Espoo report

Aurora Wind Farm

Administrative information

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Water area concerned:	Swedish exclusive economic zone

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Client: AUR Energipark AB

Date: 2023-09-18

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About AUR Energipark AB

The Aurora Wind Farm is owned by AUR Energipark AB which is a subsidiary of OX2 AB (publ.) co-owned with Ingka Investments. OX2 develops, builds and sells onshore and offshore wind and solar power facilities. OX2 offers power facilities, as well as management of wind and solar farms after completion. OX2's development portfolio consists of both proprietary and acquired projects in various phases, and the company is also active in technology development linked to renewable electricity sources, such as hydrogen and energy storage.

In line with the company's business goal, OX2 has developed a biodiversity strategy, through which they are working towards the goal of nature-positive wind and solar farms. Contributing to biodiversity is an important part of the development of all OX2's wind and solar power projects.

OX2 has operations in eleven markets in Europe and has been operating in Australia since 2023. The company has approximately 500 employees and is headquartered in Stockholm. In 2022, OX2 had sales of approximately SEK 7.6 billion, and was listed on Nasdaq Stockholm's main market.

Non-technical summary

The project

AUR Energipark AB, which is a subsidiary of OX2 AB and jointly owned by Ingka Investments (hereinafter referred to as "Company"), is planning to build an offshore wind farm in the Baltic Proper (Western Gotland Sea), within the Swedish Exclusive Economic Zone (hereinafter SEZ). The planned wind farm is called Aurora. Aurora Wind Farm will have an estimated maximum output of approximately 5 500 MW and comprise of up to 370 wind turbines, each with a maximum height of 370 metres.

This Report for Consultation under the Espoo Convention (hereafter "the Espoo Report" or "the Report") has been prepared as part of the consultation under the Espoo Convention and deals with the potential transboundary impact of Aurora Wind Farm. This report is based on the comprehensive environmental impact assessment with underlying investigations and reports produced for the project and its applications according to Swedish legislation.

Location and site description

The Aurora Wind Farm will be located in the Baltic Proper, within SEZ. The planned area is located about 30 kilometres east of Öland and about 20 kilometres south of Gotland and is approximately 1,045 km^2. The area has a water depth varying between 43–88 metres and consists entirely of open sea with no islands. The area meets the basic technical conditions and activity-specific requirements regarding strong and stable winds, as well as suitable water depths and geotechnical conditions.

The planned wind farm is located in an area where the ecological value is negligible, primarily due to the water depth and light conditions in combination with intermittently hypoxic or anoxic conditions. Studies and surveys carried out for this project, as well as obtained fisheries data have shown that the occurrence of fish is very low. The low fish stocks implies that marine mammals such as porpoises and seals are not present in the area to any great extent. The relatively large depths and the general absence of fish also means that the area is not a suitable foraging area for bird species whose diets consist largely of fish and/or mussels.

The planned Aurora Wind Farm is bordered to the south by the Natura 2000 site Hoburgs Bank and Midsjöbankarna, the distance from the wind farm to the sensitive environment of offshore banks is relatively large at about 10 kilometres for the Norra Midsjöbank and about 12 kilometres for Hoburgs Bank.

Knowledge base

During the course of this project, a number of studies have been carried out including but not limited to species inventories, sediment, collision and underwater noise modelling, maritime risk assessments. Existing data has been used, comprising inventories and mapping produced by the Swedish Agency for Marine and Water Management (HaV), the Geological Survey of Sweden (SGU) and the Swedish Environmental Protection Agency, as well as data and information from scientific literature, research results, environmental reports, technical reports and knowledge and information from various authorities.

The results from above mentioned surveys and studies carried out specifically for Aurora Wind Farm are consistent with previously published studies and data. In the assessment all available and for Aurora Wind Farm applicable data and information have been used and considered. The knowledge base developed for the Aurora Wind Farm is therefore considered to be appropriately comprehensive and of sufficient quality to enable reliable assessments of the effects and consequences of the installation of the proposed wind farm.

Consequences of the activities

The description of current conditions is based on the comprehensive knowledgebase mentioned above.

A systematic approach has been used to identify and assess the potential transboundary impacts of the planned activities, and to identify potential protective measures which may help to avoid or reduce these impacts during the construction, operational and decommissioning phases.

Wind farm technology is rapidly advancing, and the final design that will be most suitable for implementation on this site is yet unknown. Because of this, a worst-case-scenario approach has been taken, with the expectation that the real environmental impacts will never exceed the assessed impacts, and the most conservative protective measures can be suggested.

Fish

Field surveys carried out in 2021 as well as catch data from ICES and HaV generally show very low occurrence of fish in the area where the Aurora Wind Farm is planned. The area is neither considered to be an important spawning ground for fish. The fact that hypoxic or anoxic bottom waters are found within the proposed site is likely to be one of the aspects that can explain the low fish occurrence, both due to fishes' inherent oxygen requirements and a reduction in the available local food sources, which also rely on higher oxygen levels. The species found at the site are mainly sprat, herring, stickleback and cod. The extent of commercial fishing within the planned wind farm and its immediate vicinity has also decreased throughout years, mainly as a result of poor catches.

Overall, the planned wind farm is estimated to have an insignificant transboundary impact during the construction, operation and decommissioning phases with regards to the impact of sediment dispersion, underwater noise and electromagnetic fields. The transboundary impacts of the wind farm are therefore considered to be negligible.

Marine mammals

Porpoise

The area covered by the planned wind farm is not considered an important area for harbour porpoises (*Phocoena phocoena*). Porpoises occur only sporadically in the area, with few individuals detected in the surveys carried out using porpoise detectors during August 2020 – May 2023. The number of detection positive minutes is very low, even when porpoises have been detected. This may indicate that porpoises do not stay in the area of the wind farm for a long time, and not in large numbers, but rather that there are a few individuals that temporarily pass through the area. The low presence of harbour porpoises can be explained, among other things, by the scarcity of fish in the area, se previous paragraph.

Transboundary effects on harbour porpoises could potentially occur if the establishment of the Aurora Wind Farm would have a negative impact on the harbour porpoise population in the Baltic Sea. Protective measures such as soft-start, sound-absorbing equipment and acoustic methods will be implemented before and during piling to make porpoises to relocate to areas further away. Furthermore, the company commits to condition that during piling work, underwater noise shall not exceed the single pulse $SPL_{RMS\text{-fixed, VHF}}$ 100 dB porpoise re 1µPa at a distance of 9.4 kilometres from the sound source. To protect the porpoise during calving and mating period, underwater noise from piling work shall not exceed the value $SPL_{RMS\text{-fast, VHF}}$ 100 dB porpoise re 1µPa during the period from 1 May to 31 October in any part of the Natura 2000 area Hoburgs bank and Midsjöbankarna.

As protective measures will be implemented during the construction phase to minimize the impact of underwater noise, and as the area is not an important area for harbour porpoises, the construction, operation and decommissioning of the Aurora Wind Farm has been as assessed to have a minimal impact on the local harbour porpoise population. Thus, the Aurora Wind Farm does not have any negative consequences for the Baltic Sea porpoise's population development, habitats or reproductive range in the Baltic Sea in the short or long term. The Aurora Wind Farm is not expected to affect the harbour porpoises' ability to reach a favourable conservation status at either local or biogeographical level. Thus, the establishment of the Aurora Wind Farm is not expected to have transboundary effects on the population of harbour porpoises in the Baltic Sea.

Seal

The wind farm area is not considered an important foraging area for harbour seals (*Phoca vitulina*) or grey seals (*Halichoerus grypus*). Due to the low prey availability and the hypoxic or anoxic bottom conditions at depths exceeding 70 metres, the wind farm area is considered to be of little importance to the species.

As above mentioned, protective measures will be implemented and the area does not constitute an important habitat for seals, it is not considered that the Aurora Wind Farm will have negative effect on the seal populations' ability to reach a favorable conservation status the during construction, operational or decommissioning phase, at either a local or biogeographical level, and so a negligible transboundary impact is expected.

Birds

The Aurora Wind Farm is located in a sea area about 30 kilometres east of Öland and about 20 kilometres south of Gotland with water depths that vary between 43 and 88 metres. The area is therefore not significant as a habitat for seabirds seeking food in waters shallower than 30 metres. In addition, partly anoxic conditions in the bottom waters occur in the large part of wind farm area leading to unfavourable conditions for bottom flora and fauna. Relative to other sea areas in the region, wintering long-tailed ducks (*Clangula hyemalis*) birds are largely absent and auks (*Alcidae*) are present only to a limited extent in the wind farm area.

A large number of birds pass through the sea area about 30 kilometres east of Öland and about 20 kilometres south of Gotland during migration in the spring and autumn. Extensive studies of migration patterns using satellite transmitters on bird individuals, land-based distance counts, flight inventory with digital camera and LiDAR as well as radar studies both from land and ship in and around Aurora Wind Farm conducted during 2021, 2022 and 2023 show that migratory routes pass mainly northwest or southeast of Aurora Wind Farm, with the exception of a few species.

However, the geographical distribution of bird migration is weather dependent and wind conditions play a particularly important role. Based on investigations and studies, typically there is not a large migration flow passing over Aurora Wind Farm. However, in certain weather situations, significant numbers of birds can pass through the wing farm area. The potentially largest impact of a wind farm is during the operational phase, through collision risk, displacement effects and barrier effects.

Collision risks

Collision risks have been calculated by DHI based on the best available knowledge regarding both bird species migration, flight behavior and the avoidance rate of different species and species groups. For all assessed bird species and species groups, the number of collision cases were predicted to be very low, as the number of potentially affected birds represents a very small proportion of the total population. The consequences of collision are expected to be negligible because avoidance rates are high and the number of potentially affected birds constitutes a very small proportion of the population.

As the wind farm Aurora is large and there are weather conditions that arise temporarily which may entail a high risk of collision, albeit it is short-term, the company intends to follow up the impact of the wind farm in a survey programme. A three-year survey programme for some species groups will be carried out as well as operational control implemented to protect migrating bats, which will apply from the start of operational phase. The company would like to ascertain the weather conditions which can lead to impact on bird population, to ensure that the protective measures proposed within the framework of the SEZ application to reduce the impact, are as effective as possible.

Displacement

Displacement effects can occur for species that use the wind farm as a habitat thus impact has been assessed for auks and long-tailed duck birds. The project area does not constitute a significant area for foraging for the bird species. Inventories show that few auks and long-tailed duck birds occur in the area thus displacement to other areas is considered to be very low in relation to population. The impact of displacement is expected to be insignificant, and the consequences of displacement are considered negligible for the population of auks and long-tailed duck birds.

Barrier effect

Studies have shown that most species of seabird avoid flying near wind turbines during migration. However, the wind farm might impose a barrier for some migrating species of birds. If the birds choose to fly around the wind farm instead of flying through, it will result in a longer flight distance and thus a higher energy consumption. However, this additional flight distance is estimated to be only a maximum of 3.6 percent of the total flight distance for migration. The consequence is expected to be negligible.

The overall impact assessment is that the collision risk, displacement, and barrier effects for migrating and resting birds lead to negligible consequences in the construction, operation, and decommissioning phases for the Aurora Wind Farm. Aurora Wind Farm's transboundary effect on birds is expected to be negligible.

Bats

The wind farm area is not considered to be an important habitat for bats, due to the great distance to the coasts of Öland and Gotland. However, inventories show that bats can pass through and around Aurora Wind Farm during their spring and autumn migration. Migration of bats through the wind farm area may occur during a limited period of time, that is during April/May and between 15 August and 15 October. The migration generally takes place in favorable weather conditions with low winds. Conducted inventories during migration periods in 2022 show some occurrence of bats within the Aurora Wind Farm.

The company intends to carry out a three-year survey programme for bats, as well as to implement operational regulations to protect migrating bats, which will apply from the start of operational phase. The purpose of the operating controls is to protect migrating bats during the spring and autumn migration. Regulations will be applied between sunset and sunrise and when there is a risk of collision with the rotor blades of the wind turbines and bats have been detected. The survey programme will be initiated in connection with the start of operations, in order to evaluate whether the implemented protective measures are effective or if they need the be revised.

Since a survey programme will be carried out during the first year of operation, and that in the event of a significant risk of collision for bats, an operational regulation of the wind turbines will be introduced, the overall assessment shows that no negative impact on bats is expected. Thus, it can be concluded that Aurora Wind Farm is not expected to have a transboundary impact on bats migrating through the area.

Commercial fishing

Catch statistics show that the area covered by the planned wind farm is of only marginal importance for commercial fishing and the fishing industry. The bottom waters within the planned wind farm area are largely hypoxic or anoxic, which, together with other factors such as fishing quotas and population development of commercially important species, means that demersal fishing is, and for a long time has been, practically non-existent. Pelagic fishing within the planned wind farm has been sporadic and the catches represent only a very small part of the total catches in the Western Gotland Sea. It is mainly Swedish fishing fleet that is fishing in the wind farm area.

The transboundary impact that the wind farm could give rise to in the form of reduced area available for fishing is considered to have negligible consequences for commercial fishing, as the area already is of marginal importance for these activities. With future changes in fishing quotas, the assessment may change, but given the current population status and expected population evolution for commercially important species such as herring and cod, it is likely that the trend of very restrictive quotas that has been applied will continue for the foreseeable future. In August 2023, the European Commission presented a new proposal to stop the targeted herring and cod fisheries in the central Baltic Sea and the Gulf of Bothnia.

The assessment of the impact of the planned wind farm on commercial fishing is based on a worst-case scenario, which means that commercial fishing will not be possible within the Aurora Wind Farm. The assumed worst-case scenario in this case is conservative, as parts of the planned wind farm will probably continue to be used for certain commercial fishing activities. However, the presence of foundations, erosion protection, underground cables and any anchor lines must be taken into account in the possible continuation of commercial fishing within the wind farm.

Shipping

No sea lanes passes through Aurora Wind Farm, and the company has proposed a safety distance of 1.38 nautical miles to nearby routes in order to ensure sufficient maritime safety. At present, only a small number of vessels pass through the area that will be used by the planned wind farm.

During the construction phase, there is a risk of conflicts between installation vessels and other vessel traffic, as well as of ships accidentally entering the work area, which can have transboundary effects. During the construction works, measures will be taken to avoid maritime-related risks, including the monitoring of all vessel traffic by a project-specific marine coordinator, clearly marking the work areas and providing continuous information via various maritime bulletins. Specific, purpose-built areas will be used for crossing the sea lanes.

With the protective measures and precautions taken, the impact during the construction phase is considered to be insignificant and consequences are expected to be negligible. Similar conditions as during the construction phase are expected to prevail during the decommissioning phase. However, with the reservation that the decommissioning phase is going to occur very far in the future.

During the operational phase, the planned wind farm is estimated to increase the likelihood of incidents and accidents (in particular allisions), if protective measures are not applied. Calculations carried out in connection with risk analyses for shipping, do not indicate that the wind farm will significantly increase the probability of collisions. A certain increase in the probability of collision may occur if the maritime traffic that currently passes on the routes in the immediate vicinity of the wind farm are forced to choose a route slightly further from the wind farm, to keep a greater distance to the wind farm, and if there is thereby a congestion of vessel traffic. However, this is only a small increase from what are currently very low levels of collision probability.

With the protective measures and precautions that will be taken, the likelihood of incidents and accidents can be reduced. Given a certain increased likelihood of accidents, the transboundary effect of the wind farm is estimated to be small, which overall implies a moderate negative consequence.

Risk and safety

The planned wind farm may give rise to unplanned events during the construction, operation and decommissioning phase. Risks that can lead to transboundary effects consist of environmental risks such as oil spills.

Risks that the wind farm may give rise to will be continuously managed and minimized through risk analyses, the establishment of a work environment plan and the implementation of various protective measures and procedures. The Aurora Wind Farm is therefore not considered to give rise to any unacceptable transboundary effects during the construction, operation and decommissioning phase.

Climate

The establishment of the Aurora Wind Farm will have a certain climate impact in the form of the emissions generated during the production of the wind turbines and fundaments, using various materials and components, as well as during the actual construction. Based on calculations of greenhouse gas emissions per kWh of electricity produced, made for both offshore and onshore wind power, the Aurora Wind Farm is expected to generate greenhouse gas emissions below 8 gCO_2e/kWh.

Electricity production from the Aurora Wind Farm is estimated to result in 45 times less carbon dioxide emissions compared to the same average production of energy in the Nordic countries. Compared to the average energy production in Europe, the production from Aurora Wind Farm would mean about 60 times less carbon dioxide emissions. Compared to the carbon dioxide emissions generated by electricity production from a reasonable replacement mix, the Aurora Wind Farm can reduce carbon dioxide emissions by 14 million tons/year.

The Aurora Wind Farm is expected to contribute very positively in replacing fossil electricity production and thereby contribute to large-scale reduction of greenhouse gas emissions.

Cumulative effects

Cumulative effects may occur with other existing operations and those with permit, as well as the company's other projects in the vicinity of the Aurora Wind Farm.

In this respect, the company has considered that it is relevant for the cumulative assessment to consider the two existing offshore wind farms in the immediate area; Bockstigen I (about 34 km from Aurora Wind Farm) and Kårehamn (about 35 km from Aurora Wind Farm). For planned projects without permit, there is usually a very high degree of uncertainty as to both the actual realisation of a project as well its final scope, design and environmental impact, which considerably complicates and limits the possibility of assessing cumulative effects.

However, OX2 has two additional projects in the Baltic Sea, the Neptunus and Pleione wind farms, of which the Company has relevant and required knowledge and which have therefore also been taken into account in a cumulative assessment regarding the impact on the Natura 2000 site Hoburgs bank and Midsjöbankarna. Other existing wind farms in the Baltic Sea that have received permit but have not been constructed are located at a very large distance from Aurora Wind Farm, and are not expected to contribute to cumulative effects, especially as environmental impact from Aurora Wind Farm is expected to be small to insignificant and protective measures will be applied.

Fish

Elevated levels of underwater noise and sediment dispersion associated with construction work are impacts that can give rise to cumulative effects on fish. In order to avoid impacts and cumulative impacts, the company will apply protective measures that include, soft start, ramp-up, restrictions on how and when seismic equipment may be used and installations performed, as well as equipment to reduce sound propagation from installation.

When protective measures are taken to avoid cumulative impact, Aurora Wind Farm is not expected to contribute with cumulative effects, either during the construction phase or during the operation phase. The cumulative effects that occur are considered to be negligible.

Bird

When assessing cumulative effects, the two existing wind farms Kårehamn and Bockstigen I, the company's own projects, as well as shipping and commercial fishing, have been taken into account. Due to the location and design of the wind farms, their impact is not expected to give rise to significant cumulative effects for the birds that are expected to occur in the Aurora Wind Farm. At present, there are no other licensed wind farms located within such a distance that could mean that Aurora Wind Farm could have cumulative effects on birds.

The extensive migration studies carried out within the framework of the permit application for Aurora Wind Farm show that the main migration route of birds does not coincide with Aurora Wind Farm. Thus, Aurora Wind Farm does not form a barrier between the long-tailed duck's most important foraging areas in the Baltic Sea.

Bats

The company will introduce a survey programme, which will be initiated at the start of operation of the wind farm and implement operational regulation of the wind farm for protection of bats during the migration period. Therefore, no negative cumulative effect is expected to occur.

Porpoise

Construction work at any future nearby wind farms could potentially have a cumulative impact on marine mammals. Underwater noise from construction or seismic surveys may cause porpoises to move away from the site if dispersal of underwater noise for several projects overlap, which could lead to the temporary habitat loss at several sites at the same time. However, harbour porpoises move naturally over large areas in search for food. Possible cumulative effects can be avoided, for example, with adapted installation plans if another wind farm would be built in the region during the same period of time.

The extensive protective measures that the company has undertaken, such as soft start with ramp-up, double bubble curtain, and time restrictions for seismic surveys and construction work mean that the effect of Aurora Wind Farm will be reduced and minimised. Thus, Aurora Wind Farm is not expected to contribute to cumulative effects, either during the construction phase or during the operational phase.

Alternatives and non-action alternatives

The chosen location for Aurora Wind Farm has been assessed as suitable based on an extensive investigation of alternative sites, which has been carried out taking into account relevant stakeholders as well as technical, environmental and economic conditions. The extensive investigation of alternative sites has resulted in the chosen location option for the Aurora Wind Farm, which has particularly good conditions for the establishment of wind power.

The planned wind farm is located in an area where the occurring natural values, due primarily to the water depth in combination with hypoxic or completely anoxic conditions, are virtually non-existent. The extensive depths prevalent throughout the wind park limit the availability of sunlight necessary for the growth and survival of benthic flora. The bottom environments are characterized by the hypoxic or anoxic conditions that predominate water and sediment, which result in the absence of benthic fauna within the anoxic zones and low biodiversity with sparse population levels in the hypoxic regions.

Surveys carried out have shown that the presence of fish is very low. The lack of large quantities of fish means that marine mammals such as porpoises and seals do not occur in the area to any great extent. Furthermore, the considerable water depths and the prevailing scarcity of fish render the region unsuitable for bird species heavily reliant on fish and/or mussels as their primary diet.

The large available area allows for the construction of a wind farm that can contribute to environmental benefits as well as allowing for technical and economic requirements.

The non-action alternative means that the project does not come to realization. Thus, the planned Aurora Wind Farm's contribution to Sweden and the EU’s need for large-scale expansion of renewable electricity production will not materialize, which will have consequences for the national electricity supply, a transition of society and industry to sustainable energy production and for the climate. The non-action alternative means that the area remains unchanged compared to today, and that the positive long-term climate and environmental effects from Aurora Wind Farm are lost.

Contents

1. Introduction

1.1. Background and purpose

The company is planning the establishment of an offshore wind farm in the Baltic Proper off Öland and Gotland within Sweden's exclusive economic zone, see Figure 1. The planned wind farm is called Aurora Wind Farm. It is estimated that the wind farm will generate about 24 TWh of electricity per year, which corresponds to the electricity consumption of just over 5 million households.[1]

The establishment of a wind farm in Swedish exclusive economic zone requires a permit from the Swedish government in accordance with the Swedish Economic Zone Act (1992:1140) ("SEZ permit"). Since Aurora Wind Farm is located close to the Natura 2000 area, Hoburgs bank and Midsjöbankarna, the establishment also requires a Natura 2000 permit from the regional authority, the County Administrative Board of Gotland. SEZ permits and Natura 2000 permits have been applied for in 2022. The company has also applied for permission from the Swedish government to lay out the internal cable network in accordance with the Continental Shelf Act (1966:314).

1 At an estimated consumption of about 5000 kWh per household.

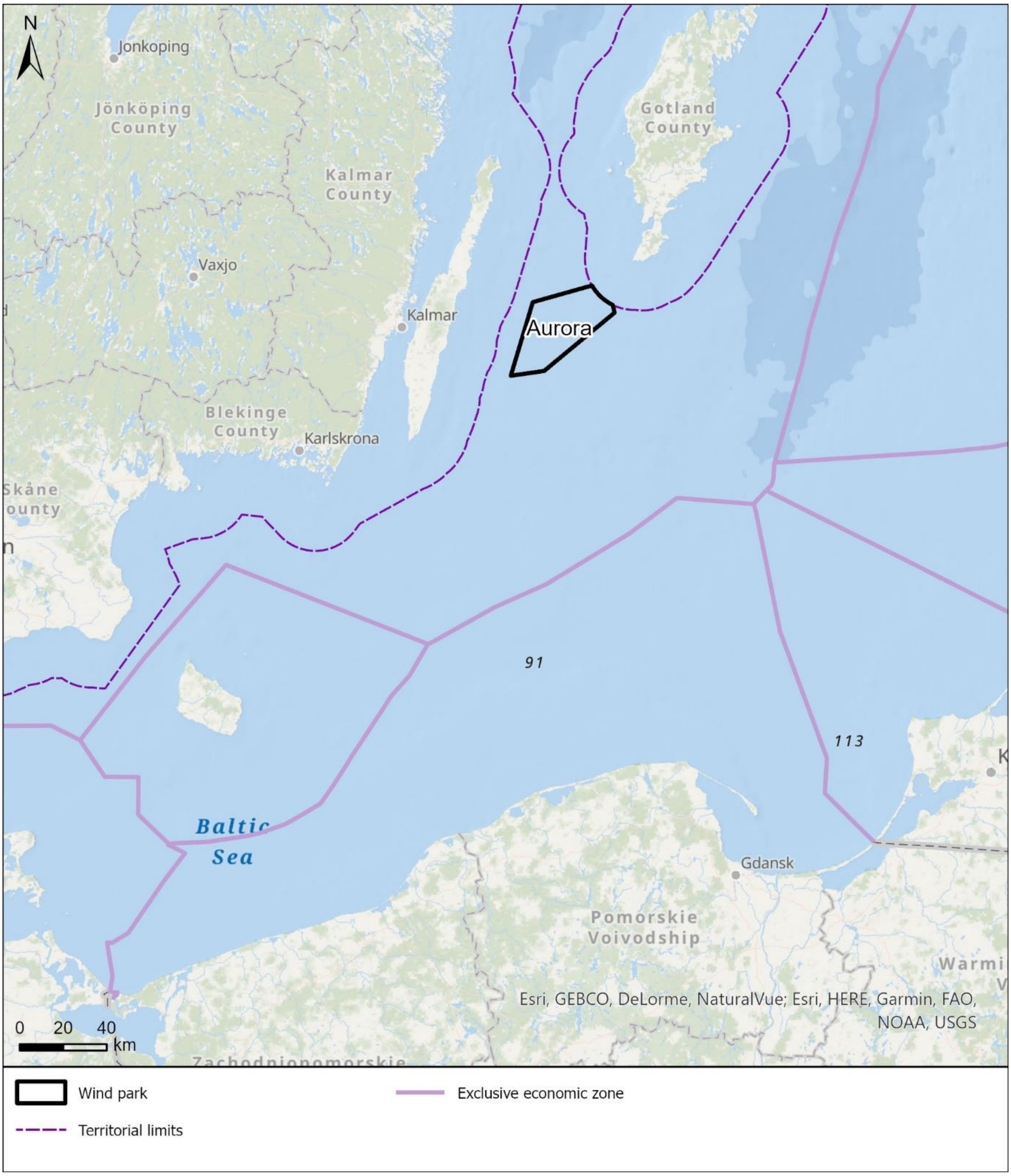

Figure 1. Overview of the location of the planned Aurora Wind Farm in the Baltic Proper. © [Lantmäteriet] 2021

In view of the possible transboundary effects of the activities, a consultation process has been launched with the neighboring countries concerned under the Espoo Convention. This report is part of the Espoo consultation and addresses the activities and their potential transboundary effects.

Chapter 7 describes the conditions for each environmental aspect. Transboundary effects are described for each environmental aspect, under a separate subheading.

1.2. Consultations under the Espoo Convention

The Convention on Environmental Impact Assessment in a Transboundary Context, the Espoo Convention, is an environmental protection convention for Europe, Canada and the United States on cooperation in preventing transboundary environmental effects.

According to the Espoo Convention, the party of origin of 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. The consultation process under Articles 3–6 of the Espoo Convention is coordinated by a responsible authority in each state concerned. As far as Sweden is concerned, the Swedish Environmental Protection Agency is the responsible authority. The Espoo procedure can be briefly summarised in the following overall steps:

1. Notification (Article 3) — Interested parties must be informed, through the competent authority, of any planned activity likely to have a significant (harmful) transboundary effect.
2. Preparation of the environmental impact assessment (Article 4) – To the extent that interested parties wish to continue to participate in consultations under the Espoo Convention, an environmental impact assessment (an Espoo report) must be prepared.
3. Consultation on the basis of the environmental impact assessment (Article 5) – The Espoo report/environmental impact assessment report shall be forwarded via the competent authority to the interested parties who intend to continue to participate in the procedure.
4. Final decision (Article 6) – Following consultation, a final decision on the proposed activity shall ensure that due account is taken of both the outcome of the environmental impact assessment and the comments received. In the case of trials of offshore wind farms located in the Swedish exclusive economic zone, the government's permit decision in the review under the Swedish Economic Zone Act (SEZ) may be considered to be the final decision, which concludes the Espoo consultation.

For the Aurora Wind Farm, the consultation process under the Espoo Convention began on 9 November 2021, when a notification was sent via the Swedish Environmental Protection Agency to Denmark, Germany and Poland. A total of 11 responses were received, five of them from Denmark, five from Germany and one from Poland. Seven consultative bodies have indicated that they wish to continue to participate in the environmental assessment process in accordance with the Espoo Convention, and that they wish to be given the opportunity to study this Espoo report. The comments received mainly concerned impacts on birds, bats, marine mammals and commercial fishing. Furthermore, comments were received regarding cumulative effects.

The establishment of a wind farm in Swedish exclusive economic zone requires a permit from the Swedish government in accordance with the Swedish Economic Zone Act (1992:1140) ("SEZ permit"). Since Aurora Wind Farm is located close to the Natura 2000 area Hoburgs bank and Midsjöbankarna, the establishment also requires a Natura 2000 permit from the regional review authority, the County Administrative Board of Gotland. SEZ permits and Natura 2000 permits have been applied for in 2022. The company has also applied for permission from the Swedish government to lay out the internal cable network in accordance with the Continental Shelf Act (1966:314).

Table 1 summarises the comments received and how they have been handled.

Table 1. Summary of comments received and how they have been handled.

Authority	Remark	Answer
Danmarks Fiskeriforening PO	Danmarks Fiskeforening PO highlights that it is important to focus on the cumulative effects that may occur.	The company has made assessments regarding cumulative effects on commercial fishing, see section 8.
	Fiskeriforeningen wants Swedish authorities to prioritize coexistence between commercial fishing and wind power by avoiding the better areas for fishing. Fiskeriforeningen believes that fishing should be allowed within existing wind farms. To succeed in catching the same amount of fish and shellfish, they believe that they need to fish in other and larger areas, which has a negative effect on the environment.	The fish trawl survey carried out show very low abundance of fish in the area of activity. Catch data also show that the area of the Aurora Wind Farm is not of major importance for commercial fishing. Shellfish fishing does not occur in the part of the Baltic Sea where Aurora Wind Farm is located, so there is no impact on shellfish fishing.
	Fiskeriforeningen claims that changing ocean currents due to substrate changes around turbine foundations change the occurrence of fish species, and that knowledge regarding the impact of offshore wind power on fish and shellfish species is not sufficiently documented and needs to be investigated.	The company has performed modelling regarding sediment dispersion and hydrographic impact. The impact on both currents and stratification in the area is expected to be negligible and not lead to any environmental impact. Thus, no impact on the occurrence of fish species is expected.
	Fiskeriforeningen would like to highlight that predators, such as cormorants, benefit from wind farms, which in turn can have a negative impact on fish stocks. They believe that seals and porpoises will increase in population, which will also reduce the fish population.	The environmental assessment shows that Aurora Wind Farm has negligible to little impact on the various biological aspects. This means that no significant changes in the marine ecosystem are expected to occur as a result of Aurora Wind Farm. Decline in fish stocks is a complex issue that depends on several aspects such as fishing, climate change, eutrophication, and more. In this context, predation pressure, which is a natural part of the ecosystem, is not considered to have a significant impact on the decline in fish stocks. Furthermore, porpoises are an endangered species whose increase is sought in conservation objectives in the Natura 2000 area and in the Baltic Sea in general.
	Fiskeriforeningen questions how noise from the operational phase will affect fish, as well as the magnetic field around the cables on the seabed.	The company has investigated the effects of operating noise from wind turbines and electromagnetic fields on fish, see section □.
Danmarks Försvarsminis-terie	Abstained.	

Danmarks Naturfrednin-gsforening Bornholm	Naturfredningsforeningen announce that they are not able to answer this time but will do so when the environmental impact assessment is available. Furthermore, they want to be notified in connection with the environmental assessment regarding the Triton wind farm.	The present Espoo consultation process concerns only the Aurora Wind Farm. For other wind farms, separate Espoo consultations will be carried out if necessary.
Danmarks Søfartstyrelse	Abstained.	
Miljøstyrelsen Arter och Naturbeskyttelse	Miljøstyrelsen Arter och Naturbeskyttelse state that they have reviewed the material and have no comments. They wish to participate in the upcoming environmental review process.	The company will include Miljøstyrelsen Arter och Naturbeskyttelse in the further process.
Bergsbruk Stralsund	Bergsbruk Stralsund does not expect any consequences for the interests and/or approved projects that the agency represents based on the planned project " Aurora Wind Farm" within Sweden's exclusive economic zone.	
Bundesamt für IUD	Abstained.	
Bundesamt fur Naturschutz (BfN)	The BfN's preliminary conclusion is that the potential transboundary effect of the planned project is likely to be small due to the great distance from the German exclusive economic zone.	
	The effects of Aurora Wind Farm on migratory birds and bats should be seen as transboundary environmental effects in terms of collision risks, barrier effects and habitat loss. Negative effects on bird range, especially for birds migrating through the German exclusive economic zone, are not considered to be excluded. BfN recommends detailed registration of relevant migratory and seabirds in the environmental impact assessment and conducting field surveys with aircraft and radar in the project area. The BfN wants the project manager to install and use long-term radar on the turbine to create a clearer picture of birds' migration patterns and migration behaviors and thus	Results from bird inventories and radar surveys over a three-year period as well as collision modelling form the basis for assessing transboundary impacts on birds and results are presented in section 7.3. In summary, studies show that bird migration mainly passes northwest and southeast of the Aurora Wind Farm. However, the geographical distribution of bird migration is weather dependent and wind conditions play a particularly important role. The assessment is that Aurora Wind Farm normally is not affected by the large migration flow. In connection with the commencement of the operational phase, the company will follow up migration in the area under specific wind conditions and adapt protective measures, see section 0.

	be able to control shutdowns of the wind turbines.	
	The BfN wants targeted investigations regarding collision risk for bats.	Inventories carried out in the wind farm area have revealed some presence of bats during migration periods, see section 7.4. The Company will apply operational regulation and implement a survey programme, see section 07.4.2.
	The BfN considers that displacement effects on seabirds may occur, which would have consequences for their distribution and have negative effects in the adjacent Natura 2000 area. A negative impact on the stock in the Swedish exclusive economic zone may have consequences for the population in the German exclusive economic zone. The BfN therefore recommends close monitoring for both wintering and passing seabirds within the site and the adjacent Protective measures, as well as a detailed analysis in the environmental impact assessment.	The area within Aurora Wind Farm is deep and partly anoxic and is not suitable as a foraging area for seabirds. In addition, inventories carried out show a low incidence of species of seabirds. Since Aurora Wind Farm is not considered a foraging area, and inventories show very limited occurrence, the displacement effect for species of seabirds is estimated to be negligible, see section 7.3.3. 0
	The BfN states that protective measures should be taken to prevent negative effects on the endangered Baltic Sea population of harbour porpoises and the threatened harbour seal population belonging to the Kalmar Strait population. To protect marine mammals, safety and noise protection measures must be tested in advance and then implemented when installing the wind farm. The BfN presents the sound exposure limit values applied in German permit processes. The BfN further recommends that piling work in connection with the construction phase be avoided during sensitive periods (reproduction and calving periods, June-September) and points out that in Germany it is standard to apply a combination of noise protection measures to ensure compliance with the limit values. The BfN highlights methods such as acoustic scare methods and in front of the start-up period that should apply to soft start when piling work is started or has been paused and resumed. The BfN states that the limit values mentioned in their opinion are generally recognised and should be complied with by standard. The BfN advises against carrying out piling work in several places in the operating area at the same time to avoid cumulative sound effects occurring. Furthermore, construction work of offshore wind power in the Baltic Sea should be coordinated between the	Protection and precautionary measures are proposed to minimise the impact on the Baltic Sea population of harbour porpoises and the harbour seal population. Protective measures have been developed in collaboration with experts. These include soft-start, acoustic methods to repel marine mammals, silencing equipment, including sound exposure limit values, see section 9. The company will plan installation so that piling is not carried out in several places at the same time in the area of operation. Furthermore, possible cumulative effects can be avoided, for example, with adapted installation plans if another wind farm is built in the region during the same period of time.

	projects to avoid piling work taking place simultaneously in several places.	
	Due to the large distance of more than 250 km between the Swedish wind farm "Aurora" and the German nature conservation area Westliche Rönnebank (DE 1251-301) and Adlergrund (DE 1249-301), the BfN does not expect any significant negative effects on the marine environment in these areas.	The company agrees with BnF on its assessment that the Aurora Wind Farm will not have negative effects on the marine environment in German Natura 2000 areas.
	The BfN wants to participate in the continued environmental impact assessment process.	The company will include BfN in the continued process.
Staatliches Amt für LUV	Abstained.	
Thünen Institute of Baltic Sea Fisheries	Thünen Institute of Baltic Sea Fisheries would like to draw attention to the fact that there is partly an overlap between the wind farm area with its associated cable corridors and with an annual international hydroacoustic survey (Baltic Acoustic Spring Survey (BASS)) conducted by the Thünen Institute of Baltic Sea Fisheries. The purpose of the survey is to obtain an annual assessment, carried out in May, of small pelagic fish stocks, in particular sprat and herring. They point out that if access is not granted to the wind farm area, it will lead to a greater negative impact on their investigation and that long detours around the park would have to be taken. However, they consider that if access to the wind farm is granted to carry out the survey, the impact is negligible for their investigation and that it would not lead to any negative impact on the wind farm.	Apart from those areas which are temporarily intercepted during the construction phase, it should continue to be possible to gain access to the area of activity for carrying out investigations.
Generalna Dyrekcja Ochrony Środowiska (GDOŚ) *Warsaw*	GDOŚ Warsaw, after reviewing the environmental impact assessment and considering the opinion of the relevant Polish environmental authorities and maritime administrations, has assessed that the project may pose a significant threat to migratory birds. They mention the cumulative effect of several additional wind farms in the Baltic Sea.	Results from bird inventories, radar surveys and collision modelling as well as transboundary effects for birds of the Aurora Wind Farm are presented in this ESPOO report in section 7.3. Data available from land-based counts and telemetry studies show that elk birds pass east of Gotland to a greater extent than between Öland and Gotland. Thus, Aurora Wind Farm is not considered to be a barrier for birds, including the long-tailed duck, that move between wintering and foraging areas, see section 7.3.6. 0
	They want to apply solutions that can provide free passage, such as the preservation of migratory corridors, for birds	The wind farm is not located within, but along the main flight direction of seabirds, which in spring is to the northeast and in autumn to the southwest (see section 7.3.4), which implies a limited impact in terms of barrier effect and impact on migratory birds. Therefore, alternative designs, including free passage through the

	to wintering and foraging areas in Polish Natura 2000 areas.	wind farm, are not considered to be an effective measure to avoid and minimise impacts on migratory species, see section 7.3.5. 00
	Special consideration should give to the long-tailed duck (*Clangula hyemalis*).	A comprehensive investigation and assessment of the impact on long-tailed ducks has been made in this Espoo report, which together shows that the transboundary effect through collisions for resting and migrating long-tailed ducks is negligible, see further section 7.3.6. 0
	GDOŚ Warsaw mention that environmental disturbances will occur, which can affect porpoises, fish and its spawning grounds, of interventions on the seabed such as disturbances in sediment and the spread of pollutants, suspended solids and underwater noise.	Investigations regarding sediment dispersion, environmental contaminants and underwater noise have been carried out within the framework of the permit application, see studies in section 5.1. 0 The impact on porpoises and fish and their spawning grounds is presented in sections 7.1 and 7.2 respectively. The company has proposed mitigation and 00precautionary measures to minimize the impact on marine mammals and fish. Protective measures have been developed in collaboration with experts in the fields, see section 9.
	Cumulative effects in terms of noise resulting from the construction of the wind farm, including impacts on marine mammals and fish spawning grounds;	The Company has made cumulative assessments regarding underwater noise, see section 8.
	GDOŚ Warsaw want to see planned noise reduction measures with associated data, from already existing wind farms, regarding its efficiency.	Modelling of the dispersion of underwater noise from construction and seismic surveys with the application of established noise abatement measures form the basis for proposed noise protection measures.

2. Scope

2.1. The project

This report covers transboundary effects and impacts resulting from the Aurora Wind Farm, with associated activities and installations. Additional activities in the form of surveys, connection cables and vessel traffic to and from the wind farm are also briefly described.

The connecting cables are not considered to have a transboundary effect because they are located at great distances from other countries and have only a limited environmental impact, which is why these are not assessed in this Espoo report.

The following applies to the activities:

The wind farm will comprise up to 370 wind turbines with a maximum turbine height of 370 metres, which will be positioned in the area based on site-specific conditions, foundation type and technology choices as well as taking into account other values in the area.

Wind farm technology is rapidly advancing, and the final design that will be most suitable for implementation on this site is as yet unknown. Because of this, a worst-case-scenario approach has been taken, with the expectation that the real environmental impacts will never exceed the assessed impacts. The assessments are based on assumptions about a maximum design scenario that takes into account by **a significant margin** of what could be the greatest impact on the environment. Different worst-case factors are assessed for different influencing factors. Section 5.3.1 presents the worst-case scenario for various influencing factors.0

2.2. Geographical delimitation

The impact assessments cover the transboundary effects that the project may give rise to and which have been deemed relevant to assess. The geographical delimitation varies for each aspect and is based on the investigations that have been conducted specifically for that aspect. Descriptions and assessments in this report focus on impacts that potentially affect Denmark, Germany and Poland.

2.3. Environmental aspects

It has been assessed that the construction, operation and decommissioning of the Aurora Wind Farm may cause transboundary effects which affect various environmental aspects, as outlined in-Table 2. Aspects which are not considered to be at risk include landscape, benthic flora/fauna, defense interests, cultural environment and aviation have therefore not been included in the present Espoo report.

