Ran Wind farm

Espoo report

2025-02-04

Administrative tasks

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Non-technical summary

Activity applied for

Ran Vindpark AB, a subsidiary of OX2 AB and Ingka Investments (the applicant is referred to in this EIA as "the Company"), is planning an offshore wind farm in Swedish territorial waters in the Baltic Proper, east of Gotland, called Ran. The wind farm is planned to comprise up to 121 wind turbines. The wind turbines will have a maximum total height of 310 metres and an estimated capacity of approximately 15-20 MW per turbine. The overall purpose of the wind farm is to produce renewable electricity and thus contribute to achieving Sweden's energy and climate goals and provide society and business with competitive energy.

This Espoo Report forms part of the consultation process being undertaken by OX2 on the potential transboundary impacts of the planned activity, in accordance with the Convention on Environmental Impact Assessment in a Transboundary Context ("Espoo Convention"). This report thus describes the potential transboundary impacts of the Ran wind farm.

Localisation and area description

The area of Ran wind farm consists of open sea and has no islands. The Ran wind farm is located approximately 12 kilometres east of Gotland, within Swedish territorial waters and covers an area of approximately 327 km^2. Within Ran wind farm, the water depth varies between approximately 40 and 85 metres. The distance from Ran wind farm to other countries is considerable.

Knowledge base

Site-specific inventory data, scientific literature and research results, environmental assessments, technical reports and information from authorities have been used as the basis for descriptions and assessments in the Espoo report. Within the framework of the project, inventories have been made of birds, porpoises and fish, among other things. Modelling and analyses have been carried out for sediment dispersion, sound propagation (under and above water), shadows, hydrography and oxygenation. Photomontages and visualisations have been produced to visualise how the wind turbines appear in the landscape. The knowledge base is judged to be robust and scientifically based and of such scope that qualified and reliable assessments of the effects and impact of the activity can be made. All background reports produced within the project constitute reference reports for this Espoo report and are referred to as R.1, R.2, R.3 etc. throughout the text, see section 13.1. Reference reports can be provided on request.

Assessed impact

This Espoo report presents the assessed transboundary impacts of the wind farm on climate, fish, marine mammals, birds, bats, commercial fisheries, maritime transport and risk and safety. Cumulative impacts of other existing and planned activities in the area have also been assessed.

Impact assessments have been carried out for all phases of the activity; construction (including investigations), operation and decommissioning. The assessment of the transboundary environmental impacts for each environmental aspect has been made by weighing together the sensitivity/value of the recipient and the extent of the assessed impact that may arise as a result of the activity. Relevant influence factors assessed include impacts from underwater noise, barrier effects and displacement.

The impact assessments in this Espoo report have been based on a worst-case scenario. The final design of the wind farm has not yet been decided but will be adapted according to the appropriate and available technology at the time of construction. The worst-case approach aims to take into account the largest possible impact. This means that the assessments of the transboundary impacts of the planned activities on the environmental aspects have been based on the largest impact that could occur to account for possible uncertainties and not to underestimate the magnitude of the impact. In reality, the influences and impacts are expected to be smaller.

Protective measures

As preconditions for the applied activity, several protective measures will be implemented to reduce impacts and effects when deemed necessary. The protective measures include methods and measures to reduce noise impacts on marine mammals, reduce collision risk for birds and bats, and signage and information to reduce the risks in relation to maritime transport.

Climate benefits and impacts

During its lifetime, from construction to decommissioning, Ran wind farm will have some climate impact. During the construction and decommissioning phase, greenhouse gas emissions will occur, for example from the manufacture of components and from transport. However, the climate benefit of the fossil-free energy production that the wind farm entails during operation is expected to far outweigh the impact that occurs during the construction and decommissioning phases.

Ran wind farm is deemed to have an overall positive impact on the climate, as it contributes significantly to the transition to fossil-free energy production and large-scale reduction of carbon dioxide emissions. The positive impact that arises from this are considered to extend across borders because the climate has no national borders and because these positive impacts contribute to meeting the common climate goals.

Fish

The establishment of the wind farm may give rise to impacts on fish during all phases. However, only the impact on fish due to underwater noise is assessed as potentially causing transboundary impacts.

During the construction phase, with protective measures in place, it is assessed that there will be mainly a localised impact on fish due to underwater noise from pile driving. The same assessment is made in relation to the decommissioning phase even if piling does not take place during this phase, which is mainly due to the fact that the final decommissioning method is not yet established. The geographical extent of the impact is small and temporary, and the area is not considered to be of particular importance for fish. The impact is assessed as insignificant as no impact at population level is expected. The transboundary impacts are therefore deemed to be negligible during these phases.

During the operational phase, the transboundary impacts on fish are also deemed to be negligible. This is because the underwater noise created by the establishment of the wind farm does not add any additional impact over and above the already existing noise level in the Baltic Sea that arises from maritime transport.

