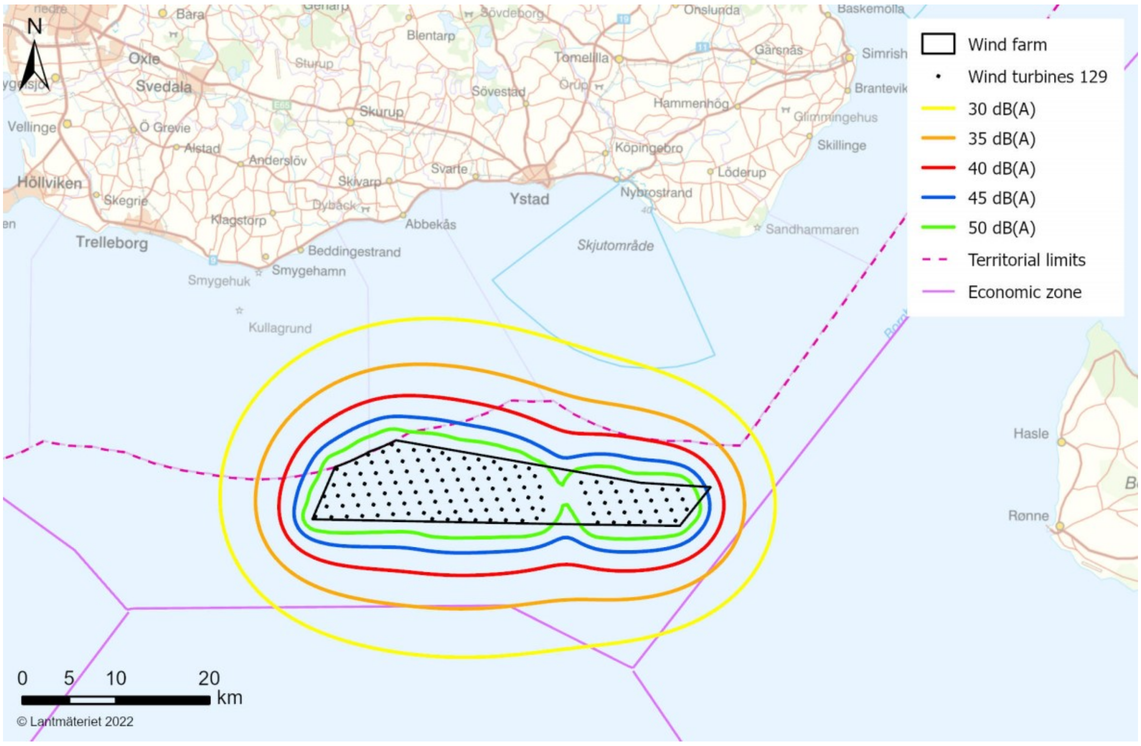


Figure 24. Sound propagation with NORD2000, with example layout 129 25 MW wind turbines, which is the worst-case scenario for airborne sound propagation.

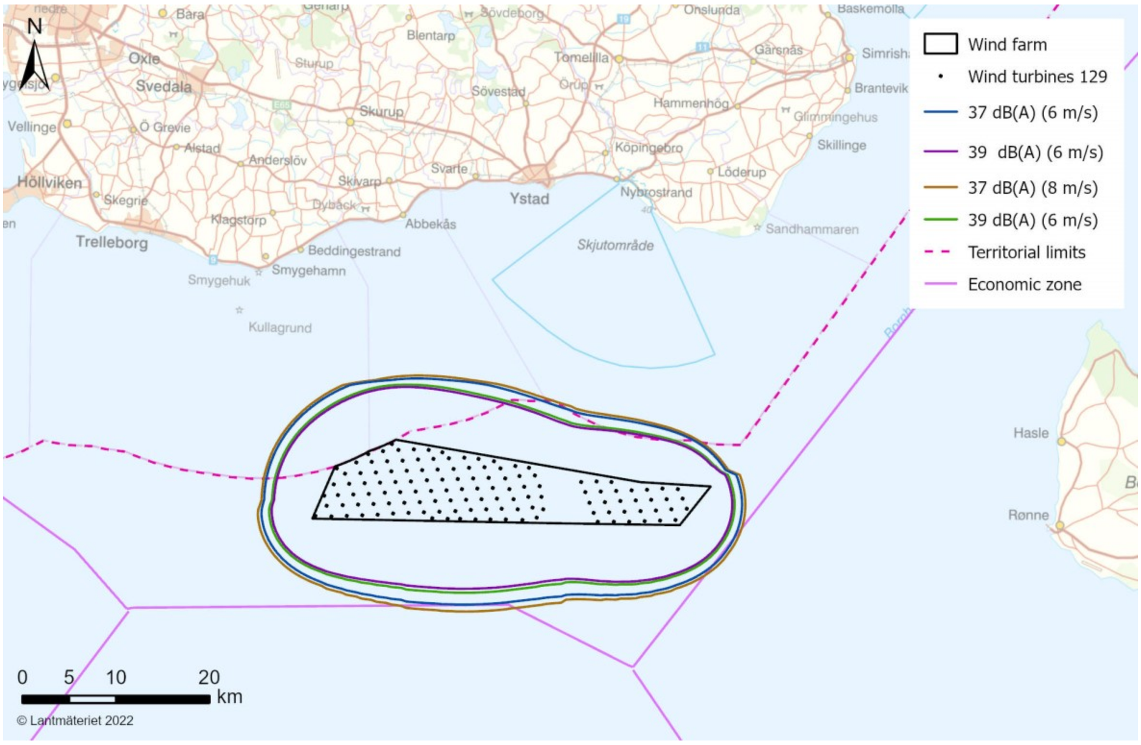


Figure 25. Sound propagation using the Danish model, with example layout 129 25 MW wind turbines, which is the worst-case scenario for airborne sound propagation.

Impact on marine mammals due to airborne noise are assessed in Chapter 7.4.

6.12 Shadows

Wind turbines give rise to shadows and reflections from the turbine towers and blades. The shadow of the tower changes according to the sun's position like a sundial, with the length of the shadow varying according to the season. When the turbines are operating and the blades cut through or reflect the rays of the sun or artificial lighting, shadows and reflections are produced. Today, however, modern turbine blades are painted with a matte anti-reflective paint that minimises reflection problems. Annoying reflections will, therefore, not be a problem for Triton.

The effects of shading and perceived disturbance are due to several factors such as angle of the sun, time of day and year, weather, visibility conditions, topography and wave movement. When the sun is low, at sunrise and sunset, and on clear winter days, shadows can be seen from distances up to about two kilometres. At these distances, however, they are only perceived as diffuse light changes.

Shadows can penetrate the water, but the limited depth of visibility means that the shadows do not reach deep water.

The extent of shadowing has been raised by OX2 to describe the shadow influence from the wind farm. The worst-case scenario with 129 25 MW turbines with 340 metre rotor diameter and 200 metre hub height has been used for the calculation. Assumptions underlying the simulation of shadowing from the farm include the sun always shining between sunrise and sunset from a cloud-free sky, that the turbines are always in operation and cause moving shadows, and that the rotor plane is always perpendicular to the rays of the sun.

The result from the simulation is shown in Figure 26. It can be seen from the figure that no shadows will reach the mainland due to the length of the distance to the coast. Shadows will only appear on the water and in the top layer of the water. Chapter 7 describes the impact of planned activities on landscape scenery, leisure activities, fish and aquatic organisms.

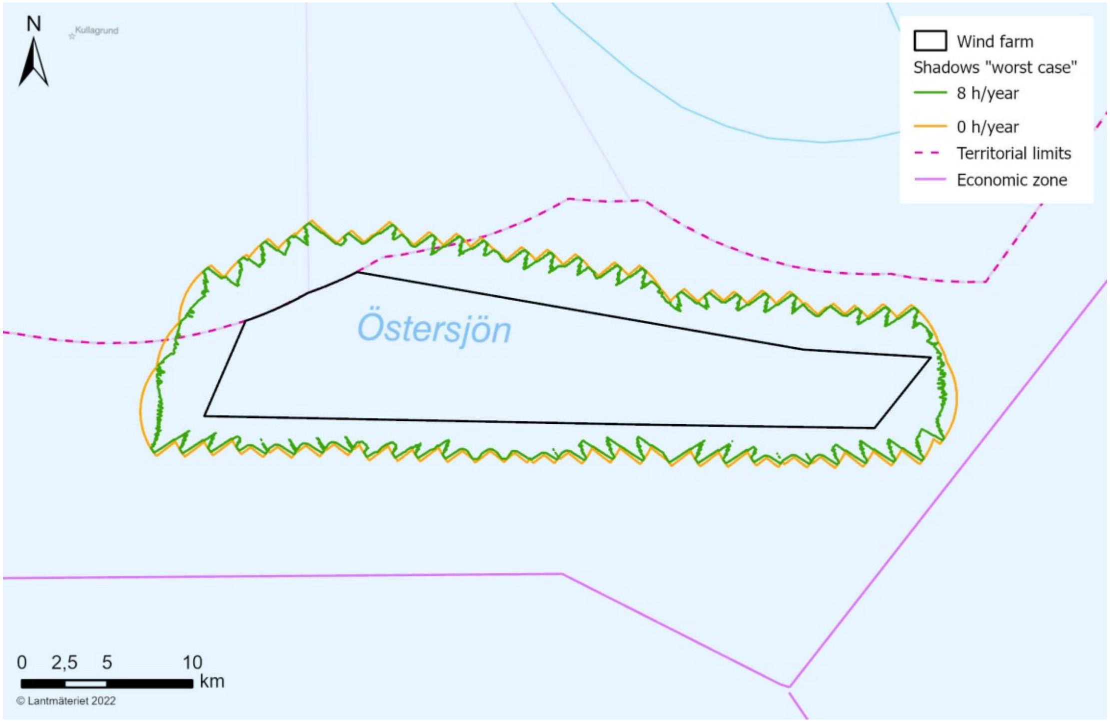


Figure 26. Shadow simulation results for 129 25 MW turbines. The different colours indicate how many hours per year a particular area will be in shade.

6.13 Nautical hazards

A number of nautical hazards have been identified in a HAZard IDentification workshop (HAZID). Nautical hazards may include collisions between vessels in the shipping lanes and between a vessel and a sailboat/fishing boat, grounding and allision (vessels entering the wind farm incorrectly) or radar interference. Allisions are primarily understood to mean that a ship comes into conflict with the wind farm, which is to say, enters the farm by mistake. This does not necessarily involve an accident, which is a ship colliding with a wind turbine. The impacts of nautical hazards are assessed in section 7.10.

7 Assessed consequences

7.1 Climate benefit and climate impact

Total impact assessment

During its lifetime, the wind farm, from construction to decommissioning, will affect the climate in various ways. During the construction and decommissioning phase, greenhouse gas emissions, for example from production and transport, are compensated for by the fossil-free generation of electricity produced by the wind farm during its operational phase.

The sensitivity of the environment (society and ecosystem) to climate change as a result of anthropogenic greenhouse gas emissions is considered high. An offshore marine-based wind farm like Triton can play an important part in society's transition to more fossil-free electricity and reduced climate impact. In terms of the individual wind farm, the global impact on the climate is slightly positive, which means that there will be a very low positive impact. In view of a regional and national impact (Sweden's greenhouse gas emissions), the operation has a moderate positive influence with major positive impacts. The Triton wind farm can also contribute to the European electricity supply and contribute a climate benefit by replacing coal and gas-generated power through electricity exports to Europe. The transboundary impact is therefore also considered to be positive.

This section describes the occurrence and assessed influence and impact of the operations on climate benefit and climate impact, which summarises reference report R.1 ”*Triton's climate benefit and climate influence*”.

7.1.1 Preconditions

The Swedish parliament's target is 100% fossil-free electricity production in Sweden by 2040. The Swedish Energy Agency writes: “It is quite possible to have a functioning 100% renewable electrical system by the 2040s. But this requires opportunities for further expansion of wind power and electricity grids” (Swedish Energy Agency, 2019).

The Triton wind farm consists of 68–129 wind turbines with an expected annual production of approximately 7.5 TWh. According to Skåne county's climate and energy strategy, renewable electricity production in Skåne can primarily be increased through construction of offshore wind power. The strategy points out that the market for offshore wind power has developed rapidly in recent years and that wind power can make up a significantly larger part of Skåne's energy system in 2030. Under the strategy, the county administration and local authorities in Skåne must improve the conditions for wind power and work towards the county being equipped for development of offshore power generation[14].

The International Climate Panel (IPCC) synthesis report (AR5) contains a compilation of life cycle emissions for different types of electricity generation[15]. Greenhouse gas emissions are calculated in the form of grammes of carbon dioxide equivalents per kilowatt-hour (g CO_2e/kWh). For wind power, according to their study, the emissions are around 11 g CO_2e/kWh[16]. There are also life cycle analyses that result in greenhouse gas emissions of between 7 and 56 g CO_2e/kWh for wind power, depending on the type of wind turbine, geographical location and other conditions. Small turbines represent the higher range. A German study's life cycle analysis has given a result of greenhouse gas emissions of 7.3 g CO_2e/kWh, for an average offshore wind turbine[17]. Vattenfall AB has also conducted life-cycle analyses for newer (on-shore) wind turbines, which resulted in lower greenhouse gas emissions, of 6–7 g CO_2e/kWh[18]. According to IPCC, offshore wind energy generates 1 g CO_2e/kWh more than on-shore[19]. From this it can be assumed, based on Vattenfall's study, that the Triton wind farm will result in CO_2 emissions of approximately 8 g CO_2e/kWh[20]. However, since production from current wind turbines is expected to be significantly higher than the on-shore turbines on which the life cycle analysis is based, CO2 emissions can be expected to be less than 8 g CO_2e/kWh for the Triton wind farm (R.1).

The calculations for a reasonable compensation mix are based on the assessment of the Wind Power Climate Benefit Network (2019)[21], which finds that the total climate benefit of wind power is in the order of 600 g/kWh. This is an overall assessment based on several studies (R.1).

Assuming that a household's electricity consumption is 5,000 kWh/year[22, 23]the Triton wind farm can supply 1.5 million households with electricity, or it can power about three million electric cars (based on an average car driving 1,200 Swedish miles per year and the electric car consuming 2 kWh/km)[24].

14 Skåne County Administration, Region Skåne and the Skåne Association of Municipalities, the Climate and Energy strategy for Skåne, 2018

15 IPCC, Climate change 2014 mitigation of climate change – Working group III contribution to the fifth assessment report of the intergovernmental panel on climate change, chapter 7.8.1, 2014.

16 Swedish Energy Agency, use of wind energy resources http://www.energimyndigheten.se/globalassets/fornybart/strategi-for-hallbar-vindkraftsutbyggnad/vindkraftens-resursanvandning_slutversion-20210127.pdf

17 Hengstler, J. et al. (2021) Aktualisierung und Bewertung der Ökobilanzen von Windenergie- und Photovoltaikanlagen unter Berücksichtigung aktueller Technologieentwicklungen. Climate Change | 35/2021

18 Vattenfall, New wind turbines give a lower carbon footprint https://group.vattenfall.com/se/nyheter-och-press/nyheter/2019/nya-vindkraftverk-ger-lagre-klimatavtryck

19 Intergovernmental Panel on Climate Change, Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, New York: Cambridge University Press, p. 1,335.

20 Intergovernmental Panel on Climate Change, Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, New York: Cambridge University Press, p. 1,335.

21 The Wind Power Climate Benefit Network consists of OX2 and five other stakeholders. Read more here at: https://www.klimatnytta.nu/.

22 The Swedish Energy Agency, Normal electricity consumption and electricity cost of residential electricity://www.energimarknadsbyran.se/el/dina-avtal-och-kostnader/elkostnader/elforbrukning/normal-elforbrukning-och-elkostnad-for-villa/

23 Energy Agency, Normal electricity consumption and electricity cost for apartments https://www.energimarknadsbyran.se/el/dina-avtal-och-kostnader/elkostnader/elforbrukning/normal-elforbrukning-och-elkostnad-for-lagenhet/

24 Vattenfall, Is there enough electricity for cars? https://www.vattenfall.se/fokus/eldrivna-transporter/racker-elen-till-elbilarna/

7.1.2 Impacts

This section describes the identified effects and impacts on climate. Table 17 shows which impact factors have been assessed and in which phase.

Table 17. Estimated influence factors for climate impact and during which phase(s) this may occur.

Influence factor	Construction phase:	Operational phase	Decommissioning
$CO2_2e$ emissions	x	x	x

In its 2021 report, the Swedish Energy Agency[25] has summarised the current state of play regarding the use of wind energy resources in *"Wind energy's resource use - A basis for a National strategy for sustainable wind energy expansion. A life-cycle perspective on the use of wind energy resources and greenhouse gas emissions*". The Energy Agency's report shows that in principle no greenhouse gas emissions are generated from the actual generation of electricity from a wind turbine. Wind power is among the power sources with the lowest greenhouse gas emissions.

In a life-cycle analysis, emissions from manufacturing, raw materials, assembly, maintenance, disassembly and recycling are the ones that make up wind power's combined impact per kWh produced. When manufacturing a wind turbine, the extraction of the metals and materials used in the turbine, installation and transport consume energy. Energy is also used during operation and during disassembly and disposal/recycling. This energy input is usually compared to how much energy is produced during the lifetime of the turbine.

For offshore wind, it takes about 5–11 months to produce the amount of electricity that corresponds to the energy required to manufacture, build, operate and dismantle the wind turbine[26]. Larger turbines (higher installed power) are more efficient from this perspective than smaller turbines, and it therefore takes shorter time for large turbines to produce the same amount of electricity as the input energy.

The turbines that will be relevant at the time of procurement and construction of the Triton wind farm are expected to have a useful life of approximately 40–45 years. This means that the turbines will produce electricity equivalent to about 60 times more than the energy input during their planned total operating period.

Construction of the wind farm and its components involves a short-term negative impact in the form of greenhouse gas emissions. However, this impact is deemed to be counterbalanced by the longer-term positive impact of the wind farm in that it can replace fossil electricity production and thereby reduce the emission of greenhouse gases on a larger scale. Calculations for the Triton wind farm show that the farm will generate greenhouse gas emissions equivalent to 7.3 g CO_2e/kWh. When compared to a reasonable compensation mix[27], the expected emission

25 Energy Agency (2021) Wind energy's resource use. A basis for a National strategy for sustainable wind power expansion. A life-cycle perspective on the use of wind energy resources and greenhouse gas emissions.

26 Hengstler et al., Aktualisierung und Bewertung der Ökobilanzen von Windenergie- und Photovoltaikanlagen unter Berücksichtigung aktueller Technologieentwicklungen https://www.umweltbundesamt.de/sites/default/files/medien/5750/publikationen/2021-05-06_cc_35-2021_oekobilanzen_windenergie_photovoltaik.pdf

27The calculations for a reasonable compensation mix are based on the assessment of the Wind Power Climate Benefit Network (2019), which finds that the total climate benefit of wind power is in the order of 600 g/kWh. This is an overall assessment based on several studies.

reduction is 4.5 million tonnes of CO_2/kWh, which corresponds to approximately 10% of Sweden's territorial emissions in 2020[28].

Table 18 shows the comparison of greenhouse gas emissions from wind power, coal, oil and natural gas.

Table 18. Estimated annual emissions from various energy sources based on 7.5 TWh annual production.

Energy source	g CO_2e/kWh	Annual emissions of CO_2e, annual production 7.5 TWh
Wind power	7.3[1]	0.055 million tonnes
Coal	740[2]	5.5 million tonnes
Oil	510[2]	3.8 million tonnes
Natural gas	290[2]	2.2 million tonnes

[1] Triton wind farm's estimated emissions
[2] Lowest value according to IPCC 2014

As seen in the table above, greenhouse gas emissions from fossil fuels would be between about 40 and 100 times as much as from wind power. Depending on the type of electricity that Triton replaces (coal, oil or gas), the farm can reduce the greenhouse gas emissions, for the same level of production, to around 1–2%.

*Table 19. Assessed impact from the climate influence. *The recipient here is the atmosphere that receives the CO2 emissions produced.*

Influence factor	Recipient* sensitivity/value	Size and extent of the influence	Impact
Reduced $CO2_2e$ emissions	High	Extremely positive	Very positive

The overall assessment of the impact in the form of reduced CO_2 emissions for the whole wind farm over Triton's lifecycle is that it provides a very positive impact for the climate and the switch to renewable electricity generation.

7.1.3 Summary of transboundary impacts

The study on the impact of the project on climate shows, as stated above, that the impact on CO_2 emission reduction is very positive. The transboundary impact is also considered to be positive in a transboundary perspective because climate change is a global issue that has no national borders.

If the Paris agreement's temperature goals are to be met, the world needs to halve annual greenhouse gas emissions over the next eight years, according to the latest UN environment programme report from 2022 (UNEP Emissions Gap Report, 2022). A rapid global shift away from fossil fuels is needed, along with a range of other measures to reduce greenhouse gas emissions. The Triton wind farm helps to achieve our mutual climate goals.

The Triton wind farm can also contribute to the European electricity supply and contribute a climate benefit by replacing coal and gas-generated power with electricity exports to Europe.

28 Swedish Environmental Protection Agency, 2019 Territorial emissions and uptake https://www.naturvardsverket.se/data-och-statistik/klimat/vaxthusgaser-territoriella-utslapp-och-upptag

7.2 Bottom flora and bottom fauna

Total impact assessment

There are no conditions for bottom flora in the farm area due to the actual depth and the seabed being made up of a soft bottom. The impact on the bottom fauna occurs mainly during the construction phase and is caused by sediment spreading and physical impact on the seabed when installing foundations and the inter-array cables. There may also be an impact from hydrographic changes, substrate changes and electromagnetic fields that can occur during the operating phase. The proportion of seabed surfaces that would be permanently and temporarily affected by physical influences or substratum changes from wind farm and inter-array cables is very small. The sediment spread that arises from the installation of foundations and inter-array cables is limited in extent and time. For all influencing factors, the impacts are assessed to be negligible except for substratum changes, which are deemed to be slightly positive. The wind farm can also have a positive impact through the formation of artificial reefs and restriction of bottom trawling.

The influence on demersal flora and fauna is considered to be very local and is not deemed to lead to any transboundary impact.

This section describes the occurrence and assessed influence and impact of the operations on demersal flora and fauna, which summarises reference report R.2 ”*Bottom environment and offshore wind power in the Baltic Sea to the south of Skåne*”.

7.2.1 Preconditions

The environment in the area is strongly influenced by the inflows of more saline water from the Kattegat, via Öresund and the Danish Straits, as well as freshwater inflows from watercourses that flow into the Baltic Sea. The brackish water conditions in this part of the Baltic Sea affect the species composition, with more marine species in the deeper parts that have a higher saline content and more brackwater species in the shallower areas and further east where the salt content is lower.

The seabed in the wind farm area consists exclusively of soft surface substrates. The outer soil types are post-glacial clay, clayey mud and gyttja clay, see Figure 4. The entire area in question is thus an accumulation seabed, where clay, silt and organic matter accumulate and settle. Depth conditions are also similar within the area, varying only between 43 and 47 metres, with an average depth of 45 metres. Most organic pollutants are bound to sediment particles and organic matter and can therefore accumulate in these areas. AquaBiota conducted a sediment test in June 2022. The sediment sampling was performed at a number of locations within the Triton wind farm in order to survey the sediment’s potential content of pollutants. The result shows that the levels of metals are consistently low, corresponding to Class 2 and shows low variation between the different sampling stations. Some levels are higher but consistently only high in the outer surface. Arsenic deflection is shown as slightly elevated against the background, but exhibits even content over both depth and sample points, which is why this increase is considered to be a natural variation. Organotin compounds were consistently detected only in outer sediments, with some elevated values (R.18).

Count data of demersal fauna has been obtained from studies both within Triton’s planned area of activity and in areas around it with similar conditions, together with information on the physical conditions of the site from SMHI and SGU. In June and August of 2021, AquaBiota commissioned

OX2 to conducted additional CTD measurements (conductivity, temperature and depth) in the current area of the Triton wind farm with the aim of obtaining information about the water temperature, salinity and oxygen conditions of the site at different depths, ranging from the surface down to the seabed.

The bottom fauna is dominated by animals that live buried in sediments, so-called infauna. Grab sampling surveys conducted in the wind farm area show that the fauna is mainly comprised of the animal groups of barnacles, crustaceans and molluscs (mussels and snails). The most common species in the area is barnacles. Common species in the area are Baltic macoma *(Macoma balthica*), Cumacea (*Diastylis rathkei*), and penis worms (*Halipcryptus spinulosus*, *Priapulus caudatus*) (ICES, 2020; SMHI Shark, 2020; Gogina et al., 2016). Because both the bottom substrate and depth are similar throughout the wind farm area, the bottom fauna is expected to have a relatively homogeneous species composition throughout the farm area.

Video surveys were conducted in the summer of 2019 on epifauna (animals living on the bottom) in the neighbouring Natura 2000 site. In connection with the video surveys, the parts of the Natura 2000 area bordering on the farm area were classified as soft base with sparse fauna (HELCOM HUB biotope, AB.H2T) (Skåne County Administrative Board, 2020). As both the Triton wind farm site and bordering areas of the Natura 2000 area have deep soft bottoms, the bottom fauna is expected to have a similar composition of species. Two red-listed species have been observed on the soft bottoms of the adjacent Natura 2000 area and the conditions are present for them also occurring in the farm area (SMHI Shark, 2020; Gogina et al., 2016). These two species are the tentacled lagoon worm *(Alkmaria romijni* and blunt gaper clams (*Mya truncata)* (SLU Species Information Centre, 2020; HELCOM, 2013). There have also been findings of unidentified sea anemones, that could be of the species *Stomphia coccinea,* (Skåne County Administrative Board, 2020, which is considered to be vulnerable according to the National Red List (SLU Species Information Centre, 2020).

Complementary modelling for the specific wind farm area shows that species that are locally common in the wind farm area as well as in surrounding areas are expected to be found over much of the Triton site.

AquaBiota conducted several field studies in the area during the summer of 2021 and 2022 (R.23). In June and August 2022, video studies were conducted at a total of 50 locations to examine the epibenthic fauna (sea-bottom animals) in the farm area. A total of 18 taxa were observed, of which shrimp-like *Mysidacea* were most commonly observed. Flounders of the species dab (*Limanda limanda*), plaice (*Pleuronectes platessa*) and flounder (*Platichthys flesus*) were observed at a few locations. At one location in the central part of the farm area, two individuals of the common starfish (*Asterias rubens*) were observed. Orange structures likely to be penis worms/ribbon worms (*Priapulida/Nemertea CF*) were relatively common on the seabed and were observed at 31 out of 50 locations. No red list species were noted within the site. All locations consisted of vegetation-free clay beds with sparse macrofauna societies and were thus classified as AB.H2T according to HELCOM HUB.

In June 2022, grab sampling was conducted at 30 locations in the farm area to investigate infauna (animals that are buried in the sediment). A total of 22 taxa were noted, of which 17 were identified by species Barnacles were the most species-rich fauna group with a total of 14 taxa followed by mussels (5 taxa), crustaceans (2 taxa) and penis worms (1 taxon). The most common species found in the area, which was found in all 30 samples, were the barnacle *Scoloplos armiger*. Then the Baltic macoma (*Macoma balthica*) and the hooded shrimp *Diastylis rathkei* were common species that were found at 29 and 27 of 30 locations, respectively. No red-listed species were found in the samples. Biotope classification according to HELCOM HUB resulted in four different biotopes, where biotope clay bed dominated by *Macoma balthica* (AB.H3L1) was by far the most common. According to HELCOM's red list of threatened habitats and biotopes, two threatened biotopes were found in the area, aphotic clay seabed dominated by Icelandic cyprine (AB.H3L3) and aphotic clay seabed dominated by astartidae (AB.H3L5). These biotopes were found at a total of nine locations in the farm area, mainly in the western and eastern parts of the site.

The seabed within the Triton wind farm site consist exclusively of accumulation beds, which means that sediment particles remain on the bottom as long as no disturbance occurs to the seabed. There is a risk that, in connection with sediment spread, environmental toxins and nutrients present in the sediments are also spread in the area.

7.2.2 Impacts

This section describes the identified effects and impacts on bottom flora and fauna. No need for specific mitigation measures based on the impact on the bottom environment have been identified, so impact assessments are conducted without mitigation measures. The impact assessments are made on the basis of a worst-case approach for each influence factor.

Due to a lack of vegetation in the wind farm area, influence factors affecting only the bottom flora are not evaluated, such as the effects of shading from the wind turbines. For the same reason, the assessments only include the influence on the bottom fauna of the area, with the exception of the influence factor substrate changes in which the recipient also includes bottom flora, because the foundation also offers new hard substrate for algae that are otherwise not found in the area.

Table 20. Estimated influence factors during the wind farm's construction, operational and decommissioning phases. An asterisk (*) indicates which influence factors and which phases are included in the cumulative effects assessment (Chapter 8).

Influence factor	Construction phase:	Operational phase	Decommissioning
Physical influence	x		
Suspended sediment and sedimentation*			x
Environmental toxins and nutrients*	x		x
Alien species	x	x	x
Substrate changes*		x	
Electromagnetic fields		x	
Hydrographic changes		x	

Construction phase:

The influence on the seabed surface during the construction phase is mainly due to the construction of foundations and the inter-array. Construction surveys also have some influence.

Physical influence

Different types of seabed mapping and geotechnical and geophysical surveys will be conducted before engineering and installation. The geophysical surveys do not involve any physical intervention on the seabed, nor do they affect or have any negative impact on the bottom flora and the bottom fauna. There may be some influence on bottom flora and bottom fauna during geotechnical investigations such as drilling or sampling in bottom sediments. The direct physical influence of these surveys is extremely local and temporary. Sediment spread in connection with the surveys is also considered to be highly local. The sensitivity of the bottom flora and the bottom fauna is moderate to the physical influence of surveys. All in all, as the effects are expected to be highly local effects and only very small areas are taken into use, the size and extent of the influence is expected to be insignificant and the impacts on bottom flora and fauna negligible.

In the wind farm's construction phase, there will be direct physical disturbance of the seabed during installation of turbine foundations, erosion protection, sub-stations and when laying the cables for in inter-array. During excavation and drilling, there is a risk of influence on plants and animals that cannot move or could be covered. The maximum physical influence that could be exerted by the wind farm seabed use has been calculated as a worst-case scenario Table 21.

Table 21. The designated areas of the project that are used when using different types of turbine foundations and substations/platforms (worst-case scenario).

	Monopile	Jacket	Jacket: Suction caissons	Gravity foundation	Substations/ platforms
Number of	129	129	129	129	6
Total bottom use with erosion protection (km^2)	0.206	0.092	0.365	0.497	0.034
Percentage of seabed area in use (%)	0.08	0.037	0.15	0.20	0.014

In a worst-case scenario, the total inter-array length is estimated at 300 kilometres. As the site consists of soft bottoms, cable installation is assumed to take place by jetting, where the width of the coil trench is calculated as 0.5 metres and its depth at 1.5 metres. A total of three km^2 of the seabed is estimated to be affected, which corresponds to about 1.2% of the farm's total seabed area.

Jack-up vessels, temporarily fixed to the bottom, are usually used for installation work when installing wind turbines and substations/platforms. The physical influence calculations assume that in a worst-case scenario four jack-up vessels are required at each site. In total, the total amount of the seabed affected by jack-up vessels is estimated to be approximately 0.22 km^2, which corresponds to approximately 0.09 % of the farm's seabed in a worst-case scenario.

Overall, the maximum physical influence (worst-case scenario) that wind farm construction can cause has been calculated, see Table 22.

Table 22. The proportion of the total seabed that is affected by the construction of foundations, erosion protection, substations and inter-array, as well as jack-up vessels when installing wind turbine foundations.

	Gravity foundation	Erosion protection	Substations/platforms	Erosion protection	Inter-array cabling	Jack-up vessels	Total
Area (km^2)	0.25	0.24	0.00094	0.033	3	0.22	3.75
Area (%)	0.1	0.1	0.00036	0.013	1.2	0.09	1.50

The areas that may be affected by a physical influence, in a worst-case scenario, represent a very small part of the total seabed of the farm (about 1.5%). The bottom surfaces used for foundations and erosion protection provide a transition from soft to hard substrate, creating the conditions for the formation of artificial rev.

A re-establishment of demersal organisms will be possible on the surfaces affected by work in connection with the construction of the inter-array and where support legs have been fixed on the seabed. Opportunistic species of barnacles, nematodes and crustaceans are quick to repopulate dredged soft bottoms while the repopulation of longer-lived species such as certain species of mussels takes longer (Hammar et al., 2009). The recovery time varies greatly from one area to another, but Hammar et al. (2009) write that the recovery of a dredged area is usually 1 to 3 years, but that the succession processes are usually slower in deep seabed than on shallow beds.

Demersal trawling currently takes place in the farm area that has a physical influence on the bottom environment. However, bottom trawling has decreased in recent years as a result of fishing bans, but some bottom trawling still takes place (The Agency for Marine and Water Management database, 2021). Although demersal fishing has declined in recent years, it causes a greater physical influence on the seabed environment and also takes place continuously, than that which is the case during construction of the Triton wind farm. During construction of the wind farm, bottom trawling will be restricted, resulting in a reduced physical influence during the farm's operational years.

The sensitivity of the bottom fauna in the area is considered moderate for the influence factor physical influence, but since the seabed surfaces involved make up a very small proportion of the total surface area of the farm area, the size and extent of the influence is considered insignificant, resulting in a negligible impact (Table 23).

Table 23. Impact assessment of the physical influence on bottom fauna in connection with the construction of the wind farm.

Influence factor	Recipient sensitivity	The influence's size and extent	Impact
Physical influence	Moderate	Insignificant	Negligible

Suspended sediment and sedimentation

The installation of foundations, erosion protection and cable laying result in sediment spreading with temporarily elevated levels of suspended particles in the water, which then settle to the bottom.

Modelling has been performed for suspended sediment and sediment deposits (reference report R.10). The models are based on the sequential construction of all foundations and cables, but the results are summarised on one map, see Figure 27. The stated sedimentation and durations shown in the map will never occur over the whole area simultaneously, but are expected to occur at different times depending on where work is performed within the area. The sediment is discharged two metres over the seabed, and when the influence on the bottom fauna is assessed, the concentrations of suspended sediment are reported as an average of the ten deepest metres. Suspended sediment with contents above 100 mg/l will be found to a limited extent in the area, mainly around the drilled foundations. The duration of 100 mg/l is, at most, approximately six hours within an area of 6.4 km^2, which corresponds to approximately 2.5 % of the total seabed of the site (Figure 27).

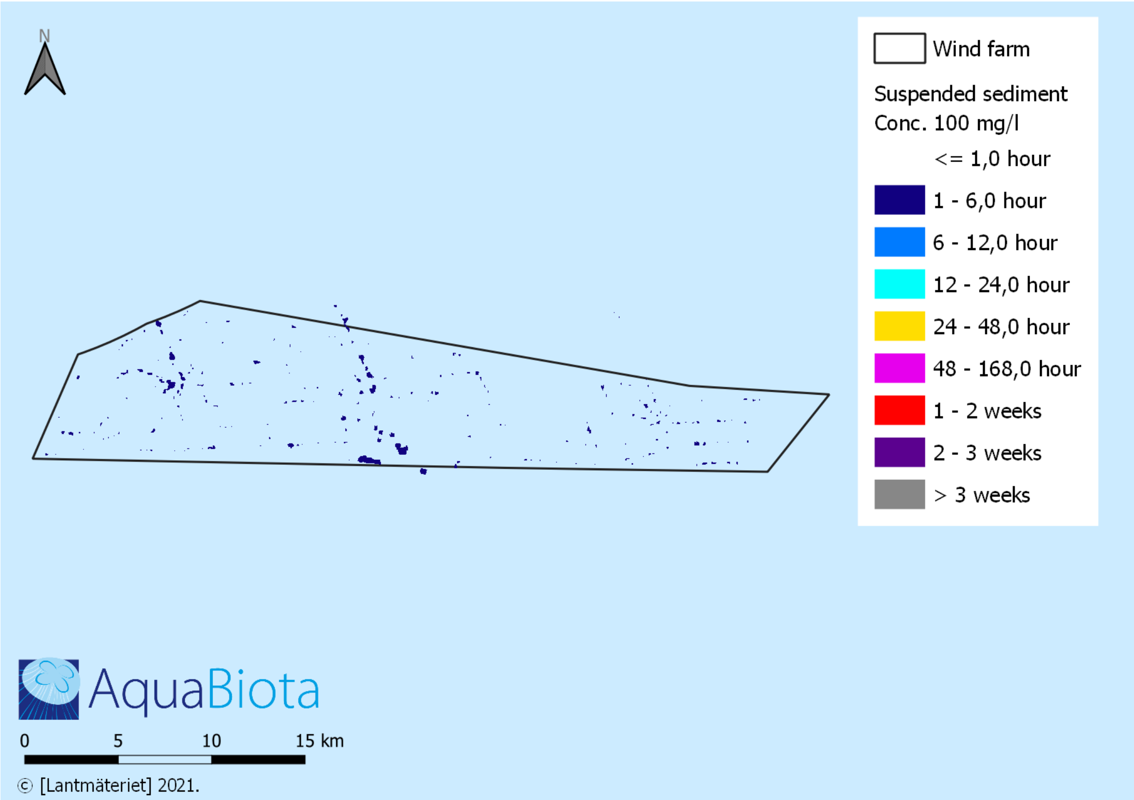


Figure 27. Simulation of the duration of 100 mg/l of suspended sediment in the construction of foundations and cables within the Triton wind farm. The duration of the content is based on an average value between the seabed and 10 metres above.

Most demersal animals are tolerant of temporary increases in suspended sediment, but long-term exposure may adversely affect some filtering species. The influence of sedimentation varies between species (Last et al., 2011) and is dependent on several factors, where the amount of sedimentation material, the total time that the organisms are covered (exposure time) and the size of the sediment particles are of great importance. Mobile animals that can move from the site and animals adapted to a life buried in the seabed usually manage better than organisms that live on top of the seabed. However, in the case of long-term coverage (Eslink, 1999), sessile organisms and animals with limited ability to dig up through the sediment can be suffocated.

The bottom fauna in the planned wind farm area is mainly made up of different species of infauna that are either predators or deposit feeders (eat dead organic material). The temporarily elevated levels of suspended sediment arising from the construction of the wind farm would not affect the food intake of these species. The presence of filtering animal species that may be sensitive to the influence of suspended sediment is limited at the Triton site. In general, animals on soft bottoms are more adapted to elevated levels of suspended sediment than animals living on seabeds with coarser substrates.

All in all, the bottom fauna in the area is thus deemed to have a slight sensitivity to the influence factor. Sediment content of 100 mg/l occurs at most for about six hours in a limited area, which leads to the influence factor being considered insignificant. This gives negligible overall impact on the bottom fauna at the farm site (Table 24).

Table 24. Assessment of the impact on bottom fauna of suspended sediment at the wind farm site.

Influence factor	Recipient sensitivity	The influence's size and extent	Impact
Suspended sediment	Small	Insignificant	Negligible

Locally, about 50 metres around the drilled foundations, the sediment amounts to 50–100 millimetres within an area corresponding to 0.13% of the total area of the wind farm. Sediment deposits in excess of five millimetres occur within an area corresponding to approximately 2 % of the total surface area of the wind farm site (Figure 28).

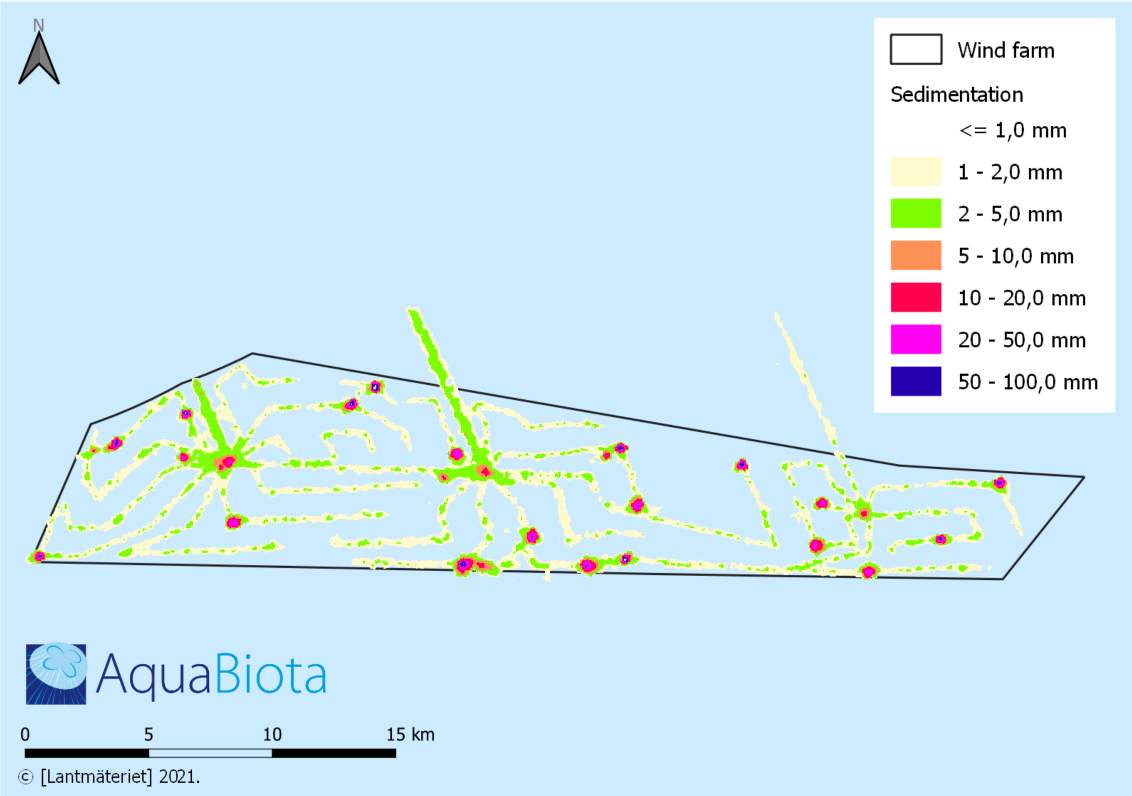


Figure 28. Simulation of sedimentation in the construction of foundations and cables within the Triton wind farm.

Sedimentation in connection with the construction of the wind farm will occur gradually, allowing the organisms to adapt continuously. The bottom fauna in the wind farm consists mainly of mobile species which can dig up through sediment deposits and are therefore deemed to be tolerant to the sedimentation that will occur within Triton. Although a certain increase in energy consumption is expected to occur for the individuals that become locally covered, sedimentation from construction of the wind farm is not considered to have any significant influence on the bottom fauna in the area.

In summary, the bottom fauna of the region is deemed to have a little sensitivity to the influence factor and, given the limited areas affected by larger sediment deposits (> 50 millimetres), the size of the influence is estimated to be insignificant. The impact of the sedimentation is therefore considered to be negligible for the bottom fauna at the site (Table 25).

Table 25. Impact assessment of sedimentation on the bottom fauna in the wind farm area.

Influence factor	Recipient sensitivity	The influence's size and extent	Impact
Sedimentation	Small	Insignificant	Negligible

Pollution spread

On the basis of the bottom surveys conducted by SGU within and outside Triton and the assumptions underlying the modelling of sediment dispersion (R.10) during the construction phase, an assessment of the potential impact of the spread of organic pollutants and metals into the aquatic environment has been made for suspended sediments; but also spread to other sites when sedimentation takes place later. In order to assess the effects, the limit values set for certain organic compounds and metals in the Agency for Marine and Water Management's regulations on classification and environmental quality standards for surface water (2019a) form the starting point. Taking into account the amount of sediment likely to be spread, the timing of the spread (i.e. the dwell time in the water mass), the volume of water in which the spread occurs and the measured levels of the investigated organic compounds and metals, there is no risk of adverse effects on the bottom fauna during the construction phase and thereafter.

The farm area is dominated by infauna species that are continuously exposed to the contents of the sediments. In the main, animals that live on top of the sedimentation surface (epibenthic organisms) could potentially be exposed to temporarily higher levels of suspended environmental toxins in connection with the construction of the wind farm. As the farm area has a sparse epifauna, the sensitivity of the bottom fauna is considered moderate. Even if the levels of some of the organic compounds and metals exceed or are just below the limit values, the dispersion of sediment will dilution as sediment is stored and dispersed in the water column. Despite a moderate sensitivity of the bottom fauna, the magnitude and size of the influence are considered to be insignificant, leading to a negligible impact (Table 26).

Table 26. Impact assessment of the spread of environmental toxins and nutrients in connection with sediment spread.

Influence factor	Recipient sensitivity	The influence's size and extent	Impact
Environmental toxins	Moderate	Insignificant	Negligible

Alien species

During the construction phase there will be presence of installation and cargo vessels that use water as ballast. Ballast water from international vessels may present a risk of alien species spreading. As most components will be transported from a final assembly port in the Baltic Sea directly to the farm area the risk of spreading alien species in connection with the shipments can be excluded. However, some components may be shipped from international manufacturers directly into the farm area. These vessels, and all those engaged in international traffic, are covered by the ballast convention set up to prevent the spread of alien organisms. The Convention has been introduced into Swedish law by the Ballast Water Act (2009:1165), ordinances and regulations. This regulatory framework regulates the management of ballast water and sets limits for the number of living organisms that may be released.

These requirements include:

- *Changes of ballast water must be conducted at least 200 nautical miles from the nearest country and over a depth of at least 200 metres. If this is not possible, the change must be at least 50 nautical miles from the nearest land area over a depth of at least 200 metres.*
- *For vessels crossing sea areas that meet these requirements, the change must take place before entering the Baltic Sea.*

The sensitivity of the recipient (Baltic Sea) consists, among other things, in the fact that alien species can affect domestic species through increased competition. Taking into account the Ballast Convention and the current regulatory framework, as well as the large number of vessels already passing through the farm area, the magnitude and extent of the impact is considered insignificant, resulting in a negligible impact on the bottom fauna of the area (Table 27).

Table 27. Impact assessment for the introduction of alien species during the construction phase.

Influence factor	Recipient sensitivity	Size and extent of the influence	Impact
Alien species	Moderate	Insignificant	Negligible

Operational phase

Substrate changes

The wind farm is planned in an area with soft bottoms and soft-bottom fauna. Hard-bottom surfaces will be added in connection with the establishment of the wind farm in the form of foundations and erosion protection. Such structures are well known to attract a rich fauna, as they create the conditions for so-called artificial reefs where hard-bottom species can establish themselves locally in connection with the wind turbines. Compared to many other types of reefs, the foundations pass through the entire water column from sea surface to seabed. This means that a habitat is created where there would otherwise have been open water.

Construction of foundations in the farm area is expected to result in increased occurrence of common mussels (*Mytilus edulis*). Barnacles often colonise surfaces closest to the splash zone (the zone exposed to both air and water as a result of wave activity) (Qvarfordt et al., 2006; Vanagt and Faasse, 2014). Next to the waterline on the foundations in the farm area, filamentous algae like *Pilayella/Ectocarpus* and *Polysiphonia fucoides* are expected to grow. The establishment of algae in the area can serve as a nursery for several species of fish and lead to higher biodiversity because the presence of algae communities is otherwise limited in the area.

However, the changes to the substrate conditions that occur at the seabed are limited. Of the total bottom surface in the wind farm area, a little more than 0.2% will be affected by changes to substrate conditions in a worst-case scenario, i.e. where the maximum number of foundations will be built as gravity foundations (see Table 21). However, due to the fact that foundations pass through the entire water column as described above, the total addition of hard substrate is considerably greater than the reduction of soft-bottom surfaces for the existing soft-bottom fauna.

All in all, the changed substrate conditions within the wind farm are expected to have a positive effect on the biodiversity of the area, as foundations, and the blocks and stones that provide erosion protection around foundations, are expected to contribute to a new habitat for hard-bottom species (Dong energy, 2006; BSH and BMU, 2014; Vanagt and Faasse, 2014). The new hard-bottom surfaces can be habitat for both common mussels, barnacles and various species of vegetation, while the small areas of soft bottom are lost are not at risk of adversely affecting the bottom fauna in the farm area.

The sensitivity of bottom flora and bottom fauna to substratum changes in the farm area is considered moderate in that it changes the habitat of species. For the flora, the foundations are expected to offer access to a new hard substrate that will enable the establishment of algae that are otherwise lacking in the current wind farm area. The artificial reefs can lead to local increased biodiversity and biomass in the area around the foundations and their erosion protection. In view of the limited area used in relation to the total seabed area of the wind farm, the overall effect of substratum changes is considered to be slightly positive for bottom fauna and flora in the farm area (Table 28).

Table 28. Impact assessment of substratum changes for the demersal flora and fauna in the area.

Influence factor	Recipient sensitivity	The influence's size and extent	Impact
Substrate changes	Moderate	Slightly positive	Slightly positive

Alien species

The new hard substrates resulting from foundations and erosion protection not only benefit domestic hard-bottom species but also offer new substrates for alien hard-bottom species that could be released ship traffic and ballast water. However, the activity is not expected to contribute to the introduction of alien species that are not already present in the area, but mainly concerns larvae that could be carried to the area by sea currents. The new addition of hard-bottom structures in connection with the establishment of the wind farm is also limited.

One alien hard-bottom species that can be expected to establish itself on foundations is the European acorn barnacle, *Amphibalus imvicus*. The European acorn barnacle has already established itself on hard surfaces in the southern Baltic Sea, but the addition of hard substrates in connection with the construction of the wind farm is considered to have a negligible effect on the spread of the species in the area. The construction of the wind farm could potentially increase the risk of spread to a certain extent, but it is likely that measures aimed at vessel traffic and ballast water will be more beneficial to achieve the objectives of the Swedish Protection of the Marine Environment Ordinance. Under the ordinance, the number of alien species newly introduced into nature through human activity must be minimised and maintained at a level that does not adversely affect ecosystems. It is unlikely that wind farm activities would add any new alien species. The extent and size of the influence is therefore considered to be insignificant. The impact is therefore deemed to be negligible (Table 29).

Table 29. Impact assessment for the introduction of alien species during the operational phase.

Influence factor	Recipient sensitivity	The influence's size and extent	Impact
Alien species	Moderate	Insignificant	Negligible

Electromagnetic fields

When the cables are carrying electricity, a weak electromagnetic field is generated around the cables in the inter-array network. The electrical field in the cables is shielded by insulation around the conductors, so that it is primarily the magnetic field that reaches outside the cable. This magnetic field can generate a maximum power of 23 µT at the surface of the sediment that is over cables buried at a depth of one metre. Locally, there may be higher magnetic fields where the cable is not buried as deeply or where there is only mechanical protection. According to a review by Albert et al. (2020) the influence of magnetic fields on bottom fauna is limited. Studies conducted with a multi-field higher magnetic field than is expected to occur in the Triton wind farm shows limited influence on the bottom fauna (R.2). Assessment based on the cautionary principle means that the effects are unlikely to have a significant influence on demersal fauna in the area. The size and extent of the influence are therefore considered insignificant and the impact of electromagnetic fields is negligible.

Table 30. Impact assessment of electromagnetic fields on demersal fauna in the farm area during the operational phase of the wind farm.

Influence factor	Recipient sensitivity	The influence's size and extent	Impact
Electromagnetic fields	Small	Insignificant	Negligible

Hydrographic changes

Changes in the structure of the seabed may result in a change in hydrodynamics in an area. In turn, this can lead to changes in the bottom substrate (Hammar et al., 2009). According to Danish studies, in a wind farm in which the distance between the wind turbines, which are responsible for the structural changes on the seabed, is large, the hydrographic changes are minimal (Dong energy et al., 2006). Further studies of marine structures have also demonstrated minimal hydrographic effects (Øresund Consortium, 2000; Edelvang et al., 2001).

On behalf of OX2, NIRAS has developed a hydrodynamic model with the aim of investigating how the wind farm may affect the hydrographic conditions of the area (R.12). All in all, the NIRAS study shows very limited and local hydrographic changes. The recipient's sensitivity to changing hydrographic conditions is considered to be moderate, because the distribution of species may be affected by changing hydrographic conditions (e.g. current conditions and salinity). The size and extent of the influence is considered insignificant, since the changed hydrographic conditions that arise are minimal and primarily affect the environment in close proximity to the foundations, which is a very small part of the total surface area of the farm site. This results in a negligible impact (Table 31).

Table 31. Impact assessment of hydrographic changes on demersal fauna in the farm area during the operational phase of the wind farm.

Influence factor	Recipient sensitivity	The influence's size and extent	Impact
Hydrographic changes	Moderate	Insignificant	Negligible

Decommissioning phase

Wind turbines have a limited-service life after which they will be dismantled. The decommissioning work can involve a physical influence on the seabed and an increased concentration of sediments and pollutants/environmental toxins in the water in connection with the wind turbines being dismantled. Elevated sedimentation levels and pollution spread can also be expected if the subsea cables have to be raised. The influence and impact during the decommissioning phase are therefore similar to the impact that occurs during construction, although to a lesser extent. The extent and size of the influence is considered insignificant, which means that the overall impact of physical effects, sediment spread including environmental toxins on the demersal flora and the fauna during the decommissioning phase is considered to be negligible.

7.2.3 Summary of transboundary impacts

From the studies conducted, it can be concluded that the influence of the project on the demersal flora and fauna of the farm site during the construction phase will be insignificant with a negligible impact.

During the operating phase, the influence is deemed to be slightly positive and the impact is slightly positive for substrate changes and reef effects, with the remaining influence factors during the operating phase being considered insignificant and the impact negligible. During the decommissioning phase, the influence is assessed to be insignificant and the impact to be negligible.

With this as a background, the impact on demersal flora and fauna becomes very local and is therefore not deemed to lead to any significant transboundary impact.

The Danish, German and Polish Natura 2000 sites are considered to be too far away to be reached sediment spread and by sedimentation. The impact for suspended sediment and sedimentation is therefore assessed to be negligible on identified nature types in the Natura 2000 sites in Danish, Polish and German waters.

7.3 Fish

Total impact assessment

Fish can be affected by wind turbines during the construction, operation and decommissioning phases. The influence depends on the size of populations, the specific species and how they react to the wind farm.

During the construction phase, the main effect on fish is caused by underwater noise and sediment spread. The most obvious effect on fish when the wind farm has been established and is in operation is considered to be the reef effect. The reef effect means that the wind turbine foundations and erosion protection function as artificial reefs, which can locally increase the number of fish and increase biodiversity. The establishment of the wind farm will protect fish and seabeds, in particular in view of the restriction of bottom trawling.

The overall assessment for the Triton wind farm is that the impact on fish, assessed from various influence factors, during the construction phase are negligible to small, and during the operational phase negligible to moderately positive, depending on the influence factors and species During decommissioning, the impact is expected to be negligible.
The influence on fish is considered to be very local and is not deemed to lead to any negative transboundary impact. The impacts on Danish, German and Polish Natura 2000 sites are considered negligible as a result of the long distance to them.

This section describes the occurrence and assessed influence and impact of the operations on fish which summarises reference report R.3 ”*Fish and offshore wind power in the Baltic Sea to the south of Skåne*”.

7.3.1 Preconditions

As a result of the brackish aquatic environment of the Baltic Sea, a mixture of salt and freshwater species is found in the project area. The inflow of salt water from the North Sea results in a north-south gradient of salinity which also reflects the species found, with more typical salt-water species in the south-west of the Baltic Sea and more typical freshwater species further north. Seabeds, such as those in the Triton farm area, consisting of soft sediments such as sand, silt and clay, are used by flat fish such as flounder and plaice, as well as cod. Species that are more common in open waters, such as herring and sprat, as well as whiting, are common in catches in commercial fishing in the area. Sporadically, probably seasonally, species such as red-listed eel, salmon, pike and trout can be present.

The project area is located in the Arkona Sea, which is part of Area 24 as defined by the marine research body, the International Council for the Exploration of the Sea (ICES) (Figure 29). This extends from the Danish Straits in the west to Bornholm in the east.

The Arkona Sea is a well-studied sea and a lot of data and research results are available from the area. There are several sources studies can be based on, including trawling data from the ICES Database of Trawl Surveys (BITS) (ICES 2014) which gives a good picture of the fish fauna in the area. In addition, exploratory fishing and eDNA surveys have been conducted within the framework of Triton.

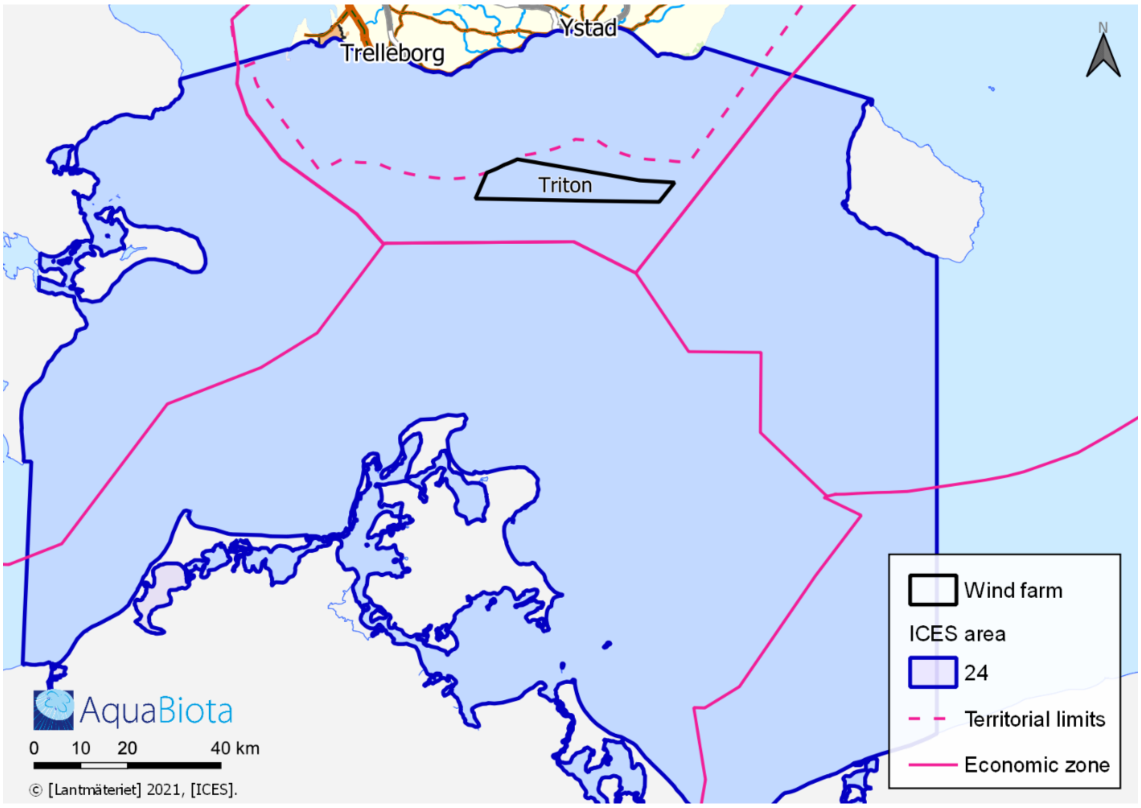


Figure 29. Map of the Baltic Sea to the south of the Triton wind farm. The ICES 24 maritime area is referred to as the Arkona Sea.

Fish species

Common

Species diversity of fish is relatively high in the Arkona basin in general. While the Triton wind farm is home to many fish species, the adjacent Natura 2000 area Sydvästskånes utsjövatten is more diverse. In general, deeper areas have fewer fish and species than shallow areas, because shallow areas often offer a more varied habitat in terms of seabed structure, plants and food supply. They can also serve as spawning grounds and nursery areas. Common species in the Arkona basin include herring and sprat, various species of cod and flatfish. The most common species in the Arkona basin according to trawling data are shown in Table 32 (R.3).

Table 32. The most common species of fish in the Arkona basin and their typical habitats.

Species		Habitat
Cod	*Gadus morhua*	Bottom and open water (Benthopelagic)
Herring	*Clupea harengus*	Bottom and open water (Benthopelagic)
Sprat	*Sprattus sprattus*	Open water (pelagic)
Plaice	*Pleuronectes platessa*	Bottoms (demersal)
Flounder	*Platichys flesus*	Bottoms (demersal)
Dab	*Limanda limanda*	Bottoms (demersal)
Whiting	*M. merlangus*	Bottom and open water (Benthopelagic)

As can be seen in Table 32, the fish are categorised based on their typical habitats, divided into three groups: Pelagic fish (open sea), demersal fish (bottoms) and another category, benthopelagic fish (bottom and open sea) living in both environments.

Red-listed species

Several species of fish in the south-west Baltic are listed in the Species Information Centre red list (SLU, 2020), HELCOM’s red list (HELCOM, 2013) and OSPAR’s list of endangered and declining species (OSPAR, 2008) (Table 33). The lists may differ in their assessments of a species’ risk of extinction, as they have different ranges for new assessments and include different sea areas. A clear example is turbot (*Scophthalmus maximus)* which, according to HELCOM, is under threat (NT), but according to the Species Information Centre is viable (LC), which could be due to the fact that HELCOM’s assessment is older and covers a larger area.

The Species Information Centre’s red list is based on the threat status of a species in a specific region and a new assessment is made every five years The HELCOM Red List includes species living in the Baltic Sea area and is based on criteria developed by IUCN (HELCOM, 2013). HELCOM’s latest threat status classifications are from 2013. OSPAR does not have a classification, but lists the species they consider to be threatened or declining within their zones and makes recommendations.