Table 2. Environmental aspects that may be subject to a transboundary effect, and the phase for which these impacts are assessed.

Aspect	Construction phase	Operational phase	Decommissioning phase
Fish	x	x	x
Marine mammals	x	x	x
Birds	x	x	x
Bats		x	
Commercial fishing	x	x	
Shipping	x	x	x
Risk and safety	x	x	x
Climate	x	x	X

3. Location and description of the area

3.1. Location

The planned Aurora Wind Farm is located in the Baltic Proper, within Sweden's exclusive economic zone. The area consists entirely of open sea and has no islands, see Figure 2 below. The area of Aurora Wind Farm is about 1,045 km^2 in size and is located about 30 km east of Öland and about 20 km south of Gotland.

The distance from the planned Aurora Wind Farm to Poland is about 190 km. The distance from the wind farm to the Danish Island of Bornholm is about 200 km. The distance from the wind farm to the German island of Rügen is about 300 km.

3.2. Natura 2000

3.2.1. Hoburg's bank och Midsjöbankarna

The planned wind farm is bordered to the south by the Natura 2000 area Hoburgs bank and Midsjöbankarna (SPA/SCI, SE0330308). In the east, the minimum distance from the planned wind farm to the boundary of the Natura 2000 area is approximately 6.5 kilometres.

The Natura 2000 area Hoburgs bank and Midsjöbankarna consists of open sea and covers an area of approximately 10 511 km^2. The water depth within the area varies between 9 and 78 metres, with the shallower areas mainly occurring on and around the offshore banks (Figure 2).

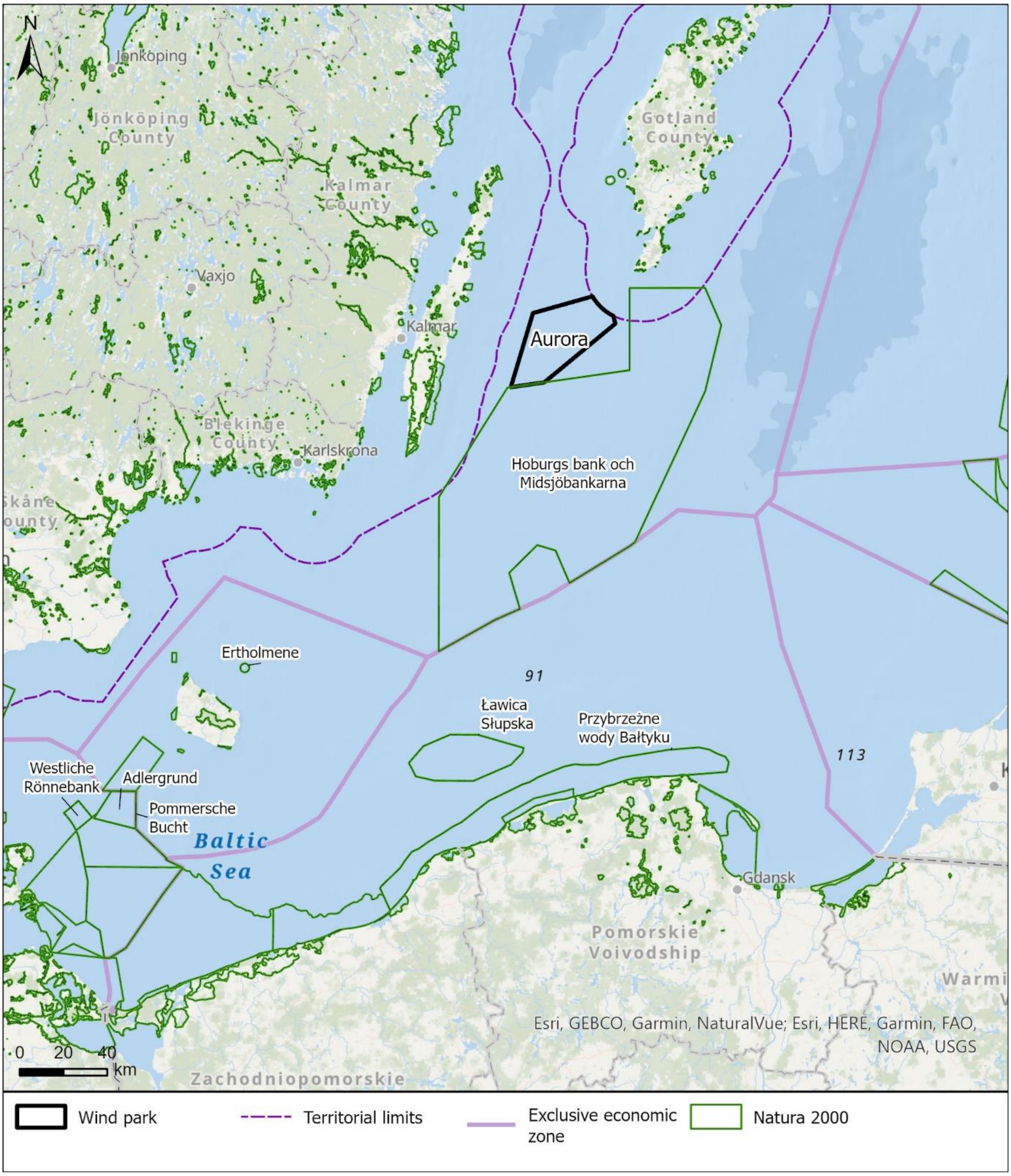

Figure 2. Overview of the location of the Aurora Wind Farm in the Baltic Sea, as well as nearby Natura 2000 sites. © [Lantmäteriet] 2021, [data: Naturvårdsverket och EMODnet]

The Natura 2000 area Hoburgs bank and Midsjöbankarna is designated under the Habitats Directive (92/43/EEC, SCI) for the Natura 2000 habitat types reefs (1170) and sublittoral sandbanks (1110) and the species porpoise (*Phocoena*, 1351) (Baltic Sea population), and under the Birds Directive (2009/147/EC, SPA) for the bird species long-tailed duck (*Clangula hyemalis*, A064) and black guillemots (*Cepphus grylle*, A202), see Table Table 3 (Länsstyrelsen, 2021).

Table 3. Designated Natura 2000 habitat types and species under the Habitats Directive (SCI) and designated bird species under the Birds Directive (SPA) for Hoburgs Bank and Midsjöbankarna (Länsstyrelsen, 2021).

Habitat types	Species
Reefs (1170)	Porpoise (1351)
Sand banks (1110)	Black Guillemot (A202)
	Long-tailed duck (A064)

The designated Natura 2000 habitat types occur mainly on or near the outlying banks in the Natura 2000 area (Figure 2). This means that the distances between the planned Aurora Wind Farm and the designated habitat types are relatively large. The distance from the planned Aurora Wind Farm to the outlying banks in the Natura 2000 area is significantly greater than the distances between the wind farm and the boundary of the Natura 2000 area. The nearest offshore bank is Norra Midsjöbanken, which is located at about 10 kilometres from Aurora Wind Farm. The distance to the Hoburg bank from the Aurora Wind Farm is about 12 kilometres.

An application for a Natura 2000 permit for Hoburg's bank and Midsjöbankarna has been submitted in early March 2022. The application is examined by the County Administrative Board of Gotland within the framework of a separate permit process.

3.2.2. Other Natura 2000 areas

Several Natura 2000 areas exist in the Baltic Sea within Danish, German and Polish waters (Figure 3). The Natura 2000 areas closest to the Aurora Wind Farm in Denmark, Germany and Poland are shown in Table 4.

Table 4. The Natura 2000 sites belonging to Denmark, Germany and Poland and located closest to the Aurora Wind Farm.

Natura 2000 area	Distance to Aurora Wind Farm (km)
Lawica Slupska – Poland	160
Przybrzeżne wody Bałtyku - Poland	175
Ertholme – Denmark	175
Adlergrund - Germany	252
Pommersche Bucht – Germany	252
Westliche Rönnebank - Germany	274

The impact of Aurora Wind Farm on birds migrating through or near the wind farm area has been assessed, regardless of the origin of the birds. Aurora Wind Farm does not constitute a barrier for seabirds migrating between foraging sites in Swedish and Polish Natura 2000 sites, see 7.3.4. Due to the large distances between the Aurora Wind Farm and the closest Natura 2000 areas in Denmark, Germany and Poland, no transboundary effects on these areas are expected to occur during the construction, operation or decommissioning phase of the wind farm.

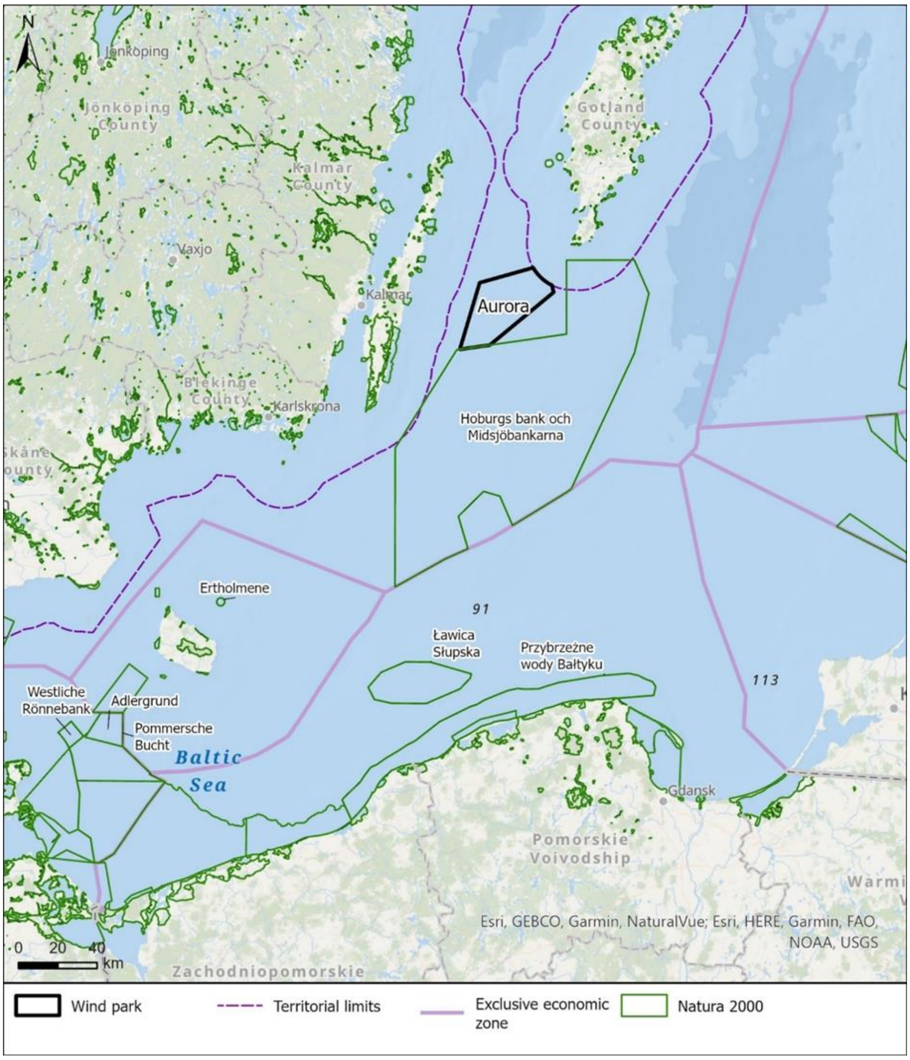

Figure 30. Natura 2000 sites. © [Lantmäteriet] 2021, [Documentation: Swedish Environmental Protection Agency]0

3.3. Geological conditions and depth conditions

3.3.1. Depth conditions and bottom topography

This section describes the bottom conditions within the Aurora Wind Farm. Bottom conditions are limited to water depth and bottom topography, bottom substrate, sediment status and the deeper geology.

Depth data for the area covered by the planned wind farm has been taken from EMODnet and provides a good overview of the depth conditions within the area. The water depth in the area varies between 43 – 88 metres and the depth increases towards the northern and northwestern parts of the park (Figure 4). The average water depth within the wind farm is approximately 67 metres.

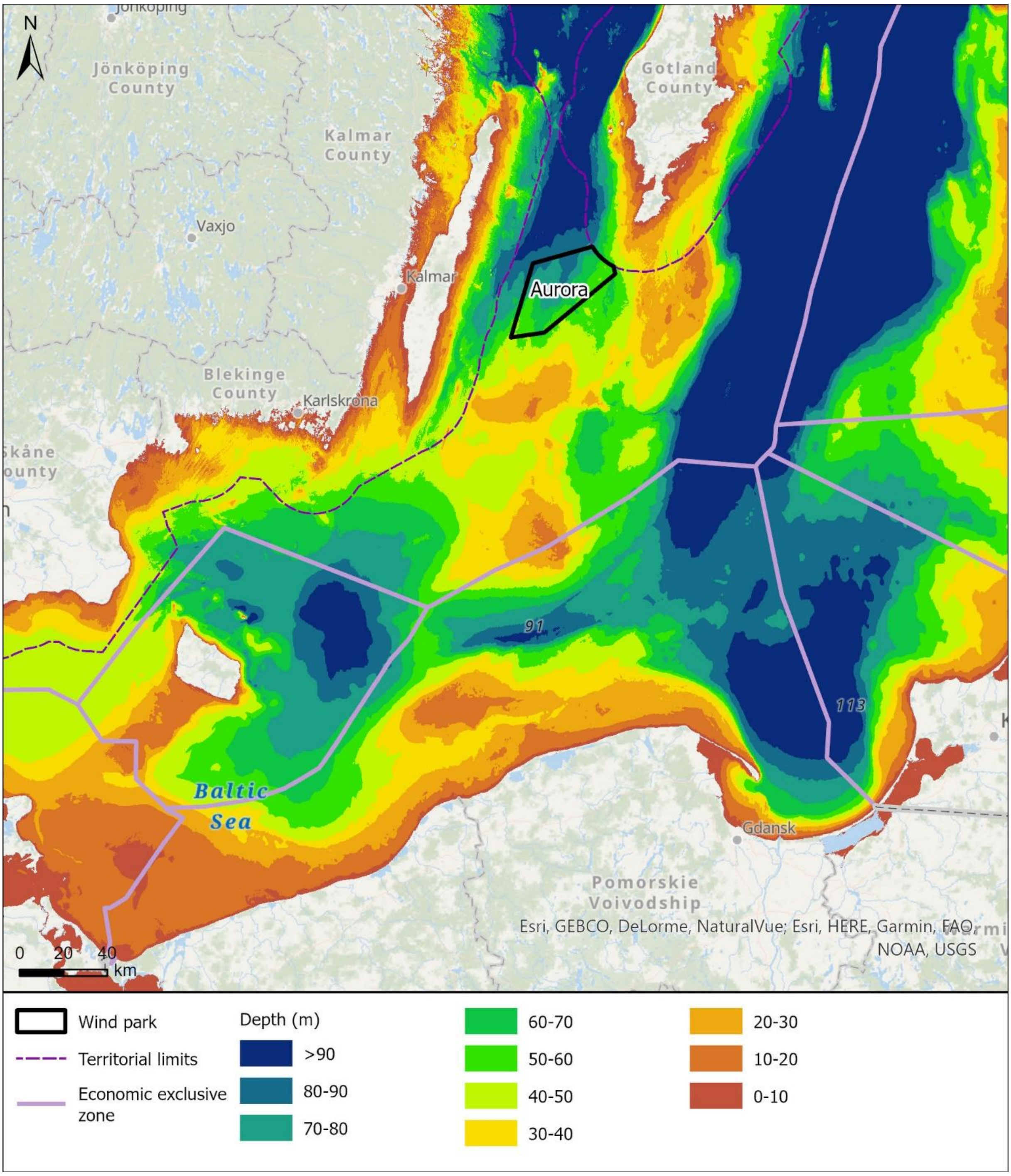

Figure 4. Map of depth conditions within the planned wind farm and in its vicinity. © [Lantmäteriet] 2021, [Documentation: EMODnet]

3.3.2. Bottom substrate

The bottom substrate within the wind farm is dominated by clay and a mixture of sand, coarse sand, pebbles and gravel, as well as clay and muddy sand (Figure 5). The deeper layers are dominated by post-glacial and glacial clay (SGU, 2023).

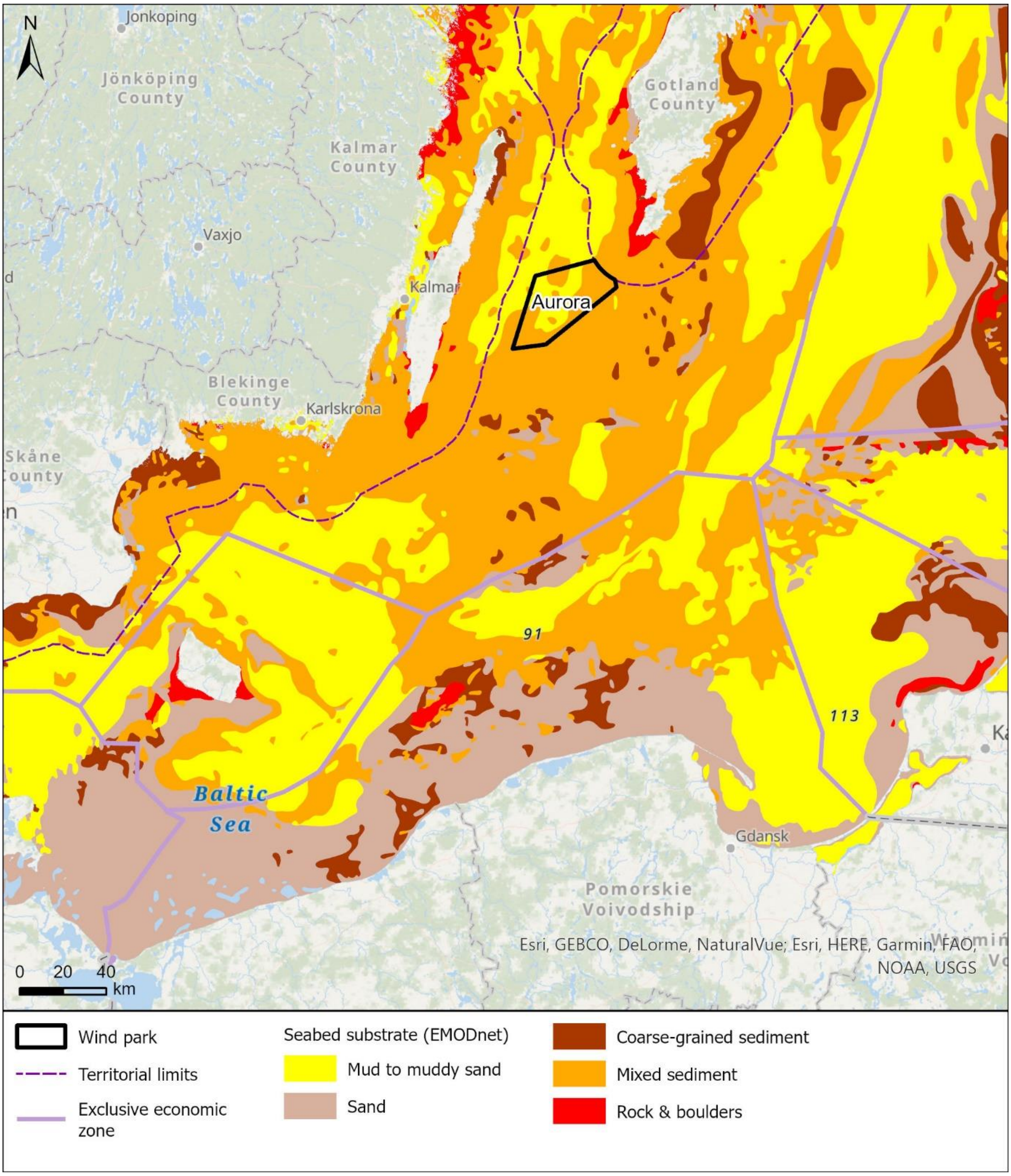

Figure 51. Map of the geology of the planned wind farm and its vicinity. © [Lantmäteriet] 2021, [Documentation: EMODnet]

3.3.3. Geology

Generally, for the wind farm, the top 0-6 metres below the seabed are expected to be mixed sediments, mainly clay, mud and muddy sand. This is followed by layers of quaternary deposits. Based on existing data, the quaternary deposits within the park include three different soil units consisting of clay and clay moraine of different compositions. The thickness of the quaternary deposits varies between 6–71 metres beneath the park area. In the northwestern part of the planned area, a west-east depression has been observed in the quaternary deposits, which may be filled with pre-quaternary deposits.

It has been noted that at least one gas pocket occurs within the Aurora Wind Farm. Shallow gas pockets are easy to identify using seismic data and will be mapped before the construction phase.

3.4. Hydrography and wind conditions

3.4.1. Currents

The overall long-term circulation in the Baltic Sea consists of an outward-directed flow of fresher surface waters, which originate from the rivers and streams that flow into the area, and a counter-directed inflow of saline deep waters from the Kattegat and Skagerrak. The rotation of the Earth affects the movement of water masses and causes currents to turn right in the northern hemisphere. This results in a large-scale slow coastal current in the surface water that moves south along the Swedish Baltic Sea coast. The magnitude of this current varies with the runoff to the Baltic Sea and therefore the season.

On shorter time scales, the current can vary widely, both spatially and in time. The narrow inlets to the Baltic Sea via the Great and Small Belt and the Sound, together with the limited size of the area, mean that the currents in the Baltic Sea are not affected by the tides. Instead, it is the wind; sea level variation (induced by wind and air pressure) and stratification that control the currents on the short term. Overall, current velocities are relatively low, compared to tides dominated areas, averaging less than 0.1 m/s with an annual maximum of about 0.4 m/s. In the part of the Baltic Sea referred to here, the current direction typically flows northward or southward for just over half the time. (ERA5, 2020)

The company has performed modelling of sediment dispersion and calculated the impact of the proposed wind farm on hydrographical conditions. The effect on both the currents and stratification in the area is expected to be negligible and not lead to any negative environmental impacts. As for the waves, the Aurora Wind Farm may lead to slightly reduced wave heights and energy content in the wave field in the lee of the park, but this is not expected to give rise to any negative environmental impacts.

3.4.2. Water levels and waves

Variations in the sea level in the Baltic Sea are controlled mainly by wind, air pressure, runoff from land, and inflow and outflow of water via the Danish straits. Tidal influences are considered insignificant (see section 3.8.1). Normally, the water level varies between +1.5 and -1.5 metres from the mean sea level. In extreme events such as severe storms, this variation could be exceeded. 3.4

The wave climate is dominated by waves from westerly and southwesterly directions, which also produce the largest waves. The average significant wave height is about 1,1 metres, with an annual maximum value of 6 metres. (ERA5, 2020)

3.4.3. Temperature

During the summer, the surface water in the Baltic Sea is warmed by solar radiation and heat exchange with the atmosphere, which gives rise to a thermocline layer. During autumn and winter, the water in the surface layer cools, causing the thermocline layer to weaken and eventually disappear, so that the water mass is well mixed down to the permanent halocline layer (see section

3.4.4). The thermocline prevents the mixing between surface water and deep water, which affects, for example, oxygen and nutrient concentrations (see section 3.4.5). Data from SMHI's measuring buoy BY38, located a few dozen kilometres north of the wind farm area (N 57.1167, O 17.6667), show that the average temperature for the years 2001–2015 was 7 °C from the surface to 30 metres of water depth, and 5 °C from 30 to 50 metres. The average temperature of the bottom water, at a depth greater than 50 metres, was about 5 °C. 00 (SMHI, 2021)

During 2020 and 2021, the company completed CTD measurements to produce vertical profiles of salinity, temperature and oxygen at a number of points within the planned wind farm. In summary, the measurements carried out show a seasonal variation in surface water temperature, while deep water temperatures are approximately constant. A shallower thermocline layer occurs during the summer with high temperatures in the surface. The rest of the year, the two water masses are separated by the permanent halocline layer.

3.4.4. Salinity

Salinity is determined by the largely continuous inflow of fresh water from land and the more episodic inflows of salt water from the Kattegat and Skagerrak. Data from SMHI's measuring buoy BY38 for the years 2001 - 2015 show that the salinity was an average of 7 PSU between the surface and 30 metres depth, and then increased to 10 PSU between 30 and 80 metres depth. For waters deeper than 80 metres, the average salinity was 10 PSU. This suggests a halocline between about 30 and 80 metres. In the same way as the thermocline, the halocline layer limits the mixing between surface water and deeper water. (SMHI, 2021)

The measurements in 2021 show much smaller variations in salinity profiles compared to the temperature profiles. The salinity of the well-mixed surface water is around 7 PSU in all months, and below this the salinity gradually increases to between 8 and 10 PSU. During all months, the halocline layer is found between 40 and 60 metres deep. In August, the thermocline layer causes the salinity to begin to increase slightly at a depth of 20 metres. Overall, the local measurements agree well with the average conditions observed at BY38.

3.4.5. Oxygen levels

Measurements made by SMHI in 2018 and 2019 show that oxygen conditions in the Baltic Sea have deteriorated, with both hypoxic and anoxic areas becoming more widespread. The Western Gotland Basin, next to which the planned Aurora Wind Farm is located, has long been characterized by both hypoxic and anoxic conditions. The mixing of the water column, which brings oxygen down from the surface water to the bottom water, is insufficient to replace the oxygen consumption in the deep water. Data from SMHI's measuring buoy BY38 for the years 2001–2015 show that the average oxygen content is 8 ml/l from the surface down to 30 metres depth and 0 ml/l from 30 to 80 metres deep. Below this depth, hydrogen sulfide occurs. (SMHI, 2021)

The measurements in 2021 in the wind farm area show a similar situation. Above the salt leap layer, the water is largely saturated with oxygen with concentrations between 7 and 8 mg/l. The oxygen levels then drop drastically through the salt leap layer below 40 metres depth down to zero or close to zero around 60 metres depth. In August, a local minimum of about 5 mg/l can be seen just below 20 metres, that is, in the temperature leap layer, with higher concentrations of between 5.5 and 7 mg/l below until the salt leap layer is reached just below 40 metres.

Results from measurements indicate that hypoxic and anoxic conditions in the water and on the bottom occur within Aurora Wind Farm. Anoxic conditions generally occur deeper than 65–70 metres, but also as shallow as at depths of 55 metres.

3.4.6. Visibility

In a survey conducted by SMHI at stations in the Western Gotland Basin in April 2021, it was determined that the visibility depth was 8 metres. The threshold value for visibility depth in the Western Gotland Sea is 8.4 metres. Visibility depth is a measure of transparency in lake and sea water and is mainly used to investigate eutrophication, as the presence of plankton and/or humic substances can be estimated (SMHI, 2021; Havs- och vattenmyndigheten, 2012). The depth of visibility in the Western Gotland Basin reaches the water quality requirements.

3.4.7. Wind conditions

In the wind farm, the average wind speed is estimated to be about 9.5 m/s, at an altitude of 100 metres above sea level. Winds are predominantly from the southwest, blowing from this direction about 42 percent of the time. (Muñoz-Sabater, 2019; Muñoz-Sabater, 2021)

4. Project overview

This chapter contains an overview of the project (the planned wind farm) and its main components, as well as the different phases of the project (construction, operation and decommissioning).

4.1. Components of the wind farm

The planned Aurora Wind Farm will have an installed capacity of approximately 5,500 MW and the wind farm will contain a maximum of 370 wind turbines, depending on the size of the individual wind turbines. The wind turbines will be anchored to foundations, which themselves may be anchored to the seabed in different ways and connected via an internal cable network to a number of transformer and/or converter stations. On the seabed around the foundations, erosion protection will be installed if necessary. In those parts of the operating area where the water depth exceeds 70 metres, floating foundations may be used. Export cables will then transfer the produced electricity from the respective transformer/inverter station to onshore connection points.

In addition to the turbines, one or more masts for meteorological measurements and buoys for wave and flow measurements may be built. Figure 6 presents a conceptual sketch of the different parts of an offshore wind farm.

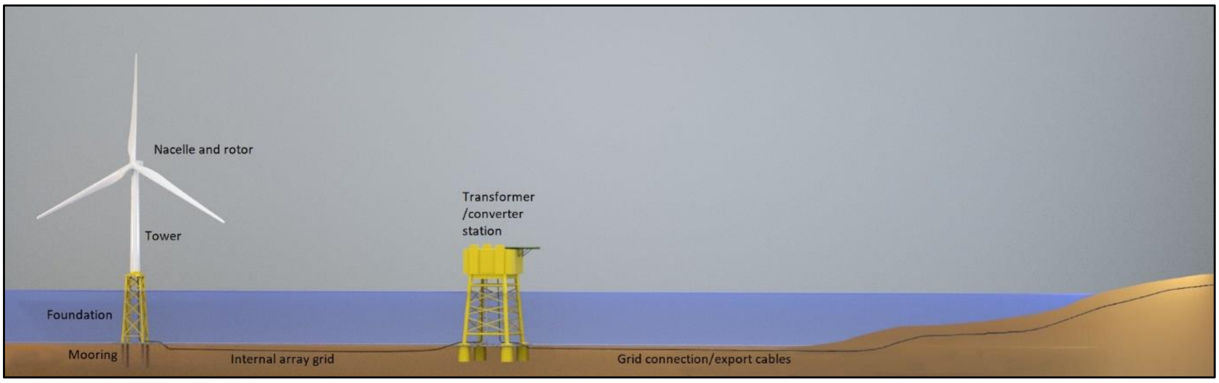

Figure 6. Conceptual sketch of an offshore wind farm.

4.2. Technology development in wind power

The offshore wind power industry is not a new industry but continues to be characterized by extensive technical development regarding wind turbine technology, foundation options and increased rotor size. This makes it difficult to predict exactly which technology will be available and what will be the best possible solution at the time the planned wind farm is built. In recent years, it has been possible to build wind turbines ever larger and thus more efficient, which is advantageous as it enables greater electricity production on the same area as before. Survey methods, the design and size of wind turbine foundations and installation techniques are also constantly being developed, streamlined and improved.

4.3. Scope and design

The permit process and the construction of an offshore wind farm takes a long time. Furthermore Swedish legislation requires various permits to be applied for from several different governmental bodies. At the same time, rapid and continuous technology development is taking place, which means that more cost- and environmentally efficient technology is gradually becoming available.

The design of the wind farm, including the placement of cables, transformer/converter stations, measuring masts and any other platforms and parts, will be adapted to the site's conditions regarding, among other things, wind, climate, waves, water currents, environmental considerations, and geotechnical properties. The company will therefore apply for a permit that provides flexibility in terms of location, design and choice of technology. The final design of the wind farm will be determined based on the technology available at the time of procurement and construction, as well as based on an optimization of electricity production. The size and number of wind turbines will result in different alternative layouts that will be evaluated based on wind conditions in the area.

Foundation technology is being continuously optimized, which presents new placement opportunities, as is the technology for the transmission of electric current to land. The design of the wind farm presented in this document should therefore be seen as an example, as available technology can be expected to change and develop before planned construction starts.

Basic information regarding the wind farm is presented in Table 5. The clearance between the water surface and the rotor tip will be at least 30 metres. The minimum distance between the wind turbines is about five rotor diametres.

Table 5. *Basic information about the wind farm.*

Basic information about Aurora Wind Farm	
Maximum number of wind turbines	370
Maximum overall height of wind turbine	370 metres
Maximum rotor diametre of wind turbine	340 metres
Expected minimum distance between wind turbines	5 x rotor diametres
Clearance between water surface and rotor tip	30 metres
Estimated cable length (internal cable network)	About 1 250 km
Maximum number of transformer platforms	9
Maximum number of connecting cables	14
Surface area of the wind farm	About 1 045 km^2
Water depth	43 – 88 metres
Estimated total effect	About 5 500 MW
Estimated yearly production of electricity	About 24 TWh

4.4. Wind turbine

Wind turbines capture the kinetic energy from wind and convert it into electrical power. The kinetic energy of the wind is transferred via blades to a shaft, which receives torque to drive a generator. The generator consists of a rotating part (rotor) and a stationary part (stator). Within the rotor there are permanent magnets (or a winding that generates a magnetic field when a current is passed through it). When the wind turbine initiates a movement in the rotor, the magnetic field is rotated, and when field this moves through the stator windings, currents are induced in these.

Two layouts with different number and size of wind turbines that may be constructed in the Aurora Wind Farm are shown in Table 6. The wind turbines that are likely to be chosen at the time of procurement and construction of the Aurora Wind Farm are expected to have a lifespan of about 40 - 45 years.

4.4.1. Components of the wind turbine

A wind turbine consists of three parts: a tower, a nacelle and rotor blades. Inside the tower is an elevator and ladder, so that the nacelle can be accessed, as well as electrical components. The main components within the nacelle are the gearbox, generator and yaw motors.

Table 6. Examples of dimensions for wind turbines with an output of 15 and 25 MW respectively and the number of turbines that may be relevant for each example model.

	Example 1	Example 2
Power per wind turbine (MW)	15	25
Number of wind turbines	370	220
Rotor diametre, D (m)	230	340
Total height, H (m)	260	370
Clearance[1], G (m)	30	30

[1]Height above water level is relative to mean sea level (MSL).

Liquid used within the turbine include transmission oil, coolant, hydraulic oils, lubricating oils and battery fluids and in addition, carbon dioxide or other gases included in the fire extinguishing equipment. In the components where oil/liquids are present, the systems are closed to prevent leakage. Should leakage occur, it is collected in designated collection trays that hold the entire potential volume of chemicals.

Some oils are replaced at intervals during the operation phase, depending on the operating hours of the wind turbine and the type of oil used. The waste grease generated in the lubrication process can be collected in special grease collection tanks and removed as part of maintenance work. The total amount of oil and liquids expected to be in a single wind turbine amounts to approximately 20 – 25 m^3.

4.4.2. Installation

A wind turbine is usually installed in parts, with several lifts, utilizing a crane vessel. The components of the wind turbine may either be transported on barges out to the wind farm and mounted on the foundations using an outrigger platform (Figure 7) or a floating crane vessel, or they may be transported out on the installation vessel itself. After installation of the tower, the nacelle is lifted and mounted, followed by the three rotor blades. This installation is weather dependent as it only can be performed during periods of good weather conditions. Solutions for installation are now being developed where turbines are built in a port, and then towed out to their final position on site.

Once the main wind turbine structure is installed, the components can then be connected to the internal wiring harness.

Figure 7. Installation of wind turbines using a jack-up vessel. Source: COWI

4.4.3. Marking of wind turbines

Wind turbines and measuring masts will be marked for aviation and shipping in accordance with current regulations and regulations at the time of construction.

4.4.4. Measurement of meteorological parametres

One or more measuring masts may be installed to supplement available wind data from the area, and to form the basis for detailed design and selection of turbines and layout. A measuring mast usually has a height that corresponds to the hub height of the wind turbines and is installed in the same way as a wind turbine, with a foundation anchored to the bottom. However, the foundation of a measuring mast is significantly smaller than the foundation of a wind turbine.

One technology that is developing rapidly and that has the potential to replace measuring masts is LiDAR (Light Detection and Ranging). Lidar technology uses lasers to measure wind speed above sea level and thus does not require a mast. The equipment can be placed either on a bottom-anchored foundation or on a floating platform.

4.5. Foundation

The choice of foundation depends on a number of different factors: water depth, geology, wind and wave conditions, as well as environmental considerations and costs. Since both water depth and geological conditions vary within the planned wind farm, different types of bottom-fixed or floating foundations may be selected.

Bottom-fixed foundations are anchored to, or stabilized on, the seabed either by piling, negative pressure applied to suction buckets, or by means of gravity in the case of gravity foundations. Technological development has meant that bottom-fixed foundations can be built in ever deeper water. Examples of different types of solid foundations are presented in Figure 8.

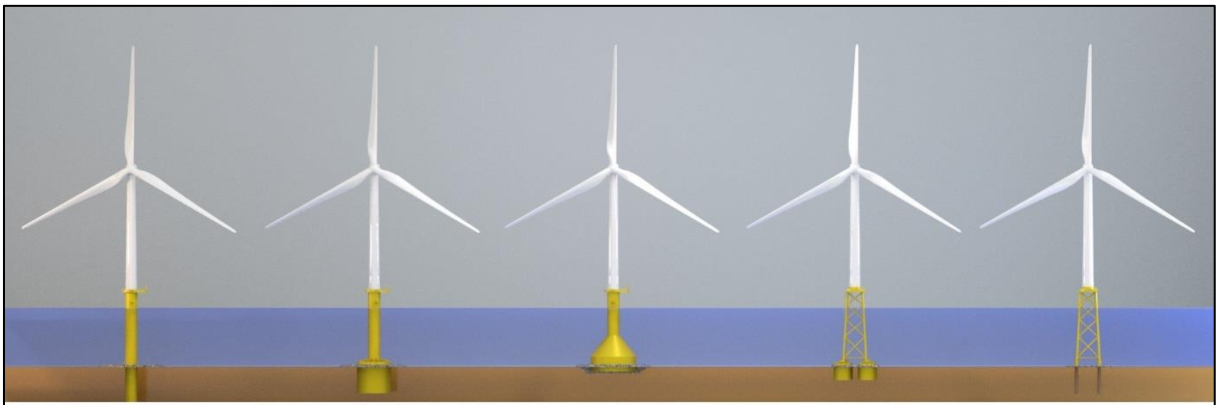

Figure 8. Examples of different bottom-fixed foundations.

An alternative to the currently used bottom-fixed foundation types is a floating foundation solution, which is emerging as an alternative for areas with a greater water depth (deeper than 60 - 70 metres). The technology is applied in the oil and gas industry, where floating foundations have been used to access oil reservoirs in deep water. Floating foundations can mainly be divided into four different concepts: barge foundation, semi-submersible foundation, savings foundation and TLP (tension-leg platform).

Several different types of foundations may be used within the planned wind farm. Based on the geological conditions at the site and the technology available today, the following foundations are considered to be relevant for the Aurora Wind Farm: monopile foundations, truss foundations with piles and floating foundations. The two basic types of solid foundations can also be combined as different hybrid solutions, such as foundations called tripods. The bottom area used from any hybrid foundations is the same as for truss foundations.

4.6. Erosion protection

In connection with the anchorage points of the solid foundations and floating foundations, erosion protection is usually installed to prevent the undermining and excavation of the seabed around the foundations.

4.7. Internal cable networks and connection to shore

Offshore transformer and converter stations will be installed in the operating area. An internal cable network will connect the wind turbines in groups, which will then be connected to one of these stations. Normally, wind turbines are connected in radials (i.e. in series), but other configurations may also be appropriate.

An internal cable network for floating foundations consists of two types of cable, dynamic and static cable, where the dynamic cable is a loosely hanging part of the cable between the floating foundation and the seabed. This allows for movement between the floating foundation and the seabed.

Substations will consist of one or more foundations and a superstructure. The available foundation types for the platform are the same as for the wind turbines. The superstructure will be manufactured on land, and contains electrical and other necessary equipment.

The final number, design and location of the substations will be determined during the detailed design of the wind farm and will be based on the best available technology for power transmission, the size and number of wind turbines, the bottom conditions and the optimal routing of cables.

When the generated electricity has been transformed and possibly redirected, it is transmitted via one or more connecting cables to an onshore connection point. The number and design of the cables depend, among other things, on the technology (HVAC - high voltage alternating current) used, as well as on the voltage level. A study is underway to investigate various possibilities for the final grid connection. Due to the size of the wind farm, several different connection points will be required.

4.8. Phases of operations

The life span of the wind farm can be described by four different phases. The project is currently in the permitting phase, which will be followed by the construction phase, the operational phase and finally the decommissioning phase. This section outlines the activities in these different phases.

4.8.1. Construction phase

The construction phase includes the detailed design, manufacturing and installation of the wind farm. During this phase, surveys will be needed, for example to determine the best foundations for the construction of the wind farm.

In the detailed design stage, a final design of the park is developed. The components are adapted based on technical requirements and site-specific conditions such as geology, hydrology and weather conditions, and are dimensioned to withstand extreme drops for temperature, wind speeds, wave height and more according to current standards. Consideration will also be given to future climate change, in particular regarding changes in sea level, temperature, and wind speeds, accounting for both average conditions and extreme events. The final design should also ensure a minimal environmental impact.

Surveys

During the detailed design and installation of the wind farm, surveys of the park area will be carried out. The purpose of these studies is to obtain information needed for detailed design, final construction documentation and the inspections of construction.

The typical survey methods that may be used are:

- Geophysical surveys to map bottom conditions, which may include sidescan sonar (SSS), multibeam echo sounder (MBES, multibeam sonar that maps the ocean floor), and seismic surveys (2D, 3D).

- Geotechnical investigations involving geotechnical drilling and sediment investigations (e.g., by tip pressure probing and vibrocores).

- Magnetometry used to examine the bottom for primarily artificial objects such as wrecks, dumped objects and left unexploded ordnance (UXO).

- Wave measurement that involves placing a buoy to get high-resolution information about wave and current conditions on the site. Wind measurement may also be relevant.

- Environmental sampling, for example for bottom sediments.

- Filming, for example with the help of a so-called remotely operated underwater vehicle, ROV (Remotely Operated underwater Vehicle).

Installation

Once the final design of the wind farm is complete and components have been procured and manufactured, installation of the wind farm can begin.

The installation of an offshore wind farm is usually carried out seasonally and is to some extent dependent on weather conditions (generally speaking, work at sea during the winter period is avoided as far as possible). Different components may be installed in different seasons, for example, foundations and cables can be installed in one season and wind turbines in another season.