Marine mammals

Four species of marine mammals may occur within the wind farm area; harbour porpoise, harbour seal, grey seal and ringed seal.

The park area is not considered to be an important habitat or breeding area for harbour porpoises, as data shows that it is rare for harbour porpoises to be in the area and there is nothing to suggest that Ran wind farm is more important as a foraging area than the surrounding waters. The park area is not considered to be an important habitat for harbour seals, grey seals or ringed seals, as it is regarded as a less significant foraging area in comparison with Gotland's coastal waters.

Ran Wind Farm is not assessed to affect marine mammals at the population level or impede their ability to reach a favourable conservation status, at either the local or biogeographical level, which is why the transboundary impacts are assessed as negligible. The primary local impact is the generation of underwater noise during the construction phase, which may prompt marine mammals in the vicinity of the wind farm to avoid the park area, resulting in a localised and temporary loss of habitat. It is not anticipated that noise generated during the construction, operation and decommissioning phases will reach the territorial waters of other countries.

During the construction phase, local impacts on marine mammals are expected to arise mainly from underwater noise generated during geophysical surveys and piling of foundations. This noise may prompt marine mammals to avoid the area. To minimise impacts, protective measures will be implemented, such as acoustic mitigation methods, soft start-up and silencing equipment such as double bubble curtains or similar. For all influence factors during this phase, the transboundary impacts are assessed to be negligible for seals and harbour porpoises.

During the operational phase, the impact of underwater noise on marine mammals is assessed to be insignificant at the population level and the transboundary impact is assessed to be negligible. Underwater noise during the operational phase consists mainly of operational noise from wind turbines and vessel noise from maintenance vessels. It is anticipated that the additional vessel traffic generated by the Ran wind farm will contribute to a negligible increase in underwater noise from vessels compared to existing vessel traffic in the adjacent shipping lanes.

During the decommissioning phase, the local impact on marine mammals is assessed to be similar to that of the construction phase but to a significantly lesser extent as no piling will occur. The transboundary impacts during the decommissioning phase are deemed to be negligible for seals and harbour porpoises. If decommissioning involves the total removal of foundations and the like, the wind farm area will revert to a scenario similar to the baseline alternative, where no impact from the wind farm occurs for marine mammals.

Protective measures will be applied in order to avoid damage or significant disturbance. Examples of protective measures include acoustic cancellation methods, soft start-up and sound attenuation equipment such as double big bubble curtains.

Birds

The migration over the Baltic Sea is extensive during spring and autumn, when a number of seabirds, most notably geese, ducks and loons, as well as nocturnal migratory birds may pass through Gotland during migration. A number of these species may also migrate across the Ran wind farm area. The depth conditions within the farm area vary between 40-85 metres, which is why the area is not assumed to be an important foraging and wintering area for seabirds, which generally forage in shallower water. The impact on birds is assessed based on the influence factors collision risk, displacement and barrier effect.

It is mainly migratory birds that may pass through the wind farm during certain time periods, and the species that migrate across the wind farm area generally show a high avoidance rate in relation to offshore wind power. A collision risk modelling has been carried out for the species that may migrate through the wind farm area. Overall, the collision risk for all bird species concerned is assessed to be low and the transboundary impacts are negligible.

The impact from displacement effects is assessed to be insignificant as the area is of little importance as a foraging area, and the species concerned therefore occur at low densities. Overall, the transboundary impacts are assessed to be negligible with respect to displacement.

For birds with documented avoidance behaviour in relation to wind turbines, there is a risk of impact in the form of a barrier effect, which may result in higher energy consumption. Considering the entire migration route and the natural migration and resting behaviour of the species, the additional energy consumption required when the birds take a different migration route has a negligible impact. Overall, the transboundary impacts are assessed to be negligible in terms of barrier effects.

In conclusion, the assessment is that breeding populations from other countries are not at risk of being significantly affected, and that the activity does not give rise to any impact at population level. The transboundary impacts are therefore assessed to be negligible for birds.

Bats

The bat species nathusius's pipistrelle has been noted in the farm area in connection with inventories carried out. It can therefore not be ruled out that the establishment of the Ran wind farm may have an impact on migratory bats. However, only long-distance migratory bat species may be affected in such a way that transboundary effects arise.

Bats are only expected to be affected as a result of increased collision risk during the operational phase. A survey programme will be conducted by the company during the initial three-year operational phase and, if necessary, the rotor blade speed can be reduced in order to reduce the risk of collision. The overall assessment is therefore that the impact on bats is negligible. As a result, the transboundary impacts on bats will be negligible.