Table 33. Reproducing species in the south-west Baltic Sea (southern Sweden) classified in the Species Information Centre (SLU 2020) and HELCOM Red List of fish and Lamprey species (HELCOM Red List of Fish and Lamprey species) (HELCOM, 2013). Species with an asterisk have been highlighted by OSPAR as species that need strengthened protection (OSPAR 2008).*

Species		Status HELCOM	Status Species Information Centre
Atlantic wolffish	*Anarhichas lupus*	Endangered (EN)	Endangered (EN)
Eels*	*Anguilla anguilla*	Critically endangered (CR)	Critically endangered (CR)
Fourbeard rockling	*Enchelyop. cimbrius*	Near threatened (NT)	Near threatened (NT)
Cod*	*Gadus morhua*	Vulnerable (VU)	Vulnerable (VU)
Common Ling	*Molva Molva*	Endangered (EN)	Endangered (EN)
Haddock	*M. aeglefinus*	Near threatened (NT)	Vulnerable (VU)
Whiting	*M. merlangus*	Vulnerable (VU)	Vulnerable (VU)
Sea lamprey	*Petromyz. marinus*	Vulnerable (VU)	Endangered (EN)
Turbot	*Scophth. maximus*	Near threatened (NT)	Viable (LC)
European river lamprey	*Lampetra fluviatilis*	Near threatened (NT)	Viable (LC)

The most common red list species in the south-west Baltic are cod and whiting (ICES, 2014.) Cod of both the western and eastern stock are widespread in the south-west Baltic because the species is very mobile and occurs both in open water and at the sea bottom (Kullander, 2012; County Administrative Board, 2020). Whiting is also a species that moves between open water and the bottom and can forage over large areas (Swedish Agency for Marine and Water Management, 2021b). Fourbeard rockling, eels, trout and haddock, all listed in both the Species Information Centre and HELCOM red lists, have been regularly observed during BITS surveys over the past ten years. There have also been observations of other species on the red lists, such as common ling, Atlantic wolffish, thornback ray, European river lamprey and turbot within the area. The OSPAR list includes some species of fish that occur or may occur in the south-west Baltic, where the most frequent are eel and cod. As with the Species Information Centre and HELCOM's red lists, the thornback ray is included as endangered in the OSPAR assessments.

The eDNA analysis in June included the species Cod, whiting and fourbeard rockling. Cod, whiting and fourbeard rockling were also present in the June trawl sampling. In August, seven red-listed species were included in the analysis: Cod, whiting, haddock, hake, fourbeard rockling, common ling and Atlantic wolffish, while in the trawl sampling there were only four species, cod, whiting, fourbeard rockling (R.13).

Fishing

There is an ongoing fishery targeting red-list species in the waters south of Skåne, although it is has reduced compared with what it used to be. They were previously fished in higher quantities, which contributed to their current endangered status (Swedish Agency for Marine and Water Management, 2021b; SLU, 2017). A comparison further back in time with regard to the catches of whiting shows a long-term sharp reduction as only 1% of the catch landed in the 1990s is now landed (SLU, 1940 2017). With a few exceptions, the endangered European eel is completely protected (Swedish Agency for Marine and Water Management. 2019e). Cod fishing in the eastern stock in the Baltic has been completely banned in ICES divisions 24, 25–30 since 2019, with the exception of area 24 for certain small vessels with severe restrictions (Swedish Agency for Marine and Water Management 202020A, Swedish Agency for Marine and Water Management, 2021c) The decision was also made to ban fishing for the western stock 2022 because this stock is also considered to be below safe biological limits (Swedish Agency for Marine and Water Management, 2021c).

Spawning fish

In the Triton area there are three species of fish whose spawning grounds overlap with the site, flounder, sprat and cod.

The flounder *(Platichthys flesus)* is present in all Swedish sea areas except the Gulf of Bothnia. The species is mainly a marine species, but it can also cope with freshwater conditions. In particular, young fish appear to congregate in shallow areas with a lower salinity (Andersen et al., 2005). Historically, the species has been considered to have two types of spawning, a coastal spawning with demersal eggs and a spawning type that spawns in deeper waters where the roe is dispersed in the open sea (Swedish Agency for Marine and Water Management, 2021b; ICES, 20202020A). It has recently been demonstrated that these types of spawning are genetically separate and the coastal spawning type was called the Baltic flounder (*Platichthys solemdali*) (Momigliano et al., 2018, Jokinen et al., 2019). As these two have not been differentiated between in the BITS study, these two species are treated as a single flounder.

Sprat breeds in the open sea between March and August within a depth range of about ten to 40 metres (Swedish Agency for Marine and Water Management, 2021b). However, according to the spawning time portal, the most intense spawning occurs between May and August (Swedish Agency for Marine and Water Management, HaV). The sprat is higher up in the water mass during spring and early summer (Stepptis et al., 2011) when the bottom water is cold. Sprat avoids cold temperatures (℃) and is found above the halocline (the boundary between heavier salter sea water and less saline water) which during this period constitutes a physiological limit for the species (Stepputtis et al., 2011). The entire Arkona Sea mainly forms a potential spawning ground for the species (HELCOM, 2021) (Figure 30). Spawning that takes place during the latter part of the spawning period seems to be the most optimal for the species because the higher temperatures in the sea during August favour survival of the fish larvae (Baumann, 2006).

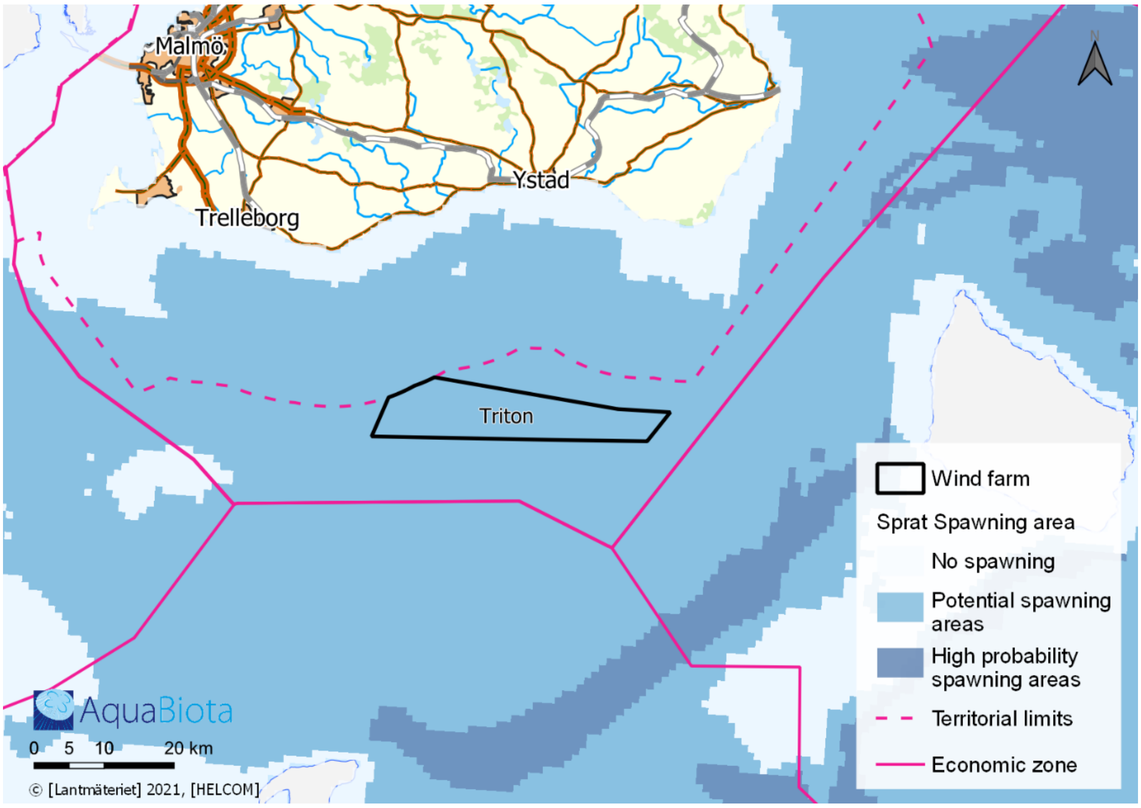


Figure 30. Map of areas near Triton where spawning of sprat is likely to occur (HELCOM 2021).

Cod spawn in the open water mass at depths where the salinity is higher (Hüssy, 2011; von Dewitz et al., 2018). After spawning, cod roe float freely in the water until they hatch. The fish larvae feed first on the yoke sacks before they switch to eating animal plankton. Survival of the roe is affected by, among other things, salinity and temperature (Pacariz et al., 2014; Hinrichsen et al., 2012).

There are two genetically separated cod stocks in the Baltic. The western cod stock is found west of Bornholm (ICES divisions 22-24), and mainly in ICES divisions 22 and 23, which corresponds to the Danish Straits and Öresund (ICES, 2020a; ICES, 2021). The eastern cod stock is mainly found in the east of the Baltic Sea, east of Bornholm (ICES areas 25-32) (ICES, 2021). The stocks overlap to some extent in the sea south of Skåne (ICES, 2019; ICES, 2020a; ICES, 2021).

The main spawning grounds for the western stock are the Bay of Mecklenburg and Kiel Bay in the Baltic Sea and the Öresund (Figure 31) (Bleil and Oeberst, 2002; Bleil et al., 2009; Hüssy, 2011). The western stock's spawning in the Danish Straits is most intensive during March-April (Vitale et al., 2005; Bleil et al., 2009). For the western stock, the spawning in the Arkona Sea is less important and more sporadic, and the spring spawning is not as intense as in other spawning grounds. When assessing the impact of the Triton wind farm, it is important to note that although the western stock can spawn in the Arkona Sea, it is not the stock's most important area. If establishment of the wind farm could in any way affect spawning cod in the area, our assessment is that the possible influence has a negligible effect on the western stock given the marginal importance of the Arkona Sea for the growth of the population.

The eastern cod stock mainly spawns in the Bornholm Deep, where the intensive spawning period is June-August (Bleil et al., 2009). The Bornholm Deep is the most important spawning ground for the survival of the eastern stock (ICES, 2019; ICES, 2020a). In the Arkona Sea, the eastern stock spawns much less than in the Bornholm Deep and the intensive spawning period takes place in June-July (Bleil et al, 2009, ICES 2020a; Nisling and Westin, 1997; Bleil and Oeberst, (2004). A larger proportion of the cod from the eastern stock spawns in the Arkona Sea than the proportion from the western stock. However, ICES (2019) argues that recruitment to the eastern stock from the Arkona Sea is so small that it does not significantly affect the stock. This is partly due to the fact that the recruitment of cod from the Arkona Sea is limited by abiotic factors such as salinity, oxygen concentration and that the area is not sufficiently deep (Hüssy, et al. 2016).

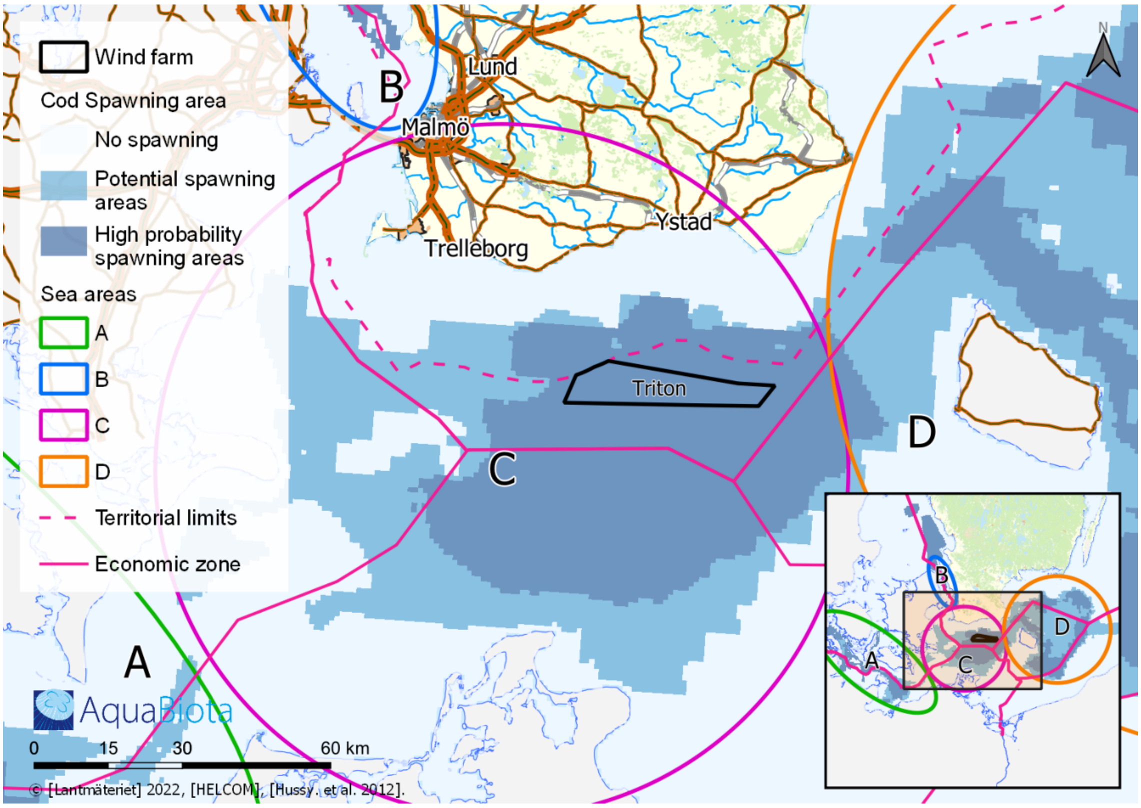


Figure 31. Map of areas near Triton where cod spawning can probably occur (HELCOM 2021). A and B = Main spawning grounds for the western stock, C = Not the main spawning grounds for either the western or eastern stock and D = The main spawning grounds for the eastern stock.

Many factors play a role in assessing the status of the cod population and its development over time. The eastern stock has been subject to high pressure from commercial fishing for a long time (Swedish Agency for Marine and Water Management, 2021), and has decreased for decades. Other factors that have affected the stock are poor oxygen and salt conditions in the Baltic Sea, with inactive spawning grounds in the Gotland Deep and the Gdansk Deep (Swedish Agency for Marine and Water Management, 2021b). Reductions in food supply and increases in parasites in cod have also had a negative effect (Haarder et al., 2014; ICES, 2020a).

The Triton wind farm is part of an area where cod spawn (Figure 31) (HELCOM, 2021). HELCOM has identified an area in the sea south of Skåne that covers about 3,800 km^2 where cod may spawn, which is considerably smaller than the main spawning grounds for the stocks (Bleil et al., 2009). The planned Triton wind farm covers about 250 km^2, and accounts for about 7 % of the cod spawning grounds.

Since 2015, the number of mature cod has been so low that the capacity to produce juvenile fish is reduced (Swedish Agency for Marine and Water Management, 2021b) and in 2018 recruitment was the weakest recorded (ICES, 2020a). This fact resulted in an emergency ban on cod fishing in the eastern stock in mid-2019, which would apply throughout the year 2020. As the stock has not yet recovered, this ban was extended to all of 2021 and has now been extended to apply in 2022 (Swedish Agency for Marine and Water Management 2020A, Swedish Agency for Marine and Water Management 2021c). In order to further protect both cod stocks, fishing targeting other species has also been banned with all types of gear from 15 May to 15 August in ICES Division 24.

The status for cod in the entire Baltic Sea has deteriorated over time for several reasons. One of the main reasons is the historically high pressure from commercial fishing. However, other factors also have a negative impact on populations, such as lack of food, anaerobic sea bottoms, predation on cod roe, and parasites (Koster and Möllmann, 2000; Haarder et al., 2014; Svedäng and Hornborg, 2014; Limburg and Casini, 2019; ICES, 2020c; Swedish Agency for Marine and Water Management, 2021b). However, other factors also have a negative impact on populations, such as lack of food, anerobic sea bottoms, predation on cod roe, and parasites (Koster and Möllmann, 2000; Haarder et al., 2014; Svedäng and Hornborg, 2014; Limburg and Casini, 2019; ICES, 2020c; Swedish Agency for Marine and Water Management, 2021b). This can therefore mean that the construction and operation of offshore wind power will have a very limited effect compared to other factors that generate greater dynamism in fish populations.

7.3.2 Impacts

This section describes the identified influences, effects and impacts on fish. The following influence factors during construction, operations and decommissioning have been identified (see Chapter 6 for more details).

Table 34. Estimated influence factors during the wind farm's construction, operational and decommissioning phases.

Influence factor	Activity	Construction	Operation	Decommissioning
Subsea noise	Wind farm	x	x	x
Sediment spread*	Wind farm + inter-array	x		x
Reef effect	Wind farm		x	
Noise above water	Wind farm		x	
Magnetic fields	Inter-array		x	
Species spread	Wind farm		x	
Shadows and lighting	Wind farm		x	
Climate			x	
Predators			x	

*Includes suspended material and sedimentation.

Construction phase:

The construction phase lasts for a limited time. The goal is to complete the entire installation in one season. Work at sea must be avoided as far as possible during the winter period when weather conditions are worse. A split over several seasons may be required. For example, foundations and cables can be installed during an initial season and the turbines during the following season. Alternatively, half of the wind farm can be installed and commissioned in a first season, in order to install and commission the remaining part of the wind farm in the following season. The total construction work for all wind turbines is expected to last for approximately one year During this period, the activities may affect fish, mainly in the form of noise and the release of sediments. High noise levels will be generated mainly in connection with monopile-type foundations being driven down into the seabed. Sediment will principally be spread when monopile foundations are being drilled. Installing a monopile foundation takes less than a day, in good conditions usually only a few hours.

Underwater noise

During installation of offshore wind turbines noise levels below the water may reached that can have effects on fish. The effect on fish depends on factors such as the volume and species composition. One important aspect is also the number of fish in the area concerned. There may be so few fish in some parts of the Swedish sea areas that only a few fish are affected. Noise is also propagated differently depending on water depth, seabed type and the aquatic environment.

The seabed at the Triton site is mainly soft and made up of clay, which offers better sound absorption capacity than hard bottoms.

Geotechnical studies planned for Triton will use vibrocorers, cone pressure testing (CPT) and drilling, as well as such geophysical studies as multibeam echo sounding and seismic surveys. Geophysical surveys have been shown to affect fish (McCauley, et al., 2003, Slotte et al., 2004). The work will be conducted for a limited period of time and use mitigatory measures, such as soft start-up, to ensure that fish do not remain close to the surveys. The noise from vessels may also lead to fish swimming away from the area before the surveys begin. As the work is conducted for a limited period of time and employs mitigatory measures, the effect on fish due to the noise influence of the geotechnical and geophysical surveys is deemed to be small.

A common way of installing structures at sea is to drive them down into the seabed, which causes noise (Andersson et al., 2016). This is the method used to anchor the monopile-type wind turbine foundations (Tsouvalas, 2020), which have been used here to describe a worst-case scenario. Installing a monopile foundation at sea takes one to two days, six hours of which is normally used for the actual piling work. The noise generated during the installation may have a temporary effect on fish that are in the vicinity of the installation site. The noise can lead to a behavioural reaction, such as flight or temporary hearing loss (Mueller-Blenkle et al., 2010; Halvorsen et al., 2012a; Halvorsen et al., 2012b).

In addition to noise relating to the work of installing wind turbine foundations, there will also be noise from the boat traffic during the day that the foundation is installed, and a few more days for mounting towers, nacelles and rotors. Marine traffic using special vessels is necessary, partly in order to conduct the work around the wind turbines and partly in order to transport material and personnel to the installation site. Fish can be disturbed by engine noise from vessels (Bruintjes and Radford, 2013; McCormick et al., 2018). At the same time, it should be noted that there is already a presence of maritime traffic in the Triton wind farm site and in nearby areas due to fishing and other commercial maritime traffic. There are well-travelled shipping lanes along the northern and eastern borders of Triton, as well as a shipping line that passes through the farm (Figure 32).

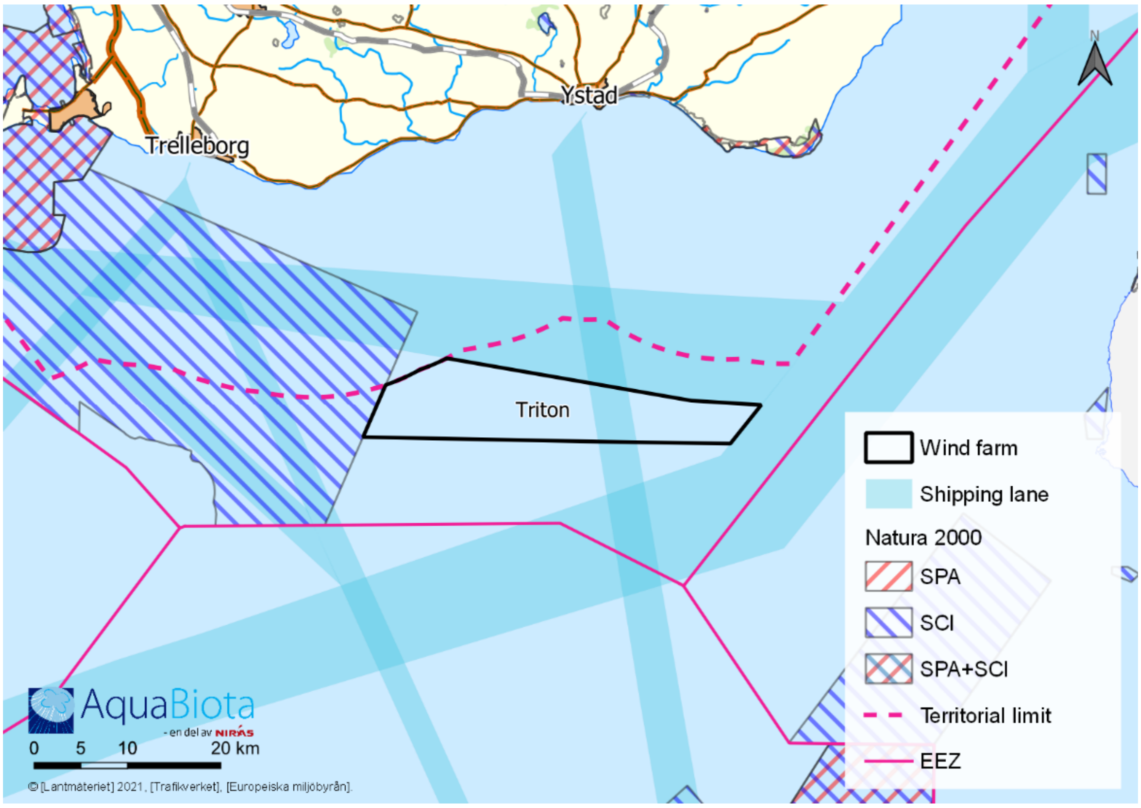


Figure 32. Shipping routes and Natura 2000 sites bordering on Triton. SPA = protected according to Birds Directive. SCI = protected according to the Species and Habitats Directive.

Fishes' hearing

Fish generally have a developed hearing capability (Popper et al., 2019). Important organs for hearing sound are the ear, the swim bladder and the lateral line. Their hearing is used, for example, to allow fish to detect a predator, search for food, orient themselves and to communicate. Their hearing capability varies between species and depends on the anatomy of the hearing organs.

Most species, such as cod, have a swim bladder that increases their hearing capability. These are called hearing generalists (Axlsen, 1999). The fish that have a connection between the swim bladder and the inner ear's auditory bones, which further enhances the ability to perceive sound, are called hearing specialists. This includes herring. There are also species that only use the ability of the ear to perceive sound, such as flatfish, which lack other organs to support hearing (Swedish Environmental Protection Agency, 2000; Gorska et al., 2005; Farm, 2006).

Increased noise levels can cause stress reactions, causing the fish to move away from the sound (Slotte et al., 2004; Smith et al., 2004). Close proximity to loud noise can cause temporary threshold shift (TTS) hearing loss. If the noise is loud enough, it can lead to permanent hearing loss (PTS). The effect of underwater noise on fish depends on factors such as the volume and the sensitivity of affected species.

Species with a better hearing capability are likely to be more sensitive to impact piling noise, while species may differ in their hearing frequency ranges. Cod and herring are hearing generalists and hearing specialists, respectively (Kastelein et al., 2008; Hawkins and Popper, 2020). This means that they are largely representative of most species of fish in the area, except flatfish and some other species without swim bladders. These species generally have poorer sound comprehension, since they can only detect particle motion (Popper, et al. 2014).

Cod use their hearing to communicate with each other. Males produce a low frequency sound during spawning using a muscle that affects the swim bladder (Fudge and Rose, 2009). These sounds are part of a well-developed spawning behaviour (Hawkins and Picciulin, 2019). External sources of sound could affect cod spawning behaviour if the sounds are within the same frequency. At the same time, the cod are close to each other during play, which is considered to make them less sensitive. Ladich et al. (2013) however, think that there are indications that most fish can adjust the frequency of the sound they emit in order to be heard over various low-frequency background noises in the sea. One example of cod spawning working, despite a lot of noise from shipping, is spawning activities in Öresund. Öresund is one of the world's busiest marine areas (Vieira et al., 2020), at the same time as it has very active cod spawning (Marine and water Authority, 202020b). Noise from wind turbines and ships lie in the same frequency range. This is why spawning activities are expected to be unaffected by a wind farm (Betke, K., 2014).

Several studies have examined how cod react to noise (Hawkins and Popper, 2020; Hammar et al., 2014; Mueller-Blenke et al., 2010). A research project conducted by Kastelein et al. (2008) found that the cod did not show any reaction to noise to which they were subjected, despite the fact that the sound level reached up towards 160 dB. One of the reasons put forward was that cod is a predator with a, compared to many other species, fearless behaviour. It may explain why, in some cases, they may exhibit a behaviour of being unaffected by sound that they still perceive. However, there are also studies that show that cod can be affected by disturbing noise. Mueller-Blenkle et al. (2010) noted that cod exposed to noise from impact piling were stressed and tried to escape, but there were indications of habituation. Impact piling noise from monopile installations was highlighted by Hammar et al. (2014) as a particular risk of noise influence on cod in the Kattegat, in relation to other effects of offshore wind power that were considered to pose a less risk of influence. Hammar et al. (2014) considered that the spawning period, in particular, was sensitive. However, the survey did not take into account existing technical solutions that could reduce the propagation of sound.

A study conducted by NIRAS (R.11.C), modelled possible sound propagation within the Triton wind farm. The study indicated that the noise from a monopile installation site could lead to temporary hearing loss (TTS) within a radius of up to 7.2–9.9 kilometres for adult cod and 10.9–14 kilometres for juvenile cod. The calculations were based on the use of sound damping measures in the form of a double bubble curtain (DBBC) and a Hydro Sound Damper (HSD). For herring, this distance was slightly shorter, between 6.4 and 9.1 kilometres. The effect varied to some extent, depending on the part of the farm on which the analysis was based. If a fish continuously swims away from the source of the noise, the effect reduces the further away from the source that the fish swims.

According to the study by NIRAS (R.11.C), physical injury to fish can occur directly in connection with loud noises at the site, but as has been described above it is likely that fish will leave the area before there is a loud sound as the initial activity will scare away the fish. Fish departure from the area can also be accelerated by generating artificial sounds (see below about FaunaGuard). The applicability of this analysis should be measured in relation to the number of fish within the radius of noise disturbance during the hours that impact piling takes place and the protective measures used.

In addition to adult fish, fish larvae and fish roe can also be affected by noise (Popper and Hawkins, 2016). They are less sensitive than juvenile and adult fish (Andersson et al., 2016). Bolle et al. (2012) however, showed that although fish larvae were subjected to a noise equivalent to piling at a distance of 100 metres, no effect was noted. It is worth noting that fish larvae and fish roe for most species are spread over large areas, in the so-called pelagic phase, when they follow the water currents. Herring does, of course, lay its roe on the seabed but has a pelagic larva phase (Swedish Agency for Marine and Water Management, 2020b). However, there is little likelihood that herring will spawn within the planned site of Triton's wind farm because they spawn on shallow gravel seabed. If there are fish larvae or fish roe that are adversely affected by noise, they make up a very small part of total amounts. The effect on fish populations is therefore deemed to be insignificant (Andersson et al., 2016).

It should also be noted that the Triton wind farm makes up only 7% of the entire area south of Skåne where cod spawning can occur. Consequently, if the noise from construction of wind turbine foundations had an impact on spawning cod in the sea south of Skåne, it would nevertheless have an insignificant effect on both the eastern and the western stocks.

Summary of effects

- Noise during the construction phase may affect fish that are in the vicinity of a location where wind turbine foundations are being installed. The impact depends on the strength of the noise, which fish are in the area, the size of the fish population, and the mitigatory measures taken to reduce the effect.
- Noise from impact piling can cause a temporary reaction and temporary hearing loss for species that are hearing specialists and hearing generalists that remain in the area. The assessment is that the impact is slightly negative and sensitivity is low to moderate. The result is therefore very small to small, depending on the species.
- Fish roe and larvae are relatively resistant to piling noise, and there are likely to be few individuals within the limited area so close to the work that they are affected by noise, in relation to the large area they are normally scattered over in the pelagic phase (when fish roe and fish larvae float in the water mass). The natural mortality of fish larvae and eggs is high. The assessment concludes that a potential local impact from the construction work is a negligible part of the natural variation.
- In the case of cod, and how noise from piling can affect spawning in the seas south of Skåne, it is of central importance to take into account both spawning of the eastern and western cod stocks in a broader perspective. The main spawning grounds for the eastern stock by far is Bornholm Deep, while spawning for the western stock is mainly in Mecklenburg Bay, Kiel Bay, the Danish Straits and Öresund. The Arkona Sea thus has, as a spawning ground, a limited impact on the survival and development of the respective stocks.
- In addition to the Arkona Sea being less important as a spawning ground, it should be noted that the wind farm site accounts for only 7% of the entire possible spawning ground in the sea. This means that if there were to be a temporary effect on cod spawning in the area during the construction phase, it would be in a limited part of the total area for cod spawning in the Arkona Sea.
- The limited importance of the Arkona Sea as a spawning ground for cod, in a broader perspective, when other major spawning grounds are taken into account, means that the impact on possible spawning is deemed to be insignificant and the impact is assessed to be negligible.

Assessed impact

- The overall assessment is that the impact of noise on fish during the construction of the Triton wind farm is very small to small.

Sediment spread

During the construction of foundations and cable laying on the seabed at the planned wind farm bottom sediment is disturbed and can be spread in the water. As soft bottoms predominate at Triton there is also a background level of suspended material. Elevated levels of suspended matter in the water can affect fish. The extent of the impact is dependent upon concentrations and exposure times where higher concentrations and longer exposures are more significant. The effect on fish also varies between species and stages of life. Karlsson et al. (2020) highlight in a scientific context that concentrations of up to 100 mg/l, for up to 14 days, generally have little impact on fish. If the exposure occurs over a shorter period of time, hours to days, several species can cope with concentrations of up to 1,000 mg/l. It is worth noting that, in addition to the concentration itself, the duration is also of central importance (Newcombe and Macdonald, 1991).

Sediment in the water and fish

There are various effects that suspended material has on fish. This may include behavioural changes, increased stress, breathing difficulties, reduced visibility or increased mortality. Roe is usually more sensitive to suspended matter than adult fish, fish larvae are more sensitive than both roe and adult fish (Auld and Schubel, 1978; Moore, 1977; Westerberg, et al., 1996; Partridge and Michael, 2010). A large fish is generally not as sensitive to suspended material as a small fish, partly because there is less risk of particles getting stuck in the gills of larger fish (Karlsson et al., 2020).

Sedimentary dispersion modelling has been performed to investigate the spread of suspended sediment at the Triton site (for the baseline under a worst-case scenario, see section 5.3.1). The modelling included installation of both foundations and cables. Turbines are installed sequentially, one by one and the time between installation can range from 1–2 days up to weeks, depending on the weather. This means that there would essentially be sediment spread from one turbine at a time. The modelling shows that spread with a concentration of 100 mg/l is limited in space and time. According to the sediment spread analysis conducted for this study (R.12), suspended sediment at a concentration of 100 mg/l will, at most, be spread over an area less than 0.2 km^2 around a foundation and the clouding is estimated to settle within 12 hours. Installation of the inter-array cabling is considered to form a very small part of the sediment spread during the construction phase.

Suspended material may interfere with food intake and breathing of fish larvae (Berg and Northcote, 1985; Zingel and Paaver, 2010; Lowe et al., 2015). Fish larvae, unlike adult fish, have more difficulty in moving away from an area with a lot of sediment. At the same time, it should be noted that fish larvae generally tolerate more suspended material than is naturally present in the sea (Karlsson et al., 2020). In addition, it should be mentioned that the majority of species in the area have pelagic roe and larvae that are carried on currents and are naturally scattered, so that they are not concentrated in a specific area (André et al., 2016; Coombs et al., 2001).

Natural mortality is very high during the pelagic phase. This means that any negative impact of suspended material will be a negligible part within the natural variation. Herring does, of course, lay its roe on the seabed but has a pelagic larva phase (Swedish Agency for Marine and Water Management, 2020b). However, there are no spawning grounds for herring in the planned wind farm.

The sensitivity to suspended material may vary from species to species. Demersal soft-bottom species, such as flatfish like flounder and plaice, generally have a higher tolerance to elevated concentrations of sediments given that they naturally stay close to sediment deposits (Moore, 1977; Karlsson, 2020). The tolerance can also vary depending on what the fish eat, since, for example, predatory fish are generally more resistant than plankton-eating fish (Johnston and Wildish, 1981, 1982; Westerberg, etc., 1996). Cod is a predator with high tolerance to suspended matter in the water. In an aquarium experiment, cod were subjected to a concentration of 550 mg/l (Humborstad et al., 2006). Despite the high concentration, the cod survived, and a physiological adjustment of the gills was noted over time. However, cod clearly prefer water with low concentrations of suspended material, if they can choose (Westerberg et al., 1996).

The establishment of the wind farm would reduce the total load of suspended material in the area because trawl fishing will be reduced in the farm area. This means that the species of fish caught (target species and by-catches) survive and that large volume sediment spread is eliminated. In addition, other demersal marine life gets an opportunity for recovery, as Coates et al. (2016) showed in a study from the North Sea. The wind farms function as a protected area. As a result, many species have a chance of recovery and growth, which can increase biodiversity and benefit the entire ecosystem.

The overall assessment is that the influence on fish fauna of sediment spread is insignificant and the impact of sediment spread is negligible.

Table 35. Summarised assessment of the impact on fish species during the construction phase.

Species	Influence factor	Sensitivity	Influence	Impact
Cod	Piling noise	Moderate	Slightly negative	Small
	Sedimentation	Small	Insignificant	Negligible
Herring	Piling noise	Moderate	Slightly negative	Small
	Sedimentation	Moderate	Insignificant	Negligible
Flatfish	Piling noise	Small	Slightly negative	Very small
	Sedimentation	Small	Insignificant	Negligible

Operational phase

Reef effect

A reef is a structure on the seabed that consists mainly of hard material, such as stone or coral. An artificial reef is a reef structure created by humans (2006). When installing wind turbines, their foundations and associated erosion protection function as an artificial reef.

As such reefs can serve as a habitat for fish and a nursery for fry, biodiversity can increase as the artificial reefs add new habitats in the wind farm, where otherwise soft seabeds with lower fish populations predominate. Wind turbines stretch all the way from the seabed to the surface, allowing habitats to be added at all of the different depths in otherwise open water.

There are several studies that show that the wind turbine foundations generate a reef effect with an increased number of fish in connection with the turbines. Andersson and Ohman (2010) investigated wind turbines in Kalmarsund in the Baltic Sea and could demonstrate that there was a clear reef effect with a large number of fish close to the foundations. A study of potential reef effects has also been conducted at Lillgrunds wind farm in Öresund (Bergström et al., 2013). The study found that there were four species in particular that increased in number in connection with the reef, namely cod, eel, shorthorn sculpin and goldsinny wrasse.

There are also studies from other countries, including Denmark (Stenberg et al., 2015), Germany (Krone et al., 2013), the Netherlands (Van Hal et al., 2017) and Belgium (De Troch et al., 2013; Reuben et al., 2011, 2013, 2014a; Vendendriessche et al., 2015) that demonstrate that a reef effect is achieved in connection with wind turbine foundations. One species of particular interest with regards to the reef effect is cod, given that it is a commercially important species which at the same time has a poor status in the Baltic Sea. A number of studies demonstrate that cod is very willing to look for, and stay around, wind turbines for food and shelter (Bergström et al., 2013; De Troch et al., 2013; Reubens et al., 2013, 2014a, 2014b; Van Hal et al., 2017).

There will probably be a reef effect for a limited number of species around the foundations of the Triton wind farm, with more fish where the foundations are located compared to the numbers that were there before the turbine. This is true both at the seabed, compared to the surrounding soft bottoms, but also in the open water column at the added structure. This is as a result of the addition of a new hard seabed environment. Some species will appear at the installations because they swim there. Other species will find a habitat there as a result of reproduction in which, after their pelagic phase, the fish larvae end up next at the foundations and continue to live there in connection with the structure. The fish fauna is dynamic and there is a natural variation. For this reason, the number of fish will vary over time. It is notable that there are also species in the area that will not be affected by the presence of the wind turbine foundations.

Several factors play a role in determining the level of the reef effect. The effect will not reach the same levels as artificial reefs in the waters off the west coast of Sweden (Ohman et al., 2006) because the Baltic is a sea with brackish water that naturally has fewer species. It is also important to consider the surrounding environment, the numbers of fish that are present, the species that naturally live in the area and the types of wind turbine foundation used. The Triton reef effect will probably resemble the situation at Lillgrund (Bergström et al., 2013) referred to above.

It should be noted that the establishment of the Triton wind farm may lead to a reduction in the pressure from commercial fishing, for example if bottom trawling is reduced in the area as a result of the wind turbines and cables. This can be compared to a so-called de facto Marine Protected Area (Esgro et al., 2020), that demonstrated that fish fauna in an area is given the opportunity to recover.

Assessed impact

The reef effect is assessed to have a positive impact in connection with each individual foundation. This is due to the fact that there are estimated to be more fish in the vicinity of the foundation than were in the same place before the wind farm was established. When the entire area of the wind farm is taken into account, the assessment is that the impact of the reef effect is very slightly positive to moderately positive, depending on the species concerned. For cod, the impact is expected to be moderately positive.

Noise

When turbines are operating noise is generated in the nacelle that can be detected in the water. The noise levels that occur are comparatively low, lower than sea-going vessels and in the same frequency range.

During operation and maintenance, some extra boat traffic will take place in the area, but this is considered negligible in relation to the existing intensive maritime traffic in the area.

The increase in fish stocks from the reef effect that has been shown to occur at existing wind turbines indicates that the sounds of wind turbines in operation are of minor importance to fish. The overall assessment is therefore that the influence of the noise generated by a wind turbine in operation or by boat traffic for maintenance, based on the operation as a whole, is insignificant. This in turn means that the impact is negligible.

Magnetic fields

Submerged electrical cables, which are widespread in Europe and other parts of the world (ESCA, 2019), generate electromagnetic fields that can affect fish. The strength of the electromagnetic field and its influence on the surrounding environment depends on several factors such as current strength, cable type and whether the cable is buried (Oman et al., 2007).

With regard to the electrical field in subsea cables in wind farms (inter-array) or connected to wind farms (export cables), these cables are shielded, so it is primarily the magnetic field that can reach outside the cable. The majority of fish species are able to sense magnetic fields (Öhman et al., 2007) and they use the earth's magnetic field to navigate (Putman et al. 2013, 2014; Naisbett-Jones et al., 2017). This is apparent physiologically because fish can have magnetic material in their body (Walker, 1984; Hanson, et al. 1984; Hanson and Westerberg, 1987).

The influence of magnetic fields can be shown through behavioural changes as a result of changes in the magnetic field (Karlsson, 1985; Tesch et al., 1992). One example of this is eels, which navigate using the earth's magnetic field and where studies have shown that they may be temporarily affected if they pass a subsea cable (Naisbit-Jones, 2017; Westerberg and Begout-Anras, 2000; Westerberg and Lagenfelt, 2008). Eels' passage past the Lillgrund wind farm has been studied, but gave not clear indication of any behavioural change (Lagenfelt et al., 2012).

Although magnetic fields would have a certain effect on fish, other factors seem to have a greater impact, for example, the availability of suitable habitat may be more important (Dunlop et al., 2016). In the case of wind farms, this may mean that the positive reef effect means more than any potential influence from magnetic fields (Bergstrom et al., 2013).

Summary of effects

- Magnetic fields have a limited influence on fish. This is shown not least in the fact that there is a reef effect around wind turbine foundations, which indicates that other factors are more important than a possible influence from subsea cables.

Assessed impact

- The overall assessment is that the impact of magnetic fields from subsea cables is negligible.

Species spread

Building foundations in an area consisting mainly of soft bottom seabed can encourage the spread of species that naturally exist in the region and prefer hard seabed environments. As a result of the reef effect, some species that can swim over large areas (such as cod) are likely to visit several wind farms. Other species may make their home in the vicinity of a foundation as a result of spawning in which fish larvae find suitable habitat (e.g., two-spotted goby).

The wind turbine foundations do not constitute an unnatural habitat because they are regarded as a hard-bottom environment from the point of view of the fish to be compared with natural stone reefs. This means that the habitat itself is not so unique that it would provide the conditions for a new fish stock in which rare species would benefit more than those naturally found in hard-bottom environments in the region.

The probability that new species will appear at the wind turbine foundations is no greater than for natural seabed areas on offshore banks or along the mainland coast. This also applies to alien and invasive species. The wind turbine foundations are so spread over the area of operation, and present so limited an area as compared with other existing hard bottom substrates adjacent to the Triton wind farm, that it is not assumed to be a significant spread vector.

Summary of effects

- The wind farm with the habitats that the wind farms can create is not considered to affect the spread of species. This also applies to alien and invasive species.

Assessed impact

- The overall assessment is that the impact of species spread is negligible.

Shadows and lighting

Wind turbines and their towers give a shadow effect in the water. The rotor blades can also produce a shadow effect (Lovich and Enn, 2013). As fish can react to sudden shadows, it could create a stress reaction, but shadows are probably of minor importance (BOEM, 2021). On the one hand, the water is to some extent naturally cloudy in the Baltic Sea, which means that changes in light do not penetrate the water to any great extent. In addition, the water is constantly moving with waves and ripples that break up the light in different directions at the surface. Shadows also occur naturally as a result of the movement of clouds.

Wind turbines have lights that make them more visible to ships and air traffic. These lights are high up in the tower and are directed straight out in such a way that ships and air traffic can see the turbines. It is considered unlikely that the wind turbine's light would influence fish is because the water is cloudy and in constant motion, which means that the light is broken at the surface.

Summary of effects

- Shadows from the wind turbine towers and blades or lighting on the tower are considered to have too little light intensity to have an effect on fish in the sea. The influence is insignificant in relation to sensitivity.

Assessed impact

- The overall assessment is that the impact of lighting and shadows is negligible.

Climate

Water temperature in the seas is increasing as one of the results of climate change. The oxygen content decreases and the stratification in the water changes. All of these factors can affect the presence and spread of fish in the seas, which in turn affects the number of fish and species composition. In Sweden's marine areas, changes to fish species and populations due to climate change are expected (Havenhand and Dahlgren 2017).

Fish at offshore wind farms are no exception. Fish and benthic organisms around the turbines are likely to have a similar composition as at the islands and offshore banks in the area. Climate change will affect all of the sea and changes on other reefs will mainly also happen at wind farms. In other words, organisms living in connection with the wind turbine foundations will not be affected differently by climate change than in their surrounding waters.

If climate change means that species that thrive in warmer climates spread to Swedish waters, more southern species that thrive on reefs will also be able to establish themselves at Swedish wind turbines.

With regard to climate change, offshore wind turbines will not impair the conditions for the fish fauna in the area. The Triton wind farm will help to counter ongoing climate change.

Table 36. Summarised assessment of the impact on fish species during the operational phase.

Species	Influence factor	Sensitivity	Influence	Impact
Cod	Reef effect	High	Slightly positive	Moderately positive
	Noise	Moderate	Insignificant	Negligible
	Magnetic fields	Small	Insignificant	Negligible
Herring	Reef effect	Small	Slightly positive	Slightly positive
	Noise	Moderate	Insignificant	Negligible
	Magnetic fields	Small	Insignificant	Negligible
Flatfish	Reef effect	Small	Slightly positive	Slightly positive
	Noise	Small	Insignificant	Negligible
	Magnetic fields	Small	Insignificant	Negligible

Predators

Great cormorants are often attracted to offshore wind farms, although not always (Dierschke et al., 2016; Fox and Petersen, 2019). For example, no increase in the great cormorant population was observed at the Lillgrund wind farm in Öresund after the wind farm had been built (Nilsson and Green, 2011). Great cormorants use the foundations as resting places to dry their wings. This gives the birds access to new foraging areas they would otherwise not use. For the wind farm to have an appeal, there must be food, i.e. fish in the surrounding area. Based on the OX2 bird counts for Triton, the density of fish-eating birds is low in the area and great cormorants have not been observed in the project area during three flight counts (16 March 2021, 27 April 2021 and 15 January 2022). In addition, the location and depth conditions at the Triton wind farm contraindicate presence of significant numbers of great cormorants at the farm. The importance of great cormorants as a consumer of fish and influence on fish densities is complex. There are studies that have shown that great cormorants can affect the number of fish individuals in closed, restricted water systems such as artificial fish ponds and small natural watercourses. In larger, open water systems such as the Arkona basin, existing studies show a wide variation in the influence of great cormorants (Ovegård, etc. 2021). There are so many different factors in such marine areas that affect fish presence that it is rarely possible to demonstrate any further effect of the great cormorants' fish consumption. All in all, it is estimated that the Triton wind farm will not attract any large numbers of great cormorants and that it is unlikely that the individuals who might be present in the wind farm will have a measurable effect on fish densities or stress levels of fish in the wind farm.

In the open water there are plenty of plankton, which is a main food for sprat. Fish is also food for birds and seals in the area. Together, these different interactions create a food web throughout the ecosystem.

Sea birds affect marine species through their food intake from the sea. The north-west part of the Natura 2000 area Sydvästskånes utsjövatten is an overwintering area for ducks and the Natura 2000 area Falsterbo-Fotoviken, north-west of Sydvästskånes Utsjövatten, is an overwintering area for a variety of seabirds (the Swedish Environmental Protection Agency, 2021).

A study on food consumption by seabirds in the Baltic Sea and the waters off Sweden's west coast found that seabirds consumed about 630,000 tonnes of fish annually (Barrett et al., 2006). In the south-western Baltic, this consumption includes cod, herring, perch and several species of flatfish (Hansson, 2018). However, the birds are far from the Triton wind farm (R.3) so that the predatory pressure of birds on fish in the farm should be low.

At many existing wind farms it has been observed that the number of species and the individual density of fish increase (Bergstrom et al. 2013, De Troch et al. 2013, Reubens et al. 2011, 2013, 2014a, Vandendriessche et a. 2015). This can potentially lead to a higher predation pressure in the farm area as both seals and porpoises have been observed feeding around underwater structures (Clausen, et al. 2021, Russel et al. 2014), which would appear to be natural because predators follow their prey. The fish fauna is dynamic and there is a natural variation. For this reason, the number of fish will vary over time. It is notable that there are also species in the area that will not be affected by the presence of the wind turbine foundations. Studies have also been able to show only a slight increase in species of fish, which suggests that they congregate at foundations in the farm area to search for food or shelter (Bergstrom et al., 2013). There are no studies that suggest that large parts of stocks will congregate in the Triton wind farm to the extent that some increased predation pressure will affect stocks. In addition, the positive effect of reduced fishing in the farm area may provide additional protection for fish in the area.

Decommissioning phase

When the wind farm is decommissioned, all structures above the seabed will be dismantled. For subsea structures (parts of foundations and cables) and erosion protection, decommissioning measures will be decided in consultation with the supervisory authority closer to the time of decommissioning. The influence is considered to be of less importance in terms of noise and suspended materials compared to the construction phase.

The greatest impact that wind turbine decommissioning is likely to have on fish concerns the loss of habitat when the foundations are removed and the reef effect that is likely to occur around them disappears, when the area returns to the state that existed before the wind farm was built. Disassembly of the turbines can therefore lead to hard bottom species losing their habitat around the artificial reef (Smyth et al., 2015). There may therefore be reason to preserve the subsea structures for species of fish that have found habitats there.

Summary of effects

- The decommissioning of the wind farm is expected to have a limited effect on fish in terms of noise and suspended material.
- Potential removal of the foundations could mean that there would be a reverse reef effect in that species that have made them their home would lose their preferred habitats. However, it is a return to the situation before the wind farm was built.

Assessed impact

- The impact of decommissioning in terms of noise and suspended material is considered to be negligible.
- As far as the impact of the dismantling of the reef effect is concerned, it is negligible since dismantling means that the environment returns to the conditions that were present before the wind farm was built.

Table 37. Summarised assessment of the impact on fish during the decommissioning phase.

Influence factor	Sensitivity	Influence	Impact
Decommissioning noise	Small	Insignificant	Negligible
Decommissioning sedimentation	Small	Insignificant	Negligible
Reef effect on decommissioning	Small	Insignificant	Negligible

7.3.3 Mitigatory measures

Mitigatory measures will be deployed during construction of the Triton wind farm. Acoustic technologies, such as double bubble curtains and Hydro Sound Damper or equivalent methods to reduce the propagation of underwater noise from the work to an equivalent extent, will be used to minimise the area that can be affected by underwater noise. In addition, impact piling will begin with a so-called soft start-up, which begins with hammer strokes of about 10–15% of maximum strength, followed by ramp up, i.e. an increase in strength of the impact. This mitigatory measure reduces the influence on fish because the fish are given the opportunity to leave the area before full-strength piling begins, given that many species such as cod, herring and sprat can swim long distances in a short time (Pethon and Svedberg, 1998).

Fish can also be scared away before the foundation work begins, with noise that is not harmful but that disturbs that fish so that they swim away from the area (Swedish Environmental Protection Agency, 2008). One such technique is, for example, “FaunaGuard”, which researchers in the Netherlands have developed and which is used in wind farms in the North Sea and the Baltic to actively keep fish and porpoises away from areas in which construction is taking place (van der Meij et al., 2015).

7.3.4 Summary of transboundary impact

As can be seen from the study conducted for the project, the influence on fish during the construction phase is considered to be insignificant and the impact is negligible. During the operating phase, the influence is deemed to be slightly positive for substrate changes, with the remaining influence factors during the operating phase being considered insignificant and the impact negligible. As described above, wind turbines generally emit lower noise levels than ships in the same frequency range when operating. The wind turbines are thus deemed to have a negligible influence on fish.

Quite a lot of boat traffic will take place in the area during the construction phase, as well as during the operational phase as part of operation and maintenance of the wind turbines. As described above, boat traffic will be of minor importance in terms of the influence on fish. The farm is also surrounded by shipping lanes with a continuous presence of vessels that create a constant noise influence within the area.

As described above, subsea cables can generate magnetic fields. Magnetic fields have a limited influence on fish and the overall assessment is that the impact of magnetic fields from subsea cables is negligible.

The overall assessment for the Triton wind farm is that the impact on fish, assessed from various influence factors, during the construction phase are negligible to small, and during the operational phase negligible to moderately positive, depending on the influence factors and species During the decommissioning phase the impacts are expected to be negligible. The influence on fish is considered to be very local and is not deemed to lead to any transboundary impacts.

7.4 Marine mammals

Total impact assessment

The impact of the planned operations on marine mammals is expected to occur mainly during the construction phase from subsea noise during geophysical surveys and foundation installation. In addition to this, there may be influence from displacement and sediment spread.

Mitigatory measures will be used during seismic surveys. Passive acoustic surveillance and observers will also be used to ensure that porpoises are not in the vicinity of the vessel when conducting surveys with seismic equipment. In view of the very short duration of the investigations (single days), the overall influence on marine mammals is deemed to be negligible to small, with no impact on the short- or long-term conservation status of populations.

Mitigatory measures will be applied during piling to minimise the impact of the wind farm on marine mammals. As the Triton wind farm is located in an area of low importance for porpoises, the overall assessment of avoidance behaviour of porpoises caused by underwater noise from impact piling is small for the Danish Straits population all year round. For the Baltic Sea population, the influence on the Baltic population is expected to be small and negligible during the summer, as they are not expected to be in the south-west part of the Baltic Sea during the summer. Porpoises are expected to avoid the site during piling work and return after a few days to weeks after completion of the piling.

During the operational phase of the planned operations, the impact on marine mammals is estimated to be insignificant to small. During the decommissioning phase of the planned operations, the overall impact on marine mammals is also estimated to be insignificant to small.

The overall impact on porpoises, common seals and grey seals is deemed to be negligible to small and without impact on the status of populations in either the short or the long term.

The transboundary impact is assessed to be the same same as in Swedish waters because the populations concerned move between countries. This also applies to the Natura 2000 sites of these countries. When using the proposed mitigatory measures, piling will provide a temporary and reversible effect for a short period of time, with a limited number of porpoises exposed to it. The impact is considered to be small without the risk of impact on population levels either in the short or long term or influence on the maintenance of the conservation

The section describes the presence and assesses influence and impact of activity on marine mammals and summarises reference report R.4.a "Marine mammals and offshore wind farms in the Southwestern Baltic*".*

7.4.1 Preconditions

Three species of marine mammals are considered to be present in the wind farm and the impact upon them has, therefore, been assessed. The species are porpoises (*Phocoena phocoena)*, common seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*).

Porpoises

Porpoises are a small toothed whale that is protected under the EU's Species and Habitat Directive (Appendix 2 and 4). The protection involves, among other things, achieving or maintaining favourable conservation status for the species. In the SLU Species Information Centre National Red List (2020), the common porpoise as a species is classified as viable (LC), with the exception of the Baltic Sea population that is classified as critically endangered (CR).

There are three genetically distinct populations in Swedish waters – the North Sea (or Skagerrak) population that is primarily found from Mid-Kattegat to Skagerrak, the Danish Straits population that is found from the Mid-Kattegat to the Southwest Baltic, east of Bornholm and the Baltic population that mainly resides in the Baltic Sea, see Figure 33 (Benke et al., 2014). The Triton wind farm is located in a transitional area where porpoises from primarily the Danish Straits population, but also the endangered Baltic population can be present (Figure 33). The Danish Straits population has a favourable conservation status and consists of about 42,000 animals, while the Baltic population is estimated to be about 500 animals and has a non-favourable conservation status (Species Information Centre, 2020). The porpoises mate in August and calve during June-July, then suckle the calf for eight to ten months (Börjesson and Read, 2003; Lockyer and Kinze, 2003). Porpoises usually live alone or in small groups that may consist of some females and their calves or a small group of males.

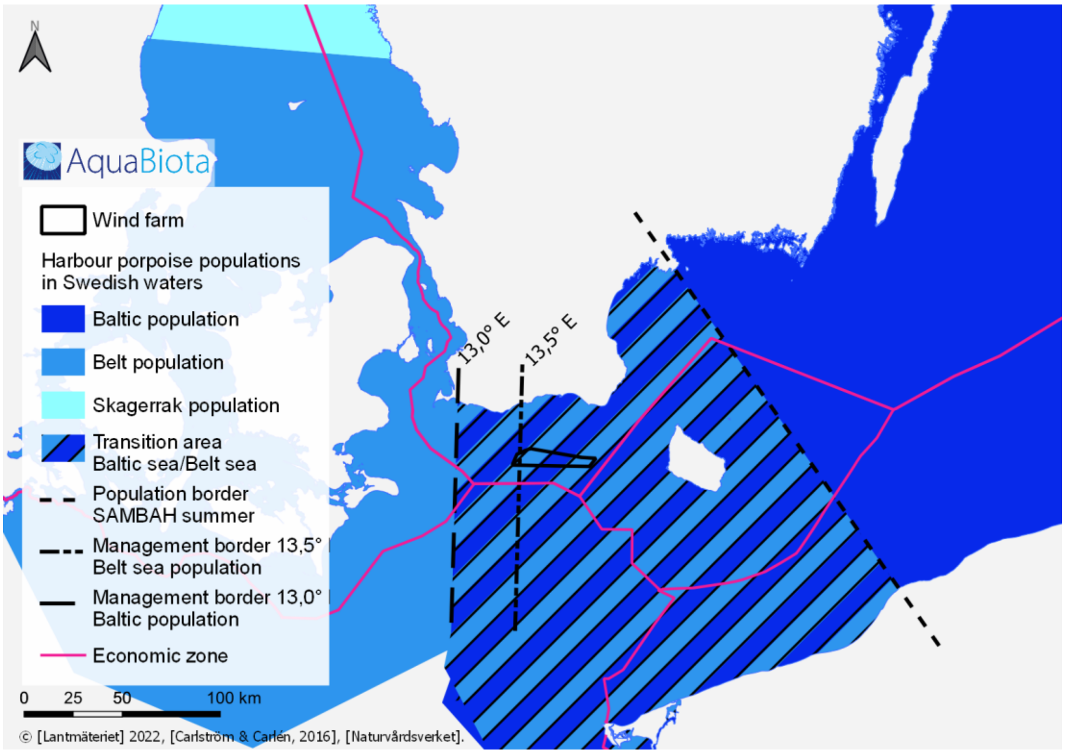


Figure 33. Porpoise populations in Swedish waters (Carlström och Carlén, 2016).

Porpoises from the Danish Straits population can be found in the southwest Skåne offshore waters, primarily during the summer and early autumn. Single individuals from the Baltic population may also be present during November to April when the Baltic population spreads over large parts of the Sea. During the summer, the Baltic population is further east around the offshore banks at Hoburgs bank and Midsjöbankarna, (Sveegaard et al., 2018; SAMBAH, 2016). A number of important areas for porpoises have been identified, some of which coincide with the Natura 2000 site, Figure 34 (Carlstrom and Carlén, 2016).

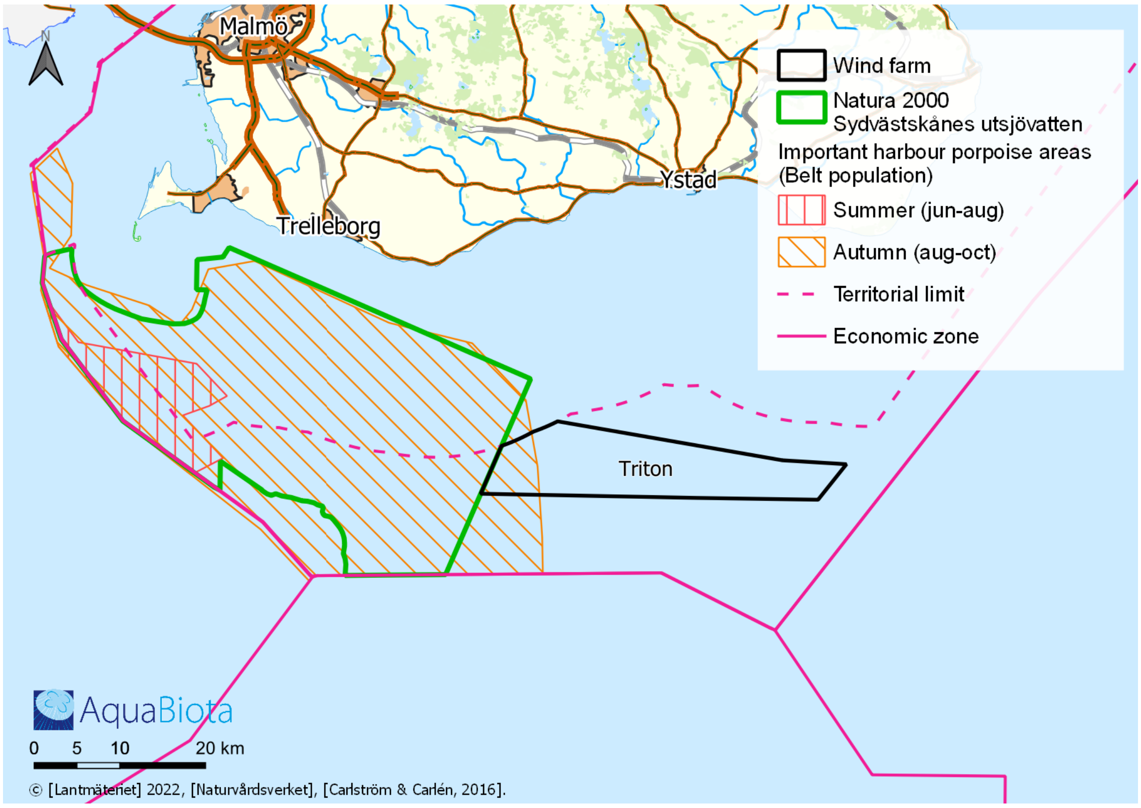


Figure 34. Important areas for porpoises in the areas bordering on Triton, per season (Carlsson and Carlén, 2016).

Multiple studies show that porpoises are unevenly distributed in coastal waters (Hammond, et al., 2002; Hammond, et al., 2013; Hammond, et al., 2017; Viquerat, et al., 2013). A new study by Aarhus University has surveyed important habitats for porpoises in waters off the Skåne region (including the Triton wind farm area). The survey is based on 111 porpoises from the Danish Strait Population tagged with Argos satellite transmitters between 1997 and 2021. The study supports the low densities of porpoises in the Western Baltic (where Triton is located) as do the SCANS counts.