A common order of installation at sea is to first install the foundations, substations and connecting cables, followed by the internal cabled. Finally, all wind turbines are assembled, with tower, nacelle and blades. Once the wind turbines are fully installed, commissioning and test runs take place, before the turbines are handed over to the operating organization.

The installation of land cables normally starts before offshore work. This is not as weather-driven as the installations at sea. The entire system should be ready when the wind turbines are installed so that they can be utilized. Installation activities normally take place in parallel with each other.

During the installation of the wind farm, several installation vessels and work platforms of various types will operate in the area, for both the installation of components and for transport of components to and from the area. In addition, a number of smaller service vessels will also be operating. It is likely that several installation steps will take place in parallel with each other, but in different parts of the project area.

4.8.2. Operational phase

During the operational phase, regular supervision and maintenance of the wind farm will take place. The wind turbines are expected to be in operation for up to 45 years.

Service and maintenance

Both wind turbines and substations are remotely monitored and are unmanned during normal operation. However, continuous maintenance of the wind farm takes place, which requires personnel and materials to be transported to the wind farm by smaller service boats, ships or helicopters.

Replacement of major components

During the lifespan of the park, larger components may need to be replaced, such as gearboxes and rotor blades on single or multiple turbines. Major maintenance operations may require support leg vessels. At substations, replacement of equipment may also need to occur.

4.8.3. Decommissioning phase

When the wind farm has reached the end of its lifetime, it will be decommissioned by dismantling the wind turbines, foundations and substations, and restoring the site to an extent according to the decommissioning plan. Approximately two years before dismantling, the decommissioning plan will be developed with the aim of minimizing the impact on the environment and ensuring that the area will be safe for ships and other future use.

According to the current state of knowledge, the decommissioning sequence is generally the reverse of the installation sequence. For example, decommissioning can take place by dismantling wind turbines and transformer stations using a crane vessel. Foundations with piles can be cut off just below the seabed, and then lifted from the site. For structures under the seabed (parts of foundations and cables) and erosion protection, the assessment is made in consultation with the relevant authorities closer to the time of decommissioning as to whether the environmental damage caused by removing the structures is higher than the environmental benefit. Components will be recycled to the greatest extent possible. According to current expectations, the decommissioning will take approximately one to two years.

The method of decommissioning will be in accordance with industry practice and in accordance with the legislation in force at the time of decommissioning. However, as technology and knowledge change rapidly (and the lifespan of a wind farm is up to 45 years), it is uncertain exactly how decommissioning will take place and exactly which parts will be dismantled in the end.

4.9. Preliminary timetable for the construction works

An overall timetable describing the principles of the construction work for the wind farm is shown in Figure 9. To provide an overview, planning and procurement are also described in the timetable. The schedule shows the duration of the construction work and when the different parts of construction work are planned in relation to each other. The wind farm will be expanded gradually over a period of several years.

The construction phase, which includes detailed design of the wind farm design, foundation design, selection of wind turbines, cables and platform, as well as procurement with associated lead times for the technical components, will last for several years. Each step until the actual installation (construction phase) can begin, is extensive and takes, individually, several years, not least due to long lead times. The actual installation of the wind turbines is the step during the construction phase that takes the shortest time. The construction phase, until the wind farm is fully commissioned, is estimated to total approximately 15 years.

Installation of a monopile foundation usually takes one to two days, where the piling itself usually takes about six hours per foundation. The additional time is needed for the repositioning and moving of vessels, any protective measures and preparations for lifting the piles. The effective piling time of monopiles within the wind farm, calculated on 370 wind turbines, amounts to about 90 days, while the total installation of foundations lasts for about 1 to 2 years, partly depending on the season during which the installation takes place, as well as how much drilling is required. Installation work at sea requires margins as the weather can be erratic and it is important to maintain a safe working environment.

Installation of a truss foundation usually takes two to three days, where the piling itself usually takes about three to seven hours per pile. Each foundation has either three or four legs. Similar to above, the additional time includes repositioning and moving of vessels, as well as any protective measures and preparations for lifting the piles. The effective piling time for the wind farm, calculated on 370 wind turbines, is expected to be just over 14 months, while the installation of foundations can last for about 3 years, depending on the season of installation.

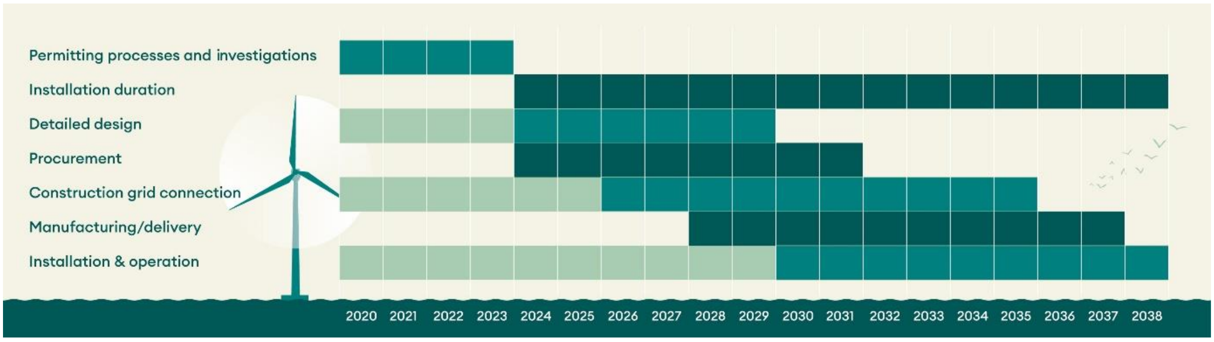

Figure 9. Preliminary time plan for Aurora Wind Farm.

5. Prerequisites and methodology for impact assessments

This chapter describes the conditions on which the impact assessments are based, as well as the methodology used in the assessments.

5.1. Basis and methods for describing prevailing conditions

The description of the current conditions has been based on information and results obtained from various project-specific surveys, measurements, inventories, investigations, modelling and calculations, which have considered porpoises, sediments, sounds, birds, bats and fish, as listed in Table 7.

Existing data from various inventories and mappings, scientific literature, research results, environmental reports, technical reports and knowledge and information from various authorities have also been taken into account.

Table 7. The investigations, inventories, modelling and studies carried out specifically for the Aurora Wind Farm and which formed the basis for the environmental impact assessment.

Report	Conducted	Method	Author
Modelling of sediment dispersion	November 2021	Modelling	NIRAS, 2021
Report of sediment dispersion, Aurora Wind Farm version 2	June 2023	Modelling	NIRAS and AFRY, 2023
Commercial fishing in the western Gotland Sea	2021	Literature review, existing data	AquaBiota, 2021
Report regarding birds Aurora Wind Farm	2022, 2023	Existing data and documentation from carried out inventories	Ottvall Consulting AB, Structor, DHI, AFRY 2022
Inventories of birds	2021-2023, see section 7.3.	Flight inventory with observer, boat inventory and radar	Ottvall Consulting AB, 2021, 2022, 2023
Inventories of bats	Spring and autumn 2022	Inventory from boat	Ottvall Consulting AB, 2022
Modelling of underwater noise	2021–2022	Modelling	NIRAS, 2021
Calculation of noise from wind power	2022	Nord2000	OX2, 2022
Investigation of shading effect	2022	WindPRO	OX2, 2022
Oxygen content, salinity and temperature	2020–2023	CTD-measurements	AquaBiota, 2023
Inventory of porpoises	2020, 2021, 2022, 2023 and ongoing	Acoustic porpoise detectors, F-pods	AquaBiota, 2023
Baltic Sea porpoises and offshore wind power	2021–2022		AquaBiota och NIRAS, 2022
Nature types in the Natura 2000 sites Hoburgs bank and Midsjöbankarna	2021–2022	Literature review, existing data	AquaBiota, 2022
Inventory of fish and marine mammals	August 2020 and March, June, September 2021	eDNA inventory, fish trawl survey, existing data	AquaBiota, 2022
Analysis of cultural heritage	April 2022, 2023	Existing data and documentation from investigations carried out	Museiarkeologi Sydost, 2022, AFRY 2023

Shadows and airborne sound	October 2021	Modelling	OX2, 2021
Visual effect and photomontage	September 2021, 2023	Photomontage	Norconsult, 2021, GisVis 2023
Investigation of contaminates in sediment and grain size	2023	Sediment sampling	NIRAS and AquaBiota, 2023
Benthic and hydrographic surveys within Aurora Wind Farm	2022	Video recording, grab sampling and CTD-measurements	AquaBiota, 2023
Safety distances and traffic distribution	2023	Analysis of AIS data, modelling and calculations based on this data	SWECO, 2023
Risk calculations	2023	Calculations based on AIS data, and risk assessment according to accepted standard	SWECO, 2023
Safety distance analysis for the Aurora Wind Farm	2023	Calculations based on AIS data	Marico Marine, 2023
HAZID workshop	2021	Risk identification by risk experts and experienced nauticals, according to accepted standards	SSPA, 2021
Flight obstacle analysis	2021	According to the standard developed by the Swedish Civil Aviation Administration	Air Navigation Services of Sweden, 2021

The overall knowledge base, as mentioned above, is of such scope that reliable, robust and scientifically substantiated descriptions of current conditions, as well as assessments of the effects and consequences of the planned activities, can be made.

Results from inventories and modelling of for example, seabirds, porpoises, habitats, and fish are consistent with results from previous inventories, as well as the data collected and analysed from authorities and scientific literature. Each background report describes in more detail the methods on which descriptions of current conditions and impact assessments are based.

5.2. Methodology for impact assessments

A systematic approach has been used to identify and assess the potential transboundary effects, effects and consequences of the planned activities on various environmental aspects and to describe protective measures to avoid, minimize or reduce local as well as transboundary effects. The methodology below is used for the activities applied for that are included in the present assessment, for the follow-up activities the impact assessment is made more overview.

In the impact assessment, the natural worth and sensitivity of the environmental aspect that is assessed are weighed together with the transboundary impacts and effects of the planned activities in order to ultimately provide a coherence. The impact assessment takes place in three stages: impact, effect and consequence. In the environmental impact assessment, the terms sensitivity, impact, effect and consequence are used.

- **Sensitivity** – the sensitivity of the receiver of the current impact. In the impact assessment, sensitivity is important for the overall magnitude of the impact, as further described below. The sensitivity or value of an environmental aspect is described based on the area's existing conditions and can be carried out by objects and/or areas as well as connections within or between these. Sensitivity depends, among other things, on properties such as size, robustness and connection to the environment.

- **Impact** – is the change in physical conditions that the implementation of the project entails. This may involve, for example, noise, emissions of pollutants, loss of valuable natural environments, increased number of transports in the area and so on. The impact can be local, regional or national and be permanent or temporary.

- **Effect** – describes the significance that the impact (change) is estimated to have for existing values in the environment, i.e. the magnitude and extent of the impact. Direct effects occur as an immediate consequence of, for example, physical intrusion, noise or impact on water. Indirect effects arise secondarily as a result of an action.

  The effect(s) that arise as a result of an impact must be related to the specific conditions of the area, i.e. natural worth, and it’s sensitivity. Thus, in an area with low natural worth, the effects can be expected to be smaller, while the effects in an area with high natural worth or if the sensitivity of the area is high, are expected to be greater. The valuation of the effect is made with regard to relevant regulations, such as the Environmental Code's, guidelines or limit values and applicable environmental quality standards.

- **Consequence** – is an evaluation of what the environmental effects mean for the interests involved, such as the climate, human health or biodiversity. When evaluating the consequences, the assessment is based on how many people are affected, the significance of the environmental value and how large the change is expected to be. When evaluating environmental impacts, the assessment is made against a comparison alternative, a so-called non-action alternative. The non-action alternative describes the expected future development if the measures applied for are not implemented.

Initially, a delimitation of impact is made; what kind of transboundary impact can the activity entail and what kind of impact is particularly important with regard to the area and the values that occur there. In order to make the overall assessment of effects and consequences, an assessment of the recipient's sensitivity is made. Thereafter, the degree of impact and effect on the recipient that is assumed to arise as a result of the operation is assessed. The assessment of the environmental impact for each value/recipient is made by weighing the sensitivity of the recipient and the extent of the impact and effect. Based on this, it is finally assessed what consequences, if any, the operation may entail and if/how these affect the interests and values identified. The following sections describe each step of the impact assessment in more detail.

5.2.1. Magnitude and scope of impact (effect)

The effect is an assessment of the magnitude and scope of the impact (Table 8) and is assessed based on: geographical distribution, duration in time, magnitude of the impact and the probability of the impact occurring. Impacts are evaluated for relevant impact during the different phases of the planned activity according to the following scale: none/insignificant, small, moderate or large. The impact is indicated as positive or negative.

Table 8. Description of levels of impact for the recipient.

Magnitude and magnitude of impact (effect)	Description
None/negligible	Impacts do not cause effects, or only give rise to small effects that are of limited distribution, less complex and of short duration.
Minor	Impacts give rise to effects of some extent, complexity and duration.
Moderate	Impacts give rise to effects of either a relatively large magnitude or that are long-lasting (for example, effects that are lasting throughout the lifetime of the wind farm).
Large	The effects give rise to effects of a large magnitude or effects that are long-lasting and occur frequently.

5.2.2. Impact assessment

For the impact assessment of the project, the sensitivity of the recipient is weighed together with the magnitude and extent of the impact (effect), resulting in a assessment of the impact. The significance of the consequence is assessed according to the scale; none/negligible, very small, small, moderate, large or very large and the consequences can be either positive or negative, see Table 9.

It should be noted that the assessment scales do not provide a precise template for assessment. In each case, a more detailed assessment is made of the specific circumstances and the type of impact being assessed. In order to make an evaluation assessment as objective as possible, it is important to report for each environmental aspect on what grounds the impact has been justified/evaluated.

Table 9. Description of levels of impact significance for the recipient.

Importance of effect	Description
None/ negligible	None or negligible effect for the recipient. No/minor disturbance to surfaces and/or functions/populations.
Very small	Slight effect for the recipient. Very small areas and/or functions and/or very small part of the population are disturbed. Without irreversible impact.
Small	Little effect for the recipient. Small areas and/or functions and/or a small part of the population are disturbed, with no irreversible impact.
Moderate	Moderate effect for the recipient. Surface, structures and/or functions and/or part of the population are damaged. May cause local irreversible effects, such as loss of conservation values. effect that may require protective measures.
Large	Large effect for the recipient. A large surface area, large part of structures and/or services and/or large part of the population is significantly damaged, with the potential to cause significant irreversible impact. The effect are classified as serious, which means that changes in operations or the application of protective measures should be considered to minimize the impact.
Very large	Very big effect for the recipient. The effects are classified as very serious, which means that changes in operations or application of protective measures should be implemented to reduce the impact.

Table 10. presents the overall scale for sensitivity and value as well as effect and the overall effect that is expected to occur for each aspect.

Table 10. Evaluation matrix of levels of impacts.

		Effect (magnitude and magnitude)						
	Impact	Very negative	Moderately negative	Small negative	Insignificant	Small positive	Moderately positive	Very positive
Sensitivity and value of recipient	Small	Moderate	Small	Very small	Negligible	Very small positive	Small positive	Moderately positive
	Moderate	Large	Moderate	Small	Negligible	Small positive	Moderately positive	Large
	Large	Very large	Large	Moderate	Negligible	Moderately positive	Large	Very positive

The assessment methodology has not been fully followed for the environmental aspects Risk and Safety.

5.3. Prerequisites for impact assessments

This section describes the conditions on which the impact assessments for identified beneficiaries are based.

5.4. Worst-case assessments

The technical development of, among other things, foundations and wind turbines is very rapid and it is not possible to determine at the time of drawing up this document which technical solution for manufacturing, installation, environmental impact and production, will be most suitable when the wind farm is to be built. For this reason, the environmental impact that the operation can potentially cause is described based on a worst-case scenario. The worst-case approach means that the final environmental impact of the facility can never be more extensive than described in this environmental impact assessment. The approach makes it possible to assess what protective measures and considerations are needed to protect the environment.

The company has produced two representative examples of how the planned wind farm may be designed. These examples are based on wind turbines with an output of 15 MW (based on 370 wind turbines) and 25 MW (based on 220 wind turbines). With increased power per turbine, the rotor diametre usually also increases. This results in an increased total height and a greater distance between the wind turbines. The power of the wind turbines is used to get a realistic size of future wind turbines. A challenge with the method used with representative examples of how the planned wind farm may be designed, is that both example designs lead to different effects for different influencing factors. The design and thus the impact of a future wind farm can fall between these examples. It may also mean that some impact together may be greater than in the example designs, for example, the turbine size may allow for a number of wind turbines that are in the middle of the range for the numbers in the example designs, but that selected foundations in this alternative may mean that the sediment spread that occurs may be higher than in any of the example designs. Hence, two example designs do not necessarily describe a worst-case scenario. In order not to underestimate the impact and at the same time design relevant conditions for the operation, the maximum impact has therefore been assessed through a combination of the above-mentioned designs. By applying the largest wind turbine to the example design that has the largest number of turbines (i.e., 370 wind turbines with a 340 metre rotor and a total height of 370 metres), the foundation for what constitutes a worst case scenario has been laid. In addition, for each impact, a worst-case scenario is defined based on the presented technology. The assessments are based on assumptions about a maximum design scenario that considers by a significant margin what could be the greatest impact on the environment.

In practice, however, this is not a realistic scenario as it would be both economically unprofitable and inefficient to construct the planned wind farm in such a way, but it also means that the assessed environmental impact is based on very conservative assumptions and the actual environmental impact is likely to be much smaller.

Table 11. shows which worst case scenario the assessments are based on in terms of impact on identified potential recipients. The description and delimitation of influencing factors is given in Chapter 6.0

Table 11.. Worst-case assumptions used in modelling/calculations for each impact linked to identified recipients.

Impact	Worst-case	Recipient
Sediment dispersion	Installation of monopile foundation of 14.3 metres in diametre. All monopile foundations are installed, in the worst-case scenario that formed the basis for the modeling, by drilling. Monopile foundations are drilled down to their maximum anchoring depth and sediment is released 2 metres above the seabed. When laying down internal cable networks and connecting cables, the assessments assume that the cables are placed via flushing, as flushing is the method that causes the greatest sediment suspension.	Benthic flora and fauna, fish, marine mammals
Sedimentation	The same as for "Sediment dispersion".	Benthic flora and fauna
Environmental contaminants and nutrients	The same as for "Sediment dispersion". The assumption is that any contaminant that can dissolve in water does so.	Benthic flora and fauna, fish, marine mammals
Underwater noise	Worst case scenario for porpoises and seals: Installation of truss foundations (with pinpiles), 4.5 metres in diametre, by piling, in March when sound propagation is greatest. The use of sound-absorbing measures corresponding to double bubble curtains and soft start-up are prerequisites for the modeling. Worst case scenario for fish: Installation of monopile foundations with 14.3 metres in diametre by piling, in March when sound propagation is greatest. The use of double bubble curtain, hydro sound damper and soft start-up are prerequisites for the modeling.	Marine mammals, fish
Airborne noise	Maximum number of wind turbines (370) with the largest rotor (340 metres in diametre) and with the highest total height (370 metres).	Marine mammals

Electromagnetic fields	Internal cable harness (dynamic cables, 1,200 A): 1,370 μT and 1,125 μT around the outer jacket of the cable for single armour. Below 0,4 μT at 7,6 metre from the centre of the cable for single armour. Other cables, internal cable harnesses and connecting cables (both alternating and direct current) are buried or covered and emit below 40 μT at the seabed.	Marine mammals, fish, benthic fauna
Shadows	Maximum number of wind turbines (370) with the largest rotor (340 metres in diametre) and with the highest total height (370 metres).	Marine mammals, fish
Displacement effects	Maximum number of wind turbines (370) with the largest rotor (340 metres in diametre) and with the highest total height (370 metres). Minimum possible distance (1,150 metres) between wind turbines.	Birds
Barrier effects	Maximum number of wind turbines (370) with the largest rotor (340 metres in diametre) and with the highest total height (370 metres). Minimum possible distance (1,150 metres) between wind turbines.	Birds
Collisions	Maximum number of wind turbines (370) with the largest rotor (340 metres in diametre) and with the highest total height (370 metres). Minimum possible distance (1,150 metres) between wind turbines.	Birds, bats
Emissions to water	For emissions to water, it is not possible to define a worst-case scenario. This is because such a scenario would be based on numerous assumptions, so would be very speculative.	Bottom flora and fauna, fish, marine mammals, birds
Nautical risks	Maximum number of wind turbines (370) with the largest rotor (340 metres in diametre) and with the highest total height (370 metres).	Shipping
Climate	The wind farm not being built, so not contributing to meeting goals for the reduction of climate change.	Bottom flora and fauna, fish, marine mammals, birds

5.4.1. Protective measures

As a prerequisite for the project, protective measures will be taken to reduce impacts and thereby the effects and consequences of the planned wind farm. The protective measures are described in chapter 9 and were included in the impact assessments. Planned protective measures include:

- Geophysical surveys using the methods of side-scanning sonar and multi-beam sonar will be used in frequencies exceeding 200 kHz to be outside the porpoise's hearing range.

- When conducting investigations with seismic equipment, protective measures are applied through soft-start, passive acoustic monitoring and observers.

- Techniques that reduce sound scattering such as double bubble curtain and Hydro Sound Damper (HSD) or equivalent will be used when piling (HSD is not used when piling truss foundations due to technical limitations).

- Piling should begin with soft-start, after which the strength of the hammer blows is gradually stepped up. Acoustic methods should also be used to deter fish and marine mammals before the soft-start and ramp-up period begins.

- The clearance between the water surface and the rotor blades has been set at 30 metres, which is important for the area's seabirds and any migrating bats. Most seabirds in the area fly low, which means that a higher clearance means a lower risk of collision. Migratory bats have been observed flying in open water at low altitude (<10 metres).

- Marking of the wind farm takes place in accordance with current guidelines.

- The extent of the wind farm must be clearly shown on nautical charts.

In addition to the protective measures briefly described above, protective measures resulting from the impact assessments will also be taken in the context of planned activities. These are presented, together with the above, in section 0.

5.4.2. Cumulative effects

Cumulative effects are assessed where there is a risk that the impact of the Aurora Wind Farm may sum with the impact of other existing and approved projects. When assessing cumulative effects, projects or other activities that have the potential to have an impact during the construction, operation or decommissioning phase of the operation have been included.

5.5. Uncertainties in the assessment

As previously stated, the present environmental impact assessment is based on information from authorities, scientific literature, environmental and technical reports, surveys, modelling of impacts, as well as calculations and modelling of sediment and sound distribution. Calculations and modelling are based on estimates which represent a worst-case scenario. The assessed environmental impact is based on conservative assumptions, so that the environmental impact is not underestimated; the environmental impact will be of lesser magnitude, but not more extensive than described.

6. Impacts

This chapter describes the impacts that the planned activities may give rise to, and whether they may be considered as transboundary impacts.

Only selected impacts have been assessed based on if they are directly or indirectly related to offshore wind farms, and whether they may lead to transboundary effects.

The identified impacts are as follows:

- Dispersion of suspended sediments and sedimentation
- Pollutant and nutrient release
- Underwater noise
- Displacement (birds)
- Barrier (birds)
- Collisions (birds)
- Electromagnetic fields

6.1. Sediment dispersion and sedimentation

During the construction phase, and also to a more limited extent the decommissioning phase, the planned operations will produce a slurry of consolidated bottom substrate (when drilling and/or piling through solid material) and re-suspension of bottom sediments (by disturbing the loose bottom sediments). Resuspension means that small particles of organic and inorganic material that had previously settled on the seabed are stirred up and brought in suspension in the water column. During the operational phase, only very limited sediment resuspension is expected to occur, for example in the event of any reparations on the bottom cables.

During the construction phase, the installation of foundations, erosion protection and bottom laid cables (the internal cable harness) will cause the suspension of sediments. The anchoring of floating foundations and the submergence of anchor lines is controlled, so only causes limited sediment suspension. During the construction phase, geotechnical investigations will be carried out, including exploratory drilling and peak pressure probing, which may give rise to a small and extremely local sediment suspension. The amount of suspended matter in the water column can affect fish, resulting in behavioral changes. Bottom fauna, such as filter feeders, can also be affected by high suspended solids and/or long exposure times, which can clog their filtration mechanisms. The sensitivity of fish and benthic organisms, and the extent to which they are affected by suspended sediment, varies between species.

6.2. Environmental contaminants and nutrients

During the construction phase, environmental contaminants and nutrients bound in the bottom sediments may be released and spread during drilling and/or piling activities. The bottoms where the substrates consist of clay and silt, constitute so-called accumulation bottoms, where the material that settles remains lying. Most environmental toxins and nutrients (both organic and inorganic) are bound to sediment particles and organic matter, so accumulate on the seabed during deposition. As long as the seabed remains undisturbed, the sediment particles, including any bound environmental toxins and nutrients, remain on the seafloor. Since sedimentation occurs more or less continuously, settled environmental toxins and build up gradually.

Pollutant emissions to the sea have occurred over a long period, from sources including coastal industries, ports, and from fluvial contamination from urban and agricultural areas lying upstream. All superficial sediments in the open sea near to Sweden's coast contain environmental toxins and nutrients, but the concentrations vary depending on the area. Higher levels of environmental toxins are more common closer to the coast than further offshore.

When sediments are resuspended during the construction and decommissioning phases, contaminants and nutrients bound in the bottom sediments could potentially spread into the water column or with the sediments, negatively affecting marine organisms. Environmental toxins and nutrients accumulate in thin layers. Any dispersal of pollutants or nutrients will follow dispersal of sediment particles and thus the influence are is limited to the area where the physical disturbance of the bottom occurs.

In the water column, there is normally a natural mixing of water due to continuous currents. Depending on whether there is a strong cline present, mixing may sometimes be limited to only a defined part of the water column. The natural mixing means that there is a rapid dilution of any environmental toxins and nutrients within the water column.

Due to the large water depth and the great distances to the surrounding Danish, German and Polish water areas, environmental contaminates are not expected to spread and cause transboundary effects in connection with the different phases of the project. This has been confirmed through sediment dispersion modelling. However, the spread of environmental contaminates and pollutants can potentially affect marine mammals and fish, of which the consequences of environmental toxins and nutrients are assessed for relevant aspects in Chapter 7.0

6.3. Underwater noise

Subsea noise refers to anthropogenic (human) generated sound, and may occur during the construction, operational and decommissioning phases of the project. It is mainly during the construction phase, during geophysical investigations of the seabed, and during the construction of the wind farm's foundations, that impulsive underwater noise might be generated.

Underwater sounds, mainly impulsive sounds, can affect marine mammals and fish by causing various behavioral changes, or by causing temporary hearing loss (temporary threshold shift, TTS) or permanent hearing loss (permanent threshold shift, PTS). Various behavioural changes in marine mammals and fish can also occur due to natural causes, for example in the event of a predator attack.

The impact of underwater noise depends on the frequency of the sound, as well as on how loud and long-lasting the sound is. Behavioural change refers primarily to avoidance behaviour that can vary from a slight change, such as a short-term disturbance in foraging, to an escape behaviour.

During the construction phase, noise will be generated from both building activities and from ships which are used for lifting and transport of materials to the area. During the operational phase, noise will be generated predominantly from ships, which are used to perform maintenance tasks, and from the wind turbines themselves. The noise from the wind turbines consists of both aerodynamic noise (from the rotating rotor blades) and mechanical noise. Transmission of sound from air to water is limited, as most of the generated sound will be reflected at the water surface (Richardson, 1995). Vibrations from a wind turbine, created from the gearbox, may be carried via the tower down into the foundation, from where it may be heard as a low-frequency sound (Tougaard & Mikaelsen, 2018).

Because of the large distances to Danish, German and Polish waters, underwater noise is not expected to cause transboundary effects in connection with any of the phases of the project. This has been confirmed with sound modelling. However, underwater noise may temporarily affect marine mammals and fish; the consequences for marine life as a result of underwater noise are assessed in chapter 7.

6.4. Electromagnetic fields

Within the planned Aurora Wind Farm, an internal cable network will be built. The internal cable network will consist of static cables, or a combination of static and dynamic cables. When a current passes through these cables, an electromagnetic field will be generated. Both AC and DC cables generate electromagnetic fields. Alternating current generates an alternating magnetic field while direct current generates a static magnetic field.

Around submarine cables, the electric field is shielded by the insulation of the cables and, for cables located in the seabed, surrounding bottom substrate. The magnetic field is measured in microtesla (μT) and the strength of the field at any given point depends on several factors, such as the instantaneous variation in current load and how deep the cable is buried. The voltage and how phases are positioned in relation to each other also affect the strength of magnetic field. However, the strength of the field decreases rapidly with distance from the cable.

Since no submarine cables are built in Danish, German or Polish waters, and since the influence of magnetic fields that can occur from the internal cable network is local and concentrated in the few metres from the cable, this impact will not be described further in this Espoo report.

6.5. Displacement

Displacement occurs as a result of disturbances in the environment, for example, wind turbines in operation (due to the physical presence of the wind turbines with associated sound and lighting) or ships servicing the wind farm. Disturbances in birds' foraging areas can result in displacement by forcing the birds to search for food elsewhere, which can lead to increased competition if alternative foraging areas are few.

6.6. Barrier

Barrier effects mean that a disturbance occurs in birds' flight paths, which means that the birds may need to use alternative routes. The use of alternative routes can lead to increased energy consumption, which can particularly affect birds that have to pass through an area with a wind farm daily, for example for travel between foraging areas and overnight places (Masden, et al., 2009). For all birds that pass through the Aurora Wind Farm during migration in spring or autumn, this potentially higher energy consumption is of marginal importance according to the conclusion in Fox & Petersen 2019. (Fox & Petersen, 2019)

6.7. Collisions

The establishment of wind turbines that stand in the way of natural movement patterns can lead to collision risks. Collision risk for birds refers to the risk of birds colliding with and being injured by the rotor blades or towers of wind turbines. The risk of collision for birds depends, among other things, on the design of the wind turbines, such as the sweeping surface and rotational speed, the altitude at which the bird flies, the bird's avoidance behavior, weather conditions, flight speed and the number of individuals passing by. Results from behavioral studies have been used in the model regarding the degree to which birds avoid flying near wind farms (macro-avoidance), in the vicinity of wind turbines within wind farms (meso-avoidance) and how the birds avoid being hit by the rotor blades at the last moment (micro-avoidance). Bats can also be affected by collision risks from wind farms, if these are located within paths used by bats.

7. Effects and consequences of the project

This chapter describes the transboundary environmental effects that may arise from the construction, operation and decommissioning of the planned wind farm. The assessments have been carried out according to the methodology described in Chapter 5, with all assessments based on a worst-case scenario. Where protective measures are deemed necessary they have been included in the impact assessments, and this will be clearly stated. All protective measures are described in detail in Chapter 9.5

7.1. Fish

This section describes the current conditions, protective measures and possible transboundary effects of the proposed wind farm on fish. Data from ICES, HaV and surveys conducted specifically for Aurora Wind Farm in 2020–2021 (exploratory fisheries and eDNA surveys) form the basis of the assessment.

7.1.1. Current conditions

In the wind farm area, abundance of fish is very low, and the area is not considered to be unique or important spawning ground. The fact that hypoxic or anoxic bottom waters are found within the wind farm is likely to impact fish numbers, both because access to food (small fish and other benthic organisms) is low, and because fish require oxygen to breathe. Eutrophication, fishing and climate change are main factors that have an impact on the abundance of fish in the Baltic Sea.

Demersal fish, like flatfish (*Pleuronectiformes*), dwell on the surface layer of the sediment, where their food consists of small fish and other demersal animals. Benthopelagic fish inhabit deep waters, and repeatedly seek out the bottom in search for food, which can consist of crustaceans, worms and mussels. Pelagic fish are found in the open water, where they consume zooplankton, fish larvae and eggs as well as smaller fish. Sampling carried out in the area shows no widespread occurrence of vegetation-covered bottoms and only a very limited presence of benthic fauna.

Surveys and sampling of fish fauna

According to field surveys carried out in 2021, as well as data from ICES and HaV, abundance of fish was very low within the proposed Aurora Wind Farm area. In fish trawl surveys in June 2021, 20 individuals were caught and in September 2021, only three individuals were caught. Pelagic and bentopelagic species have a higher prevalence within the wind farm zone than demersal species. This is expected, as they can stay higher up in the water body, where oxygen concentrations are higher. Data from ICES and HaV show that mainly sprat (pelagic), herring and stickleback (both bentopelagic) are present in the park area. The remaining species that have been observed within the park area appear to be either sporadic visitors or occur in low numbers.

Cod (*Gadus morhua*) occurs in the area, as evidenced by both eDNA sampling and net sampling. A total of 18 individuals of mature cod were caught using net-sampling in June 2021. It is the Bornholm Deep that is the most important spawning area for the eastern cod stock. Cod spawning may also be possible within the Aurora Wind Farm due to the favorable water depth and salinity, however, the oxygen deficiency in large parts of the wind farm area make the area non-optimal. Any spawning within the area is not considered likely, or of such magnitude that it has the potential to affect the Cod stock.

Other species found during fish trawl survey were European flounder (*Platichthys flesus*) and shorthorn sculpin (*Myoxocephalus scorpius*). In the eDNA sampling, DNA from garfish (*Belone belone*), salmon (*Salmo salar*), shorthorn sculpin or fourhorn sculpin (*Myoxocephalus quadricornis*), European eelpout (*Zoarces viviparus*), sand goby (*Pomatoschistus minutus*), lesser sand eel (*Ammodytes tobiatus*), European smelt (*Osmerus eperlanus* L), eel (*Anguilla anguilla*), black goby (*Gobius niger*), rock gunnel (*Pholis gunnellus*) and fourbeard rockling (*Enchelyopus cimbrius*) were also detected, although in low concentrations.

Only the species of sprat has designated probable spawning grounds in the sea area where the Aurora Wind Farm will be located. Areas where sprat spawning is most likely to occur are mainly to the north and west zones of the wind farm, see Figure 10. Aurora Wind Farm constitutes a small part of the total spawning area in the Baltic Sea, and as sprat is considered to be a single stock, the potential effects of disturbed spawning at the population level are considered to be negligible (ICES, 2020).

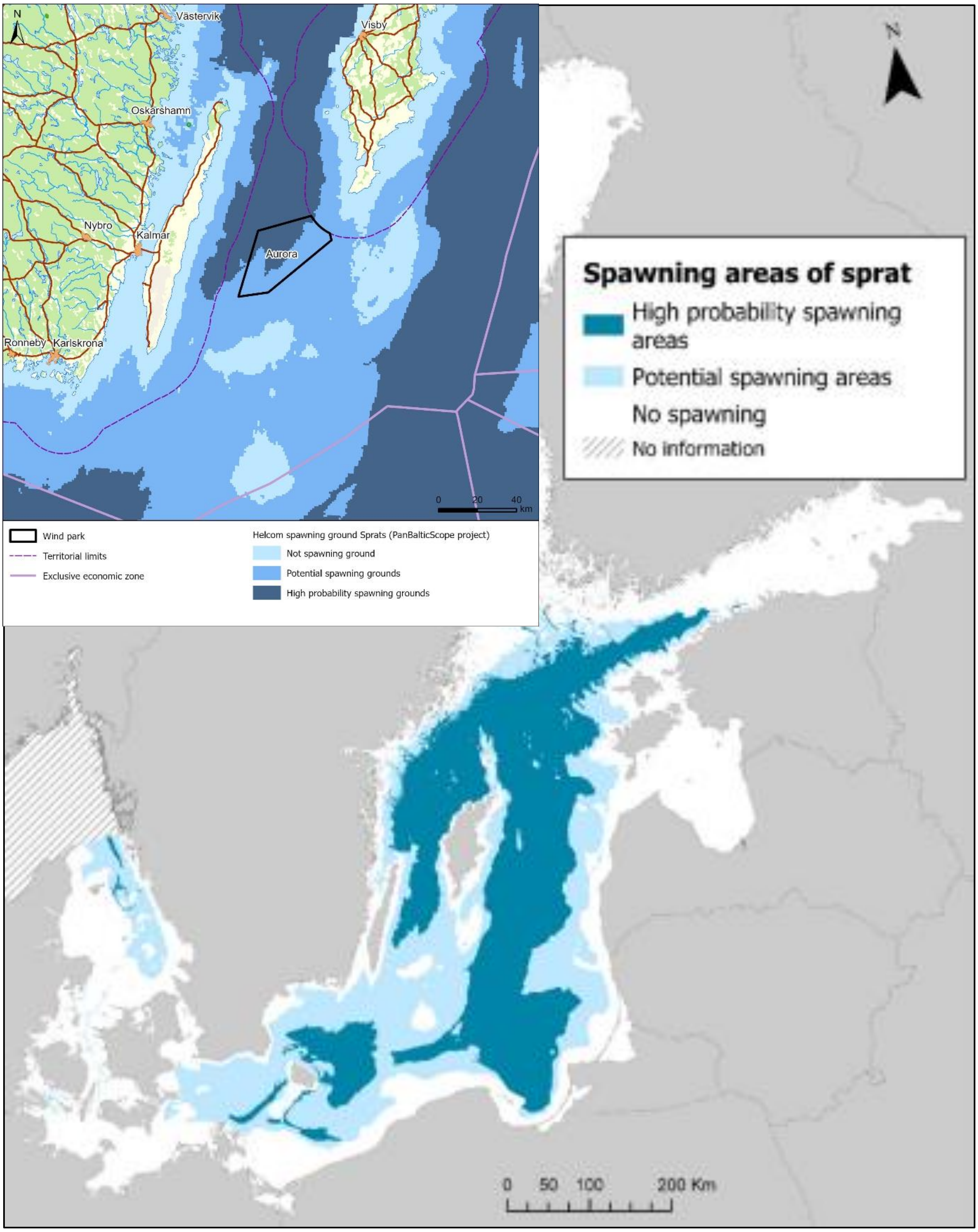

Figure 10. Map of the probability of herring spawning within the wind farm Aurora Wind Farm and its surrounding area. © [Lantmäteriet] 2021, [Documentation: HELCOM].

7.1.2. Protective measures used in assessments

- For the protection of marine mammals and fish, soft start shall be applied before seismic equipment is used.
- Piling work must use sound-absorbing equipment.

7.1.3. Transboundary environmental effects

Construction phase

Underwater noise

When installing foundations by piling, underwater sounds are generated that can affect fish, fish larvae and eggs that reside or occur in the vicinity of a wind farm. Factors that determine the effect on fish include the level of the sound, the surrounding environment, the number of fish exposed to the sound and which species may be present in the area. By applying sound-dampening protection measures, such as a double bubble curtain or equivalent, the effect of underwater noise is reduced.

The results from a computer simulation carried out, show that the underwater noise from piling is only strong enough to induce PTS for cod and herring within a radius of about 25 metres from the sound source. The damage threshold distance for eggs and larvae is about 450 metres from the sound source. Sound propagation varies depending on the position of the foundations within the wind farm, as the surrounding environment, such as depth and bottom sediment, varies. The results from the modelling based on the stated worst-case scenario show that sound levels from the installation of foundations can potentially mean a temporary hearing loss (TTS) within a radius of 3.9 – 7 kilometres for herring (hearing specialists) and 4.5 – 7 .9 kilometres for adults and 7.7 – 11.7 kilometres for juvenile cod (hearing generalists).

Geophysical surveys planned for the construction of the wind farm may also generate sounds that have a temporary effect on fish. As investigations are ongoing for a limited time and a soft start-up is planned to be used, to allow fish to swim away from the area. The effects on fish are considered to be insignificant.

If fish are present in the area at the start of sound-generating works, they are likely to swim away because of the noise generated and the soft start mitigation provides them with the opportunity to do so in good time. Pelagic fish eggs cannot move independently, and fish larvae have poor swimming abilities, so have no or little opportunity to actively avoid the area. They travel on currents, which means that they could pass near an ongoing piling work. In relation to the large area over which fish eggs and larvae are normally scattered during the pelagic phase, the areas concerned by piling operations are very small. In addition, the natural mortality of fish larvae and eggs is very large.

The possible effects from underwater noise on fish during the installation of the Aurora Wind Farm are only local, and insignificant in comparison to natural variation. Susceptibility to underwater sounds has been assessed to be low for hearing generalists and moderate for hearing specialists. When sound-absorbing protective measures are applied, such as soft start with gradual escalation, bubble curtain or similar, the effect of underwater noise is reduced and is considered insignificant. The effect on fish at population level is estimated to be negligible.

Sediment dispersion

Suspended matter can affect fish behaviour, stress levels, make breathing difficult, and lead to impaired vision and increased mortality. Susceptibility to suspended matter differs between different species and functional groups. Larger, adult fish are generally hardier and can handle higher concentrations of suspended matter better. Fish that are smaller, fish eggs, and in particular fish larvae, are more sensitive to high concentrations of suspended matter. Since many species have pelagic eggs and fish larvae that are spread over large areas, the effect on juvenile fish from sediment dispersion is estimated to be small. Early life stages also have a naturally high mortality rate.

The concentration and duration of suspended sediment in the water, as well as the size of the dispersion surface, are the factors that determine the severity of the effects for fish. Most fish species can withstand a concentration of up to 100 mg/l suspended solids for two weeks. According to the sediment dispersion modelling performed, the level of 100 mg/l will generally be exceeded for about two to eight days (48 to 168 hours) during an installation period. Note that these days don't necessarily have to be contiguous; exceedances of a concentration level may occur at different times during the simulation period. The duration exceeds two weeks only at a few points in a very limited area, where the central platforms are intended to be installed.

Not all foundations and cables will be laid at the same time. The concentrations and durations indicated will never occur over the entire area at the same time. Instead, high levels will occur at different times and are likely to be at the foundation that is being installed in that moment. In addition, the sediment simulations are based on a worst-case scenario in terms of the extent of drilling and expected sediment spillage.

The assessment is thus that sediment that could be released into the water, because of foundations and internal cable networks being built within the operational area, is expected to have an insignificant effect on fish, except within a few kilometres of where the central platforms are installed. High concentrations of suspended sediments occur only in the bottom waters, minimizing the impact on pelagic eggs and larvae. Although sprat spawns in the area, suspended sediment is not considered to influence the population level, given that sprat spawns over large parts of the Baltic Sea. The susceptibility to the influence of sediment suspension in fish, fish eggs and fish larvae is considered to be low, and the effect is considered insignificant. The effect of suspended sediment at the fish population level is considered negligible.

Operational phase

Changes in hydrography

The company has performed modelling of sediment dispersion and calculated the impact of the proposed wind farm on hydrographical conditions. The impact on both the currents and stratification in the area is expected to be negligible and not lead to any environmental effects. Thus, no negative effect on fish is expected in terms of changing current conditions.

Underwater noise

A wind turbine in use can emit sounds that can be perceived in the water. The sound that comes mainly from the mechanics of the nacelle, and also as a result of wind-induced vibrations in the tower, can spread down into the structure of the work. However, wind turbines in operation emit noise levels that are generally lower in sound levels than, for example, vessels in the same frequency range. Fish can be affected by sound in different ways. Unlike porpoises, there are no established thresholds for behavioural responses in fish. This is because behavioural reactions differ from species to species and even from individual to individual (Kastelein, et al., 2008; Harding, et al., 2020).

By looking at possible effects of wind turbines that are currently in operation, the possible effect due to noise from wind turbines can be investigated. Bergström et al. found a lower catch of some species (eelpout and eel), while the catch of other species was unaffected (cod and bullhead) within the Lillgrund wind farm compared to reference sites (Bergström, et al., 2013). No significant large-scale effect was noted on the diversity and abundance of demersal fishes. Westerberg noted a higher catch per unit of effort in the vicinity of non-operational wind turbines, but slightly lower catches within 200 metres of wind turbines that were in operation (Westerberg, 1994). Winter et al. However, found no large-scale avoidance behavior in sole and no difference in the presence of cod near foundations when turbines were in operation (Winter , et al., 2010).

Wahlberg and Westerberg concluded that noise from wind farms in operation will be perceived by fish at a distance of 0.4-25 km (with wind speed of 8-13 m/s) depending on the hearing capacity of the fish species, but that a regular escape behavior would only occur within 4 m of a wind turbine at wind speed above 13 m/s (Wahlberg & Westerberg, 2005). In an experiment, Båmstedt et. Al. noted no behavioral change in fish (trout, roach, perch) that were exposed to sound effects similar to those generated by a wind turbine at a distance of 80 metres (Båmstedt , et al., 2009).

There are too few data to establish thresholds for the impact on fish behaviour. Studies of wind farms in operation do not provide clear evidence that fish avoid using and staying in the wind farm areas. Thus, no negative effects on fish from underwater noise is expected.

Electromagnetic fields

The submarine cables are buried about one metre below the bottom sediments or covered by erosion protection, which minimises the propagation of the generated magnetic field. For the cables in the internal cable network and connecting cables, a worst-case scenario has been defined where the strength of the magnetic field at the sediment surface above the cables is a maximum of 40 μT. Magnetic fields from submarine cables are estimated to have a limited effect on fish, as the strength of the fields decreases rapidly with distance from the cable. At about four metres from the cable, the strength has already decreased to about 1 μT.

Dynamic cables with a current of 1200 A are used between floating foundations and the seabed. Magnetic fields generated around the outer jacket of the cable have a strength of about 1,370 μT for single armour, which is a worst case for dynamic cables. At a distance of 7,6 metres from the center of the cable, the strength of the field decreases below 0,4 μT. When using the "dry design" cable type, the magnetic field can be reduced by 20–70 percent.

Previous studies show that most fish species are not affected by magnetic fields from cables on the bottom. There are species of fish, such as eel and salmon, that show that they sense the weak magnetic field from the cable. A couple of studies have shown that eels passing near a submarine cable can temporarily become disoriented, while other studies have not been able to demonstrate any effect from electromagnetic fields at all from eels (Dunlop, et al., 2016; Bergström, et al., 2013; Bartos, et al., 2020; Fey, et al., 2019; Wodruff, et al., 2012).

The sensitivity of fish to electromagnetic fields is considered to be small and the impact itself will be very locally limited. Cables will be buried, which will further reduce the electromagnetic load in the area. An indication of this is the increased presence of fish within wind farms, which can partly be explained by the reef effects that may occur. However, the density of fish is low in the proposed Aurora Wind Farm area and any effects from the submarine cables are expected to be insignificant.

The magnetic fields from cables within the Aurora Wind Farm are not expected to have any effect on fish in the area, and the impact is estimated to be negligible.

Decommissioning phase

During the decommissioning phase, the number of vessel transports to and from the wind farm increases as the various parts of the wind farm are dismantled and transported away. The impact is considered to be temporary and limited. In comparison with the construction phase, the effect on fish from underwater noise and sediments released is insignificant. The impact during the decommissioning phase is considered to be insignificant and the effect to fish is considered to be negligible.

Summary

During the construction phase, the main effect on fish arises from underwater noise and sediment dispersal. During operation, the establishment of the wind farm will be able to provide protection for fish and the sea floor, especially considering that trawl fishing will be restricted, although it is currently very limited. During the decommissioning phase, similar impacts are expected as in the construction phase. An important starting point for the assessment is that the fish trawl survey carried out shows that only a very limited number of fish occur in the operational area. This generally means that the influence of underwater sounds, electromagnetic fields and sediment suspension during the construction and operation phase is likely to affect only a few individuals and thus have a very small overall effect on fish stocks.

The overall assessment for the Aurora Wind Farm is that the transboundary effect on fish, assessed on the basis of various impacts, during all phases of the project will be negligible. In summary, the effect on fish is considered to be negligible and is not expected to lead to any transboundary effect.

7.2. Marine mammals

7.2.1. Current conditions

Three species of marine mammals are estimated to occur continuously within the wind farm and have therefore been assessed for transboundary effects. These are porpoises (*Phocena phocena*), harbor seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*).

Porpoise

There are three genetically distinct populations of porpoise in Swedish waters, the Skagerrak population (part of the North Sea population) which is primarily found from the middle Kattegat to the Skagerrak, the Belt Sea population which is found from the middle Kattegat to the southwestern Baltic Sea just east of Bornholm, and the Baltic Sea population which mainly lives in the Baltic Proper (Lah, et al., 2016; Sveegaard, et al., 2015; Wiemann, et al., 2010). Most relevant to the project area is the Baltic Sea population of porpoises. The porpoise is a designated species in the nearby Natura 2000 site Hoburgs bank and Midsjöbankarna. The Baltic Sea population of harbour porpoises is classified as critically endangered and in Sweden's latest report to the Habitats Directive, the conservation status of the Baltic Sea population of harbour porpoises was assessed as poor. The number of harbour porpoises in the Baltic Sea declined sharply in the last century, mainly as a result of by-catches in gillnet fishing, but probably also due to environmental pollution affecting fertility.

Porpoises are mobile animals, and individuals move over very large areas over hundreds of kilometres in search of prey such as herring, cod, sprat, and goby (Teilmann, et al., 2022). Density of harbour porpoises has been shown in several scientific studies to be strongly linked to the productivity of areas and the presence of food (Embling & o.a., 2010; Gilles, et al., 2016; Stalder, et al., 2020; Sveegaard, et al., 2012).

Porpoises usually live alone or in small groups, which may consist of a few females and their calves or a small group of males. According to data from the SAMBAH study (which took place in the Baltic Sea during April 2011-May 2013), a large part of the Baltic Sea population in the Natura 2000 site Hoburgs bank and Midsjöbankarna is present during the summer (May-August) to give birth to their calves and mate, see Figure 11. Summer is the period of the year when porpoises are particularly sensitive to disturbances. During calving and during the calf's first growing up period, the porpoise needs access to undisturbed and relatively shallow areas in which to establish the vital contact between the female and the calf (Naturvårdsverket, 2011). In the Baltic Sea, calving occurs mainly in June-July and mating around August. The female gives birth to a calf just over ten months later, and then suckles the calf for eight to ten months (Börjesson & Read, 2003; Lockyer & Kinze, 2003). The calf is then completely dependent on the female's milk during the first months but soon begins to catch solid food and becomes more independent as time goes on (Oftedal, 1997).

During the rest of the year (September-January), porpoises leave the Natura 2000 site Hoburgs bank and Midsjöbankarna to a large extent and spread out over large parts of the Baltic Sea, see Figure 12 (Amundin, et al., 2022). The detection rate is therefore significantly lower over large parts of the Natura 2000 area, including at the stations in the northwestern parts of the Natura 2000 site, which lie closer to the Aurora Wind Farm, and in the actual area of the wind farm, see Figure 13 . In the more central parts of the Natura 2000 site, around Norra Midsjöbanken, the detection rate is higher during the rest of the year. The highest mean detection rate during the study occurred in the western parts of the Baltic Sea and at Norra Midsjöbanken (Amundin, et al., 2022).

The wind farm area is not considered an important area for harbour porpoises. Data collected from AquaBiota's own surveys (conducted on behalf of the Company) and from the national environmental monitoring confirm the picture that the densities of harbour porpoises are significantly higher at Norra Midsjöbanken and further south in the Natura 2000 site than near or in the Aurora Wind Farm, and that the area for the Aurora Wind Farm is not an important area for harbour porpoises.The latest surveys of the presence of harbour porpoises continue to show that porpoises occur sporadically in the area with few recorded porpoise positive minutes within the Aurora Wind Farm.

Table 12 summarises the surveys with harbour porpoise detectors carried out in 2020–2023. The station with the most detections (6263) is located within the Natura 2000 site. Figure 13 also shows the location of the different detectors and the average number of porpoise positive days per month throughout the survey period August 2020-May 2023. Here too, it can be seen that the number of detection positive minutes is lower in the Aurora Wind Farm than in the Natura 2000 area, especially in comparison with the detections around the Norra Midsjöbanken. All stations within the Aurora Wind Farm have on average fewer than one detection positive minute per month. This may indicate that porpoises do not stay in the area of the wind farm for long periods of time or in large numbers, but rather that it is a few individuals that temporarily pass through the area as they move naturally over very large areas in search of food. The low presence of harbour porpoises can be explained by the scarcity of fish in the area, which both the exploratory fisheries carried out and the low prevalence of commercial fishing confirm.

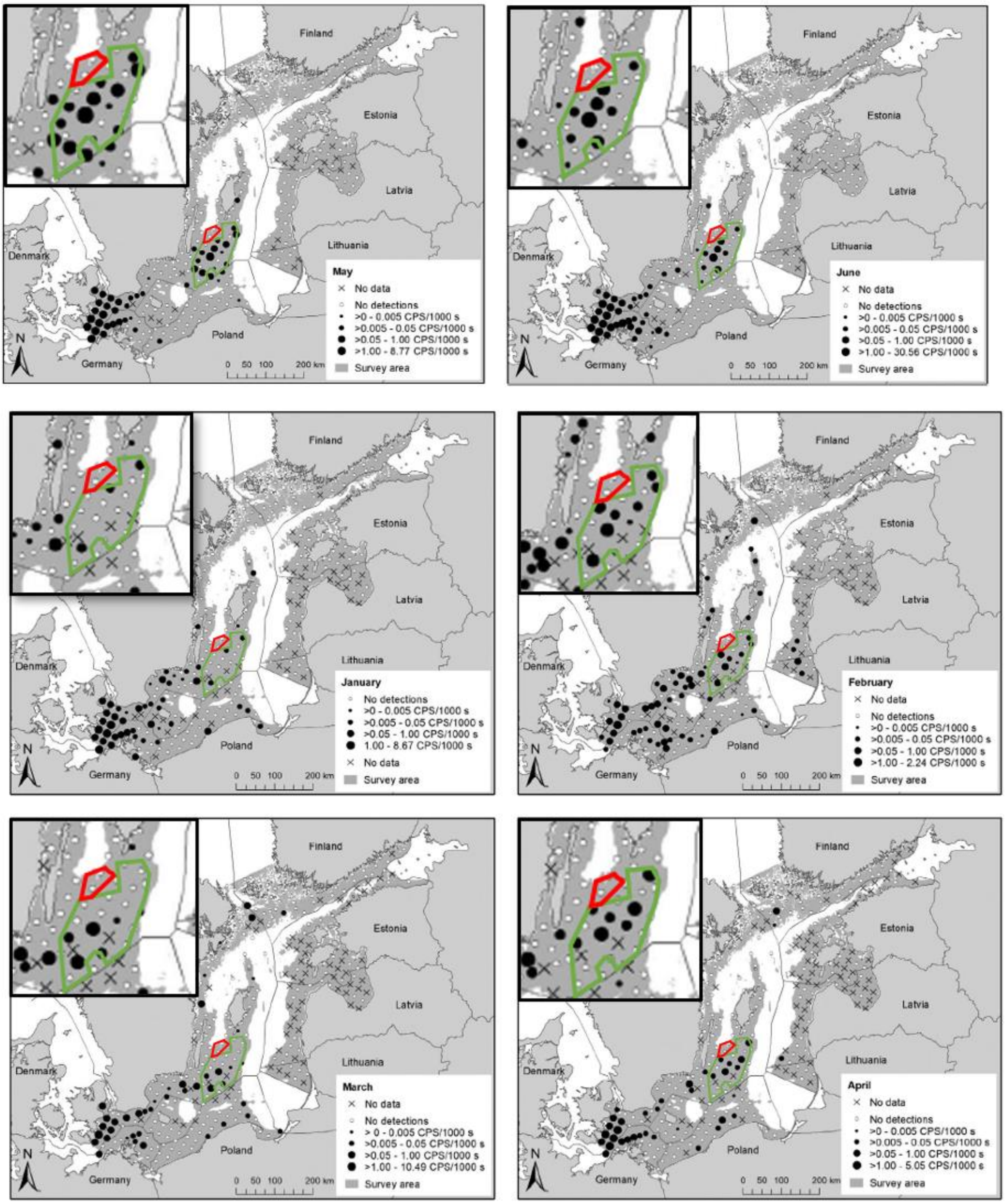

Figure 11. Average detection rate of harbour porpoises per station per month (January-June). The detection rate is measured in click-positive seconds (CPS) per 1000 s of survey effort. White dots are stations without detections and black dots are different sizes depending on the degree of detection in the station. The larger the dot, the higher the percentage of click-positive seconds. The shaded area shows the main survey area during the SAMBAH study (Modified from Amundin et al. 2022) with wind farm Aurora (red) and Natura 2000 site Hoburgs bank and Midsjöbankarna (green) plotted).

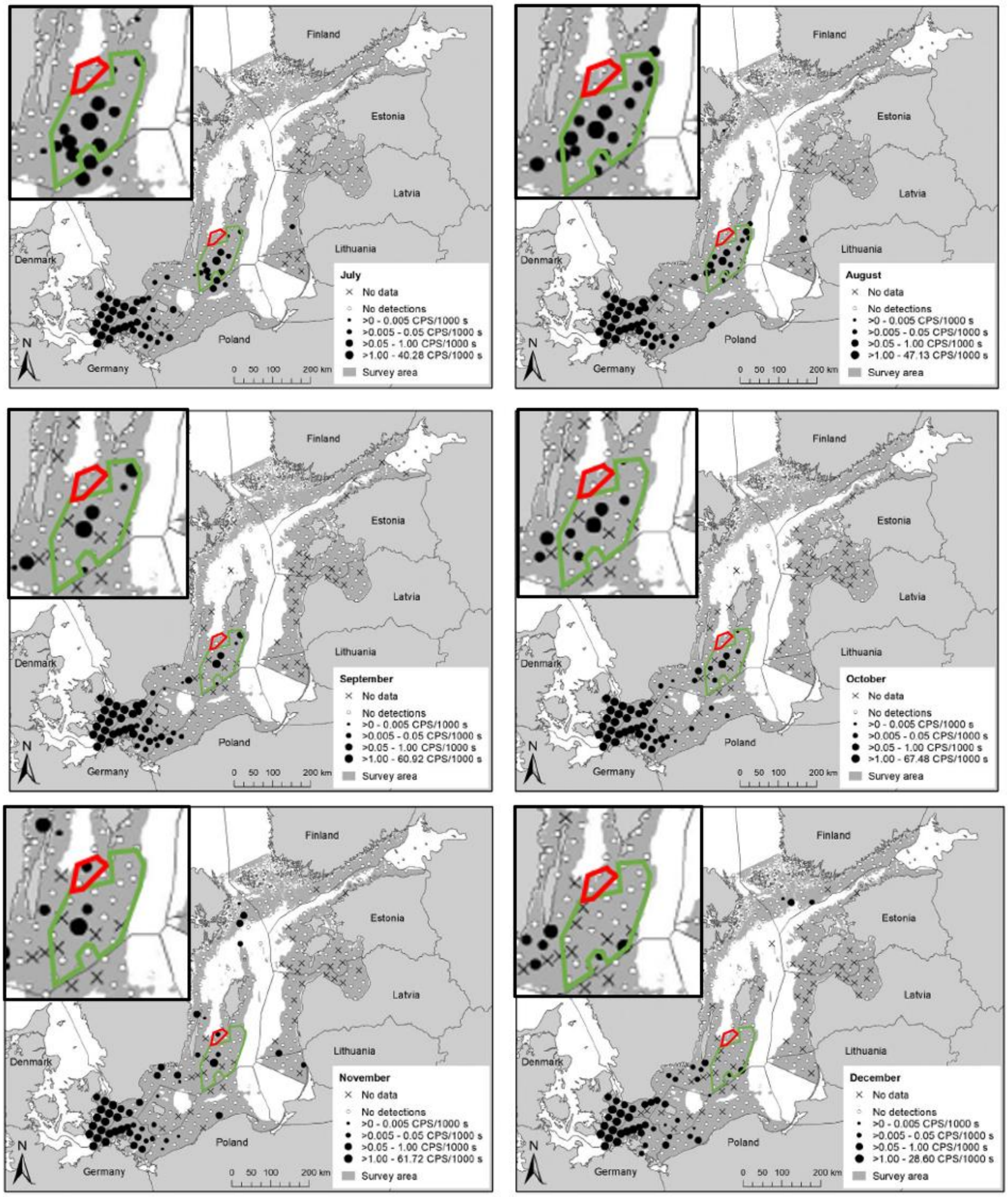

Figure 12. Average detection rate of harbour porpoises per station per month (July-December). The detection rate is measured in click-positive seconds (CPS) per 1000 s of survey effort. White dots are stations without detections and black dots are different sizes depending on the degree of detection in the station. The larger the dot, the higher the percentage of click-positive seconds. The shaded area shows the main survey area during the SAMBAH study (Modified from Amundin et al. 2022 with wind farm Aurora (red) and Natura 2000 site Hoburgs bank and Midsjöbankarna (green) plotted).

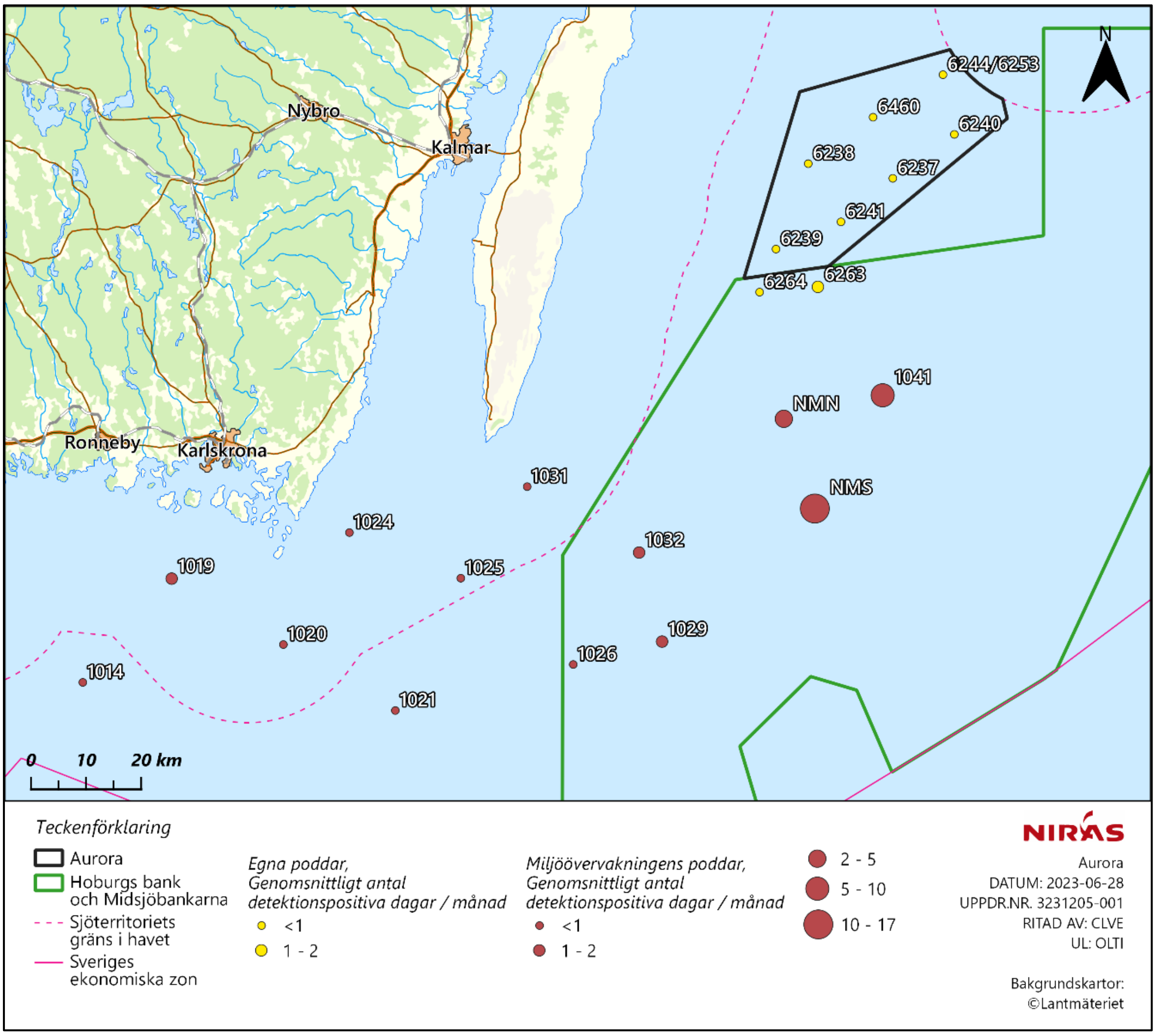

Figure 13. Average number of detection positive days per month for harbour porpoise detectors within wind farm Aurora August 2020-May 2023 (F-POD data converted to C-POD) and national environmental monitoring detectors 2015-2020 (C-POD) (from SHARKweb 2023) as well as the Natura 2000 area Hoburgs bank and Midsjöbankarna.

*Table 12. The number of detection positive minutes per month and detector during the entire period of the study. Red fields mark months with zero detections, black fields mark months without data due to lost detector or batteries running out prematurely, *indicates detectors in the Natura 2000 site.*

Sum of DPM equivalent to COPD, per month.									
	6237	6238	6239	6240	6241	6244/ 6253	6263*	6264*	6460
2020									
August	0	0	0	0	0	0	0	0	
September	0	0	0	0	0	0	0	0	
October	0	0	0	0	0	0	0	0	
November	0	0	0	0	0	0	0	0	
December	0	0	0	0	0		0	0	
2021									
January	0	0	0	0	0		0	0	
February	1	1	0	4	2		7	1	
March	0	0	0	0	0	0	2	0	
April	0	0	0	0	1	0	0	0	
May	0		0	0	0	0	0	0	
June	1	0	1	0	0	1	2	0	0
July	0	0	0	0	1	0	0	0	2
August	0	1	0	0	4	0	0	0	0
September	0	1	0	0	0	1	0	1	0
October	0	0	0	0	0	0	0	0	
November	1	0	0	0	0	2	0	1	
December	1	0	0	0	0	7	1	0	0
2022									
January	1	0	0	0	0	2	3	0	0
February	0	0	0	0	0	0	0	0	0
March	1	0	0	0	0	0	0	0	0
April	1	1	0	0	0	0	0	0	0
May	1	0	0	0	1	4	0	2	3
June	0	0	1	2	3	1	12	0	1
July	0	9	0	0	1	0	4	0	0
August	0	0	7	0	0	0	5	2	1
September	0	0	0	1	0	0	3	2	0
October	0	0	0	0	0	0	12	0	0
November	1	0	0	0	0	0	4	0	7
December	0	0	0	0	0	0	12	0	1
2023									
January	0	0	0	0	2	0	19	0	0
February	0	0	0	4	0	0	0	0	0
March	1	0	0	0	0	0	0	0	1
April	0	7	0	0	0	0	0	0	0
May	1	0	0	0	1		1	0	12
Total	11	20	9	11	16	18	87	9	28

Porpoises use echolocation where they produce high-frequency sounds and listen for reflective echoes to get an idea of their surroundings (Miller, 2010; Wisniewska, et al., 2016; Villadsgaard, et al., 2007). The greatest hearing sensitivity in porpoises is between 90–140 kHz with a hearing threshold of 10–140 dB re 1 µPa (Kastelein, et al., 2002), which coincides with the frequency range with the highest energy in porpoise echolocation (Møhl & Andersen, 1973).

How porpoises react to underwater noise from piling work changes with the distance from the piling site, so that the reaction of the individual becomes weaker the further away from the piling site they are (Dähne, et al., 2013) The individual's age, gender, behavioral status and previous experience of loud underwater sounds can also play a role in the impact of underwater sounds (Southall, et al., 2021). The behavioural impact that can occur during piling when sound-absorbing protective measures are used primarily means a temporary loss of habitat because the animals avoid areas where individual foundations are installed. The consequence of habitat loss at individual and population level for harbour porpoises depends on whether the area is an important foraging area or not.

Scientific studies with individual-based modelling indicate that the effect on harbour porpoises from wind power is small compared to, for example, bycatch and environmental toxins (Bergström, et al., 2022; Nabe-Nielsen, et al., 2018; van Beest, et al., 2017; Cervin, et al., 2020). When modelling the population level effects on harbour porpoises from wind power construction in an area of the North Sea over the course of 9,7 years, Nabe & Nielsen (2018) showed that piling had no clear effect at the population level. This was probably due to the fact that the porpoises were able to return to the wind farm within a few hours after piling ceased at individual piling sites. The consequence of the temporary elevated noise levels therefore had little effect on the individual's energy stores and survival (Nabe-Nielsen, 2021).

Harbor seal

The seal is divided into three subpopulations in the Baltic Sea: Kattegat, southwestern Baltic Sea and southern Kalmar Strait. The project area includes harbour seals belonging to the Kalmarsund population. The seals in Kalmarsund belong to their own isolated population that has increased in number since the 1970s to about 1100 individuals in the latest count. The population is classified as vulnerable (VU) but has according to HELCOM's latest classification achieved good status. (HELCOM, 2018) (SLU Artdatabanken, 2022) (HELCOM, 2018b)

Usually the population stays and forages mostly in shallow areas in the Kalmar Strait or near the southeastern coast of Öland, where their important sleeping areas are also located. The nearest sleeping area for harbour seals is in the Natura 2000 area Southeast Öland's Lakelands (SE0330174), which is located about 35 kilometres southwest of Aurora Wind Farm. The Natura 2000 site Ottenby (SE0330108), located about 45 kilometres southwest of the wind farm area, is also an important sleeping area for harbour seals. For seals in the Baltic Sea region, the diet usually consists of eel, which made up 42 percent of the diet of the individuals studied, as well as cod, whitefish, flounder and turbot. Due to the low prey availability and near-anoxic bottom conditions below 70 metres depth, the planned wind farm area is not considered an important foraging area for harbor seals. (Scharff-Olsen et al., 2019)

Common seals are not considered to be affected by the Aurora Wind Farm and are not species relevant for the assessment of transboundary effects.

Grey seal

Grey seals are the most common seal species in the entire Baltic Sea. Since 2014, the population has been estimated at more than 30,000 individuals, the population is assessed as least concern (LC) according to the Swedish Red List and has reached a good status according to HELCOM. (NIRAS, 2021) (SLU Artdatabanken, 2021) (HELCOM, 2018)

Grey seals have a feeding pattern similar to that of the harbour seal. The diet varies over the year and depends on which prey animals are available and depending on which part of the Baltic Sea it resides. The diet consists mainly of herring, sprat and cod.

There are few studies of the grey seal's vision and hearing ability, but due to anatomical similarities with the harbour seal, it can be assumed that vision and hearing are similar to those of the harbour seal. In air, the grey seal hears well in the 3–20 kHz spectrum, however, the state of knowledge regarding the grey seal's hearing ability under water is poor. With reference to the anatomical similarities of grey seals to harbour seals, the same underwater noise threshold applied to harbour seals is recommended to be used as an estimate of the threshold value for grey seals.

Grey seals can move over large areas, individuals that occur within the Aurora Wind Farm belong to the Baltic Sea population. Like the Common Seal, the Grey Seal is often found in shallow areas. Documented sleeping areas where grey seals change fur are available both on Öland and Gotland. The closest sleeping area for grey seals to Aurora is located in southern Gotland, about 20 kilometres from the wind farm area. The Natura 2000 area Ottenby (SE0330108), located about 45 kilometres southwest of the wind farm area, is the nearest sleeping area on Öland. (HELCOM, 2018)

As grey seals move over large areas, the operating area can be used for feeding grey seals in transit during transport between berths on Öland and Gotland. The wind farm area is not considered an important foraging area for grey seals, due to its low prey availability and near-anoxic bottom conditions at depths exceeding 70 metres, and is therefore considered to be of little importance for the species.

7.2.2. Precautionary measures

During the construction phase, a number of protective measures will be taken:

- For the protection of marine mammals (and fish), soft start-up shall be applied before seismic equipment is used.
- During the start-up of survey work with seismic equipment, passive acoustic monitoring shall also be used and there shall be observers on the vessel who look for marine mammals in the vicinity of the vessel.
- For the protection of harbour porpoises, equipment for examinations using the side-scanning sonar and multi-beam sonar methods shall be used with a sound frequency exceeding 200 kHz.
- For the protection of harbour porpoises, underwater noise from seismic surveys during the period 1 May to 31 October shall not exceed the value $SPL_{RMS\text{-}fast,\ VHF}$ 100 dB re. 1 µPa within the Natura 2000 site Hoburgs bank and Midsjöbankarna.

- Prior to piling work, acoustic methods that remove porpoises, with techniques adapted for porpoises, will be used to the required extent.
- Piling work will begin with a soft start-up, after which the strength of the hammer blows is gradually stepped up to full strength (ramp-up). The period of soft start-up and gradual escalation, together with other protective measures, shall be sufficient to protect marine mammals against underwater piling noise exceeding the permanent hearing loss (PTS) and temporary hearing loss (TTS) thresholds for harbour porpoises respectively.
- Piling work must use sound-absorbing equipment.
- During piling operations, underwater noise shall not exceed the single pulse value $SPL_{RMS\text{-}fixed,\ VHF}$ 100 dB porpoise re 1μPa at a distance of 9,4 kilometres from the sound source.
- To protect the porpoise calving and mating period, underwater noise from piling operations during the period 1 May to 31 October shall not exceed the value $SPL_{RMS\text{-}fast,\ VHF}$ 100 dB porpoise re 1μPa within the Natura 2000 site Hoburgs bank and Midsjöbankarna.

7.2.3. Transboundary environmental effects

It is estimated that the impact on marine mammals from the activities sought could mainly occur during the construction phase in the form of underwater noise from construction work. Underwater noise from construction work is not expected to cause elevated sound levels in Danish, German or Polish waters. Therefore, transboundary impacts are assessed based on the impact of Aurora Wind Farm at the population level and the maintenance of the favourable conservation status of the populations.

Construction phase

In the construction of the Aurora Wind Farm, underwater noise from seismic surveys and piling work has been identified as the main influencing factors for marine mammals. In order to assess the impact of Aurora Wind Farm on harbour porpoises, NIRAS has, on behalf of the Company, performed site-specific underwater sound modelling for the pre-construction surveys and construction work that can cause the most powerful underwater noise and thus risk having the greatest impact (NIRAS 2022a, b). Modelling is thus based on a worst-case scenario and includes protective measures such as soft start-up, ramp-up, double bubble curtains and is based on the site-specific geophysical and hydrographic conditions. Weighted thresholds were used for TTS, PTS, and avoidance behavior for porpoises according to (Southall, et al., 2019; Tougaard, et al., 2015; NOAA, 2018), i.e., 140 dB re. 1 μPa 2 s (SEL), 155 dB re. 1 μPa ^{2}s (SEL) and 100 dB re. 1 μPa ($SPL_{RMS\text{-}fixed}$), respectively.

Surveys

In the worst-case scenario when using kickers, mini airguns and innovators, porpoises may exhibit avoidance behavior within 2,150 metres of the survey vessel. Conservatively calculated (with equal impact in a circle around the survey vessel), this corresponds to an area of approximately 14.5^{km2} and becomes the area where habitat loss occurs around the survey vessel. The densities of harbour porpoises in the vicinity and in the area of the Aurora Wind Farm, according to available data, were estimated to be very low all year round, so the risk of a porpoise being affected by the surveys is low. The impact is also temporary as the vessel is constantly in motion during the investigation period, which is assumed to be a few weeks. The risk zone for porpoises to develop

PTS is within 25 metres of the survey vessel if the equipment were to run at full power without soft start-up. The corresponding risk zone for TTS is within 160–625 metres of the survey vessel when the equipment is started at full power without soft start-up. A smooth start-up of 30 minutes would give a porpoise swimming 1.5 metres/second the ability to get 2.7 kilometres away before the equipment runs at full power.

The company's proposed and far-reaching protective measures for both geophysical surveys and civil engineering work will ensure that no porpoises, either inside or outside the Natura 2000 area, are at risk of being exposed to TTS or PTS and that the temporary behavioral impact that can come from elevated underwater noise levels is limited. Proposed protective measures will at least correspond to the best sound dampening measures available on the market today and these, together with soft start-up and ramp up, will prevent loud sudden impulsive sounds from occurring. The smooth start-up and ramp-up procedure, where sound levels are slowly increased, gives the porpoises time to leave the area before the sound levels get too high. Studies in the construction of wind farms have also shown that the presence of harbour porpoises decreases even before piling work has started as porpoises avoid areas with high activity/presence of construction vessels and areas with high noise levels (Rose, et al., 2019; Benhemma-Le Gall, et al., 2021). Thus, porpoises can be expected to move away from the piling area even before the soft start-up begins.

Pilling

In the construction of the Aurora Wind Farm, piling will only take place at one foundation at a time, which means that it is a limited area that the porpoises are displaced from at each individual pile. The results from the modelling show that sound levels high enough to cause TTS and PTS in harbour porpoises only occur within 90 and 25 metres of the piling site, respectively. It is unlikely that porpoises will occur so close to the piling site as the activities themselves are likely to push porpoises away from the area, of which the risk of hearing damage is estimated to be extremely small. Sound levels that cause porpoises to avoid the area (avoidance behavior) are estimated to occur within 9.4 kilometres.

As described in section 7.2.1, harbour porpoises are highest in the Natura 2000 site with core areas located on the productive offshore banks around Norra Midsjöbanken and Hoburgs bank. Piling work that could potentially have a behavioural impact into the Natura 2000 area is mainly located in the southern part of the Aurora Wind Farm. As the worst-case pile avoidance threshold can reach up to 9.4 kilometres from the piling site for truss foundations, this means that piling about 77 of the foundations can cause avoidance behaviour into the Natura 2000 site for an example layout for 15 MW turbines (which is the scenario with the most foundations). Thus, it is not the piling of all foundations within the Aurora Wind Farm that can give rise to avoidance behaviour for harbour porpoises within the Natura 2000 site, but up to about 20% of the foundations closest to the Natura 2000 site. Piling of other foundations within the wind farm will not cause noise levels exceeding the threshold value for avoidance behaviour for harbour porpoises in the Natura 2000 site. Other foundation anchoring techniques that may be used result in lower noise levels and thus fewer foundations that can cause behavioural impacts in the Natura 2000 site.

The installation of a truss foundation is estimated to take two to three days, where the piling itself takes three to seven hours per pile depending on the bottom conditions at the site. This means for the worst case (with maximum number of hours and maximum number of piles for the foundations) a maximum of about 90 days ((7h x 4 piles x 77)/24h) when piling noise can potentially cause avoidance behavior in porpoises. At most, a very small part of the Natura 2000 site (0.59%) can be affected by piling individual foundations closest to the Natura 2000 site. No significant behavioural impact is expected to occur as a result of construction work in the Aurora Wind Farm.

The precautions and conditions proposed in section 7.2.2 are considered to provide sufficient protection for marine mammals and thereby prevent hearing damage such as TTS or PTS from occurring, such as the application of soft-start for piling work and seismic equipment surveys. The time limit for the propagation of underwater sounds into the Natura 2000 site, proposed as a condition for the Natura 2000 permit, will also provide a high level of protection for the harbour porpoise population. 0

Since the densities of harbour porpoises in the area are low, the risk of a porpoise being affected at a single piling occasion is low. Densities of grey seals are also low as the wind farm area is not considered an important foraging area for grey seals due to the low prey availability, and near completely anoxic bottom conditions at depths exceeding 70 metres. Only a very small part of the Baltic Sea population (0.02% of the population) and the grey seal population are estimated to be at risk of being affected by noise levels exceeding the threshold for avoidance behaviour at a piling time.

According to the worst-case scenario, a short-term displacement on a single occasion is not considered to have a significant impact on the individual and thus not on the population (Tougaard, 2021). The behavioural impact that the temporary displacement could potentially entail, from an area of minor importance where the detection rate of harbour porpoises is low, is not considered to affect individuals' ability to find food or the Baltic Sea population's ability to reach a favourable conservation status.

In summary, only very limited parts of porpoise and seal populations are estimated to be affected by sound levels above the threshold for avoidance behaviour. The transboundary impact during the construction phase is thus estimated to be very small to negligible for marine mammals and is not expected to have an impact on an individual or population level.

Operational phase

In a conservative calculation, the impact of the wind turbines from underwater noise during the operational phase in the form of hearing loss and behavioural impact is estimated to be insignificant for both the Baltic Sea population of harbour porpoises and harbour seals and grey seals at a distance of 100 metres. During the operational phase of the Aurora Wind Farm, the impact on marine mammals is considered to be of an insignificant nature with regard to identified impacts underwater noise, sound and electromagnetic fields. The overall assessment is therefore that the transboundary impact on marine mammals will be negligible during the operational phase of the wind farm.

Decommissioning phase

The overall assessment for the decommissioning phase is that the impact of identified impacts sediment suspension and sedimentation, environmental toxins and nutrients as well as underwater noise entails a significantly smaller impact than at construction and therefore has an insignificant impact on marine mammals. It is therefore assessed that the transboundary impact on marine mammals will be negligible during the decommissioning phase of the wind farm.

Summary of assessment

The construction, operation and decommissioning of the Aurora Wind Farm is estimated to have limited impact on marine mammals with small consequences, which is why neither the Baltic Sea population of harbour porpoises and grey seals' population development, habitats or distribution area in the Baltic Sea is expected to be affected in the short or long term. Aurora Wind Farm is not considered to affect the ability of current marine mammals to reach a favourable conservation status at either local or biogeographical level, of which no transboundary impact is expected at individual or population level.

7.3. Birds

In order to obtain data for assessments of wind farm Aurora's impact, the Company has engaged an independent expert in the field (Ottvall Consulting AB) to carry out seabird inventory and migration studies within and in the immediate area around wind farm Aurora. In addition, radar studies and collision modelling have been performed. Expertise from the Danish Hydrological Institute (DHI), NIRAS, Ottenby Bird Observatory, as well as experienced ornithologists from Öland and Gotland has also participated in the work. Based on this data, environmental impact assessments have been made regarding the impact of the Aurora Wind Farm on bird life. Only those species flying through or occurring within or near the aurora are relevant for the present assessment of transboundary impacts on birds.

7.3.1. Condition

Existing knowledge of which bird species are expected to occur regularly in the operational area and carried out inventories show that the vast majority of bird species pass through Aurora only during migration and that night migratory birds constitute the large proportion of the migration flow. They also show that the species that regularly stay in the foraging area are limited to a few species.

Among migratory bird species, cranes, birds of prey and seabrids are primarily treated here. The sea area about 30 kilometres east of Öland and about 20 kilometres south of Gotland is not a significant migration route for birds of prey and cranes, which mainly use thermals (warm air that rises) when migrating over land masses. Many of the birds that pass through the Aurora during migration, winter in western Europe, the Mediterranean or Africa. This means that in spring the birds fly in a mainly north-easterly direction of migration, and in autumn in a southwesterly direction of migration. There are several bird species that migrate along different flight routes during spring and autumn, which may mean that a higher proportion of a bird species' population can pass in connection with Aurora one way but in lower numbers the other migratory route. The normally used flight route can also be affected by prevailing winds that drive migrating birds away from the shortest flight distance. The number of individuals in autumn is many times higher than in spring, when many of all chicks born during the summer will also migrate to wintering areas. (Hansson, 2019)

7.3.2. Knowledge base, inventories and investigations

During the investigation, existing data on birds in the area have been collected and supplemented with new inventories 2021-2023, see Table 13 below. It is important to emphasize that the inventories carried out for the current trial follow established methodology in the field, which means that the collected data is quality assured and comparable with other studies.