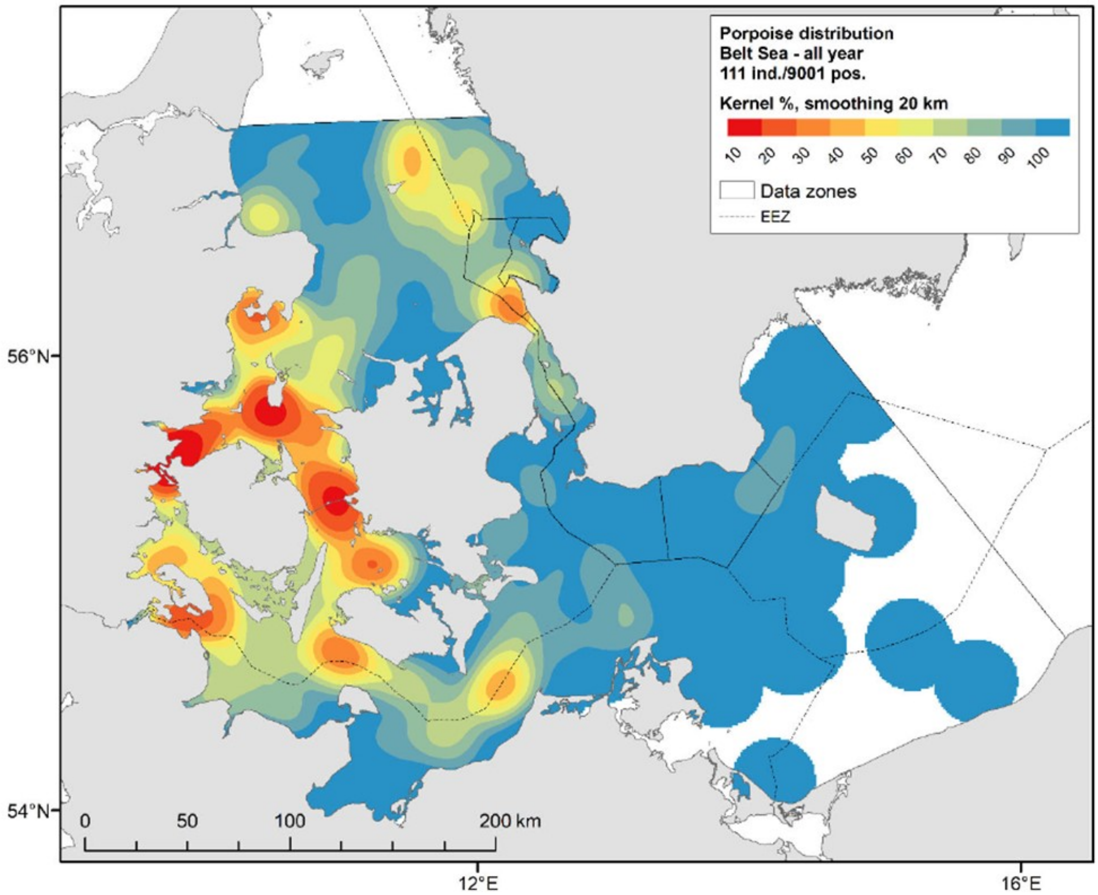


Figure 35. The spread of 111 porpoises tagged with satellite transmitters in the Danish Straits and the southwestern Baltic Sea analysed by the Kernel densities throughout the year, the redder the areas, the higher the densities of porpoises (Teilmann et al. 2022).

As shown in Figure 35, the highest concentrations of porpoises are found north of Öresund and in Danish near-coastal waters. The area south of Skåne is used more often during the summer and autumn, when only the Danish Strait population can be found in the area, than during the winter and spring. In the winter, Skåne's waters are generally of the least importance for the tagged porpoises from the Danish Straits population (Teilmann et al., 2022).

F-Pods were placed[29] on behalf of the project in Triton's farm area during the summer of 2021 (see Figure 36). To allow comparison with prior studies, a scaling factor was then used to standardise F-Pod data to match C-Pod[30] data. The data from the survey support the observations from SAMBAH[31], that is that porpoises are present in the area during summer and early autumn, but with relatively few detections compared to, for example, Kattegat. In June and August 2021, samples and surveys were also conducted of porpoises at the wind farm site using environmental DNA (eDNA) (R.13). Presence of porpoises was only detected in 2.5% of all samples. In a corresponding study in the Kattegat (Birgersson et al., 2021), porpoises were detected in 66% of the samples. Based on the latest studies of the presence of porpoises, it is

29 Passive acoustic device that detects and records the click sounds of the porpoise's echo location. The detections are analysed to evaluate the presence and activity of porpoises.

30 Passive acoustic device that detects and records the click sounds of the porpoise's echo location. The detections are analysed to evaluate the presence and activity of porpoises. Predecessor to F-pods.

31 Static Acoustic Monitoring of the Baltic Sea Harbour Porpoise. International project to preserve the population of the Baltic Sea harbour porpoises.

estimated that the wind farm area (and its vicinity) is of low importance to porpoises (both porpoises from the Danish Straits and the Baltic Sea populations) (R.4.a).

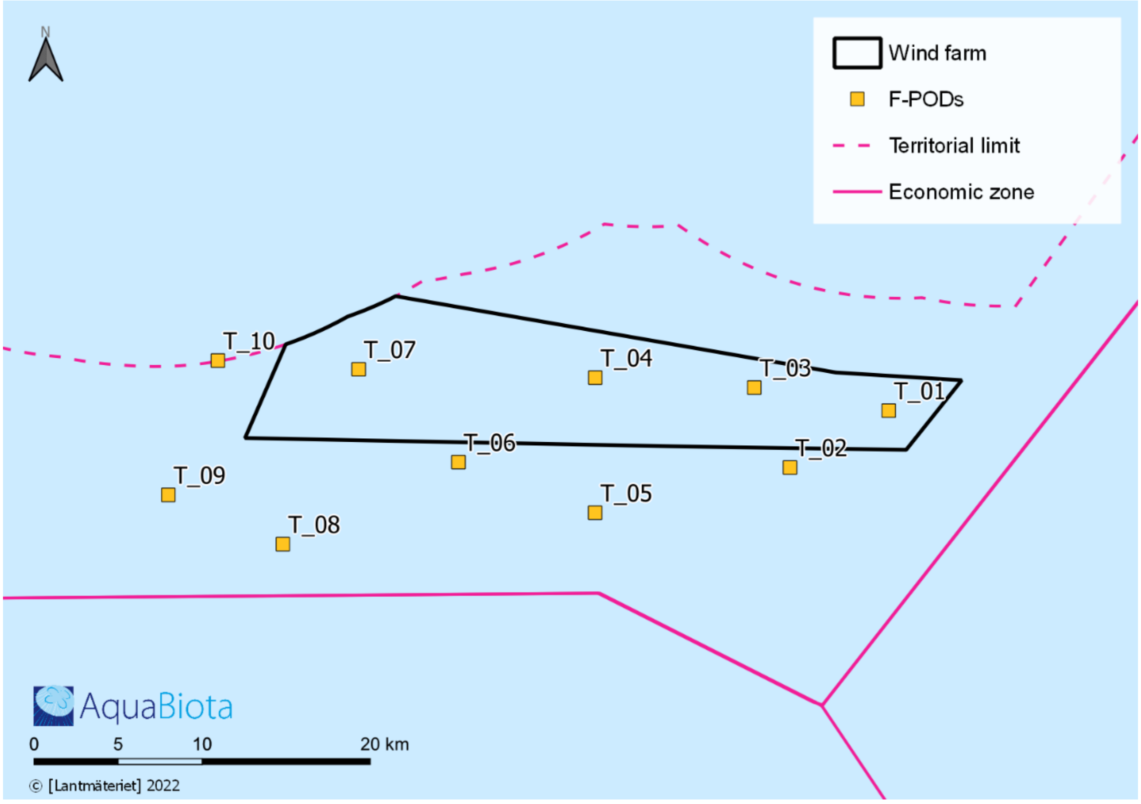


Figure 36. Positioning of F-pods within and near the wind farm area.

Grey seal and common seal

Both of the species, grey seals and common seals, are protected under the EU's Species and Habitat Directive (Appendix 2 and 5). In the SLU Species Information Centre National Red List (2020), the common seals as a species is classified as viable (LC), with the exception of the Kalmarsund population that is classified as vulnerable (VU). In the SLU Species Information Centre Red List (2020) the grey seal is classified as viable (LC). Grey seals and common seals feed mainly in shallow areas with depths down to 40 metres (Tollit et al. 1998; Sjöberg and Ball, 2000). The nature reserve called Måkläppen is about 50 kilometres north-west of Triton. The nature reserve consists of a long sand shoal situated just south of the Falsterbo Peninsula and is an important basking site for both grey seals and common seals. During the preparatory work for the EIA for Krieger's Flak offshore wind farm in Danish waters, seals (both common seals and grey seals) were fitted with GSM transmitters (Dietz et al., 2015). A total of ten common seals and eleven grey seals were fitted with satellite transmitters at Måkläppen during the period 2012-2013 and 2009-2013. Figure 37 and Figure 39 show the patterns of movement of the ten common seals and eleven grey seals respectively and their estimated habitat for the whole year. GPS data showed that one of the common seals and grey seals swam into the Triton wind farm area. GPS data shows that the area is not important for seals, as also evidenced by the eDNA surveys conducted as part of the Triton wind farm studies in June 2021 (R.13). Grey seals were detected in one of 20 samples in June and none of 20 samples in August while no detection was made of the common seal in the eDNA sampling. It is expected that the site of the Triton project will contain common seals and grey seals, but the site is considered to be of low/moderate importance for common seals and grey seal since neither of the species appear to use the site as a particular foraging area, as demonstrated in the eDNA counting (R13).

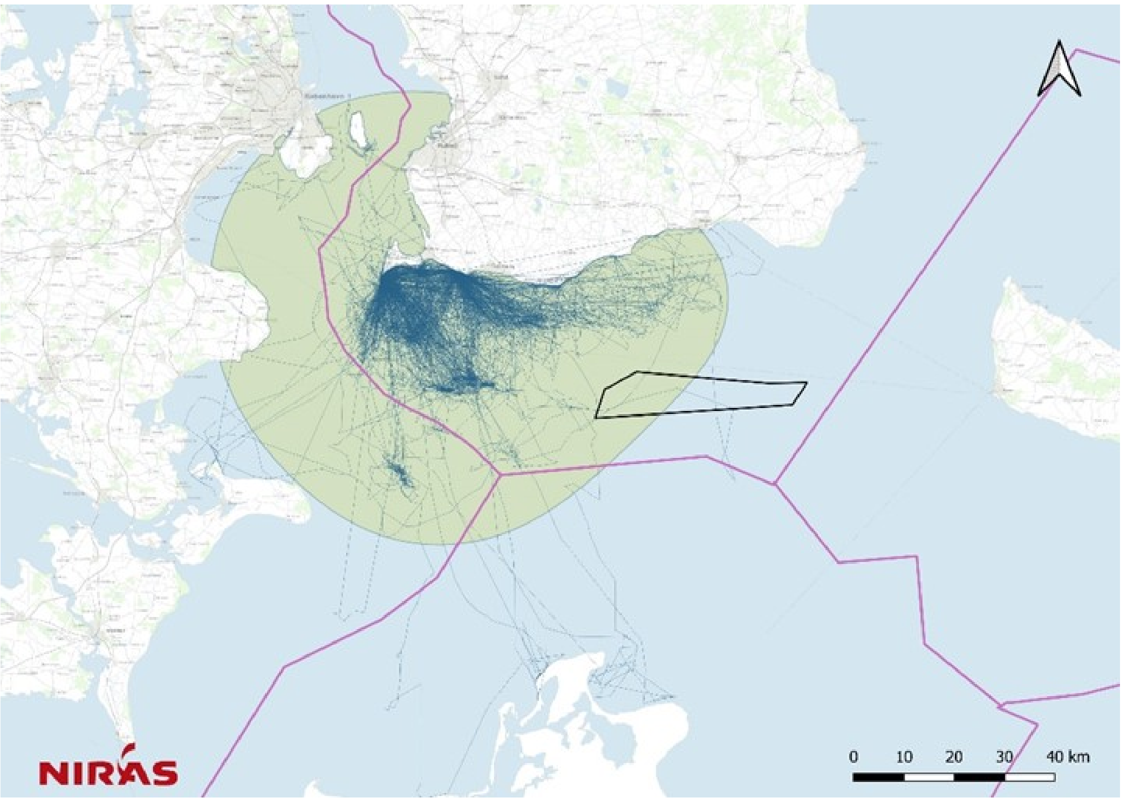


Figure 37. Movement patterns (blue lines) from ten common seals fitted with GPS transmitters at Måkläppen, Sweden in connection with the preparation of the EIA for Kriegers Flak OWF in Danish waters. The green area is the estimated core area (95%) based on the motion pattern of the common seal. Modified after Dietz et al. (2015). GPS data was collected by DCE, Aarhus University. © SDFE

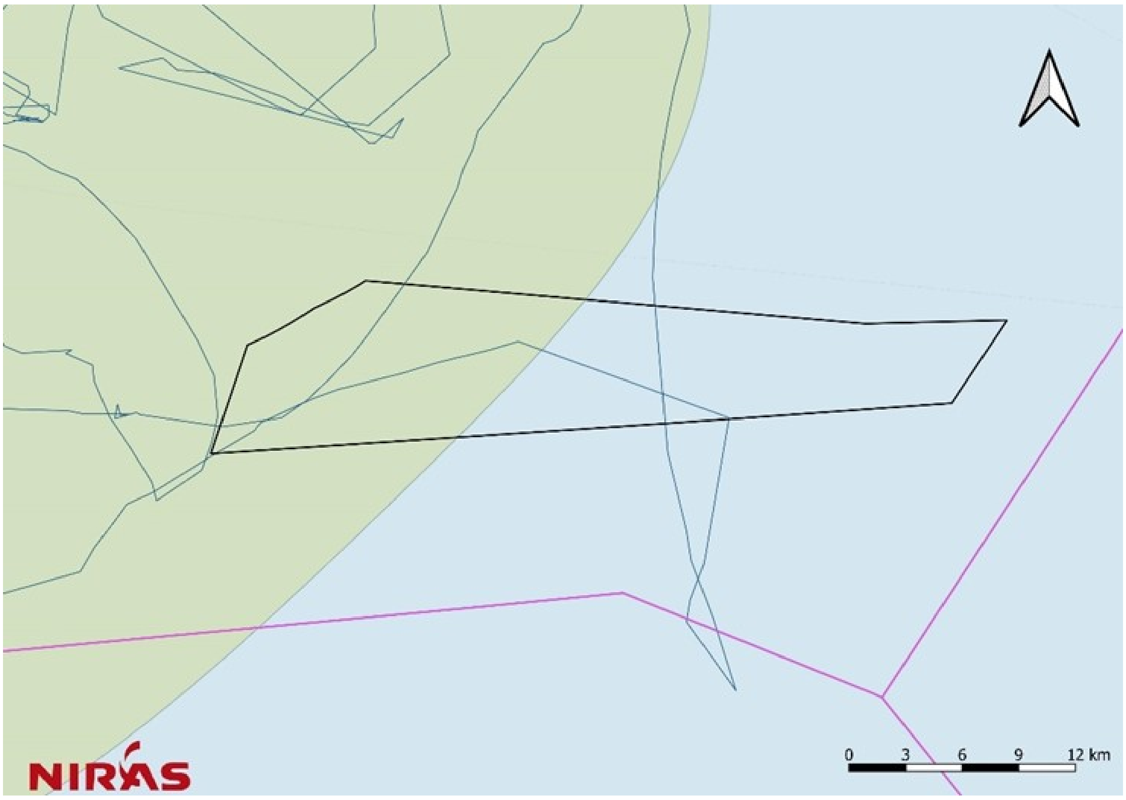


Figure 38. The movement pattern of the common seal that swam in the Triton wind farm area. Common seals fitted with GPS transmitters at Måkläppen, Sweden in connection with the preparation of the EIA for Kriegers Flak OWF in Danish waters. The green area is the estimated core area (95%) based on the motion pattern of the common seal. Modified after Dietz et al. (2015). GPS data was collected by DCE, Aarhus University. © SDFE

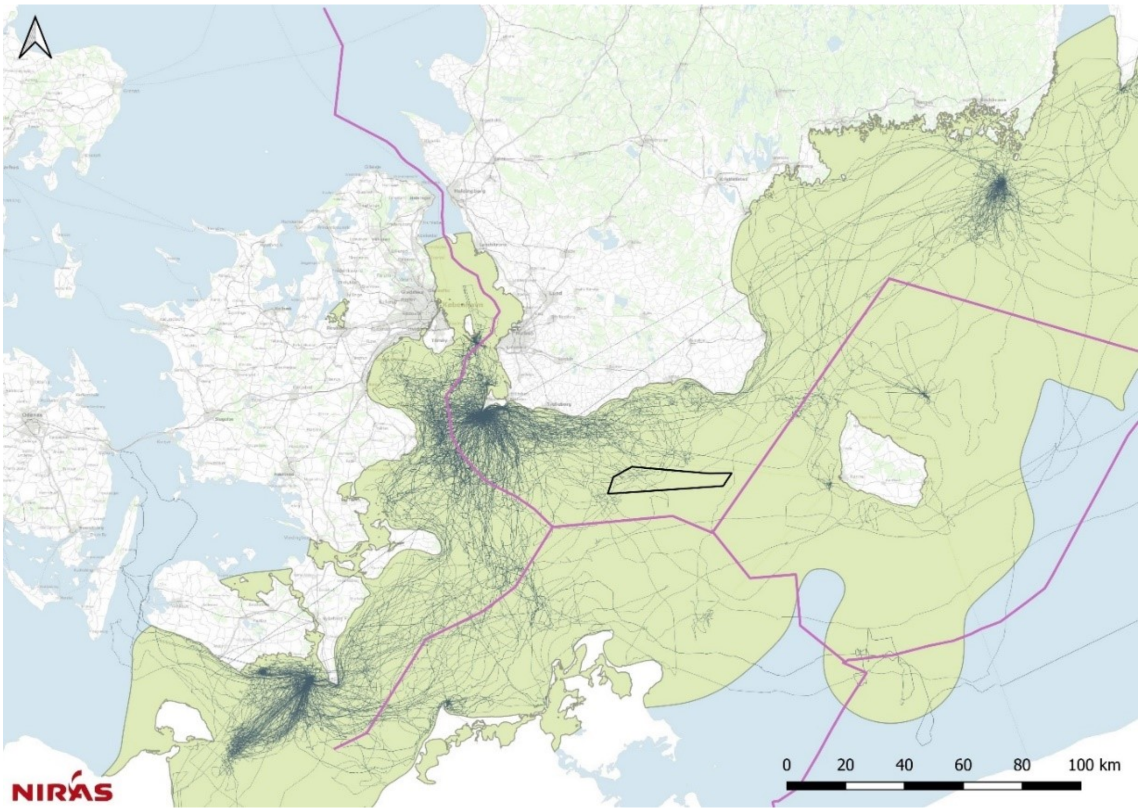


Figure 39. Movement patterns (blue lines) from eleven grey seal fitted with GPS transmitters at Måkläppen, Sweden in connection with the preparation of the EIA for Kriegers Flak OWF in Danish waters. The green area is the estimated core area (95%) based on the motion pattern of the common grey seal. Modified after Dietz et al. (2015). GPS data was collected by DCE, Aarhus University. © SDFE

Figure 40. The movement pattern of the grey seals that swam in the Triton wind farm area. Grey seals fitted with GPS transmitters at Måkläppen, Sweden in connection with the preparation of the EIA for Kriegers Flak OWF in Danish waters. Modified after Dietz et al. (2015). GPS data was collected by DCE, Aarhus University. © SDFE

7.4.2 Impacts

This section describes the identified effects and impacts on marine mammals. The following influence factors during construction, operations and decommissioning have been identified (see Chapter 6 for more details).

Table 38. Estimated influence factors during the wind farm's construction, operational and decommissioning phases.

Influence factor	Activity	Construction	Operation	Decommissioning
Underwater noise	Wind farm	x	x	x
Sediment spread*	Wind park + inter-array	x		x
Airborne noise	Wind farm	x	x	x
Electromagnetic fields	The inter-array cabling		x	
Reef effect	Wind farm		x	

*Includes suspended material and sedimentation.

Construction phase:

The main risk of impact on marine mammals during the construction phase is underwater noise from geophysical surveys and impact piling for foundations, which may result in loud and/or impulse sounds that especially porpoises are sensitive to . During the construction phase, the influence can also come through sediment spread caused by foundation installation and drilling.

Underwater noise

Impact assessments assume the use of mitigatory measures, see below and for more details see section 7.4.3.

Studies

When geophysical studies are conducted, mitigatory measures will be taken to avoid any influence on marine mammals. When scanning with sonar and echo-location devices, the equipment operates at frequencies above 200 kHz, which is outside porpoises' hearing range. Porpoises have good hearing at frequencies from 10 kHz to 140 kHz, but they are most sensitive in the range of 90 kHz to 140 kHz with a hearing threshold of approximately 40 dB to 60 dB re 1 µPa (Kastelein et al, 2002). A harbour porpoise can also hear sounds with frequencies below ten kHz but with decreasing sensitivity to lower frequencies. Above 140 kHz, sensitivity decreases as opposed to higher frequencies.

In order to investigate the influence of seismic studies on porpoises, OX2 has performed site-specific underwater sound modelling (R.22). Modelling of sound propagation for different equipment scenarios and distance for limit values for avoidance behaviour, TTS and PTS have been calculated for different positions. For TTS and PTS, modelling has been performed for a representative 24 hour study period. The modelling also includes new scientific data from actual seismic surveys in the North Sea, where underwater noise has been measured and examined in detail (Pace et al., 2021).

The sound modelling has been based on three different equipment scenarios where scenario 1 corresponds to studies with the equipment Innomar, Sparker and Mini G airgun whose use is planned in the wind farm area. However, there may be some areas within the wind farm area that do not need to be investigated with the Sparker devices, which is equipment scenario 2.

Equipment scenario 3 refers to the part of the survey area that consists of cable corridors and possibly certain areas within the wind farm, see Table 39.

Table 39. Equipment scenarios for geophysical studies used in modelling.

Equipment scenario		Equipment	Equipment model
1		Innomar (SBP)	Innomar SES-2000 Medium 100
		Sparker (SBP)	GeoSource 200–400
		Mini G airgun	Sercel Mini G 60 Cu. Inch
2		Innomar (SBP)	Innomar SES-2000 Medium 100
		Mini G airgun	Sercel Mini G 60 Cu. Inch
3		Innomar (SBP)	Innomar SES-2000 Medium 100

The greatest sound propagation in the water occurs during March and the modelling is therefore performed for that month (worst-case scenario). The models are based on three representative positions within the wind farm. The seabed topography in the entire wind farm is relatively flat and the bottoms have a similar sediment composition (mainly clay) so that the selected positions within the wind farm are expected to represent the area well.

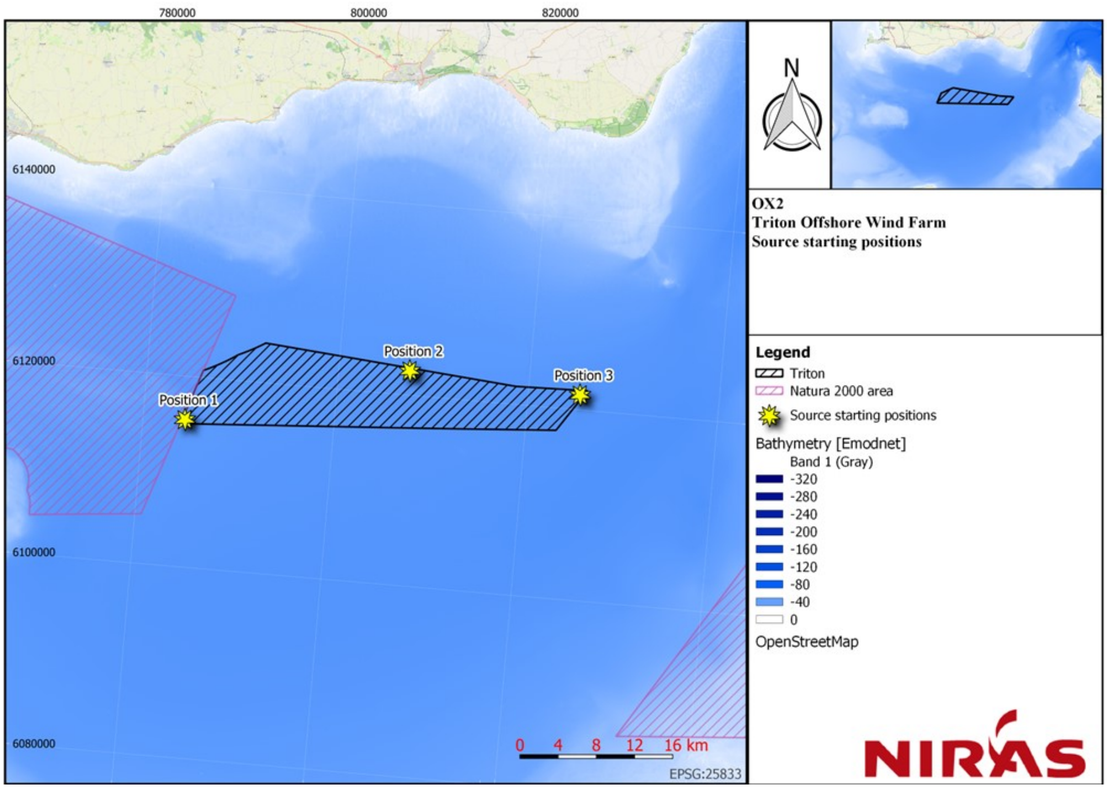


Figure 41. Source positions (yellow stars) selected for underwater sound modelling in the wind farm.

The results of the modelling of underwater noise from the geophysical surveys are summarised in Table 40, and are presented in detail in Annex B.1. The results correspond to the minimum distance the individual must keep to the survey vessel at the start of the survey at full power in order to avoid the respective influences. A range of the distance of influence is specified for TTS that represents the dependence of the porpoise's position with regard to the survey vessel, where the minimum distance represents a porpoise behind or perpendicular to the vessel, while the maximum distance represents a porpoise in front of the vessel.

Table 40. Distance to limit value for seismic surveys in the Triton wind farm for three equipment scenarios. Distance to limit values for PTS and TTS show the distance, in metres, that an individual must be from the survey vessel at least at the start of the survey at full strength to avoid the stated influence. The results represent the month of March for different positions within the region of interest and are considered to be a "worst-case scenario". The modelling is done without conservation measures (Annex B.1) with weighted limit values for the harbour porpoise (VHF) and seals (PCW).

Scenario	**Position**	**Distance to limit value (m)**				
		Porpoises			Seals	
		Avoidance behaviour $L_{p,rms,125ms} = 103\ dB$*	TTS $L_{E,cum,24h} = 140\ dB$	PTS $L_{E,cum,24h} = 155\ dB$	TTS $L_{E,cum,24h} = 170\ dB$	PTS $L_{E,cum,24h} = 185\ dB$
1: Sparker (SBP)/Mini G air gun/ Innomar (SBP)	1	1800	375-950	< 50	< 50	< 25
	2	1550	250-625	< 50	< 50	< 25
	3	1850	275-675	< 25	< 50	< 25
2: Mini air gun/Innomar (SBP)	1	1600	350-900	< 25	< 50	< 25
	2	1350	250-600	< 50	< 50	< 25
	3	1350	250-625	< 25	< 50	< 25
3: Innomar (SBP)	1	1600	375-925	< 50	< 50	< 25
	2	1350	250-650	< 50	< 50	< 25
	3	1350	275-650	< 25	< 50	< 25

* The latest literature from Tougaard (2021) suggests a limit value of 103 dB, instead of the more conservative and previously used 100 dB.

Porpoises

In scenario 1, the worst-case scenario (Innomar, Sparker and airgun), porpoises can demonstrate avoidance behaviour within 1,850 metres of the survey vessel (threshold 103 dB) Table 40. Conservatively calculated (with equal influence in a circle around the survey vessel), this corresponds to an area of about 10.2 km^2 around the survey vessel. For porpoises, it is unlikely that PTS can occur if the porpoise is at a distance of more than <50 metres from the survey vessels, at the start of the seismic surveys at full power, while for TTS the distance is 950 metres.

The distance to the limit value for avoidance behaviour of the porpoises $L_{p,rms,125ms,VHF} = 103\ dB\ re\ 1\ \mu Pa$ for the various sources of noise at position 1 and at position 3 respectively in the wind farm is illustrated Figure 42 respectively Figure 43. Sparker (SBP) is the sound source that makes the largest contribution to the propagation of sound, which corresponds to the results in Table 40 where the distance to the limit is longer for scenario 1 than for scenarios 2 and 3. As can be seen in the figures below, behavioural influences are carried out in close connection with the source and the area of influence is within Sweden's territorial borders.

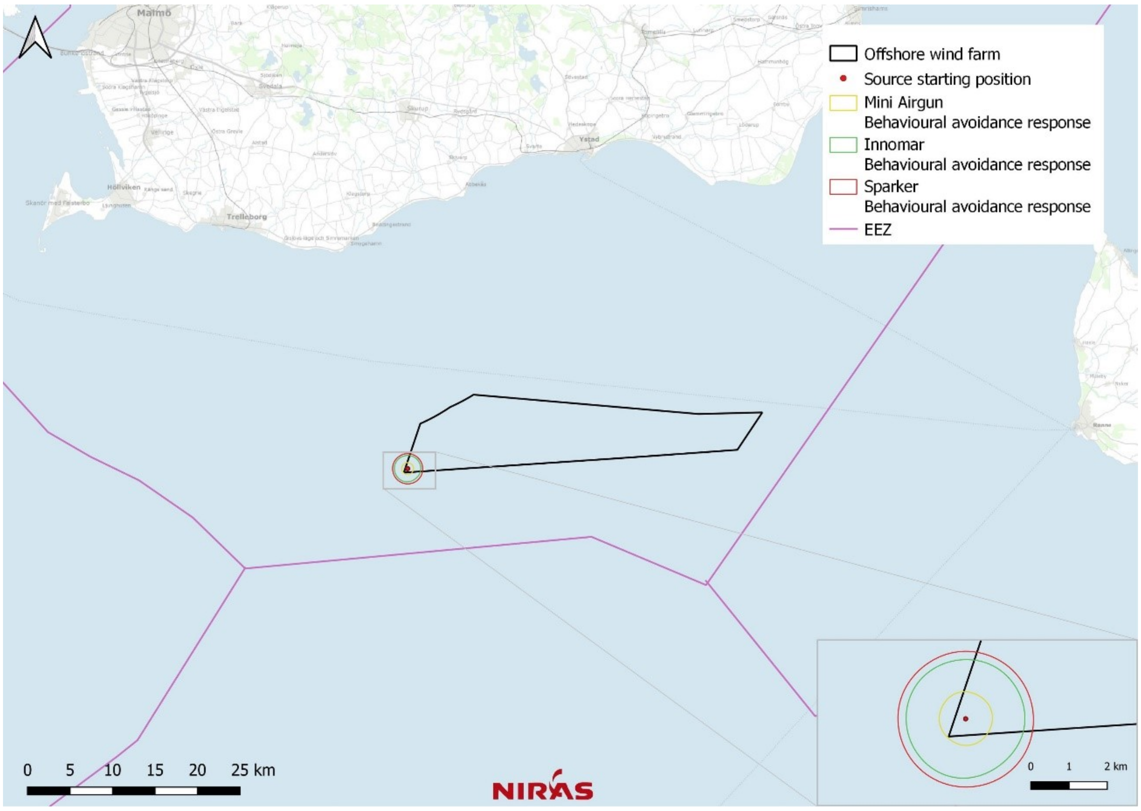


Figure 42. Sound propagation to the limit value for avoidance behaviour of porpoises (103 dB) with Innomar (SBP), Sparker (SBP) and Mini Airgun devices at the west end of the wind farm (position 1).

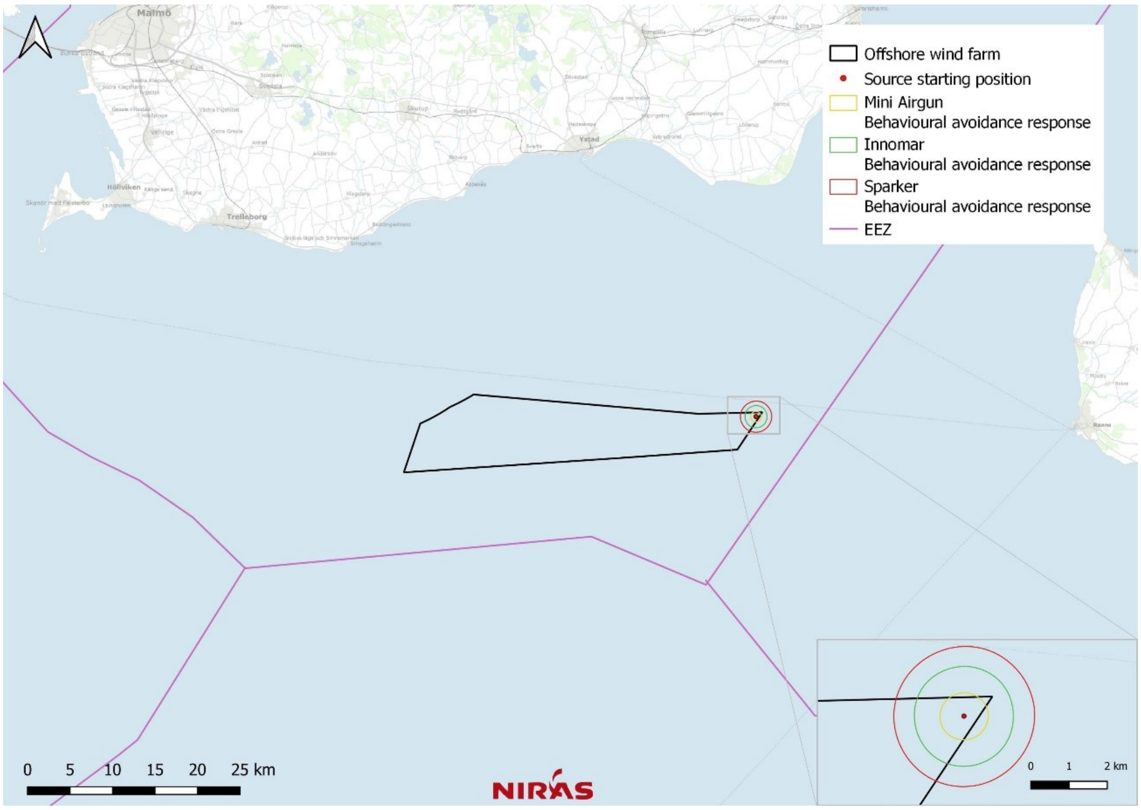


Figure 43. Sound propagation to the limit value for avoidance behaviour of porpoises (103 dB) with Innomar (SBP), Sparker (SBP) and Mini Airgun devices at the eastern end of the wind farm (position 3).

Mitigatory measures, such as soft start-up, minimise the risks of TTS and PTS in marine mammals. Soft start-up may include a period of slow increase in energy and/or fire rate, giving individuals time to swim out to a safe distance before operations begin at full strength. As an example, a 30-minute soft start-up can allow an individual swimming at a speed of 1.5 m/s to reach a distance of 2.7 kilometres before the devices are operated at full power, which will therefore be outside the effective range for TTS and PTS. If seismic surveys are temporarily interrupted, the equipment should be restarted with a period of soft start-up. Placing observers on board the survey vessel may further reduce the risk of individuals being in the vicinity of the vessel at the start of the surveys. Porpoises are particularly sensitive to the impulsed underwater sounds that seismic equipment can generate and their sensitivity to hearing loss is high for PTS and moderate for TTS. When soft start-up is used it is unlikely that porpoises will experience hearing loss and the risk of TTS and PTS is therefore negligible.

Thus, the mitigatory measures that will be applied to the geophysical surveys with seismic equipment are the use of passive acoustic monitoring and observers and the initiation of surveys with a soft start-up period of 30 minutes to minimise porpoises' and seals' risk of hearing disturbance (TTS and PTS), after which the strength of the devices can gradually be stepped up to full strength (ramp-up). Soft start-up must be performed even if the work is interrupted.

In addition to the limited range of influence, it is important to consider that the survey vessel will be under way throughout the survey period. The area of influence therefore moves with the movements of the vessel. Therefore, porpoises and seals will very temporarily avoid the immediate vicinity of the seismic surveys. They are expected to return to the area as soon as the survey vessel has passed. This means a very short and rapid transitory influence in the form of individuals temporarily avoiding a certain area and they will not be exposed to harmful sound levels that pose a risk of TTS or PTS. The surveys are expected to last approximately 60 days.

The survey area for the Triton wind farm is situated on the edge of the respective range of porpoise populations and is not an important reproduction area for either the Danish Straits population or the Baltic Sea population (Carlén et al., 2018, Teilmann et al., 2022). The density of porpoises in the area is low, especially when compared with the densities west of the wind farm toward the Danish waters inhabited by the Danish Straits population. The probability of presence of porpoises in the Triton area is thus low. It is expected that most of the porpoises in the Triton survey area are among the favourable Danish Straits population, although it cannot be ruled out that single porpoises from the Baltic Sea population may be present in the region during the winter.

With the proposed mitigatory measures, porpoise sensitivity is considered to be moderate for the Baltic Sea population and small for the Danish Straits population. The size and extent of the influence are considered to be slightly negative since the influence distance is short and the time period for the surveys is relatively limited. The low density of porpoises in the area makes the risk of influence low. The impact for the Baltic Sea and Danish Straits populations are therefore deemed to be small. The seismic surveys are also assessed not to affect the conservation status of the porpoises, either in the short or long term, and also to be without risk of injury or disturbance of significance at the individual level. Porpoises are expected to return once the survey vessel has passed.

Seals

There are no studies that have investigated how and at what distances seals react to underwater sounds from seismic surveys. Conservatively calculated, the same distance of influence as for porpoises can be used, however, note that seals are generally less sensitive than porpoises and have higher limit values for TTS and PTS.

The modelled distances of influence for the different equipment scenarios are shown in Table 40. The results show that for seals there is a low risk of permanent hearing loss (PTS) within 25 metres of the survey vessel, while for TTS the distance to the limit is 50 metres when the equipment is operating at full strength without mitigatory measures. Due to the very short distance of influence, the risk of seal hearing loss (TTS or PTS) is almost non-existent.

Both common seals and grey seals may be present in the study area. Seals, unlike porpoises, can actively reduce the impact of underwater noise by keeping their head above the water. Soft start-up and gradual increase of power of the seismic equipment gives the seal time to leave the area before the devices run at full power.

It is 50 kilometres from the Triton wind farm to the nearest known location for common seals and grey seals at Måkläppen. The sensitivity of seals to the seismic surveys is deemed to be low. With proposed mitigatory measures, the size and extent of the influence is considered to be slightly negative as seals are expected to avoid the local area for the investigations on a temporary basis. However, the spread of influence is very limited because the influence distances for seals are relatively short (less than 25 metres for PTS and less than 50 metres for TTS) and the duration of the survey is short-term. The overall assessment is therefore that the influence is considered to be very small for both common seals and grey seals without any impact on the populations either in the short or long term. Both common seals and grey seals are expected to return once the survey vessel has passed.

As the sound of drilling and other geotechnical studies is low frequency, they are expected to have a limited impact on marine mammals. The sound of drilling is similar to the sound of cargo vessels, which are common in the area.

Installation

During installation of the wind farm, underwater noise affecting marine mammals can arise from the construction of the various components in the wind farm, mainly during installation of foundations for wind turbines, substations and platforms. Underwater noise can also come from ship traffic. However, the wind farm lies between two major shipping lanes and in an area of intensive shipping, where the numbers of installation vessels will be very small in relation to other traffic, the influence on marine mammals is therefore considered to be small/limited. As marine mammals are particularly sensitive to severe sudden sounds, impact piling is the activity that can primarily affect marine mammals.

The propagation of underwater noise during installation of foundations by piling has been modelled (R.11.C). The noise propagation models have been based on a worst-case scenario in sound propagation, using monopiles (14 metres in diameter), based on four different positions in the wind farm during the time of year when the sound propagation is greatest (during the month of March). The modelling of the distance of influence of underwater noise during piling has been made for two cases. In the first case, it has been assumed that sound-damping measures will be used with a reduction in sound equivalent to the use of a single big bubble curtain (BBC) (the sound-damping measures used are described in Chapter 10. In addition to the modelling of underwater noise with sound-damping measures equivalent to a single big bubble curtain (BBC), underwater noise with silencing measures equivalent to a double big bubble curtain combined with a Hydro Sound Damper (DBBC+HSD) has been modelled, as discussed below. Both cases have also assumed use of a soft start-up and ramp-up process, in which the intensity of the hammer's energy gradually increases.

Based on the modelling, the distance of influence for avoidance behaviour, temporary hearing loss (TTS) and permanent hearing loss (PTS) has been calculated (for limit values, see section 6.1). Noise levels at which hearing influences or behavioural influences may occur differ between porpoises and seals (both grey seals and common seals).

Porpoises

The results of the modelling of sound exposure levels (SEL) for porpoises are shown in Figure 44. There is no risk that porpoises will be exposed to noise levels involving PTS if the mitigatory measures included in the modelling are taken (single bubble curtain or equivalent, soft start-up and double bubble curtain, Hydro Sound Damper or equivalent, and soft start-up). Sound levels within the limit of temporary hearing loss can occur in a worst-case scenario during impact piling in a very limited area within the wind farm, only directly adjacent to the installation site. It is unlikely that marine mammals will be exposed to levels beyond the TTS when the propagation of sound beyond the TTS limit occurs only within 300 metres of the sound source when using a BBC, and because porpoises will have been encountered by a margin beyond this distance due to the movements of the vessel; the acoustic methods and the use of soft start-up. Avoidance behaviour by porpoises will occur within parts of the wind farm, see Table 41, Table 42 and Table 43.

Table 41. The result of modelled underwater noise for porpoises, worst-case scenario. Assuming single bubble curtain and soft start-up. Influence distance where PTS, TTS and avoidance behaviour can occur for porpoises.

	Influence	**Distance of influence**
Porpoises	PTS	<25 metres
	TTS	300 metres
	Avoidance behaviour	11.6 kilometres

Table 42. The result of modelled underwater noise for porpoises, worst case scenario. Assuming double bubble curtain, Hydro Sound Damper and soft start-up. Influence distance where PTS, TTS and avoidance behaviour can occur for porpoises.

	Influence	**Distance of influence**
Porpoises	PTS	<25 metres
	TTS	<50 metres
	Avoidance behaviour	6.7 kilometres

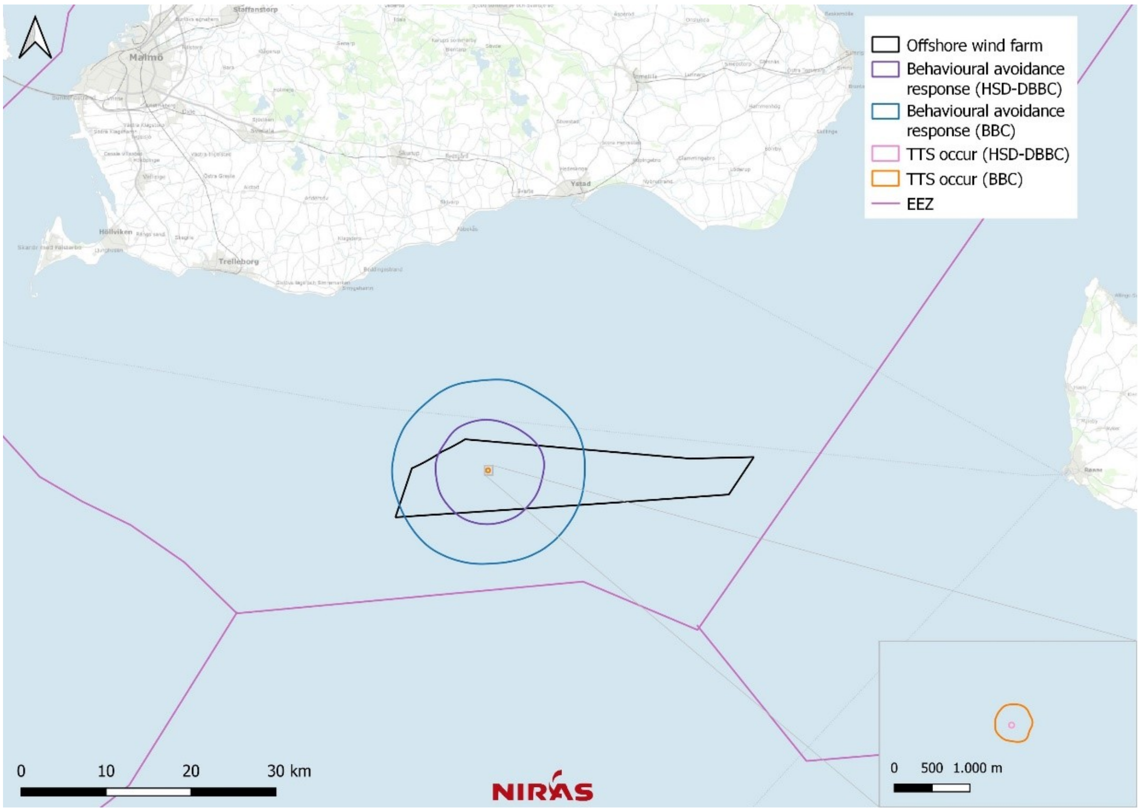


Figure 44. The result of modelled underwater noise for porpoises during piling in the area in, worst-case scenario. Orange and pink rings show the area where TTS occurs with single and double bubble curtain and Hydro Sound Damper. The blue ring (approximately 23 kilometres in diameter) and the purple ring (approximately 13 kilometres in diameter) indicate the area in which behavioural influence can occur with single and double bubble curtain and Hydro Sound Damper, (R.4.a). (Source: Lantmäteriet (the Swedish mapping, cadastral and land registration authority)

Modelling of sound exposure levels (SEL) for a worst-case scenario for transboundary impacts has also been conducted and can be seen in Figure 45 and Figure 46. In the western part of the area, it can be seen that the area in which behavioural influences can occur with a single bubble curtain reaches right to the border of the German EEZ. In the eastern part of the area it is seen that the area in which behavioural influences can occur with a single bubble curtain reaches the Danish economic zone and that areas within which behavioural influences can occur with a double bubble curtain and Hydro Sound Damper reach just the border of the Danish economic zone.

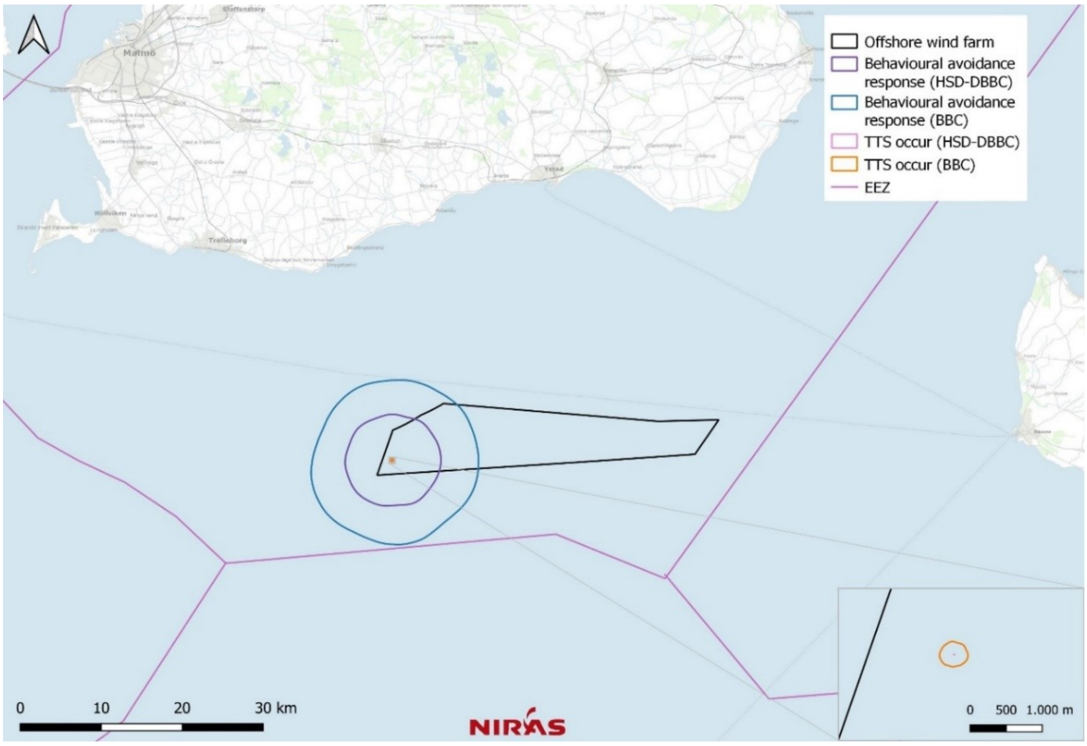


Figure 45. The result of modelled underwater noise for porpoises during piling in the area, worst-case scenario in the western part of the project. Orange and pink rings show the area where TTS occurs with single and double bubble curtain and Hydro Sound Damper. The blue ring (approximately 23 kilometres in diameter) and the purple ring (approximately 13 kilometres in diameter) indicate the area in which behavioural influence can occur with single and double bubble curtain and Hydro Sound Damper. (Source: Lantmäteriet (the Swedish mapping, cadastral and land registration authority)

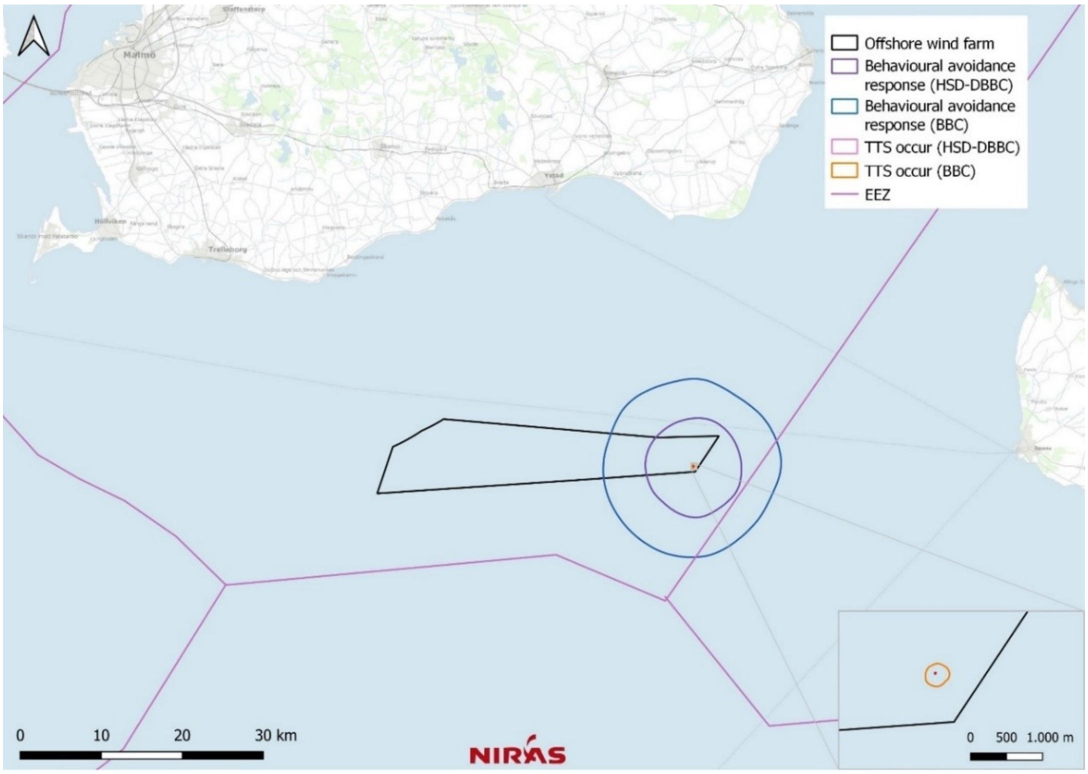


Figure 46. The result of modelled underwater noise for porpoises during piling in the area, worst-case scenario in the eastern part of the wind farm area. Orange and pink rings show the area where TTS occurs with single and double bubble curtain and Hydro Sound Damper. The blue ring (approximately 23 kilometres in diameter) and the purple ring (approximately 13 kilometres in diameter) indicate the area in which behavioural influence can occur with single and double bubble curtain and Hydro Sound Damper. (Source: Lantmäteriet (the Swedish mapping, cadastral and land registration authority).

The number of potentially affected porpoises from the Danish Straits population in Table 43 is based on an estimate of the density of porpoises in the area from porpoise counts by SAMBAH[32] and SCANS II[33]. During the summer the density is about 0.02–0.2 individuals/km2 and during the winter about 0.01–0.1 individuals/km^2 (Hammond, 2006; SABAH, 2016; R.4.A). In the winter, porpoises from the Baltic Sea population may be present in the area and, based on the relationship between the two populations, approximately 1 % of the porpoises present in the area are expected to belong to the Baltic Sea population Table 43.

The result from sound modelling shows that the total number of porpoises from both the Danish Straits and Baltic Sea populations that are potentially affected by underwater noise from piling is small and that the influence is temporary. As described above, the effect is that the porpoises temporarily avoid the area where impact piling occurs. Underwater noise from piling that can cause behavioural effects can occur at a distance of up to 11.6 kilometres when using a single bubble curtain (worst-case scenario). In the worst-case scenario, 4–39 porpoises from the Danish Straits population and fewer than one porpoise from the critically endangered Baltic Sea population could be exposed to underwater noise levels that exceed the threshold of avoidance behaviour during the installation of a monopile during the winter. During the summer, harbour porpoises from the Baltic Sea population are not present in this area, while 8 to 78 porpoises from the Danish Straits population may be exposed to underwater noise levels that exceed the threshold for avoidance behaviour. When using a double bubble curtain and Hydro Sound Damper, underwater noise from piling that exceeds the threshold for avoidance behaviour can occur up to 6.7 kilometres in the worst-case scenario. In this worst-case scenario, it is estimated that 1–13 porpoises from the Danish Straits population are affected by underwater noise exceeding the threshold for avoidance behaviour during installation of a monopile foundation during the winter period, see Table 45. For porpoises from the critically endangered Baltic Sea population, the estimate is far fewer than one individual (0.1 harbour porpoises).

Table 43. The result of modelled underwater noise for porpoises, worst-case scenario. Assuming single bubble curtain and soft start-up. The area for each area in which TTS and avoidance behaviour may occur and the estimated number of porpoises.

Influence	**Affected area**	**Number of porpoises from the Danish Straits population that may be affected**		**Number of porpoises from the Baltic Sea population that may be affected**
		Summer (0.02–0.2 individuals/km^2)	Winter (0.01–0.1 individuals/km^2)	Winter (1.19% of porpoises in the area)*
TTS	<1 km^2	<1	<1	<<1
Avoidance behaviour	<390 km^2	8–78	4–39	<1

*It is not possible to distinguish between porpoises from the Baltic Sea population and the Danish Straits population. However, since the Danish Straits population (42,000) is much larger than the Baltic Sea population (500), the ratio of the two populations ((500/42000)*100=1,19%) has been used to estimate the number of porpoises likely to be affected.

Table 44. The result of modelled underwater noise for porpoises during piling, worst-case scenario. Assuming single bubble curtain and soft start-up. Avoidance behaviour for each population.

Population	**Population size**	**Number of affected porpoises**		**Affected porpoises at population level**	
		Summer	Winter	Summer	Winter
Baltic Sea population	500	-	<1	-	0.01–0.095%
Danish Straits Population	42,000	8–78	4–39	0.019–0.19%	0.01–0.093%

32 Static Acoustic Monitoring of the Baltic Sea Harbour Porpoise. International project to preserve the population of the Baltic Sea harbour porpoises.

33 Small Cetaceans in the European Atlantic and North Sea.

Table 45. Potential influence of piling on the two porpoise populations at the Triton wind farm. Assuming double bubble curtain and Hydro Sound Damper. Area where avoidance behaviour may occur and estimated number of porpoises affected.

Influence	Influence	Affected area	Number of affected porpoises	Affected porpoises at population level
Baltic Sea population	Avoidance behaviour	<122 km^2	<<1	0.0029–0.029%
Danish Strait Population	Avoidance behaviour	<122 km^2	1–13	0.0028–0.028%

No individuals will be injured when mitigatory measures are applied. Nor is the ability of individuals to survive, reproduce or forage affected. Porpoises are expected to avoid the site during piling work and return after a few days to weeks after completion of the piling. The affected area (Table 43-Table 45) reported for avoidance behaviour[34] due to impact piling in the modelling is the worst-case scenario and does not necessarily mean that porpoises completely avoid the area. Studies have shown that behavioural effects reduce with increased distance from the sound source. Porpoises can also become accustomed to underwater noise and become more tolerant (Graham, 2019), for example, from the first to the last installation of foundations within the planned wind farm.

Because the period that piling takes place is relatively short, at the same time as the number of porpoises that can be temporarily exposed to underwater noise is limited and the effect is reversible, the influence of underwater noise from piling is deemed to be insignificant and small for hearing loss and behavioural effects, respectively. As the sensitivity to underwater noise in the Danish Straits population is moderate, the impact of underwater noise from piling is assessed to be negligible to small with the use of a single bubble curtain. For the Baltic Sea population, sensitivity is deemed to be high due to the conservation status of populations, but the impact is still assessed to be negligible, as the probability of an influence on a single individual from the Baltic Sea population is low. With a double bubble curtain and Hydro Sound Damper (or equivalent), the effect of underwater noise from piling is even smaller, but the impact assessment remains the same.

Table 46. The estimated impact of the influence factor underwater noise on the harbour porpoises during the construction phase.

	Recipient sensitivity/value	Size and extent of the influence	Impact
Danish Straits Population	Moderate	Insignificant/small	Negligible to small
Baltic Sea population	High	Insignificant/small	Negligible to small

Seals

Seals (both grey seal and common seal) will not be exposed to noise levels resulting in PTS. Table 49 shows the size of the area in which TTS and avoidance behaviour for grey seals and common seals could occur. Seals are generally considered to react less, and adapt more quickly, to underwater noise than porpoises (Blackwell et al., 2004; Mikkelsen et al., 2017). As a precaution, however, the same levels of avoidance behaviour for seals have been used as for porpoises.

34Changes to behaviour would mainly involve avoidance behaviour that can vary from a small change, for example short disturbance in foraging to flight behaviour.

There is no known information about the density of seals in the wind farm and the number of affected grey seals and common seals cannot therefore be estimated in the same way as for porpoises. Instead, we have estimated how much of the seals' habitat is temporarily affected by underwater noise. The closest and most important basking site is the colony at Måkläppen in Skåne, where grey seals and common seals have been tagged with satellite transmitters. The area that may be affected by underwater noise lies within, or overlaps, the habitats[35] of both the grey seal and the common seal, Figure 47 and Figure 48. Grey seals have a significantly larger habitat than the common seal, so that a smaller proportion of the grey seals' habitat will be affected compared with the common seal. Marine mammals will not be exposed to levels beyond the TTS when the propagation of sound beyond the TTS limit occurs only within 825 metres of the sound source when using a BBC, and because seals will have been encountered by a margin beyond this distance due to the movements of the vessel; the acoustic methods and the use of soft start-up, Figure 47 and Figure 48 as well as Table 47 and Table 48.

Modelling of sound exposure levels (SEL) for a worst-case scenario for transboundary impacts in the eastern part of the farm has also been carried out and can be seen in Figure 49 and Figure 50. In the eastern part of the area it is seen that the area in which behavioural influences can occur with a single bubble curtain reaches the Danish economic zone and that areas within which behavioural influences can occur with a double bubble curtain and Hydro Sound Damper reach just the border of the Danish economic zone. In the western part of the area, it can be seen that the area in which behavioural influences can occur with a single bubble curtain reaches right to the border of the German EEZ.

Table 47. The result of modelled underwater noise for porpoises, worst-case scenario. Assuming single bubble curtain and soft start-up. The distance of influence in which PTS and TTS can occur for grey seals and common seals.

	Influence	**Distance of influence**
Seals	PTS	<25 metres
	TTS	825 metres

Table 48. The result of modelled underwater noise for porpoises, worst-case scenario. Assuming double bubble curtain, Hydro Sound Damper and soft start-up. The distance of influence in which PTS and TTS can occur for grey seals and common seals.

	Influence	**Distance of influence**
Seals	PTS	<25 metres
	TTS	<50 metres

35 Habitat is a biological concept that defines the area which is more or less the permanent residence of one or more individuals of a particular species of animal.

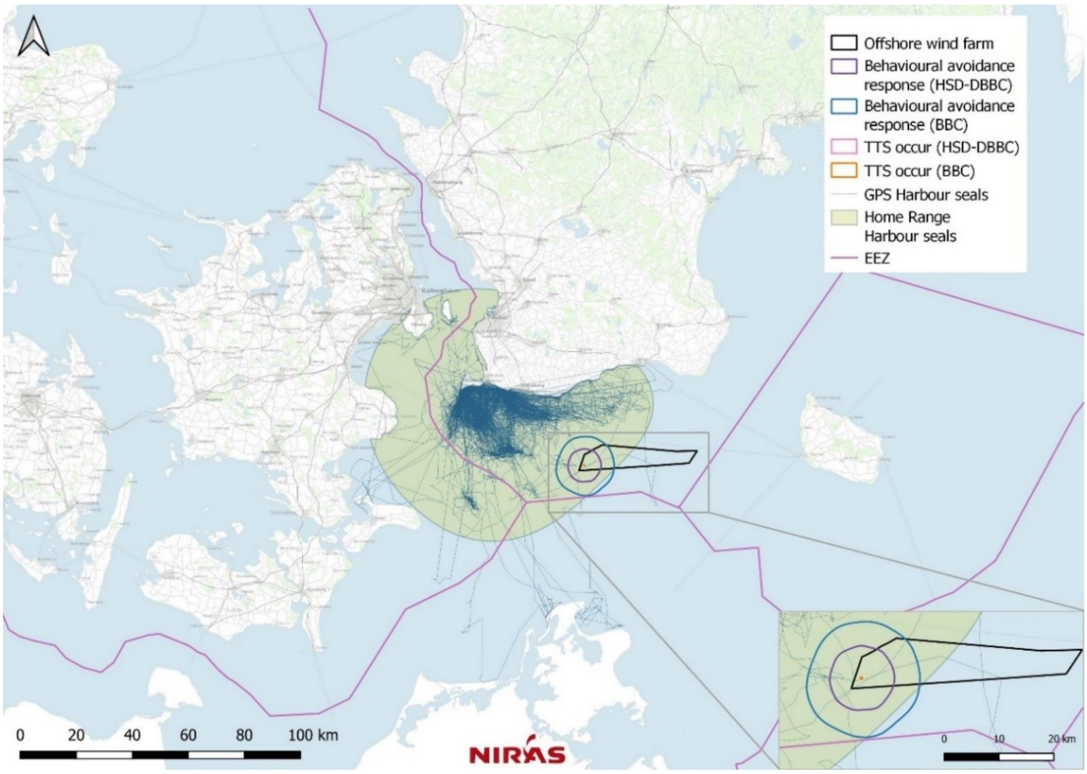


Figure 47. Results from modelled underwater noise and overlapping with the habitat of the common seal during piling in the wind farm area. Orange and red rings show the area where TTS occurs with single and double bubble curtain and Hydro Sound Damper. The blue ring (approximately 23 kilometres in diameter) and the purple ring (approximately 13 kilometres in diameter) indicate the area in which avoidance behavioural influence can occur with single and double bubble curtain and Hydro Sound Damper (R.4.a).