The wind farm area has been inventoried with regard to the bird species that can pass through or use the area during migration, wintering or the breeding season. Special focus has been placed on migration studies. During the autumn of 2021, inventories were carried out with LiDAR from aviation. A radar was active around the clock at the southern tip of Öland 35 days in April-May 2022 and 60 days in September-October 2022. In parallel with the radar, ornithologists were on site for several days for species-specific collection of radar tracking and counting of migrating waterfowl. In addition, boats with radar and observers were used to collect corresponding data in Aurora or adjacent to Aurora and east of Gotland. In total, migration studies were conducted over 59 days at sea in spring and autumn 2022 and spring 2023. Horizontal directional radar was mainly used, but in autumn 2022 and spring 2023 there was also a vertically directed radar on boats for studies of night migratory birds.

To follow up on auk's behavior on Aurora, an area south of the Karlsöar to Norra Midsjöbanken was inventoried from a boat on December 18, 2021, for three days at the turn of the month May-June 2022 and an inventory was carried out from flights 5 days in 2021, January 9, 2022, March 23, 2022, November 27, 2022, February 22, 2023 and June 12, 2023.

Data for the migration study collected in 2022 has been analyzed by DHI and has been compiled into two technical reports, one for the spring and one for the fall. During the inventories from boats in the spring of 2023, so much data was collected that not everything has yet been fully analyzed by DHI. Analyses of night migration are ongoing and selected results are presented in Section 7.3.4.

Table 13 below summarises all inventories carried out as a basis for the Swedish application for permits under SEZ and Natura 2000, as well as for the assessment of transboundary effects in this Esbo report. In addition to own inventories, the knowledge base has also been expanded through inventories carried out by other parties, as well as research conducted by, among others, SLU. Among other things, the reports from the Gotland Ornithological Society (GOF) are described by migration studies in April 2022 (Jonsson, et al., 2022) and by resting seabirds in April-July 2022 (Hjernquist, et al., 2022). For most seasons and species groups, there are at least two years of studies. As described above, the inventories will continue in the autumn of 2023, to further strengthen the knowledge base for future survey programmes regarding operational regulation, which aims to further investigate the movement patterns and avoidance of migratory birds in relation to the wind farm. The reported data is considered to be fully sufficient to make assessments of the transboundary impact of the activities on bird life.

Collision risk modelling has been carried out by DHI to assess the risk of birds being killed by the turbines' rotor blades. The collision calculations were made using the so-called collision project. The belt model, with conservative assumptions about the migration of birds and the design of the wind farm.

Displacement effects for seabirds have been calculated using parametres such as available density data, displacement rates and experience from previous studies. Estimation of barrier effects for migrating seabirds has been based on the same methodology as for previous studies with a conservative assumption that birds always choose the maximum flight distance required to fly around the wind farm (Masden, et al., 2009).

Table 13. Compilation of all inventories performed for Aurora and the purpose of each inventory.

Date	Method	Comment
8 January 2021	Visual inventory by airplane	Long-tailed duck, common murre and razorbill
28 February 2021	Visual inventory by airplane	Long-tailed duck, common murre and razorbill
23 Mars 2021	Visual inventory by airplane	Long-tailed duck, common murre and razorbill
20 June 2021	Visual inventory by airplane	Summer occurrence
12 August 2021	Visual inventory by airplane	Summer occurrence
Fall 2021: 13 days	Migration: LiDAR[2] from airplane	Fall migration
18 December 2021	Inventory from boat	Long-tailed duck and common murre
9 January 2022	Visual inventory by airplane	Long-tailed duck, common murre and razorbill
23 Mars 2022	Visual inventory by airplane	Long-tailed duck, common murre and razorbill
Spring 2022: 18 days	Migration: radar study from boat	Spring migration
9-12 April 2022	Visual observations and radar from boat	Spring migration
27 April – 5 May 2022	Visual observations and radar from boat	Spring migration
25-30 May 2022	Visual observations and radar from boat	Spring migration
Spring 2022: 35 days	Migration: radar study from the south point of Öland	Spring migration
31 May - 2 June 2022	Inventory from boat	Auks
Fall 2022: 21 days	Migration: radar study from boat	Fall migration
1-6 September 2022	Visual observations and radar from boat	Fall migration
25 September – 3 October 2022	Visual observations and radar from boat	Fall migration
16-23 October 2022	Visual observations and radar from boat	Fall migration
Fall 2022: 60 days	Migration: radar study from the south point of Öland	Fall migration
27 November 2022	Visual inventory by airplane	Long-tailed duck, common murre and razorbill
9 January 2023	Visual inventory by airplane	Long-tailed duck, common murre and razorbill
22 February 2023	Visual inventory by airplane	Long-tailed duck, common murre and razorbill
Spring 2023: 20 days	Migration: radar study from boat	Spring migration
29-31 Mars 2023	Visual observations and radar from boat	Spring migration
22-29 April 2023	Visual observations and radar from boat	Spring migration
21-29 May 2023	Visual observations and radar from boat	Spring migration
12 June 2023	Visual inventory by airplane	Summer occurrence

[2] Light Detection and Ranging

7.3.3. Results from completed investigations and inventories of resting seabirds

Long-tailed duck

The depths of the aurora exceed what is biologically relevant for long-tailed duck (*Clangula hyemalis*) to access bottom-dwelling food. Thus, the aurora is not a foraging area for the species. The species has been observed in low numbers during inventories in the wind farm area.

The inventories from flights during winters 2021-2022 and 2022–2023 show that Aurora has marginal significance as a foraging area and resting place for the species during the period that long-tailed ducks in the Baltic Sea. During flight surveys in January and March 2021, the number of long-tailed ducks was estimated at fewer than 100 individuals within Aurora. Slightly more long-tailed ducks were counted in the inventory on 22 February 2023 compared to 27 November 2022, but out of a total of 346 long-tailed duck birds in February 2023, 45 were observed within the Aurora Wind Farm area, the rest were outside the wind farm area, see Figure 14 and Figure 15 Figure 14The presence of 346 long-tailed duck in February 2023 represents a fraction of what was found on the offshore banks during the same time.

Based on the available data, Aurora is considered to be of marginal importance as a foraging area and resting place for long-tailed ducks.

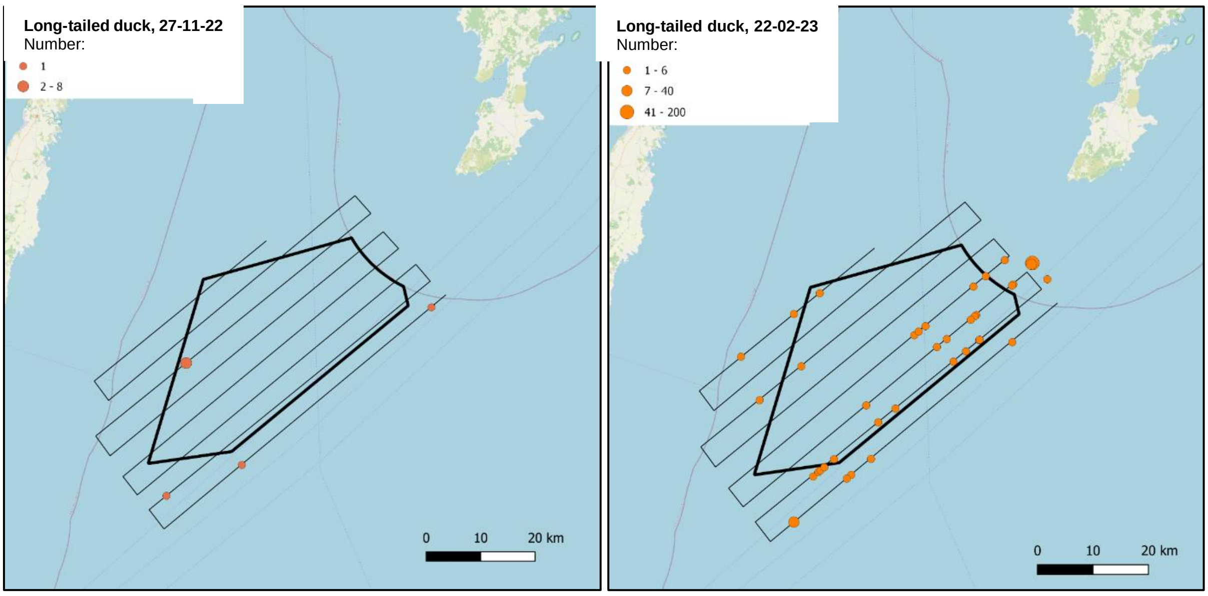

Figure 14. Left: long-tailed ducks during inventory at Aurora in November 2022, a total of 8 long-tailed duck s were observed within the wind farm area. Figure 15. Right: long-tailed ducks during inventory at Aurora in February 2023. All observations in the Aurora Wind Farm area consist of 1–6 long-tailed ducks, and a total of 45 long-tailed ducks were observed in the wind farm area. Source: Ottvall Consulting AB, 2023.

Auks

The group of auks includes the closely related species common murre (Uria aalge) and razorbills (*Alca torda*). The flight inventories in Aurora in 2021 showed average densities of 0.43 auks/km^2 in summer (June and August) and 0.67 auks/km^2 in winter (January, February and March). In an inventory from a boat at the turn of the month May-June 2022, the density of auks was estimated to be 1.0 auks/km^2. A higher density of auks was noted in Aurora during flight on 22 March 2022 when 3 auks/km^2 were recorded. Thus, wind farm Aurora, in line with the inventories, can be considered an area with low densities of auks (Durinck, et al., 1994). The depth conditions prevailing in Aurora are used more frequently by common murre than razorbills (Durinck, et al., 1994), which is also confirmed in the distribution between the species in inventories carried out from boats.

Common eider

Common eider (*Somateria mollissima*) passes Aurora during the spring and autumn migration with the greatest contact in the spring when the common eider flies past Aurora in the northwest and southeast edge of Aurora. Conducted inventories indicate that common eiders are resting in smaller numbers in the area of operation. Migratory eiders can occur over large areas in this part of the Baltic Sea. The species is discussed in the section on migration, see section 7.3.4. 0

Seagulls

During the winter months, the common gull (*Larus canus*) is the most numerous seagull bird species on Aurora. The great black-backed gull (*Larus marinus*) was not noted at all in the 2022–2023 flight inventories, and in previous winters inventories only few sea gulls have been seen. The little gull (*Hydrocoloeus minutus*), the black-headed gull (*Chroicocephalus ridibundus*) and the european herring gull (*Larus argentatus*) are also observed only few during the winter.

Most of the seagulls that stay on Aurora during the winter most likely come from Russia, Finland and the Baltic States. Swedish-born seagulls essentially spend the winter along the coasts of western Europe (find map from the Ringing Centre, the Swedish Museum of Natural History's website).

Lesser black-backed gull (*Larus fuscus*) winter in eastern Africa or in the eastern Mediterranean. The species is found in the Baltic Sea area mainly between April and September. For this review, inventories carried out in 2021 and additional inventories from boats 31 May–2 June 2022 and 11 June 2023 did not register a single lesser black-backed gull in wind farm Aurora, although GOF's inventories (Hjernquist, et al., 2022) by boat found a few individuals in the wind farm area in 2022.

Common tern and arctic tern

Common tern (Sterna *hirundo*) and arctic tern (*Sterna paradisaea*) occur in the area of activity during migration, where about 100 individuals were counted in the inventory from flights on August 12, 2021. Previous studies have shown that during the breeding season, terns rarely fly longer distances than 25 kilometres from the colonies. During the summer inventory on June 20, 2021, an individual was observed within Aurora, which indicates that it is just a few occasions that this can occur of terns nesting on Öland or Gotland. (Carloni, 2018; Bartos, et al., 2020)

Other bird species

During the flights within the Aurora Wind Farm, a number of bird species have been observed in addition to those mentioned above. The observations have consisted of migrating birds or temporarily resting individuals in the project area. For example, on February 28, 2021, 22 swans (*Cygnini*) migrated to the northeast and on March 23, 2021, twelve migrating geese were counted. Isolated individuals of the Common shellduck (*Tadorna tadorna*), Greylag Goose (*Anser anser*), common goldeneye (*Bucephala clangula*), red-throated loon (*Gavia stellata*), red-breasted merganser (Mergus *serrator*), great cormorant (*Phalacrocorax carbo*) and common merganser (*Mergus merganser*) also belong to the category of temporary species.

7.3.4. Results of migration studies

Bird migration over the sea area about 30 kilometres east of Öland and about 20 kilometres south of Gotland is complex and is not easily summarized in short terms. What is unique to this part of the Baltic Sea are migratory movements involving millions of seabirds. Most of these spend the summer in the Russian tundra and the winter in western Europe. The largest knowledge base on this migration movement is based on long-standing observations by ornithologists positioned at strategically located headlands in the Baltic Sea. GPS transmitters on seabirds have provided detailed information on the flight behaviour of a limited number of individuals during migration for a few species. In a study of the spring migration of seabirds, GOF has, based on its own observations from boats out at sea in April 2022 and from land, made combined assessments of the migration routes of several seabird species in relation to Gotland (Jonsson, et al., 2022). Assessments are largely based on what can be observed from land, and where reported observations to Artportalen weigh heavily in assessments and conclusions made by the association. These are well-founded but contain the uncertainty that exists with this type of collected data.

The purpose of the migration studies carried out at Aurora has been to describe the migration about 30 kilometres east of Öland and about 20 kilometres south of Gotland and also east of Gotland. This is to investigate whether there are concentrations of seabirds in so-called migration routes and, if so, where these are located in order to better understand the basic conditions of migration and the birds' behavior during migration.

Conducted radar studies for Aurora show that there are migration routes about 30 kilometres east of Öland and about 20 kilometres south of Gotland and that in the spring there is a migration divider where migratory seabirds either choose to fly along a western route or along an eastern route in relation to Gotland. This in itself is not new information, but what is new is that there is now actual data from the above-mentioned radar studies on what these routes are likely to look like. This knowledge is of great importance to be able to assess the influence of Aurora on the migration of day migratory seabirds.

From completed studies, there is now also data for the autumn migration of migratory seabirds, which shows how the main migration route passes Öland and Gotland in relation to Aurora. Also in the autumn there is a western route and an eastern route in relation to Gotland, but where these are slightly different compared to routes in the spring. See further description of the migration routes in the following sections (examples in Figures: Figure 17 and Figure 19)

7.3.5. Results from migration studies of seabirds

The following section initially describes the main migration routes for birds during spring and autumn in the area about 30 kilometres east of Öland and about 20 kilometres south of Gotland based on inventories carried out. The migration patterns of specific species are then described and finally differences in migration during day and night time are described.

Spring migration

The results from radar studies show that when the seabirds pass the southern tip of Öland, the average flight direction is 65° and that this direction is maintained up to at least twelve kilometres, which was the distance the birds could be followed by radar. If seabirds maintain this direction of flight all the way past the Aurora, they will fly south of the Aurora as they follow the eastern route.

Radar data collected from a position five km southwest of Aurora and 50 km northeast of Öland's southern cape in the spring of 2023 showed that the flight direction for seabirds was the same as at Öland's southern cape, which provides further support for the assessment that the passage takes place south of Aurora.

The flight directions collected at a position in the spring of 2022 in the southern part of Aurora showed that the flight direction was slightly more northerly than at the position southwest of Aurora, which may be an adjustment in relation to Gotland's southern cape. The seabirds that chose the western route passed the northwestern part of the Aurora with an average flight direction of 37°, which in the long run leads to them making contact with the west coast of Gotland at the height of the Eksta coast and the Charles Islands. If the seabirds are to fly the shortest distance up to the west coast of Gotland after passing the southern tip of Öland, they must turn towards a more northerly flight direction before arriving at the Aurora Wind Farm. Radar data indicate that this is also the case for most migratory seabirds, as illustrated in Figure 16 which shows flight directions for birds that were followed by radar at the southern tip of Öland in the spring of 2022. In Figure 16 it can be noted that already at the southern tip of Öland there are flight directions of migrating seabirds heading towards the west coast of Gotland and thus in a direction that goes west of Aurora.

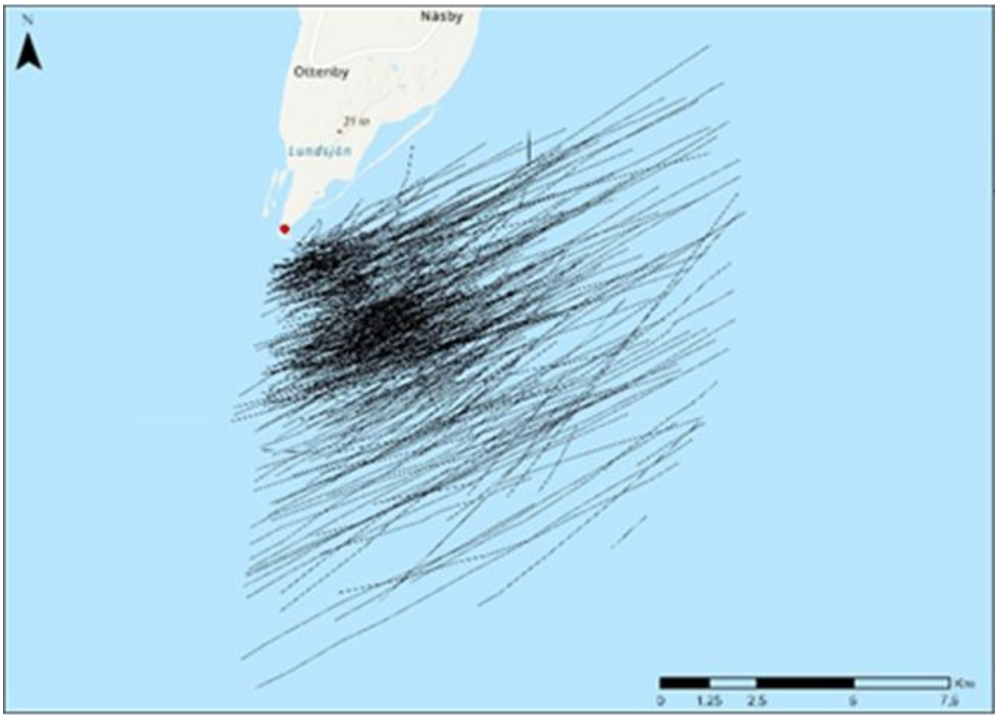

Figure 16. Flight directions for birds followed by radar at the southern tip of Öland in spring 2022. Each black line in the map image corresponds to a radar tracking of flying birds. Data analyzed by DHI.

According to radar studies, some of the seabirds pass through Aurora, which GOF has also noted in their studies from boats in spring 2022. These make up a smaller proportion of the total amount of seabirds that pass between the southern tip of Öland and Gotland during the spring. This proportion is difficult to quantify, but the map Figure 17. exemplifies where migration routes for brant geese (*Branta bernicla*) are estimated to be located and shows that the majority of brant geese that passed through the southern tip of Öland in May 2022 followed the eastern route of Gotland. Data from May 2023 confirmed this migration pattern for brant geese. Main migration routes for migrating seabirds are largely considered to follow the same pattern, see red arrows in the map in Figure 17.

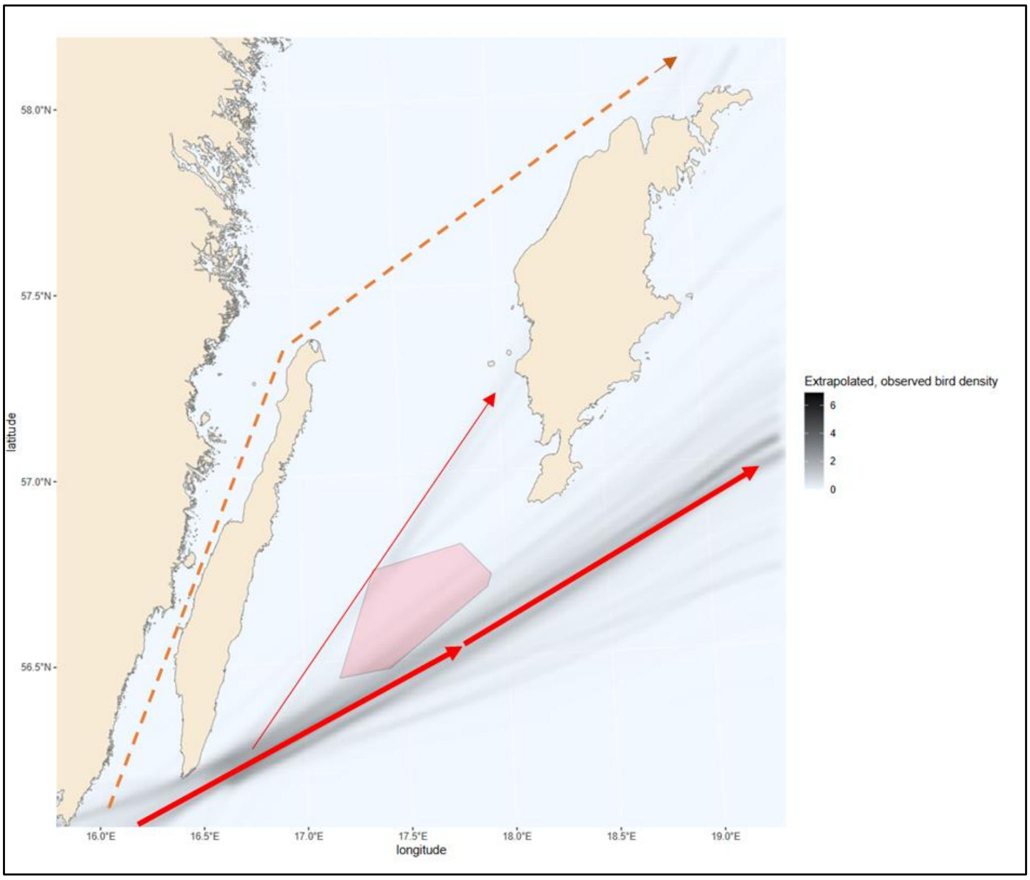

Figure 17. Radar data on migrating brant geese was collected in the spring of 2022 at four different positions about 30 kilometres east of Öland and about 20 kilometres south of Gotland and one position east of Gotland. Most of the brant geese flew south of Aurora and continued east of Gotland south of Gotland's southern cape. A small proportion of brant geese touched the northwest corner of Aurora and continued in the direction of the west coast of Gotland at the height of the Karlsöarna, and a few more flew through Aurora in the southern part. Modeling performed by DHI. The brown dotted line corresponds to an alternative flight route through Kalmarsund further to the northeast and northern Gotland. Modeling regarding the migration routes of the brant geese is carried out by DHI, shown in the map as gray - black lines. Red arrows show where the main migration routes for migrating seabirds are estimated to go during the spring migration, the thickness of arrows corresponds to the number of birds. Brown dashed arrow corresponds to an alternative flight path through Kalmarsund further to the northeast and northern Gotland.

The modelling of radar data has assumed that migratory seabirds continue in the direction recorded at the observation points where radar has been active (DHI, 2023a; DHI, 2023b). Since no significant flight course changes have been observed in radar tracking made by individual birds or flocks up to 12 km, our assessment is that the assumption of a stable flight course is reasonable and that the modelling thus provides a relevant basis.

The expected reaction to the Aurora Wind Farm is that seabirds adjust their flight course slightly so that they pass outside the wind farm.

Fall migration

During the autumn of 2022, radar tracking was carried out at four points, three of which were at sea according to Figure 18. The main flight direction in the fall was to the southwest. Seabirds that followed the eastern coast of Öland had a more southerly flight course before rounding the southern tip of Öland.

The autumn migration of migratory seabirds mainly affects eastern Öland, where high numbers of seabirds are observed from several localities along the coast. Often, winds from the east mean that migration is closer to land and winds from the north mean that seabirds fly further out from the coastline and are then mainly observed as "horizon birds". This migration is mainly concerned by seabirds that follow a westerly route that does not pass through the Aurora. The barnacle goose (*Branta leucopsis*) is an exception where the migration corridor overlaps to some extent with Aurora in the autumn. The seabirds that fly east of Gotland follow the coastline at a shorter distance compared to spring, which means that they round southern Gotland so that they pass through the Aurora wind power area to a greater extent than in spring. However, the main route along the eastern route still runs beyond Aurora.

The number of individuals of seabirds was lower in the eastern route passing southeast of Aurora compared to those passing along the eastern coast of Öland, see Figure 19. Counted bird individuals indicate that about one-third of the seabirds passed southeast of or through the Aurora and two-thirds west of the Aurora near the eastern coastline of Öland. There were also no flight movements with the radar through the Aurora from the north. The main migration routes for migrating seabirds during the autumn are illustrated with red arrows in the map in Figure 19.

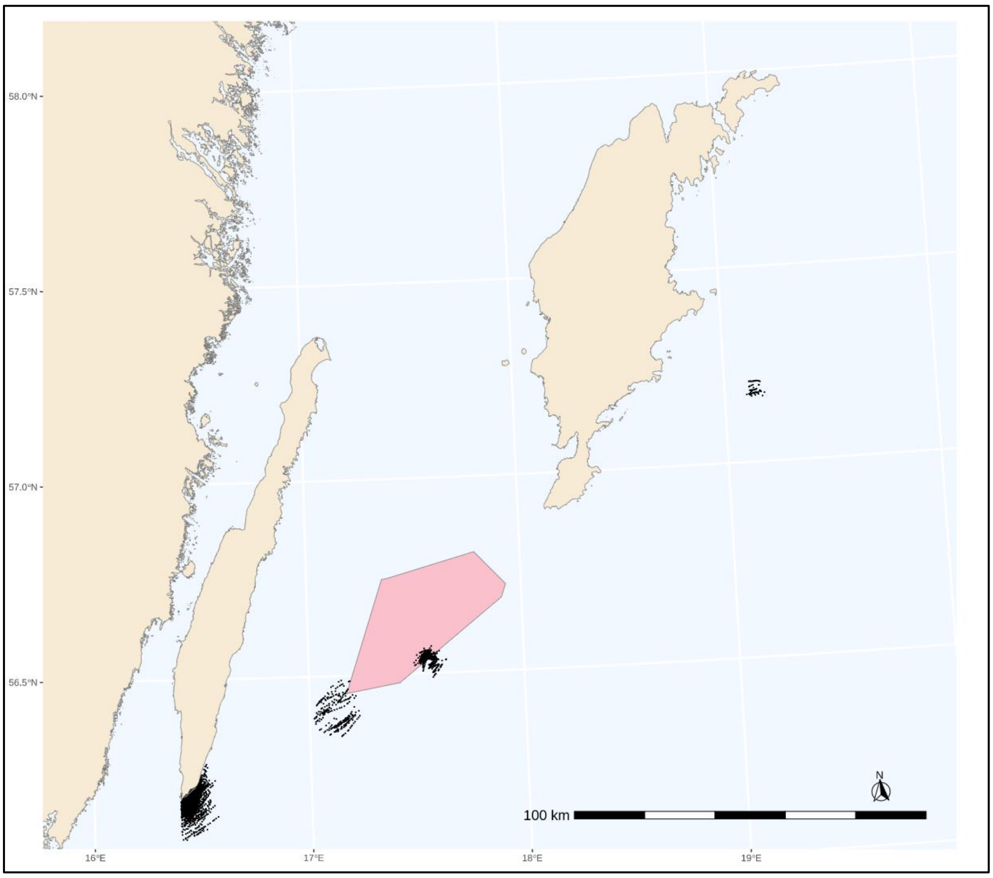

Figure 18. Radar data for migrating seabirds was collected during the autumn of 2022 at four different positions between Öland and Gotland. Map produced by DHI.

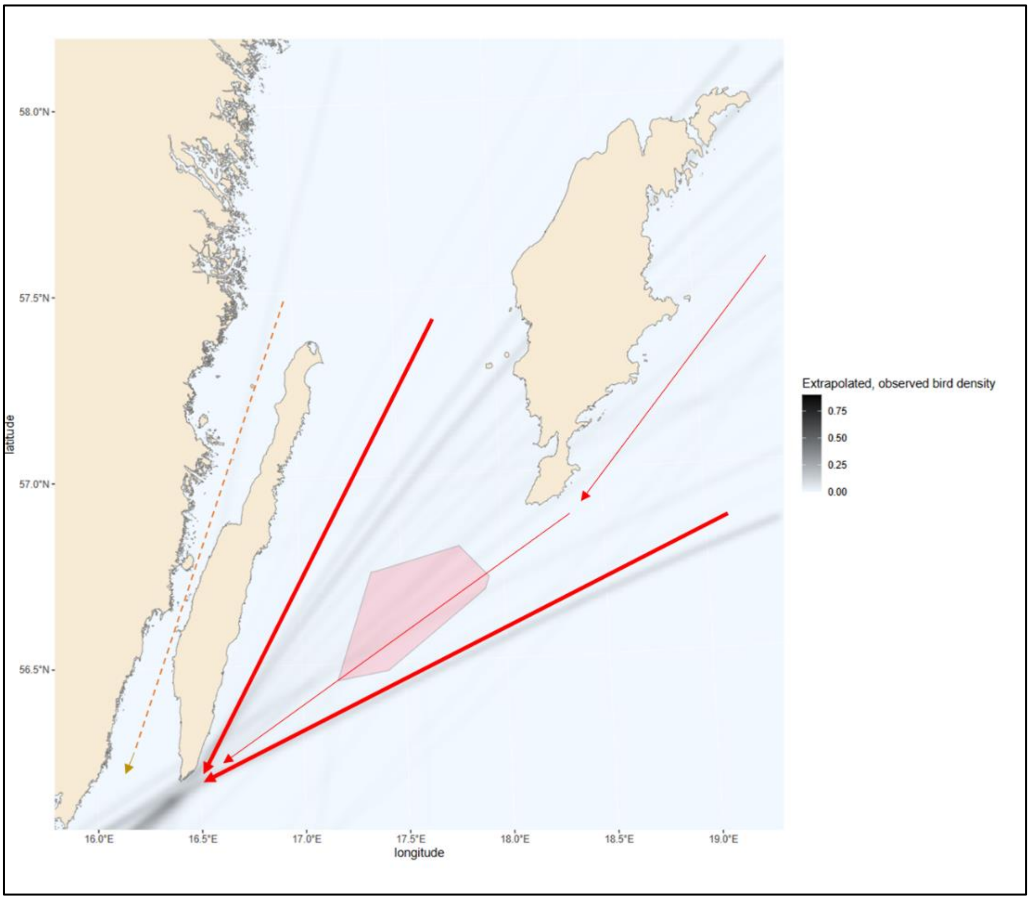

Figure 19. Modelling of migration routes for migratory common scoter (Melanitta nigra) based on radar data collected during the autumn of 2022 at four different positions between the southern tip of Öland and southeast of Gotland. About half of the sea urchins are estimated to have passed south of the Aurora, while the same number passed west of the Aurora. A few flocks had flight directions that involved passages through the Aurora. Modelling regarding sea urchins' migration routes is performed by DHI, shown in the map as grey - black lines. Red arrows show where the main migration routes for migrating seabirds are estimated to go during the autumn migration, the thickness of arrows corresponds to the number of birds. Brown dashed arrow corresponds to an alternative flight path through Kalmarsund.

Species migration patterns

An assessment of the transboundary impact of Aurora on migratory bird species through the operational area concerns in particular some species that have significant wintering areas in Danish, German and Polish sea areas in the Baltic Sea. In the future, species-specific reports will be made on the species deemed relevant.

Long-tailed duck

Seasonal migrations of long-tailed duck on their way to and from wintering areas further south in Swedish, Danish and German waters, can pass through the Aurora on two occasions per year. Long-tailed ducks wintering in the Baltic Sea spend the summer breeding on the Russian tundra. After breeding, long-tailed ducks change feathers (moults) before migrating to the Baltic Sea via the White Sea and the Gulf of Finland. The first individuals arrive in September, but the large influx takes place in October-November. When long-tailed ducks reach the Baltic Sea in the Gulf of Finland, there are two alternative flight routes to the south. The shortest distance for the long-tailed ducks is going to the Gulf of Riga, the eastern coast of Gotland, Hoburgs bank, Södra Midsjöbanken, Slupsk bank and the Polish coast, is to fly east of Gotland, where there are also many suitable foraging areas along the way. The long-tailed ducks that are going to the Swedish east coast, Öland or on to Blekinge, Skåne and Denmark are estimated to fly west of Gotland to fly the shortest distance.

Telemetry studies of long-tailed ducks conducted in winter along the southern Baltic coast and published in Quillfeldt et al. (2021) indicates that there are more long-tailed ducks using the flight path east of Gotland than those flying west of the same island. This is reasonable based on the reasoning about the shortest migration distance in the previous paragraph. The long-tailed ducks that choose the eastern route will not pass the Aurora Wind Farm, while those that fly west of Gotland can do so if they fly closer to the west coast of Gotland in the autumn to get to, for example, Norra Midsjöbanken.

The visual counts carried out by Ottvall from a boat in autumn 2022 and spring 2023 indicate that about ten times more long-tailed ducks in both spring and autumn choose to migrate east of Gotland compared to about 30 kilometres east of Öland and about 20 kilometres south of Gotland in the western migration route, see Figure 20. The data available from land-based counts and telemetry studies also show that long-tailed ducks to a greater extent pass east of Gotland than between Öland and Gotland.

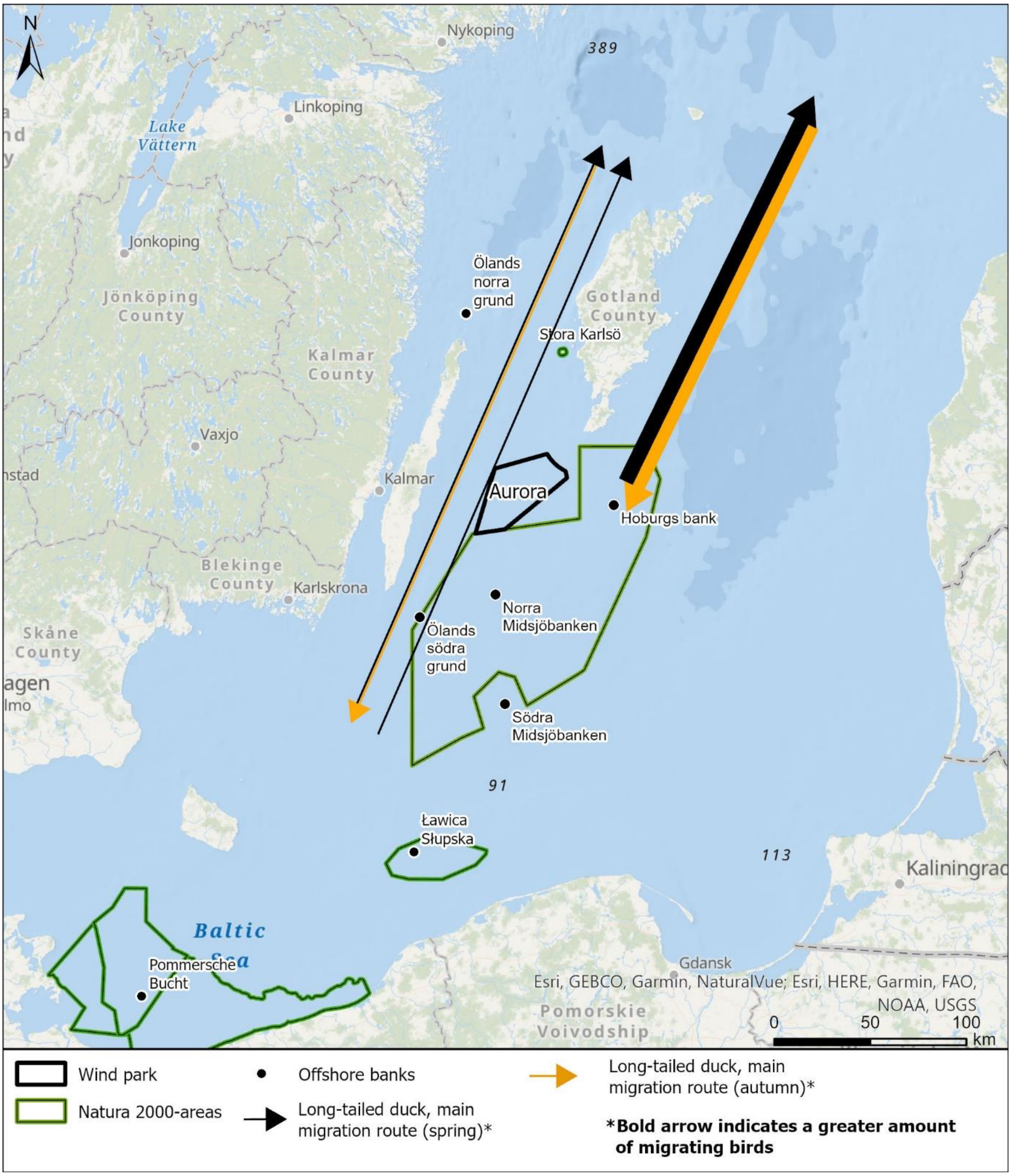

Figure 20. Schematic overview of long-tailed duck migration routes in the Baltic Sea area in relation to the Aurora Wind Farm and relevant Natura 2000 sites. Passage of long-tailed ducks through Aurora can occur at the annual migration occasions and the impact is assessed according to a worst-case scenario based on both barrier effect and collision risk.

Common eider

The common eider has a more northerly flight direction in the spring where they mainly continue north in the Baltic Sea towards the archipelago of Stockholm, Åland and Finland. About 80% of the common eider pass north through Kalmarsund, and among the other 20% that fly east of Öland's southern cape, the majority take the western flight path past Gotland. These eiders then interact with Aurora Wind Farm in the northwest corner of the park. In the autumn, most of the common eider fly east of the eastern coast of Öland, but by a margin west of Aurora. A relatively large proportion passes off the eastern coast of Gotland in the autumn and interacts with Aurora Wind Farm in the south, an air route that is only used to a lesser extent in the spring.

Black-throated loon and red-throated loon

Inventories from airplane carried out in 2021, together with previously conducted studies, show a sparse occurrence of black-throated loon (*Gavia arctica*) and red-throated loon (*Gavia stellata*) in the Aurora Wind Farm area. Studies show that the main corridor for the migration of these birds has been east of Gotland.

Unlike most other seabird species, many black-throated loons migrate to eastern Europe in autumn, meaning that the dominant flight direction in spring is north-northwest rather than east-northeast. In autumn, the flight direction is reversed, towards south-southeast rather than southwest, which is otherwise the dominant flight direction among seabirds in autumn. However, there are considerably more, probably a magnitude more, bighorns flying east of Gotland and at a long distance from Aurora.

Barnacle goose

Barnacle geese migrate about 30 kilometres east of Öland and about 20 kilometres south of Gotland on a broad front and often fly straight over the islands and do not always turn off and change course on arrival at the coastline.

The barnacle geese that pass through the southern tip of Öland in the spring with an east-northeast flight direction largely follow the migration route in the eastern air corridor south of the Aurora but with birds that also pass straight through the Aurora (Figure 21).

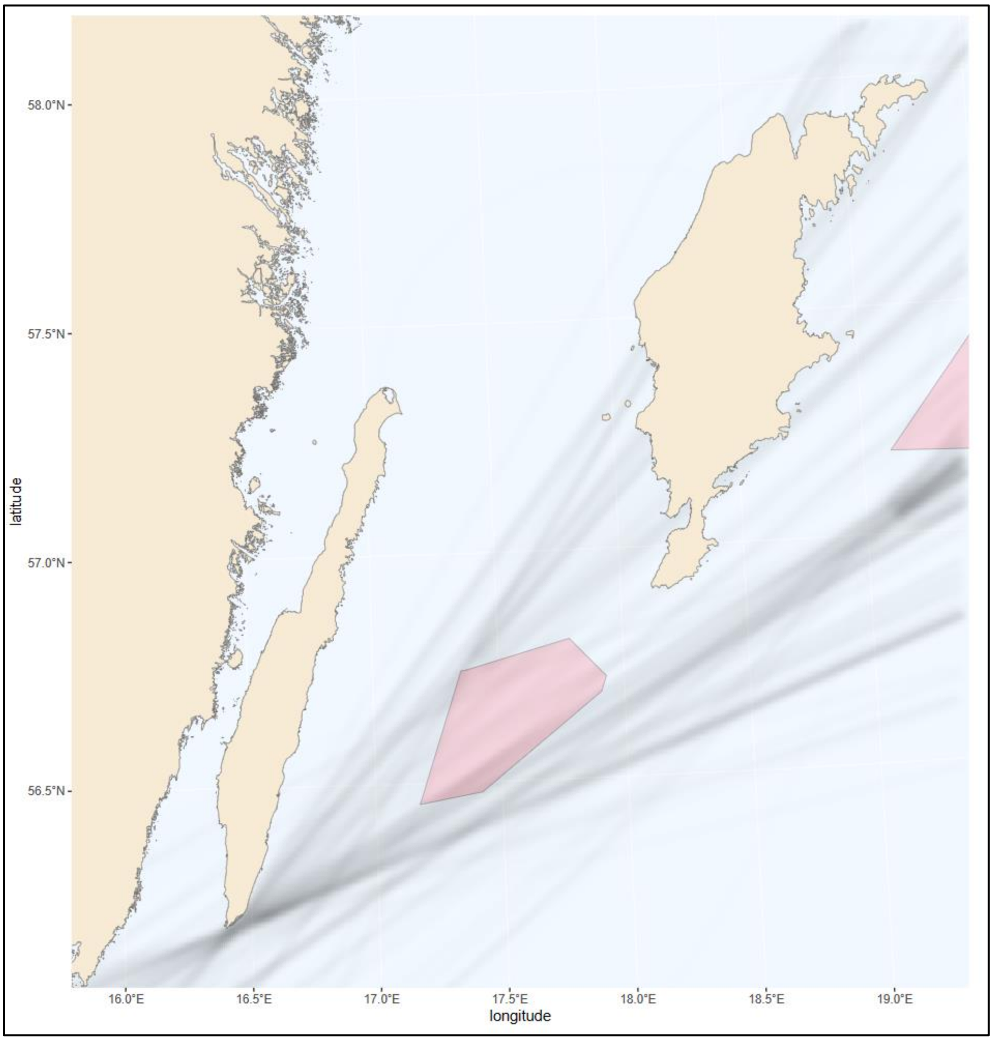

Figure 21. Modelling performed by DHI of migration routes for migrating barnacle geese based on radar data collected during the spring of 2022 and 2023 at five different positions between the southern tip of Öland and southeast of Gotland. Slightly more than half barnacle geese are estimated to have passed south of Aurora, while almost as many passed west of Aurora. Some flocks had flight directions that involved passages through the Aurora.