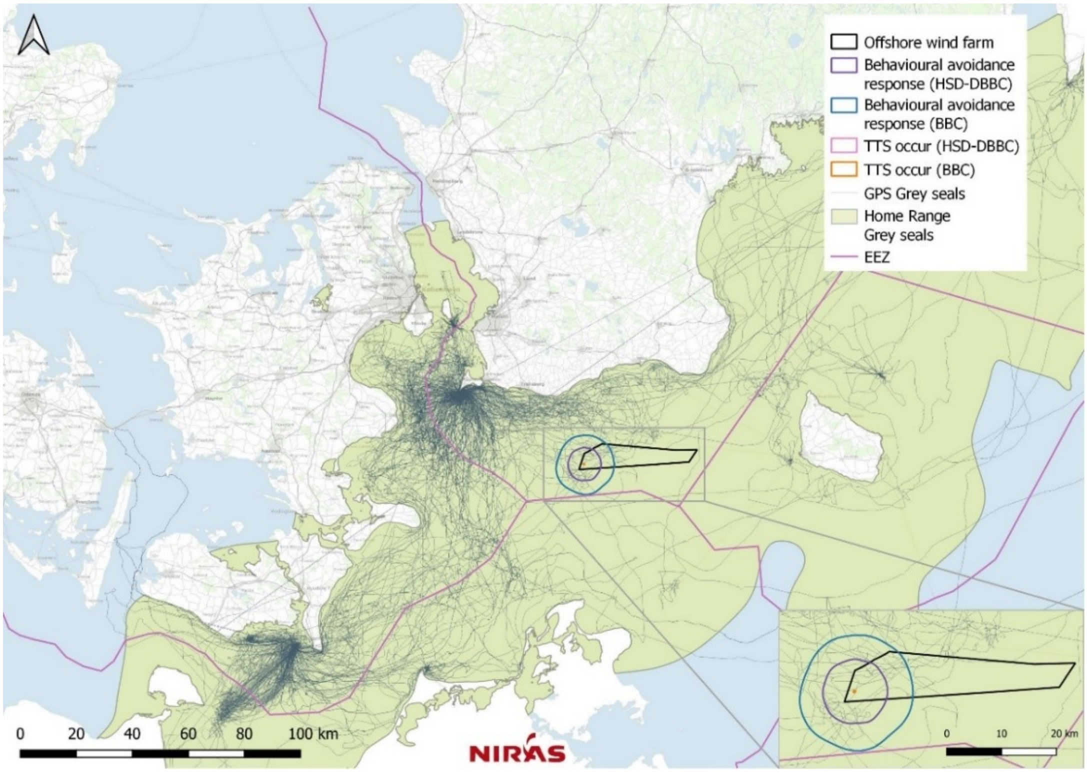


Figure 48. Results from modelled underwater noise and overlapping with the habitat of the grey seal during piling in the wind farm area. Orange and red rings show the area where TTS occurs with single and double bubble curtain and Hydro Sound Damper. The blue ring (approximately 23 kilometres in diameter) and the purple ring (approximately 13 kilometres in diameter) indicate the area in which avoidance behavioural influence can occur with single and double bubble curtain and Hydro Sound Damper (R.4.a).

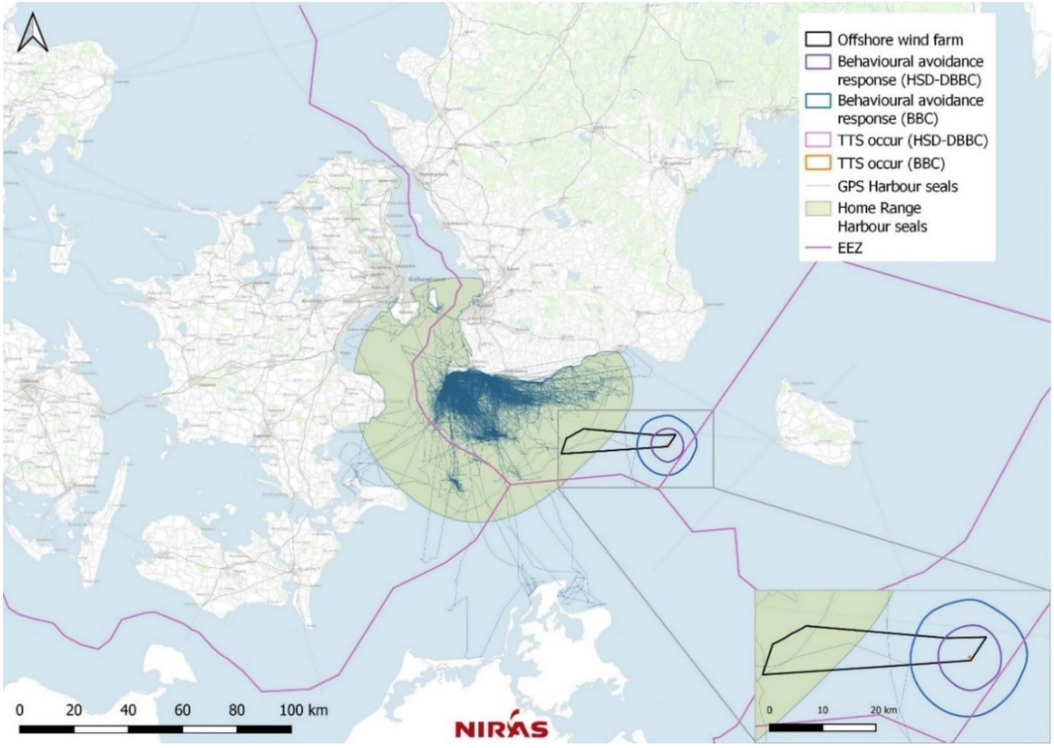


Figure 49. The result of modelled underwater noise and overlap with habitats for common seals during piling in the wind farm area, worst-case scenario in the western part of the project. Orange and pink rings show the area where TTS occurs with single and double bubble curtain and Hydro Sound Damper. The blue ring (approximately 23 kilometres in diameter) and the purple ring (approximately 13 kilometres in diameter) indicate the area in which behavioural influence can occur with single and double bubble curtain and Hydro Sound Damper. (Source: Lantmäteriet (the Swedish mapping, cadastral and land registration authority)

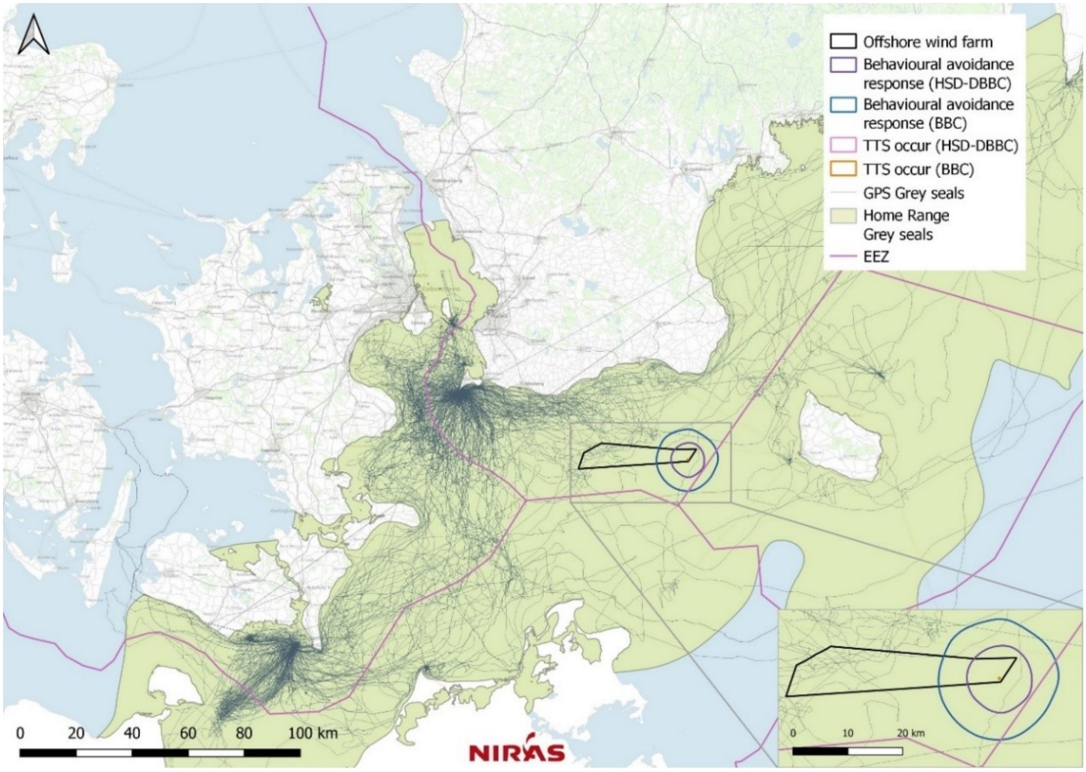


Figure 50. The result of modelled underwater noise and overlap with habitats for grey seal during piling in the wind farm area, worst-case scenario in the western part of the project. Orange and pink rings show the area where TTS occurs with single and double bubble curtain and Hydro Sound Damper. The blue ring (approximately 23 kilometres in diameter) and the purple ring (approximately 13 kilometres in diameter) indicate the area in which behavioural influence can occur with single and double bubble curtain and Hydro Sound Damper. (Source: Lantmäteriet (the Swedish mapping, cadastral and land registration authority)

Table 49 shows the size of the area in which the avoidance behaviour of grey seals and common seals can occur and the size of the proportion of the respective habitat is affected.

Table 49. The result of modelled underwater noise during piling, worst-case scenario. The proportion of the seals'' habitat in which avoidance behaviour may occur. The calculation is based on use of a single bubble curtain.

Area	Species	Affected Area (worst-case scenario)	Habitat	Percentage (%) of habitat affected
Triton	Common seal	<390 km^2	<5.234 km^2	7.5%
	Grey seal		<70.727 km^2	0.55%

Table 50. The result of modelled underwater noise during piling, worst-case scenario. The proportion of the seals'' habitat in which avoidance behaviour may occur. The calculation is based on use of double bubble curtain and Hydro Sound Damper.

Area	Species	Affected Area (worst-case scenario)	Habitat	Percentage (%) of habitat affected
Triton	Common seal	<122 km^2	<5.234 km^2	2.3%
	Grey seal		<70.727 km^2	0.17%

While the foundations are being built, both common seals and grey seals will temporarily avoid the area in which piling takes place. Piling work at Triton is temporary and seals return after piling has ceased. Seals are also opportunistic hunters and are not limited to a foraging area. The wind farm area itself is considered to be of low/medium importance for common and grey seals because neither of the species appears to use the area as a particular foraging area.

The impact of underwater noise from piling works on the seal and grey seals is considered to be small since it is the area of the seal's habitat in which underwater noise exceeds the limit for behavioural influence and a very limited area where TTS may occur. In the worst-case scenario (with a single bubble curtain), up to 7.5% of the common seal's habitat and 0.55% of the grey seal's habitat are affected during a short period of underwater noise levels exceeding the threshold of avoidance behaviour. When a double bubble curtain is used, 2.3% of the common seals' habitat and 0.17% of the grey seals' habitat will be affected for a short period. Seals are generally considered to be more tolerant of underwater noise than porpoises. It should be noted that the values in Table 49 are based on the assumption of use of a single bubble curtain (or equivalent) and smooth start-up. If double bubble curtains and Hydro Sound Dampers are used, the influence will be limited further (Table 50).

Table 51. The estimated impact of underwater noise during the construction phase.

Influence factor	Recipient sensitivity/value	Size and extent of the influence	Impact
Underwater noise	Small	Insignificant- small	Negligible-small

Airborne noise

There may also be airborne noise in addition to underwater noise during installation of foundations. Porpoises only come up to the surface to breathe and swim underwater for the rest of the time. They are therefore not considered to be affected by airborne noise from construction activities. Seals can, however, be affected by airborne noise from construction and especially if it occurs at their basking sites. Seals can, however, be affected by airborne noise from construction and especially if it occurs at their basking sites. Given the size of the distance between the wind farm and the seals' basking sites, disturbing noise from the wind farm will not reach the seals. The influence on seals from airborne noise during the construction phase is therefore considered to be insignificant. This means that the impact is deemed to be negligible.

Table 52. Estimated impact on marine mammals of the airborne noise during the construction phase.

Influence factor	Recipient sensitivity/value	Size and extent of the influence	Impact
Airborne noise	Small	Insignificant	Negligible

Sediment spread

Foundation construction will cause some spread of suspended sediment and sedimentation. Sediment spread becomes most extensive when foundations are constructed using drilling, which is why drilling has been used as the construction technique when assessing the worst-case scenario for sediment spread. Foundation construction by drilling means less underwater noise than piling, which is the influence factor that can affect marine mammals most. Porpoises use their echo location mainly when hunting, which means they can hunt even in muddy waters and at night. Both grey seals and common seals are adapted to living in coastal waters where they are often exposed to muddy waters as a result of sediments from a storm, for example, and seals can also hunt in muddy waters.

The influence of sediment is local and decreases with distance from the source. Most of the suspended sediment will settle relatively quickly. The influence on marine mammals from sedimentation is considered to be insignificant. In the case of marine mammals, the impact is considered to be negligible.

Table 53. Estimated impact on marine mammals of sediment spread during the construction phase.

Influence factor	Recipient sensitivity/value	Size and extent of the influence	Impact
Sediment spread	Small	Insignificant	Negligible

UXO

UXO[36] is not expected to be found in the farm area, but if there were to be, the first step is to avoid building in that particular part of the area. If the area cannot be avoided and the UXO must be removed, a separate assessment will be made because explosions are considered to be special cases not directly related to the wind farm. Each UXO is a unique site-specific situation that needs underwater sound modelling and therefore cannot be done in advance. It is possible, and is recommended, to use mitigation measures whenever underwater detonations cannot be avoided, in order to reduce emitted sound energy. A mitigatory measure is so-called deflagration where a small blast charge is used to neutralise the UXO (NPL, 2020). In this way, the blast charge will be considerably smaller, resulting in a reduced sound energy level. If it is not possible to avoid major explosive charges, the stated sound energy level can be reduced by using bubble curtains (Nüzel, 2008; Schmidtke, 2010; Koschinski, 2011).

Operational phase

Wind turbines in operation emit two types of noise; mechanical and aerodynamic. The mechanical noise is generated by the alternator, fan system and. occasionally, the gearbox. The aerodynamic noise makes up the dominant part of the sound from a wind turbine and is caused by the passage of the rotor blades through the air (See R.14). The noise from the turbines will be present during the entire operating phase except for short periods without wind, during storms or during repairs. The noise is low and of a permanent nature (occurs when the turbines are in operation). In previous studies both seals and porpoises have been observed at offshore wind

36 Unexploded ordnance (Duds)

farms in operation in the same numbers or to a greater extent than before the wind farm was built (Tougaard et al., 2006; Scheidat et al., 2011). A recent study by Clausen et al. (2021) shows that porpoises can be attracted to offshore oil and gas platforms, regardless of the underwater noise of the activities, probably due to potentially greater numbers of prey in the area. Seals can hear noise from wind turbines at a greater distance than porpoises. The study has shown that some common seals are actively attracted foundations for foraging (Russell et al., 2014). Underwater noise connected to the operations during the operational phase also is also generated by ship transport of personnel and equipment. Small vessels are mainly used for such transport. The adjacent shipping lanes already cause underwater noise and the additional shipping services in the area as a result of Triton are expected to contribute to a negligible increase in underwater noise from ships, compared to the existing shipping traffic already taking place today. The effect of underwater noise from ship transport to the wind farm is local and is only temporary during service. The impact on marine mammals from sound connected to the operation phase is considered to be small and locally limited. As marine mammals' sensitivity is low, the impact is considered to be negligible.

The inter-array cables that are laid at the wind farm produce electromagnetic fields (Chapter 6.7). The strongest magnetic field is generated directly above the cables, 23 μT in the worst-case scenario. The magnetic field then decays rapidly and about four metres from the centre line the magnetic field is less than 1 μT. The sensitivity to magnetic fields in marine mammals is considered to be low. The electromagnetic field effect is very locally limited to close to the cables, so the electromagnetic field does not cover the entire surface of the wind farm. The influence on marine mammals as a result of electromagnetic fields is estimated to be insignificant with a negligible impact. During the operational phase, the overall influence of the wind farm and inter-array cabling on marine mammals is estimated to be negligible.

By attracting more fish, the new hard seabed environments (the foundations and erosion protection) can also increase the food supply for marine mammals, which can potentially have a slight positive effect on marine mammals.

Table 54. Estimated impact on marine mammals during the construction phase.

Influence factor	**Recipient sensitivity/value**	**Size and extent of the influence**	**Impact**
Noise during operational phase	Small	Small	Negligible
Inter-array cables	Small	Insignificant	Negligible
Reef effect	Insignificant	Insignificant	Slightly positive

Decommissioning phase

During the decommissioning phase, underwater underwater noise and sedimentation may occur, but on a significantly smaller scale and spread than during the construction phase. The decommissioning of the Triton wind farm and its associated inter-array cabling is therefore not considered to have any negative impact on marine mammals.

Table 55. Estimated impact on marine mammals during the decommissioning phase.

Influence factor	**Recipient sensitivity/value**	**Size and extent of the influence**	**Impact**
Decommissioning phase	Small-moderate	Insignificant- small	Negligible

Species protection

The overall assessment is that the influence on harbour porpoises as a result of operations (wind farm and inter-array) at an individual level is insignificant-small and without risk of impact on population level. Porpoises are protected under the Species and Habitats Directive and are listed in the Directive's Annex 4. The temporary impact on porpoises from the wind farm and the inter-array is deemed to be negligible to limited provided the above mitigatory measures are taken. Under these conditions, it is concluded that protection of porpoises is maintained.

Common seals and grey seals are protected under the Species and Habitats Directive and are listed in the Directive's Annex 2 and 5. The activities are not considered to have a negative influence on the seal species and the conclusion is that protection of common seals and grey seals is maintained.

7.4.3 Continued work and mitigatory measures

A number of mitigatory measures will be taken during the construction phase:

- Soft start-up, passive acoustic monitoring and observers will be used during seismic surveys.
- During impact piling, acoustic methods to discourage porpoises, using techniques adapted for porpoises, should be used to the extent necessary.
- During piling, sound-damping equipment with a performance equal to a double bubble curtain (Double Big Bubble Curtain, DBBC) and Hydro Sound Damper should be applied.
- Underwater noise from piling must not exceed the value of Single Pulse SELss, VHF≤120 dB porpoise re 1μPa^{2}s at a distance of 750 metres from the sound source.
- Underwater noise from piling shall not exceed the value of Single Pulse SPL_{RMS}-fixed, VHF 100 dB porpoise 1μPa at a distance of 11.6 kilometres from the sound source.
- During side-scanning sonar and multi-beam sonar studies, the equipment should operate at frequencies above 200 kHz in order to protect porpoises.
- Impact piling must begin with soft-start, after which the strength of the hammer impacts is gradually stepped-up strength (ramp-up). The period of soft-start and ramp-up, together with other mitigatory measures, should be sufficient to protect marine mammals against underwater noise from piling that exceeds the threshold values for permanent hearing loss (PTS) and temporary hearing loss (TTS) for the harbour porpoise.

7.4.4 Summary of transboundary impacts

The study conducted on the impact of the project on marine mammals shows, as stated above, that the impact on marine mammals is negligible to small when the planned mitigatory measures are applied. The transboundary impact is assessed to be the same because the populations concerned move over large area between countries.

Triton is situated in a transitional area between the Danish Straits population and the Baltic Sea population and does not overlap at first sight any important area for either the Danish Straits population or the Baltic Sea population; However, data from SAMBAH from 2011–2013 show that a small part of the western corner of the Triton wind farm overlaps with an area that was identified as an important area between August and October (Figure 34). The OX2 F-pods survey supports the observations from SAMBAH, but shows relatively few detections compared to, for example, Kattegat (Birgersson, 2021). The eDNA study shows low levels of detection of porpoises in the region (R.13). On the basis of the most recent studies, the site is considered to be of low importance to porpoises (R.4.A).

Some of the geophysical studies, with equipment such as Innomar (SBP), Sparks (SBP) and Mini G airgun, produce sound that is within the auditory area of marine mammals. In order to minimise the potential impact of these, OX2 will take precautions such as soft starting of the seismic equipment over a period of 30 minutes. The surveys, combined with the mitigatory measures that OX2 undertakes to use (see section 7.4.3 and Chapter 10) are deemed to have a small negative influence. The low density of marine mammals in the area makes the risk of influence low. The impact of underwater noise on marine mammals is therefore considered to be very small (grey seal and common seal) to small (porpoise). The seismic surveys are also deemed not to affect the conservation status of the porpoises, either in the short or long term, and also to be without risk of injury or disturbance of significance at the individual level. No impact on the populations of grey seal and common seal is assessed in the short or long term. Figure 42 and Figure 43 show that behavioural influences take place in the close vicinity of the source and the area of influence is within Sweden's territorial borders.

Different approaches are applied in the various countries to assess the influence of impact piling on marine mammals. The latest scientific literature recommends that the cumulative noise exposure level and frequency weighting be used to estimate TTS and PTS. Therefore, auditory frequency weighting is applied in accordance with the National Marine Fisheries Service (2018) and Southall and et al. (2019), see 7.4.2. The latest Danish guidelines for piling are, for porpoises, 155 dB re 1 Pa^2s (PTS), 140 dB re 1 Pa^2s (TTS) and 103 dB re 1 Pa, 125ms (behavioural change) and for the common seal and grey seal 185 dB re 1 Pa^2S (PTS) and 170 dB re 1 Pa^2S (TTS) (Swedish Energy Agency, 2022), which are the guidelines used in the calculations.

Germany's Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and Consumer Protection (BMU) has established guidelines for protecting harbour porpoises from adverse effects during the construction of offshore wind farms in the German exclusive Economic Zone of the North Sea (BMUB, 2014). The German Federal Maritime and Hydrographic Authority (BSH) has set a threshold for acceptable sound levels. The German guidelines focus on a single pile drive and do not include thresholds for accumulated sound exposure (SELcum), it is the appropriate measure for estimating TTS and PTS thresholds and should therefore be used with caution. Furthermore, the German guidelines are based on a study by Lucke et al. 2009, which induced TTS in porpoises with air rifle signals as sound source and not a pile-driving sound. Since the German guidelines were published, much more knowledge has been published about how impact piling noise affects both porpoises and seals that show higher TTS thresholds compared to the threshold set by Lucke et al. (2009), which further supports the prudent use of the German TTS threshold (R.4.A).

Figure 45 to Figure 50 show the transboundary impact of impact piling on marine mammals. In the western part of the site, the behavioural impact area will reach right to the border of the German EEZ if a single bubble curtain is used. If a double bubble curtain and Hydro Sound Damper are used, the area of behavioural influence is closer to the source of the impact piling and within Sweden's borders. In the eastern part, the area of behavioural influence reaches over to the Danish economic zone with a single bubble curtain but with a double bubble curtain and Hydro Sound Damper, the area of behavioural influence will stay within the Swedish borders. The sensitivity for porpoises is considered to be moderate to high and for seals is considered to be small. The effects of underwater sound from impact piling are considered to be insignificant/small and the impact is therefore negligible for marine mammals.

The Natura 2000 area that is considered to be affected is in the offshore waters of the southwest Skåne, see Figure 34. The Swedish, German, Polish and Danish Natura 2000 sites that are located further away are not considered to be affected. For impacts on Natura 2000, see section 11.2. Piling may cause underwater noise levels above the behavioural reaction threshold for porpoises up to a distance of 6.7 kilometres (piling using DBBC+HSB). Because the distance to the closest of the other Natura sites is more than 25 kilometres they will not be directly affected by underwater noise above the behavioural threshold as a result of construction of the Triton wind farm. When monopiles are installed in the seabed by impact piling, the marine mammals will temporarily move away from the monopile area to 6.7 kilometres from the site of the pile (worst-case scenario). As the area of the Triton wind farm is not an important area for marine mammals (not a foraging area), the temporary influence on the habitat near the sites is considered to be small.

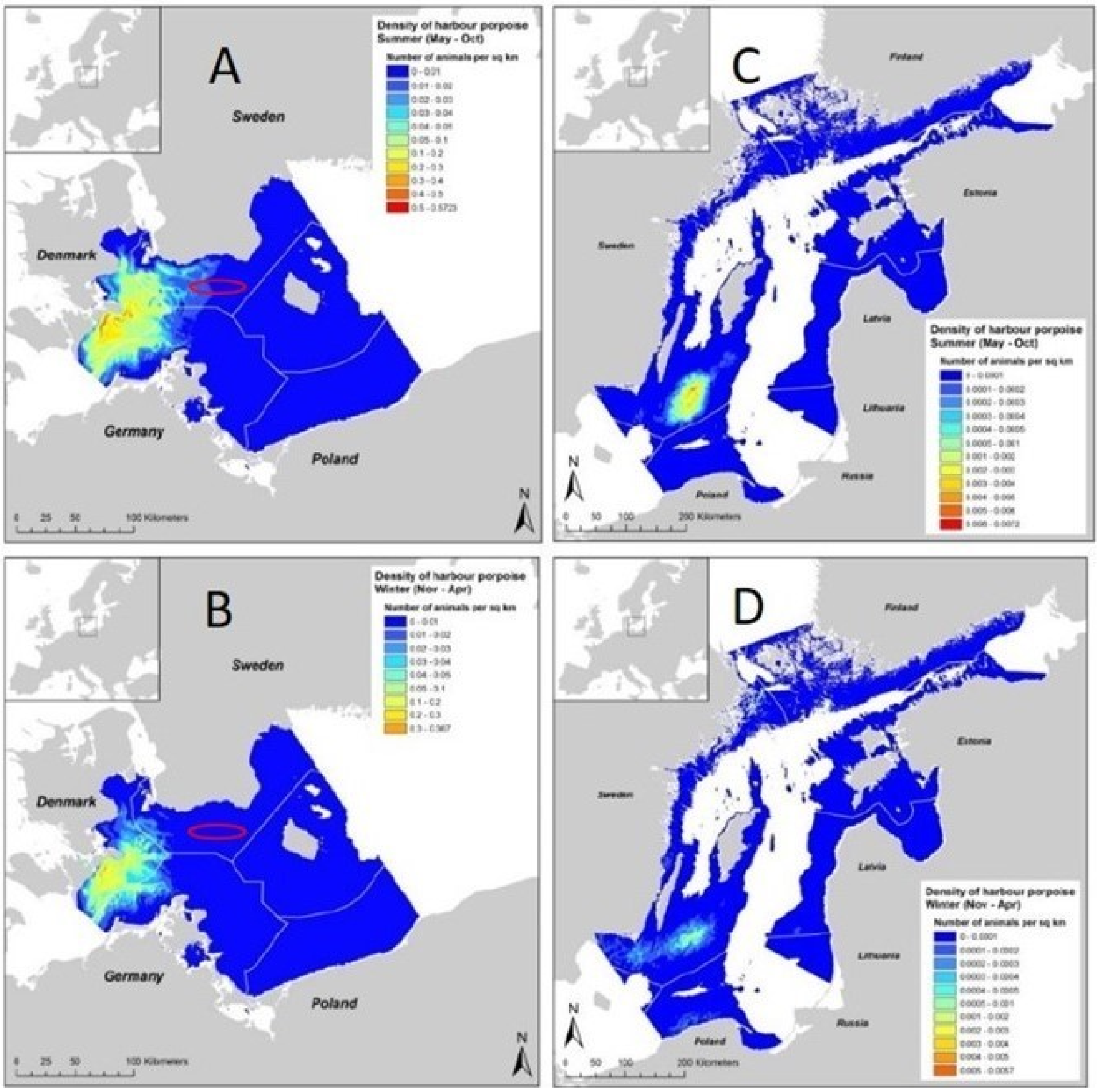


Figure 51. Estimated density of porpoises (expressed as number of individuals per km^2) for the south-western (A-summer). B-winter) and the north-eastern (C-summer, B-winter) parts of the Baltic Sea. The Triton wind farm development area is located in the Baltic Proper. Since the number of porpoises in the south-western Baltic is significantly higher than the number in the north-east, the contour colours for sub-figures A and B have a different scale than subfigures C and D. Modified from (SAMBAH, 2016).

7.5 Bats

Total impact assessment

Based on existing knowledge, it is unlikely that the farm area will be used as a foraging area for stationary bat species, because the distance to the closest coastline is between 20 and 30 kilometres. Migration across the Baltic Sea during spring and late summer/early autumn usually takes place in calm weather. In the case of the Triton wind farm it is therefore mainly migratory bats that can could be be affected by increased risk of collision with the wind turbines during the operational phase.

The use of mitigatory measures in the form of operational regulation during times of high migration means that the influence of the wind farm is considered to be insignificant and the impact negligible. The transboundary impact is therefore also considered to be insignificant and the impact negligible.

This section describes the occurrence and assessed influence and impact of the operations on bat fauna and summarises reference report R.3 ”Assessment of impacts on bat fauna resulting from the designed Triton offshore wind farm, to the south of Ystad”.

7.5.1 Preconditions

Most European bats move between summer and winter colonies. In Sweden there are at least two bat species that migrate south during the autumn and then return during the spring; the common noctule (*Nyctalus noctula)* and Nathusius’ pipistrelle (*Pipestrellus nathusii*) (Ahlén et al., 2009; Rydell et al., 2014). There are no islands between the Triton wind farm and the Swedish south coast or the northern coast of Germany, and therefore no obvious guiding lines. The distance that any bats need to cover over the Baltic Sea in the area in question from Sweden to Germany is about 75–90 kilometres that, for example, Nathusius’ pipistrelle can fly during a single night (Ahlén, 2009).

Bats have been observed at offshore wind farms, but there are few studies that have used recorded monitoring. The few studies that have been conducted suggest that bats mainly fly at low altitudes (<10 metres) over open waters, even though individual registrations have been made at hub heights (Ahlén et al., 2009; Rydell and Wickman, 2015; Brabant et al., 2019). However, the majority of all registrations have been made during nights with lulls or weak winds (Rydell and Wickman 2015; Brabant et al., 2019).

AquaBiota conducted a bat count for Triton during the migration period in late summer 2021. The count covered two nights within Triton’s planned area of activity (28–29/8 and 31/8–1/9). During these two full nights, a total of 18 bat recordings were noted, of which 17 were recorded during the second night when the wind was weak (0–1,5 m/s). During the first night, when only one recording was noted, the wind speed was between 2.6 and 10-6 m/s. Three to four species that migrate short or longer distances were identified; Nathusius’ pipistrelle, the common noctule, the parti-coloured bat (*Vespertilio murinus*) and possibly the serotine bat (*Eppsicus serotinus*). The serotine bat is classified as near-threatened –NT (Species Information Centre, 2020) and is difficult to determine the species from a short recording, but it cannot be excluded either, so it is also reported. All these species of bats are listed in Annex 4 of the Species and Habitats Directive.

Studies and experiences from onshore wind power of collisions between bats and the turbines were compiled in the early 2000 (Ahlén, 2002; Rydell et al., 2011). Since then, the state of knowledge has improved considerably in relation to which species are most at risk and at which times of the year, and at which wind speeds the risk of mortality is highest at onshore wind farms. (Rydell et al., 2011; Rydell et al., 2017). The updated synthesis report from Vindval recommends operating regulation (Bat mode), which has made this issue conditional on several decisions regarding onshore wind power. In the case of offshore wind power, far fewer studies have been conducted regarding the influence on bats. However, some long preliminary studies have been conducted during the planning of offshore wind projects in Dutch, German and Danish waters, several of which are located in the Baltic Sea.

The Danish part of the Krieger's flak wind farm, for which a bat count was conducted in 2013 is not far from Triton. The study was a long-term monitoring of bat activity from August to November 2013. During the count period, mostly individual bats were recorded from the beginning of August to the end of September. The same four species mentioned above were also identified here; Nathusius' pipistrelle, the common noctule, the parti-coloured bat (*Vespertilio murinus*) and the serotine bat (*Eppsicus serotinus*). Nathusius' pipistrelle dominated the activity and accounted for 85% of all recordings. The activity mainly originates from one night when 75% of all recordings were noted (Aarhus University, 2015).

Within German territorial borders, about 20 kilometres south of Triton, the Baltic Eagle offshore wind farm conducted counts during 2013 and 2014, covering a total of 40 nights. A few Nathusius' pipistrelle, soprano pipistrelle, and probably common noctule, as well as an unidentified Myotis species were recorded then. The conclusion was that the influence on bats was low as the registered activity was low. The German offshore wind power project O-1.3, about 25 kilometres south-east of Triton, also conducted bat counts during the spring and autumn of 2014 and 2015. These counts noted a low incidence and activity of Nathusius and soprano pipistrelles and a few registrations of the genus Nyctalus (common or lesser noctules).

There are no studies showing that southward migration of bats from Sweden takes place through the Triton wind farm area. However, the project's own counts show that there are migratory bats in the farm area. The assessment is that further short pre-studies/counts do not provide sufficient data to draw any far-reaching conclusions on the extent of migration of bats within Triton wind farm area. Experts have ascertained that conducting a multi-year long-term study aimed at assessing the impact of a wind farm so far out at sea is not justified prior to the wind farm has been established in the area. This is because a wind farm can change bats' movement pattern while it is only possible to examine the presence of bats in a relevant way once the wind farm has been built. A multi-season study should therefore be conducted after the wind farm has been commissioned and that mitigatory measures in the form of bat mode or similar can be taken as necessary during the study period and during subsequent operations.

7.5.2 Impacts

This section describes the identified effects and impacts on bats. Table 56 shows which influence factors have been assessed and in which phase. No influence is expected during the construction and decommissioning phases. The inter-array is not considered as such to have any influence on bats.

Table 56. Potential influence factors on bats that occur during the different phases of the wind farm.

Influence factor	Construction phase:	Operational phase	Decommissioning phase
Risk of collision		x	

Operational phase

Based on existing knowledge, it is unlikely that the farm area will be used as a foraging area for stationary bat species, because the distance to the coast is between 20 and 30 kilometres.

It is mainly migratory bats that could be adversely affected and suffer an increased risk of collision with wind turbines during the operational phase when the blades of the wind turbine rotate.

A low level of activity of migratory bats species registered in the three studies at the Danish part of Krieger's flak, about 22 kilometres west of Triton, at the Baltic Eagle and at O-1.3 south of Triton in the German EEZ indicates that there is migration in this part of the Baltic Sea. However, the results from the reports do not indicate a very high level of activity, which could mean a low level of bat migration through these areas. The two count nights conducted in Triton's area of operations during 2021 show that some bat activity occurs in the area.

Studies of offshore wind farms show two migration peaks in the Baltic Sea region. The first occurs during spring migration from mid-April to May and the second occurs during autumn migration from mid-August to the end of September. Migration usually takes place in calm weather. The risk of bat collisions can thus occur in about three to four months of the year, the rest of the year the wind farm does not pose a threat to bat fauna.

Studies of two onshore wind farms in high-risk areas show that regulation of operations regulation has the intended effect and protects the most vulnerable species (Pettersson, 2020; Jens Rydell, verbally). Based on the results of the studies conducted with recording equipment at offshore wind farms, there is no reason to consider that the pattern differs from onshore wind farms.

As a safeguard, equipment for detecting bats will therefore be installed on wind turbines and the influence of the established wind farms will be recorded in a three-year study, which is one year longer than the experts have suggested in the expert report. As an extra precaution, the wind farm will also be fitted with operations control equipment. If the results of the studies indicate a significant risk of collision with migratory bats, the application of operational regulation under migration conditions to minimise the risk of collisions may be prescribed.

The impact is expected to be negligible as operational regulation during sensitive periods and weather has been shown to reduce the influence significantly. With the safeguarding measures to be taken, the overall assessment is that the impact on bat fauna in the area will therefore be negligible.

Table 57. Assessed impact on bats during the operational phase with operational regulation.

Influence factor	Recipient sensitivity/value	Size and extent of the influence	Impact
Risk of collision	Moderate	Insignificant	Negligible

Obstruction marking

The Triton wind turbines will need to be marked with aviation obstruction lighting. The regulations on obstruction marking of wind turbines are contained in the Swedish Transport Agency's regulations (currently edition TFS 2020:88). A turbine with a total height above 150 metres must be fitted with a high intensity white flashing light on the nacelle. When the nacelle has a height of more than 150 metres, the tower should also be marked with at least three low-intensity lights at half height up to the nacelle. Additional marking and lighting may be required for wind turbines of the size that is relevant for Triton, and decisions must be taken by the Transport Agency. If new regulations are established for obstruction marking, which, for example, stipulate that obstruction lighting must be regulated to protect bats, birds, etc., the company will apply these regulations. This is because the company has undertaken to apply the Transport Agency's regulations on obstruction marking that are current when building the farm.

Species protection

As the presence of, and risks to, bats will be investigated within the framework of the study programme and when necessary precautions will be taken to minimise the risk of collisions, the species protection of bats will be maintained.

7.5.3 Summary of transboundary impacts

The study conducted for bats in the area, as well as other studies, show that there are two migration peaks in the Baltic Sea area, spring migration (mid-April to May) and autumn migration (mid-August to the end of September). Mitigatory measures in the form of equipment for the detection of bats will be used and the influence of the established wind farm will be recorded in a three-year study programme. The wind farm will also be equipped with operational control equipment. Under the proposed mitigatory measures, the impact on bat fauna in the area is deemed to be negligible. The transboundary impact is therefore also considered to be insignificant and the impact negligible.

7.6 Birds

Total impact assessment

A significant migration of birds takes place across the sea between the south coast of the Skåne region and the German Baltic coast. Birds that migrate in daytime include raptors and cranes. Raptors fly over the sea in the Arkona Basin in relatively low numbers because the migration is concentrated on the Falsterbo peninsula and further north in the narrowest part of Öresund. A majority of the Swedish-Norwegian population of cranes overfly the Arkona basin during migration in spring and autumn. Many species of birds migrate at night and represent a large share of migration flows. During autumn migration almost 100,000 birds can pass through Triton wind farm area overnight, the majority of which are made up of numerous small bird species. The influence of wind turbines on bird life may cause displacement, barrier effects and collisions. The influence of wind turbines on bird life may cause displacement, barrier effects and collisions. The impacts are considered to be negligible because the wind farm area is not an important habitat for the birds and is not in an area through which the birds frequently fly.

Collision risk calculations have been performed for a selection of representative bird species. The results show negligible impact for all species except the crane, where the impact of collision risk is assessed to be small.

Mitigatory measures to minimise the impact of the wind farm on bird life are only considered to be justified for cranes. Control of operations during periods of high migration effectively reduces the risk of collision. With the proposed safeguarding measures, the impact on migrating cranes is negligible. Transboundary effects and impact are also considered to be negligible for all species except for cranes where the impact is deemed to be small without mitigatory measures, and negligible with mitigatory measures.

This section describes the occurrence and assessed influence and impact of the operations on birds and summarises reference report R.6 ”*Birds and offshore wind power in the Baltic Sea to the south of Skåne*”.

7.6.1 Preconditions

Methodology

Existing published bird data are used to describe the conditions for bird life in the area, as well as data from flight counts and studies of migratory cranes in March-April and September-October 2021. The risk of collision for migratory birds passing through Triton's planned farm area has been modelled using an internationally used method (Band, 2012). In order to assess the impact of the planned wind park on bird life, an assessment method is used which takes into account the conservation status of species and the extent of the influence.

It is also crucial to assess compatibility of impact assessments on bird life with the EU Birds Directive.

Collision risk modelling

The expected number of migratory birds at risk of colliding with rotor blades in Triton has been calculated using the 2012 Band model. The model calculates collision risk based on technical data for the wind turbines in the farm, as well as bird physiology, behaviour in relation to wind turbines, flight altitude, flight speed and the number of passing individuals.

Birds' behaviour in the vicinity of wind farms has been described as various degrees of avoidance, from avoiding flying near wind farms (macro avoidance), near wind turbines within the wind farm (meso avoidance) and how the birds avoid being hit at the last moment by the rotor blades (micro avoidance).

Collision risk modelling has been conducted by NIRAS (R.6), for a representative sample of 18 species passing through the Triton area during the spring and autumn migration periods. The selection was in line with a worst-case scenario, which means that no species with higher sensitivity to collisions were missing in modelling. This selection includes species from different species groups (five raptor species, two geese species, two loon species, two gull species, one swan, two species of waders, nightjar and grey heron).

Presence of sea fowl

Bird numbers in the Arkona Basin have been documented in various geographical areas under a number of counts in Germany, Denmark and Sweden, see Table 58.

Table 58. List of bird counts in the Arkona Basin.

Area	Method	Time of the year	Bird species	Year	References
South coast of Skåne	Land counts	Winter	Sea fowl	1964–2018 (in process)	Nilsson 2020
Rügen-Skåne	Radar	Spring (March-April)	Cranes	1972–1973 + 1978	Alerstam 1975, Pennycuick et al. 1979
Entire area	Boat	Winter	Sea fowl	1987–1993	Durinck et al. 1994
South coast of Skåne	Radar	Spring	Sea fowl	2003	Pettersson 2003
Kriegers flak	Radar	Spring+autumn	Day+night migration	2003	IfAÖ 2003, Kube et al. 2004a,b
Skåne, around Bornholm, south-east Denmark, Bay of Pomerania	Air, boat (Germany)	Winter	Sea fowl	2004–2009, 2013, 2015–2018	Skov et al. 2011, Mortensen et al. 2020
Kriegers flak	Radar	Autumn 2013, Spring 2015	Cranes, raptors	2013 and 2015	Skov et al. 2015
Kriegers flak + Falsterbo + Skåne's southern coast+Denmark's east coast	Rangefinder	Autumn 2013, Spring 2015	Cranes, birds of prey	2013 and 2015	Skov et al. 2015, Mortensen et al. 2020
Baltic 2 and Wikinger	Radar	Spring and autumn	Day+night migration	2010–2016	Welcker & Vilala 2019
Triton	Plane	March-April	Seafowl	2021	Ottvall and Tiblom, 2022
South coast of Skåne	Rangefinder	Spring+autumn	Cranes, raptors	2021	Ottvall and Tiblom, 2022
German waters	Air and boat	Winter	Sea fowl	In progress	Borkenhagen et al. 2018
Danish waters	Plane	Winter	Seafowl	In progress	Holm et al. 2021

The Triton wind farm site consists exclusively of deep soft seabed with no blue mussel banks, which means that deep sea demersal fauna-eating divers (such as eider ducks, velvet scoters, common scoters and long-tailed ducks) are mainly not present in the area. Nor does the area have the conditions for seabirds searching for plant food in shallow water (several species of dabbling ducks, swan and geese, coots, and common goldeneye, greater scaup and tufted duck). These are found only temporarily out to sea, mainly during migration. These conditions mean that it is mainly fish-eating sea fowl that can be expected to occur in the farm area.

Previous counts in the Arkona Basin, combined with modelling the expected incidence of various sea fowl, have shown that the relevant farm area does not accommodate any significant number of species of sea fowl. An aerial survey of seabirds was conducted in March and April 2021 to supplement previous data/counts. Resting mute swan, red-throated loon, eider ducks and common murre/razorbill can be found at the wind farm site, as well as common gulls and herring gulls. A compilation has been made by Richard Ottvall and Olov Tiblom, see R.6. The flight counts confirm the results and knowledge of previous studies and modelling.

Migratory birds

A large number of birds pass through the Arkona Basin during spring and autumn migration periods. Many overwinter in Western Europe, the Mediterranean or Africa, which means they take a north-east migration route in the spring and a south-west migration route in the autumn. In principle, all species of birds flying across the Baltic Sea between the continent and the Skåne coast will be within the farm area during migration.

Night-migrating birds account for the large proportion of migrating birds. Their migration across the Arkona Basin has been studied in detail over several seasons at the Baltic 2 and Wikinger offshore wind farms. The majority of the night-migrating birds in the Arkona Basin are made up of large numbers of small bird species such as warblers, robins, song thrush, redwings and goldcrest.

In addition to sea fowl and night-migrating birds, a significant number of cranes cross the Baltic Sea between Skåne and Denmark/Germany, as well as a small number of raptors. It is estimated that there is a marginal proportion of other day-migrating birds flying through the Arkona Basin, with the risk of passing through the Triton wind farm.

Cranes

Data on migratory cranes (*grus grus*) is available from a number of studies that have been conducted over a long period of time. These studies have compiled knowledge of migration times, routes and flight altitudes, etc. To complement these earlier studies, in March-April and September-October 2021 targeted counts were conducted along the southern coast of the Skåne region, as well as at Krieger’s flak. Cranes with satellite transmitters were also studied (R.6).

Most of the spring migration takes place west of the Triton wind farm, autumn migration takes place on a broad front over southern Sweden but mainly goes between the southern coast of Skåne and Rügen. Wind direction affects migration routes that can shift to the east and west when passing over the Arkona Basin. The wind also affects when the crane migration takes place, the vast majority of birds choose to fly on days with good thermal development, good visibility and tailwinds.

Modelling performed by DHI (Danish Hydrological Institute) shows that during the spring the cranes usually pass Triton at heights that coincide with the sweep area of the turbine’s rotor blades, while in the autumn they can to some extent pass through Triton above the overall height of the wind turbine.

Raptors

During the migration, raptors are concentrated to a large extent on the Falsterbo Peninsula in the autumn and Skagen in Jutland in the spring, and the passage over Öresund from Zealand to Skåne between Helsingør and Helsingborg is also important. Most of the raptors with breeding sites in Sweden and Norway migrate to overwintering areas in western Europe and Africa, but some species have a more easterly migration route.

Studies of migratory raptors have been conducted in connection with the wind farm on the Danish side of Krieger's flak. The study shows that the altitude at which the raptors fly largely means that they are at risk of being hit by wind turbine blades. One assumption from the study is that the number of raptors subsides further east in the Arkona Basin in line with increasing distance to the Falsterbo Peninsula. This has provided an assessment of the number of raptors of different species that can pass through the Triton (R.6) wind farm. There are a limited number of raptors passing the Triton wind farm, and there are relatively few individuals flying over the Arkona pool and the main passage west of Triton.

7.6.2 Impacts

The effects of wind farms on birds are divided into three influence factors: collision risks, displacement effects and barrier effects, which are described in more detail in sections 6.8 and 6.9. All of the following impacts on bird species are based on the data and studies compiled and presented in (R.6). For full source citations and detailed assessments, please refer to this report.

Table 59. Overview of influence factors and bird species or species groups subject to impact assessment.

Influence factor	Species/groups
Collision risks	Common murre, razorbill, red-throated loon, black-throated loon, grey heron, tundra swan, greater white-fronted goose, barnacle goose, eider ducks, seagulls, bar-tailed godwit, wood sandpiper, Arctic tern, nightjar, cranes, white stork, raptors, day-migrating and night-migrating birds
Displacement effects	Common murre, razorbill, red-throated loon, eider ducks and seagulls
Barrier effects	Overwintering and migratory sea fowl

Construction phase:

Collision risks

The construction phase has a very limited impact in terms of collision risk. There is a theoretical risk of birds colliding with towers or blades on turbines that are not yet in operation. The construction phase is only active for a relatively short period of time and the impact of collision risk in this phase is considered negligible at Triton.

Displacement effects

A certain displacement effect may arise as a result of increased marine activity and work linked to the construction of the wind farm, but it is considered to be a marginal influence in relation to existing vessel activity. Activities during the construction phase of the wind farm are assessed to have insignificant negative influence on both overwintering auks and overwintering red-throated loon at Triton. The impact on the few species that feed on pelagic fish that are present around the farm area in the summer half-year is deemed to be negligible. If there are changes to commercial fishing in the farm area, the presence of seagulls is likely to be affected as they actively seek out fishing boats. All in all, displacement effects can occur during the construction phase, but this phase is relatively short and the impact is deemed to be negligible.

Barrier effects

All in all, displacement effects can occur during the construction phase, but this phase is relatively short and the impact is deemed to be negligible. However, it is only at the end of the construction phase that barrier effects on migratory birds can be considered as the wind turbines occupy an increasing part of the wind farm area. The impact of barrier effects is considered to be negligible during the construction phase of the wind farm. The assessment is further developed in the section on the operational phase below.

Operational phase

Collision risks

Overwintering sea fowl

During the winter half of the year, small numbers of auks and red-throated loon are expected at the Triton wind farm. Auks fly low above the surface of the water, that is, lower than the sweep surface of the rotor blades, and red-throated loon largely avoid wind turbines. The risk of collision is considered to be insignificant and the impact negligible.

At the Triton wind farm, small numbers of common gulls, herring gulls and great black-backed gulls are also expected during the winter. Their presence in the area is linked to fishing boats, because the seagulls look out for these in search of food. The risk of collision is considered to be insignificant and the impact negligible.

Migratory birds

A significant number of birds pass through the south-west Baltic between Skåne and Denmark/Germany during the spring and autumn migrations. This consists partly of birds that fly north-south over the sea, and partly birds that fly south-west-north-east in parallel with, or along, the coasts. The risk of collision has been calculated for a number of different species during migration, a comprehensive table of the number of migrant individuals of different species, the degree of avoidance behaviour, and estimated annual collisions can be found in Table 60.

Table 60. A selection of bird species passing through an 80-kilometre corridor between Sweden and Germany. The migration corridor for cranes was 140 kilometres. Estimated number of migrant individuals in spring and autumn and the number of collisions in one year at different degrees of avoidance of the turbines at 129 turbines with rotor diameters of 340 metres and overall height of 370 metres. Collisions have been calculated according to Band (2012) using a worst-case scenario.

Species	Spring number	Autumn number	Protection status of the migrant population	Avoidance	Estimated collisions/year
80 kilometre migration corridor					
Greater white-fronted goose	10,000	25,000	Viable (LC)	99.5%	2.4
Eurasian Marsh Harrier	400	144	Viable (LC)	98%	0.28
Little gull	10,000	15,000	Viable (LC)	98%	1.1
Eider Duck	220,000	250,000	Endangered	98%	42
Osprey	500	300	Viable (LC)	98%	0.3
Rough-legged buzzard	140	440	Near threatened	98%	0.3
Grey heron	400	600	Viable (LC)	98%	0.5
Wood sandpiper	260,000	230,000	Viable (LC)	98%	17
Tundra swan	2,000	3,000	Viable (LC)	99.5%	0.5
Bar-tailed godwit	3,000	5,000	Near threatened	98%	2.5
Nightjar	2,000	4,000	Viable (LC)	99%	1.5
Red kite	400	100	Viable (LC)	98%	0.2
Arctic term	10,000	20,000	Viable (LC)	98%	0.1
Black-headed gull	15,000	30,000	Near threatened	98%	0.4
Red-throated loon	4,000	10,000	Near threatened	98%	0.1
Sparrowhawk	2,000	3,000	Viable (LC)	98%	1.5
Black-throated loon	2,000	4,000	Viable (LC)	98%	0.2
Barnacle goose	258,000	184,000	Viable (LC)	99.5%	28
140 km migration corridor					
Cranes	84,000	84,000	Viable (LC)	83%	382

Cranes

The risk of collision has been calculated for migratory cranes passing through the Triton wind farm. The risk has been calculated on the basis of a number of conservative assumptions: that the cranes pass evenly through the migration corridor in the southern Baltic (most of the cranes are highly likely to migrate west of Triton), that the cranes have an avoidance degree for offshore wind turbines of only 83% and on the basis of a worst-case scenario for the wind farm design (129 turbines with rotor diameters of 340 metres and overall height of 370 metres). 83% of the avoidance degree is based on empirical data from a wind farm in the Arkona Basin (Skov et al., 2015), and can be compared with 99.9% avoidance degree from an onshore wind turbine study (Drachmann et al., 2020).

These assumptions result in estimated annual collision cases for the cranes corresponding to less than 0.5% of the crane population passing through the Arkona Basin during migration. If the calculation instead takes an assumption of 68 turbines of the same dimensions, the collision cases for cranes are of 0.25% of the population. By comparison, the estimated rate of collisions drops with a 99.9% avoidance degree (recorded at an onshore wind farm) to 0.03%.

Although the cranes do not fly around offshore wind farms, their ability to avoid turbine rotor blades is high. In addition, a greater distance between the turbines reduces the risk of the cranes coming close to wind turbines, resulting in a significantly lower collision risk.

In order to evaluate the significance of the estimated collision cases for cranes at the Triton wind farm, the calculations used have applied the Potential Biological Removal (PBR) concept. In summary, the result means that the crane population is assessed using a margin to compensate for the loss caused by collisions with the turbines at Triton. This applies both with an assumption of a continued population increase of 4%, and assuming that the population level remains unchanged. The calculations assume that at the same time there will be no crane mortality from any other factor.

Cranes are not currently threatened and have had a strong population development. The species thus has a slight sensitivity to an influence from collisions. The modelling indicates that 1.4% of passages through Triton are at risk of collision, based on the conservative assumptions and the worst-case scenario. Under these conditions, the influence is considered to be moderate, but it has been assessed by a good margin not to risk affecting population size. The impact assessment is that the risk of collision in Triton for migrant cranes is a small impact without mitigatory measures and negligible impact with mitigatory measures. For further information, please refer to section 0 below for mitigatory measures.

White stork

Collision risk modelling has not been performed for white storks, because they are not expected to pass through the Triton wind farm during migration. The storks avoid, as far as possible, flying over open sea. There is, therefore, a negligible risk of collision at Triton for migrant storks.

Raptors

Raptors have a relatively high risk of collision with wind turbines compared to many other bird groups. Because they have a long lifespan and a slow rate of reproduction, increased mortality caused by wind farms can have an influence on population levels.

Raptors crossing the Baltic Sea between Skåne and Germany usually do so in a corridor to the west of Triton, although the birds can drift from this main corridor to some extent, depending on the wind direction. However, relatively few individuals are expected to pass through the Triton wind farm. The risk of collision has been modelled for a number of representative raptor species and the results of the modelled species can be transferred to the other species.

Calculated collision cases for raptors are low with one individual or less per year for the species modelled, with the exception of the sparrowhawk, which is estimated to have two collision cases per year The risk of collision is considered to be insignificant for all raptor species that can be expected to be present in the Triton wind farm.

Red-throated loon and Black-throated loon

Red-throated and Black-throated loons largely avoid flying into wind farms during migration. The influence of collisions is assessed to be insignificant and the impact for migrant loons is deemed to be negligible.

Geese

Populations of geese, for example, greater white-fronted geese and barnacle geese pass through the Arkona Basin in high numbers during migration. Geese have a high degree of avoidance of wind farms and are assessed to only have a few annual collisions with the wind farm. All in all, the impact of collisions at Triton for migrant goose populations is deemed to be negligible.

Eider Duck

Eider ducks pass through the Arkona Basin during migration. Migrant eider avoid flying near offshore wind turbines and therefore have a low risk of collision. The influence risk is considered to be insignificant and the impact of the wind farm negligible.

Tundra swan

The tundra swan has a similar behaviour as geese and eider ducks within wind farms, with clear avoidance behaviour. In addition, the Triton wind farm area is not located along the main migration route for the tundra swan. The influence of collisions is considered to be insignificant and the overall impact is negligible.

Seagulls

Seagulls fly into wind farms more frequently than most other birds, but fly at low altitudes with a relatively low collision risk. The impact of the risk of collision is considered negligible for the seagulls regularly present in the area.

Grey heron

Grey herons often fly at risk altitudes for collisions with wind turbines, but the numbers passing through the Triton wind farm are assessed to be low and the number of collisions very few. The influence of collisions is therefore considered to be insignificant and the impact negligible.

Waders

There are about 25 wader species that can pass through the Triton wind farm during migration. Collision risks were modelled for wood sandpipers and bar-tailed godwits. In general, waders have little risk of collision during migration as they often fly at altitudes greater than the overall height of the wind farms. Overall, the impact is considered to be negligible.

Nightjar

The migration route of the nightjar is mainly concentrated to the east of the Arkona Basin and the number of individuals expected to pass through the wind farm is relatively low. Only a few individuals can be expected to pass through Triton at heights that overlap with the blade sweep area. The impact is therefore deemed to be negligible.

Arctic term

Arctic terns often fly at altitudes below 20 metres, but often fly into wind farms and are subject to a certain collision risk. However, the number of estimated collisions is low and the impact is deemed to be negligible.

Night Migrant Birds

Levels of knowledge about collisions with small night-migratory birds at offshore wind farms is limited, but studies at wind farms in the North Sea and the German Baltic show few collisions in relation to the number of passing birds. Night-migrating birds generally fly at higher altitudes than day-migrating birds. For the Triton wind farm, the collision cases of night-migration birds in a worst-case scenario are estimated to account for about 0.02 ‰ (parts per thousand) of the estimated number of birds passing the Arkona Basin at night during migration in one year The impact of the risk of collision for night-migration birds is considered to be negligible.

Other daytime migrant birds

In relation to the millions of birds passing through Falsterbo (further west) by day, only a fraction migrates over the Arkona Basin during the day. The impact of the risk of collision for daytime migrant birds (except the crane) is considered to be negligible.

Displacement effects

Red-throated loon and Black-throated loon

Red-throated loon have been shown to be sensitive to offshore wind farms as they avoid being in or near the farm. The Triton wind farm is not an important environment for loons because their main food is demersal fish that they can catch in shallower waters. Red-throated loon and, to a lesser extent, Black-throated loon may be found in the area on a random basis and in low numbers. Single individuals may avoid the area, but this is not considered to affect the population development of the species. The influence is therefore deemed to be insignificant and the impact to be negligible.

Common murre and razorbill

The site of Triton wind farm is considered to be of limited importance for common murre and razorbill, with low observed numbers. A certain displacement of the auks cannot be ruled out at the wind farm. However, the effect of displacement has proved to be variable between areas and there is also a lack of studies of displacement in wind farms with the large distances between the wind turbines that is intended at Triton. The distance between wind turbines within a wind farm is likely to be of importance for the extent of any displacement effect. However, the impact is assessed on the basis of a worst-case scenario; if the auks were not to use the Triton wind farm area at all after it had been built, this would involve the displacement of about one per thousand (‰) of the Baltic Sea stock of auks.

The fact that a displacement is not automatically an effect in the form of increased difficulties in finding food, with the risk of increased mortality among displaced individuals or those who may have to compete with the displaced individuals. The influence is assessed to be insignificant and the overall impact is deemed to be negligible.

Eider ducks, common scoters and long-tailed ducks

Eider ducks, common scoters and long-tailed ducks feed in shallow waters and are only found temporarily within the Triton wind farm. The impact displacement effects on these species is considered to be negligible as they do not forage in the area.

Seagulls

The assessment is that seagulls will very rarely avoid flying through the Triton wind farm so that the displacement effect will be insignificant with negligible impact.

Barrier effects

The effects on sea birds may occur either during migration or in connection with foraging sites. Migratory sea fowl often adjust their flight course to fly around offshore wind farms. Eider ducks have also been observed flying between the rows of wind turbines within the wind farm. The additional flight distance caused by a detour around the Triton wind farm during migration is irrelevant in relation to the total distance that the birds fly between breeding areas and overwintering sites. During migration, for example, weather conditions have a greater impact, because wind drift can mean considerably longer flight distances.

The farm area is not located in an area with significant daily movements of birds, so that the impact of barrier effects is considered negligible for sea fowl in the area.

Obstruction marking

As mentioned above, wind turbines will need to carry obstruction marking. For regulations on obstruction marking, see 7.5.2.

It has been reported that birds crossing the open sea are attracted to sources of light such as lighthouses, coastal buildings and oil platforms and this poses a collision risk. Migration of birds across open sea is energy-intensive and birds with low energy reserves that are attracted to illuminated structures can get caught up in circling movements and experience further exhaustion (Jones, 1980).

Several studies indicate that the risk of collision is lower for the birds that migrate at night (Welcker, etc.) 2017). Some nights with high migration activity and bad weather conditions, such as fog and poor visibility, could probably increase the risk of collision for migratory birds. Fijn et al. (2012), Welcker et al. (2017) and Welcker & Vilela (2019) consider, however, that such weather conditions, i.e. large numbers of migratory birds and fog/poor visibility at the same time, to be rare. Obstruction lighting on wind turbines did not involve more collisions of night-migrating birds than at turbines without such lighting, according to a study of onshore wind farms in North America (Kerlinger, et al.) 2010). It seems that flashing lights involve a lower risk of collision than a steady light, and a red light seems to attract fewer birds than a white light (Gehring et al. 2009, Rebke et al. 2019).

Based on published studies of wind turbine obstruction lighting and its effects on birds, it is not likely that mass death phenomena detected at extreme light sources may occur for wind turbine obstruction lighting. In order to reduce collision risks, light minimisation can be conducted to the extent the Swedish Transport Agency's regulations permit.

Decommissioning phase

Collision risks

During the decommissioning phase, the wind turbines will be taken out of operation and dismantled one at a time. The impact of collision risk for birds during the decommissioning phase is considered to be negligible.

Displacement effects

During the wind farm's decommissioning phase, maritime activities will mean some displacement from the wind farm area. These activities are time-limited and localised to certain parts of the wind farm. These are thus deemed to have a negligible influence on the birds.

Barrier effects

The barrier effects are assessed to be negligible even when the wind farm is in operation, but the risk reduces as the wind farm covers an increasingly smaller area when the wind turbines are dismantled. All in all, barrier effects are deemed to be negligible during the decommissioning phase.

Table 61. Summary of assessed species and species groups of birds, influence factors, sensitivity and impacts (R.6).

Recipients	Phase	Influence factor	Recipient sensitivity	Size and extent of the influence	Impact
Birds: summer	Construction	Displacement	Small	Insignificant	Negligible
Birds: winter	Construction	Displacement	Small	Insignificant	Negligible
Birds	Construction	Risk of collision	Small	Insignificant	Negligible
Birds	Construction	Barrier effects	Small	Insignificant	Negligible
Seafowl	Operation	Risk of collision	Small	Insignificant	Negligible
Cranes: without mitigatory measures	Operation	Risk of collision	Small	Moderate	Small
Cranes: with mitigatory measures	Operation	Risk of collision	Small	Insignificant	Negligible
White stork	Operation	Risk of collision	High	Insignificant	Negligible
Grey heron	Operation	Risk of collision	Small	Insignificant	Negligible
Raptors	Operation	Risk of collision	Moderate	Insignificant	Negligible
Red-throated loon and Black-throated loon	Operation	Risk of collision	Small	Insignificant	Negligible
Geese	Operation	Risk of collision	Small	Insignificant	Negligible
Tundra swan	Operation	Risk of collision	Small	Insignificant	Negligible
Eider Duck	Operation	Risk of collision	Small	Insignificant	Negligible
Seagulls	Operation	Risk of collision	Small	Insignificant	Negligible
Waders	Operation	Risk of collision	Small	Insignificant	Negligible
Arctic term	Operation	Risk of collision	Small	Insignificant	Negligible
Nightjar	Operation	Risk of collision	Small	Insignificant	Negligible
Night Migrant Birds	Operation	Risk of collision	Small	Insignificant	Negligible
Day Migrant Birds	Operation	Risk of collision	Small	Insignificant	Negligible
Black-throated loon	Operation	Displacement	Small	Insignificant	Negligible
Red-throated loon	Operation	Displacement	Moderate	Insignificant	Negligible
Common murre and razorbill	Operation	Displacement	Small	Insignificant	Negligible
Eider Duck	Operation	Displacement	Small	Insignificant	Negligible
Seagulls	Operation	Displacement	Small	Insignificant	Negligible
Seafowl: overwintering	Operation	Barrier effects	Small	Insignificant	Grey heron
Seafowl: migratory	Operation	Barrier effects	Small	Insignificant	Negligible
Birds	Decommissioning	Risk of collision	Small	Insignificant	Negligible
Birds	Decommissioning	Displacement	Small	Insignificant	Negligible
Birds	Decommissioning	Barrier effects	Small	Insignificant	Negligible

7.6.3 Continued work and mitigatory measures

As described above, the Triton wind farm is expected to have a minor impact on cranes during the wind farm's operating phase. It is during the cranes' intensive migration period that a certain influence may arise as a result of the increased collision risk and, mitigatory measures will be applied in order to minimise the impact on migratory cranes. Operation of the turbines will be adapted in order to reduce the impact on migratory cranes at the Triton wind farm. Operation will be adapted in cases of particularly high migration activity and during weather conditions associated with higher risk of collisions by lowering the rotor speed or shutting down the turbines. Such situations are expected to occur on only a few days in a year, at most five days in the spring and three days in the autumn, and can be identified by radar in the wind farm and possibly also by birdwatchers, or with the development of models and technologies that analyse weather conditions for a wider geographical area. Based on these assumptions, the assessment is that operational regulation may be needed for a total of 80 hours (R.6).

Operational regulation can either mean a reduced rotor speed on one or more turbines or a temporary shutdown of all or part of the wind farm. Studies have shown that a total shutdown will rarely be necessary. Control of the rotation speed has proved to be an effective measure in reducing the risk of collision. Control of the rotation speed has proved to be an effective measure in reducing the risk of collision. Under the proposed conditions of operation, the wind farm must be equipped with detection and operational control equipment to avoid the risk of collision with migrant cranes during the most intensive spring and autumn migration period. Operational control of wind turbines would need to be applied for a maximum of 100 hours per turbine per year This is considered to be the case when the majority of the cranes passage through the Arkona Basin lies west of Triton and migration is typically concentrated to fewer than ten days and accumulated to over a few hours on high intensity days. According to estimates and recommendations, it is clear that day-time regulation will be required for a total of 80 hours per turbine per year and that this is considered an effective mitigatory measure for migrating cranes (R.6). The mitigatory measures proposed as a condition therefore constitute additional precautionary measures and are considered to be well-founded.

The activities will also have a survey programme in which radar surveys, bird observations, etc. are conducted to investigate the patterns of movement of migratory cranes and the degree of avoidance in the area of activity and the impact of the wind farm, including the effect of, for example, reduced rotor speed. The survey programme is proposed developed in consultation with the Swedish Environmental Protection Agency and the Skåne County Administrative Board.

With operational control of wind turbines during days with a high crane migration intensity, the risk of collision of migratory cranes is significantly reduced even if it is not completely eliminated. However, it is deemed sufficient to minimise the impacts and to ensure that the provisions of the EU Birds Directive are complied with. Operational regulation can ensure that the Triton wind farm will not intentionally cause a collision risk for birds and/or cause disturbance during their migration periods, and that no impact will occur on the crane population. These safeguards are designed to ensure that the impact for cranes is negligible.

7.6.4 Summary of transboundary impacts

Sweden is a Member of the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals, CMS). The Bonn Convention is a global environmental convention for the protection of migratory species of wild fauna, their habitats and migratory routes. The parties to the convention must promote and jointly support proposals for the protection and care of migratory species.

The study conducted for birds in the area shows that there are negligible impacts on all species except cranes, where there is little impact without mitigatory measures and negligible impacts with mitigatory measures. The study shows that cranes are at greatest risk of being influenced during the spring and autumn migrations. Mitigatory measures in the form of equipment for the detection of cranes will be used and the influence of the established wind farm will be followed up in a survey programme. The wind farm will also be equipped with operational control equipment. The study conducted on the impact of the project on cranes shows, as stated above, that the impact on cranes is negligible to when the planned mitigatory measures are applied.

The identified bird species in the neighbouring Danish, Polish and German Natura 2000 sites and bird protection areas are not considered to be affected by the Triton wind farm because the area is not used as a foraging area for the identified species. The size and extent of the influence on migration is considered to be insignificant and the consequence is therefore negligible.

7.7 Landscape and heritage environment

Total impact assessment

Photo montages have been made from three representative, coastal viewpoints on Bornholm: Rønne, Hasle and Hammershus in order to assess the transboundary impact on landscape scenery. The distance between the viewpoint and the nearest wind turbines is approximately 38 kilometres at Rønne and at most about 42 kilometres at Hammershus. The wind farm is visible from all three viewpoints. At Rønne, the wind farm will be seen in a relatively narrow sector on the horizon and will be seen as a single group. At Hasle the Triton wind farm will be visible over the horizon in the west. A slightly larger part of the wind farm will be visible from Hammershus, reinforcing the impression, as the viewer is over 70 metres above sea level compared to views from viewpoints at similar horizontal distances with an eye level only a few metres above sea level. At Rønne the influence is deemed to be insignificant and the impacts on the landscape and heritage environment negligible, at Hasle the influence is assessed to be small and the impacts very small and at Hammershus the influence is deemed to be small and the impacts moderate. However, wind turbines as a group within a limited sector are still assessed to be minuscule in the vast seascape.

The assessment of the visual influence of the wind power development on the seascape and the heritage environment is based on photo montages that simulate the future view from three representative, coastal viewpoints on Bornholm. Three viewpoints on Bornholm, from Rønne, Hasle and Hammershus, have been chosen to visualise the change that future wind power expansion will bring to the seascape. The eye height of the viewer varies from about two metres above sea level (Rønne) up to over 70 metres above sea level (Hammarshus). The distance between the viewpoint and the closest wind farm is shortest (38 km) at Rønne and approx. 42 kilometres at Hammershus.

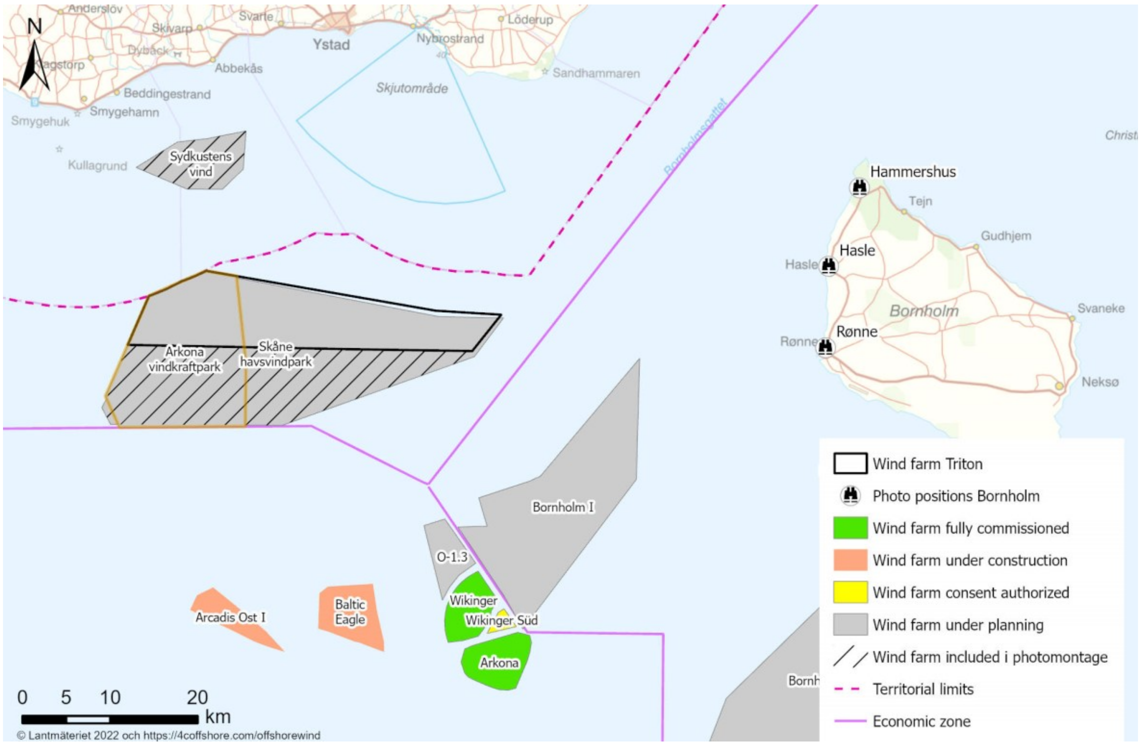


Figure 52. Photo points on Bornholm.

7.7.1 Rønne

Rønne is Bornholm's largest town and logistical destination for passenger transport to and from the island. A viewpoint at Nordre kystvej, to the north of the town centre, has been chosen as a viewpoint because the port facilities and ferry terminal would largely obscure the view towards the wind turbines from a viewpoint in the centre of the town.

The Triton wind farm will be visible from the selected viewpoint at Rønne, see Figure 53. The wind farm, however, will be seen in a relatively narrow sector on the horizon and will be seen as a single group. Port facilities and ship traffic to and from the port of Rønne create both static and moving elements in the seascape to which the eye is drawn. These elements in the foreground and the distance (about 40 km kilometre to the wind farm) contribute to the wind farm being insignificant in the seascape.

All in all, the influence is estimated to be insignificant and the impacts on the seascape and the heritage environment negligible.

Figure 53. Photo montage with the Triton wind farm. The turbines are marked by icons. See the same montage in larger format in Appendix B.2.

7.7.2 Hasle

At Hasle, the selected viewpoint is located west of the roundabout at the junction of Strandvejen and Bykaervejen with a view of Hasle harbour to the west.

The Triton wind farm will be visible over the horizon in the west and can be seen both from seaside areas of Hasle along the street running parallel to the shoreline, Strandgade, and from certain open areas further the inland as the terrain rises in the east.

The huge, open seascape is characterised by groynes and low, terraced buildings, but there are otherwise no major landscape elements and landmarks. The Triton wind farm is still considered to be subordinate to the seascape because the farm is perceived as a single group, see Figure 54. The distance between Hasle and the nearest turbines is about 40 kilometres. All in all, the influence isdeemed to be small and the impacts for the seascape and heritage environment are very small.

Figure 54. Photo montage of the Triton wind farm from Hasle. The farm's turbines are marked by icons. See the same montage in larger format in Appendix B.2.

7.7.3 Hammershus

The viewpoint is located on the north-west end of Bornholm on the Hammeren peninsula, at the Hammershus castle ruins.

The Triton wind farm will be visible from the selected viewpoint near Hammershus see Figure 55. A slightly larger part of the wind farm will be visible, reinforcing the impression, as the viewer is over 70 metres above sea level compared to views from viewpoints at similar horizontal distances with an eye level only a few metres above sea level. Distance to the nearest wind turbine is more than 40 kilometres. The fortress ruins dominate, while the wind turbines are seen in the background along the horizon. The varied topography of the area helps to provide a variety of views and the horizon is partly obscured by vegetation. The experience of the wind turbines is probably seen somewhat more clearly from the beach because no buildings stand between the viewer and the open sea. However, wind turbines as a group within a limited sector are still assessed to be minuscule in the vast seascape. All in all, the influence on the area’s high heritage values and landscapes is deemed to be only slightly negative and the impacts moderate.

Figure 55. Photo montage of the Triton wind farm from Hammershus. The turbines are marked by icons. See the same montage in larger format in Appendix B.2.

7.8 Accommodation and recreation

Total impact assessment

The Triton wind farm is located so far out at sea that sound levels are calculated to be below the Swedish Environmental Protection Agency’s guideline values 40dB(A) and 35 dB(A), respectively, for residential and outdoor areas by a large margin. No influence is therefore expected to occur on any nearby residential or outdoor areas. The distance to the coasts and the fact that the 30 dB(a) level of Triton is far away from the closest coastline means that there will be no low frequency noise risk for those living on the coast. The wind farm is not located in an area of high value for outdoor activities and recreation, but recreational boat traffic, recreational fishing and diving does take place in the area.

During the construction and decommissioning phase, recreational fishing and divers will not, for safety reasons, be allowed to use certain areas in which work is taking place. This has only a temporary influence and will not involve the whole farm area at the same time, so the impacts are deemed to be small. During the operational phase, the area will be available for recreational fishing and diving again and the reef effect can then have a positive impact on these interests. This also applies to transboundary recreational fishing in the area.

7.8.1 Preconditions

Residential environment, noise

When operating, wind turbines emit two types of noise; mechanical and aerodynamic. In modern wind turbines, mechanical noise has been largely reduced by insulating the nacelle and mounting the gearbox on elastic fittings. The aerodynamic noise makes up the dominant part of the sound from a wind turbine and is caused by the passage of the rotor blades through the air. Noise levels decay in line with the distance from the turbines. The audibility and spread of the noise depends also on meteorological conditions, mainly wind speed, humidity and air temperature. In addition, sound propagation is affected by surface absorption, in which water is acoustically hard, which means that the absorption is less over the sea compared to over land.

The Triton wind farm is located far enough at sea that the acoustic level is determined not to exceed the Swedish Environmental Protection Agency´s reference value for residential areas and natural habitats, 40dB(A) and 35 dB(A), respectively, with a great margin for a worst case scenario (Figure 24). No influence is therefore expected to occur on any nearby residential or outdoor areas.

The Danish shows method also that the A-weighted equivalent sound level guideline values, 39 dB(a) and 37 dB(a) respectively, do not reach any coast (Figure 25).

Leisure

Recreational fishing is defined as fishing that does not require a commercial fishing license and therefore catches are prohibited from being sold (County Administrative Board, 2020). In the planned farm area there are currently local companies and activities that engage in scuba diving and fishing from leisure craft. These operations are ongoing throughout the year, on average, a leisure craft business visits the planned wind farm area about twice a month, although it is somewhat more frequent in the summer. The main focus of their fishing is on cod, salmon and trout (R.8).

In general, recreational fishing is at its peak in May–June on the southern coast of Sweden (Agency for Marine and Water Management, 2019b). Most of the recreational fishing on the south coast is conducted with hand gear, for example with a rod or a jig. Spinner fishing gear predominates, and in 2017 accounted for 46% of all coastal and offshore recreational fishing. The cod stocks in this part of the Baltic Sea consist of fish from both western and eastern stocks (see Chapter 7.3 on fish) (ICES, 2020a; Hüssy et al., 2016). When the Triton wind farm has been built, any wrecks will be left untouched in the area by surveying and avoiding them, so they are not affected by the construction. When the foundations of the wind farm have been built, they too will become artificial reefs in the same way as the wrecks, leading to positive effects in the way of increased biomass of fish and the promotion of more species (Langhammer, 2012). The wind turbine foundations can thus increase biodiversity in the area through a so-called reef effect. It is widely recognised that structures such as oil platforms, wind turbines and wrecks increase the number of fish (Methratta et al., 2019; Ajemain et al., 2015; Claisse et al., 2014).

The area of activity is located far out at sea, so other traffic with leisure craft is likely to be very limited.

Table 62. Potential influence factors on residential areas and leisure that occur during the different phases of the wind farm.

Influence factor	Construction phase:	Operational phase	Decommissioning phase
Impact of noise on residential areas	-	-	-
Impact on recreation and outdoor activities	x	x	x

7.8.2 Impacts

Construction phase:

Residential environment, noise

The Triton wind farm is so far from land that the 40 dB(A) guideline is complied with a good margin. The influence of wind farm noise is not expected to have any impacts on residences during any phase of the wind farm's life. The distance to the coast and the fact that the 30 dB(a) level of Triton is far away from the coast means that there will be no low frequency noise risk for close residents. Nor is it considered that construction of the inter-array will have any influence from noise.

Leisure

During the construction phase, boat traffic and fishing in the affected part of the farm area will be affected by temporary safety zones established during that phase for safety reasons. Recreational opportunities and accessibility within the area of activity will therefore be adversely affected during the periods in which construction is ongoing.

The impact is expected to be slightly negative during the construction phase, because safety zones are introduced in the farm area for one part at a time and for a limited period, and recreational fishing is deemed to have the option of choosing other fishing and diving areas during that period.

Table 63. Estimated impact on leisure during the construction phase.

Influence factor	Recipient sensitivity/value	Size and extent of the influence	Impact
Temporarily reduced availability for boat traffic in the farm area.	Small	Very small	Slightly negative

Operational phase

During the operational period, boat traffic and fishing will be allowed within the wind farm. The reef effect from the foundations after the establishment of the Triton wind farm is expected to have a positive impact on recreational fishing activities in the area, and for diving, because the conditions for increased biomass and several new species should make the area more attractive.

The inter-array is laid under the seabed and is not considered as such to have any influence on recreational fishing.

The impact is expected to be slightly positive during the operational phase, because turbine foundations in the wind farm create an artificial reef effect throughout the entire operating period, about 40–45 years.

Table 64. Estimated impact on leisure during the operational phase.

Influence factor	Recipient sensitivity/value	Size and extent of the influence	Impact
Reef effect from foundations.	Moderate	Small	Slightly positive

Decommissioning phase

During the decommissioning phase, boat traffic and fishing in the farm area will be affected by temporary safety zones established during that phase for safety reasons. Recreational opportunities will therefore be adversely affected during the decommissioning period.

The impact is expected to be slightly negative during the decommissioning phase, because safety zones are introduced in the farm area for one part at a time and for a limited period, and recreational fishing and divers are deemed to have the option of choosing other fishing and diving areas during that period.

Table 65. Estimated impact on leisure during the operational phase.

Influence factor	Recipient sensitivity/value	Size and extent of the influence	Impact
Temporarily reduced availability for boat traffic in the farm area.	Small	Very small	Slightly negative

7.8.3 Summary of transboundary impacts

As is shown in the study conducted for the project, there will be no application for a fishing ban or an access ban in the farm area except for a safety distance around turbines and work areas. During the construction and decommissioning phase, recreational fishing and divers will not, for safety reasons, be excluded from specific areas in which work is taking place. This has only a temporary influence and will not involve the whole farm area at the same time. The operating phase is therefore not expected to impose any restrictions on recreational fishing apart from the safety distances that will be established directly around the turbines and the influence is therefore considered to be insignificant with negligible impact. This also applies to transboundary recreational fishing in the area.

The influence of wind farm noise is not expected to have any impacts on residences during any phase of the wind farm's life.

7.9 Commercial fishing

Total impact assessment

The assessment is based on a worst-case scenario, which involves bottom trawling being completely stopped in the wind farm while pelagic trawling is expected to continue within the farm area, with certain adjustments. However, bottom trawling makes up a small part of total catches in the area and is deemed to be extremely capable of geographic relocation.

Fishing in the area has declined sharply in recent years, and there is also a ban on both fishing for both cod and herring. The area is also not designated as a national interest area for commercial fishing nor a designated area for commercial fishing in the marine spatial plan. The farm area is currently deemed to have less significant value for the fishing industry.

Transboundary fishing from Poland, Denmark and Germany may be affected by the fact that a reduced catch area is created in the area of activity when the wind farm is established.

The local impact caused by the wind farm in the form of reduced surface area available for bottom trawling is currently considered to have very little impact on the commercial fishing industry. In addition, additional reef effects and reduced fishing pressure could, in the long term, improve the status of stocks of commercially important fish species, which in the long term also benefits the fishing industry. With future changes in quotas, the assessment may change, but given the population status of commercially important species such as herring and cod, it is likely that the past and current trend of restrictive quotas will continue.

The fishing industry can be affected by the wind farm during the construction and decommissioning phase, since for safety reasons it will not be able to specific sub-areas related to work areas.

The influence on commercial fishing for Sweden, Germany, Poland and Denmark is assessed to be slightly negative and the impact isdeemed to be very small. In a worst-case scenario, Swedish, Polish, German and Danish fishing activities conducted within the wind farm will need to be redistributed and conducted in other areas.

7.9.1 Preconditions

This section describes the occurrence and assessed influence and impact of the operations on commercial fishing and summarises reference report R.8 ”*Commercial and recreational fishing in the south-west Baltic Sea*”.

Methodology for assessing the impact on commercial fishing

Geographic scale

In order to examine and describe the impact of planned wind farms on commercial fishing, analysis has used three different geographical scales:

- The large area covering the southern Baltic, that is, ICES sub-area 27.3.D.24 (Figure 56);
- Regional for Triton’s surrounding geographic ICES areas 38G3, 38G4, 39G3 and 39G4, and

- locally within the Triton wind farm area.

This makes it possible to compare the commercial fishing in the Southern Baltic as a whole with the local fishing around and within Triton.

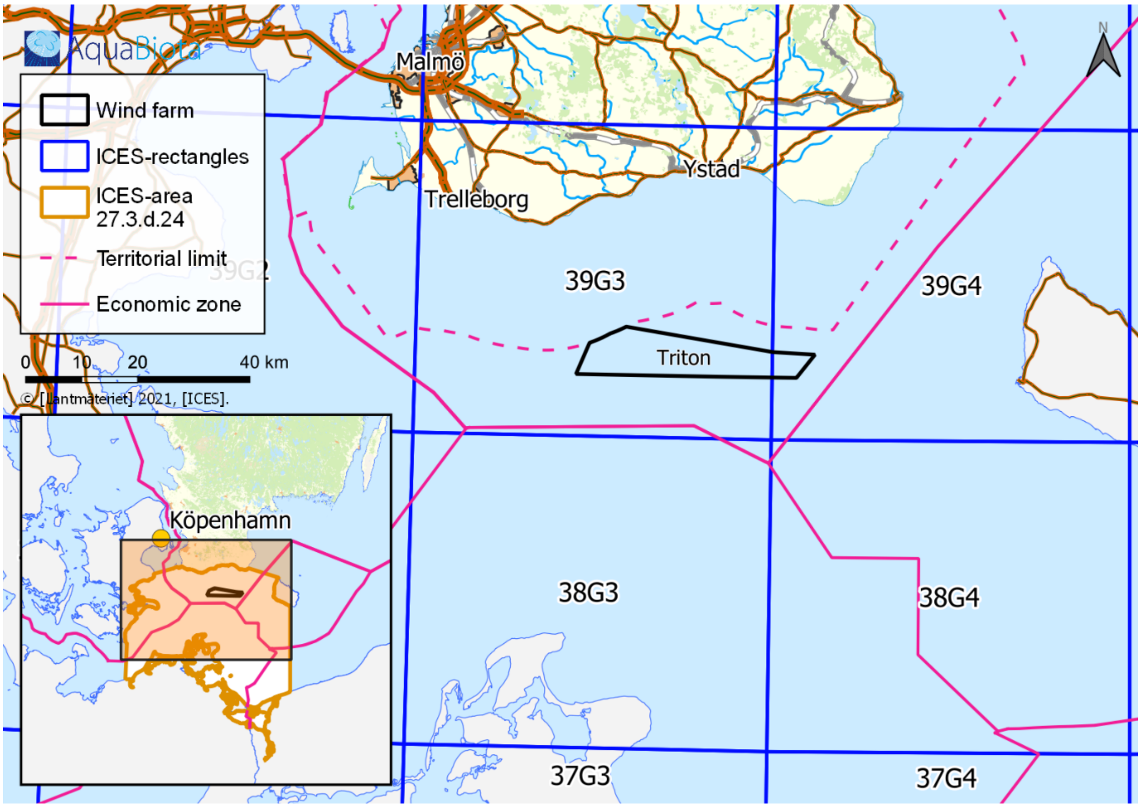


Figure 56. Triton wind farm, the Swedish territorial border and Economic Zone, ICES boxes (39G3, 39G4, 38G3, 38G4) and sub area (27.3.d.24) included in the analysis.

The time period for the survey varies between the different geographical scales:

- ICES sub-area 27.3.D.24 was studied between 2015 and 2019.
- German fishing in ICES boxes (39G3, 39G4, 38G3 and 38G4) was studied in 2009-2020.
- Swedish fishing in the local farm area was studied in 2009–2020.
- Danish fishing in the local farm area was studied between 2010 and 2020.
- Polish fishing in the local farm area was studied between 2009 and 2019.

The comparison between the countries was made between 2011 and 2019. The reason for the different scales is, in particular, that different types of information can be extracted from the scales' data. For example, the fishing method for local fishing in the farm area is not indicated, but it could be analysed in the study of the ICES sub-area 27.3.D.24. If one assumes that fishing for commercial species takes place in the same way throughout the Baltic Sea, the method used for fishing, the size of the boat and the season for local fishing can be derived from the rough breakup. The assumption is that specific species are to a large extent fished using similar methods and fishing gear. Sprat and herring are examples of this, as pelagic trawling is by far the most common method, regardless of nation.

It is important to mention that some catch data did not contain related geographical information because small fishing boats (less than 12 metres) are not equipped with the technology required for any vessel monitoring system (VMS). This applies to all EU-registered boats. It is therefore likely that a small proportion of the catch in the area has not been included in the analysis for countries fishing locally at and within the Triton wind farm area.

Available catch data

The study and impact assessment are based on known facts and data concerning commercial fishing.

The main documentation for the survey is the EU fisheries database (Fisheries Dependent Information, FDI) (Gibin & Zanzi, 2020) and Agency for Marine and Water Management's catch data for commercial fishing (Agency for Marine and Water Management, 2020). Catch data from the commercial fishing activities of Denmark, Germany and Poland in the farm area were provided by the Danish Fisheries Administration (Fiskeristyrelsen DK, 2021), the German Federal Office for Agriculture and Food, BLE (2021) and the Polish National Marine Fisheries Research Institute–PIB (2021). The data presented is estimated to provide comprehensive information on the fisheries sector from the nations that account for the majority of commercial landings from the Triton wind farm area.

In order to get a picture of commercial fishing in the area of the planned wind park, we have calculated the fishing pressure on the main commercial species, based on the commercial catch data from the Agency for Marine and Water Management for the period 2009-2019. This gives information on the weight in tonnes of Swedish catches from in and around the farm area. Catch data has been summarised for the period by species and reporting location. After being summarised, the region's catch data has been interpolated using multivariate interpolation, where unknown points are assigned values based on a weighted average from the known points.

Assessment methodology

In order to assess the impact of wind power establishment on commercial fishing, the effects of the planned establishment are compared with a zero alternative, see below.

The size and extent of the influence is based on the scenario that is expected to have the greatest influence, a so-called worst-case scenario. The worst-case scenario for commercial fishing is that no bottom trawling will be possible in the farm area during the construction phase. Commercial bottom trawl fishing in wind farms is subject to safety risks as fishing gear could be caught and/or damaged by erosion protection and inter-array cables. The worst-case assessment has also assumed that different parts of the farm will have to be blocked off at different periods in the construction and decommissioning phases in order to establish a safety distance from work in progress, and that fishing will not be possible within the safety distance during these periods. In addition, the assessment has been based on the assumption that during the operational phase, certain safety distances will have to be established around foundations within which fishing cannot take place, but that pelagic trawling and fishing with passive gear will be able to be conducted in the wind farm during the entire operational phase. This assessment is based on the large distance between the foundations (1 200–2,380 metres) which will allow fishing to be continued using these methods.

Fishing in the Baltic Sea south of Skåne

The project area is located in the Arkona Sea, which is part of Area 24 as defined by the marine research body, the International Council for the Exploration of the Sea (ICES) (Figure 56). This extends from the Danish Straits in the west to Bornholm in the east. The water depth in the farm area varies between 43-47 metres Common species of fish in the sea area are herring, sprat, cod and various species of flatfish. The sea area has a long history of fishing, where herring and cod, in particular, have played an important role.

The wind farm area is not a national interest area for commercial fishing nor a designated area for commercial fishing in the marine spatial plan. The national interest area for commercial fishing is located on the north side of the farm, off the Skåne coast (Figure 57).

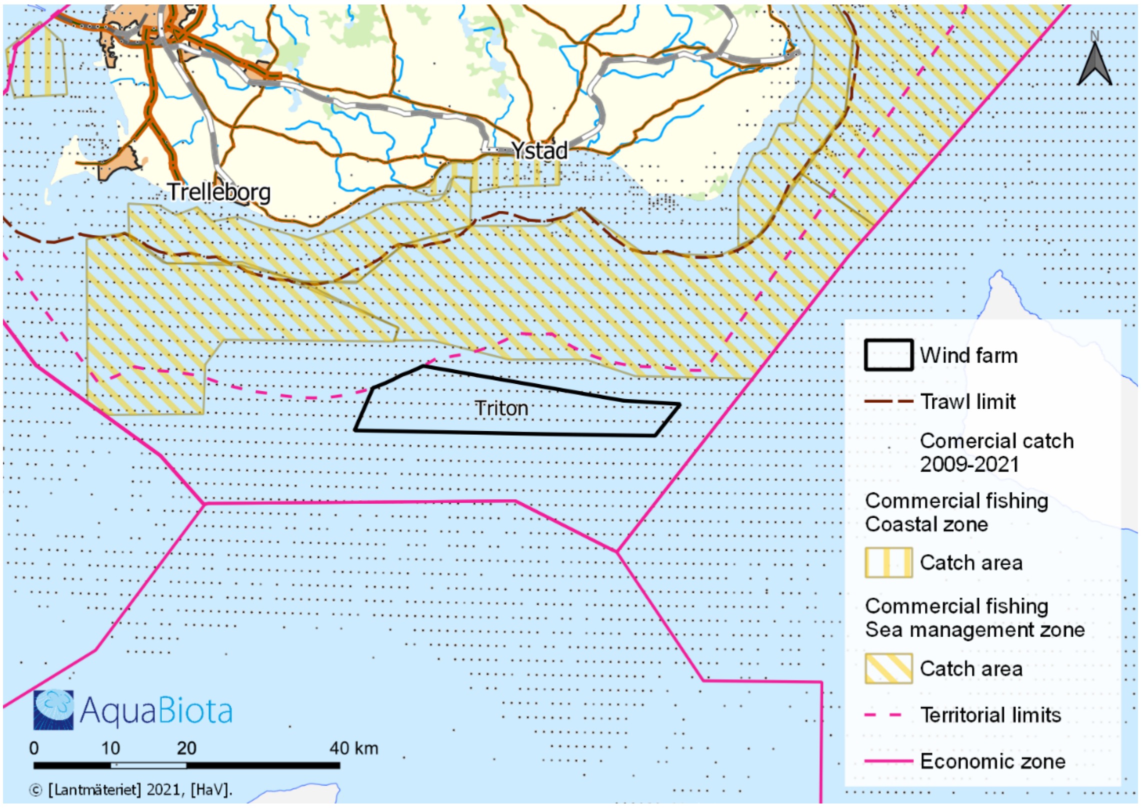


Figure 57. The position of Triton in relation to national areas of interest for fisheries (the Agency for Marine and Water Management 2022), Natura 2000 sites and trawler borders four nautical miles from the coast (within which trawling is prohibited).

Fishing quotas and pressure within ICES boxes

Fishing quotas are allocated by the EU through the Common Fisheries Policy (CFP). The quotas are determined in consultation with ICES, an intergovernmental research institute which, among other things, manages the natural fishery resources in northern Europe through its body, the *Fisheries Resources Steering Group* (FRSG) (2016). Consultations are also held with *the Scientific, Technical and Economic Committee for Fisheries* (STECF), the EU Fisheries Committee.

The fishing quotas concern sub-areas of the Baltic Sea, in this case ICES sub-areas 27.3.D.22-24 as shown in Figure 58 (Agency for Marine and Water Management, 2016). Fishing is also regulated by rules on closed seasons, fishing-free areas and bans on fishing gear (Bergenius et al., 2018).

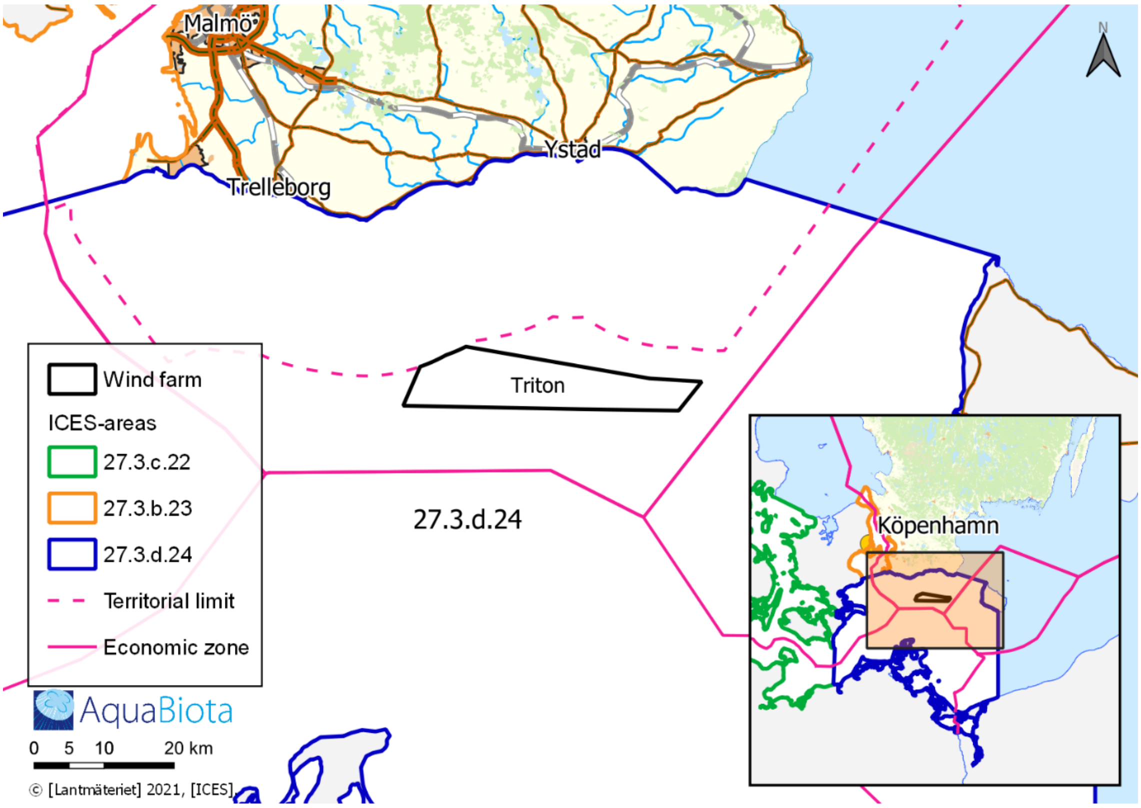


Figure 58. Triton's location in ICES sub-area 27.3.D.24 and ICES sub-areas 27.3.D.22-23.

The fishing quotas for herring, cod and sprat for the years 2012-2022 are shown in charts (Figure 59, Figure 60 and Figure 61). Please note that the fishing quotas for herring and cod apply to the western Baltic Sea (sub-areas 27.3.D.22-24) and the sprat quotas apply to the whole Baltic Sea. The quotas for herring have been substantially reduced since 2017 and targeted fishing for herring in 2022 in the Western Baltic is now being stopped (Figure 59).

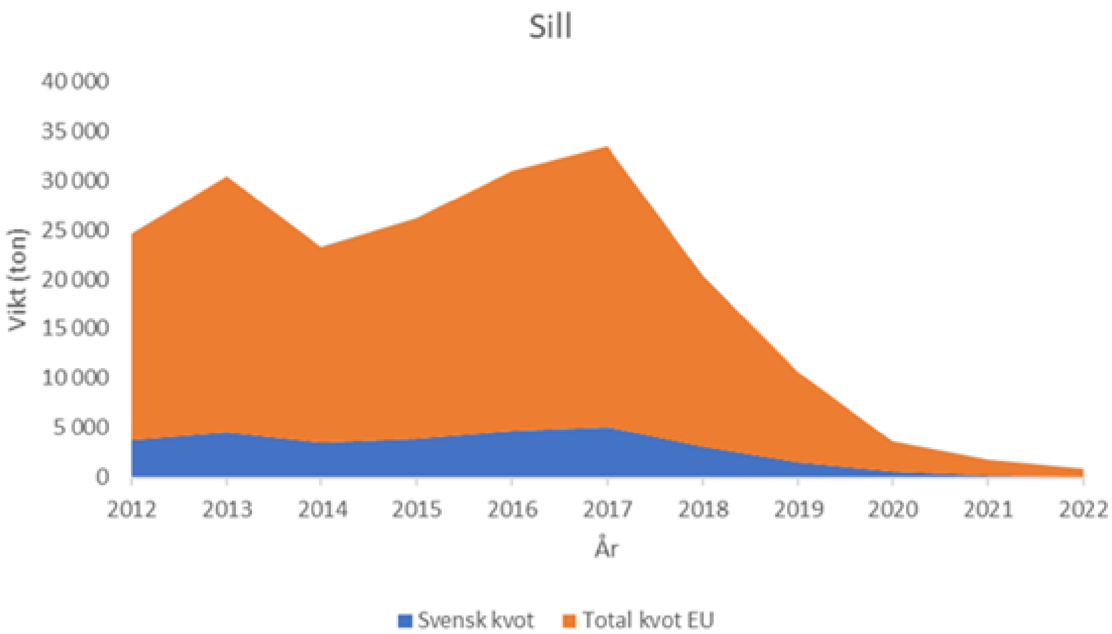


Figure 59. Swedish fishing quota for herring in relation to the overall EU quota in the Western Baltic Sea (27.3.D. 22 – 24).

The quotas for cod fishing have been reduced since 2012 with only a temporary increase in 2019, which is now only made up of bycatch quotas, see Figure 60. In 2022, all fishing for cod in the Baltic Sea will be stopped. Targeted fishing for the eastern stock has been stopped since 2019 and in 2022 fishing bans will also be imposed on the western stock.

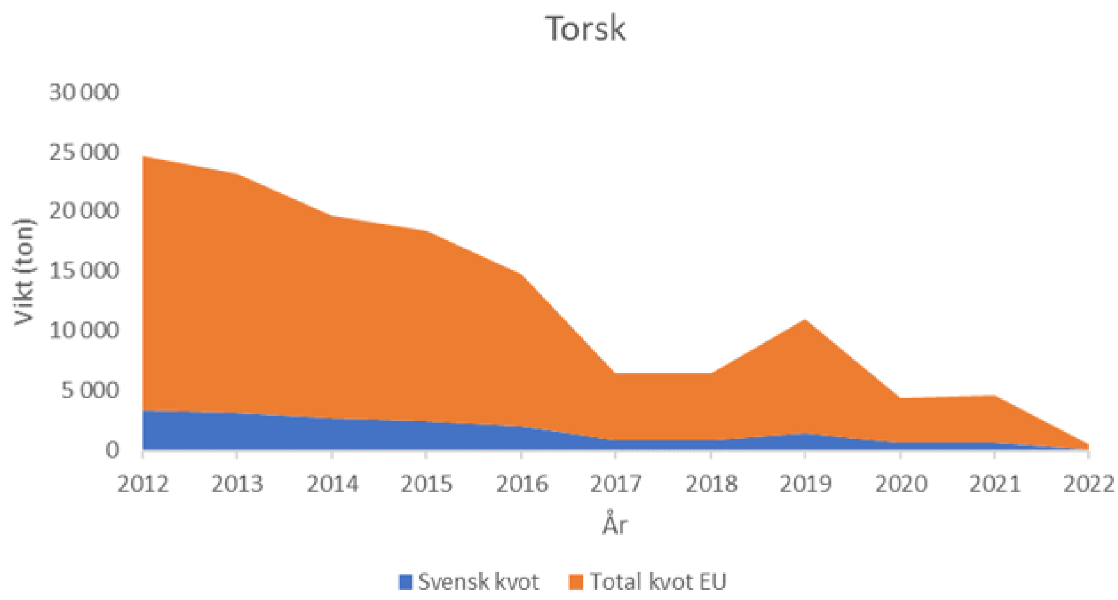


Figure 60. Swedish fishing quota for cod in relation to the overall EU quota in the Western Baltic Sea (27.3.D. 22 – 24).

At present, the sprat stock is considered to be above the authorised fishing range, but the fishing mortality rate is considered to be too high according to the ICES recommendation report (ICES, 2020b). However, for 2022, the sprat quota is increased by 13%, see Figure 61. Sprat mainly goes to the processing industry, which uses this catch for fish meal for animal consumption (76% of the catch in 2020).

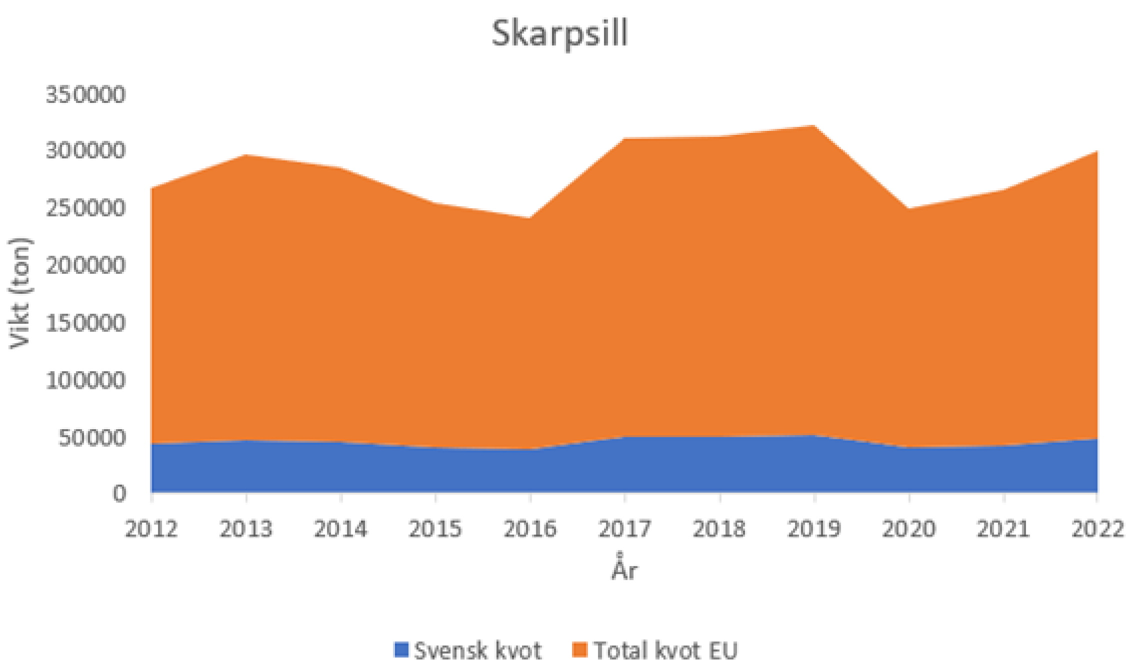


Figure 61. Swedish fishing quota for sprat in relation to the overall EU quota in the entire Baltic Sea 2012 – 2022.

Swedish fishing pressure on sprat during the years 2009–2019 has been modelled, see Figure 59. There seem to have been very low levels of fishing for sprat with Swedish fishing boats in the wind farm area during the years of the survey.

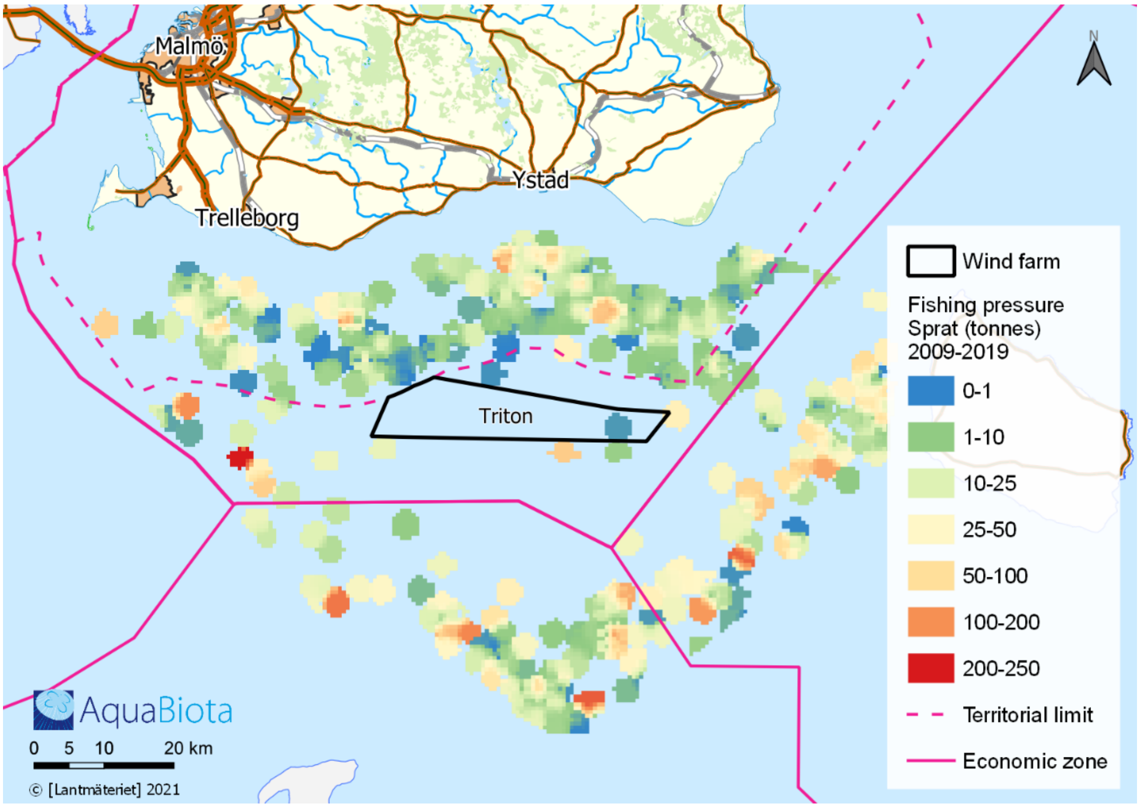


Figure 62. Aggregated Swedish fishing pressure in tonnes for sprat in the period 2009–2019. The values are based on the period's total catch value aggregated per reporting point (Swedish Agency for Marine and Water Management 2020).

Swedish fishing pressure on flatfish during the years 2009–2019 has been modelled, see Figure 63. Fishing for flatfish (plaice, flounder and turbot) is more intense closer to the coast. Demersal fishing, that is, fishing for species that live on or near the bottom, is often conducted by small and medium-sized boats.

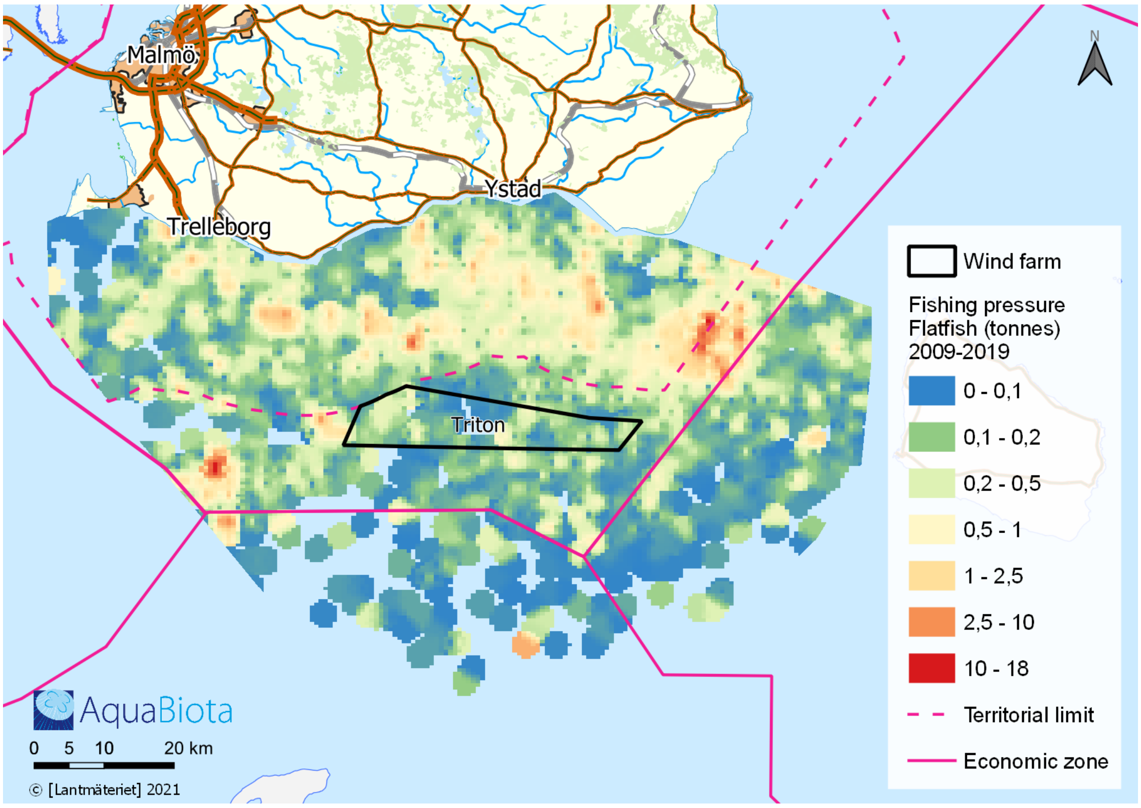


Figure 63. Aggregated Swedish fishing pressure in tonnes for flatfish in the period 2009– 2019 (Agency for Marine and Water Management] 2020). The values are based on the period's total catch value aggregated per reporting point. The model illustrates the combined pressure of fishing for plaice, flounder and turbot.

Fishing in the wind farm area

Mainly Germany, Poland, Sweden and Denmark fish in the wind farm area. Of Poland, Sweden and Denmark, Poland accounted for about 87% of the total catch in 2019 (see Figure 64), which was dominated by herring and sprat. Catches within the planned wind farm area are dominated by pelagic trawling. In total, some 287 tonnes (by Poland, Sweden and Denmark) were landed from the planned wind farm area in 2019, which represents approximately 1.3 % of the total fishing in ICES boxes 38G3, 38G4, 39G3 and 39G4 that year.

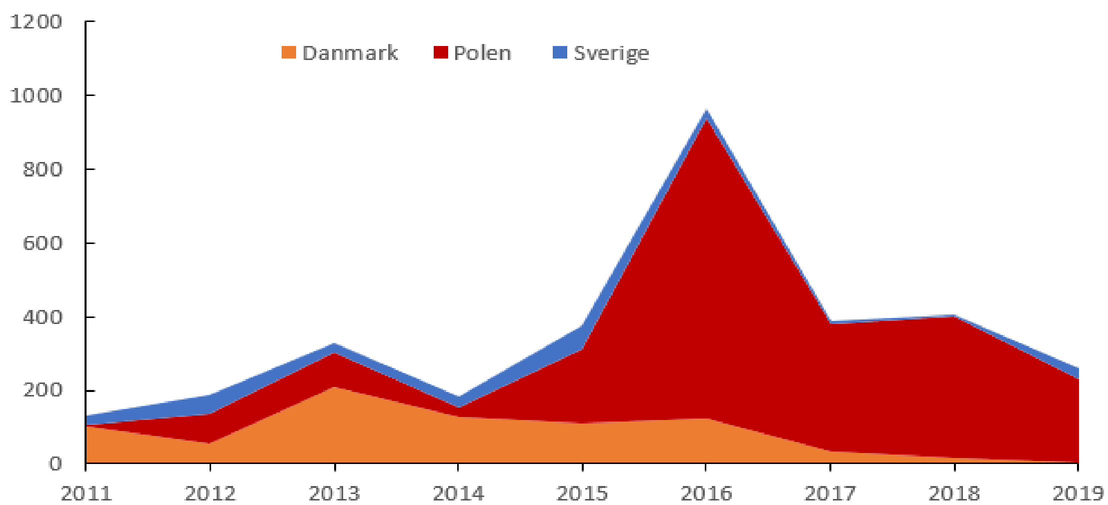


Figure 64. Danish, Polish and Swedish catch data in the Triton wind farm area between 2011 and 2019.

For German fishing, data is available only for the surrounding ICES boxes (39G3/39G4/38G3/38G4) and not specifically for the planned wind farm area. Therefore, the results presented here can only give a certain idea of what German fishing activity in the wind farm area. Figure 65 shows that German fishermen almost only fish for herring in the ICES boxes where Triton is located. It is therefore likely that fishing in the Triton area is also dominated by herring fishing, followed by flounder at significantly lower levels. There has also been a significant decrease in German fishing since 2018 in the ICES boxes analysed.

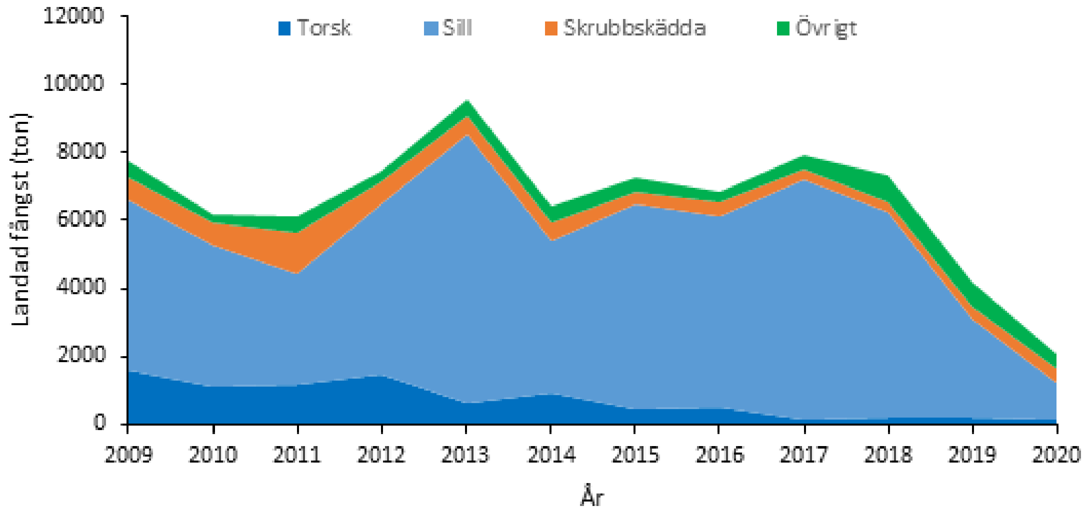


Figure 65. German catch data for various species within ICES boxes (39G3/39G4/38G3/38G4) between 2009 and 2020. German catch data specifically from the Triton wind farm area is not available.

Polish and Danish fishermen land flatfish (plaice, flounder and turbot) within Triton. Catches from Danish vessels throughout ICES sub-area 27.3.D.24 have been relatively stable, but have varied greatly within Triton, see Figure 66. These large local variations indicate that the flatfish fishery is highly adaptable for geographical redistribution. In ICES division 27.3.D.24, approximately 40 % of flatfish are fished with passive gear, methods which are deemed to be usable even when the wind farm is in operation.

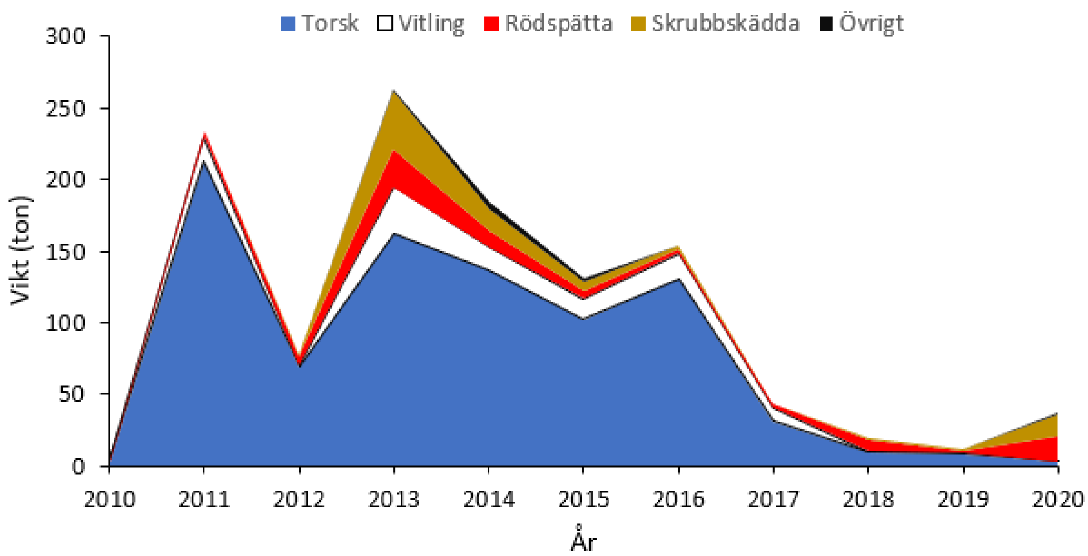


Figure 66. Danish catch data in tonnes of different species in the Triton wind farm area between 2009 and 2020.

Figure 64, Figure 65 and Figure 66, show how fishing has declined sharply in and around the Triton wind farm in recent years. Fishing pressure modelling shows that Swedish fishing pressure has also historically been considerably lower in the farm area compared to adjacent areas (Figure 62 and Figure 63). The importance of the area for the future fishing industry is determined by the EU's Common Fisheries Policy (CFP). The two most valuable fish stocks in the past, cod and herring, have had very poor population trends. For 2022, targeted fishing for both cod and herring has been stopped (bycatch quotas only) in order to reverse the negative trends for the species. Given the population status of these species, it is likely that the trend of restrictive quotas will continue.

The main type of fishing that could be affected by the Triton wind farm is demersal fishing for flatfish. However, this type of fishing represents a very small part of total fish catches in ICES sub-area 27.3.D.24 and is also deemed to be capable of relocation.

In view of the above, the farm area is currently considered to have little value for the fishing industry.

7.9.2 Impacts

During the construction phase, a safety distance to work in progress will be established which may limit part of the wind farm's availability for fishing. As targeted fishing for both cod and herring has been stopped, it is not considered that fishing will be affected at all during the construction phase.

Only sprat and flatfish fishing can therefore be affected by the establishment of a safety distance from work in progress, which may limit part of the availability of the wind farm for fishing. In 2019, fishing in the Triton wind farm accounted for only about 1.3% of total catches (Sweden, Denmark, Poland) in ICES boxes 39G3, 39G4, 38G3 and 38G4. All in all, the farm area is considered to have less extensive value for the fisheries sector.

The influence on commercial fishing is expected to be slightly negative during the construction phase, with a very small impact due to the temporary nature of the work.

Influence, effects and impacts of the operational phase

Bottom trawl fishing in wind farms is subject to safety risks as fishing gear could be caught and damaged by erosion protection and inter-array cables. In assessing the impact of the wind farm on commercial fishing, a worst case scenario assumes that bottom trawling has been completely stopped in the wind farm. Pelagic trawling is expected to be able to continue in the wind farm, with certain adjustments.

Impact on herring and sprat fishing

The herring quota in sub-area 27.3.D.24 has shown a dramatic negative trend since 2017 and by 2022 the targeted fishing has been completely stopped. The sprat quota has not experienced the same negative trend but has been at more stable levels and the 2022 quota is slightly higher than in the previous year (Figure 59). Fishing for herring and sprat in the farm area is mainly conducted by Polish boats, which also account for a significant part of the total catch. Furthermore, this fishery is almost exclusively conducted by pelagic trawlers, a fishing type that is not expected to be restricted by the Triton wind farm. The influence on herring and sprat fishing is therefore considered to be insignificant and the impact is deemed to be negligible.

Impacts on cod fishing

The western cod stock is considered to be more productive and in better condition than the eastern stock (ICES, 2020a). However, the trend has also deteriorated for the western stock, which has resulted in a ban on targeted fishing of the western stock in 2022 as well. If the western cod stock recovers and cod fishing can be resumed, cod fishing in the area will probably increase, as cod once constituted the majority of landings from Swedish and Danish fishermen. It should be added, however, that cod from both western and eastern stocks are present and breed in the Arkona Basin, even if the area is not the main spawning area for the stocks. Thus, the area (ICES 27.3.D.24) is believed will remain affected by restrictions on fishing for the eastern stock, despite a possible recovery of the western stock. Commercial fishing is likely to continue to be restricted by restrictive quotas and these are deemed to have a far greater influence on fishing in the area than the practical constraints that would result from the establishment of the Triton wind farm.

Demersal cod fishing with bottom trawls may be affected as the farm area, in the worst-case scenario, becomes unavailable for bottom trawling. However, this fishery is already strongly limited by the current, and probably future, fishing bans, and the Triton wind farm is currentently deemed to have a negligible influence on cod fishing and the impact is assessed to be negligible.

Impacts for flatfish fishing

In the worst-case scenario, fishing for flatfish and other demersal species with bottom trawls will be restricted within the Triton wind farm. However, this type of fishing represents a small part of total fish catches and is mainly conducted by Polish and Danish fishing vessels. The fishing pressure modelling of Swedish commercial fishing also shows that the fishing pressure in the farm area is considerably lower than in adjacent areas closer to the coast.

The impact could be greater for Poland and Denmark, which land more flatfish. Poland lands most flatfish within Triton but in the whole ICES area 27.3.D.24 Poland lands around 50% flatfish using passive gear, methods that are expected to continue to be used, making the fishing adaptable.