Birds of prey

Birds of prey use thermal winds in migration, which means that they use a technique of circling in rising hot air and then gliding for varying distances with rising warm air. Birds of prey therefore prefer to move over land as far as possible. Both in spring and autumn, migration of birds of prey takes place on a broad front over southern Sweden, but the majority passes to a significant extent via Skåne. In northern Europe, the Falsterbo Peninsula in autumn and Skagen in Jutland in spring are known for a significant concentration of migratory birds of prey. Gotland with its isolated location is not subject to any significant migration of birds of prey (Hansson, 2019).

Information about the migration of birds of prey about 30 kilometres east of Öland and about 20 kilometres south of Gotland has been reported to Artportalen. On Sudret, which is the southernmost cape of Gotland, there are reported daily totals of recorded birds of prey in the autumn. For example, the highest daily totals have been 11 individuals of hen harrier (*Circus cyaneus*), 93 individuals rough-legged buzzard (*Buteo lagopus*), 100 individuals Eurasian sparrowhawk (*Accipiter nisus*), 257 individuals common buzzard (*Buteo buteo*) and 25 individuals common kestrel (*Falco tinnunculus*). These daily totals are not from the same day but are reported for different dates.

During the migration study, hen harrier, rough-legged buzzard, Eurasian sparrowhawk, common buzzard and common kestrel were observed from land. The conclusion from the land-based migration studies shows that the main migration route is located east of Gotland and not within the Aurora Wind Farm.

Crane

Cranes (*Grus grus*), like birds of prey, use thermal winds for transport. Thus, cranes are forced to use active flight when crossing the open sea on the Baltic Sea, but also during days with weak thermal development over land. Migration of cranes takes place on a broad front over southern Sweden, the largest majority over the southern coast of Skåne.

Data on the migration of cranes about 30 kilometres east of Öland and about 20 kilometres south of Gotland are reported to Artportalen (Artportalen, u.d.). In the spring, there are no large accumulations of cranes on Öland and Gotland, as they pass by to the breeding grounds without stopping. Migration movements have been observed several autumns from the southern part of Gotland towards the southwest in the direction of northern Öland, at most around 1,200 individuals in 2021. A compilation of the number of reported cranes in the autumn that are estimated to leave Gotland has for the period 2002–2021 been an average of 537 individuals. During the spring, a maximum of 118 cranes have been observed passing through Gotland during migration.

The cranes' migration routes probably pass north of Aurora where the distance over the open sea is shortest. Northerly winds can cause more cranes to fly over to Öland further south and near or within Aurora.

Daytime and night time migration

Seabirds not only migrate in daylight, but also fly regularly at night. Regardless of the time of day, seabirds often fly together in groups. During the day, they prefer not to fly over land, which means that seabirds adapt flight paths to the coastlines. Thus, both Öland and Gotland are migration dividers where seabirds choose different flight paths depending on the final destination.

All birds want to migrate in the best possible weather conditions, which usually means weak tailwinds and clear weather. At the same time, birds sometimes encounter fog or heavy precipitation. Seabirds flying over the sea can then lie down on the water and wait until the bad weather conditions pass by, while night migratory small birds cannot do this (as they lack swimming ability) but must fly on. If it is only a question of a local fog bank, seabirds can be observed flying around the fog bank and it is likely that small birds do the same (e.g. according to radar study conducted in Kalmarsund, Vindval report 6589 and Pettersson 2005).

Night migratory small birds usually fly sparsely and scattered without gathering in groups. Of importance for assessing the potential impact of the Aurora Wind Farm is that the number of night migrating small birds that cross the sea about 30 kilometres east of Öland and about 20 kilometres south of Gotland in the autumn is clearly linked to wind direction. An autumn dominated by winds from the east means that more small birds drift across the Baltic Sea instead of following the coastline along the Baltics and Poland. The night migration of small birds takes place on a broad front without following migration corridors as seabirds do, which according to the present studies also applies to Aurora. (Gezelius & Hedenström, 1988)

Night migratory birds – small birds

The radar study of the night migration of small birds at sea, which covered eight nights in September-October 2022 and 14 nights in April-May 2023, is estimated to have resulted in qualitative and representative data. On most of the studied nights, the migration activity of migrating small birds was low, but on isolated nights large numbers of migratory small birds were recorded.

During the autumn, there was very high activity during two nights (28–29 September and 21–22 October), when a large proportion of the birds were also found at altitudes below 370 m.

The flight altitudes of small birds at night varied slightly between different nights depending on weather conditions and which species were active on specific nights. Also in the spring study, a shorter occasion was recorded with a large number of birds circling the boat at what was probably a precipitation front that passed for an hour on the night between 24-25 April 2023.

Flight altitudes were generally slightly higher in spring 2023 when about 30% of birds flew at rotor altitude up to 370 m altitude compared to about 45% in rotor height in autumn 2022, nights with low-flying birds attracted to the boat's light not included. These flight altitudes are on par with what has been recorded in other radar studies (Bruderer, et al., 2018).

7.3.6. Precautionary measures

The precautionary measures suggested by the company will be implemented in accordance to commitments in the application.

7.3.6.1. Alternative design and free passages

The wind farm is not located within, but along the main flight direction of seabirds, which in spring is to the northeast and in autumn to the southwest, which means a limited impact in terms of barrier effect and impact on seabirds. According to documentation prepared for the application, migratory birds are expected to largely choose to fly around the wind farm, with a limited barrier effect as a result and negligible consequences.

Alternative designs, including free passage through the wind farm, are therefore not considered to be an effective measure to avoid and minimise the impact on migratory species.

7.3.6.2. Turbine regulation

Bird protection systems and adaptation of turbine regulation

Bird protection systems that can be used in offshore wind farms have been applied differently for several years but are still under rapid technological development. It is therefore not appropriate to already today account for exactly which system can be used when starting up Aurora because a lot of technical development will take place and experiences of different technologies will be evaluated before it is time to procure these for Aurora. The intention is to use a system that can identify birds and then adjust the rotational speed of the wind turbines, not to stop them completely.

Weather-controlled systems are already being used in different places in the world to use modelling to warn when weather conditions are favourable for high migration activity and thus potential collision risks for small birds. The accuracy of these models is currently not at such a level that it is only warned on nights where there is in reality an extensive night migration at relevant flight altitudes, i.e. at rotor altitude. Thus, there is a risk that energy production, and the main very positive environmental benefit of wind power, will be significantly reduced without actually providing the protection for birds that is the objective.

An alternative to weather-based systems for adapting wind turbine production is the use of, for example, radar for monitoring bird migration on site. The night migration of small birds is studied with vertical radar or 3D radar where flight altitudes and migration flow are recorded.

There are also automatic collision sensor systems installed in some offshore wind farms (e.g. in Taiwan), which detect a collision, and with cameras simultaneously take pictures where a bird or bat can be identified. This could also be one of several systems that can contribute to optimize operational control.

For migratory birds, a system can be used that combines digital cameras, AI and radar technology to detect, identify and follow birds during an air passage through the wind farm. This technology has been around for a few years and is under rapid development. Since the technology can regulate the operation of individual wind turbines where a risk of collision may arise, the loss of production is limited.

Scope of turbine regulation

Day migrating geese, birds of prey and cranes

The operating control that the company has undertaken to implement and use for Aurora refers to 3 hours on average per wind turbine. This means a total possible operating time of 1110 hours with a wind farm comprising 370 wind turbines. The purpose of the turbine regulation is to reduce the risk of collision for migrating cranes, birds of prey and, on occasions with large numbers of migrating geese. The number of migratory cranes and birds of prey about 30 kilometres east of Öland and about 20 kilometres south of Gotland is relatively low, but they are birds that a technical system can identify with high certainty and operating control can be used at the specific wind turbines where the birds may be on a collision course.

Migratory seabirds are mainly expected to pass off the coast of Aurora, but it is likely that occasions may arise when geese, especially barnacle geese, may choose to fly in the direction of Aurora. *In the first instance* , the assessment is that geese adjust the flight course and fly around the wind farm so that the risk of collision is avoided altogether. *Secondly,* geese can choose to fly through parts of the wind farm as the separation distance between wind turbines is large. The purpose of the operating control is to reduce the risk of collision on such isolated occasions.

The turbine regulation time is considered to be ample for migrating cranes, birds of prey and geese as there is no need to regulate the entire wind farm at the same time and that the birds' expected reaction to the wind farm is to largely avoid a passage through it.

Small migratory birds

The results of the studies of night migratory birds show that during certain nights a very large number of birds pass by, and that 30-50% of them pass at rotor height depending on the season, species composition and weather conditions. This indicates that there may be a need for protective measures to be applied, such as turbine regulation, during occasions of very high night migration at rotor height.

The company proposes a condition regarding turbine regulation for the protection of night migratory small birds, during spring and autumn migration, with up to a maximum of 10 hours/wind turbine/year (calculated on average per wind turbine), or a total of 3700 hours per year if 370 wind turbines are built in the wind farm.

In order to provide effective protection against collisions between night migratory birds and the rotor blades of the wind turbines, it is considered reasonable to regulate the operation of the wind turbines during large migratory flows, and when it is at the same time weather conditions with reduced visibility (fog, precipitation) that affect the birds' flight behavior.

The scope of the proposed operating control for Aurora is considered reasonable based on previous studies' results of night migration of small birds at sea, which is developed below.

Nine years of radar studies at ten existing wind farms in the German Baltic Sea and the North Sea (Welcker & Vilela, 2019). indicates that 27% of all collisions can be prevented by operational control when the migration flow exceeds 500 MTR, which in the conducted study occurred about 30 hours annually. In light of the study, it is reasonable to assume that the actual collision risk is linked not only to migratory flows (i.e. the number of migratory bird individuals), but also to weather conditions. The risk of collision can be assumed to be particularly high in the event of reduced visibility, precipitation or similar weather conditions affecting the birds' ability to orientate or fly behaviour. The German study indicates that such special weather conditions occur simultaneously with high migration activity between 0.5 - 8 hours per year, depending on which weather conditions are considered to affect the birds' behavior and what is a high migration flow.

Radar data from a Belgian offshore wind farm indicated that a flow of night migratory small birds exceeded 500 MTR for a total of 14 hours in autumn 2019 and not at all in spring 2021 (Brabant, et al., 2021). Inventories during the spring at Aurora 2023 showed that night migratory birds' flight altitudes were significantly higher than in autumn. Thus, operational regulation is expected to be relevant mainly in the autumn.

Based on the above-mentioned studies, as well as the results from own inventories of night migratory small birds in the area of the Aurora Wind Farm, the proposed operating control for the protection of night migratory birds, of up to 10 hours per wind turbine and year, is considered to be well adapted to constitute a sufficient protection measure for night migratory birds. However, it is necessary to continue monitoring migration in the area and the possible impact on night migratory species within the framework of a survey programme. Based on the results of the survey programme, the level of operating control may need to be adjusted. Such a possibility is proposed within the framework of a delegation condition.

With regard to turbine regulation and survey programmes in general, the proposed conditions are considered sufficient to minimize the impact on bird life.

7.3.7. Transboundary environmental impact

The transboundary impacts of wind farms on birds are divided into three impacts: collision risks, displacement effects and barrier effects, which are described in more detail in Section 6. All assessments of transboundary impacts on bird species are based on the evidence and studies compiled.

For each impact, a number of reference species are assessed. The species selection has been made based on birds that occur regularly in Aurora, have a documented sensitivity to wind power, and to obtain a varied group of species with different behaviors, sizes and migration strategies.

Construction phase

In the construction phase, the wind turbines are built gradually, which means a local impact for a limited time. Vessel activity will be slightly higher than the existing one, with nearby vessel routes and fishing activities. The wind turbines are put into operation on an ongoing basis as they are connected, test-run and start producing electricity as they go.

Collision risks

Collision risk refers to the risk of birds being hit by the rotor blades of wind turbines in operation. Birds sometimes fly into the towers of the works, but this normally makes up a limited proportion of all collision cases. During the construction phase, there is a theoretical risk that birds will collide with the wind turbines even though they have not been put into operation, but this risk is considered negligible in Aurora. The risk of collision with rotor blades only becomes relevant when the turbines are in operation, assessment of the impact of the wind turbines in operation is made within the framework of section 7.3.6.2 below (Rydell, et al., 2017).

In the event of a gradual expansion of the wind farm over several years, the installation of wind turbines can be done in a sequence where the wind farm takes different forms (for example, U-shape or L-shape). A U-shape may mean an increased collision risk during the autumn for migrating birds that do not fly around the wind farm but continue into the U-shape. When the birds encounter wind turbines in the southern part of the wind farm, they are expected to fly through the wind farm. The assessment is that a U-shape has a marginal impact on migrating birds as the number of bird individuals that pass near the west coast of Gotland in the autumn is relatively few (own radar studies) and that clearance of 30 metres below the bottom tip of the rotor blades means that the risk of collision for seabirds is small.

As the risk of collision is deemed to be negligible during the construction phase, the transboundary impact during the construction phase in terms of the risk of collision is deemed to be negligible.

Displacement effects

During the construction phase, vessel activity and work linked to the wind farm are estimated to constitute a marginal impact in relation to already existing vessel activity. Several studies have investigated the extent to which different seabirds are disturbed by vessel activity, which can potentially displace birds from the park area. Loons have largely been shown to avoid areas with high ship activity, while auks are not as sensitive (Dierschke, et al., 2011; MMO, 2018). Auks, though probably not loons, can wean themselves to some degree of repeated interference from ship activities (MMO, 2018). Displaced birds seek other nearby areas

Activities in the construction of the wind farm are considered to have little negative impact on auks staying in the area of operation. The same applies to long-tailed ducks that are not estimated to winter within Aurora but can temporarily stay in the area. The number of individuals of these species is low in the field of activity, the large water depth of which implies poor conditions as a habitat. Displacement effects at construction are considered to have an insignificant impact on birds even during the summer months when only a few bird species stay this far out at sea, and then in low densities. These bird species are mainly gulls and gulls as well as migrating terns, all of which are little affected by vessel activities, and displacement from the park area by the same.

Overall, displacement effects may occur to a small degree during the construction phase, this phase is also short in relation to the operational phase. The transboundary impact of displacement during the construction phase is considered negligible.

Barrier effects

The risk of impact of barrier effects is initially very limited but increases as more wind turbines are completed. However, it is only in the final phase of the construction phase, when wind turbines occupy an increasing part of the operating area, that barrier effects can occur for migrating birds. At the same time, the construction phase represents a limited period of the overall life of the wind farm and any barrier effects are mainly relevant to the operational phase. The magnitude and extent of the impact is therefore considered insignificant. The transboundary impact of barrier effects during the construction phase of the wind farm is estimated to be negligible.

Operational phase

Collision risks

The collision risk for a number of species and species groups was calculated with the collision risk modelling in accordance with the Band model. The modelling used a double worst-case scenario regarding the design of the wind farm, which means 370 wind turbines with a total height of 370 metres. This scenario is very unlikely because wind turbines of that size cannot be placed so tightly. This means that the impact of collision risks is in all likelihood overestimated in the modelling.

Wintering seabirds (not long-tailed duck)

During the summer months, an insignificant number of seabirds are expected to occur in the operating area. The low incidence of individuals means a very small risk of impact of collisions and therefore the consequence is estimated to be negligible during the summer months. Throughout the year, auks (common murre and black guillemots) are expected to occur in low numbers. Auks fly low above the water surface, i.e. lower than the sweep surface of the rotor blades, with little risk of collision as a result. The risk of collision is considered to be insignificant and the transboundary impact negligible. (Fox & Petersen, 2019)

In addition to the above-mentioned species, low numbers of little gulls, common gulls, herring gulls and great black-backed gulls are expected to occur in the Aurora Wind Farm during the winter. Their presence in the area is mainly linked to fishing boats, as gulls seek them out to find food. Taking into account the low number of individuals and flight altitudes largely lower than 30 metres, the impact of the collision risk is considered to be insignificant and the transboundary impact is therefore negligible.

Long-tailed duck - Wintering and migratory

Aurora is located in an area where no or a very small number of wintering long-tailed ducks occur. The long-tailed ducks that occur in the Aurora probably use the area as a temporary resting place. The birds in the area can pass the wind turbines repeatedly and thus be exposed to collision risks. Seasonal migrations of long-tailed ducks on their way to and from wintering areas further south, in Swedish, Danish and German waters, can pass through the Aurora and be subject to collisions on two occasions per year. The extent to which the species' migration route passes through the Aurora is less known. Therefore, a worst-case scenario, with regard to how many individuals may pass through Aurora, was chosen when modelling the collision risks for migrating long-tailed ducks within the Aurora Wind Farm.

There are two characteristics that make the local long-tailed ducks less susceptible to collisions. The first is that the number of individuals wintering in the aurora is low. The second is that the species is low-flying, the majority fly lower than 20 metres altitude, where the proportion that passes the rotor-swept zone of a wind turbine, with a clearance of 30 metres, has been set at 2 percent.

Estimates of potential collisions for local long-tailed ducks have been assessed based on modelling. Waterfowls have a high avoidance rate, for example, 99.3 percent or even higher than 99.9 percent (Krijgsveld, et al., 2011). An avoidance rate of 99.5 percent has been assessed as a realistic scenario for long-tailed ducks (SmartWind, 2013). Modelling on this avoidance rate provides an estimate of one collision per year for wintering long-tailed ducks and three collisions per year for migratory long-tailed ducks.

The estimated maximum number of collisions represents less than 0.01% of the species' biogeographical population (Wetlands International, 2022). Consequently, the magnitude and extent of the impact are deemed insignificant. Consequently, the transboundary impact of collisions on resting and migrating long-tailed ducks is considered to be negligible.

Migration geese

Populations of barnacle geese that nest on the Russian tundra pass through Öland and Gotland in high numbers during migration. The barnacle geese usually have a more southerly migration route, via the German coast, but can in certain weather conditions pass close to the coast of Öland and Gotland. There are some more species of geese that cross the region during migration, for example, brant geese.

Modelling of collision risks has been done for barnacle geese and brant geese, where an avoidance rate of 99 percent has been used. For barnacle geese, modelling of collisions with wind turbines in Aurora resulted in 465 collisions per year and for brant geese 45 collisions per year. This scenario is a worst-case scenario as the number of individuals assumed in the collision risk model to pass through Aurora is significantly higher than the number of individuals that inventories have shown pass through the area.

The estimated number of collisions is low given the large size of the biogeographical populations concerned, representing less than 0,03 % of the population of barnacle geese and less than 0,02 % of the population of brant geese (Wetlands International, 2022). The transboundary impact is therefore deemed to be negligible. The transboundary impact on the greater white-fronted goose (*Anser albifrons*), bean goose (*Anser fabalis)* and greylag goose (*Anser anser*) is also considered to be negligible. Overall, the transboundary impact of collisions within the Aurora Wind Farm for migratory geese populations is estimated to be negligible.

Migratory eider

The eiders that pass through the Aurora area during migration breed in the Finnish and Swedish archipelagos. The common eider is the duck bird that is counted in the highest numbers along Skåne's southeast coast, however, the decrease has been sharp during the 2000s (Wirdheim & Green, 2020). The behaviour of migrating eiders in relation to offshore wind farms has been thoroughly studied (Fox & Petersen, 2019). They avoid flying near wind turbines and the risk of collision is thus small. An avoidance rate of 99.5% has been used in collision risk modelling. The model for the collision risk for migrating eider at Aurora shows three collisions per year.

Consequently, a very small part of the Baltic eider population is estimated to collide with wind turbines within the Aurora every year (Wetlands International, 2022). Three individuals represent far fewer than 0.01 percent of the breeding eider population in the Baltic Sea. Therefore, the transboundary impact on migrating eider in terms of collision risk is considered to be negligible.

Migrating waterfowls (not long-tailed duck and eider)

Due to the depth of the water, no waterfowls (anseriformes) regularly forage at the area of Aurora windfarm. Therefore, modelling of collision risks has only been done in relation to migratory individuals. As an example, one of the most numerous species within each species group, diving ducks and swimming ducks, namely common scooter and Eurasian wigeon (*Mareca penelope*), is presented here. Seasonal migrations of common scooter and Eurasian wigeon, can pass wind farm Aurora. A worst-case scenario was used that assumes the corridor encompasses the Aurora to model the collision risks.

According to data from DHI, a large majority of common scooters fly below 20 metres altitude, and the percentage passing through the rotor-swept zone for a wind turbine with a clearance of 30 metres was set at 1 percent (Zydelis, 2014).

Waterfowls have a high avoidance rate, where an avoidance rate of 99.5 percent has been used in collision risk modelling. The estimated number of annual collisions for common scooter and Eurasian wigeon is one collision for each species, representing less than 0.01% of the species' biogeographical populations (Wetlands International, 2022). Thus, the transboundary impact of collisions for migratory ducks, such as common scooter and Eurasian wigeon, is considered to be negligible.

Tundra swan

Tundra swans (*Cygnus colombianus*) occur in Sweden only during migration and breed on the Russian tundra. The species, like several of the geese, has increased in number, which is also noticeable in the behavior during the migration through Sweden towards wintering areas in Western Europe. It has a similar behavior towards wind farms such as geese and eider with a clear avoidance, where the avoidance rate of 99 percent was used in the modeling (Fijn, et al., 2012). Wind farm Aurora is not located along the main migration route, which makes it likely that the risk of collisions is lower and rather zero (Griffin, et al., 2016). Thus, the transboundary impact regarding the risk of collision for the tundra swan is considered to be negligible.

Migrating gullbirds

Gulls fly into wind farms to a greater extent than most other birds, but fly at low altitudes with an overall relatively low risk of collision. An avoidance rate of 99 percent has been used in the modelling. The more numerous species in the area of activity during migration are black-headed gulls, with large populations in Eastern Europe. Little gulls occur more sporadically and in varying numbers in Aurora. With an avoidance rate of 99 percent, the number of collision cases for little gulls is estimated at zero.

It is likely that isolated collision cases may occur of the more numerous species of black-headed gulls and common gull. Transboundary impacts due to collision risk are considered negligible for all species of gulls that regularly occur in the operational area, as they have a strong avoidance behavior for wind turbines.

Migrating wader birds

There are about 25 species of wading birds (*Charadriidae*) that can pass Aurora during migration. Generally, waders have little risk of collision during migration as they often fly at higher altitudes than the total height of the wind turbines. Studies of great snipe (*Gallinago media*) and black-tailed godwit (*Limosa limosa*) show that wading birds regularly fly at an altitude of several thousand metres during migration (Senner, et al., 2018; Lindström, et al., 2021). Collision risks were modelled for common redshank (*Tringa totanus*), which breeds in Sweden. The common redshanks that may pass through Aurora during migration consist mainly of individuals from Gotland, Finland and the Baltic States. Krijgsveld (2011) estimated the avoidance rate for waders at 98.3 percent, an avoidance rate of 98 percent has been used in the modeling. This results in four collisions of common redshank per year, which corresponds to less than 0.1 percent of the biogeographical population passing through the Baltic Sea. Thus, the transboundary impact of collisions is considered to be negligible for migratory wading birds.

Migrant common crane, also known as the Eurasian crane

Sterna paradisaea has in Sweden a viable population with unchanged or slightly increasing population size (Wirdheim & Green, 2020). It often migrates together with the common tern and is the bird species in the world that flies the longest distance during migration (Alerstam, et al., 2019). Silver terns generally fly at altitudes lower than 20 metres. The species often flies into wind farms and is then exposed to a certain risk of collision (Dierschke, et al., 2016). An avoidance rate for terns of 98 percent was used in the modelling of collision risk. For such a scenario, the modelling results in one collision case per year of the Arctic tern, of 30,000 passages when migrating through the Aurora.

The risk of collision falls for the Sterna paradisaea is considered to be small, as the migration takes place at low altitude under the rotor's sweep surface (1 percent of individuals were assessed as flying at rotor height in the collision risk modeling). Thus, the transboundary impact regarding collisions is considered to be negligible for the Sterna paradisaeas.

Other tern species have a similar behavior to the Sterna paradisaeas, and except for the Sterna hirundo, they pass the aurora in significantly lower numbers. The transboundary impact of collision falls for all migratory tern species is thus considered negligible.

Night migratory birds

The results of radar studies of night migratory birds carried out in 2022 and 2023 at Aurora are consistent with previous studies in the field, showing that most nights there is a low migration activity and that migration is concentrated in a few nights with very high migration activity.

Although it is not possible to calculate collision cases of night migratory birds for the Aurora with great precision, it is reasonable that the number of collision cases of night migratory small birds represents a fraction of the total number of migratory small birds, as was the case in the study on the German wind farms in the Arkona basin. In relation to the naturally high mortality rate of small birds passing through the area of activity during migration, mortality within Aurora is a vanishingly small proportion.

It has long been reported that birds crossing the open sea are attracted to light sources, such as lighthouses, coastal buildings, and oil platforms with the risk of collision as a result. Migration for birds across the open ocean is energy-intensive and birds with low energy reserves attracted to luminous structures can get stuck there in circling motions and exhaust further (Jones, 1980). A field experiment in the North Sea with different lights showed that it was usually special weather conditions, such as fog and drizzle, but also only in overcast weather, combined with artificial lights that led to an increased accumulation of birds around the light source. In the same study, it was found that birds are more attracted to continuous than to flashing lights (Rebke, et al., 2019). Obstacle lighting on wind turbines did not involve more collisions of nocturnal migratory birds than at turbines without such lighting, according to a study of land-based wind farms in North America (Kerlinger, et al., 2010). Offshore wind farms are illuminated for safety reasons for traffic such as aircraft and ships and can thus potentially lead to migrating birds being attracted to wind farm areas. The weather conditions that pose an increased risk to night migratory birds, in relation to artificial light, very rarely coincide with extensive migration occasions (Krijgsveld, et al., 2015; Welcker & Vilela, 2019; Welcker, et al., 2017)

Based on the fact that a large number of night migratory small birds can pass by during a few nights, and that these in weather conditions with poor visibility run an increased risk of collision with the wind turbines, operational regulation is proposed during spring and autumn migration, see section 7.3.5. 0

Transboundary impacts for night migratory birds are considered negligible as the impact risks covering an insignificant proportion of the bird populations passing through Aurora.

Migratory birds (excluding birds of prey and Eurasian cranes)

Previous studies have shown that migrating ringed pigeons flying towards southwestern Europe fly along the Swedish coast until they reach Falsterbohalvön in southwestern Skåne where the shortest passage over the open sea was available (Alerstam & Ulfstrand, 2008). At most, 20,000 extending ringed pigeons have been counted from the southern tip of Gotland in the autumn (The species portal). Distance data for other species such as stock dove, woodlark, Eurasian siskin and Eurasian chaffinch show that the numbers leaving Gotland at this cape are quite low (The species portal). In addition, not all migratory birds leave Gotland at the southern cape, but also along the west coast of the island further north where the distance to the nearest land area, Öland, is shortest. These birds then mainly pass north of the Aurora Wind Farm.

The number of collision cases is estimated to be low in relation to the population sizes of the species. The transboundary impact of collision risks for migratory birds (not birds of prey and cranes birds) is thus assessed as negligible.

Migratory birds of prey

Birds of prey have a relatively high risk of collision at wind turbines compared to many other bird groups. Since they have a long lifespan with a slow reproduction rate, an increased mortality from wind power can have an impact on the population level (Green, et al., 2017). Studies of migratory birds of prey have shown clear avoidance behaviours at onshore wind farms and overall avoidance rates of over 98% (Whitfeld & Madders, 2006; Cabrera-Cruz & Villegas-Patraca, 2016).

However, there is a high degree of uncertainty regarding the rate of avoidance of birds of prey in relation to offshore wind farms. Studies of the flight behaviour of birds of prey at established offshore wind farms in Denmark have indicated that birds of prey at sea may be at greater risk of colliding with offshore wind turbines compared to land-based turbines (Jensen, et al., 2016; Skov, et al., 2016). However, the studied wind farms were located in concentrated migration routes for birds of prey, and with relatively small and more densely located wind turbines than is relevant in Aurora. Overall, an avoidance rate of 98% is considered relevant for assessing collision risks for birds of prey in Aurora.

The number of migratory birds of prey from Gotland is generally low, with the highest numbers recorded at the southern tip of the island. For most species, the main migration direction in autumn is southwesterly. The species expected to appear in the highest numbers and observed in the inventories (one individual observed August 2021), is the Eurasian sparrowhawk.

The collision risk modelling for rough-legged buzzards and Eurasian sparrowhawks, respectively. gave a result of 0 and one expected collisions per year with wind turbines within the Aurora Wind Farm. The results from modelling of rough-legged buzzards can be transferred to other bird of prey species with similar flight behavior (active migration flight) and size. Osprey, red kite, western marsh harrier, , hen harrier and European honey buzzard, which are similar in size and flight behavior to rough-legged buzzard, are expected to pass the aurora in lower numbers than rough-legged buzzard, even for these species no collision cases are expected according to the modelling. common buzzard fall into the same size category and can appear in the equivalent numbers of rough-legged buzzards.

Falcons, mainly merlin but possibly also peregrine falcon and common kestrel, have similar flight behavior as Eurasian sparrowhawk. These species are expected to behave sparingly during migration between Öland and Gotland, and with few individuals able to pass through the Aurora, the risk of collision will be small. As the number of passing birds of prey in the area is low, the transboundary impact on the risk of collision for birds of prey is considered negligible.

Migratory Eurasian cranes

A large part of the Eurasian cranes' seasonal migration across the Baltic Sea takes place in the corridor between Bornholm and Zealand (Skov, et al., 2015), and thus does not concern Aurora. Migration movements have been observed several autumns from the southern part of Gotland towards the southwest in the direction of northern Öland, at most around 1,200 individuals in 2021. These movements are likely to pass north of the Aurora where the distance over the open ocean is shortest. Northerly winds can cause more Eurasian cranes to pass near or through the operating area. (Skov, et al., 2015)

Due to a low observed macro avoidance in Eurasian cranes at offshore wind turbines, the species is exposed to a higher collision risk compared to situations at onshore wind turbines where the Eurasian cranes have a very high avoidance The avoidance rate is estimated for Eurasian cranes at 83 percent at offshore wind farms according to Skov, et al., (2015) it is a conservative assumption. Based on assumptions about the number of Eurasian cranes crossing the migration corridor about 30 kilometres east of Öland and about 20 kilometres south of Gotland in spring and autumn, and that Aurora makes up 25 percent of the corridor, this gives 15 collision cases within Aurora per year. In relation to the total population size of just over 100,000 individuals, Aurora has negligible transboundary impact.

Displacement effects

Common murre and razorbill

Common murre and razorbill have viable populations that have increased in number according to the Swedish Red List (Artportalen, u.d.). The species live pelagically and catch fish at a depth of preferably 20–50 metres (Durinck, et al., 1994). For most of the year, they are not limited to certain areas of the Baltic Sea. The importance of aurora for Common murre and razorbill is assessed as minor with reference to low observed densities in connection with inventories Durinck et al. (1994)

There are no studies measuring the long-term effects of offshore wind farms on Common murre and razorbill. According to the studies carried out on direct impacts and the first years thereafter, the tendency is for both species to be displaced and decrease in number at the wind farm in the first years after wind farm establishment, but the displacement effect is not consistent and highly variable between areas. In the studies of displacement in wind farms, the distances between the turbines have been significantly smaller than what is relevant for Aurora. There is also a lack of studies of displacement in wind farms with the distances between turbines that are relevant in Aurora. When displacement has been ensured, the number of auks has usually been reduced by up to 50 percent inside the wind farm. In some wind farms, no change in numbers has been observed, and in some other cases, the number of auks has instead increased in number after wind power has been established. The highest displacement effect has been observed in a study from the Netherlands, with around 75 percent reduction in auks in wind farms, and 50 percent displacement in a zone of 2 kilometres outside the wind farms. (Heinänen & Skov, 2018)

The distance between the wind turbines within a wind farm is likely to be of importance for the extent of any displacement effect. Several studies have been conducted on the issue, including eider, where the results have shown that the longer the distance between the wind turbines, the greater the proportion of eiders passed through the park (Masden, et al., 2009).

According to the results of performed aerial inventories, the density of auks within the aurora has an average value of at most 1 individual per km^2. Densities of this order of magnitude are also confirmed by previous studies of winter densities (Durinck, et al., 1994; Skov, H; o.a., 2011). The total number of Common murre and razorbill in activity is therefore very limited. Even when a 2-kilometre zone outside is included in the calculation, the displacement effect as described above due to the Aurora Wind Farm corresponds to well below 1 % of the Baltic populations of Common murre and razorbill.

Although existing studies show different results of the displacement effect on auks, and it is unclear how the distance between the wind turbines affects the effect, a worst-case assessment has been made for Aurora, which by a good margin has taken account of uncertainties. Some displacement of the auks cannot be ruled out at Aurora, but the displaced birds can seek out other fishing grounds in the Baltic Sea with a small impact overall. It is estimated that there are plenty of alternative areas for foraging. A few individuals of the Baltic Sea population of auks are affected and the area is not considered critical for the individuals who may be displaced. The risk of impact on populations of Common murre and razorbill is assessed as insignificant and the transboundary impact is therefore considered negligible.

Long-tailed duck

For the whole of Aurora, a maximum density, i.e. the density that is estimated to be the highest level that can occur during the winter, of just over 1 long-tailed duck/km^2, means that about 1,100 long-tailed ducks can stay at the same time in the wind farm area. However, the number of long-tailed duck within Aurora is significantly lower during much of the winter. The company's six inventories from flights carried out for three winter seasons support that this assessment is reasonable. The area of the Aurora Wind Farm is not a foraging area for long-tailed duck as it is located in a deeper sea area, about 10–50 kilometres from the shallower areas of the Hoburgs bank where the highest concentrations of long-tailed duck are found. Most long-tailed ducks are found in areas with sea depths of between 0–30 metres because they forage demersal fauna. Mussels, which are the most important food resource for elk birds, are missing or inaccessible at the depths found in the Aurora Wind Farm. This has also been confirmed by a benthic fauna inventory in the Aurora Wind Farm in 2022, carried out by AquaBiota on behalf of OX2. These conditions explain the few sightings of long-tailed duck within Aurora in our inventories.

The presence of long-tailed ducks in the area is considered temporary due to the nature of the sea area with extremely limited opportunities for foraging.

According to calculated estimates, in a conservatively calculated worst-case scenario, a maximum of 1,100 long-tailed ducks may be displaced from the wind farm area in winter, which constitutes about 1 per mille of the total wintering elk population of over 700,000 individuals in the Swedish Baltic Sea or 0.7 per mille of the entire wintering population of long-tailed duck in the Baltic Sea. Since the wind farm area is considered to be of no importance as a foraging area (only a temporary residence area for a limited number of individuals), this means an insignificant impact. Around the wind farm area there are large areas of seas with similar conditions and thus the consequence is considered negligible.

The avoidance behavior can also be affected by the park design within Aurora and the distance between the wind turbines. This has been studied on eider, where avoidance behavior has decreased with a greater distance between the wind turbines. Conclusions about avoidance behavior thus risk being overestimated. Since there is no basis for assessing avoidance behavior in the case of "sparse" placement of offshore wind turbines, the assessment for the impact of Aurora is based on a worst-case scenario, where the species will exhibit moderate to strong avoidance behavior linked to the planned wind farm.

Wind farm Aurora is not considered to cause any displacement of significance for the species and thus the transboundary effects are considered negligible.

Gulls

Gulls and puffins exhibit limited avoidance behaviors in the face of wind farms and thus fly into wind farms more often than most other bird species. (Dierschke, et al., 2016; Fox & Petersen, 2019). black-headed gull, common gull, European herring gull, great black-backed gul, Baltic lesser black-backed gull, black-legged kittiwake, and little gull, occur regularly in the region, usually as occasional passers-by. It is estimated that gulls will only to a small extent avoid flying through the Aurora Wind Farm. As a result, the crowding-out effect is negligible with negligible transboundary environmental impact.

Barrier effects

Barrier effects can occur at wind farms that obstruct flying birds so that they are forced to fly around or over the wind turbines. This phenomenon has mainly been studied for waterfowl but has also been observed for other bird groups (Fox & Petersen, 2019; Rydell, et al., 2011). Barrier effects on waterfowl are assessed below for common eider, long-tailed duck, common scoter and Eurasian wigeon, but can be applied to other migratory waterfowl.

Migratory common eider

Since common eider do not winter in Aurora, there are basically no daily movements within the operational area. Those staying in the wind farm do so as temporary resting during migration. Both spring and autumn migration of common eider runs along the Swedish Baltic Sea coast. At the latitude of the Aurora Wind Farm, the vast majority of common eider pass through the Kalmar Strait in spring and to some extent along the west coast of Gotland. The species also migrates through Aurora and the barrier effect may be relevant for a smaller proportion of the migratory population in the Baltic Sea. A limited proportion of migrating common eider in the Baltic Sea is expected to pass through Aurora during autumn and spring. Since common eiders are mainly assumed to avoid flying into wind farms (Fox & Petersen, 2019), a barrier effect arises as they have to fly around the wind farm. The avoidance leads to a longer flight distance; however, this is a marginal part of the total flight distance that common eiders move. Thus, the transboundary impact is considered to be negligible in terms of barrier effect in migration due to the wind farm.

Migratory long-tailed duck

The most important foraging areas of long-tailed ducks in the Baltic Sea are Hoburgs bank, Midsjöbanks, Slups bank, Gulf of Riga and Pomeranian Bay. As these shallow foraging areas are located east and south of Aurora, the wind farm is not expected to generate any barrier effect between these areas if long-tailed ducks choose to fly between foraging areas. Thus, the consequences of barrier effects are assessed only for migratory long-tailed ducks.

The migration routes of long-tailed ducks between the wintering areas in the Baltic Sea and breeding sites in the Russian tundra are considered to be mainly outside the operational area of Aurora. Nevertheless, a worst-case scenario, with a migration route assumed to pass through Aurora, is used when assessing the barrier effect. The barrier effect of the wind farm on migrating long-tailed ducks has been estimated at a maximum detour of 107 kilometres as the longest distance required to round the Aurora Wind Farm, which corresponds to 3.19 per cent of the entire migration distance from the Russian tundra to the wintering areas in the southern Baltic Sea. Such an increase in energy costs is negligible as the variation in the individual migration routes, and the effects of weather conditions are certainly greater.

Transboundary impact on barrier effects for migrating long-tailed ducks is considered to be negligible. Furthermore, the distance between the wind turbines also allows long-tailed ducks to possibly fly through the park.

Migratory common scoter and Eurasian wigeon

The exact migration corridors for common scoter and Eurasian wigeon, which winter in Danish and German waters, are not fully understood, but the available information provides sufficient basis for assessments. Most other seabirds passing through Aurora have similar flight distances to fly during migration as common scoter and Eurasian wigeon. With a worst-case scenario involving a migration route through Aurora, the barrier effect for migrating common scoter and Eurasian wigeon was estimated to mean a detour of 107 kilometres, which corresponds to 3.57 percent of the total migration from the Russian tundra to the wintering areas in the southern Baltic Sea. Such an increase in energy costs is negligible because the variation of individual migration routes, and the effects of weather conditions, are greater. The transboundary impact of the barrier effect is therefore considered negligible for common scoter and Eurasian wigeon. The wind farm's design with large distances between the wind turbines provides good conditions for the species to pass through the wind farm if no avoidance behavior exists.

Conclusion

Collision risk: The area of Aurora is crossed by a large number of migratory birds in spring and autumn. The results from the collision risk modelling show that the Aurora Wind Farm results in a limited number of collisions and for all assessed species and species groups the consequences are estimated to be negligible. Many seabirds fly at low altitudes and a clearance above sea level of 30 metres, which the Aurora Wind Farm will have, is of great importance in reducing the risk of collision. The transboundary impact of the risk of collision is considered to be negligible in these cases. For night migratory birds, it is more difficult to calculate collision cases. In relation to the population sizes of the bird species passing over the area of Aurora Wind Farm, mortality within Aurora Wind Farm is estimated to be negligible. The number of passing birds of prey is low and therefore the transboundary impact on collision risk is considered negligible. The Eurasian cranes' migration route mainly passes outside the Aurora Wind Farm area. The number of collisions is estimated to be small.