The Danish fishing industry lands the majority of flatfish catches with bottom trawls, which may be restricted. Flatfish catches from Danish vessels have varied considerably within Triton, but have remained stable in ICES sub-area 27.3.D.24. Large catches in the farm area in 2013 (66 tonnes) were followed by low catches in 2015 to 2019 (2 to 11 tonnes), and then increased again in 2020. These large local variations indicate that the Danish flatfish fishery is highly adaptable for geographical redistribution.

All in all, flatfish fisheries account for only a small part of the total fishing in ICES sub-area 27.3.D.24 and a relatively large part (about 40%) is operated with passive gear which will not be restricted in the Triton wind farm. In addition, the fishing shows large local variations from year to year, which indicates that it is highly adaptable for redistribution. Taking this into account, the influence is deemed to be slightly negative and the impact is assessed to be very small.

Other impacts for the fishing industry

The Triton wind farm can also have some positive effects on the fishing industry. Reef effects may occur when hard substrate in the form of foundations and erosion protection are built and offer new habitats for fish and other organisms (Langhamer, 2012). This may lead to an increased abundance of fish and increased biodiversity (Leonard et al., 2011; Rubens et al., 2013; Bergstrom et al., 2014).

If the fishing pressure in the farm area is reduced, positive effects on recruitment and recovery of spawning stocks may be seen. A comparable example can be taken from the protected spawning grounds that have been introduced in the Kattegat, from Falkenberg to Skälderviken. The areas had fishing bans introduced in 2009 to counteract the observed decline in cod stocks. Since the establishment of the protected areas, recruitment has been positively affected and has contributed to the recovery of the cod spawning stock. However, it should be taken into account that cod, like many other species, has occasional year recruitment variations, which are affected by factors other than fishing pressure and may result in weak recruitment years regardless of whether there are fishing-free areas or not (SLU, 2018). A reduction in fishing pressure in the area of the Triton wind farm may have a positive impact on mature cod and in turn strengthen stocks.

Total impacts for the fishing industry

Fishing quotas are the aspect that affects the fishing industry most. Development for the fishing industry in ICES sub-area 27.3.D.24 has been negative in recent years, as the landings have decreased and, therefore, the value of the total commercial fishing for the area. Both cod and herring have very poor population development and a ban on both species was introduced from 2022 in order to try to reverse the negative stock trend. The importance of the area for the future fishing industry is determined by the EU's Common Fisheries Policy (CFP).

No catches were reported by the Swedish commercial fishing industry from the farm area in 2020. The fishing pressure models for Swedish fisheries show that the fishing for herring, sprat and flatfish is at its greatest closest to the coast. The cod fishery has had a more even distribution across the Arkona Basin, but has now been banned. The wind farm area is not a national interest area for commercial fishing nor a designated area for commercial fishing in the marine spatial plan.

The main type of fishing that could be affected by the wind farm is demersal fishing for flatfish. This type of fishing represents a small part of total fish catches in ICES sub-area 27.3.D.24 and is deemed to be extremely capable of geographic relocation.

The addition of reef effects and reduced fishing pressure are expected to improve the stock status of commercially important fish species in the long term, which also benefits the commercial fishing industry (Goñi et al., 2008; Langhammer, 2012; Reuben et al., 2013).

All in all, the farm area is currently assessed to have less extensive value for the fisheries sector. The influence on commercial fishing is deemed to be slightly negative and the impact is assessed to be very small.

Impacts during the decommissioning phase

The worst-case scenario for commercial fishing is no bottom trawling will be allowed within the farm area during the decommissioning phase and that parts of the farm will have to be blocked off to maintain safety distances. The influence on commercial fishing is considered to be slightly negative during the decommissioning phase with a very small impact.

7.9.3 Summary of transboundary impacts

Transboundary fishing from Poland, Denmark and Germany may be affected by the fact that a reduced catch area is created in the area of activity when the wind farm is established.

Bottom trawl fishing in wind farms is subject to safety risks as fishing gear could be caught and damaged by erosion protection and inter-array cables. In assessing the impact of the wind farm on commercial fishing, a worst case scenario assumes that bottom trawling has been completely stopped in the wind farm. Bottom trawling represents a small part of the total fishing activities within the wind farm. Pelagic trawling is expected to be able to continue in the wind farm, with certain adjustments.

The Triton wind farm can also have some positive effects on the fishing industry. Reef effects may occur when hard substrate in the form of foundations and erosion protection are built and offer new habitats for fish and other organisms (Langhamer, 2012). This may lead to an increased abundance of fish and increased biodiversity (Leonard et al., 2011; Rubens et al., 2013; Bergstrom et al., 2014).

The addition of reef effects and reduced fishing pressure are expected to improve the stock status of commercially important fish species in the long term, which also benefits the commercial fishing industry (Goñi et al., 2008; Langhammer, 2012; Reuben et al., 2013).

All in all, the farm area is currently assessed to have less extensive value for the fishing industry because this area only represents a less extensive part of total catches. The influence on commercial fishing for Sweden, Germany, Poland and Denmark is deemed to be slightly negative and the impact is assessed to be very small.

7.10 Maritime activities

Total impact assessment

There are shipping lanes to both the north and south of the Triton wind farm and there is a ferry route through the farm area. To the east of the wind farm there are so-called traffic separation schemes (TSS) where traffic in different directions is separated. At the TSS there is also a so-called *Precautionary Area*, an area where the ship's officers must exhibit extra care.

There will be a certain risk of conflict with construction vessels and other maritime traffic during the construction phase and of vessels' incorrect entry into the working area. OX2 will take a number of measures during the construction phase, such as monitoring of maritime traffic by a dedicated project *marine coordinator*, and individual work areas will be identified as closed for unauthorised traffic and clearly marked. The sensitivity of maritime traffic to vessel accidents may be seen as high, but with the measures taken, the influence is deemed to be insignificant with negligible impact. Similar conditions exist in the decommissioning phase.

During the operating phase, the wind farm is calculated, without taking risk mitigation measures into account, to increase the likelihood of accidents (collisions, grounding and allisions with wind turbines). The sensitivity of maritime traffic to vessel accidents may be seen as high, but the influence is deemed to be small, which implies moderate negative impacts. With the planned mitigation measures, however, the increase in the probability of accidents is expected to be significantly reduced.

The wind turbines can make access and accessibility difficult where they are established in the event of environmental remediation and emergency response action. However, the distance between the wind turbines is more than one kilometre, which enables navigation inside the wind farm and the wind farm will be fitted with safety equipment that can limit the possible spread of discharges. With the continuous monitoring of the farm and the availability of rescue equipment and personnel in the area, the wind farm can facilitate emergency response actions in the event of an accident.

Wind turbines can also cause radar interference for passing vessels. The extent of radar interference on ship traffic from the wind farm will therefore be studied and, if necessary, radar will be installed within the wind farm as a safety measure.

The above description of the impact of the wind farm on shipping also includes international traffic and thus the transboundary impact. With various measures being introduced during both the construction and operational phases, the risks will be reduced to a level that can be defined as ALARP, as low as reasonably possible. The sensitivity of maritime traffic to vessel accidents may be seen as high, but the influence is deemed to be insignificant, which implies negligible impacts.

7.10.1 Preconditions

Shipping lanes

The Triton wind farm site is surrounded by major shipping lanes with heavy traffic to the north, east and south of the area, see Figure 67 below. These areas of ship traffic are also considered a national area of interest in the shipping lane Falsterborev - Bornholmsgat and Gedser - Svenska Bjorn.

A traffic route mainly trafficked by passenger ships and Ro-Pax vessels that run scheduled routes between Ystad and Świnoujście/Sassnitz passes through the wind farm site. This route is also designated as a route of national interest for shipping lanes. The area also has small shipping lanes, one of which crosses the western corner of the farm area and another through the eastern part of the area.

To the east of the wind park is the traffic separation zone *TSS Bornholmsgat* , where three traffic lanes meet. In this TSS area there is also a so-called *Precautionary Area*, which is an area in which vessels must navigate with particular care and in which the direction of traffic flow may be defined. The bordering parts of the *Precautionary Area* are defined as shipping lanes; the other lanes are shipping routes.

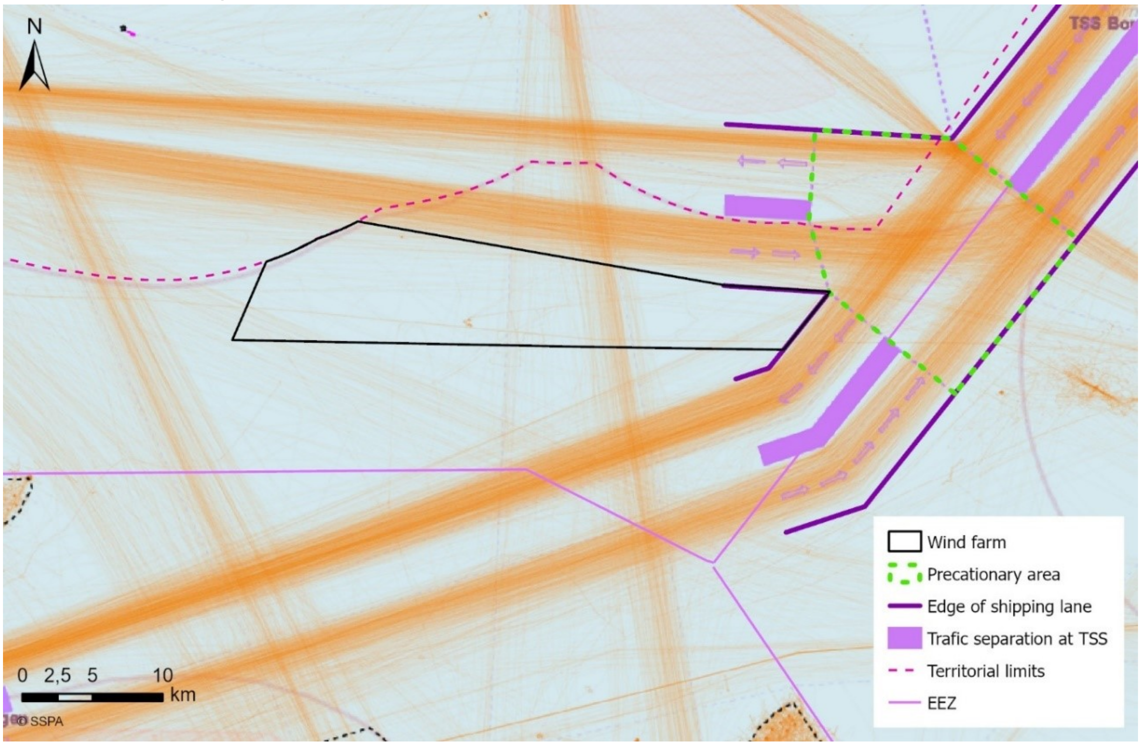


Figure 67. The routing system east of Triton, marked "Precautionary area". Purple areas show traffic separation zones (TSS).

Traffic flows

Ship traffic in the area mainly sails three routes, see Figure 68. *Route 1* refers to traffic north of Triton for traffic to and from the Baltic Sea via Öresund. *Route 2* refers to traffic south of Triton to and from the Baltic Sea at the Danish Straits and traffic via the Kiel Canal. *Route 3* refers primarily to ferry traffic in the shipping route through the farm area between Ystad and Poland (Świnoujście). With a safety distance of 500 metres between the wind turbines and the border of the shipping lane in route 3, the shipping lane is approximately five kilometres wide. Maritime traffic in the area has been analysed based on AIS data[37] primarily from 2020. The traffic pattern has been analysed from statistics on ship passage in the years 2016–2019.

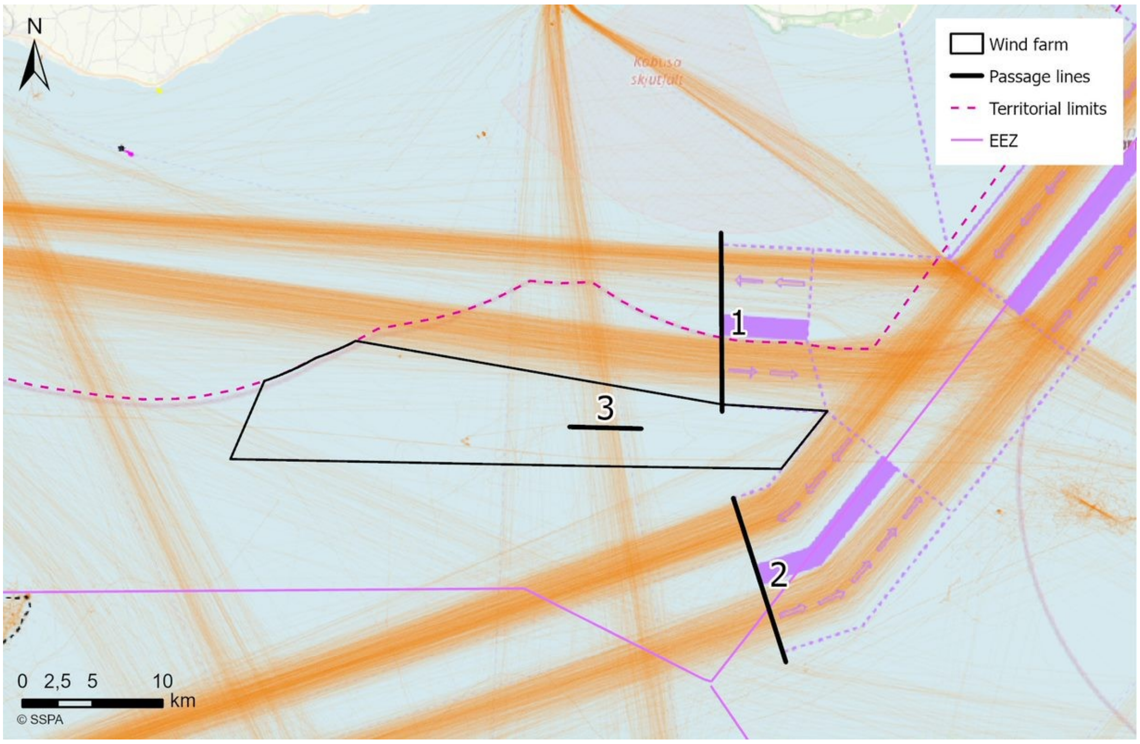


Figure 68. Traffic movements in part of the southern Baltic Sea and the three routes analysed from a risk perspective. The purple zones indicate traffic separation at TSS's.

19,185 vessels sailed *route 1*, north of Triton, in 2020. Of these vessels, about 93% were vessels with a length of up to 200 metres, the majority of which were so-called general cargovessels[38] of smaller size (up to 150 metres in length). Tankers and bulk carriers are also common. Vessels of 200 metres have been assessed in route 1 on a size risk assessment perspective. Vessels in the length segment 200–250 metres account for approximately 1,100 movements per year.

24,212 vessels sailed *route 2*, to the south of Triton, in 2020. Here too, the bulk were general cargo type vessels, but tankers, container vessels, Ro-Ro vessels[39] and bulk carriers are also common. This route is trafficked by larger vessels than the route to the north of Triton (route 1). In 2020, nearly 3,500 vessels were registered in the length segment up to 250 metres. For Route 2, a ship length of 250 metres is estimated to be dimensioning from a risk assessment perspective. The largest registered vessels in Route 2 are Maersk's container ships, which are 399 metres long with a beam of 59 metres, and a draught of about 12 metres. In 2020, about 80 movements were registered by vessels over 300 metres in length. Vessels in the length segment 250–300 metres account for approximately 850 movements per year.

Route 3 covers traffic between Sweden and Poland. 3,027 movements were registered in 2020. These are primarily passenger ships and Ro-Pax ships[40] which regularly run between Ystad and

37 AIS: Automatic Identification System, which allows a vessel to be identified and monitored by other vessels and traffic monitoring centres.

38 General Cargo: groupage cargo ships

39 Ro-Ro: Roll on, Roll off. Ro-Ro vessel is the term used for ships carrying rolling loads cars, trailers and trains.

40 Ro-Pax: Roll on roll off and passengers, Ro-Pax vessels carry both rolling stock and passengers on board.

Świnoujście, with a length of up to 200 metres. For route 3, a vessel length of 180 metres is estimated to be dimensioning, which is, among other things, the length of the Polferries' ship, Cracovia, which had 523 movements 2020.

To sum up, there are approximately 19,000, 24,000 and 3,000 movements per year, respectively, which corresponds to an average flow of 50, 65 and 8 movements per day. For route 1, traffic flow has not changed very much in recent years, while for passenger line 2 it has decreased from about 28,000 movements of vessels in 2017 to about 24,000 movements in 2020.

Globally maritime traffic is estimated to have decreased by 4.1% in 2020 due to the Covid-19 pandemic (UNCTAD, 2020). Based on the traffic forecasts from the Swedish Transport Agency, the volume of freight transport (tonnes km/year) by sea can be expected to increase by about 20% from Year 2020 to Year 2030 (Trafikverket, 2020).

Identified risks and risk analysis

A risk analysis has been conducted for nautical risks due to the planned wind farm. The analysis is based on a risk identification conducted together with SSPA, among other things based on an early "Hazid" workshop in which various risks were identified as well as possible mitigatory measures. The purpose of the risk analysis has been to identify potential risks to be taken into account in the further design of the wind farm, and what mitigatory measures should be introduced or be the subject of dialogue with the relevant maritime authorities. The risk analysis has been carried out on the basis of a design of the wind farm that is the worst-case scenario for the risk analysis, and consists of two alternatives comprising 129 turbines spaced at a distance of 500 metres (see Figure 69) and 1,000 metres respectively to the borders of adjacent shipping lanes.

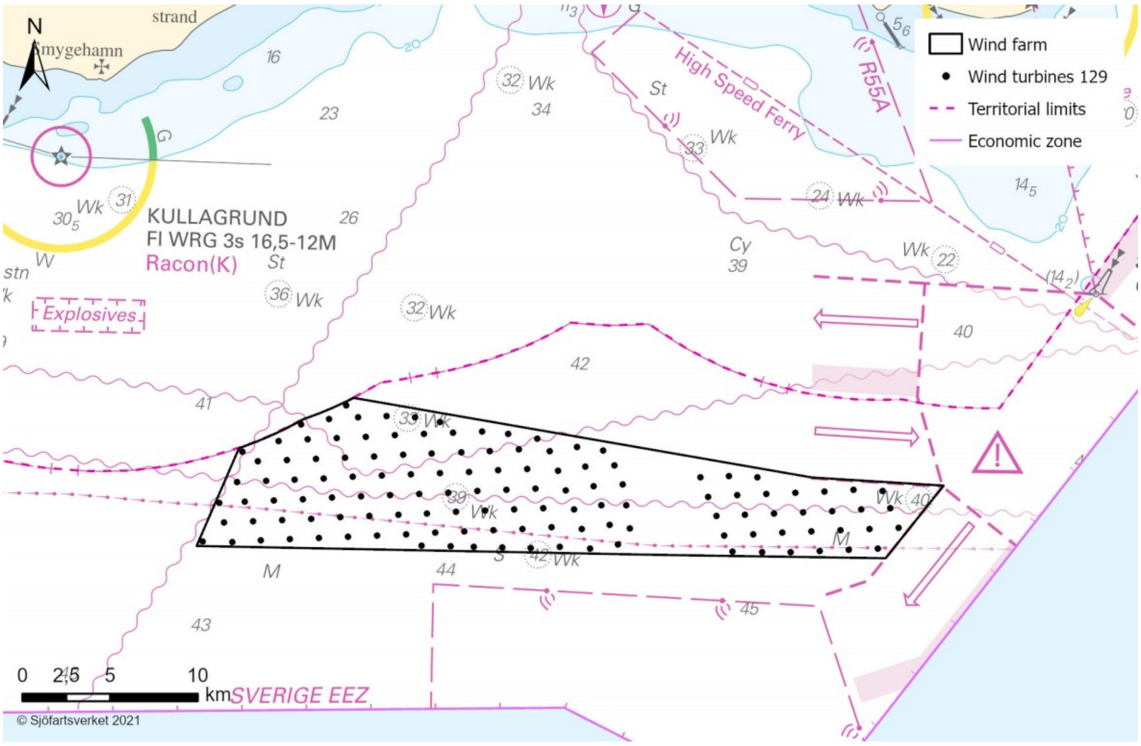


Figure 69. Layout with 500 metre safety distance.

The map shown in Figure 70 shows the area applied for within which foundations may be placed, which means a safety distance between the edge of the farm area and the nearest wind turbine with respect to bordering shipping lanes, and an extra large safety distance in the eastern corner with respect to *the Precautionary Area.*

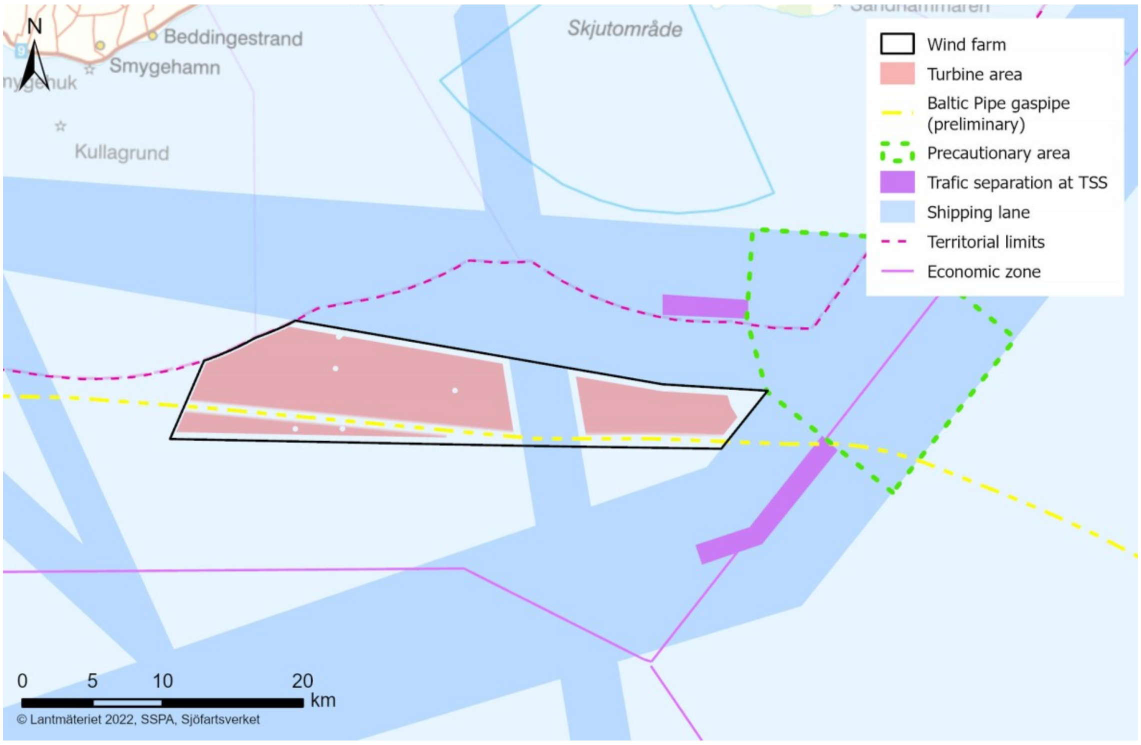


Figure 70. Area within which wind turbines may be placed. Due to the particular risk at the Precautionary Area to the east of the farm, no work is located near this area, and an about five-kilometre broad lane is ensured for ferry traffic through the area.

The identified risks can be divided into six different parts, four of which are linked to north, south and through Triton, and to the *Precautionary Area*, the other two relate to general hazards not directly linked to a specific geographical area and to hazards associated with the construction phase. All in all, the identified risks are:

- Maritime risks
  - Collision between vessels
  - Grounding
  - Allisions[41] (wind farm area, wind turbines)
  - Conflicts[42] with installation vessels
  - Conflicts with maintenance vessels
  - Conflicts with leisure craft
- Technical hazards
  - Interference to navigational equipment
  - Difficulties with emergency anchorage
- Environmental accidents
  - Difficulties with rescue operations
  - Difficulties in cleaning up discharges

41 "Allision" is understood to mean, in the marine context, as being when a vessel collides with a fixed object (as opposed to a collision which is a collision with a moving ship). Allisions also include when a vessel enters a wind farm, without thereby colliding with a wind turbine.

42 Conflicts here mean that two ships come too close together and force changes of course.

Construction phase:

During the construction phase, traffic in the area will be increased by vessels moving between the farm area and ports for, among other things, manufacture, final assembly and loading. The ports to be used have not yet been decided. The port that will be used for installation purposes will manage passenger transport and transport of smaller components. Movement to and from this port will cross shipping lanes most and most frequently, with daily return trips.

Additional traffic in the area during the construction phase will consist of vessels of varying sizes that use different routes, such as boats carrying crew (also known as *crew transfer vessels* (CTV)) and guarding, barges with foundations, dredgers, cable-laying vessels and other vessels carrying materials.

Figure 71. Example of crew transfer vessel (Photo: Göran Loman).

Potential risks during the construction phase have been identified related to:

- *Transport to and from the farm site.* Leads to increased traffic and crossing of shipping lanes.
- *Work with vessels or platforms outside the farm area.* In the immediate vicinity to routes with heavy traffic, potentially limiting the space to manoeuvre to avoid collisions
- *Work boats in shipping lanes in connection with cable laying.* This may involve a non-moving ship/slow-moving ship on a different course.
- *The external borders of the farm will not be clearly marked before the turbines are in place.* Ships that stray off course may collide with foundations during construction or other structures that cannot be visually observed above the surface of the water.
- *Interference effects*. Radar interference and risk of dazzling passing vessels if work platforms have strong lighting that is not shielded from traffic in the shipping lanes.

Mitigatory measures, such as continuous information to shipping, monitoring by a *Marine coordinator* and marking the area, are deemed to be effective measures to avoid risks and influences on shipping, see safeguarding measures in section 7.10.4 below.

7.10.2 Operational phase

During the operational phase, the maritime risks are mainly related to shipping traffic in shipping lanes routes near the wind farm, i.e. the shipping lanes north and south of Triton, *the Precautionary Area* east of Triton and the ferry route passing through the wind farm.

The risks in relation to the shipping lanes are collisions, grounding and allisions. The main hazard in the *Precautionary Area* is where south-western traffic from the Baltic Sea is going down the route south of Triton, crossing the east-running traffic coming from the lane north of Triton. In the case of the south-west traffic, the difficulty lies in possibly having to manoeuvre for traffic from the west and then potentially need to hold out to the starboard side and then turn down on its route toward the south side of the wind farm again.

Other identified risks include radar interference and complicated progress and accessibility within the wind farm in the event of, for example, environmental remediation and rescue operations.

Collisions, grounding and allisions

The wind farm itself creates a risk of ships entering the wind farm area and possibly colliding with a wind turbine. The wind farm may also lead to an increased risk of collision between vessels in the shipping lanes, if these vessels, in order to create a greater distance from the farm, use a smaller width of the shipping lane. In some situations, at wind farms closer to the coast, a wind farm may also pose an increased risk of grounding.

The IWRAP Mk2 (*IALA Waterway Risk Assessment Program*) is used to assess whether and how the wind farm, in its operational phase, may affect the likelihood of grounding and collision between ships and to estimate the likelihood of ships drifting into the wind farm and colliding with a wind turbine. Based on AIS data, the current area is modelled by defining vessel routes, so-called legs, and nodes, so-called waypoints, to resemble the current marine traffic pattern. The analysis was based on the dimensioning sizes of the vessels (stated above) and a traffic scenario in 2030, which represents an increase in traffic by 20% on all routes compared to AIS data for 2020.

Collision (between two vessels) is categorized as follows:

- *Head-on* – collision between meeting vessels
- *Overtaking* – collision when overtaking in the same lane
- *Crossing* – collision when lanes cross each other
- *Merging* – collisions at node points where lanes converge
- *Bend* – collisions at node points where the lanes bend

Grounding is categorized as either *powered grounding*, when a ship is runs aground while under way due to human error, or *drifting grounding*, when a ship due to some technical failure, such as a blackout, drifts without its engines running. *An allision* means that a ship accidentally enters the wind farm area, which does not necessarily mean that there is a need for a collision with a single wind turbine to take place. Allisions are categorised in the same way as grounding (*powered allision* and *drifting allision respectively).* In the event of allisions, a collision with an individual wind turbine can occur if ships that drift towards the farm do not have time to emergency anchor or regain manoeuvrability before interaction with the wind farm takes place.

Modelling of the likelihood of accidents and incidents

For the above-mentioned risk events, the probability of collision, grounding and allisions has been calculated from traffic patterns and traffic intensity in 2020 (“base case”) and an assumed traffic scenario in 2030 where traffic is expected to have increased by 20% compared to 2020. As stated above, risks have been analysed on the basis of modelled vessel traffic and a wind farm with a safety distance of at least 500 metres from the existing border of the shipping lane and with a safety distance of 1,000 metres, and in comparison with the risks and probable accidents in the zero alternative (i.e. if the wind farm is not built).

In view of the intensity of the traffic in the shipping lanes, the likelihood of ***a collision*** in the area is relatively high even if a wind farm is not built. Based on the current traffic scenario (2020), the IWRAP analysis shows that the probability can increase slightly with the wind farm if it results in a congestion of traffic in existing shipping lanes, i.e. if the vessels choose a route further from the wind farm. The calculation results show that the probability of a collision in the shipping lane with a distance of 1,000 metres between the lane and the wind farm is 0.11 incidents per year if there is congestion, which is the same as if the farm does not get built (the zero alternative). If the distance between the border of the shipping lane and the wind farm to 500 metres and there is congestion of traffic, the likelihood increases slightly to 0.12 incidents per year.

In the corresponding calculation of the probability of a collision based on the traffic scenario in 2030, the results show an increase from 0.11 to 0.16 events per year in the shipping lanes without a wind farm (the zero alternative). The same result is achieved if the wind farm has a safety distance of 1.000 metres between the edge of the lane and the wind farm, even if congestion occurs. If the distance is reduced to 500 metres, there is a slight increase in incidents in the shipping lane (0.17 incidents per year), if the ship traffic is congested. The probability of collision is therefore largely due to the forecast increase in traffic in the area in 2030. In addition, it should also be noted that the shipping lane narrows further west so traffic congestion is not a unique phenomenon in the area.

The IWRAP analysis shows that the probability of ***grounding*** does not change significantly (it decreases slightly) when building the wind farm due to the lack of shallow sections in and around the wind farm.

The likelihood of a ship entering the wind farm (***allision***) naturally does not occur in the zero alternative, but with the wind farm established, the overall probability of an incident or accident increases. In an allision, an accident occurs only if the ship entering the wind farm collides with a wind turbine. The distance between the wind turbines in the wind farm will be more than one kilometre. In the case of a powered allision, vessels can therefore most likely manoeuvre freely in relation to the turbines. Vessels affected by blackout which, due to the prevailing wind conditions, drift towards the farm, if manoeuvrability is not recovered quickly enough, will need to anchor to avoid drifting into a wind turbine. There is therefore a risk of collision with wind turbines if a ship enters the wind farm and fails to manoeuvre or emergency anchor the ship. However, collisions with wind turbines are assumed to be less severe than collisions between ships, but can cause property damage, personal injury, and environmental damage.

Based on the current traffic scenario, the probability of an allision (worst-case) with a wind turbine is calculated as 0.041 times a year (once in 24 years), if a distance between the shipping lane and the wind farm of 500 metres is used and no congestion effects occur. If the wind farm causes a congestion effect on the shipping lane, the likelihood of an incident with wind turbines is reduced to 0.019 times a year (once in 52 years). As above, the likelihood will increase if traffic density increases. In 2030, the corresponding probability of a collision with wind turbines is therefore estimated to be 0.049 and 0.023 events per year, respectively.

However, the estimate of risk of collision in the event of allision is based on a conservative assumption that the wind turbines have a critical width of 100 metres, including that part of the blade that could touch a high ship. In practice, the critical width is smaller, especially for ships that do not have a high superstructure, and the lowest clearance (distance between the tip of the blade and the surface of the water) is 30 metres. The wind farm will be monitored and in the event of an incident when a vessel enters the wind farm, the relevant wind turbines will be stopped and the blades placed so that a rotor blade points straight down, is thus in line with the turbine tower. The position of this blade (i.e. the whole rotor) will also be adjusted away from the side on which the vessel is in danger of drifting into the turbine. This makes the critical width about five-times smaller than the critical width used in the calculation. This means that the calculated probability of a collision in the calculations is overestimated.

Safe distance for avoidance manoeuvre

The wind farm is a limitation for vessel navigation, but vessel traffic can usually adapt to wind farms with little risk of changing course away from the wind turbines and the risk of collision. Due account needs to be taken of the required safety distance between heavily trafficked shipping lanes and a wind farm for the possibility of avoidance manoeuvres in the event of an incident.

In Sweden, with the exception of the offshore wind farm Lillgrund, large-scale wind farms have not yet been built offshore, and there is therefore a limited basis for the effect of wind farms on shipping in Swedish conditions. However, there is experience from a number of other existing wind farms in the Baltic Sea, North Sea and Irish Sea, and many of these wind farms are located next to intensively trafficked shipping lanes, see Figure 72 (DNV, 2021). The distance from vessel traffic to wind turbines is generally about one kilometre or less. The Swedish wind farm, Lillgrund in the south of Öresund is about one kilometre from a major shipping lane (Drogden).

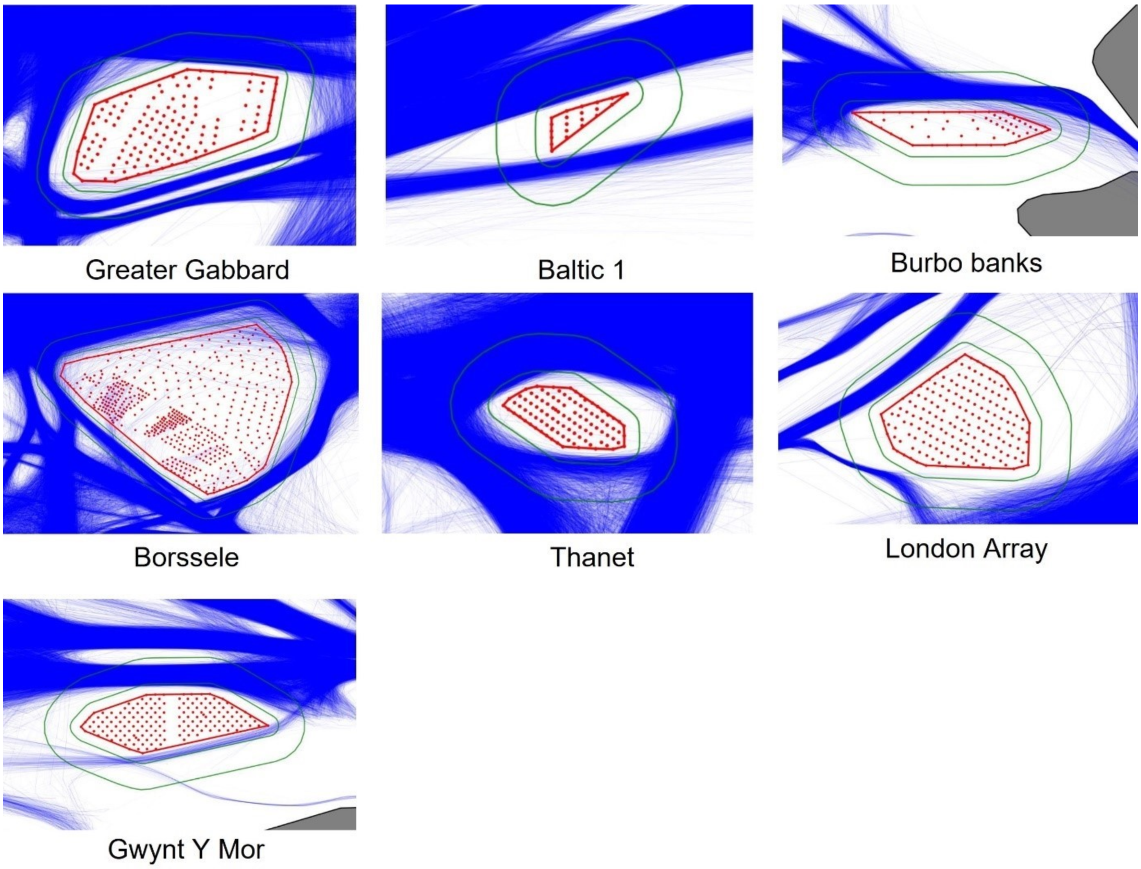


Figure 72. Shipping traffic around some wind farms in Europe. The red line indicates farm areas, the green lines 1 kilometre and 5 kilometres respectively from the wind farm, and the blue lines are vessel plots from AIS. In general, a distance of about one kilometre to the wind farm is maintained, in some cases the distance is significantly smaller (Borssele outside the Netherlands, Thanet at the entrance to the Thames, and Gwynt Y MOR off the Welsh coast).

In the case of the Triton wind farm, the distance between the wind turbines is so great that it allows navigation inside the wind farm, even for larger vessels, although this is something to be avoided. In the case of the required safety distance between the border of a lane and a wind farm, it shall be sufficient for safe avoidance manoeuvring to be conducted, however, for vessels to be able to navigate in a narrower area. In Europe, various general guidelines have been applied to calculate the required width of a shipping lane, including a safety zone, in order to maintain good maritime safety.

According to a model described by the PIANC, the safety distance required must be determined in two steps (PIANC, 2018). In a first step, based on a preliminary concept design, a standard safety distance value is calculated based on the design length of the vessel. When the final design of the wind farm has been established (detailed design), a detailed analysis of the required safety distance is made, based on, for example, analysis of traffic data, risk analysis and simulations, and a cost/benefit assessment. For traffic north of Triton, the PIANC step 1 gives a standard safety distance of 2,256 metres (1,2 M), for traffic south of Triton the distance is 2 556 meters (1,4 M). These distances apply from a defined border of a lane. However, for the shipping lanes at Triton there is no set border that is required to correctly apply the PIANC model.

In the UK, a model developed by the British Maritime & Coastguard Agency (MCA) is applied. According to MCA, a safety distance of 3.5 nautical miles is always most satisfactory, but the distance can be as short as 0.5 nautical miles if the residual risk is “as low as reasonably practicable” (ALARP), when local conditions are taken into account. In the absence of a Traffic

Separation Scheme (TSS), shipping lanes where oncoming traffic is separated by traffic separation zones), the MCA, states that the safety distance must be given from the area of a ship's route in which 90% of the vessels sail (see example in Figure 73). This is an adaptation to the practical conditions in a shipping lane and may involve both a longer and shorter distance than if the distance was based on an administrative border.

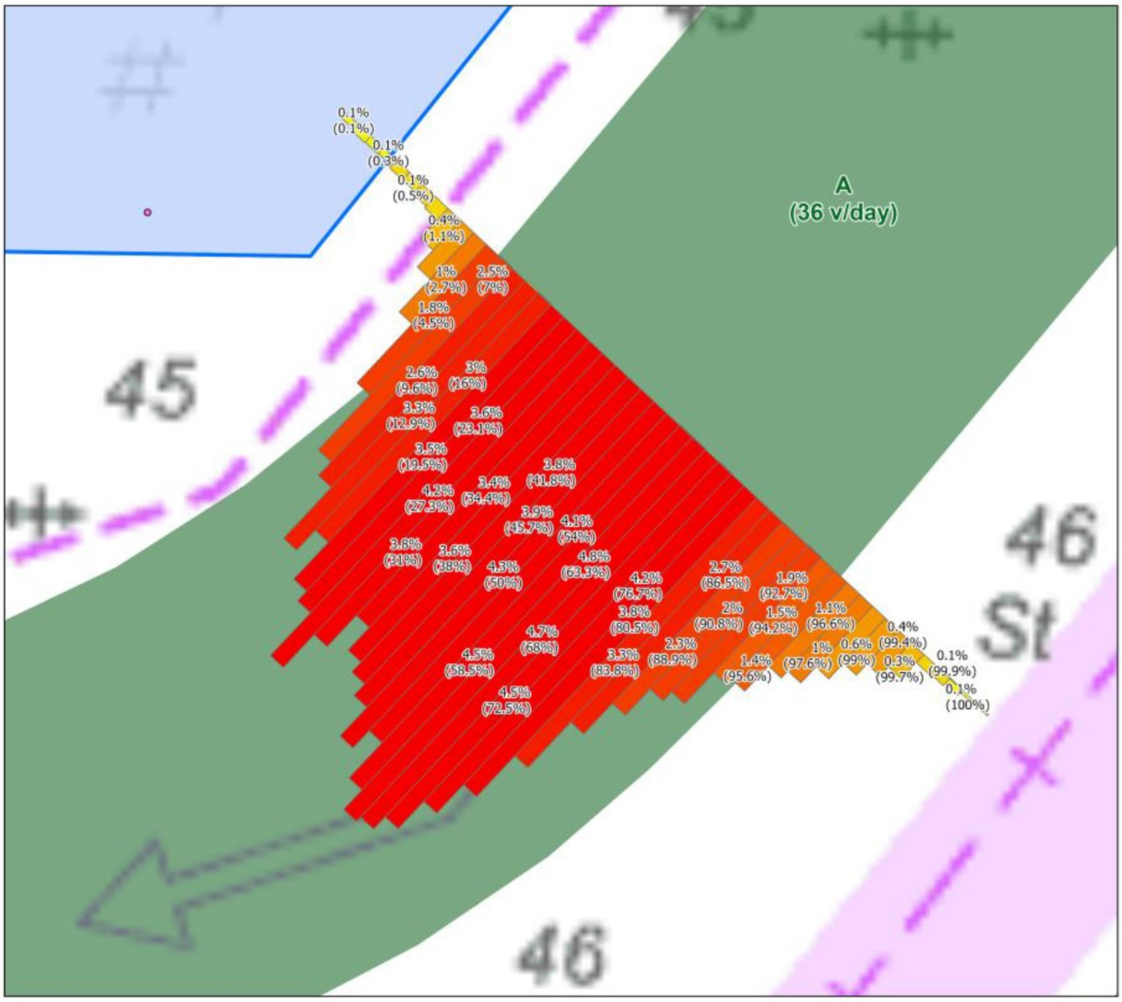


Figure 73. The green zone marks the area where 90% of ship traffic is sailing and where the safety distance according to the MCA model is to be calculated.

Triton safety zone

According to the PIANC, in a step 2, more detailed analyses of the required safety distances are to be conducted, based on the prevailing local conditions. Marico Marine has performed a more detailed analysis of the required safety distances according to the MCA model for Triton, which can be compared to the PIANC Step 2. In this report (R.33) Marico Marine has identified the following facts:

- Traffic density – traffic flow near Triton is moderate/high;
- Ship sizes – larger ships are present across the whole width of the lane, but the majority of ship traffic follows in the middle of the field for the 90 percentile;
- Environmental conditions – Tides are negligible, a dominant wind from west to south-west is of little importance as there is sufficient space for ships to operate;

- Traffic profile - cargo ships represent the main type of vessel (59%) within 10 miles of the wind farm. Fishing boats and leisure craft account for 6% of vessels within 10 nautical miles of the wind farm; and
- Shipping lanes – the 90-percentile fields have a moderate/high traffic flow, most shipping lanes are wide enough to allow safe navigation;

The conclusion of Marico’s analysis is that a safety distance of 0.5 nautical miles is satisfactory.

Final selection of the safety distances and the required width of the shipping lanes depends on the local conditions and the final layout of the wind farm. This requires simulations and assessments to be made in dialogue with the relevant authorities based on farm layout, wind turbine selection and other environmental influences.

Radar interference

Ships passing close to the wind farm are in danger of suffering interference with their radar, with false echoes and shadow effects. Figure 74 illustrates how radar interference can occur. Note that in the figure both the vessels and the turbines are greatly exaggerated in size, in relation to the distance to the turbines and the distances between the turbines. Radar echoes from the red wind turbines reflect in the orange vessel and the radar on the yellow vessel interprets the signals as the wind turbines being behind the red vessel. Radar echo from the orange vessel is reflected in a yellow wind turbine and the radar on the yellow vessel interprets it as the orange vessel being behind the wind turbines.

The influence on radar interference for the shipping will be investigated in connection with the final positioning of the wind turbines. If necessary, measures such as radar will be installed. A distance of 0.8 nautical miles, which most of the passing vessels keep to the wind farm, is sufficient to limit radar interference on passing ships’ radar, or precautions can be taken to avoid possible radar interference.

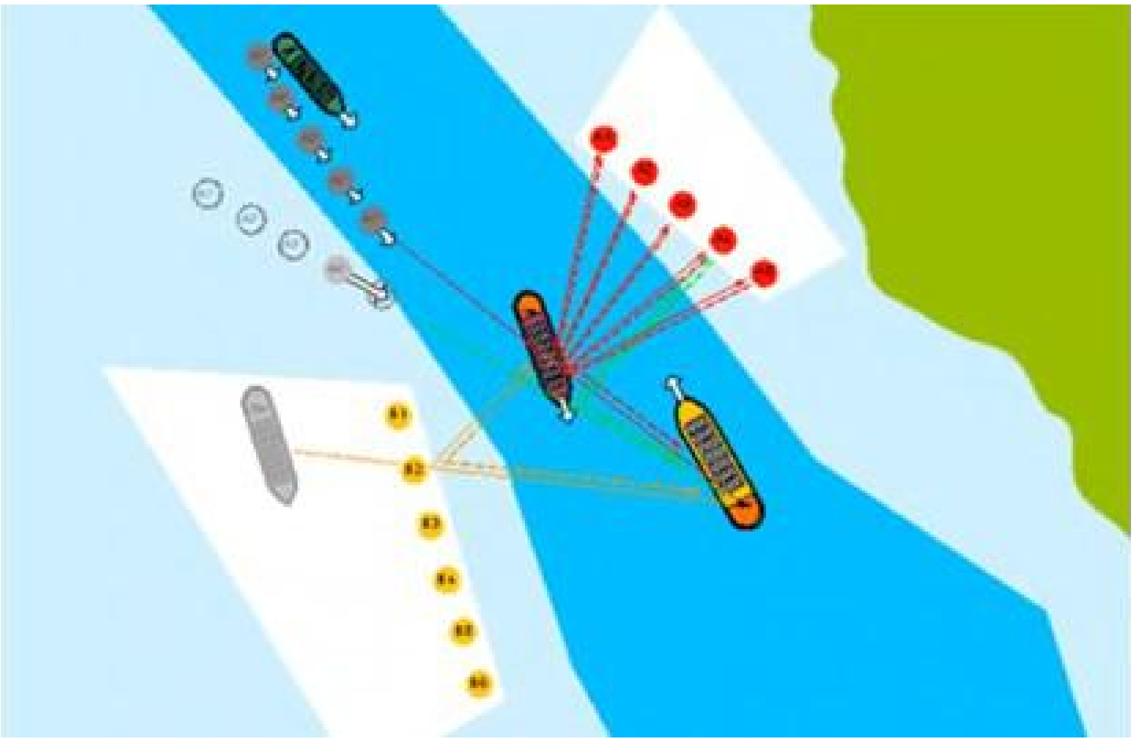


Figure 74. Diagram of principle illustrating the occurrence of radar interference (from DNV, 2021). Note that both the vessels and the turbines are greatly exaggerated in size in relation to the distance to the turbines and the distances between the turbines.

Environmental remediation and rescue operations

The wind turbines can make progress and accessibility difficult where they are established in the event of environmental remediation and emergency response actions. If an oil spill occurs in the vicinity of the wind farm area, the wind farm may, therefore, cause difficulties for the Coast Guard when working with limiting the spread of the discharge and oil spill clean-up. However, it should be noted that the distance between the wind turbines is more than one kilometre, which allows navigation inside the wind farm. The wind farm will also be equipped with protective equipment that can limit the potential spread of spills from both outside the wind farm that drift in and spills within the wind farm. The probability of a major spill occurring in the wind farm area is considered to be very small, since the area, apart from ferry services, is assumed to be operated only by service and maintenance vessels. Minor spills of oil or other chemicals may occur in connection with the maintenance of wind turbines but are minimised by equipment such as waste trays or other means of collecting a possible spill such as booms, etc.

Helicopters may be used for rescues at sea. It is essential that the turbines are stopped during such actions. In the same way as in environmental remediation, vessels from the wind farm can be quickly in place during a rescue operation.

Figure 75. Sea rescues being practised at Lillgrund wind farm.

7.10.3 Overall assessment

Construction and decommissioning phases

There will be a risk of conflict with construction vessels and other maritime traffic during the construction phase and of vessels' incorrect entry into the working area. During construction work, measures will be taken to avoid shipping-related risks (see below), including the fact that all ship traffic will be monitored by a project-dedicated *Marine coordinator*, the work areas will be clearly marked and ongoing information will be provided in various shipping bulletins. Special areas will be used for crossing the shipping lanes.

The sensitivity of maritime traffic to vessel accidents may be seen as high, but with the measures taken, the influence is deemed to be insignificant with negligible impact.

Similar conditions as in the installation phase are present at the decommissioning stage.

Operational phase

Without taking special mitigatory measures, the wind farm is expected to increase the likelihood of accidents (collisions, grounding and allisions with wind turbines), see above. The risk of collisions between ships is not considered to increase to any significant extent as a result of the establishment of the wind farm, but there is a risk of some increased likelihood of collision with wind turbines. With the actions (section 7.10.4) that OX2 will take, this probability can be reduced. Such actions may include increased distance to the TSS, wind turbines stopped at risk of allision, racon (transponder) on the turbines and remote surveillance. The wind farm will also be clearly marked and there will be room for manoeuvring both within shipping lanes and between wind turbines in the wind farm. The sensitivity of maritime traffic to vessel accidents may be seen as high and, with a certain increased probability of accidents, the influence resulting from the wind farm is assessed to be small, which, taken together, implies a moderate negative consequence.

Today, small ships pass through what will become the farm site. This is expected to be possible even after the farm has been built. The sensitivity of maritime traffic to not being able to use the farm area is considered moderate, since no restriction is likely to occur for these small boats through the farm area, the influence is considered to be small, which means a small negative impact.

A wind farm can cause radar interference, with false echoes and shadow effects. The sensitivity of shipping to radar interference that a wind farm may cause can be considered to be moderate. The influence on radar interference for shipping will be investigated in connection with the final positioning of the wind turbines. If necessary, measures in the form of radar will be installed. With these measures, the influence is assessed to be small, which means a small negative impact.

Efficient and safe environmental remediation and emergency response (SAR) operations are essential for shipping. The wind farm may make such efforts more difficult due the physical constraints the farm imposes, but at the same time the wind farm can assist in such efforts and it is essential that ships from the wind farm are able to get in place quickly and that the facility can also detect accidents early. The distances between the turbines will be large enough to allow rescue helicopters to operate at the wind farm. A contingency plan will be developed to deal effectively and safely with accidents. The negative influence of the wind farm and its positive influence are therefore assumed in this part to cancel each other out. This will make the wind farm's impact negligible.

7.10.4 Mitigatorymeasures and continued work

A number of mitigatory measures will be taken to minimise the influence on shipping, including the mitigatory measures identified by the risk analysis.

As several of the identified risks relate to the distances between the wind farm area and the shipping lanes on the north and south-east sides respectively, the location of wind turbines in the area will need to be the subject of further dialogue and consultation with the Swedish Maritime Administration and the Swedish Transport Agency. Further work on optimising wind farm design will therefore involve a dialogue with the relevant authorities, including on the need for further risk mitigation measures. One such measure may also be to increase the distance between the main shipping lane and the outer border of the wind farm, adjust the number of wind turbines or adjust positions to allow for example greater space for evasive manoeuvring. A displacement of the shipping lane on the north side could be achieved by reducing the width of the TSS at the north-east corner of Triton, taking into account the risks of possible congestion.

In partnership with the authorities, the company will work out a farm design that maintains good maritime safety, and will take into account other appropriate mitigatory measures. In order to achieve this, simulations have been proposed in order to study how shipping traffic takes place at the wind farm and its possible designs. Because the final choice of the wind farm layout, including the distance between, and location of, wind turbines, will be determined at a later date, such simulation should be conducted with a view to deciding on the final design of the farm.

In addition to the above, the following measures will be implemented to avoid maritime risks:

Construction phase:

- All marine work during installation will be monitored by a *marine coordinator,* who will monitor the farm's own traffic (which ships are in the area, which tasks are to be conducted, which persons are in the area, etc.). A *marine coordinator* will also monitor other vessel traffic and can assist it. Through active monitoring of the area and its traffic, vessels heading toward the farm, or otherwise deviating from the normal traffic pattern,

can be detected early and communicated with to avoid potential interaction with the wind farm or other vessels/units involved in the establishment phase.
- Special awareness will be shown to ongoing ferry traffic when installation vessels cross the ferry route, from the west to the east of the wind farm. During installation work, the *marine coordinator* will provide daily updates of upcoming ferry services.
- During the construction phase, a 500-metre safety zone will be displayed around the different workplaces, both fixed workplaces such as installation of foundations and wind turbines, as well as mobile workplaces such as cable installations.
- Clear and frequent information shall be provided through the UFS Swedish Notices to Mariners, the Admiralty's Notices to Mariners and the Danish Maritime Authority's Notices to Mariners on the construction process in progress and the areas concerned.
- The area will be defined and marked out on charts and visually using buoys with racon or radar reflectors.
- Work lights on work vessels and platforms will be shielded as far as possible from passing traffic.
- The crossing of ferry traffic lanes will be based on ferry service schedules.

Operational phase:

- The location of the wind turbines will be determined after consultation with the Swedish Maritime Administration and the Swedish Transport Agency. Prior to consultation and the establishment of positions for the wind turbines closest to the shipping lanes, a simulation with navigation in a ship's simulator shall be developed by the maritime traffic, which will be submitted to the Swedish Maritime Administration and Transport Administration
- The wind turbines and met masts will be fitted with obstruction markings according to the regulations of the Swedish Transport Agency and the Swedish Maritime Administration, in accordance with TFS 2017:66 or its equivalent, and the maritime safety marking required according to the position of the wind farm in relation to shipping lanes and traffic routes and marking for aviation (TFS 2020:88).
- The spread of the wind farm will be marked on charts.
- Ships used for service and maintenance will have equipment for marine rescue and environmental measures, such as rescue equipment, defibrillators, stretchers and booms to limit the spread of chemicals.
- Service and maintenance vessels that more or less daily pass through the shipping lanes shall do so within specially defined zones.
- A study of possible radar disturbances on vessel traffic from the wind farm shall be conducted and radar established if necessary.
- Information about major marine operations shall be provided a clear through the UFS Swedish Notices to Mariners, the Admiralty's Notices to Mariners and the Danish Maritime Authority's Notices to Mariners on the work in progress and the areas concerned.
- The wind farm and the area around the wind farm will be remotely monitored to enable, among other things, the detection of vessels on an allision course with the wind farm.
- In particular, the company will monitor a safety zone of at least 500 metres from installation ships during the operational phase when maintenance work with installation ships is being conducted in order to avoid shipping-related risks.

7.10.5 Summary of transboundary ïmpacts

The Triton wind farm is located between two shipping routes, the northern route is partly within Swedish territorial waters, partly within the Swedish economic zone, and the route in the south is in the Swedish economic zone. These shipping routes are important for international shipping. This creates transboundary impacts. During the construction phase, there may be conflicts between construction and other shipping traffic, and during the operational phase the wind farm may lead to an increased likelihood of ship accidents such as collisions and allisions. The above description of the impact of the wind farm on shipping also includes international traffic and thus the transboundary impact. With various measures being introduced during both the construction and operational phases, the risks will be reduced to a level that can be defined as ALARP, as low as reasonably possible. The sensitivity of maritime traffic to vessel accidents may be seen as high, but the influence is deemed to be Insignificant, which implies negligible impacts.

In the context of the risk analysis, the probability of various ship accidents in nearby shipping routes has been calculated. These analyses have, on a preliminary basis, adopted a safety distance of 500 metres and 1,000 metres between shipping routes and the wind farms. At present, the probability of an accident amounts to approximately 2×10-1. Overall, the wind farm, with the design used in the calculations, increases the likelihood of accidents (collisions, grounding and allisions with wind turbines) by approximately 10-20%.

A number of measures have been planned to reduce disruption to shipping. During the construction phase, a marine coordinator will monitor shipping traffic and coordinate traffic with different types of construction vessels. Shipping routes will be crossed in such a way as to eliminate conflicts. Special mitigatory measures will be taken in connection with cable installation in shipping routes. The wind farm will be clearly marked with navigation lights and AIS. Further analysis will clarify the necessary safety distance from nearby shipping routes. In addition, measures will be evaluated to limit the impact of radar interference, for example with additional radar equipment.

An increase in the likelihood of accidents (collisions, grounding and allisions with wind turbines) is considered to have a moderate negative transboundary impact on the surrounding vessel traffic without action. With the planned mitigation measures, however, the increase in the probability of accidents is expected to be significantly reduced.

7.11 Aviation

Total impact assessment

A flight obstruction analysis from the Swedish Civil Aviation Administration shows that Malmö Airport's MSA area and TMA a area (terminal area) are influenced by the Triton wind farm. The flight obstruction analysis also shows that the MSA area for Rønne/Bornholm airport is within the area of influence from the Triton wind farm. The company therefore has an ongoing dialogue with Malmö Airport about the possibilities of increasing altitudes in the MSA area for the southern sector, and adapting the TMA a-area. The company is also conducting a dialogue with Rønne Airport, Naviair, about adapting its MSA area.

Marker beacons will be designed and installed according to current guidelines.

The overall assessment is that the Triton wind farm can be built without any negative impact on aviation after adaptation of the obstruction-limiting areas of the airports. This also applies to transboundary impacts.

7.11.1 Preconditions

Minimum sector Altitude (MSA) areas are the areas where ground obstructions can affect flight procedures to and from an airport. Established flight procedures will be followed during landing and take-off using instruments. The MSA zone covers an area of 55 to 60 kilometres from the airport landing aids. Most of southern Sweden is covered by MSA areas belonging to existing airports.

There are airports near the Triton wind farm whose flight procedures may be affected.

For Malmö Airport, the MSA area and the TMA a-area (terminal area) are influenced by the Triton wind farm.

The flight obstruction analysis also shows that the MSA area for Rønne/Bornholm airport is within the area of influence from the Triton wind farm.

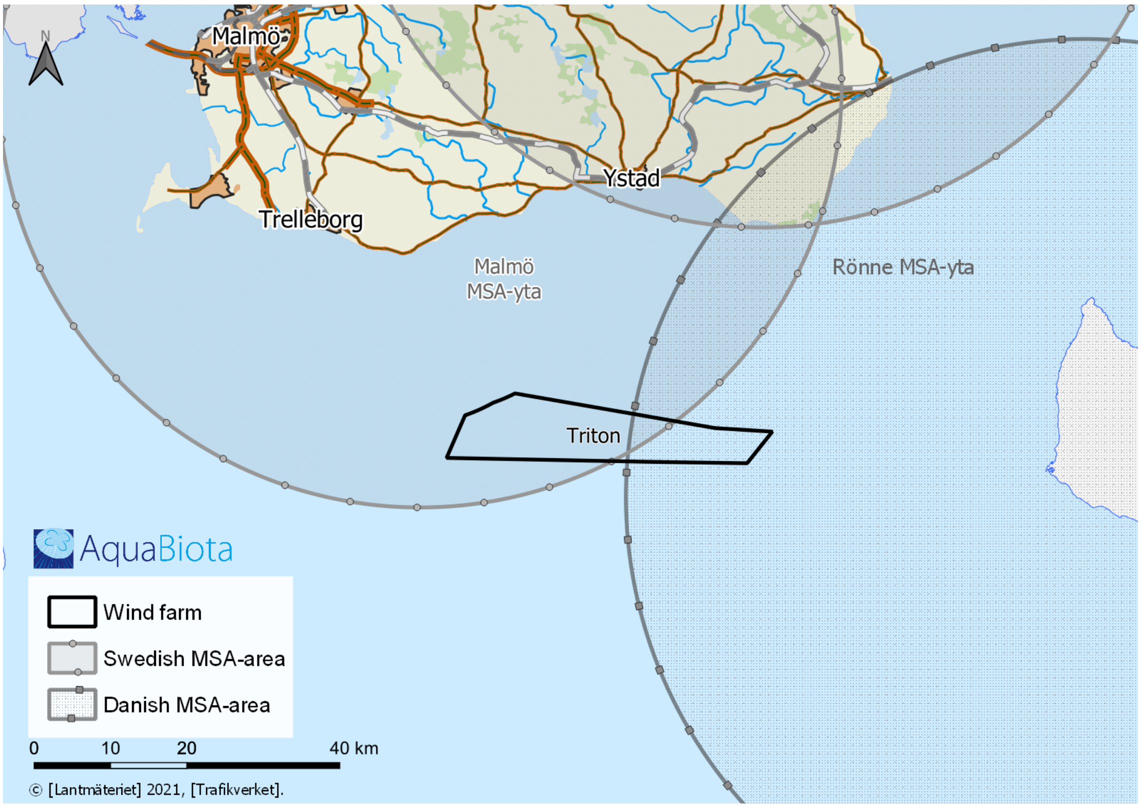


Figure 76. The airports concerned are Malmö and Rønne with MSA areas.

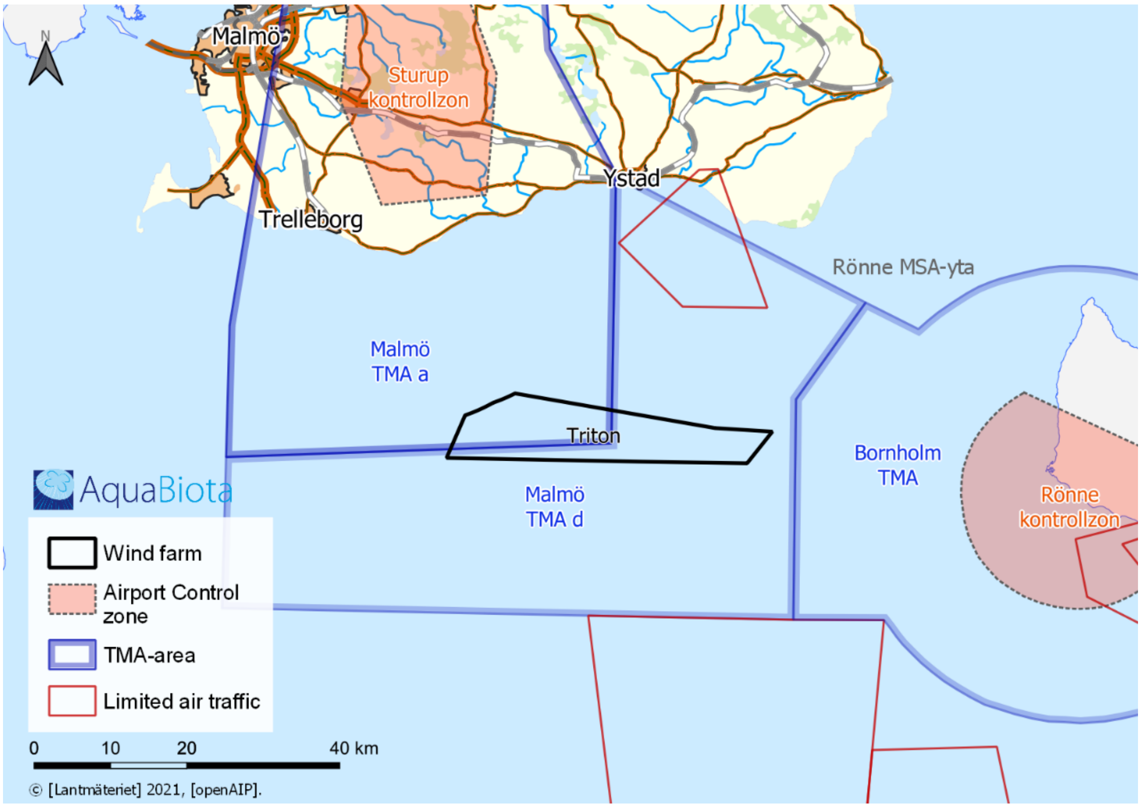


Figure 77. The airports concerned are Malmö and Rønne with TMA areas.

Flight altitudes in the sectors concerned needs to be increased during both the construction, operation and decommissioning phases. The company has an ongoing dialogue with Malmö Airport about the possibilities of increasing altitude in the MSA area for the southern sector, and adapting the TMA a-area. The company is also conducting a dialogue with Rønne Airport, Naviair, about adapting its MSA area.

Table 66. Potential influence factors on aviation that occur during the different phases of the wind farm.

Influence factor	Construction phase:	Operational phase	Decommissioning phase
Physical interference in the airspace	x	x	x

7.11.2 Impacts

Construction phase:

The company has an ongoing dialogue with the airports concerned about the adaptation of obstruction-limiting areas. During the construction phase, wind turbines will be gradually erected to the final height and numbers, and high building cranes will be used. Marker beacons will be designed and installed according to current guidelines.

The inter-array is not considered as such to have any influence on aviation.

The assessment is that the influence on aviation is negligible.

The impact is considered to be negligible during the construction phase, because adaptation of the obstruction-limiting areas of the airports is a prerequisite for the construction of the wind farm. Aviation obstruction marker guidelines will be met.

Table 67. Estimated impact on aviation during the construction phase.

Influence factor	Recipient sensitivity/value	Size and extent of the influence	Impact
Physical interference in the airspace	Small	Insignificant	Negligible

Operational phase

During the operational phase, the alignment of obstruction-limiting areas will already have been completed before the facility opens. Similarly, aviation obstruction markings will continue to work in the same way.

The impact is considered to be negligible during the operational phase, because adaptation of airports' obstruction-limiting is assumed to be completed. Aviation obstruction marker guidelines will be met.

Table 68. Estimated impact on aviation during the construction phase.

Influence factor	Recipient sensitivity/value	Size and extent of the influence	Impact
Physical interference in the airspace	Small	Insignificant	Negligible

Decommissioning phase

Wind turbines will be dismantled using cranes in the decommissioning phase. During this period, the aviation obstruction markings will continue to function according to the applicable guidelines, as in the construction phase.

The impact is considered to be negligible during the decommissioning phase, because adaptation of the obstruction-limiting areas of the airports is a prerequisite for permission for construction. Aviation obstruction marker guidelines will be met.

Table 69. Estimated impact on aviation during the construction phase.

Influence factor	Recipient sensitivity/value	Size and extent of the influence	Impact
Physical interference in the airspace	Small	Insignificant	Negligible

7.11.3 Summary of transboundary impacts

As stated above, the company is conducting a dialogue with Rønne Airport, Naviair, about adapting the MSA area for Rønne/Bornholm. Marker beacons will be designed and installed according to current guidelines.

The overall assessment is that the Triton wind farm can be built without any negative impact on aviation after adaptation of the obstruction-limiting areas of the airports.

7.12 Defence interests

Total impact assessment

The Danish Ministry of Defence has stated that the Triton wind farm could affect radar systems on the Danish island of Bornholm and that this issue should be investigated. OX2 has commissioned an independent consultant to conduct technical analyses to assess the influence on the Ministry of Defence facility in accordance with the wishes of the Danish Ministry of Defence. The Danish Ministry of Defence will, when the analysis is completed receive information about the influence of wind farm on radar systems.

In dialogue with the Danish Ministry of Defence, OX2 will take necessary and reasonable precautions to minimise the wind farm's potential interference with the radar system at Bornholm.

The planned Triton wind farm has been adapted to completely avoid the military exercise area managed by NATO called Bravo 2, 3, 4 and 5.

7.12.1 Preconditions

This section relates to the transboundary impact of the activities on defence interests, where the Danish Ministry of Defence has submitted comments in the framework of the Espoo consultation.

The planned Triton wind farm has been adapted to be completely outside a military exercise area managed by NATO called Bravo 2, 3, 4 and 5. The original wind farm area was reduced to less than half during the adjustment, and now completely avoids the military exercise area, see Figure 85 in section 10.

7.12.2 Impacts

An offshore wind farm with high wind turbines/objects can affect the Swedish National defence interests in a number of ways. Wind farms can, for example, constitute a physical barrier in airspace and constitute a restriction on the Swedish Defence Forces' operations, for example in low-altitude flight areas where wind turbines, depending on location and design, can limit the defence force's ability to operate low-altitude flight operations. Communication and radar systems, and technical interference from these many have a negative influence on the Swedish Defence Forces' operations. Reconnaissance radar can be affected by signals being blocked by the wind turbines, small targets are difficult to distinguish in their vicinity and reflected signals can cause false so-called "ghost targets". Weather radar is also affected by signal blocking. Additional influences may be conflicts with marine exercise areas.

In order to minimise the influence on military interests, foundations will not be built closer than 500 metres from the border with the NATO training areas (Bravo 2, 3, 4 and 5) south of the wind farm as indicated in Annex A.2.

7.12.3 Summary of transboundary impacts

The Danish Ministry of Defence have stated that the Triton wind farm could affect their radar system on the Danish island of Bornholm. OX2 has ordered and will, through a third party, conduct technical analyses to assess the influence on the Ministry of Defence facility in accordance with the requests concerning extent and design that the Danish Ministry of Defence has put forward. The Danish Ministry of Defence will, when the analysis is completed receive information about the influence of wind farm on radar systems. Based on the results of the above analysis, OX2 will enter into a dialogue with the Danish Ministry of Defence, and other relevant parties, regarding necessary adjustments and safeguards so as to minimise wind farm interference with the radar systems at Bornholm.

OX2 collaborates with specialists in how offshore wind farms can affect civil and military radar operators. Through its partners, OX2 is following developments in order to better understand, identify and implement adaptations or interference-reducing solutions for radar and other communications equipment. These adjustments and mitigatory measures will help to ensure the coexistence of wind farms and military requirements.

7.13 Risk and safety

Total impact assessment

The operations can give rise to various risks during the construction, operation and decommissioning phases. Risks will be continuously managed and minimised through risk analyses, working environment plans and mitigatory measures and routines. The activities are not considered to give rise to any unacceptable risk, including the transboundary impacts.

This section describes accident and environmental risks both generated by the operation and from external events.

7.13.1 Preconditions

The following describes how OX2 works, and will continue to work, with safety issues. In addition, various examples of risks that may occur in the course of the business are given.

In general, risks in large-scale construction projects can be divided into those relating to health, the environment and property; in addition, there are risks that affect several of these aspects (financial risks are not addressed in this EIA).

The environment in which a offshore wind power project is being implemented is characterised by many major challenges. The fact that no wind farm has been built in the Swedish EEZ in the past underlines the need for careful planning of such a facility and for clarification of different roles, for example in response to accidents. This is something the project will focus on during the further project development phase.

The environment means that offshore wind projects have several unique conditions related to *workplace accidents* (including accidents involving third parties), such as the marine environment, that work can take place at height and in confined spaces, and include heavy lifting and electricity. Risks to *the environment* are often the result of uncontrolled discharges of various kinds, such as chemicals, noise and sediments. The risk of property damage mainly concerns the installation itself and can often be a result of handling extremely heavy components, but accidents such as sealing can also affect third parties. Table 32 below illustrates various examples of the risks that may arise within the framework of the business, and gives examples of measures in parentheses. Shipping risks are described separately in section 7.10 of this EIA.

Table 70. Examples of hazards and remedies.

Category	Example of risk (suggested action)
Environment	• Oil and chemical discharges (emergency response)
Risk of accident	• Falling towers (certification, manufacturing, installation and operational checks) • Falling nacelle (certification, manufacturing, installation and operational checks) • Loose blades (certification, manufacturing, installation and operational checks) • Loose turbine components (certification, manufacturing, installation and operational checks) • Fire, overheating, short circuit (detectors, extinguishing systems)
Occupational health and safety risks*	• Working at heights (training, barriers, body harness) • Hot work (training, certification) • Electricity (training, certification) • Heavy lifts (lift plans, no persons under suspended loads) • Moving parts (mechanical protection, training) • Man overboard (training, life jackets, rescue net, survival suits)
External events	• Extreme weather • Geological hazards • Unexploded ordnance (investigations) • Maritime risks/collisions

*Design, RAMS and toolbox talk are general measures as well as personal protective equipment.

Note that the above summary illustrates various examples of risk events, not their causes. For example, a maritime hazard event may be caused by a captain choosing to increase the distance to the wind farm, a wind turbine breakdown may be caused by false assumptions about external loads (due to climate change), and a workplace accident may be caused by inadequate procedures.

7.13.2 Action hierarchy

The various risks involved in the project are of a varying nature, which also means that the measures identified will be conducted at different times, during planning, in preparation for the establishment of a construction site or in connection with construction. Identified risks will be managed according to a so-called action hierarchy (see Figure 78).

- First, a risk must be completely eliminated by removing the situation that causes the risk.
- Secondly, the risky situation must be replaced by one that is less risky.
- Thirdly, different technical measures should limit the risk.
- Fourth, different procedures should limit the risk.
- Lastly, fifth, personal protective equipment should limit the risk.

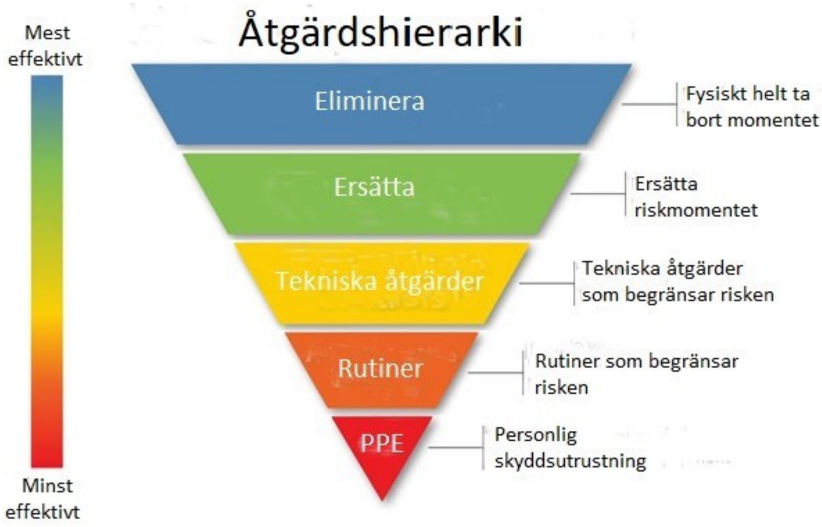


Figure 78. Action hierarchy. The most effective action is to completely remove a situation that causes a risk. As a final measure, PPE should be used (this means of course that the relevant PPE should always be used, but before this action the risk should have been eliminated or reduced by other remedies).

7.13.3 Environmental hazards

Spills of oil or other chemicals may occur from ships and from the facility. The oils and fuels in the turbines need to be regularly replaced or topped up. There is a risk of involuntary spills during these operations. The probability that a major spill occurs from a vessel within the wind farm is considered to be small because the farm area is assumed to be operated mainly by service and maintenance vessels and small numbers of leisure craft.

Minor spills of oil or other chemicals could occur in connection with the maintenance of the turbines, but it should be noted that wind turbines and other equipment are designed with, for example, waste trays and/or other means of collecting a possible spill. The wind farm will have equipment such as booms for managing such spills.

In the run-up to construction, a Contingency and Rescue Plan will be drawn up after consultation with the relevant authorities and municipalities, which will include a plan for action to protect the environment in the event of oil spills and the recovery of any damaged ships.

7.13.4 Risk of accident

A range of different events could occur during wind turbine operation. A wind turbine could suffer a fire due to, for example, an electrical fault, overheating or a lightning strike. Fires can also occur on transformer platforms and on service vessels. Careful design and ongoing maintenance, together with continuous monitoring of operating conditions (e.g. temperature, quality of oils), should reduce the likelihood of fire due to electrical failure or overheating. The blades are fitted with lightning arrestors to protect the structure from lightning strikes.

In the event of a fire, the nacelle is fitted with an automatic extinguishing system, for example, which can fill the space with carbon dioxide, thereby smothering the fire. It is very rare for a fire to occur when someone is in the nacelle (the carbon dioxide extinguishing system must be shut down if there are personnel in the nacelle), if this happens, the first action is to attempt to extinguish the fire with available equipment such as fire extinguishers and fire blankets, the next action is to evacuate the nacelle. It must be possible to evacuate the nacelle safely, with alternative and independent exits, for example the internal ladder and an exterior winch. Lifts must not be used for evacuation.

The management of accidents at wind turbines will also be included in the emergency response and rescue plan drawn up for the construction work.

7.13.5 Occupational health and safety risks

Health and safety risks will be managed within the framework of the work environment plan that will be drawn up. In the first place, health and safety risks must be avoided and minimised by limiting hazardous activities using technical protection measures, organisational protection measures and personal protective equipment, as well as through procedures and exercises.

7.13.6 External events

Climate adaptation

During the lifetime of the wind farm, ongoing climate change can have an impact on the area's hydrography, such as increasing water levels and changing wind conditions, and also changing the frequency of strong winds. The development of the Triton wind farm also takes into account climate aspects in a shorter perspective of thirty years, because the climate and its changes affect the design of the facility, primarily due to wind, ice and waves.

The warming climate leads to a reduction in the spread of sea ice, thus reducing the influence on the wind farm and increasing accessibility. One example of how the wind farm can be climate-adjusted is to make the foundations slightly higher than would otherwise have been the case. If the wind farm is adapted to the climate so that the wind turbines are dimensioned for a future climate, the risk is considered marginal for accidents resulting from climate change.

Unexploded ordnance

According to the Defence Forces' risk mapping, there are no unexploded munitions and other weapons in the wind farm area. The possible presence of unexploded ordnance (UXO) will be surveyed as part of the detailed engineering. Objects that are identified will either be avoided by taking them into account when locating wind turbines and cables or be made harmless before a work operation can be conducted.

Before installation begins, a final check of conditions will be made to ensure that there is no unexploded ordnance at the specific location, where a support leg vessel is positioned, where a foundation is placed or where a cable is laid. After this, various forms of seabed preparation will be conducted before the foundation is constructed on the site. Should unexploded ordnance or chemical weapons be found during seabed surveys prior to installation, the relevant authorities will be notified immediately. If there is a risk to the installation work, an assessment will be made in consultation with the supervisory authority and the Armed Forces as to whether the object should be moved or destroyed in a controlled explosion. Alternatively, the object can be avoided by selecting a different foundation position or cable route. In the event of movement or detonation of objects, appropriate precautions should be taken to minimise the impact on marine mammals, fish and sea fowl likely to be in the area. Appropriate safeguards will be developed with the relevant authorities.

Gas pipeline

Baltic Pipe runs through the southern part of the wind farm. In order to minimise the risk of influence, a distance of 500 metres will be maintained for anchoring and jack-up vessels, which is in line with the distances to other interests used as safeguarding measures for Baltic Pipe.

Maritime risks

Risks related to shipping are described in section 7.10. In order to reduce the risk of ship collisions, grounding and drifting ships, several mitigatory measures and precautions will be taken, based on recommendations in the marine risk analysis.

Prior to the start of construction, a contingency and rescue plan will be drawn up after consultation with the regulatory authorities, other relevant authorities and the local authorities concerned, including maritime rescue operations, rescue operations and salvage of any damaged ships. Consultations will also be held with the Swedish Maritime Administration and the Swedish Transport Agency in preparation for the construction phase on measures required to protect against disruptions to shipping. Monitoring in the area of activity will take place during the construction phase and also continue during the operational phase if the Swedish Maritime Administration or the Swedish Transport Administration considers that such need exists. Ships that are at risk of navigating incorrectly in relation to the wind farm will be warned.

7.13.7 Continued work and mitigatory measures

OX2 will continue to work with risk management and risk minimisation during any further work. The following is a comprehensive description of this work.

The project's HSSE Management Proceedings

OX2 has initiated the establishment of a Health, Safety, Security and Environment (HSSE) Management Proceedings, which describe how the project will plan, manage, monitor and coordinate health, safety and environmental issues throughout the design, engineering and commissioning phases for the wind farm.

Emergency response and rescue plan

In good time before the construction phase, OX2 will, in consultation with the relevant authorities (such as the Coast Guard, the Swedish Maritime Administration, the Skåne County Administrative Board, the Skåne Regional Authority and the municipalities concerned) establish a contingency and rescue plan. The plan will clarify the division of responsibility for various incidents and accidents, what measures should be taken, where equipment is located and who should be informed.

Risk Register

An important part of the HSSE work is to continuously identify all risks and register them in a project-specific risk register. A detected risk must be assessed and accompanied by an action. This register must describe, among other things, risk events and their underlying causes, which can be a chain of events or several parallel events, the probability and consequence of risk events, various actions and the effect of the actions on probability and impact, and who is responsible for the risk being managed and when it should be managed.

It is important that risk analysis work is started early in project development. When designing components or when designing an operation, the risks that the component or operation may give rise to and the risk reduction measures that can be taken must be assessed. During procurement it must be ensured that suppliers understand and respect the project's high risk awareness. Routines must also be continuously monitored among suppliers and their subcontractors, including in the manufacture of components.

Checks, RAMS, Toolbox talk

Documented checks will be performed on an ongoing basis during component manufacturing. Finished components will be checked in a so-called Factory Acceptance Test (FAT) and after delivery will be inspected in a Site Acceptance Test (SAT). The final installation will be checked and reconciled against a so-called Reference Turbine before the trial operation begins.

Prior to different work stages, a risk assessment method statement (RAMS) will be conducted in which the various potential risks are identified and it clearly describes how the operation is to be conducted. Just before a work operation is started, a so-called "tool box talk" is held, in which everyone involved gathers together to take a look at the operation and what risks may be present. After the work has been conducted, a follow-up must be conducted and any non-conformances, including incidents that have not led to an accident, will be reported.

Qualifications and training

People involved in the construction and operation of the operation will have relevant qualifications and training that have been adapted to offshore wind power, for example coordinated by the Global Wind Organisation.

Prior to the offshore part of the installation, a workshop will be held, identifying potential risk events, developing proactive measures and drawing up action plans. The result is compiled into a risk folder, which clearly describes the actions to be taken and by whom, for the various risk events. In the event of an accident, there must be an easily accessible guide on what to do.

7.13.8 Summary of transboundary impacts

Various risks can arise within the framework of the operation that can be divided into environmental risks, accident risks, occupational health and safety risks and external events. Examples of the risks that may arise in the context of transboundary impacts are, in particular, oil or chemical spills, extreme weather and geological hazards (see more in Table 70).

Minor spills of oil or other chemicals could occur in connection with the maintenance of the turbines, but it should be noted that wind turbines and other equipment are designed with, for example, waste trays and/or other means of collecting a possible spill. The wind farm will have equipment such as booms for managing such spills.

The management of accidents at wind turbines will also be included in the emergency response and rescue plan drawn up for the construction work.

OX2 will continue to work with risk management and risk minimisation during any further work. See also section 7.13.7.

8 Cumulative effects

This chapter describes the assessment of cumulative effects. Cumulative environmental effects are the cumulative effects of plans for the Triton wind farm combined with the potential influence from related activities or actions. So, the overall effects of the planned Triton wind farm combined with potential influences from related projects are described here.

A starting point for assessing cumulative effects is to include existing and permitted activities located near the Triton wind farm area, which may potentially affect the same environmental aspects as the Triton wind farm. These activities consist of other wind farms, pipelines, electrical cables and activities such as shipping and fishing. For existing and licensed activities, see Table 4.

The cumulative effects of activities planned and in the early stages of project planning are also described, as far as possible, on the basis of information available about these activities. While existing and permitted activities generally have the necessary practical information to make relevant cumulative assessments, there is, as a rule, considerable uncertainty regarding the scope, design, environmental impact and the possibility of realisation of a project for planned and non-permitted activities; making cumulative assessment difficult and limited. For example, the design of the Triton farm area has changed considerably during the planning process, for example in order to adapt to the surrounding interests.

Several wind power projects are operating, has permits or under development in the area and near the wind farm (Figure 79). Of these, five wind farms are currently in operation: the Danish Krieger's flak, EnBW Baltic 1, Wikinger, Arkona and Baltic 2. The Wikinger Süd and O-1.3 wind farms have been procured/are out for auction and are also estimated to be in place when construction for Triton begins. In addition to other wind farms, Baltic Pipe (gas pipeline), Hansa PowerBridge (planned power cable), shipping, fishing, Energinet export cable and the Bornholm energy island as well have also been included in the cumulative impact assessment.

Ørsted is designing the Skåne Havsvindpark, which will partly occupy the same area as the Triton wind farm. The licence application for the project was submitted in late September 2021. Eolus Vind is also designing the Arkona wind farm, which also partly occupies the same area as the Triton wind farm. Consultations for the Arkona wind farm took place during the winter of 2021/2022.

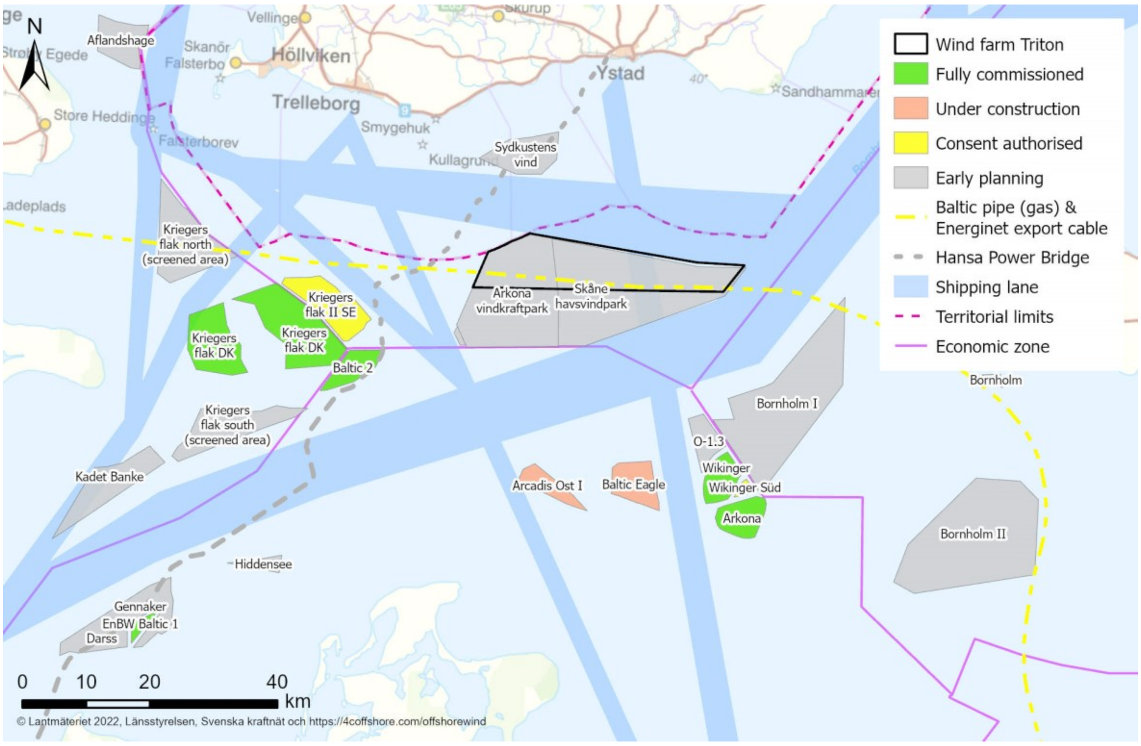


Figure 79. Neighbouring wind farms and projects.

The construction of several wind farms in the area could possibly mean that greater constraints on the aviation side would be required than for the Triton wind farm alone. However, the adaptation of the airports' obstruction-limiting areas is a prerequisite for building and the impact is therefore considered to be small.

The environmental aspects in which a cumulative effect is expected to occur are described in more detail below.

8.1 Construction phase:

The Triton farm phase is not considered to overlap with the construction phase of any of the other identified wind farms (Figure 79). The cumulative effects are therefore considered negligible.

However, in the event of several wind farms being built at the same time, the following assessments have been made.

For the influence of direct or indirect sediment spreading and suspended material, other wind farms are assessed to be too far away from Triton to be reached by sediment spread as a result of the construction of Triton.

Cumulative effects on underwater noise may occur during the construction phase, and in particular if construction work causing high impulse noises (such as piling) is conducted simultaneously in a nearby wind farm. This influence could be particularly affecting marine mammals and fish. According to the data simulations performed (R.11.C) described in section 6.1 , the noise from the construction of a monopile foundation in a worst-case scenario could lead to temporary hearing loss (TTS) in fish. This may happen if an adult cod is within a radius of less than ten kilometres from the piling work, with mitigatory measures applied. In order for cumulative effects to occur in parallel construction work in another wind farm and result in TTS for cod, it is considered that the distance between work in progress must be less than two miles. Most wind farms are located too far away from the Triton wind farm to produce a cumulative effect from underwater noise. In the case of sediment spread between installations, the distance is too great for the concentration levels and duration of suspended material to be high enough for an additive effect between wind farms. This also applies to projects in the vicinity, such as the Bornholm energy island and Hansa PowerBridge.

OX2 will have a dialogue with Energinet regarding the export cable that Energinet plans along Baltic Pipe. In the case of projects running concurrently, a timetable will be established to ensure the necessary safety distances between the Energinet's cabling laying and the activities of OX2 to ensure that no cumulative effects occur. For Baltic Pipe, a distance of 500 metres will be maintained for vessels and foundations to ensure that there is no impact on the pipeline.

If several wind farms were built at the same time as Triton's wind farm, it could theoretically result in an additive effect through restrictions on marine traffic and fishing in several areas during the construction phase. As the entire wind farm is not built at the same time, protection zones around work areas will be smaller both in terms of time and area. Together with the restrictive fishing quotas now decided, fishing is not expected to be affected during the construction phase. All in all, the negative cumulative effects on the fishing industry, which could arise from the construction of another wind farm at the same time, are considered to be negligible.

8.2 Operational phase

8.2.1 Bottom flora and bottom fauna

As can be seen in section Hydrographic changes above, the influence of the wind farm on hydrodynamic conditions is very local. The impact on the mean current velocity and salinity occurs in the immediate vicinity of the foundation at a distance of about 125 and 450 metres, respectively. As the other wind farms and other planned projects are located at a distance beyond this, no cumulative effects on hydrodynamic conditions are considered to be present as a result of the Triton wind farm. During the decommissioning phase, the influence is deemed to be insignificant and the impact to be negligible.

8.2.2 Fish and marine mammals

The underwater noise that can be generated by the turbines during the operating phase is significantly lower than the noise generated during the construction phase. The adjacent shipping lanes already cause underwater noise and the additional shipping services (during maintenance) as a result of Triton are expected to contribute to negligible increase in underwater noise from ships, compared to the existing shipping traffic. The cumulative effect on fish and porpoises from underwater noise in the operating phase is considered to be negligible.

8.2.3 Birds

Bird life is affected by the cumulative effects of the activities under way and planned in the vicinity of the Triton wind farm. Existing and permitted activities are included in the assessment of cumulative effects on bird life. There are currently five wind farms in operation in the vicinity of Triton, two permitted wind farms, and another three that are purchased/out for auction and are deemed to be in place when construction for Triton begins. The wind farms in the cumulative assessment comprise a total of around 900 wind turbines including the Triton wind farm. In addition, a number of non-permitted projects in the area are planned which have not been included in the cumulative assessment due to the size of the uncertainties regarding their extent, design, timetable and permitting.

The most significant influence factors are collision risk, displacement and barrier effects. These factors affect different species groups in different ways, among other things, depending on whether or how they use the area as a habitat, or whether they pass through the area during migration. The development of wind power facilities in the area of the Triton wind farm is deemed to have negligible consequences for all species/species groups assessed, except for collision risk for migratory cranes. Assessments of this can be found in section 7.6. In assessing the cumulative effects, the additive contribution from the Triton wind farm must be assessed together with the effects of other activities in the immediate vicinity.

Collision risks

The estimated number of cranes at risk of collision in the wind farms included in the cumulative assessment (existing and permitted, and Triton) represents 1.3 % of the annual migration across the Arkona Basin, according to a worst-case scenario and when no mitigatory measures are taken at some of the farms. It is an increase in mortality that is lower than the estimated biologically sustainable level that the crane population is expected to be able to cope with in order not to decrease in numbers, calculated using the PBR model. If all known planned projects were to be built without mitigatory measures, the number of annual crane collision incidents is estimated to correspond to 2.6% of the cranes that migrate annually across the Arkona Basin. In such a worst-case scenario, there is a risk that the number of collision incidents could lead to a decrease in crane population size.

The impact on cranes of the Triton wind farm alone is assessed to be small without mitigatory measures, but with the measures planned in accordance with the licensing conditions, the impact is deemed to be negligible. The cumulative assessment of the impact on cranes of Triton and other permitted and already operational wind farms is assessed, without mitigatory measures, to be moderate, because the number of collisions is relatively high compared to what is considered to be a biologically sustainable level. In the case of wind farm development that includes all planned projects, the impact for cranes, without mitigatory measures, is considered to be great.

The proposed measures for the Triton wind farm include operational regulation and closure of all or part of the wind farm for up to 100 hours during the intensive spring and autumn migrations, as well as research programmes to study movement patterns of migratory cranes and their degree of avoidance in the area of operation and the influence from the wind farm. However, with proposed mitigatory measures for the Triton wind farm, the cumulative effect of Triton on cranes is deemed to be insignificant, with negligible impacts. The application of mitigatory measures to other existing and future wind farms is beyond the operator’s control, but it is considered that there are good conditions for significantly reducing the adverse impacts of cumulative effects through mitigatory measures.

The total migratory flow of birds at night over the Arkona Basin is estimated at 350 million annually. Based on the assumption of collision incidents of night-migration birds at two existing farms, the cumulative number of collisions would be less than 0.1 ‰ (per mille) of the total number of migratory birds. The cumulative impact on night-migration birds is considered to be negligible, where the additive effect of Triton is insignificant.

For example, for raptors, the additional effect of collision incidents from Triton is considered to be insignificant, as these migrate further west.

Displacement effects

The effect of displacement is that birds avoid using the wind farm area as a foraging area, making the areas inaccessible as a habitat for birds. The effect varies between species, some being more, some being less likely to avoid the wind farms. The impact of displacement depends entirely on the importance of the area to the species in question.

In assessing cumulative effects on displacement, it is therefore of great importance to consider the importance as habitat and foraging area that Triton and other wind farms are considered to have. The consequences of the displacement effects of the Triton wind farm have been assessed for common murre, razorbill, red-throated loon, eider, long-tailed ducks, common scoters and seagulls. The number of resting and feeding seabirds is low in the area of the Triton wind farm, according to the results of counts and previous studies. For all species/species groups assessed, the impact is deemed to be negligible.

In terms of the cumulative displacement effect, combined with existing and permitted wind farms, the Triton wind farm is expected to contribute only minor displacement effects and negligible cumulative influence.

Barrier effects

The effects on sea birds may occur either during migration or in connection with foraging sites.

Migratory sea fowl often adjust their flight course to fly around offshore wind farms. The additional flight distance caused by a detour around the Triton wind farm during migration is irrelevant in relation to the total distance that the birds fly between breeding areas and overwintering sites. The same applies to the assessment of other existing and permitted wind farms in the Arkona Basin. During migration, for example, weather conditions have a greater impact, because wind drift can mean considerably longer flight distances.

The Triton wind farm is not located in an area with significant daily movements of birds, so that the impact of barrier effects is considered negligible for sea fowl in the area.

All in all, the additive effect of the Triton wind farm is considered to be insignificant as regards barrier effects for overwintering and migratory seabirds. The assessment of the cumulative barrier effect of Triton, together with existing and permitted wind farms in the area, is that it is small.

8.2.4 Landscape and heritage environment

Cumulative effects include effects from the Triton wind farm and other wind farms that are considered relevant from geographical distance between each other and that may affect the heritage environment or landscape. The assessment of cumulative effects on landscapes includes four wind farms in addition to the Triton wind farm. The four wind farms in addition to the Triton wind farm included in the assessment are the three wind farms in Krieger’s flak that are currently in different stages of expansion and the planned wind farm, Sydkustens Vind, which is in an early phase of planning. However, there are still a number of uncertainties regarding the design of projects in the planning phase. Nor is it certain that all of the wind farms will be built. At present, the wind farms in the German and Danish parts of Krieger’s flak are in operation, but a number of uncertainties are associated with the other wind farms included in this cumulative analysis.

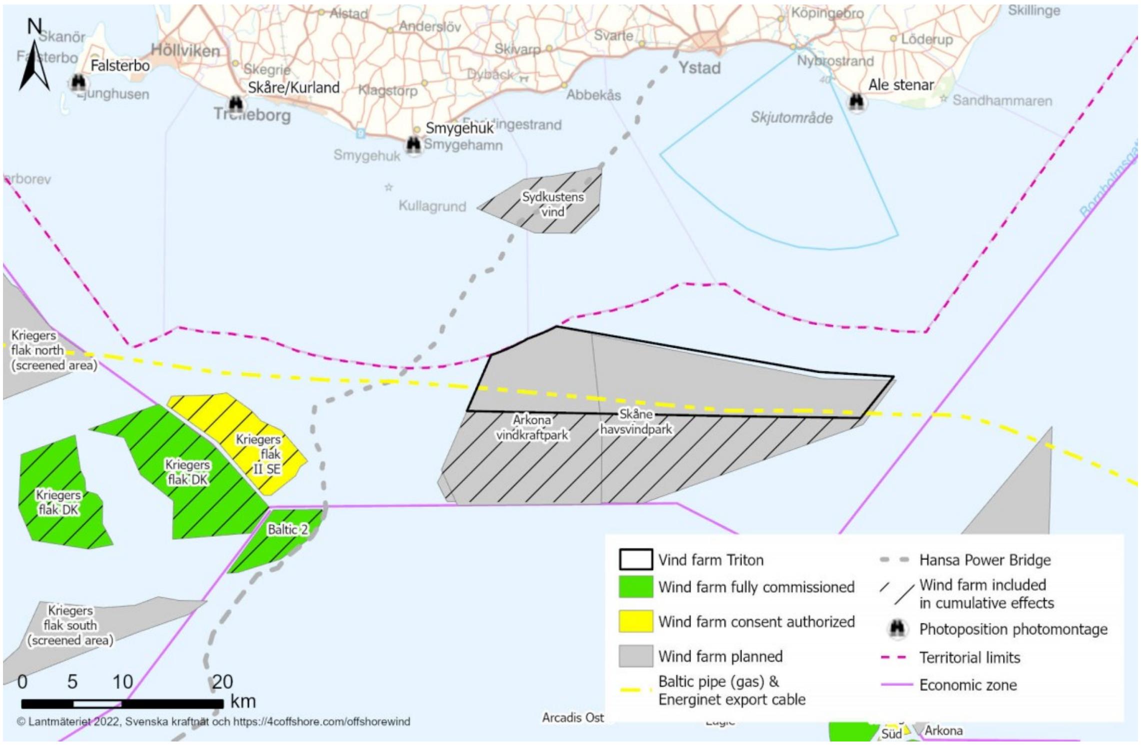


Figure 80. Wind farms in the vicinity that are considered to have a cumulative effect on landscape and heritage environments.

Cumulative visual impact on the experience values of Ale's stones (photo point 2) further weakens the character and outlook of the area when both the Sydkusten vind and Triton farms are visible on the horizon in a wide sector at distances of about 30 kilometres and 27 kilometres from Ale's stones. The wind farms at Krieger's flak will not contribute to cumulative visual influence. All in all, the visual influence on the experience value is deemed to be great, but no threshold effect, i.e. no step change but a gradual increase, is considered to occur. The influence in question, that is, in this case visual influence, from the wind farms is reversible because a wind farm will be dismantled after its operational lifetime and, looking from a longer time perspective, is a temporary part of the landscape. The cumulative negative impact on the landscape and heritage environment is therefore considered to be moderate from Ale's Stones.

If the Skåne havsvindpark farm is built in its entirety, wind turbines will be visible in a larger sector on the horizon than Triton, still as a group from Rønne. The wind turbines at Sydkustens vind will not be visible from Rønne. Port facilities and port traffic will still be the most dominant elements of the seascape. All in all, the cumulative visual impact on the heritage environment and landscape is assessed to be insignificant and the impact negligible from Rønne.

Figure 81. Photo montage with cumulative influence on Rønne. The turbines are marked by icons.

The Skåne havsvindpark farm will be visible on the horizon from Hasle, but the grouping will be seen as marginally larger compared to the Triton wind farm. The Sydkustens vind farm will also be visible from Hasle, but the wind farm will form a somewhat smaller group along the horizon and will be dwarfed by the seascape because of its large distance from Hasle. All in all, the cumulative influence is deemed to be small and the cumulative impacts for the seascape and heritage environment are very small from Hasle.

Figure 82. Photo montage with cumulative influence on Hasle. The turbines are marked by icons.

From Hammershus, the difference is marginal when comparing the influence of only the Triton wind farm with the cumulative effect. The distance is 40 kilometres to the nearest turbines that form two contiguous groups. All in all, the cumulative influence on the heritage environment and landscape is deemed to be small and the impact moderate from Hammershus.

Figure 83. Photo montage with cumulative influence on Hammershus. The turbines are marked by icons.

8.2.5 Commercial fishing

Multiple wind farms in operation at the same time could lead to a reduction in access to bottom trawling in the Arkona Sea. Other fishing methods are expected to be able to continue with current restrictions. As bottom trawling has already been drastically reduced in the region as a result of the ban of fishing for cod, the impact of the wind farm development is currently deemed to be slightly negative with a very small impact.

The reduction in fishing is generally positive for fish stocks and the reduction in bottom trawling is also positive for the rest of demersal flora and fauna, which could benefit biodiversity and the recovery of herring and cod stocks in the southern Baltic. In that case, it would be a cumulative mitigatory effect that would eventually benefit fisheries.

8.2.6 Bats

The impact of cumulative effects on bats are deemed to be the same as described in Chapter 7 above. With the introduction of a study programme at start-up to investigate any need for regulation of the wind farm during the migration period, no negative influence has been found during assessment.

8.3 Decommissioning phase

The decommissioning of each wind farm is so far in the future that it is not possible to predict what other activities will coincide with the decommissioning of Triton and thus contribute to cumulative effects. It is therefore not possible to assess the cumulative effects of this phase.

9 Alternatives

9.1 Introduction

An environmental impact assessment must review alternative solutions and locations for the operation and the zero alternative. The alternative review describes the options studied for the operation and the choices made with regard to environmental effects and other criteria. In accordance with practice, a starting point for the studied alternatives has been to fulfil the purpose of the business, see Chapter 1.

The zero alternative is described in section 9.1.3.

9.1.1 Criteria for the location

OX2's strategy for the company's offshore project portfolio is to operate several large-scale projects along the Swedish coast, more or less in parallel. This is to accelerate the expansion of offshore wind power in Sweden in the fastest possible way and to meet the urgent need for renewable electricity, which is of crucial importance in order to reach Sweden's climate targets, which say, among other things, that Sweden should not have any net greenhouse gas emissions by 2045 and that, by 2040, electricity production should be 100% renewable.

The aim has been to select the areas around southern Sweden's coastal areas that have the best conditions for establishing wind power facilities, based on a broad approach and thorough investigation of possible offshore areas. The areas must meet the selection criteria with the least possible opposing interests, limited negative environmental effects and with the possibility of electricity connection.

The following technical and financial conditions have been central to the location of an offshore wind farm:

- Stable and strong wind conditions.
- Suitable water depth, taking into account, among other things, the types of foundations that can be built in different depths of water.
- Suitable geology, taking into account, among other things, the types of foundations that can be built on different seabed conditions.
- The size of the wind farm needs to be sufficient to achieve the financial sustainability of the project and competitive electricity generation.

In addition to the technical and financial conditions, consideration has been given to, among other things, the natural environment (such as Natura 2000 sites, sensitive habitats and species), the heritage environment, commercial fishing, shipping, defence interests and other existing activities and facilities.

In the light of the selection criteria and considerations, OX2 has investigated a number of alternative locations around the Swedish coast, several of which are now subject to project development.

Selected alternative

The south-west Baltic Sea offers very good conditions for establishing wind power facilities with regard to wind conditions, possible connection points to Skåne and the great need for increased electricity generation in this part of Sweden. The location survey, in which the wind farm is intended to supply electricity to southern Sweden and lie outside protected natural areas and shipping lanes, limits the possible alternatives in this part of the Baltic Sea to a relative extent.[43]

The chosen location for the Triton wind farm has been deemed to be the most suitable for the establishment of a wind power facility because it is one of the few contiguous areas that does not coincide with protected areas for other interests such as the military and nature. The location of the area far from the coast (22 kilometres) has less impact on the landscape than if the wind farm is placed closer to the shore. The location is optimal with respect to wind energy, with stable and strong wind conditions. The limited and homogeneous water depth and bottom conditions are also suitable for installation of foundations that are fixed on the seabed. The seabed environment is not considered to offer particularly valuable natural resources.

In addition to the search for the location of the Triton wind farm, OX2 has investigated sites that are closer to land in an area designated as an area of national interest for energy generation and a larger area south of the location for which the licence has been applied, see Figure 84. All locations are suitable from the point of view of wind resources and the depths that enable the construction of wind turbines.

The area that is closer to the coast than the Triton wind farm offers better financial conditions for grid connection, precisely because of the shorter distance to land. The shallower water depth is

43 The shortage of other suitable wind power generation areas in this part of the Baltic Sea is confirmed by the fact that two other companies are also planning wind farms in part the same area as the Triton wind farm, see section 3.5.

also beneficial, but the bottom conditions here are more heterogeneous and complex. The proximity to land, however, makes the alternative less suitable, as it would cause a greater interference with the landscape and heritage environments along the coast. The area also coincides with an area of national interest in the fisheries sector. All in all, this area has been considered less suitable than the Triton wind farm site.

The area just south of the Triton wind farm would also be technically suitable for the establishment of a wind farm, but as the area overlaps with military interests and is an important military exercise area, OX2 has not considered this area as appropriate as the chosen option. The longer distance to land would also lead to longer feeder cable connection, Figure 84.

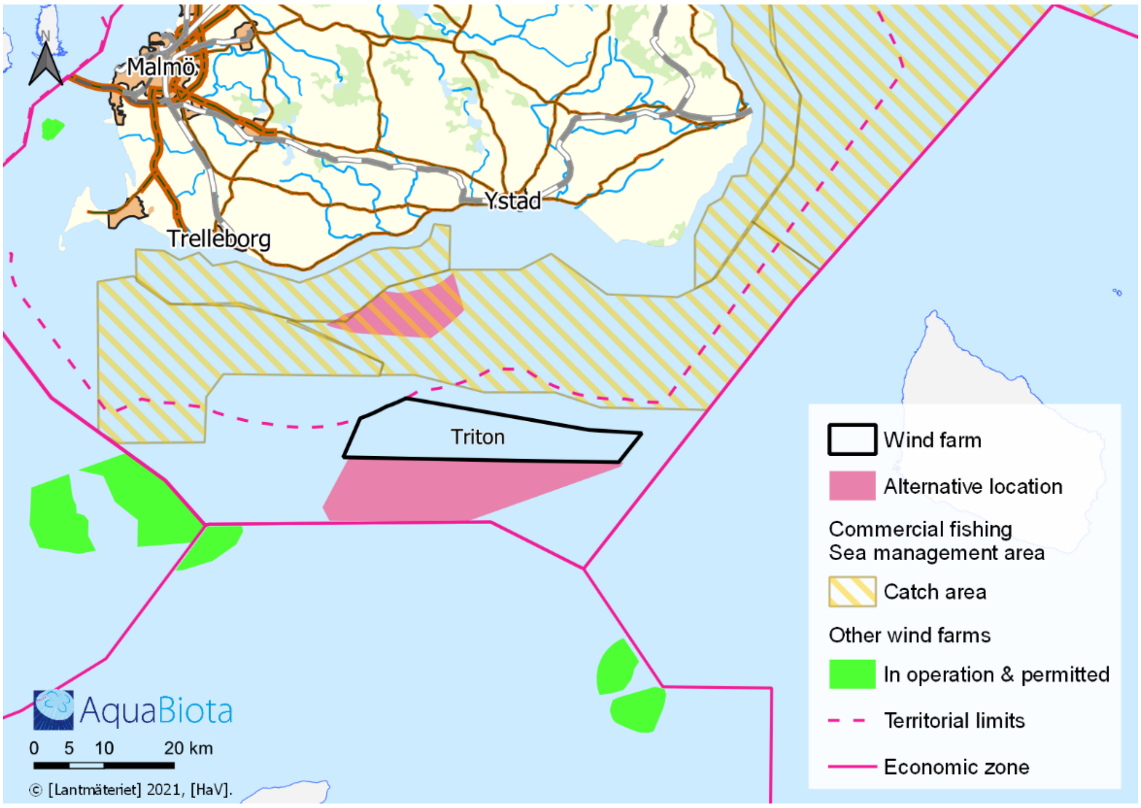


Figure 84. Triton wind farm and alternative locations for wind farms in the south-west Baltic Sea in relation to other interests.

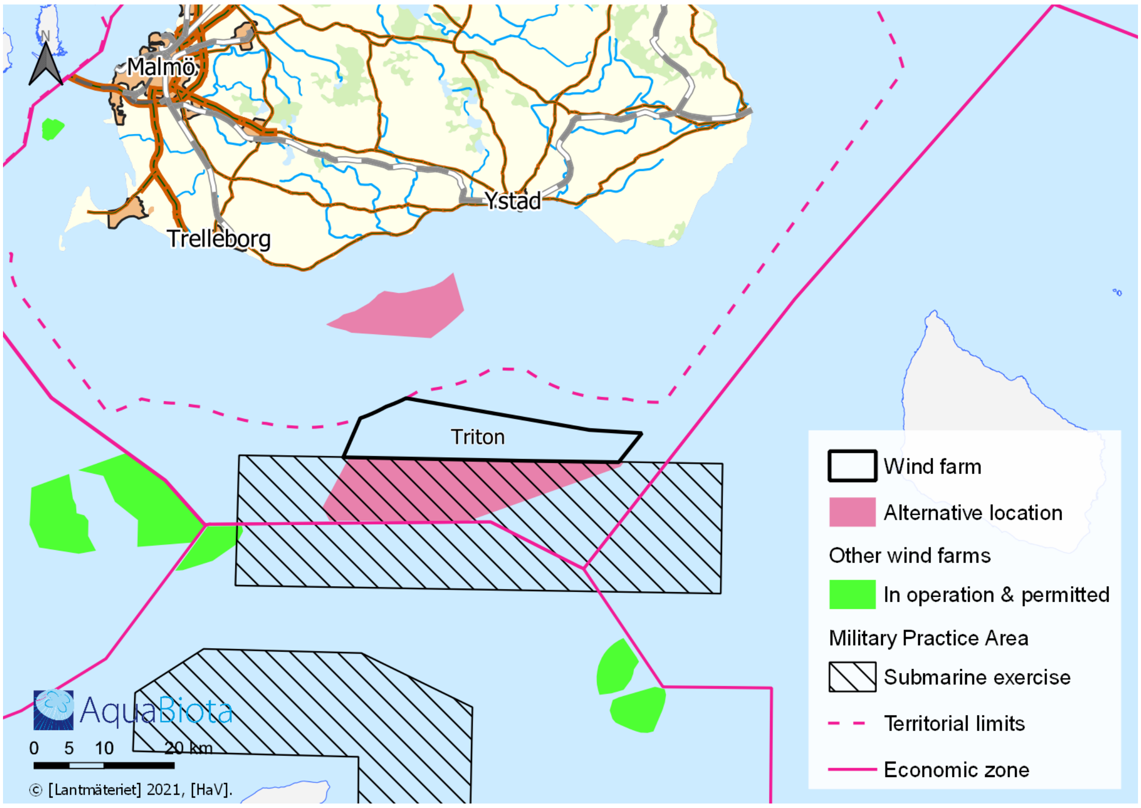


Figure 85. Triton wind farm and alternative locations for wind farms in the south-west Baltic in relation to military interests.

9.1.2 Design alternatives

Various designs for the wind farm have been studied within the framework of the activities. Possible design options using different combinations of numbers, power and height are within the framework of the design scenarios described in the technical description, among other things. In order to achieve flexibility in the design of the wind farm and at the same time not underestimate its influence on the environmental, the assessments are based on a worst-case scenario with a maximum number of wind turbines (129) with a maximum overall height of 370 metres. The maximum design parameters have formed the basis for the environmental impact assessments, based on the design options that make up the worst-case scenario.

One starting point is that the wind farm and its design needs to be optimised, based on a combination of interests, in which as much renewable electricity generation as possible and its climate benefits are the main driving forces, while minimising the influence of the operation on the environment and protected areas, species and habitats.

It is financially most sustainable to build wind farms with higher potential levels of electricity generation because investment costs form a large part of the company's costs and the more kWh the costs can be charged against, the lower the LCOE.[44] However, the possibilities of geographically expanding this particular wind farm area are limited by Natura 2000 sites, a military exercise training area managed by NATO and existing shipping lanes.

44 Levelised Cost of Electricity (measure of the average current net cost of electricity production for a production plant during its lifetime)

Technically, it is possible to reduce the spacing distances between the wind turbines in order to accommodate more wind turbines within the same farm area. However, this assumes building smaller wind turbines because the quantity of electricity produced by each wind turbine will otherwise be reduced due to wind shading. This means a poorer use of wind resources. One disadvantage of a reduced distance between the wind turbines is a greater environmental impact with regard to certain environmental aspects linked to the utilisation of the seabed area, the construction of more foundations and closer distances between the wind turbines. More foundations could have a greater impact on nature types and species in the nearby Natura 2000 area, mainly through sediment spread. A greater number of small wind turbines is also expected to be worse for birds in terms of displacement and barrier effect.

If smaller wind turbines are built, these have a lower output, needing a larger area to be used to achieve the same amount of electricity generation. This is not considered to be possible in view of the constraints related to the Natura 2000 areas, military areas and shipping lanes. The rapid technological development toward larger and more efficient wind turbines also means that smaller wind turbines can gradually no longer be purchased on the market.

The farm area that has applied for a licence has been adapted in respect of the area in which wind turbines can be built to take into account nearby shipping lanes, in order to maintain sufficient safety distances between the wind farm and the shipping lanes. The area for the location of foundations has also been adapted to take into account known heritage remains and the planned Baltic Pipe gas pipeline.

Flexibility in the layout of the wind farm within the permitted area is necessary in order to optimise the design based on the wind turbines and the technology available on the market when the farm is to be built. For this purpose, the starting point for SEZ/KSL-EIA is to assess the impact of the design of the wind farm that has been considered to be the worst-case scenario from the various factors of influence, see Chapter 5.3.1.

9.1.3 Zero alternative

The zero alternative means that the operation does come to fruition. Consequently, no environmental influence will arise as a result of the operation, nor will there be any change in the area in the form of established wind turbines and associated installations. This means, among other things, that marine traffic and commercial fishing can continue as it is at present, and that no impact on marine mammals, birds, fish etc. will occur.

The zero alternative also means that Triton’s contribution to the large-scale expansion of renewable electricity generation will not be forthcoming, with consequences for electricity supply and the climate. The Triton wind farm cannot then contribute to the achievement of the EU’s climate targets and contribute to the phasing out of fossil-based electricity production.

10 Mitigatory measures and controls

The following mitigatory measures are proposed taken within the framework of planned activities and have either been provided as a precondition for impact assessments or have been dropped as a result of impact assessments.

Location and design:

- The location of the wind turbines will be determined after consultation with the Swedish Maritime Administration and the Swedish Transport Agency. Prior to consultation and the establishment of positions for the wind turbines closest to the shipping lanes, a simulation with navigation in a ship's simulator shall be developed by the maritime traffic, which will be submitted to the Swedish Maritime Administration and Transport Administration.
- Wind turbines and met masts must be fitted with obstruction markings according to the regulations of the Swedish Transport Agency and the Swedish Maritime Administration.
- Foundations may only be built in the area marked in Annex A.2 to the application.
- Foundations must not be built within 500 metres of the Baltic Pipe pipeline and the boundary of the NATO exercise areas (Bravo 2, 3, 4 and 5) south of the wind farm as indicated in Annex A.2.

Shipping and safety at sea

- In connection with the construction work being approved, the operator will have to comply with the instructions given by the Swedish Maritime Administration and the Transport Agency so that vessel traffic to and from the areas where construction is being conducted does not pose a risk to other shipping.
- During the construction phase, the area will be monitored from the operations centre. In particular, the operator will monitor a temporary protection zone of at least 500 metres from installation vessels when construction and maintenance work by installation vessels is conucted. Ships that are at risk of navigating incorrectly in relation to the wind farm will be warned. Continued monitoring shall take place during the operational phase if the Swedish Maritime Administration or the Swedish Transport Administration consider that such need exists.
- In order to protect shipping, the wind turbines will be located with a safety distance that is in accordance with international guidelines as set out in Annex A.2.
- At least three months before the start of construction work, the operator must consult the Maritime Administration and the Transport Administration about the measures required to protect against disruption for shipping.

Chemicals and waste

- The equipment for collecting spills of oil and other liquid chemicals from wind turbines and substations must be in place.
- Waste, whether solid or liquid, must be disposed of, sorted and stored in such a way that there is no risk of contamination or other inconveniences and then transported onshore for disposal.

Marine archaeology

- A marine archaeological survey must be conducted. If marine archaeological objects are identified within the wind farm area, these must be avoided as far as possible when designing the wind farm and underwater cables.

National Defence

- At the request of the Swedish Defence Forces, the operator must bear the cost of acquiring and installing equipment to ensure the security of the Swedish Defence Forces' marine surveillance or for any other purpose determined by the Swedish Defence Forces that is conducted with the aim of avoiding the influence of the wind farm on the interests of the Swedish Defence Forces. If installation of such equipment is to take place within the wind farm, the operator must, in consultation with the Defence Forces, enable construction and access to the relevant parts of the wind farm.

Survey programme

- The presence of bats within the area of operations and the influence of the wind farm on migratory bats must be studied for a period of three years after the wind farm is commissioned. During the study period, the wind farm must be equipped with detection and control equipment to enable wind turbines to be operated in such a way as to avoid significant risk of collision with spring and winter migrant bats.
- Radar surveys, bird observations, or other appropriate surveys shall be conducted for a period of three years after commissioning to investigate the pattern of movement of migrant cranes and their degree of avoidance within the wind farm and its influence on the wind farm.

Operating control for birds

- In order to protect migratory cranes, the wind farm must be equipped with detection and control equipment to control wind turbines in the event of high migration activity among the cranes during their spring and autumn migration and avoid significant risk of collision. Operational control would need to be applied for a maximum of 100 hours per turbine per year

Underwater noise

- Soft-start should be applied before using seismic equipment in order to protect marine mammals and fish.
- When starting up seismic survey work, passive acoustic monitoring must also be used and observers must be provided on the vessel who can look for marine mammals in the vicinity of the vessel.
- During side-scanning sonar and multi-beam sonar studies, the equipment should operate at frequencies above 200 kHz in order to protect porpoises.
- During impact piling, acoustic methods to discourage porpoises, using techniques adapted for porpoises, should be used to the extent necessary.
- Soft start-up must be used when starting impact piling. The period of soft-start and ramp-up, together with other mitigatory measures, should be sufficient to protect porpoises against underwater noise from piling that exceeds the threshold values for permanent hearing loss (PTS) and temporary hearing loss (TTS) for the harbour porpoise.
- During impact piling, sound-dampening equipment with a performance equal to double bubble curtain and Hydro Sound Damper should be used for protection of marine mammals and fish.
- During impact piling, underwater noise from the piling operations must not exceed the value of single pulse $SEL_{SS,VHF}$ ≤120 dB porpoises re 1µPa^2s at a distance of 750 metres from the sound source and $SPL_{RMS\text{-}fast,\ VHF}$ 100 dB tumble dryer re 1µPa at a distance of 6,7 kilometres from the sound source.

Risk and safety

- The possible presence of unexploded ordnance (UXO) will be surveyed as part of the detailed engineering. Objects that are identified will either be avoided by taking them into account when locating wind turbines and cables or be made harmless before a work operation can be conducted.
- Contingency and rescue plans will be developed in consultation with the relevant authorities. The plan will clarify the division of responsibility for various incidents and accidents, what measures should be taken, where equipment is located and who should be informed.

OX2 will develop a programme of checks in consultation with the Supervisory Authority after authorisation has become effective. The purpose of operational check programmes is to account for compliance with the conditions attached to the authorisation for the operation. Examples of parameters that will be followed up in check programmes are underwater noise during construction and continuous sampling for follow-up and an action plan for any environmental toxins.

The check programme will also be coordinated with the conditions set out in the Natura 2000 and SEZ/KSL authorisations.

11 Overall assessment of transboundary effects

11.1 The cumulative impact of the transboundary impact of the operation

The Triton wind farm contributes positively to Sweden's and the EU's environmental goals, which include handing over a sustainable society to the next generation. The Triton wind farm is expected to form an important part of Sweden's and Europe's process of switching to renewable energy sources and contributing to the achievement of Sweden's and the Europe climate goals. The wind farm is expected to have a very significant positive impact on replacement of fossil electricity production and thus on a large scale reduction in greenhouse gas emissions. These more long-term positive consequences need to be related to the negative impact that may arise, which in most cases are of a more transitory and time-limited nature. Influence and impact assessments are made on the basis of a worst-case. The assessments are based on assumptions of a maximum design scenario that will significantly increase what could be the greatest impact on the environment. This enables the design of the wind farm to be based on the limits set by the licence. This approach has been used to cover all cases with less influence and impact. The environmental influence can thus be less extensive but not more extensive than described in this EIA.

For recipients and values linked to demersal flora, fauna and fish, the influence is considered to be very local and is therefore not deemed to lead to any transboundary impacts. For marine mammals, the transboundary impact is assessed to be the same as in Swedish waters, because affected populations move across large areas between different countries. The impacts are mainly linked to the construction phase and influence factors are mainly sediment spread and sedimentation and underwater noise when installing foundations. No direct physical impact will occur in Danish, German or Polish waters. The construction phase will be ongoing for a limited period and mitigatory measures will be taken, which means that the impacts during the construction phase are deemed to be local and therefore negligible from a cross-border perspective. During the operational phase, the influence is deemed to be even more local, whish means that no cross-border impacts will arise.

During the operational phase, negative impacts are expected to occur mainly for birds. These impacts are mainly due to the turbines.

For birds, the main influences and impacts are assessed to be linked to displacement and collisions with wind turbines. The risk of collision is greater or less depending on the species of bird. Overall, the impacts are assessed to be small to negligible.

The wind farm is visible from Bornholm Island. Three viewpoints have been chosen: Rønne, Hasle and Hammershus. At Rønne, the wind farm will be seen in a relatively narrow sector on the horizon and will be seen as a single group. At Hasle the wind farm will be visible on the horizon in the west and at Hammershuset a slightly larger part of the wind farm will be visible. At Rønne the influence is deemed to be insignificant and the impacts on the landscape and heritage environment negligible, at Hasle the influence is assessed to be small and the impacts very small and at Hammershus the influence is deemed to be small and the impacts moderate. However, wind turbines as a group within a limited sector are still assessed to be minuscule in the vast seascape.

The farm area is currently deemed to have little value for the fishing industry because this area only represents a small part of total catches. The influence on commercial fishing for Sweden, Germany, Poland and Denmark is assessed to be slightly negative and the impact is deemed to be small. This is because areas used for fishing are used and restrict access to fishing, while, among other things, there are good opportunities for redistributing fishing to other locations. Positive effects on fish populations, such as the reef effect, can in the long term benefit commercial fishing.

The impacts on leisure and outdoor activities are deemed to be negligible.

The wind farm is located between two shipping lanes with international traffic. A shipping lane mainly trafficked by passenger ships and Ro-Pax vessels on routes between Ystad and Świnoujście/Sassnitz passes through the wind farm site. The traffic separation scheme that passes to the east of the wind farm, TSS Bornholmsgat (partly in the Swedish economic zone, partly in the Danish economic zone) is where three shipping lanes meet. This creates a transboundary impact. During the construction phase there may be conflicts between civil engineering work and other shipping traffic and during the operational phase the wind farm may increase the likelihood of ship accidents such as collisions and allisions. With different measures applied during both the construction and the operational phases the risks will be reduced to a level that can be defined as ALARP, as low as reasonably possible. The sensitivity of maritime traffic to vessel accidents may be seen as high, but the influence is deemed to be Insignificant, which implies negligible impacts.