Displacement effect: The significance of Aurora Wind Farm for common scoter and Eurasian wigeon is assessed as minor due to low observed densities. Although some displacement of the auks cannot be ruled out at Aurora Wind Farm, it affects only a few individuals who can seek out other fishing grounds in the Baltic Sea. It is estimated that there are plenty of alternative areas for foraging. In this respect, the transboundary impact is deemed to be negligible. Given that the wind farm area is completely of no value as a foraging area for long-tailed ducks, that the number of individuals is low in the area of influence and there are other areas around and in the nearby Natura 2000 area that are expected to be used by the birds instead, Aurora Wind Farm is not expected to cause any displacement effect of significance for the species and thus the transboundary impact is estimated to be negligible. It is estimated that gulls will only to a small extent avoid flying through the Aurora Wind Farm. As a result, the displacement effect is negligible.

The barrier effect: Most seabirds and common eiders are assumed to avoid flying into wind farms, which leads to a longer flight distance, however, this is a marginal part of the total flight distance that common eiders migrate. Since common eider do not overwinter but temporarily rest during migration in Aurora Wind Farm, the transboundary impact on the species is estimated to be negligible. The migration routes of eel birds are considered to be mainly outside the scope of Aurora Wind Farm. The transboundary impact of barrier effect on migrating long-tailed ducks is considered to be negligible. The wind farm's design with large distances between the wind turbines provides good conditions for seabirds such as common scoter and Eurasian wigeon to pass through the wind farm if no avoidance behavior exists.

Decommissioning phase

Collision risks

As the wind turbines will be out of service and gradually dismantled, the risk of collision for all bird species is negligible during the decommissioning phase with negligible transboundary impact on the birds.

Displacement effects

During the decommissioning phase of the wind farm, activities at sea will involve some displacement from the wind farm area. These activities are time-limited and localized to certain parts of the wind farm. The transboundary impact is estimated to be similar to that during the construction phase, which means negligible impact on birds.

Barrier effects

Barrier effects are considered to be negligible even with the wind farm in operation, but the risk of impact decreases as the wind farm occupies an increasingly smaller area when the wind turbines are dismantled. Overall, barrier effects are estimated to have negligible transboundary impacts during the decommissioning phase.

Summarized impact assessment

Aurora Wind Farm is located in a sea area about 30 kilometres east of Öland and about 20 kilometres south of Gotland with deeper water. The area is thus not significant as a habitat for seabirds seeking food in shallower waters than 30 metres. In the area, foraging auks and resting long-tailed ducks occur to a limited extent.

A large number of birds pass through the sea area about 30 kilometres east of Öland and about 20 kilometres south of Gotland during migration in spring and autumn. Review of studies with satellite transmitters on bird individuals, performed land-based stretch counts, flight inventories with digital camera as well as LiDAR and radar studies at sea and on land over a three-year period, indicates that the wind farm area is subject to a significant bird migration in spring and autumn, primarily of seabirds and night migratory small birds. Overall, this migration is estimated to pass mainly north or south of Aurora Wind Farm. However, the geographical distribution of bird migration is weather dependent and wind conditions play a particularly important role. In certain weather situations, significant numbers of birds can pass through the area of activity.

The greatest impact risk is found during the wind farm's operational phase for the impacts collision risk, displacement effects and barrier effects. Collision risks have been calculated based on the best available knowledge regarding bird species migration, flight behaviour and the avoidance rate of different species/species groups. For all assessed bird species and species groups, the transboundary impact of the collision risk is considered to be negligible. However, for some species groups, it is considered justified to further investigate the impact of the wind farm in a study programme, see section 7.3.5.

Displacement effect may occur when some species choose to use the wind farm as a habitat to a lesser extent. This impact is assessed for, among other things, auks and long-tailed ducks. The transboundary impact is considered to be negligible as Aurora Wind Farm does not constitute a significant area for foraging, and displacement to other areas is considered to be very limited.

For seabirds, which have a documented ability not to fly near wind turbines, there is a risk of impact in the form of barrier effect. If the birds choose to fly around the wind farm instead of through, there will be a longer flight distance and thus higher energy costs. This extra flight distance is estimated to represent a maximum of 3.6 per cent of the total flight distance for migration and is estimated to have negligible transboundary impact.

The overall assessment is that the collision risk, displacement effect and barrier effect for migratory and resting birds have negligible transboundary impacts in the construction, operation, and decommissioning phases.

7.4. Bats

7.4.1. Current conditions

Inventories carried out

Inventory of bats in the project area for Aurora Wind Farm was carried out from a boat in connection with bird inventories during the spring and autumn of 2022. The inventory covered an area from Hanöbukten in the south to just southeast of Gotland in the north. The timing of the inventory coincides with the migration period of bats. A total of seven bats were registered in the bat inventory, two of which were registered in connection with the Aurora Wind Farm's operating area. The two bat registrations carried out in connection with the project area for Aurora Wind Farm show that there is some bat activity in the current area in the Baltic Sea between Gotland and Öland.

Migration

Most European bat species migrate between summer and winter colonies. In Sweden, there are at least two species that migrate south in the autumn and then fly back in the spring: Common noctule (*Nyctalus noctula*) (Vigorous) and Nathusius' pipistrelle (*Pipistrellus nathusii*) (Least concern) . (Rydell, et al., 2014; Ahlén, et al., 2009). Bats can be out at sea in connection with seasonal migration (Hatch, et al., 2013) and have been observed up to 14 kilometres from the coast of Kalmarsund (Ahlén, et al., 2009), which has been confirmed by the company's inventories. During inventories carried out from boats, bats were noted within the Aurora Wind Farm at 54 kilometres from the coast

Studies in the Kvarken in the northern part of the Baltic Sea have shown that the Nathusius' pipistrelle flies from Finland to Sweden via islands and then follows the Swedish coast southwards (Schneider & Fritzén, 2020). In the middle part of the Baltic Sea, it has been suggested that troll bats from Finland and the Baltic countries either follow the west coast of these countries southwards or fly over the open sea, via Åland or Gotland, to the Swedish coast and then further south (Rydell, et al., 2014; Gaultier, et al., 2020). From the few studies conducted at offshore wind farms, data suggest that bats primarily fly at a low altitude, lower than 10 metres, over open water, with only occasional records of flight altitude at hub height. (Ahlén, et al., 2009; Rydell & Wickman, 2015; Brabant, et al., 2019)

Once the wind farm is in place, migrating bats leaving Gotland can pass through the wind farm in the direction of Öland and on the way south. Any migrating bats passing through the wind farm may collide with the wind turbines. A risk of collision may occur for a short period in spring (April/May) and late summer to early autumn (15 August to 15 October) as a result of bats' migration movements. According to studies conducted at offshore wind farms, the majority of passing bats fly at low altitude, under the rotor blades. In Aurora Wind Farm, the rotor blade has a clearance distance of 30 metres, which means that there is a distance of 30 metres between the bottom tip of the rotor blade to the water surface. The clearance distance should serve as an additional mitigation measure for low-flying migratory bats.

7.4.2. Protective measures

Survey programme

The investigation programme proposed by the company aims to investigate the presence of bats in the operating area and investigate the wind farm's impact on migrating bats, i.e., whether there is any collision risk and population impact on the bat species that may potentially occur in the area. Based on the results of the study programme, it is proposed that the scope of the operating control can be adjusted if deemed necessary to protect migratory bats within the framework of a delegation condition.

Operating control

Since bats have been registered, it is considered likely that there may be migratory bats within the park. The company therefore proposes a condition relating to operational regulation for the protection of migratory bats that shall apply from the start, i.e., also during the period of the investigation programme. It follows from the condition that operating controls for the protection of migrating bats during the spring and autumn migration shall be applied between sunset and sunrise when there is a risk of collision with the rotor blades of the wind turbines and bats have been detected.

The company estimates that an operating control of a maximum of 5 hours on average per turbine and year is sufficient to rule out that the Aurora Wind Farm will have a negative impact on migrating bats. This means that a total of 1,850 hours per year, for a wind farm of 370 wind turbines, can be allocated for operating control of the wind turbines where there is such an actual need, i.e., risk of collision. The company's commitment of up to 1,850 hours per year can be compared with a detected migration period of bats in Kalmarsund of 37 hours per year (Ahlén, 2009). The mitigation measure now proposed is therefore considered to be ample.

Bats migrate singly and at most in smaller groups for limited periods, which – together with knowledge of known migration routes – contributes to the assessment that not the entire wind farm affects the bats. The bats that would possibly pass through the wind farm are likely to pass in passages/corridors through the wind farm at low altitude and not through the entire wind farm in width at the same time. An application of operating control of all wind turbines in the entire park area at the same time is therefore not considered to be justified. A needs-driven system is therefore judged, both from a protection and cost perspective, to be the most appropriate solution. Such a demand-driven or active system is based on an actual detection of bats within the park area.

7.4.3. Transboundary environmental effect

Effects for bats are only expected to occur in the operational phase. Based on existing knowledge, it is unlikely that the park area will be used as a foraging area for stationary bat species because the wind farm is located far out to sea. It is therefore mainly migratory bat species that could be adversely affected and suffer from an increased risk of collision with wind turbines during the operation phase when the wind turbine blades rotate.

Provided that a survey programme is carried out during the first year of operation and that, in the event of a significant risk of collision for bats, an operational regulation of the wind turbines is introduced, the overall assessment is that there will be no negative effect on bats. Thus, the transboundary effects for the bats that may occur in the wind farm area will be negligible and the effect on Baltic populations will also be negligible, of which no transboundary effects are expected to occur.

7.5. Commercial fishing

The company has commissioned an investigation of the potential impact of its operations on commercial fishing. Commercial fishing refers to fishing intended for commercial sale which requires a commercial fishing licence. In the area covered by the planned Aurora Wind Farm, it is mainly Swedish fishermen who are active.

7.5.1. Current conditions

Basis for analysis of the extent of commercial fishing

In order to investigate and describe the transboundary impact of the Aurora Wind Farm on commercial fishing, this has been analysed in two different geographical scales. A larger area comprising the Western Gotland Sea, i.e., International Council for the Exploration of the Sea (ICES) sub-area 27.3.d.27 (see Figure 22), and a smaller area, which includes the area that constitutes the Aurora Wind Farm. A smaller part of the planned wind farm is also located within ICES sub-area 27.3.d.25 (Bornholm Sea), see Figure 22. The majority of fishing in the Bornholm Sea is carried out by Polish boats. This fishery is not representative of the Aurora Wind Farm or its vicinity, where Swedish boats account for most of the fishing, and data for sub-area 27.3.d.25 are therefore not included in the analysis.

The data used for the study is primarily the EU fisheries database (FDI) (Havs och vattenmyndigheten , 2021; Gibin & Zanzi, 2020). The data presented thus provides a comprehensive picture of both international and Swedish commercial fishing. The larger area, ICES sub-area 27.3.d.27 (Western Gotland Sea) was investigated for the years 2015 – 2019 and the Swedish fisheries within the area that constitutes the Aurora Wind Farm were investigated for the years 1999 – 2020.

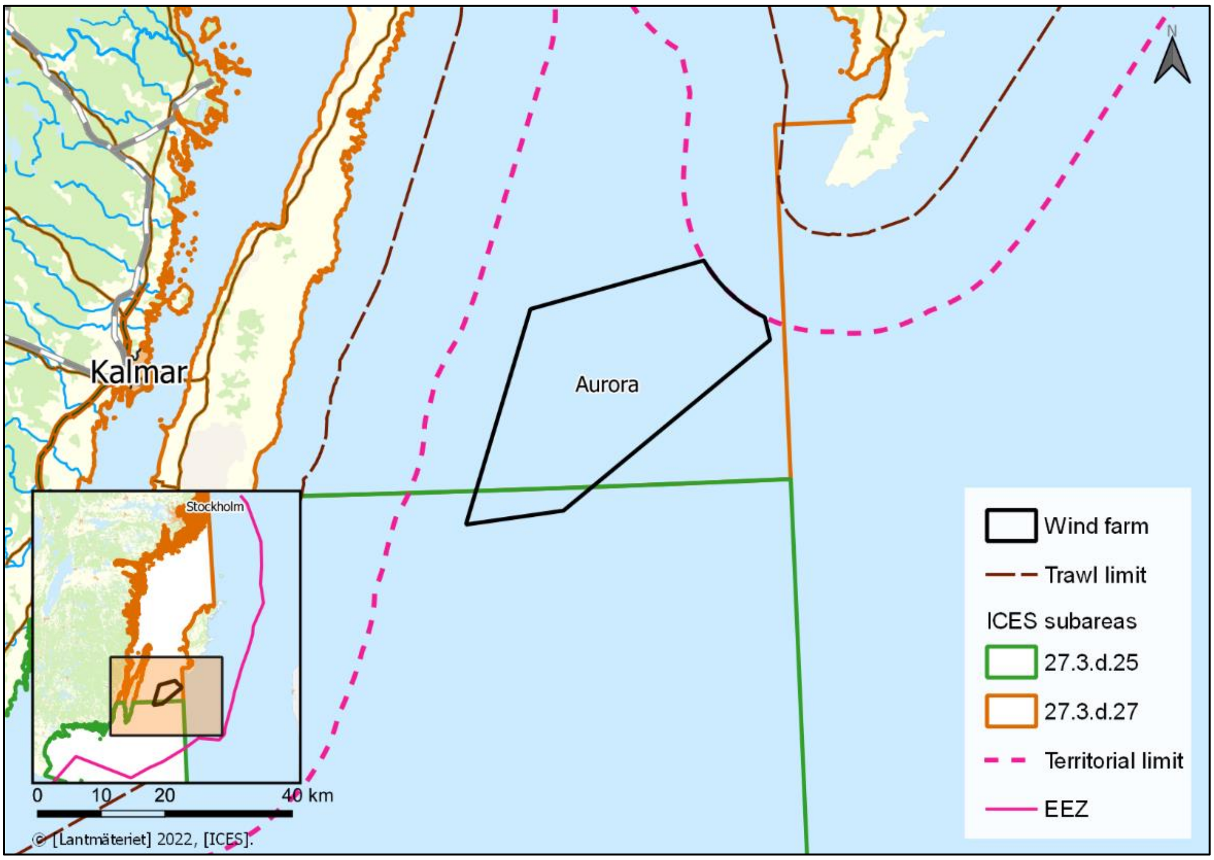

Figure 22. Location of the Aurora Wind Farm in the Baltic Sea in relation to ICES sub-areas 27.3.d.27 and 27.3.d.25, and trawl boundary. EEZ: Exclusive Economic Zone.[3]

Scope of commercial fishing

Herring and cod have historically been the most important commercial species. In the Baltic Sea, catches of these three species have had clear historical peaks between the 1960s and 1990s. The size of landings has since levelled off and in the 2000s catches have generally decreased. In particular, catches of herring and cod have fallen markedly.

[3] The figure shows a trawl limit of four nautical miles. In November 2021, a decision was made to move the trawl limit to twelve nautical miles on a trial basis.

Fishing quotas for herring increased until 2018 and then decreased annually. The Swedish quotas for herring have decreased by 42 percent since 2018, and a reasonable assumption is that they will not increase as long as the recruitment of fish is considered weak. In August 2023, the European Commission presented a new proposal to stop the targeted fishing of herring and cod in the Central Baltic Sea and the Bay of Bothnia. (European Comission, 2023).

Herrings dominate fisheries in ICES sub-area 27.3.d.27 and accounted for 99.5% of catches in the area in 2019. Pelagic fishing is thus almost the only existing large-scale fishery in the sub-area.

Herring fishing was the most common fishery in ICES sub-area 27.3.d.27 during the period 2015 – 2019, both in terms of weight and value. During the period, herring catches have been stable, with a slight increase in both 2018 and 2019. The most commonly used method is pelagic trawling. Herring fishing is concentrated along the east coast of Öland, while fishing within the planned wind farm has generally been marginal during the period 2009 - 2020 (Figure 23).

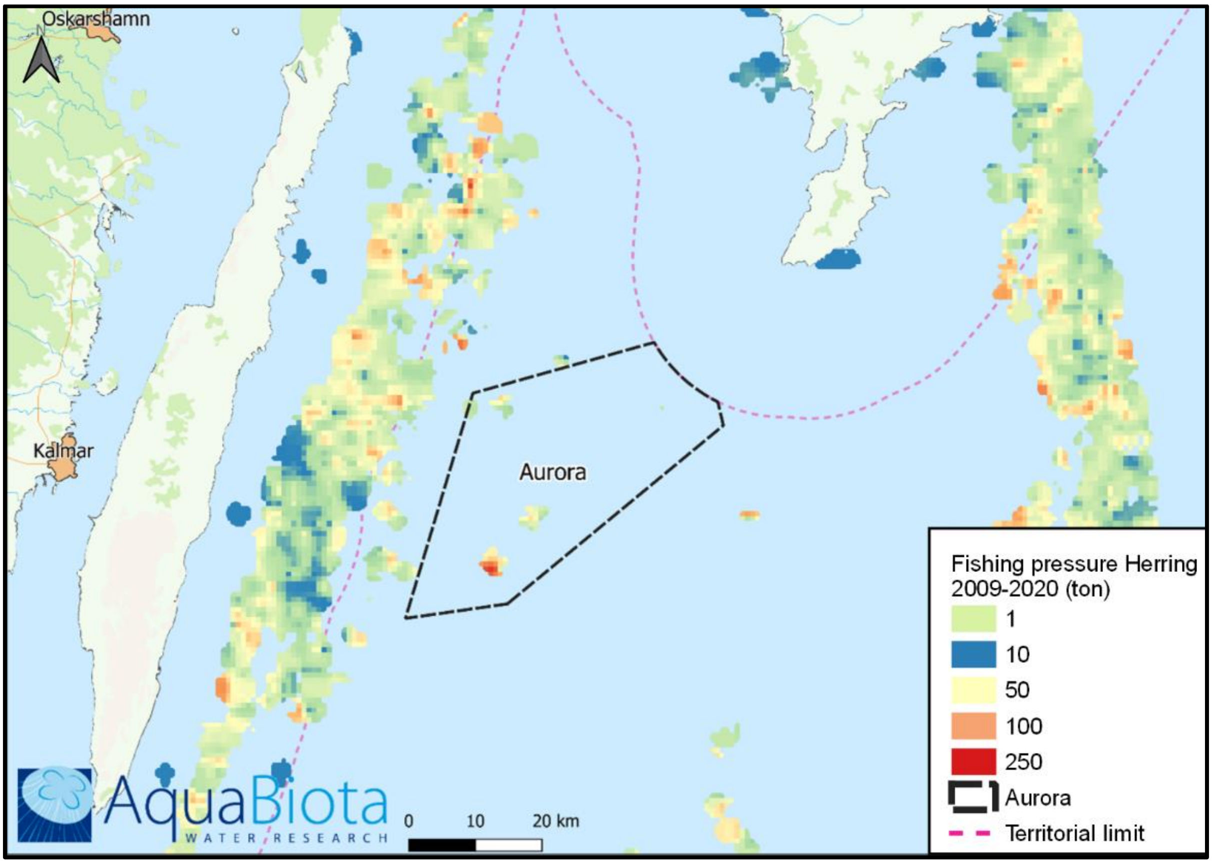

Figure 23. Fishing pressure of herring in the area around the planned wind farm during the period 2009 – 2020.

Sprat landed in relatively even quantities during the years (2015 - 2019), but increased somewhat after 2017, and the weight landed was highest in 2019. The quotas for 2022 mean a 13% increase in sprat fishing. Despite the increase, ICES considers that fishing mortality is above what is sustainable, however, they consider that the spawning stock is above average and within acceptable levels. Fishing pressure on sprat within the planned wind farm has been modelled and is presented in (ICES, 2020b) Figure 24 below.

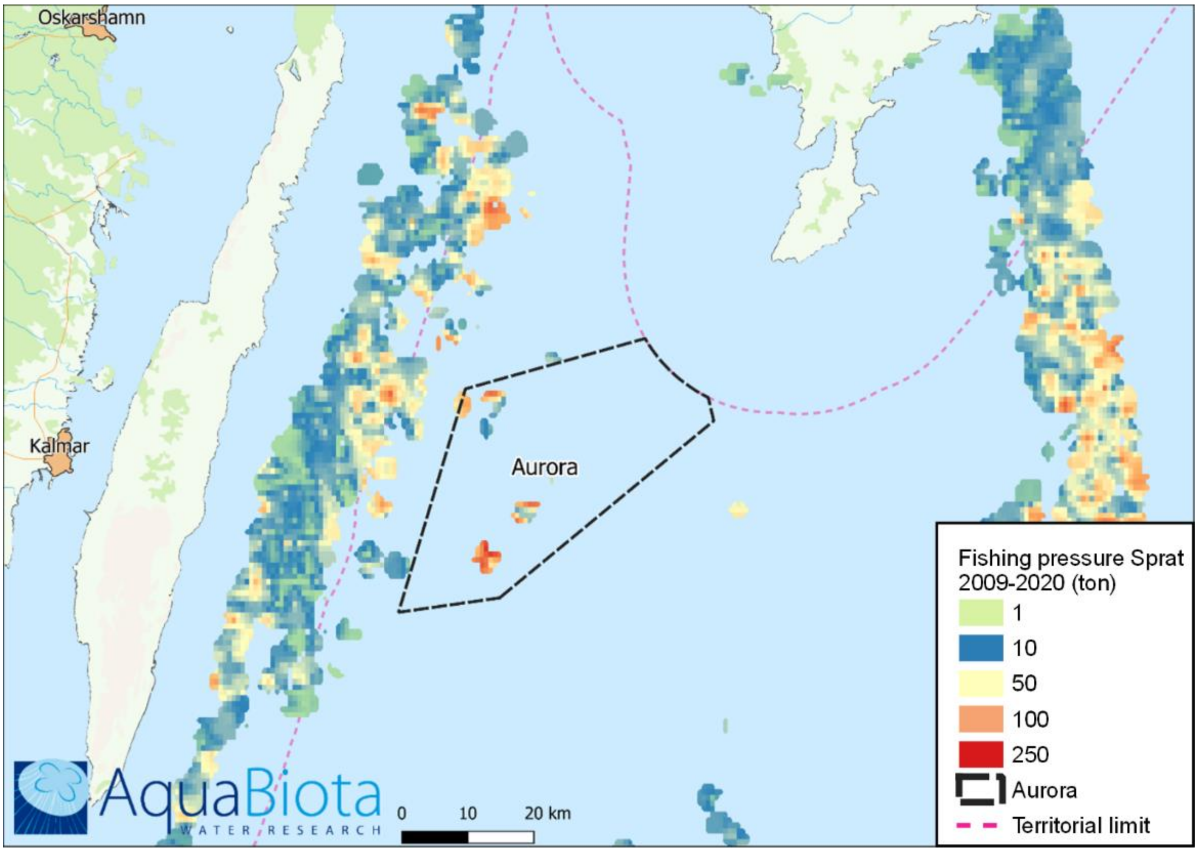

Figure 24. Fishing pressure of sprat in the area around the planned wind farm during the period 2009 – 2020.

In the ICES sub-area where the Aurora Wind Farm is located, cod fishing has been sparse, notwithstanding the closure of fishing. This is illustrated in where it is only possible to see small catches, especially along the southern tip of Öland. Furthermore, landings of cod during the period 2015 - 2019 (Bryhn, et al., 2021) have decreased drastically throughout the Baltic Sea, and then stopped completely in 2019. Cod is threatened by hypoxic and anoxic bottoms, parasites, food shortages and human uptake and the situation is considered critical (ICES, 2021b). This has led to a halt to all targeted fishing for cod throughout the Baltic Sea in 2022.

Fishing quotas for cod fisheries have been steadily decreasing since 2012, with the exception of a slight increase in 2014, to currently consist only of by-catch quotas. Since 2019, targeted fishing for cod has been stopped in, among other places, the Eastern and Central Baltic Sea, and in 2022 the targeted fishing for cod will be closed throughout the Baltic Sea. Due to current restrictions, fishing for cod has completely ceased in the Baltic Proper. It is noteworthy, however, that virtually no cod has been landed within the planned wind farm since 2004, which indicates that even before the fishing ban the area was of very little importance for cod fishing (Figure 25).

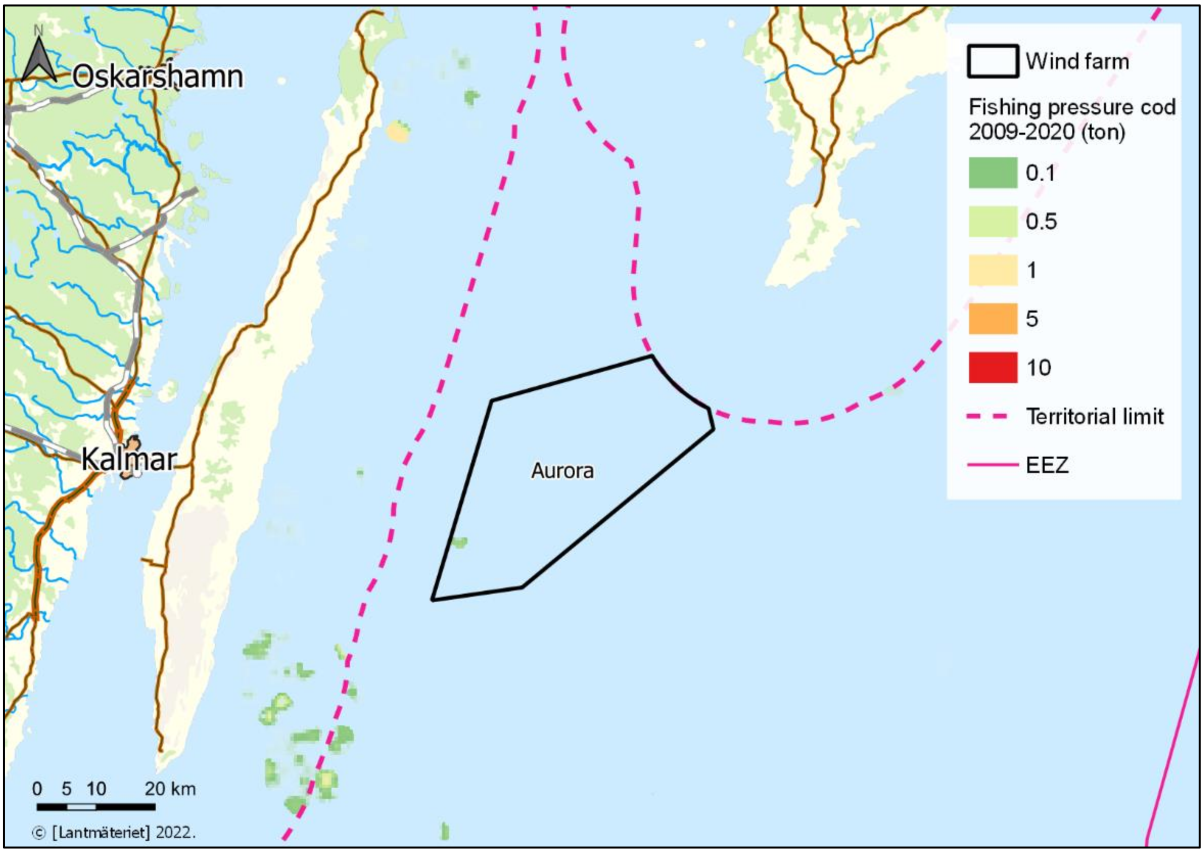

Figure 25. Fishing pressure of cod in the area around the planned wind farm during the period 2009 - 2020.

Available catch data from the EU (2015 - 2019), show that Swedish vessels have landed an average of 25,295 tonnes of fish annually in ICES sub-area 27.3.d.27. For the same period, an average of 140 tonnes of fish were landed annually within the planned wind farm. This corresponds to 0.5% of the annual fishery in ICES sub-area 27.3.d.27. The area constituting the planned wind farm is thus of marginal importance for pelagic commercial fishing.

The commercial fishing carried out at the Aurora Wind Farm is almost exclusively pelagic trawling and the species fished are herring and sprat. However, the landed catch varies greatly within the wind farm. This is not only the result of changing quotas but is a common local pattern in offshore waters and is largely due to pelagic trawlers fishing where they find schools of fish, the geographical distribution of which can vary from year to year.

As in the previous year, fishing within the planned wind farm was marginal in 2020 (Figure 26). The main fishing pressure is concentrated in the area within Swedish territory along the east coast of Öland.

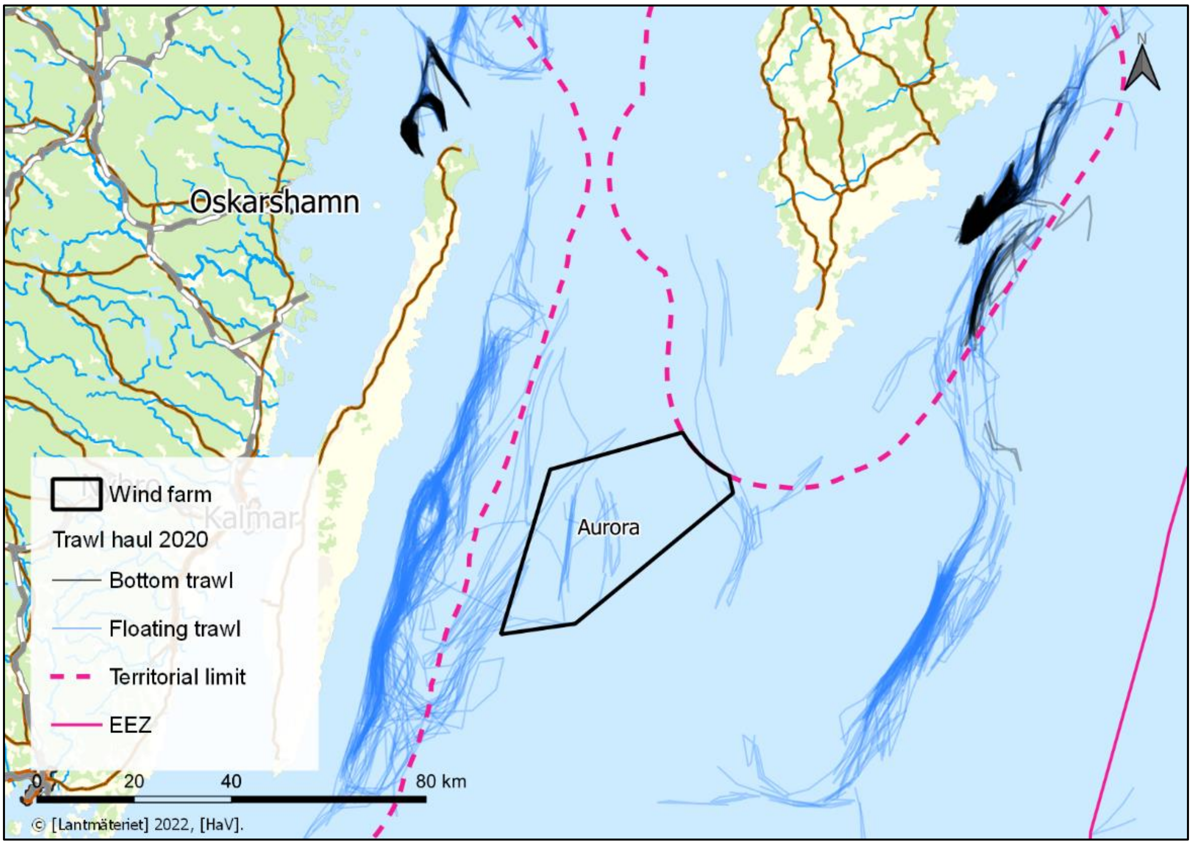

Figure 26. Trawl haulage in and around wind farm Aurora Wind Farm in 2020 (Swedish Agency for Marine and Water Management 2021b).

Overall, the development of the fishing industry in the ICES sub-area 27.3.d.27 in recent years has been negative. The landings have decreased and with it the value of the total commercial fishing for the area. Fishing within the wind farm has been extremely limited and has consisted of sporadic catches of herring and sprat by pelagic trawlers. Historically, fishing pressure has been significantly higher closer to the east coast of Öland.

Two valuable fish resources, cod and herring, have had negative population trends in the Central Baltic, resulting in fishing bans and reduced quotas. The quotas for 2022 continue to mean no targeted fishing for cod and sharply reduced quotas for herring, which is likely to mean a further reduction in fishing pressure in and around the Aurora Wind Farm. In view of this, the area covered by the planned wind farm is currently considered to be of marginal importance for commercial fishing. Furthermore, additional, albeit limited, reef effects and reduced fishing pressure may in the long run improve the stock status of commercially important fish species, which in the long run also benefits commercial fisheries. (Goñi, et al., 2008; Langhamer, 2012; Reubens, et al., 2013)

7.5.2. Transboundary effect

The area covered by the planned wind farm is of only marginal importance for commercial fishing and the fishing industry in general and that it is mainly Swedish fishermen who use the area. The bottoms of the planned wind farm are largely hypoxic or anoxic, which, together with other factors such as fishing quotas and population development for commercially important species, means that demersal fishing is, and for a long time has been, virtually non-existent. Pelagic fishing within the planned wind farm has been sporadic and the catches represent only a very small part of the total catches in the Western Gotland Sea. Furthermore, modelling of Swedish fishing pressure shows that the area covered by the planned wind farm has also historically been of significantly less importance for fishing compared to other, nearby areas.

The worst case scenario for commercial fishing is that commercial fishing will not be able to be conducted within the Aurora Wind Farm. This is because experience shows that commercial fishing within wind farms is decreasing, even though there have been no formal bans on fishing in the areas. The worst case in this case is conservative as parts of the planned wind farm will be available for commercial fishing.

International fishing in the Aurora Wind Farm is small. In ICES sub-area 27.3.d.27, Swedish fishermen accounted for 85 percent of the landed catch in 2019. Danish fishermen accounted for twelve percent and their presence in and around the Aurora Wind Farm is thus limited. The Aurora Wind Farm is thus estimated to have negligible transboundary consequences for commercial fishing.

The environmental assessment shows that Aurora Wind Farm has negligible to little impact, which means that no significant changes in the marine ecosystem are expected to occur because of Aurora. Decline in fish stocks is a complex issue that depends on several aspects such as fishing, climate change, eutrophication, and more. In this context, predation pressure, which is a natural part of the ecosystem, is not considered to have a significant impact on the decline in fish stocks. Furthermore, porpoises are an endangered species whose increase is sought in conservation objectives in the Natura 2000 area and in the Baltic Sea in general.

7.6. Navigation

7.6.1. Conditions

No sea lane passes through Aurora Wind Farm, and the company has proposed a safety distance of 1.38 nautical miles to nearby routes to ensure good maritime safety. At present, only a small number of vessels pass through the area that will be used by the planned wind farm.

Near the planned Aurora Wind Farm, there are a number of different ship routes (see Figure 27). On the south-east side of the wind farm is a sea lane through which a significant part of the traffic to and from the Baltic Sea passes. South westbound (orange) and north eastbound (green) traffic are controlled and separated by two TSSs (Traffic Separation Schemes): TSS Off Öland Island in the southwest and TSS North Hoburgs bank in the northeast. To the southeast of this route, at a distance of just over 50 kilometres from the planned wind farm, there is a deep-water route (a so-called DW route), which is the recommended route for vessels with a draught exceeding 12 metres. This traffic is also controlled and separated by two TSSs: TSS Midsjöbankarna and TSS South Hoburgs bank. West of the Aurora Wind Farm, the traffic that uses the route passes between TSS Off Öland Island in the southwest and TSS West Klintehamn.

In addition to these three sea lanes, there is another route, which is mainly used for ferry traffic between Nynäshamn and the Polish city of Gdansk. The latter crosses the other three ship lanes and passes by the northeast corner of the planned wind farm.

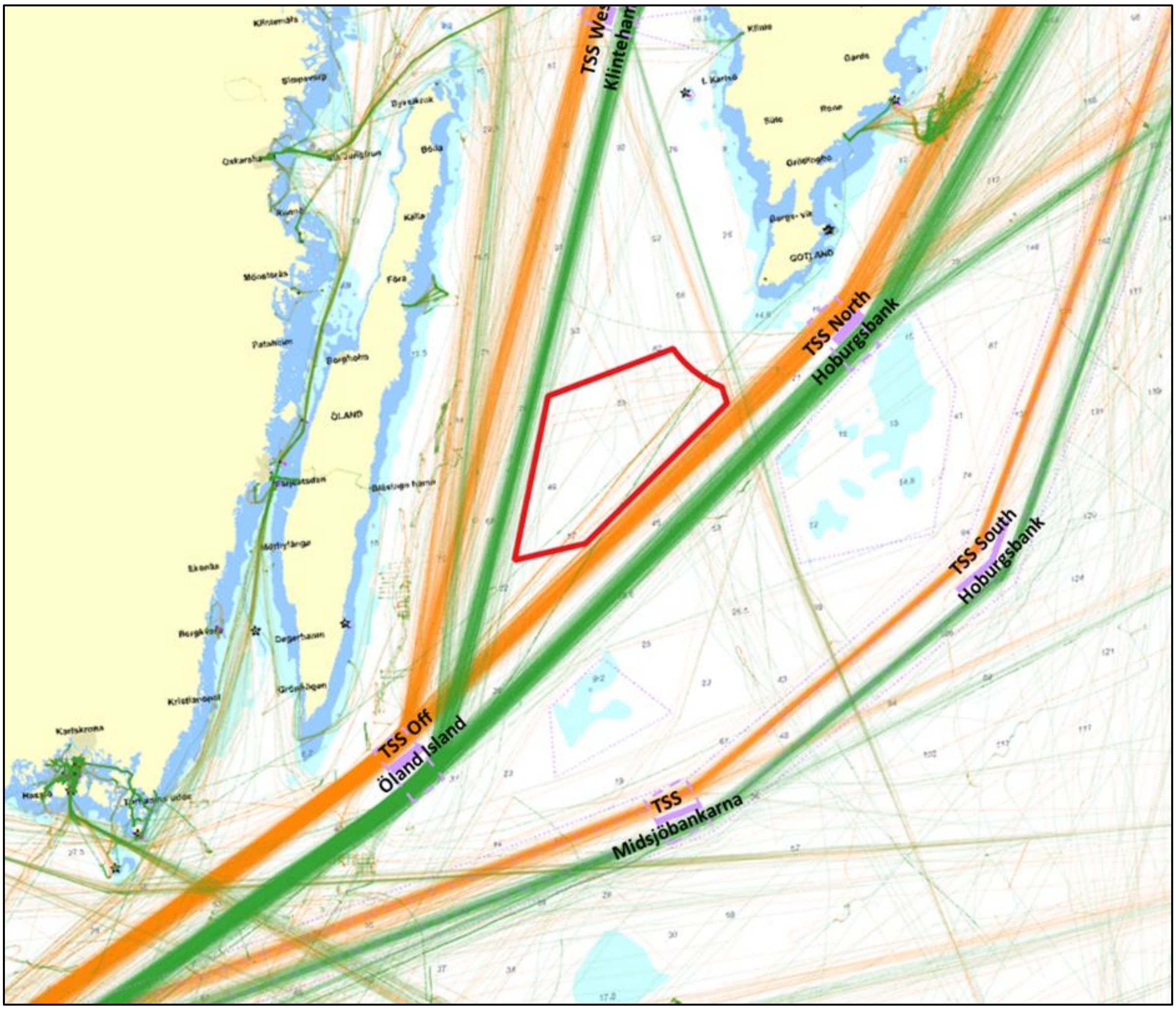

Figure 27. Ship routes adjacent to the planned Aurora Wind Farm and traffic patterns based on AIS data from 2020. South westbound traffic in orange and north eastbound traffic in green.

7.6.2. Risk identification

The analysis of AIS data provides an important basis during risk identification, where traffic patterns, traffic intensity and vessel characteristics are of great importance. The vicinity of the planned wind farm will be served through the routes surrounding the wind farm on the western, southeastern and northeastern sides, as well as through the deep water route, which is just over 50 kilometres to the southeast. Some vessel traffic also passes through the area that constitutes the area of operation of the planned wind farm.

Based on prevailing conditions and conditions and based on previous risk analyses carried out in connection with other offshore wind power establishments, potential hazards are identified. Identified hazards are mainly those that may entail an increased likelihood of collision and grounding for shipping, as well as hazards that may lead to interaction with the wind farm and thus possible risk of collision or allision with the wind farm components. Indirect hazards, such as impact on the conditions for sea and environmental rescue, disruptions to navigation equipment and possible impact on the possibilities of emergency anchoring, are also identified.

Identified risks and risk analysis

A risk analysis of the risks to shipping arising during the construction, operation and decommissioning phase of the planned wind farm has been carried out. The risk analysis is based on a risk identification, which was carried out by the Company in cooperation with SSPA Sweden AB (SSPA). The risk identification was conducted as a so-called HAZID workshop (HAZard IDentification workshop) where experienced nauticals, risk analysts and representatives from the Company participated. The purpose of a HAZID workshop is to identify the risks that should be studied more closely and to discuss the possible risk protective measures that can be implemented. The HAZID workshop does not include quantitative assessments of risk levels. Thus, based on the HAZID workshop, it is not possible to say whether individual risks need to be addressed.

Identified hazards have been structured by division into three different areas: the impact of the planned Aurora Wind Farm on traffic on TSS Off Öland Island, traffic on the TSS Off Öland Island to TSS North Hoburgs bank route (i.e. traffic immediately southeast of the wind farm) and Aurora Wind Farm's impact on traffic on the TSS Off Öland Island to TSS West Klintehamn route (i.e. traffic west of the planned wind farm). In addition, general hazards not directly linked to a specific geographical area and hazards linked to the construction phase were identified. All identified potential hazards, their primary causes, possible preventive safety measures, and immediate and final consequences were documented in a HAZID protocol.

Construction phase

During the construction phase, a certain amount of traffic will be added to the area through the vessels that move between the operational area of the planned wind farm and ports for, among other things, manufacturing, final assembly and loading, as well as within and around the operating area. Which ports will be used has not yet been determined. From the port that will be used as the installation port, personnel transports and transports of smaller components will take place. It is during transport to and from this port that crossings of sea lanes occur to the greatest extent and most frequently, with daily trips round trips. The additional traffic that will arise in connection with the construction phase of the Aurora Wind Farm is estimated to total about ten vessel movements per day.

Additional traffic in the area during the construction phase will consist of vessels of varying sizes using different routes, such as smaller boats used for personnel transport (also called crew transfer vessel (CTV)) and surveillance, barges with foundations, dredgers, cable-laying vessels, and other vessels carrying materials.

The risks identified as possible during the construction phase relate to the following:

1. *Transport to and from the area of operation.* Leads to increased traffic and crossing of ship routes.
1. *A theoretical scenario where the outer limitations of the wind farm are not clearly marked before the wind turbines are fully assembled.* Ships that go off course could collide with foundations during construction or other structures that cannot be visually observed above the water surface.
1. *Interference effects*. Radar interference and risk of glare of passing vessels if work platforms have bright lighting that is not shielded from traffic in the routes.

Of the identified risks for the construction phase, the risks associated with the increased traffic intensity and crossing of the ship routes are considered to be the most critical. Surveillance vessels and CTV vessels, which account for the majority of the passages, are smaller vessels that are relatively fast and have a good manoeuvrability, which means that they can be assumed to have good conditions to avoid potential collisions with other vessels. However, the larger installation vessels can be assumed to have poorer conditions to adjust their course and speed. The risk of incidents or collisions when crossing ship paths is reduced by the project using a *so-called marine coordinator* during the construction phase, who keeps track of vessel traffic in the area in question and who can control where and when crossing passages over existing ship routes should take place.

The probability of other identified hazards is assessed as lower and these also give rise to less serious consequences. Risk protective measures, such as ongoing information to shipping, monitoring with a *marine coordinator* and marking of the area, are considered effective measures to avoid risks and impact on shipping, see protective measures in section 8.12.7 below. 0

7.6.3. Operational phase

During the operational phase, the shipping-related risks are mainly related to vessel traffic in the sea lanes adjacent to the wind farm, i.e. the west, southeast and northeast of the Aurora Wind Farm. The deep-water route southeast of the planned wind farm is located at just over 50 kilometres from the wind farm, which means that only insignificant risks can be considered to exist in relation to this route.

The risks in relation to the sea lanes consist of collisions, groundings and allisions. Other identified risks are radar disturbances and impaired accessibility and accessibility within the wind farm in connection with, for example, environmental remediation and rescue operations.

Collisions, groundings and allisions

The physical presence of the wind farm itself entails a risk of ships entering the operating area and possibly colliding with one of the wind farm's construction elements (in particular wind turbines, but collision could also occur with a station or with a measuring mast). The wind farm may also lead to an increased risk of collision between vessels in the sea lanes, if these vessels, to create a greater distance to the wind farm, would use a smaller part of the sea lane. In some situations, for wind farms located closer to land, a wind farm may also pose an increased risk of grounding.

To assess if and how the planned wind farm may affect the probability of groundings and collisions between ships, and to estimate the probability of ships sailing or drifting into the wind farm, the IWRAP Mk2 (IALA Waterway Risk Assessment Program) is used. Based on AIS data, traffic in the area in question is modelled by defining vessel routes, so-called legs, and node points, so-called waypoints, to resemble the current maritime traffic pattern. The analysis has been based on dimensioning vessel sizes for the different vessel routes and on a traffic scenario for 2030 that entails an increase in traffic by 20 percent on all routes, compared to AIS data for 2020.

Which direction a ship will drift is primarily affected by wind direction. The ISWRAP model has therefore been supplemented with probability of different operating directions based on wind statistics for the area. The prevailing wind direction in the area under consideration is southwest - west, which means that in most cases a ship with a blackout will drift northeast - east.

In addition to the prevailing wind directions, the direction of the current also affects the course of operations in drifting grounding and drifting allision scenarios. The speed of ocean currents is generally moderate in the waters in question, and their direction may vary temporarily depending on the current weather situation. The influence of ocean currents is not taken into account in the ISWRAP calculations carried out.

Collision (between two ships) is categorized as follows:

1. *Head-on* - collision of oncoming ships
2. *Overtaking* - collision when overtaking in the same traffic lane
3. *Crossing* - collision at intersecting ship paths
4. *Merging* - collisions at emergency points where traffic routes converge
5. *Bend* - collisions at distress points where the ship lanes bend

Grounding is categorized as either powered grounding, when the ship runs aground during propulsion due to human error, or *drifting grounding,* when the ship drifts aground without the propulsion machinery running aground due to a technical fault, such as a blackout.

An allision means that a ship accidentally enters the area of the wind farm, however, this does not mean that there needs to be a collision between the ship and any of the wind farm's components. Allisions are characterized in the same way as grounding; powered allision, when the ship sails into the wind farm during propulsion due to human error, or *drifting allision*, when the ship drifts into the wind farm due to a technical fault, such as blackout, without the propulsion machinery running. In allisions, collisions can occur if vessels drifting towards the wind farm do not have time to emergency anchor or regain maneuverability before interaction with the wind farm occurs.

Modelling of probability of accidents and incidents

Based on the above-mentioned risk events, the probabilities of collision, grounding and allision have been calculated based on traffic patterns and traffic intensity for 2020, as well as for an assumed traffic scenario for 2030 where traffic is assumed to have increased by 20 per cent compared to 2020. Risks have been analysed based on modelled vessel traffic and for a wind farm with a safety distance of 1,000 metres (which corresponds to approximately 0.54 M) from the existing outer edge of the sea lanes, and in comparison with risks and accident probabilities in the non-action alternative (i.e. if the wind farm is not built).

The IWRAP analysis shows that the probability of groundings does not change significantly (it decreases slightly) during the construction of the wind farm. This is due to the lack of shallow sections in and around the wind farm

A situation where a ship sails or drifts into the wind farm (allision) naturally does not occur in a scenario without a wind farm, but with the wind farm established, the overall probability of an incident or accident increases.

Completed calculations show that a ship can be expected to drift or sail into the wind farm once in about three years. In about a third of these cases, i.e. once in nine years, a ship can be expected to drift or sail into one of the wind turbines. If the wind turbines are stopped and put into a so-called "bunny ear position" (a position where a rotor blade is vertical and points downwards along the tower), a ship is estimated to drift or sail into one of the turbines once in about 45 years.

In the event of an allision, an accident only occurs if the vessel entering the wind farm collides with one of the wind farm's components, mainly the wind turbines. Since the distances between the individual wind turbines are large, a ship in the event of a powered allision can very likely maneuver relatively free in relation to the wind turbines.

There is a risk of collision with an individual wind turbine if a ship enters the wind farm and fails to manoeuvre to avoid the wind turbines. However, collisions between ships and wind turbines are assumed to be less serious than collisions between ships, but they can nevertheless cause property damage, personal injury and environmental damage.

7.6.4. Protective measures

A number of different protective measures and precautionary measures will be taken to minimise the impact on shipping, including the risk protective measures identified through the risk analysis.

Together with Swedish maritime authorities, the company will develop a design of the wind farm that maintains good maritime safety. An updated nautical risk analysis will be carried out in connection with the final design of the wind farm being determined.

In addition to the above, the following measures will be implemented to avoid maritime-related risks:

Construction phase

- All marine work during the construction phase will be supervised by a *marine coordinator*, who oversees its own traffic (which ships are in the area, what tasks are to be performed, which people are where, and so on). A *marine coordinator* will also supervise other vessel traffic and can assist it. Through active monitoring of the area and traffic, vessels heading towards the wind farm, or otherwise deviating from the normal traffic pattern, can be detected early and called in order to avoid a potential interaction with the wind farm or other vessels/units involved in the construction works.
- During the construction phase, a protection zone of 500 metres will be declared around the various workplaces, this applies both to fixed workplaces such as the installation of foundations and wind turbines, as well as to mobile workplaces such as cable installations.
- Clear and frequent information must be provided via UFS (Notification for Seafarers) and NtMs (Notice to Mariners) about which construction work is in progress and which areas are affected.
- The area is defined and marked out in charts and visually with buoys with racon or radar reflectors.
- Work lights on work vessels and platforms will as far as possible be shielded from passing traffic.
- Any crossings of ferry traffic routes take place taking into account timetables for ferry traffic.

Operational phase
- Wind turbines and measuring masts shall be equipped with obstacle marking and marking in accordance with relevant regulations.
- The extent of the wind farm must be shown on nautical charts.

- On the vessels used for service and maintenance, there must be equipment for sea rescue and environmental efforts, such as opportunities to salvage people, defibrillators, stretchers and booms to limit the spread of possible spills of oil or other chemical products.
- Service and maintenance vessels that cross routes more or less daily must do so within specially defined zones.
- A study of possible radar disturbances to vessel traffic from the wind farm shall be carried out and, if necessary, measures to reduce the risk of radar interference shall be taken.
- In major naval operations, clear information must be provided via UFS (Intelligence for Seafarers) and NtMs (Notice to Mariners) about what work is ongoing and which areas are affected.
- The wind farm and the area around the wind farm are monitored remotely to enable, among other things, the detection of vessels on a collision course with the wind farm.
- In order to avoid shipping-related risks, the company shall monitor a protection zone of at least 500 metres from installation vessels during the operational phase when maintenance work with installation vessels is carried out.

7.6.5. Transboundary effects

Construction and decommissioning phase

During the construction phase, there is a certain risk of conflicts with construction vessels and other vessel traffic, as well as vessels entering the work area incorrectly. The company will take a number of measures during the construction phase, such as monitoring maritime traffic by a project-linked marine coordinator and that individual work areas will be closed to unauthorised traffic and clearly marked see section 7.6.2. The susceptibility of shipping-to-shipping accidents may be seen as high, but with the measures taken, the transboundary impact is expected to be negligible. 0

Similar conditions as during the construction phase are expected to prevail during the decommissioning phase. However, with the reservation that the decommissioning phase is very far in the future.

Operational phase

During the operational phase, the planned wind farm is estimated to increase the likelihood of incidents and accidents (in particular allisions), without taking into account specific risk protective measures. The calculations do not indicate that the wind farm will significantly affect the probability of collisions. A certain increase in the probability of collision may occur if the wind farm means that the vessel traffic that currently passes on the ship routes in the immediate vicinity of the wind farm chooses a route slightly further from the wind farm, in order to keep a greater distance to the wind farm, and if there is thereby a congestion of vessel traffic. However, this is only a small increase from what are currently very low levels.

A wind farm can cause radar interference, with false echoes and shadow effects. In connection with the final positioning of the wind turbines, the risks of impact on shipping through radar jamming will be investigated. If necessary, the necessary measures will be taken.

During the calculations performed, the wind farm will not affect the probability of collisions to any great extent, however, the wind farm may cause radar interference. As measures will be taken to minimize radar interference, the transboundary impact is assessed as small negative.

7.6.6. Conditions

Below is a description of how the company works and will continue to work with issues related to safety, as well as the typical risks associated with the establishment and operation of an offshore wind farm. Overall, risks in large-scale civil engineering projects can be divided into those that affect health, environment and property. In addition, there are risks that affect several of these aspects.

The environment means that offshore wind projects have several unique conditions related to workplace accidents (including accidents affecting third parties), such as the marine environment, that work can take place at heights and in confined spaces, and that work can involve heavy lifting and electricity. Risks to the environment are often the result of uncontrolled emissions of various kinds, such as chemical products, noise and sediment.

Risks that may arise within the framework of operations that may cause transboundary effects are emissions of oil and chemicals. An example of a measure that can minimize or completely prevent the impact is that there is emergency preparedness.

Discharges of oil or other chemical products can occur from ships and from the various components of the turbine. The oils and other chemical products found in the wind turbines need to be regularly replaced or refilled. At these moments there is a risk of emissions. The probability of a major spill from a vessel within the wind farm is considered to be small, as the operating area is assumed to be operated primarily by service and maintenance vessels and recreational craft to a small extent.

Minor spills of oil or other chemical products could occur in connection with maintenance of the turbines, however, it should be noted that the wind turbines and other parts are designed with, for example, waste trays and/or other possibilities for collecting a possible discharge. The wind farm will have equipment in the form of, for example, booms for handling such emissions.

For a scenario where, in the unlikely event of a release of environmentally hazardous substances, this is not limited and dealt with immediately, calculations for how such a release could move have been carried out. For such a discharge, its movements in the water are considered to be mainly dependent on the surface currents within the area where the discharge occurs. For wind speeds between 5 and 30 m/s, the current velocity at the water surface can be assumed to be about 3 percent of the wind speed. The most common wind speeds in a west-southwest direction are between 4 - 8 m/s. As a reference example for a theoretical worst-case scenario, where the wind and flow direction at the time the discharge occurs is constant and lies straight towards one of the offshore banks, it is estimated that it takes about 12 hours for a possible discharge to reach Norra Midsjöbanken and about 14 hours to reach Hoburgs bank, at a wind speed of 8 m/s. In light of the preparedness and monitoring that will be in place within the Aurora Wind Farm, it is estimated that vessels, personnel and equipment can be in place to limit and handle a possible spill before it reaches the above distances.

Before construction work begins, a contingency and rescue plan shall be drawn up after consultation with the supervisory authorities, other relevant authorities and the municipalities concerned regarding, inter alia, sea rescue operations, rescue measures and the salvage of any damaged ships. The plan will include, among other things, a plan for measures to protect the environment in the event of oil spills and for the salvage of any damaged ships. Consultation will also take place with the Swedish Maritime Administration and the Swedish Transport Agency prior to the construction phase on measures required for protection against disruptions to shipping. Monitoring in the operational area shall take place during the construction phase and also continued during the operational phase if the Swedish Maritime Administration or the Swedish Transport Agency deems that such a need exists. Vessels at risk of misnavigating in relation to the wind farm shall be warned.

7.6.7. Transboundary effect

Risks that the operation may give rise to will be continuously managed and minimized through, among other things, risk analyses, the establishment of a work environment plan and the implementation of various protective measures and procedures. Handling of accidents at wind turbines will also be included in the preparedness and rescue plan prepared for the construction works. The activity applied for is therefore not considered to give rise to any unacceptable risk.

Wind farm Aurora Wind Farm is not expected to have a negative transboundary impact on risk and safety as protective measures are taken during the construction, operation and decommissioning phase to avoid emissions of chemical products.

7.7. Climate

This section describes the climate impact in the form of the operation's impact on the climate, where the focus is on greenhouse gas emissions, energy use and management of natural resources.

7.7.1. Conditions

Structor Miljöpartner (Structor) has, on behalf of the company, conducted an investigation with the aim of clarifying the climate impact and climate benefits of offshore wind power.

Through the life cycle analysis, the total impact per kWh of electricity produced can be calculated and compared with other types of power. The completed study of wind power life cycle assessments shows greenhouse gas emissions between 7 and 56 g CO2e/kWh, depending on the type of wind turbine, geographical location and other conditions. It is the small wind turbines that account for emissions in the higher range. A German study's life cycle analyses show greenhouse gas emissions of 7.3 g CO2e/kWh, for an average offshore wind turbine. Vattenfall AB has also carried out life cycle assessments for newer (onshore) wind turbines, resulting in lower greenhouse gas emissions, of 6–7 g (Hengstler, et al., 2021)$_{CO2}$e/kWh. (Vattenfall, 2019)

According to the IPCC, offshore wind generates 1 g$_{CO2}$e/kWh more than onshore wind power. Therefore, based on Vattenfall's study 2019 and the IPCC's assumptions on offshore wind power, it can be assumed that wind power in Aurora Wind Farm entails carbon dioxide emissions of approximately 8 g (IPCC, 2014)$_{CO2}$e/kWh. However, as production from Aurora Wind Farm is expected to be significantly higher compared to land-based ones, carbon dioxide emissions can be expected to be lower than 8 g CO2e/kWh for Aurora Wind Farm.

Aurora's emissions of approximately 8 gCO 2 e/kWh can be compared with the average climate impact from Nordic production (Nordic mix) which generates approximately 365 gCO 2/kWh and the average impact from European production (European mix) which generates 486 gCO_2/kWh. CO2 (AIB, 2019) emissions from Aurora Wind Farm's expected annual production of 24 TWh would be around 45 times less, compared to the same production of energy from the Nordic mix. Compared to the European mix, the production from Aurora Wind Farm would mean about 60 times less carbon dioxide emissions. The assessment is thus that the Aurora Wind Farm provides a significant climate benefit as significantly less CO2 is generated per produced kWh.

7.7.2. Transboundary implications

The establishment of the Aurora Wind Farm will have a certain climate impact in the form of the emissions generated during the production of the wind farm's various materials and components, as well as during the actual construction of the wind farm. Based on calculations of greenhouse gas emissions per kWh of electricity produced, made for both offshore and onshore wind power, the Aurora Wind Farm is expected to generate greenhouse gas emissions of less than 8_{gCO2}e/kWh.

Electricity production from the Aurora Wind Farm is estimated to result in 45 times less carbon dioxide emissions compared to the same average production of energy in the Nordic countries. Compared to the average energy production in Europe, the production from Aurora Wind Farm would mean about 60 times less carbon dioxide emissions. Compared to the carbon dioxide emissions generated by electricity production from a reasonable replacement mix, the Aurora Wind Farm can reduce carbon dioxide emissions by 14 million tonnes/year. Therefore, Aurora Wind Farm is considered to be an extremely important part of Sweden's national work to achieve the climate goal of fully renewable electricity production by 2040 and zero net emissions of greenhouse gases by 2045. Aurora Wind Farm is expected to contribute very positively to the work of replacing fossil electricity production and thereby contribute to large-scale reduction of greenhouse gas emissions.

As shown above, the consequences of reduced emissions of$_{CO2}$ will be very positive. The impact is also considered positive in a transboundary perspective as the climate is a global issue that has no national borders. To meet the temperature targets of the Paris Agreement, the world needs to halve annual greenhouse gas emissions over the next eight years, according to the United Nations Environment Programme's latest report from 2021 (UNEP Emissions Gap Report, 2021). A rapid global transition away from fossil fuels is needed, along with a range of other measures to reduce greenhouse gas emissions. The Aurora Wind Farm contributes to achieving the common climate goals. The Aurora Wind Farm can also contribute to the European electricity supply and contribute to climate benefits by replacing coal and gas power through electricity exports to Europe.

8. Cumulative effects

This chapter describes the cumulative effects from the planned Aurora Wind Farm in combination with the potential effects from any nearby offshore wind farms and related activities. Other maritime and commercial fishing activities in the area are also subject to cumulative assessments.

At the early planning stage of a project, there is usually a high degree of uncertainty of the final scope, design, and environmental impact that the project will have. This therefore introduces a level of uncertainty in assessing the cumulative effects.

It is relevant to consider the two existing offshore wind farms in the immediate area; Bockstigen I and Kårehamn (around 34 and 35 km respectively from Aurora Wind Farm), for which there is a foreseeable basis for a cumulative assessment. The company has two additional projects in the Baltic Sea, the Neptunus and Pleione Wind Farms. The company has relevant knowledge of these projects and therefore they have been included in the cumulative assessment regarding the impact on the Natura 2000 area: Hoburgs bank and Midsjöbankarna (Table 14).

The cumulative effects of other licensed though not yet constructed wind farms in other parts of the Baltic Sea situated far from Aurora Wind Farm have not been assessed.

Table 14. Existing wind farms and the company's own planned projects in the vicinity of Aurora Wind Farm for which cumulative effects are assessed.

Existing wind farms	**Project status**	**Distance to Aurora Wind Farm (km)**	**Year of construction**
Bockstigen I	In operation since 1998	34	1998
Kårehamn	In operation since 2013	35	2013
Neptunus	In the planning phase		-
Pleione	In the planning phase		-

The environmental aspects of the construction, operation and decommissioning phases where a cumulative effect is expected to occur are described in more detail below.

8.1. Construction phase

8.1.1. Marine mammals and fish

Construction work at any future nearby wind farms could potentially have a cumulative impact on marine mammals and fish. Surveys and installation work generate underwater noise as well as sediment suspension and dispersal that could affect fish, fish larvae and spawn.

Considering the extensive protective measures that the Company has undertaken, such as a soft start with gradual escalation, double bubble curtain, and time restrictions, the temporary displacement of marine mammals that may occur is not expected to have negative consequences either at the individual level or population level and thus also not affect marine mammals or fish. The conservation status of harbour porpoises or their ability to achieve good conservation status are not affected in the short or long term.

If another wind farm is built in the region simultaneously then possible cumulative effects can be avoided with adapted installation plans. The construction phase of an offshore wind farm, consisting of surveys and installation work at sea is planned well in advance. Each supervisory authority will also be involved in the development of the control programmes for both wind farm Aurora Wind Farm and for any other projects. In addition, both control programmes and installation plans for the various projects will be submitted to the supervisory authority several months before the work commences. The supervisory authority will thus have an overall picture of planned construction work in the area, which will enable the supervisory authority together with the operators, to coordinate the projects.

Protective measures are taken to avoid cumulative impacts from construction work from possible future projects and there are no existing licensed wind farms located in the close vicinity of Aurora Wind Farm in either Swedish or international waters. There are therefore no expected cumulative nor transboundary cumulative effects on marine mammals or fish during the construction phase.

The increased vessel traffic in connection with surveying and installation work is not expected to have any cumulative transboundary effects on shipping or commercial fishing as no other licensed wind farms are located in the vicinity of Aurora Wind Farm.

8.1.2. Bird

No cumulative effects on birds are expected to occur during the construction phase.

8.1.3. Bats

No cumulative effects on bats are expected to occur during the construction phase.

8.1.4. Commercial fishing

During the construction phase, maritime traffic in the area will temporarily increase. As commercial fishing is not widespread in the area and the presence of fish is low, no cumulative effects on commercial fishing are expected to occur.

8.1.5. Navigation

During the construction phase, maritime traffic in the area will temporarily increase. Taking into account the protective measures implemented for shipping in the construction phase, see section 9, no cumulative effects on shipping are expected to occur.

8.2. Operational phase

8.2.1. Marine mammals and fish

The underwater noise that may occur during the operational phase is significantly lower, and of a different nature, than that that occurs during the construction phase. These underwater sounds are expected to occur mainly in the immediate vicinity of the individual wind turbines. Shipping in adjacent sea lanes already gives rise to underwater noise and the additional vessel traffic (mainly smaller maintenance and service vessels) as a result of the Aurora Wind Farm is estimated to contribute to an insignificant increase in underwater noise from vessels in comparison to existing vessel traffic. The nature and small magnitude of underwater sounds during the operational phase results in negligible cumulative effects on populations of fish and marine mammals. Cumulative effects on harbour porpoises and fish of the Aurora Wind Farm and the existing wind farms Bockstigen I and Kårehamn are estimated to be negligible due to the large distances between the wind farms.

8.2.2. Bird

The cumulative effects that may occur on birds during the operational phase are assessed in relation to existing activities in the area, which consist of the wind farms Kårehamn and Bockstigen I and shipping in the area.

The two existing wind farms Kårehamn and Bockstigen I are relatively small, with significantly fewer and lower turbines than is relevant for Aurora Wind Farm. The assessment is therefore that the cumulative effects for collision risk, displacement and barrier effects are essentially the same as for Aurora Wind Farm alone. This means that the impacts, for all influencing factors and species/species groups, are negligible. The consequences of collision risks have been assessed based on modelling and assumptions based on a worst-case scenario for Aurora Wind Farm. The additional collision risks that affected species are exposed to due to the two existing wind farms are negligible.

The existing wind farms partly include other environments, to the extent that the same species are subject to impacts in the form of displacement. The consequence of the cumulative effect is nevertheless considered to be negligible. Barrier effects have been assessed for the Aurora Wind Farm mainly with regard to migratory birds, the two existing wind farms to some extent cover the same migration routes, but the very limited extent of existing wind farms means that the consequence of cumulative impacts is negligible.

During the operational phase there will be some vessel traffic too, from and within the wind farm. Since there is traffic adjacent to the wind farm along two sea lanes east and west of Aurora Wind Farm, cumulative impacts should be assessed. The impact of the increased vessel traffic during the operational phase is considered to be insignificant and the additive contribution from the Aurora Wind Farm is considered negligible.

The collision risk modelling for Aurora Wind Farm shows that even in a worst-case scenario, there will only be negligible consequences for all assessed species/species groups. The protective measures and investigation programmes recommended for Aurora Wind Farm are considered to be able to minimize the wind farm's contribution to collisions to a very large extent.

The extensive migration studies carried out within the framework of the permit application show that the main migration route of migratory birds does not coincide with Aurora Wind Farm. Thus, Aurora Wind Farm does not constitute a barrier between the birds most important foraging areas in the Baltic Sea, which are the Swedish and Polish outlying banks (including Stupska Lawica), see section 7.3.4. 0

Given the great distance, Aurora Wind Farm's location outside the main migration routes, proposed protective measures and the limited scope of existing wind farms, Aurora Wind Farm is not expected to have cumulative effects on birds.

8.2.3. Bats

For bats, the consequences of possible cumulative effects are estimated to be the same as described in section 7.4 above. With the introduction of a survey programme, which is based on the planned wind farm's start of operation and the implementation of operational regulation of the wind farm about bats during the migration period, no negative cumulative impact is expected to occur.0

8.2.4. Commercial fishing

The conditions for maintaining commercial fishing in the Baltic Sea are not affected by the establishment of the Aurora Wind Farm. This is because the wind farm's area of operation has neither today, nor for the past 15 years, been an important catch area for commercial fishing. Nor is there any indication that the importance of the area for commercial fishing may change in the foreseeable future. The planned wind farm will not be closed to vessel traffic, so it does not constitute an obstacle for fishing vessels choosing to pass through the wind farm. The wind farm will also not affect the maritime safety of fishing vessels, see section 7.6. 0

8.2.5. Navigation

During the operational phase of Aurora Wind Farm, there will be an increase in vessel traffic in the area, which could increase the risk of collisions. However, the additional vessel traffic is considered to be insignificant in relation to the existing vessel traffic in the area. Furthermore, the vast majority of vessel transport to and from the wind farms during the operational phase will be done with smaller maintenance and service vessels which can be expected to have good manoeuvrability, which reduces the risk of collisions.

The existing wind farms Bockstigen I and Kårehamn are located at too great a distance from Aurora Wind Farm to have cumulative effects on shipping. The distances between the sea lanes that pass through Aurora Wind Farm, and where traffic can be affected to some extent, to Bockstigen I and Kårehamn are so great that there are no cumulative effects.

In summary, Aurora Wind Farm is not expected to have a negative cumulative impact on shipping in the operational phase.

8.3. Decommissioning phase

The decommissioning phase of the Aurora Wind Farm and of the other planned projects is so far into the future that at the time of the creation of this document it is impossible to predict what other measures or activities may coincide with the decommissioning of the Aurora Wind Farm and which may thus contribute to cumulative effects. It is therefore not possible to assess the possible cumulative effects of this phase.

9. Protective measures

Protective measures have been proposed as conditions for the permits for planned activities relating to the Aurora Wind Farm. These have either been included as prerequisites in impact assessments, or have been deemed irrelevant as a result of the impact assessments or comments from authorities. Within the framework of the impact assessments that have been produced, an assessment has been made of which protective measures are justified based on the consequences that the activities entail for various aspects concerned. Several of the protective measures listed below are suggested as permit conditions that the operator is obliged to comply with.

Cumulative effects

- If necessary, the Company shall, at least three (3) months before the construction work begins, submit an installation plan to the County Administrative Board of Gotland that describes how cumulative effects through coordination with other civil engineering projects are to be minimized.

Maritime transport and safety

- Wind turbines and measuring masts must be marked in accordance with the Swedish Transport Agency's and the Swedish Maritime Administration's regulations.
- All marine work during the construction phase must be supervised by a marine coordinator, who supervises its own traffic (which vessels are in the area, what tasks are to be performed, which people are where, and so on). A marine coordinator will also supervise other vessel traffic and can assist it.
- Clear and frequent information about which construction activities are in progress and which areas are affected should be provided via UFS (Notifications for Seafarers) and NtMs (Notice to Mariners).
- The area shall be defined and marked out in charts and visually with buoys with Racon or radar reflectors.
- Work lights on work vessels and platforms shall, as far as possible, be shielded from passing traffic.
- Any crossings of ferry routes shall take into account ferry timetables.
- Prior to consultation and determination of positions for the wind turbines closest to sea lanes, an updated nautical risk analysis shall be carried out.
- Wind turbines shall be located with a minimum distance of 1.38 nautical miles in relation to the sea lanes Nynäshamn – Gdansk (east), Ölands Södra Udde – Gulf of Finland (southeast) and Ölands Södra Grund – Svenska Björn. Shorter safety distances may be decided between the nearest wind turbine or substation and these traffic routes if an updated nautical risk analysis for the wind farm shows that maritime safety can be maintained even with a shorter safety distance.

- On the vessels used for service and maintenance, there must be equipment for sea rescue and environmental efforts, such as opportunities to salvage people, defibrillators, stretchers and booms to limit the spread of possible spills of oil or other chemical products.
- A study of possible radar disturbances to vessel traffic from the wind farm shall be carried out and, if necessary, radar shall be established.
- In major naval operations, clear information must be provided via UFS (Intelligence for Seafarers) and NtMs (Notice to Mariners) about what work is ongoing and which areas are affected.
- The wind farm and the area around the wind farm will be monitored remotely to enable, among other things, the detection of vessels on an allision course with the wind farm.
- In order to avoid shipping-related risks, the company shall monitor a protection zone of at least 500 metres from installation vessels during the operational phase when maintenance work with installation vessels is carried out.

Detection and operational regulatory equipment

- The wind farm will be equipped with detection and operation control equipment to enable operational control of wind turbines to reduce the risk of collision for birds and bats.

Clearance

- The clearance between the water surface and the rotor blades shall be set at 30 metres, to protect the seabirds and bats in the area.

Protection measures for marine mammals and fish

- For the protection of marine mammals and fish, soft-start shall be applied before seismic equipment is used.
- During the start of survey work with seismic methods, passive acoustic monitoring will also be used and there will be observers on the ship who look for marine mammals in the vicinity of the vessel.
- For the protection of harbour porpoises, equipment for examinations using the side-scanning sonar and multi-beam sonar methods shall be used with a sound frequency exceeding 200 kHz.
- For the protection of harbour porpoises, underwater noise from seismic surveys during the period 1 May to 31 October shall not exceed the value $SPL_{RMS\text{-}fast,\ VHF}$ 100 dB re. 1 μPa within the Natura 2000 site Hoburgs bank and Midsjöbankarna
- Prior to piling work, acoustic methods that remove porpoises, with techniques adapted for porpoises, will be used to the required extent.
- Piling work shall begin with a soft-start, after which the strength of the hammer blows is gradually escalated to full strength (ramp-up). The period of soft start-up and gradual escalation, together with other protective measures, shall be sufficient to protect marine mammals against underwater piling noise exceeding the permanent hearing loss (PTS) and temporary hearing loss (TTS) thresholds for harbour porpoises respectively.

- Piling work must use sound-absorbing equipment.
- During piling operations, underwater noise shall not exceed the single pulse value $SPL_{RMS\text{-}fixed,\ VHF}$ 100 dB porpoise re 1µPa at a distance of 9,4 kilometres from the sound source.
- To protect the porpoise calving and mating period, underwater noise from piling operations during the period 1 May to 31 October shall not exceed the value $SPL_{RMS\text{-}fast,\ VHF}$ 100 dB porpoise re 1µPa within the Natura 2000 site Hoburgs bank and Midsjöbankarna.

Protection measures and survey programmes for migratory birds

- The responsible party shall investigate the movement patterns of migratory birds through the wind farm and the risk of collision with the rotor blades of the wind turbines for a period of three (3) years from when the first wind turbine is put into operation.
- The company proposes operating control that refers to 3 hours on average per commissioned wind turbine to reduce collision risks for migrating cranes, birds of prey and geese during spring and autumn migration to be applied between sunset and sunrise when the risk of collision with the wind turbines' rotor blades is elevated. This means a total possible operating time of 1110 hours with a wind farm comprising 370 wind turbines.
- The company proposes a condition regarding operating control for the protection of night migratory small birds, during spring and autumn migration, to be applied between sunset and sunrise when the risk of collision is increased, i.e. large migration flow at rotor height and bad weather conditions with limited visibility, with up to a maximum of 10 hours/wind turbine /year (calculated on average per commissioned wind turbine), or a total of 3700 hours per year if 370 wind turbines are built in the wind farm.

Survey programme for bats

- The responsible party shall investigate the presence of bats in the operating area and the impact of the wind farm on migrating bats for a period of three (3) years after the first wind turbine has been put into operation.
- The company proposes a condition regarding operating control for the protection of migrating bats, during spring and autumn migration, with up to a maximum of 5 hours/wind turbine/year (calculated on average per commissioned wind turbine), or a total of 1,850 hours per year if 370 wind turbines are built in the wind farm.

10. Comprehensive assessment of transboundary impacts

Below is a summary of the overall transboundary impact of the activities.

The Aurora Wind Farm contributes positively to Sweden's and the EU's environmental goals and is expected to be an important part of Sweden's and Europe's process of switching to renewable electricity sources and contributing to meeting Sweden's climate goals. The wind farm is expected to have **long-term positive consequences** in terms of replacing fossil electricity production and thus lead to a large-scale reduction of greenhouse gas emissions. These longer-term positive consequences need to be related to the negative consequences that may arise and which in most cases are of a more temporary and time-limited nature.

Impact and impact assessments are based on a worst-case scenario. The assessments are based on assumptions about a maximum design scenario that takes into account by a significant margin what could be the greatest impact on the environment. This enables a design of the wind farm based on the limits set by the permit. This approach has been used to cover all cases with less impact and consequences. The environmental impact may thus be smaller but not more extensive than described in this report.

Consequences for fish and marine mammals are mainly linked to the construction phase and influencing factors are, above all, sediment dispersion and sedimentation as well as underwater noise when installing foundations. The construction phase will last for a limited period of time and protective measures will be taken. These factors are therefore considered **to have negligible transboundary effect.**

For birds, the main impacts and consequences are estimated to be linked to the risk of collisions with wind turbines. Depending on the bird species and weather conditions, the risk of collision is greater or less. Proposed protective measures in the form of operational control are expected to reduce the risk of collisions. Overall, the consequences are thus considered **to be negligible**.

For commercial fishing, the impact is estimated to be **negligible.** This is because the area covered by the planned wind farm is only of marginal importance for commercial fishing, while there are, among other things, good opportunities for redistribution of fishing to other places. Any positive effects on fish populations may benefit commercial fishing in the long run.

For shipping, the wind farm during the operational phase, without taking into account risk protective measures, is estimated to mean a certain increase in the likelihood of incidents. However, with planned risk protective measures, the probability of accidents is expected to be so low that the risk is acceptable. Overall, the consequences are estimated to be **small to moderate.**

No unacceptable risks are deemed to arise as a result of Aurora Wind Farm. The wind farm will be designed in such a way that it can withstand climate change. Furthermore, the company will work with risk management and risk minimization by, among other things, developing a contingency and rescue plan in consultation with supervisory authorities and other relevant authorities and municipalities.

The negative impacts that may arise from the wind farm are in many cases short-term and limited, due to the fact that they are mainly linked to the construction phase and that they mainly occur within the wind farm area itself.

Table 15. shows the size of the consequences for each recipient and interest. On some issues, continued dialogue remains, this is also indicated in the table.

Table 15. Summary of assessed consequences for each recipient/interest

Interest/Recipient	**Consequence**
Fish	Negligible
Marine mammals	Very small - negligible
Bird	Negligible
Bats	Negligible
Commercial fishing	Negligible
Navigation	Small - Moderate
Risk and safety	No unacceptable risk
Carbon footprint	Negligible – Positive

11. Alternatives

The alternative report describes the various alternatives studied for the operation, as well as the choices and trade-offs that have been made taking into account the environmental effects of the operation and other criteria.

The non-action alternative, which refers to a description of the effects that are expected to occur or not occur if the activity applied for does not materialize.

11.1. Localisation starting point

The choice of location for the applied operations has been based on a detailed and comprehensive location investigation, where the company's final choice of offshore design areas is the result of a systematic evaluation, based on, among other things, expected environmental effects, where less suitable locations have been gradually selected.

The primary objective of the location investigation has been to select the areas around southern Sweden's coastal areas that have the best conditions for the establishment of offshore wind power, based on a broad approach and a thorough investigation of possible areas at sea. The company's completed location study has resulted in a number of different suitable areas in the Kattegat, in the Southern Baltic Sea and in the Baltic Proper.

The main opportunity for significantly increased electricity production in southern Sweden is large-scale offshore wind power, and the potential for offshore wind power in southern Sweden is far greater than the corresponding conditions for onshore wind power.

The following paragraphs describe the basic starting points that have been applied to investigate and evaluate possible locations and which have thus constituted criteria for assessing the different location options.

11.2. Analysis and selection

For a more detailed analysis of suitable project areas, the company's basic technical and economic conditions for the location, i.e. an area's wind conditions, water depth, geology and size, as well as other selection criteria for the location, i.e. impact on natural and cultural environments, commercial fishing, shipping and other relevant interests, have been applied. In addition, the investigation has been supplemented and refined by considering some fifty different parametres linked to 16 different categories. The 16 categories are:

- Marine mammals
- Birds
- Fish
- Bottom flora and fauna
- Bats
- Protected areas
- Red listed species
- Navigation
- Total Defence
- Fishing
- Maritime spatial planning
- Pipelines and cables
- Air traffic
- Cultural environment
- National interests
- Environmental toxins and unexploded ordnance

The current parametres have been compiled in a geographic information system (GIS) where different layers of maps and interests have been added as building blocks in a detailed analysis of the waters of the Baltic Proper, the Southern Baltic Sea, the Bothnian Sea, the Kattegat and Skagerrak. The location investigation has paid particular attention to sensitive species that can typically be expected to be affected by wind farms and it has been a central starting point for the Company to avoid, as far as possible, the areas where the sensitivity, with regard to marine species and habitats, is greatest.

The detailed location analysis in the second stage of the investigation resulted in several of the initially identified potential alternatives being discarded, ultimately resulting in the most suitable areas in the Baltic Proper, Southern Baltic and Kattegat that OX2 is now developing more or less in parallel. The planned Aurora Wind Farm is one of these areas.

11.3. Selected alternative

Within the framework of the in-depth location analysis, a number of natural boundaries arose in relation to existing protection and interest areas. In addition, consideration of the expected environmental impact, different possibilities for connections and overall technical conditions has resulted in the chosen location option for Aurora Wind Farm, which has particularly good conditions for the establishment of wind power.

The planned wind farm is located in an area where the existing natural values, due primarily to the water depth in combination with hypoxic or completely anoxic conditions, are virtually non-existent. Since no sunlight reaches the bottom, the area lacks bottom flora. The bottom environments are characterized by the hypoxic or anoxic conditions that predominate in the deep areas, which means a lack of benthic fauna within the anoxic areas and a low biodiversity with few individuals in the hypoxic areas.

Surveys carried out have shown that the presence of fish is very low. The lack of large quantities of fish means that fish-eating marine mammals such as porpoises and seals do not occur in the area to any great extent. The relatively great depths and the general absence of fish also mean that the area is not a suitable foraging area for bird species whose diet consists largely of fish and/or mussels.

The planned wind farm does not overlap with any Natura 2000 sites or nature reserves.

The size of the available area also allows for the construction of a relatively large wind farm, bringing environmental, technical and economic benefits.

11.4. Non-action alternative

The non-action alternative means that the activity applied for does not come to fruition. Thus, the planned Aurora Wind Farm's contribution to Sweden's and Europe's need for large-scale expansion of renewable electricity production will not materialize, which will have consequences for, among other things, the national electricity supply, the conditions for a transition of society and industry and for the climate. The non-action alternative thus means that the area in question remains unchanged compared to today, and that the positive long-term climate and environmental effects that the applied operation will entail, are lost.

Carbon footprint

From a climate perspective, the non-action alternative means that emission reductions are not promoted, which in turn can cause difficulties in reducing the climate impact linked to the use of fossil fuels. As described in the section above, the expansion of offshore wind power can meet both the need for electrification in the industrial and transport sectors, as well as the need to enable electricity exports that crowd out fossil-based power generation in Europe. These possibilities are limited in the non-action alternative, provided that the same power generation is not deployed by other means and locations. Calculations of the climate benefits of wind power can be made in different ways. In summary, however, it can be stated that the Aurora Wind Farm enables extensive emission reductions regardless of whether these are calculated with regard to electrification or displacement of fossil energy and regardless of which calculation models are used. The climate benefit is not realized in the non-action alternative, which may make it more difficult to achieve Sweden's and the EU's climate and environmental goals.

12. Follow up and control

The company will develop a control programme for the planned operations in consultation with the supervisory authority after a permit has gained legal force. The purpose of the inspection programme is to report on compliance with the conditions laid down in the permit. Examples of parametres that will be followed up within the framework of the developed control programme are underwater noise that occurs during the construction phase.

The monitoring programme of activities will be coordinated to include the conditions set out in the Natura 2000 permit granted.

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