No unacceptable risks are deemed to arise as a result of Triton. The wind farm will be designed in such a way that it can withstand climate change. Furthermore, OX2 will work on risk management and risk mitigation by, inter alia, developing a contingency and rescue plan in consultation with regulatory authorities and other relevant authorities and municipalities.

The Danish Ministry of Defence have stated that the Triton wind farm could affect their radar system on the Danish island of Bornholm. OX2 has therefore initiated technical analyses to assess the influence on the Ministry of Defence's facility in accordance with the requests made by the Danish Ministry of Defence. If necessary, the necessary measures will be taken to minimise, adapt or establish mitigatory measures so that wind farm disturbances on the radar system at Bornholm are minimised.

The negative impacts that can arise from the wind farm are in many cases short-lived and limited, because they are mainly linked to the construction phase and that they occur mainly within the wind farm area. These should be set up against the longer-term positive impacts that may arise from the new structures created within the wind farm. The wind farm has moderately positive impacts in the form of the creation of artificial reefs that promote biodiversity (so-called "reef effect"). The reef can serve as a habitat and protection for fish and nursery for fry. By adding new living environments, biodiversity can increase, which is also important from a wider ecosystem perspective. The wind farm is therefore assessed not only to have positive effects and impacts in terms of reducing carbon dioxide emissions and the climate, but also in the longer term for the marine environment in the area, including transboundary effects.

If commercial fishing, including bottom trawling, is reduced in the wind farm area, the activity will provide additional protection for organisms present in the activity area moving between the sub-areas and the neighbouring Natura 2000 area. This positive impact depends on the continuing dialogue with commercial fishermen and on the reality of the possibility of continuing bottom trawling. There is a conflict of interests between different stakeholders.

The size of the impacts on each recipient and stakeholder is shown in Table 71 On some issues, the dialogue continues, as indicated in the table.

Table 71. Summary of the assessed transboundary impacts for each recipient/stakeholder with proposed safeguards.

Stakeholder/recipient	Impact
Climate impact and climate benefit	Positive
Bottom flora and bottom fauna	None
Fish	Negligible
Marine mammals	Negligible - slightly negative
Bats	Negligible
Birds	Negligible
Landscape and heritage environment	Negligible - moderate
Residential areas	None
Leisure	Small Reef effect positive for recreational fishing and diving
Commercial fishing	Very slightly negative A positive long-term effect from the reef effect and reduced fishing pressure
Maritime activities	Negligible to moderately negative
Aviation	No negative influence
Risk and safety	No unacceptable risk
Defence interests	Continued dialogue / technical studies are ongoing

11.2 Natura 2000

The construction of the Triton wind farm does not involve any physical intrusion or the use of any seabed surfaces in any Swedish, Danish, Polish or German Natura 2000 site. Targets for identified nature types linked to distribution and structures are therefore not affected by the operation. Identified species in German, Danish and Polish Natura 2000 sites are not considered affected, see section 7.2, 7.3, 7.4 and 7.6.

Only the Natura 2000 area Sydvästskånes utsjövatten is assessed to be affected by the Triton wind farm. Negative impacts on protected nature types and species in the Natura 2000 area as a result of the operation are expected to occur mainly during the construction phase and are mainly linked to sediment spread and sedimentation and underwater noise during the installation of foundations. A small reef in the Natura 2000 area Sydvästskånes utsjövatten, located about six kilometres from the wind farm may be affected by underwater noise that can cause TTS in fish. But the remaining much larger areas of reef and sand banks will not be affected by noise or sediment. The deep soft seabeds in this area may be affected, but these areas are not a Natura 2000 nature type. For birds, the operational phase is considered to be the phase in which negative impacts consequences can mainly occur.

The Triton wind farm does not affect the conditions for favourable conservation status of the designated nature types or species (for porpoises, consideration is given to commitment to mitigatory measures). The mitigatory measures that will be taken are linked to reducing the impact of underwater noise that occurs during the construction phase, partly during seismic surveys and partly during impact piling during installation of foundations. When piling foundations, the use of acoustic methods, soft start-up and sound damping equipment will be applied with regard to porpoises. The impact on fish is also reduced when using soft start-up and sound damping techniques. For Sydvästskånes utsjövatten, it is estimated that no significant impact occurs on the designated nature types sand banks and reefs (including typical species of fish, demersal flora and fauna and associated birds).

11.2.1 Baltic Sea Action Plan

The updated BSAP was adopted in 2021 and contains about 200 specific actions to be implemented by 2030. The actions are grouped into four main areas with specific objectives:

- Biodiversity, with the objective of a ‘Favourable conservation status of biodiversity’;
- Eutrophication, with the objective of ‘A Baltic Sea undisturbed by excessive inputs of nutrients’;
- Hazardous substances and marine litter, with the objective of ‘Concentrations of hazardous substances close to natural levels’;
- Marine-based activities, with the objective of “Maritime traffic and offshore activities carried out in an environmentally friendly way”

The measures are divided up to reflect the influence from land, the influence from maritime activities and the ecological status of the ecosystem.

Impact assessment

Table 72 assesses how each main area may be affected by the wind farm during construction, operation and decommissioning.

Table 72. Potential influence of Triton wind farm on the four main areas of the BSAP.

MAIN AREA (ENVIRONMENTAL OBJECTIVES)	POTENTIAL INFLUENCE FACTOR	ASSESSMENT OF THE INFLUENCE
Biodiversity -Viable populations of all native species - Natural distribution, presence and quality of habitat and associated flora and fauna communities - Functional, healthy and resilient food webs	Underwater noise	With the use of such mitigatory measures such as bubble curtains or equivalent and soft start and ramp up during piling work, the influence is deemed to be insignificant-small (marine mammals) and very small-small (fish), see sections 7.3 and 7.4.
	Collision risk and barrier effects for birds and bats.	With the use of mitigatory measures such as operational control, the impact is estimated to be insignificant for birds and bats, see sections 7.5 and 7.6.
	Sedimentation	Sedimentation is expected to be transient and the influence insignificant, see section 7.2
	Contamination	The influence is estimated to be insignificant, see section 7.2.
	Reef effect	The reef effect is deemed to have a slightly positive influence, see sections 7.2, 7.3 and 7.4.
Eutrophication - Concentration of nutrients near natural level - Clear water - Natural level of algal blooms - Natural distribution and presence of plants and animals - Natural oxygen levels	Contaminants and nutrients.	The influence is estimated to be insignificant, see section 7.2.
	Sedimentation	Sedimentation is expected to be transient and the influence insignificant, see section 7.2
Hazardous substances and marine litter - A healthy marine life - Concentrations of hazardous substances are close to natural levels - All food from the sea is safe to eat - Minimum risk to humans and the environment from radioactivity – No damage to marine life from marine litter	Contamination	The influence is estimated to be insignificant, see section 7.2.
	- Litter from construction and dismantling.	The influence is estimated to be negligible, see section 7.2.
Offshore activities - No or minimal disturbance to biodiversity and the ecosystem - Activities that affect habitats on the seabed do not threaten the long-term viability of species populations and communities – No or minimal damage to marine life from noise from human sources	Increased vessel traffic	The influence is estimated to be small, see sections 7.3 and 7.4.
	Fishing-free areas	Bottom trawling will be restricted within the farm area, which means a slightly positive influence for species dependent on undisturbed seabed environments, see section 7.2.
	Underwater noise	With the use of mitigatory measures such as bubble curtains, etc. and start-up ramping during construction work, the impact is deemed negligible, see sections 7.3 and 7.4.

11.3 Climate objectives

In 2015, the countries of the world agreed, under the Paris Agreement[45], that the global temperature increase would be kept well below two degrees and that we should strive to limit it to 1.5 degrees. The Paris agreement also links with the UN's Agenda 2030, in which one of the main objectives is to resolve the climate crisis. In order to meet the objectives of the Paris agreement, the Swedish Parliament has decided on phased targets for reducing the country's climate impact. According to the phased targets, Sweden will not have any net greenhouse gas emissions to the atmosphere by 2045 in order to achieve negative emissions, i.e. to reduce the greenhouse gas content in the atmosphere. In addition, according to the Swedish parliament's target, electricity production in Sweden will be 100% renewable by 2040. These objectives are also reflected in the environmental quality objective, Limited Climate Impact, described in section 7.1. In both the government[46] and the Energy Agency[47] opportunities for future expansion of wind power are required to achieve the goals of fossil-free electricity generation.

The EU is working on a review of its climate, energy and transport legislation within the framework of the so-called 55 % package to bring existing legislation into line with EU climate goals by 2050. The plan includes reducing overall EU emissions by 55% by 2030 compared to 1990 and achieving climate neutrality by 2050. The plan also aims to raise the EU goal for the overall energy mix to be made up of renewable energy sources from 32% to at least 40% by 2030.

The planned Triton wind farm is expected to produce the same amount of electricity as was used for manufacture, construction and decommissioning within six months of the start-up of the wind farm. During its lifetime, the farm will replace fossil electricity production, thus reducing greenhouse gas emissions on a grand scale. The planned wind farm is therefore expected to contribute positively to the fulfilment of Sweden's climate objectives and thus also to the Paris Agreement and Agenda 2030. The Triton wind farm is also expected to contribute positively to the achievement of the EU's climate objectives.

45 Agreement between the countries of the world to keep the global temperature increase below 2 degrees, preferably to stop at 1.5 degrees. More information: https://www.regeringen.se/regeringens-politik/parisavtalet/. Retrieved 03/10/2022

46 Sweden's climate policy framework: https://unfccc.int/sites/default/files/resource/LTS1_Sweden.pdf Miljödepartementet. Retrieved 03/10/2022

47 https://www.energimyndigheten.se/nyhetsarkiv/2019/sa-kan-100-procent-fornybar-elproduktion-se-ut/ Retrieved 03/10/2022

12 Expertise

12.1 OX2's Project organisation

The OX2 Triton wind farm project organisation possesses many years of knowledge of wind power. The followings persons have been involved in the preparation of current licence applications, project engineering and project planning.

Table 73. OX2 project organisation for the Triton wind park.

Name	Project role	Experience
Hans Ohlsson	Project Manager/EIA Manager	23 years of experience in offshore project development. Hans has been involved in several licence applications in Sweden. Hans also works with the technical parts of the Swedish Environmental Protection Agency's research programme "Vindval" regarding the effects of wind power installations on marine life and with the Norwegian Research Council to assess various innovations. Hans also previously worked with and held responsibility for Swedish wind power research in the mid-90s.
Emelie Zakrison	Technical Project Manager	Emelie previously worked for DONG Energy (now Ørsted) and RWE Renewables on project development of offshore wind power. Emelie has been active in the Westermost Rough and Södra Midsjöbanken projects, as well as a number of other projects in the UK, Germany and France.
Lise Toll	Project manager	Lise previously worked at E.ON Climate & Renewables (now part of RWE Renewables), with experience in project development of offshore wind power in Sweden. Lise has also worked in Germany to develop strategies for the operation and maintenance of E.ON C&R's established offshore wind farms in Denmark, UK & Sweden.
Matilda Hagert	Reviewer	Matilda previously worked at RWE Renewables, with experience in project development of offshore wind power in Sweden and Norway. Matilda has worked with the Södra Midsjöbanken project, as well as the Norwegian auctions and is a project manager for OX2's early project portfolio.

12.2 Expertise engaged on behalf of OX2

The following is a review, pursuant to Section 19 of the Environmental Assessment Ordinance of how the requirement for expertise in Section 15 has been met. The organisation below consists of EIA editors and experts within their respective fields of expertise who have produced the underlying studies that have formed the basis for the EIA The experts have then been involved in the EIA process and have assured the quality of the respective EIA chapters.

Table 74. Expertise engaged on behalf of OX2.

Name	Qualifications	Experience
Petra Adrup, Structor	Master of Philosophy Biology, SU	Petra has more than 20 years of experience working with permit applications and EIAs. Petra has worked with, and was responsible for, permit applications incl. the creation of EIAs in a number of major and complex projects including urban development, infrastructure, industry and ports. Examples of assignments in which Petra was involved and responsible for EIA include permit applications for nuclear fuel storage for Kärnbränsleförvaret, applications for SSAB in Oxelösund, applications for the Mälar project and application for the rebuilding of Slussen in Stockholm and regulations of the Mälar river. Petra has worked on Natura 2000 issues in several projects, for example in the Slussen project, 26 Natura 2000 sites around the Mälar river were studied.
Katarina Helmersson, Structor	Graduate engineer, Natural resources Technology, Lulea University of Technology	Katarina has worked with permitting issues since 2020 (incl. (EIA) according to the Environmental Code.
Anna Gustafsson, Structor	M.Sc. Biology, Uppsala University	Anna has more than 20 years of experience working with EIAs and various permit applications in accordance with the Environmental Code, in several different roles (municipality, regional authority, consultant and operator). Anna has been responsible for the development of EIA's for many different offshore activities, permit applications, infrastructure projects and environmentally hazardous activities.
Kajsa Andersson, Structor	Bachelor's degree in Biology. Master's degree in Biology, Plant Ecology specialisation. Stockholm University + Freie University of Berlin.	Kajsa has 10 years of experience working with applications and inspections in accordance with the Environmental Code, both from the authorities and in the private sector. Kajsa has worked as an environmental consultant and project manager since 2017, mainly with environmental impact assessments and permit applications according to the Environmental Code. Before that Kajsa worked in the regional authority with permit applications and inspections pursuant to Chapter 7 of the Environmental Code. Her latest assignments as an environmental consultant have included consultation and EIA coordination for onshore wind farms, environmental coordinator during the construction of wind farms and environmental impact assessments for detailed plans.

		In environmental impact assessments, Kajsa is often responsible for in-depth assessments and assessments of the natural environment, bird life and species protection.
Carina Lundgren, Structor	B. Sc. Health and Environment Protection, University of Umeå	Carina is a project manager and environmental consultant and has been working on permitting issues for wind power and other complex projects for more than 11 years. Carina has extensive knowledge and experience of environmental studies, consultation processes with authorities, EIAs, the environmental and permitting process pursuant to the Environmental Code, project management, management systems and goal management.
Olov Tiblom, AquaBiota	Master of Philosophy Biology, SU	Olov has a master's degree in marine biology from Stockholm University. Olov has worked on several different permit applications for offshore wind power, he also works with marine and limnic nature protection counts. Olov has very good knowledge of species and wide experience in the species identification of macrophytes and demersal fauna, both in field studies and in laboratory analyses of collected seabed and vegetation samples.
Maria Wilson, NIRAS	Ph D Animal physiology, AU	Maria has over 10 years of experience in research on underwater noise, marine mammals, fish and noise influences. Maria has been working since 2018 on environmental assessments of marine ecosystems with a major focus on underwater noise and potential influences on marine life (marine mammals, fish and invertebrates).
Rasmus Bisschop-Larsen, NIRAS	B Sc Biology, University of Copenhagen (KU).	Rasmus has 10 years of experience in environmental impact assessments of birds in relation to offshore wind farms and has worked with more than 15 offshore wind farms in England and Denmark. Rasmus has a further 20 years of experience in bird counts at sea. Rasmus has extensive knowledge of the methods used for the counts, subsequent data processing and modelling of spatial distribution of birds at sea.
Richard Ottvall, Ottvall Consulting	PhD, Animal ecology, Lund University, Post Doc CRNS-CEFE, Montpellier	Richard has background as a researcher in bird ecology at Lund University, Campus Gotland and Hedmark University College. Richard has a very good knowledge of species and 30 years of experience in bird counts. Offshore, Richard has c 50 bird counts from the air in cooperation with Lund University, the Swedish Environmental Protection Agency, regional authorities and wind power

		companies. Richard was co-author of Vindval's synthesis report 6740 on the effects of wind power on birds and bats and has had government assignments on the presence and ecology of marine birds.
Mathilda Karlsson, AquaBiota	M. Sc. Marine Biology, Stockholm University (SU)	Mathilda holds a master's degree in marine biology from Stockholm University. She has previously participated in projects at Stockholm University that focus on fish ecology in the Baltic Sea. She is currently working to a large extent on permitting issues in offshore wind power. She is also conducting field studies and has thus become accustomed to methods such as eDNA, counts of benthic fauna using grab sampling, counts of porpoises using acoustic detection (F-Pods) and trawl exploratory fishing according to the ICES "Baltic International Trawl Survey" method.

13 Referenser

Aarhus universitet 2015. Environmental Impact Assessment. Technical background report. Birds and bats.

Ahlén I, Baagøe H, and Bach L., 2009. Behavior of Scandinavian bats during migration and foraging at sea. Journal of Mammalogy, 90(6):1318–1323.

Ajemain MJ, Wetz JJ, Shipley-Lozano B, Shively JD, Stunz GW., 2015. An Analysis of Artificial Reef Fish Community Structure along the Northwestern Gulf of Mexico Shelf: Potential Impacts of "Rigs-to-Reefs" Programs. PLoS One. 2015;10(5):e0126354. Published 2015 May 8. doi:10.1371/journal.pone.0126354.

Albert, L., Deschamps, F., Jolivet, A., Olivier, F., Chauvaud, L. och Chauvaud, S., 2020. A current synthesis on the effects of electric and magnetic fields emitted by submarine power cables on invertebrates. Marine Environmental Research 159, 104958. https://doi.org/10.1016/j.marenvres.2020.104958

Alerstam, T., 1975. Crane Grus grus migration over sea and land. Ibis 117:489-495

Andersson MH, Öhman MC, 2010. Fish and sessile assemblages associated with wind-turbine constructions in the Baltic Sea. Marine and Freshwater Research 61: 642–650.

Andersson, M.H., Andersson, B. L., Phil, J., Persson, L. K., Sigray, P., Andersson, S.,.. & Hammar, J., 2016. Underlag för reglering av undervattensljud vid pålning.

André C, Svedäng H, Knutsen H, Dahle G, Jonsson P, Ring AK, Sköld M, Jorde PE., 2016. Population structure in Atlantic cod in the eastern North Sea-Skagerrak-Kattegat: early life stage dispersal and adult migration. BMC research notes, 9(1): 1-11

Artdatabanken, S., 2020. Rödlistade arter i Sverige 2020.. s.l.:s.n.

Auld AH, Schubel JR., 1978. Effects of suspended sediment on fish eggs and larvae: a laboratory assessment. Estuarine and Coastal Marine Science 6: 153–164.

Axelsen BE., 1999. In situ of Cape horse mackerel (Trachurus capensis). ICES report

Band. B., 2012. Using a collision risk model to assess bird collision risks for offshore wind farms. Rapport, mars 2012.

Barrett RT, Chapdelaine G, Anker-Nilssen T, Mosbech A, Montevecchi WA, Reid JB, Veit RR,. 2006. Seabird numbers and prey consumption in the North Atlantic. ICES Journal of Marine Science 63: 1145-1158

Baumann H, Hinrichsen HH, Möllmann C, Köster FW, Malzahn AM, Temming A., 2006. Recruitment variability in Baltic Sea sprat (Sprattus sprattus) is tightly coupled to temperature and transport patterns affecting the larval and early juvenile stages. Canadian Journal of Fisheries and Aquatic Sciences 63: 2191- 2201

Benke, H., Bräger, S., Dähne, M., Galles, A., Hansen, S., Honnef, C. G. & Narberhaus, I., 2014. Baltic Sea harbour porpoise populations: status and conservation needs derived from recent survey results. Marine Ecology Progress Series, 495, 275–290.

Berg L, Northcote TG., 1985. Changes in territorial, gill-flaring, and feeding behavior in juvenile coho salmon (*Oncorhynchus kisutch*) following short-term pulses of suspended sediment. Canadian Journal of Fisheries and Aquatic Sciences 42: 1410–1417.

Bergenius, M., Ringdahl, K., Sundelöf, A., Carlshamre, S, Wennhage, H., & Valentinsson, D., 2018. Atlas över svenskt kust- och havsfiske 2003-2005. Aqua reports 2018:3. Sveriges lantbruksuniversitet, Institutionen för akvatiska resurser, Drottningholm Lysekil Öregrund. 245 s.

Bergström L, Sundqvist F, Bergström U, 2013. Effects of an offshore wind farm on temporal and spatial patterns in the demersal fish community. Marine Ecology Progress Series 485: 199–210.

Bergström, L., Kautsky, L., Malm, T., Rosenberg, R., Wahlberg, M., Capetillo, N. Å., & Wilhelmsson, D. 2014. Effects of offshore wind farms on marine wildlife—a generalized impact assessment. Environmental Research Letters, 9(3), 034012.

Betke, K., 2014. Underwater construction and operational noise at alpha ventur. s.l.; Ecological Research at the Offshore Windfarm alpha ventus, 171-180.

Birgersson V, Bergland F, Berggren T & Andersson-Li M., 2021. eDNA-inventering av fisk och marina däggdjur – Galatea-Galene, Hallands län. AquaBiota Rapport 2021:08. ISBN: 978-91-89085-32-9.

Blackwell, S., Lawson, J. & Williams, M., 2004. Tolerance by ringed seals (Phoca hispida) to impact pile driving and construction sounds at an oil production islan.. s.l.:JASA. 115:2346-2357.

Bleil M., Oeberst R., 2002. Spawning areas of the cod stock in the western Baltic Sea andminimum length at maturity. Archive of Fishery andMarineResearch49:243–258

Bleil M., Oeberst R., 2004. Comparison of spawning activities in the mixing area of both the Baltic cod stocks, Arkona Sea (ICES Sub-divisions 24), and the adjacent areas in the recent years.ICES Document CM,50, 08

Bleil M., Oeberst R., Urrutia P., 2009. Seasonal maturity development of Baltic cod in different spawning areas: importance of the Arkona Sea for the summer spawning stock.Journal of Applied Ichthyology25:10-17

BMUB, 2014. Concept for the protection of Harbour Porpoises fromSound Exposure during the Consruction of Offshore Wind Farms in the German North Sea.. s.l.:Federal Ministry for the Environment, Nature Conservation, Building and Nuclear safety. 35 p. Available as ASCOBANS Document AC21/In 3.2.2a (P)..

BOEM, 2021. Vineyard Wind 1 Offshore Wind Energy Project. Final Environmental Impact Statement Volume I. US Department of the Interior, Bureau of Ocean Energy Management.

Bolle LJ, de Jong CAF, Bierman SM, van Beek PJG, van Keeken OA m.fl., 2012. Common Sole Larvae Survive High Levels of Pile-Driving Sound in Controlled Exposure Experiments. PLoS ONE 7: e33052

Borkenhagen, K., Guse, N., Markones, H., Markones, N., Schwemmer, H. & Garthe, S., 2018. Seabird monitoring in the German North Sea and Baltic Sea 2018. Research and Technology Centre West Coast (FTZ), Kiel University, Hafentörn 1, D-25761 Büsum.

Brabant R, Laurent Y, Poerink B. J, and Degraer S., 2019. Activity and behaviour of Nathusius' pipistrelle Pipistrellus nathusii at low and high altitude in a North Sea offshore wind farm. Acta Chiropterologica, 21(2): 341–348.

Bruintjes R, Radford AN., 2013. Context-dependent impacts of anthropogenic noise on individual and social behaviour in a cooperatively breeding fish. Animal Behaviour 85: 1343-1349

Brzana, R., & Janas, U. 2016. Artificial hard substrate as a habitat for hard bottom benthic assemblages in the southern part of the Baltic Sea–a preliminary study. Oceanological and Hydrobiological Studies, 45(1), 121-130.

BSH och BMU, 2014. Ecological Research at the Offshore Windfarm alpha ventus – Challenges, Results and Perspectives. Federal Maritime and Hydrographic Agency (BSH), Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Springer Spektrum. 201 sid. Rapid increase of benthic structural and functional diversity at the alpha ventus offshore test site. Lars Gutow, Katharina Teschke, Andreas Schmidt, Jennifer Dannheim, Roland Krone, Manuela Gusky. Rapid increase of benthic structural and functional diversity at the alpha ventus offshore test site.

Bundesanstalt für Landwirtschaft und Ernährung (2021). Kommersiella fångstdata 2009-2020 [Dataset]. Bundesanstalt für Landwirtschaft und Ernährung, Bonn, Tyskland.

Börjesson, P. & Read, A.J., 2003. Variation in timing of conecption between populations of the harbour porpoise. Journal of mammalogy 84 (3):948–55.

Carlström, J. & Carlén, I., 2016. Skyddsvärda områden för tumlare i svenska vatten. s.l.:AquaBiota Report 2016:04. 91 sid.

Claisse, J. T., Pondella, D. J., Love, M., Zahn, L. A., Williams, C. M., Williams, J. P., & Bull, A. S.,2014. Oil platforms off California are among the most productive marine fish habitats globally. Proceedings of the National Academy of Sciences of the United States of America, 111(43), 15462–15467. https://doi.org/10.1073/pnas.141147711.

Clausen, K. et al., 2021. Echolocation activity of harbour porpoises, Phocoena phocoena, shows seasonal artificial reef attraction despite elevated noise levels close to oil and gas platforms.. s.l.:Ecol Solut Evidence;2: e12055. https://doi.org/10.1002/2688-8319.12055.

Coates DA, Kapasakali DA, Vincxa M, Vanaverbeke J., 2016. Short-term effects of fishery exclusion in offshore wind farms on macrofaunal communities in the Belgian part of the North Sea. Fisheries Research 179: 131-138.

Coombs SH, Morgans D, Halliday NC., 2001. Seasonal and ontogenetic changes in the vertical distribution of eggs and larvae of mackerel (Scomber scombrus) and horse mackerel (Trachurus trachurus). Fisheries Research 50: 27-40.

De Troch M, Reubens JT, Heirman E, Degraer S, Vincx M., 2013. Energy profiling of demersal fish: A case-study in wind farm artificial reefs. Marine Environmental Research 92: 224-233

Degraer, S. Carey, D., A., Coolen, J, W.P., Huchison, Z., L., Kerckhof,. Rumes, B. & Vanaverbeke, J., 2020. Offshore Wind Farm Artificial Reefs Affect Ecosystem Structure and Functioning: A synthesis.

DHI., den 10 Mars 2021. *Metocean Data Portal*. Hämtat från Global, Met. Parameters (incl. 10m wind) at 0.2 deg., Climate Forecast System Reanalysis (CFSR), NCEP NOAA: https://www.metocean-on-demand.com/#/main

Dierschke, V., Furness, R.W. & Garthe, S. 2016. Seabirds and offshore wind farms in European waters: avoidance and attraction. Biological Conservation 202:59-68.

Dietz, R. et al., 2015. Marine mammals - Investigations and preparation of environmental impact assessment forKriegers Flak Offshore Wind Farm, s.l.: Energinet.dk.

DNV, 2021. Further review of selected OWFs, Detailed review of traffic compositions and distances.

Dong Energy, Vattenfall, Danish Energy Authority, The Danish Forest och Nature Agency, 2006. Danish offshore wind- key environmental issues. Prinfo Holbæk-Hedehusene, Denmark. 244 sid.

Drachmann, J., Waagner, S. & Haaning Nielsen, H., 2020. Klim Vindmøllepark – Monitering af fuglekollisioner år 1 og år 3 (2016/2017 og 2018/2019). Resumé. Vattenfall Vindkraft A/S, januari 2020.

Dunlop ES, Reid SM, Murrant M., 2016. Limited influence of a wind power project submarine cable on a Laurentian Great Lakes fish community. Journal of Applied Ichthyology 32: 18-31.

Edelvang K., Møller A.L., Hansen E.A., 2001. DHI. Lillgrund Vindkraftpark, Environmental impact assessment of hydrography and sediment spill. Final Report.

Energiföretagen, 2021. Färdplan för fossilfri konkurrenskraft, Elbranschen.

Energimyndigheten, 2019. Nyhetsarkiv.
https://www.energimyndigheten.se/nyhetsarkiv/2019/sa-kan-100-procent-fornybar-elproduktion-se-ut

Energimyndigheten, 2021. Vindkraftens resursanvändning. Underlag till Nationell strategi för en hållbar vindkraftsutbyggnad. Ett livscykelperspektiv på vindkraftens resursanvändning och växthusgasutsläpp.

Energistyrelsen, 2022. Guidelines for underwater noise, Prognosis for EIA and SEA assessments, Energistyrelsen maj 2022.

ERA5, 2020. Eurpean Centre for Medium Range Weather Forecasts: https://www.ecmwf.int/en/forecasts/charts

ESCA., 2019. An introduction to subsea cables around the UK and North-western Europe. European Subsea Cables Association Report

Esgro MW, Lindholm J, Nickols KJ, Bredvik J., 2020. Early conservation benefits of a de facto marine protected area at San Clemente Island, California. PLoS ONE 15: e0224060.

Essink, K., 1999. Ecological effects of dumping of dredged sediments, options for management. Journal of Coastal Conservation, 5, 69-80.

Europeiska Kommissionen, 2008. DIRECTIVE 2008/56/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 June 2008, establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).

Farm HROW., 2006. Hydroacoustic monitoring of fish communities in offshore wind s. Horns Rev Offshore Wind Farm-Annual Report.

Fijn, R., Krijgsveld, K.L., Tijsen, W., Prinsen, H.A.M. & Dirksen, S., 2012. Habitat use, disturbance and collision risks for Bewick's Swans Cygnus columbianus bewickii wintering near a wind farm in the Netherlands. Wildfowl 62:97-116.

Fiskeristyrelsen DK, 2021. Kommersiella fångstdata 2010-2020 [Dataset]. Fiskeristyrelsen, Köpenhamn, Danmark.

FOI, 2021. Möjligheter till samexistens mellan Försvarsmaktens verksamhet och utbyggd vindkraft – en delrapport.

Fox, A.D. och Petersen, I.K., 2019. Offshore wind farms and their effects on birds. Dansk Ornitologisk Forenings Tidskrift 113:86–101.

Fredholm, M., 2019. Hansa PowerBridge, Arkeologisk utredning, steg 1, RAÄ 74:43, Bjäresjö socken, Ystad kommun, Skåne län, Sjöhistoriska museet arkeologisk rapport nr 2019:3, Stockholm.

Fudge SB, Rose GA., 2009. Passive- and active-acoustic properties of a spawning Atlantic cod (Gadus morhua) aggregation. ICES Journal of Marine Science 66: 1259–1263.

Försvarsmakten, 2019. Riksintressen för förvarets militära del i Skåne län 2019. Bilaga 13 SkÂne 2019.pdf (forsvarsmakten.se)

Gehring, J.L., Kerlinger, P. & Manville II, A.M., 2009. Communication towers, lights, and birds: successful methods of reducing the frequency of avian collisions. Ecological Applications 19:505-514.

Geo (Geo Subsurface Expertise), 2020. Seismic interpretation at Triton, Offshore Sweden - Interpretation of Sub-Bottom-Profiler single and multi-channel seismic data. Lyngby, Danmark.

Gibin, M., & Zanzi, A., 2020. Fisheries landings & effort: data by c-square (2015-2019). European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/79745491-f847-450a-a26d-fd4a8e4a14f4

Gogina, M., Nygård, H., Blomqvist, M., Daunys, D., Josefson, A. B., Kotta, J., Maximov, A., Warzocha, J., Yermakov, V., Gräwe, U. och Zettler, M. L., 2016. The Baltic Sea scale inventory of benthic faunal communities. ICES Journal of Marine Science, 73(4), 1196-1213.

Gorska N, Ona E, Korneliussen R., 2005. Acoustic backscattering by Atlantic mackerel as being representative of fish that lack a swimbladder. Backscattering by individual fish. ICES Journal of Marine Science 62: 984-995.

Graham, I. et al., 2019. Harbour porpoise responses to pile-driving diminish over time. s.l.:Royal Society open Science. 6: 190335.

Haarder S, Kania PW, Galatius A, Buchmann K, 2014. Increased Contracaecum osculatum infection in Baltic cod (Gadus morhua) livers (1982–2012) associated with increasing grey seal (Halichoerus gryphus) populations. Journal of Wildlife Diseases 50: 537-543

Halvorsen MB, Casper BC, Matthews F, Carlson TJ, Popper AN., 2012b. Effects of exposure to pile driving sounds on the lake sturgeon, Nile tilapia, and hogchoker. Proceedings of the Royal Society B 279:47.

Halvorsen MB, Casper BM, Woodley CM, Carlson TJ, Popper AN., 2012a. Threshold for onset of injury in Chinook salmon from exposure to impulsive pile driving sounds. PLoS ONE 7

Hammar L, Wikström A, Molander S., 2014. Assessing ecological risks of offshore wind power on Kattegat cod. Renewable Energy 66: 414-424

Hammar, L., Magnusson, M., Rosenberg, R., Granmo, Å., 2009. Miljöeffekter vid muddring och dumpning – En litteratursammanställning. Naturvårdsverket. Rapport 5999. 71 sid.

Hammond, P., 2006. Small Cetaceans in the European Atlantic and North Sea (SCANS II).

Hammond, P., Berggren, P., Benke, H., Borchers, D., Collet, A., Heide-Jorgensen, M., . . . N., 2002. Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. Journale of Applied Ecology, 361-376.

Hammond, P., Lacey, C., Gilles, A., Viquerat, S., Börjesson, P., Herr, H., . . . Øien, N., 2017. Estimates of cetacean abundance in European Atlantic waters in summer 2016 from SCANS-III aerial and shipboard surveys.

Hammond, P., Macleod, K., Berggren, P., Borchers, D., Burt, L., Canadas, A., . . . Leaper, R., 2013. Cetacean abundance and distrubution in European Atlantic shelf waters to inform conservation and management. Biological Conservation 164, 107-122.

Hanson M, Westerberg H, 1987. Occurrence of magnetic material in teleosts. Comp. Biochem. Phys. A Physiology 86: 169-172.

Hanson M., Karlsson L., Westerberg H., 1984. Magnetic material in European Eel (Anguilla anguilla) Comp Biochem. Phys A Physiology 77: 221-224 26.

Havenhand J, Dahlgren T., 2017. Havsplanering med hänsyn till klimatförändringar. Havs- och vattenmyndighetens rapport 2017:26.

Havs- och vattenmyndigheten, 2016. Svenskt yrkesfiske 2020 – Hållbart fiske och nyttig mat.

Havs- och vattenmyndigheten, 2019a. Havs- och vattenmyndighetens föreskrifter om klassificering och miljökvalitetsnormer avseende ytvatten. HVMFS 2019:25.

Havs- och vattenmyndigheten, 2019b. Fritidsfiske i Sverige, En inblick i fritidsfiskets omfattning under åren 2013 – 2017. Havs- och vattenmyndighetens rapport: 2019:5.

Havs- och vattenmyndigheten, 2019e. Regler för Ålfiske. Uppdaterad: 2019-06-11. Hämtad: 2021-10-27 https://www.havochvatten.se/fiske-och-handel/regler-och-lagar/arter-regler-for-fiske-ochrapportering/regler-for-alfiske

Havs- och vattenmyndigheten, 2020a. Fiskestopp- På denna sida listas olika typer av fiskestopp för 2021. Hämtad: https://www.havochvatten.se/fiske-och-handel/kvoter-uppfoljning-och-fiskestopp/kvoter-och-fiskestopp/fiskestopp.html

Havs- och vattenmyndigheten, 2021b. Fisk - och skaldjursbestånd i hav och sötvatten 2020: Resursöversikt. Rapport: 2021:6.

Havs- och vattenmyndigheten, 2021c. Fiskestopp- På denna sida listas olika typer av fiskestopp för 2022. Hämtad: https://www.havochvatten.se/fiske-och-handel/kvoter-uppfoljning-och-fiskestopp/kvoter-och-fiskestopp/fiskestopp.html#h-FiskestoppfortorskfiskeiOstersjonomrade242532

Havs- och vattenmyndigheten, 2022. Fångstdata 2009–2021 [Dataset]. Havs- och vattenmyndigheten

Havs- och vattenmyndigheten, december 2019c. Hållbarhetsbeskrivning av havsplaner för Bottniska viken, Östersjön och Västerhavet.

Havs- och vattenmyndigheten, december 2019d. HaV:s arbete med vrak. https://www.havochvatten.se/miljopaverkan-och-atgarder/miljopaverkan/fororeningar-och-farliga-amnen/vrak/havs-arbete-med-vrak.html

Havs- och vattenmyndigheten, HaV. Lektidsportalen. Version 1.0 2020-02-01. Hämtad: 2022-11-23.

Havs- och vattenmyndigheten, 2020. Kommersiella fångstdata 2009–2019 [Dataset]. Havs- och vattenmyndigheten.

Havs- och vattenmyndigheten VMS databas, 2021. Vessel Monitoring System (VMS). [Hämtad: 2021–09–14].

Hawkins AD, Picciulin M., 2019. The importance of underwater sounds to gadoid fishes. The Journal of the Acoustical Society of America 146: 3536–3551.

Hawkins AD, Popper AN., 2020. Sound detection by Atlantic cod: An overview. The Journal of the Acoustical Society of America 148: 3027.

HELCOM, 2013. HELCOM Red List of Baltic Sea species in danger of becoming extinct. Balt. Sea Environ. Proc. No. 140.

HELCOM, 2021. http://maps.helcom.fi/website/mapservice/

Hengstler, J. et. al., 2021. Aktualisierung und Bewertung der Ökobilanzen von Windenergie- und Photovoltaikanlagen unter Berücksichtigung aktueller Technologieentwicklungen. Climate *Change* | *35/2021.*

Hinrichsen HH, Hüssy K, Huwer B., 2012. Spatio-temporal variability in western Baltic cod early life stage survival mediated by egg buoyancy, hydrography, and hydrodynamics. ICES Journal of Marine Science 69: 1744-1752

Holm, T.E., Nielsen, R.D., Clausen, P., Bregnballe. T., Clausen, K.K., Petersen, I.K., Sterup, J., Balsby, T.J.S., Pedersen, C.L., Mikkelsen, P. & Bladt, J., 2021. Fugle 2018-2019. NOVANA. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 196 s. - Videnskabelig rapport nr. 420 http://dce2.au.dk/pub/SR420.pdf

Humborstad OB, Jørgensen T, Grotmol S., 2006. Exposure of cod Gadus morhua to resuspended sediment: an experimental study of the impact of bottom trawling. Marine Ecology Progress Series 309: 247–254, 2006

Hüssy K., 2011. Review of western Baltic cod (Gadus morhua) recruitment dynamics. ICES Journal of Marine Science, 68: 1459-1471

Hüssy, K., Hinrichsen, H. H., Eero, M., Mosegaard, H., Hemmer-Hansen, J., Lehmann, A., & Lundgaard, L. S., 2016. Spatio-temporal trends in stock mixing of eastern and western Baltic cod in the Arkona Basin and the implications for recruitment. ICES Journal of Marine Science, 73(2), 293-303.

Hårding, KC, Härkönen TJ., 1999. Development in the Baltic grey seal (Halichoerus grypus) and ringed seal (Phoca hispida) populations during the 20th century. Ambio 28: 619–625

Härkönen T, Karlsson O, Bäcklin BM, Moraeus C., 2011. Sälpopulationer och sälhälsa. Havet 2011: 95-96

ICES., 2014. *Database of Trawl Surveys (Datras)* [Dataset]. https://datras.ices.dk/data_products/download/download_data_public.aspx

ICES., 2018. ICES Fisheries Overviews - Baltic Sea Ecoregion.

ICES., 2020a. Baltic Fisheries Assessment Working Group (WGBFAS). ICES Scientific Reports. 2:45. 643 pp. http://doi.org/10.17895/ices.pub.6024

ICES., 2020b. ICES Advice on fishing opportunities, catch, and effort. Baltic Sea and Greater North Sea ecoregions. Sprat (Sprattus sprattus) in subdivisions 22 – 32, (Baltic sea).

IfAÖ., 2003. Environmental Impact Study for the Construction of the "Kriegers Flak" Offshore Wind Park.

IPCC, 2014. Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment. Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA]

Jakob Tougaard, 2021. Thresholds for behavioural responses to noise in marine mammals. Background note to revision of guidelines from the Danish Energy. Aarhus University, DCE – Danish Centre for Environment and Energy, 32 pp. Technical Report No. 225 http://dce2.au.dk/pub/TR225.pdf

Johnston DD, Wildish DJ., 1982. Effect of suspended sediment on feeding by larval herring (Clupea harengus). Bulletin of Environmental Contamination and Toxicology 29: 261–267

Johnston DW, Wildish DJ., 1981. Avoidance of dredge spoil by herring (Clupea harengus). Bulletin of Environmental Contamination and Toxicology, 26, 307–314.

Jokinen H, Momigliano P, Merilä J., 2019. From ecology to genetics and back: the tale of two flounder species in the Baltic Sea. ICES Journal of Marine Science 76: 2267-2275

Jones, H.P., 1980. The effect on birds of a North Sea gas flare. British Birds 73, 547–555.

Karlsson L., 1985. Behavioural responses of European silver eel (Anguilla anguilla) to the geomagnetic field. Helgolander Meeresuntersuchungen 39: 71–81.

Karlsson M, Kraufvelin P, Östman Ö., 2020. Kunskapssammanställning om effekter på fisk och skaldjur av muddring och dumpning i akvatiska miljöer. En syntes av grumlingens dos och varaktighet. Aqua reports 2020:1.

Kastelein A, Heul S, Verboom WC, Jennings N, Veen J, Haan D., 2008. Startle response of captive North Sea fish species to underwater tones between 0.1 and 64 kHz. Marine Environmental Research 65:369-377.

Kastelein, R. A. et al., 2002. Audiogram of a harbor porpoise (Phocoena phocoena) measured with narrow-band frequency modulated signals. Journal of the Acoustical Society of America, pp. 112, 334-344.

Kerckhof, F., Rumes, B., Norro, A., Houziaux, J. S., & Degraer, S., 2012. A comparison of the first stages of biofouling in two offshore wind farms in the Belgian part of the North Sea. Offshore wind farms in the Belgian Part of the North Sea: Heading for an understanding of environmental impacts. Royal Belgian Institute of Natural Sciences, Management Unit of the North Sea Mathematical Models, Marine ecosystem management unit, Brussels, 17-39.

Kerlinger, P., Gehring, J., Erickson, W.P. & Curry, R., 2010. Night migrant fatalities and obstruction lightning at wind turbines in North America. The Wilson Journal of Ornithology 122:744-754.

Koschinski, S., 2011. Underwater noise pollution from munitions clearance and disposal, possible effects on marine vertebrates, and its mitigation. s.l.: Marine Technology Society Journal 45:80–88.

Krone R, Gutow L, Brey T, Dannheim J, Schröder A., 2013. Mobile demersal megafauna at artificial structures in the German Bight - Likely effects of offshore wind farm development. Estuarine, Coastal and Shelf Science 125: 1–9

Kullander SO, Nyman L, Jilg K, Delling B., 2012. Nationalnyckeln till Sveriges flora och fauna. Strålfeniga fiskar. Actinopterygii. ArtDatabanken, SLU, Uppsala.

Köster F, Möllmann C, 2000. Trophodynamic control by clupeid predators on recruitment success in Baltic cod? ICES Journal of Marine Science 57: 310–323

Ladich, F., 2013. Effects of noise on sound detection and acoustic communication in fishes. In Animal communication and noise (pp. 65-90). Springer, Berlin, Heidelberg.

Lagenfelt I, Andersson I, Westerberg H., 2012. Blankålsvandring, vindkraft och växelströmsfält. Naturvårdsverket Vindval Rapport 6479.

Langhamer, O., 2012. Artificial reef effect in relation to offshore renewable energy conversion: state of the art. The Scientific World Journal, 2012.

Last, K. S., Hendrick, V. J., Beveridge, C. M. och Davies, A. J., 2011. Measuring the effects of suspended particulate matter and smothering on the behaviour, growth and survival of key species found in areas associated with aggregate dredging. Report for the Marine Aggregate Levy Sustainability Fund.

Limburg K, Casini M., 2019. Otolith chemistry indicates recent worsened Baltic cod condition is linked to hypoxia exposure, Biology Letters 152019035220190352

Lockyer, C. et al., 2003. Monitoring growth and energy utilisation of the harbour porpoise (*Phocoena phocoena*) in human care. NAMMCO Scientific Publications, pp. 5: 107-120.

Lovich JE, Ennen JR., 2013. Assessing the state of knowledge of utility-scale wind energy development and operation on non-volant terrestrial and marine wildlife. Applied Energy 103: 52-60.

Lowe, M. L., Morrison, M. A., & Taylor, R. B., 2015). Harmful effects of sediment-induced turbidity on juvenile fish in estuaries. Marine Ecology Progress Series, 539, 241-254.

Lucke, K., Siebert, U., Lepper, P. & Blanchet, M., 2009. Temporary shift in masked hear-ing thresholds in a harbor porpoise (Phocoena phocoena) after exposure to seismic airgun stimuli.. s.l.:J Acoust Soc Am 125:4060–4070.

Länsstyrelsen Skåne, 2018. Klimat- och energistrategi för Skåne.

Länsstyrelsen Skåne, 2020. Trygg elförsörjning i Skåne län – underlagsrapport.

Madsen. P., Wahlberg, M., Tougaard, J., Lucke, K., & Tyack, P., 2006. Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. Marine Ecology Progress Series 309.

McCauley RD, Fewtrell J, Popper AN., 2003. High intensity anthropogenic sound damages fish ears. The Journal of the Acoustical Society of America 113: 638–642.

McCormick MI, Allan BJM, Harding H, Simpson SD., 2018. Boat noise impacts risk assessment in a coral reef fish but effects depend on engine type. Scientific Reports 8: 3847.

Methratta, E. T., & Dardick, W. R., 2019. Meta-analysis of finfish abundance at offshore wind farms. Reviews in Fisheries Science & Aquaculture, 27(2), 242-260.

Mikkelsen, L. et al., 2017. Simulated seal scarer sounds scare porpoises, but not seals: species specific responses to 12 kHz deterrence sound. s.l.:r. Soc. Open. Sci. 4:170286.

Momigliano P, Denys GP, Jokinen H, Merilä J., 2018. Platichthys solemdali sp. nov.(Actinopterygii, Pleuronectiformes): a new flounder species from the Baltic Sea. Frontiers in Marine Science 5: 225

Moore PG., 1977. Inorganic particulate suspension in the sea and their effects on marine animals. Oceanography Marine Biology Annual Review 15: 225–363.

Mortensen, L.O., Skov, H., Tjørnløv, R.S. & Tuhuteru, N., 2020. Assessment of areas for development of offshore wind farms on Rønne Bank in relation to birds. Energistyrelsen/DHI.

Mueller-Blenkle C, Gill AB, McGregor PK, Metcalfe J, Bendall V, Wood D, Andersson MH, Sigray P, Thomsen F., 2010. Behavioural reactions of cod and sole to playback of pile driving sound. The Journal of the Acoustical Society of America 128: 2331

Naisbett-Jones LC, Putman NF, Stephenson JF, Ladak S, Young KA, 2017. A magnetic map leads juvenile European eels to the Gulf Stream. Current Biology 27: 1236–1240.

Naturvårdsverket, 2000. Vindkraft till havs - en litteraturstudie av påverkan på djur och växter. Naturvårdsverket rapport 5139

Naturvårdsverket, 2008. Åtgärdsprogram för Tumlare 2008–2013 (Phocoena phocoena). Rapport: 5946

Naturvårdsverket, 2017. Mikroplaster. Redovisning av regeringsuppdrag om källor till mikroplaster och förslag på åtgärder för minskade utsläpp i Sverige. Rapport 6772. Juni 2017.

Naturvårdsverket, 2021. https://skyddadnatur.naturvardsverket.se/

Naturvårdsverket, Sveriges officiella statistik, 2019. https://www.naturvardsverket.se/data-och-statistik/klimat/vaxthusgaser-territoriella-utslapp-och-upptag/

Newcombe CP, MacDonald DD., 1991. Effects of suspended sediments on aquatic ecosystems. North American Journal of Fisheries Management 11:72–82.

Nilsson, L. & Green, M. 2011. Birds in southern Öresund in relation to the wind farm at Lillgrund. Final report of the monitoring program 2001–2011. Biologiska institutionen, Lunds universitet I uppdrag åt Vattenfall Vindkraft AB.

Nilsson, L., 2020. Changes in numbers of and distribution of wintering waterbirds at the south coast of Scania, Sweden, during 55 winters, 1964-2018. Ornis Svecica 30:38-52.

Nissling A, Westin L., 1997. Salinity requirements for successful spawning of Baltic and Belt Sea cod and the potential for cod stock interactions in the Baltic Sea. Marine Ecology Progress Series 152: 261-271

NPL, 2020. Final report: Characterisation of acoustic fields generated by UXO removal – Phase 2.. s.l.:NPL REPORT AC 19. Pp 60..

Pacariz S, Björk G, Jonsson P, Börjesson P, Svedäng H,. 2014. A model study of the large-scale transport of fish eggs in the Kattegat in relation to egg density. ICES Journal of Marine Science 71: 345-355

Pace, F, Robinson, C, Lumsden, C & Martin, S, 2021. Underwater Sound Sources Characterisation Study: Energy Island, Denmark, Document 02539, Version 2.1, s.l.: Technical report by JASCO Applied Sciences for Fugro Netherlands Marine B.V.

Partridge GJ, Michael RJ., 2010. Direct and indirect effects of simulated calcareous dredge material on eggs and larvae of pink snapper Pagrus auratus. Journal of Fish Biology 77: 227-240.

Pennycuick, C.J., Alerstam, T. & Larsson, B., 1979. Soaring migration of the Common Crane Grus grus observed by radar and from an aircraft. Ornis Scandinavica 10:241-251.

Pethon P, Svedberg U., 1998. Fiskar i färg. Norstedts Natur.

Pettersson, J., 2003. Vårflyttningen av sjöfåglar över Kriegers flak i sydvästra Östersjön. JP Fågelvind. For Sweden Offshore Wind AB.

Pettersson, S. 2020. Kontrollprogram fladdermöss vid Kvilla vindpark, Torsås kommun, 2018–2019. Rapport på uppdrag av Windevo AB.

PIANC, 2018. MarCom WG Report n° 161 - 2018, Interaction between offshore wind farms and maritime navigation. PIANC The World Association for Waterborne Transport Infrastructure.

Popper AN, Hawkins AD, Sand O, Sisneros JA., 2019. Examining the hearing abilities of fishes The Journal of the Acoustical Society of America 146: 948-955.

Putman NF, Lohmann KJ, Putman EM, Quinn TP, Klimley AP, Noakes DLG, 2013. Evidence for geomagnetic imprinting as a homing mechanism in Pacific Salmon. Current Biology 23: 312-316.

Putman NF, Jenkins ES, Michielsens CGJ, Noakes DLG, 2014. Geomagnetic imprinting predicts spatio-temporal variation in homing migration of pink and sockeye salmon. J. R. Soc. Interface 11: 20140542.

Qvarfordt, S., Kautsky, H. och Malm, T., 2006. Development of fouling communities on vertical structures in the Baltic Sea. Estuarine, Coastal and Shelf Science 67, 618–628.

Reubens JT, Degraer S, Vincx M., 2011. Aggregation and feeding behaviour of pouting (Trisopterus luscus) at wind turbines in the Belgian part of the North Sea. Fisheries Research 108: 223-227

Reubens JT, Vandendriessche S, Zenner AN, Degraer S, Vincx M., 2013. Offshore wind farms as productive sites or ecological traps for gadoid fishes? Impact on growth, condition index and diet composition. Marine Environmental Research 90: 66-74.

Reubens JT, Degraer S, Vincx M., 2014a. The ecology of benthopelagic fishes at offshore wind farms: a synthesis of 4 years of research. Hydrobiologia 727: 121-136.

Reubens JT, Maarten DR, Degraer S, Vincx M., 2014b. Diel variation in feeding and movement patterns of juvenile Atlantic cod at offshore wind farms. Journal of Sea Research 85: 214-221.

Richardson, W., Greene, C., Malme, C. & Thompson, D., 1995. Marine mammals and noise. Academic Press, New York, s.l.: Academic Press New York.

Russell, D. et al., 2014. Marine mammals trace anthropogenic structures at sea. s.l.:Current Biology 24: R638-R639.

Rydell, J., Engström, H., Hedenström, A., Larsen, J.K., Pettersson, J. & Green, M., 2011. Vindkraftens påverkan på fåglar och fladdermöss. En syntesrapport. Rapport 6467, Naturvårdsverket.

Rydell J, Bach L, Bach P, Guia Diaz L, Furmankiewicz J, Hagner-Wahlsten N, Kyheroinen E-M, Lilley T, Masing M, Meyer M M, Petersons G, Suba J, Vasko V, Vintulis V and Hedenstrom.A., 2014. Phenology of migratory bat activity across the Baltic Sea and the south-eastern North Sea. Acta Chiropterologica, 16(1): 139–147.

Rydell J and Wickman A., 2015. Bat activity at a small wind turbine in the Baltic Sea. Acta Chiropterologica, 17(2): 359–364.

Rydell, J., Ottvall, R., Pettersson, S. & Green, M., 2017. Vindkraftens påverkan på fåglar och fladdermöss. Uppdaterad syntesrapport 2017. Rapport 6740, Naturvårdsverket.

SAMBAH, 2016. Static Acoustic Monitoring of the Baltic Sea Harbour Porpoise (SAMBAH). Final report under the LIFE+ project LIFE08 NAT/S/000261., SE-618 92 Kolmården, Sweden. 81 pp: Kolmårdens Djurpark AB.

Scheidat, M. m.fl., 2011. Harbour porpoises (*phocoena phocoena*) and wind farms: a case study in the Dutch North Sea. S.l.: Environmental Research Letters 6:025102

Schmidtke, E., 2010. Damping of Shock Waves from Sea Mine Blasts to protect Marine Mammals – Results from Bubble Curtain Trials in Heidkate 2008 - 2010. Neumünster. s.l.:s.n.

Sjöberg, M. & Ball, J.P., 2000. Grey seal, Halichoerus grypus, habitat selection around halout sites in the Baltic Sea: bathymetry or central-place foraging? Canadian Journal of Zoology 78: 1661–1667.

Skov, H. m.fl., 2011. Waterbird populations and pressures in the Baltic Sea. TemaNord 2011:550.

Skov, H., Desholm, M., Heinänen, S., Johansen, T.W. & Therkildsen, O.R., 2015. Birds and bats at Kriegers Flak. Baseline investigations and impact assessment for establishment of an offshore wind farm. Aarhus University, DHI, NIRAS på uppdrag av Energinet).

Slotte A, Kansen K, Dalen J, Ona E., 2004. Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. Fish Res. 67, 143–150

SLU, 2017. Svenskt fiske i historiens ljus - en historisk fiskeriatlas. Aqua reports: 2017:7

SLU, 2018. Bottentrålning - effekter på marina ekosystem och åtgärder för att minska bottenpåverkan. Aqua report 2018:7.

SMHI Shark, 2020. Zoobenthos. https://www.smhi.se/data/oceanografi/datavardskap-oceanografi-och-marinbiologi/sharkweb [Hämtad: 2020-12-21].

SMHI, 2020. https://www.smhi.se/data/oceanografi/havsis.

SMHI, 2021a. Rapport från SMHI:s utsjöexpedition med R/V Svea. 2021-06-03. Sveriges Meteorologiska och Hydrologiska Institut, Oceanografiska Laboratoriet.

SMHI, 2021b. Oxygen Survey in the Baltic Sea 2020 – Extent of Anoxia and Hypoxia, 1960–2020. Report Oceanography No.70, 2020. Swedish Meterological and Hydrological Institute, Göteborg, Sweden.

Smith ME, Kane AS, Popper AN., 2004. Noise-induced stress response and hearing loss in goldfish (Carassius auratus) Journal of Experimental Biology 207: 427-435

Smyth K, Christie N, Burdon D, Atkins JP, Barnes R, Elliott M., 2015. Renewables-to-reefs? - Decommissioning options for the offshore wind power industry. Marine Pollution Bulletin 90: 247–258

Sokolova M, Buchmann K, Huwer B, Kania PW, Krumme U, Galatius A, Hemmer-Hansen J, Behrens JW., 2018. Spatial patterns in infection of cod Gadus morhua with the seal-associated liver worm Contracaecum osculatum from the Skagerrak to the central Baltic Sea. Marine Ecology Progress Series 606: 105-118

Southall, B. et al., 2019. Marine mammal noise exposure criteria: Updated Scientific Recommendations for Residual Hearing Effects. s.l.:Aquatic Mammals, 45(2), 125-323.

Stepputtis D, Hinrichsen HH, Boettcher U, Goetze E, Mohrholz V., 2011. An example of meso-scale hydrographic features in the central Baltic Sea and their influence on the distribution and vertical migration of sprat, Sprattus sprattus balticus (Schn.). Fisheries Oceanography 20: 82-88

Svedäng H, Hornborg S., 2014. Selective fishing induces density-dependent growth. Nature communications 5: article number 4152, https://doi.org/10.1038/ncomms5152

Sveegaard, S., Nabe-Nielsen, J. & Teilmann, J., 2018. Marsvins udbredelse og status for de marine habitatområder i danske farvande. s.l.:Aarhus Universitet, DCE - Nationalt Center for Miljø og Energi, 36s. Videnskabelig rapport nr. 284. http://dec2.au.dk/pub/SR284.pdf.

Teilmann, J., Dietz, R. & Sveegaard, S. 2022. The use of marine waters of Skåne by harbour porpoises in time and space. Aarhus University, DCE - Danish Centre for Environment and Energy, 76 pp. Technical Report No. 236. http://dce2.au.dk/pub/TR236.pdf

Tesch FW, Wendt T, Karlsson L., 1992. Influence of geomagnetism on the activity and orientation of eel, Anguilla anguilla, as evident from laboratory experiment. Aquatic Ecology Freshwater Fish 1: 52-60

Tollit, D.J., Black, A D., Thompson, P.M., Mackay, A., Corpe, H.M., Wilson, B., Van Parijs, S.M., Grellier, K. & Parlane, S., 1998. Variations in harbour seal Phoca vitulina diet and dive-depths in relation to foraging habitat. Journal of Zoology, 244(2), 209-222.

Tougaard J, Hermannsen L, Madsen PT, 2020. How loud is the underwater noise from operating offshore wind turbines? The Journal of the Acoustical Society of America 148: 2885

Tougaard, J. & Michaelsen, M., 2018. Effet of larger turbines for the offshore wind farm at Kriegers Flak, Swweden. Assessment of impact on marine mammals., s.I: Aarhus University, DCE – Danish Centre for Environment and Energy

Tougaard. J. m.fl., 2006. Harbour seals on Horns Reef before, during and after construction of Horns Rev offshore wind farm. S.l.:P. 67. NERI Im Auftrag von Vattenfall A/S.

Tougaard, J., Wright, A. & Madsen, P., 2015. Cetacean noise criteria revisited in the light of proposed exposure limits for harbour porpoises. s.l.:Marine Pollution Bulletin 90. 196-208.

Trafikverket, 2020. Prognos för godstransporter 2040 - Trafikverkets Basprognoser 2020. Trafikverket.

Tsouvalas A., 2020. Underwater noise emission due to offshore pile installation: A Review. Energies 13: 12

UNCTAD, 2020. Review of Maritime Transport 2020. Geneva: United Nations.

United Nations Environment Programme, 2022. Emissions Gap Report 2022: *The closing Window – Climate crisis calls for rapid transformations of societies*. https://www.unep.org/resources/emissions-gap-report-2022

van der Meij H, Kastelein R, van Eekelen E, van Koningsveld M., 2015. FaunaGuard: a scientific method for deterring marine fauna. Terra et Aqua 138: 17-24

van Hal R, Griffioen AB, van Keeken OA., 2017. Changes in fish communities on a small spatial scale, an effect of increased habitat complexity by an offshore wind farm. Marine Environmental Research 126: 26-36

Vanagt T och Faasse M., 2014. Development of hard substratum fauna in the Princess Amalia Wind Farm. Monitoring six years after construction. eCOAST report 2013009.

Vandendriessche S, Derweduwen J, Hostens K., 2015. Equivocal effects of offshore wind farms in Belgium on soft substrate epibenthos and fish assemblages. Hydrobiologia (2015) 756:19–35

Vattenfall, 2019. Nya vindkraftverk ger lägre klimatavtryck.

von Dewitz B, Tamm S, Höflich K, Voss R, Hinrichsen HH., 2018. Use of existing hydrographic infrastructure to forecast the environmental spawning conditions for Eastern Baltic cod. PloS One, 13(5), e0196477.

Walker MM., 1984. A candidate magnetic sense organ in the yellowfin tuna, Thunnus albacares. Science 224: 751

Welcker, J. & Vilela, R., 2019. Weather-dependence of nocturnal bird migration and cumulative collision risk at offshore wind farms in the German North and Baltic Seas. Technical report. Bio-Consult SH, Husum. 70 pp.

Welcker, J., Liesenjohann, M., Blew, J., Nehls, G. & Grünkorn, T., 2017. Nocturnal migrants do not incur higher collision risk at wind turbines than diurnally active species. Ibis 159:366-373.

Westerberg H, Begout-Anras M-L., 2000. Orientation of silver eel (Anguilla anguilla) in a disturbed geomagnetic field. Proc. 3rd conference on fish telemetry in Europe. Norwich 20–25 juni, 1999.

Westerberg H, Lagenfelt I., 2008. Sub- Sea power cables and the migration behaviour of the European eel. Fisheries Management and Ecology 15:369-375

Westerberg H, Rönnbäck P, Frimansson H., 1996. Effects on suspended sediments on cod egg and larvae and on the behaviour of adult herring and cod. ICES Council Meeting Papers 13

Zingel P, Paaver T., 2010. Effects of turbidity on feeding of the young-of-the-year pikeperch (Sander lucioperca) in fishponds. Aquaculture Research 41: 189–197

Öhman M.C. 2006. Konstgjorda marina rev och fiskbiotoper. Kustfiske och fiskevård, sid. 187–191 (redaktörer Lindgren B, Carlstrand H)

Öhman M.C., Sigray P., Westerberg H., 2007. Offshore windmills and the effects of electromagnetic fields on fish. Ambio 36: 630–633

Öhman MC, Karlsson M, Staveley T., 2021. Fisk och havsbaserad vindkraft i Kattegatt - Vindpark Galatea Galene. AquaBiota Report 2021:06

Øresundskonsortiet, 2000. Environmental impact of the construction of the Øresund fixed link. Copenhagen 96 pp.