Commercial fishing

Based on catch data in the area, the Ran wind farm area is deemed to constitute an active commercial fishing area in the Eastern Gotland Sea. Fishing activity is greatest in the north-eastern part of the Ran wind farm, where Sweden and Denmark account for most of the commercial fishing. Large-scale commercial fishing is relatively low-frequency and focuses on forage fish with lower economic value. The species currently fished in the area are almost exclusively sprat and herring. In a worst-case scenario, the construction of Ran wind farm is expected to make trawling impossible in the area during the construction, operation and decommissioning phases of the wind farm. Such an obstacle to trawling is already planned for the wind farm area, as the Swedish government has proposed that the trawling limit, at least for parts of the coast, should be permanently moved 12 nautical miles from the coast along the entire Baltic Sea. As a result, there are uncertainties regarding what type of commercial fishing that will be possible in the area in the future.

Pelagic fishing is dynamic and not as sensitive to area restrictions as fishing for more stationary fish species. Herring and sprat are fish species that move over large geographical areas to find food and to spawn. At present, restrictive fishing quotas govern the uptake of herring, and fishing activity within Ran wind farm should therefore have good prospects of being redistributed to areas within a radius of 10-20 kilometres from the wind farm.

Navigation through the constructed energy park is not expected to be restricted during the operational phase and fishing vessels will have the possibility to move through the energy park. During the construction and decommissioning phase, the ability to navigate through the park area may be restricted due to protective distances being established. However, this is limited in time and scope.

Overall, the wind farm is assessed to give rise to an insignificant to small transboundary impact on commercial fisheries in the Eastern Gotland Sea. The transboundary impacts are therefore assessed as negligible to very small for commercial fishing, as foreign vessels rarely use the area for commercial fishing.

Risk and safety

The risks that the activities may give rise to will be continuously managed and minimised through risk analyses and the implementation of various protective measures and procedures. A contingency and rescue plan will be developed. The planned project is not considered to give rise to any unacceptable risk from a transboundary perspective, provided that the proposed protective measures are followed.

Maritime transport

Ran wind farm is located between three shipping lanes, but outside established routes.

The risks in relation to maritime transport have been assessed within the framework of a nautical risk analysis. When evaluating the risks identified, no unacceptable risks have been found. All assessed risks have been classified as acceptable or as "as low as reasonably practicable". For risks classified as acceptable, the risks are considered to be so low that no protective measures need to be taken. For risks classified as 'as low as reasonably practicable', the risks are considered tolerable if reasonable precautions are taken.

The distance between the maritime traffic and the wind farm means that there is plenty of room for vessels to navigate safely even when the wind farm is built. This applies to both current and future traffic scenarios. The wind farm does not affect the conditions for navigation within or near any traffic separation zone, nor does it affect the possibilities for maritime traffic to follow straight courses in shipping lanes between traffic separations. Ports are therefore not affected.

Vessel traffic through the farm area is currently limited to two vessels per day. Passage through the wind farm, for example for fishing vessels, will still be possible after its establishment. For those vessels that choose a different route, the journey may be slightly longer, but the effect is considered negligible.

Overall, the sensitivity of maritime transport in the area is assessed to be moderate for all phases of the wind farm: construction, operation and decommissioning. Taking into account the protective measures taken, such as the development of a contingency and rescue plan and the appointment of a marine coordinator, the effect on maritime transport during all phases of the planned wind farm is deemed to be slightly negative. The transboundary effect on maritime transport is assessed to be the same as in Swedish waters, which overall means that Ran wind farm is assessed to have small negative transboundary impact for maritime transport.

Cumulative effects

The starting point for the assessment of cumulative effects has been to assess the existing and permitted activities in the vicinity of the farm area, which could potentially affect the same environmental aspects as Ran wind farm. After the preparation of the Environmental Impact Assessment (EIA), the Swedish government announced the rejection of 13 applications for permits for offshore wind projects in the Baltic Sea on 4 November 2024. Consequently, the likelihood of these projects being realised is minimal. Pleione energy farm has been considered in the Company's cumulative assessment, as have Neptunus energy farm and Aurora wind farm in the Company's cumulative assessment of the Natura 2000 application. This has been done despite the rejection decisions for the farms in question, indicating that the Company's cumulative assessments are very conservative and take into account a worst-case scenario where the rejected windfarms will be established, albeit this is highly unlikely.

For the construction phase, it is mainly cumulative effects with Pleione energy farm that are assessed, as the construction phases of the projects are expected to overlap. For the construction phase, the assessment is that no cumulative effects arise with regard to sediment dispersion, underwater noise (piling work will not take place at the same time), vessel traffic and maritime transport. For commercial fishing, negligible to very small impact is deemed to arise during both the construction and operational phases due to the loss of fishing areas, as the Ran wind farm and Pleione energy farm utilise small parts of an area where active commercial fishing takes place. For the operational phase, the assessment is that there will be negligible impacts on fish, marine mammals, birds and bats. Even from a transboundary perspective, the cumulative effects are assessed to be negligible for all assessed environmental aspects, apart from commercial fishing, where the cumulative effects are assessed to be very small to small with regard to the loss of fishing areas, which mainly affects Swedish commercial fishing.

Natura 2000 and other national interests

Around the Baltic Sea, Natura 2000 sites exist both at sea and along the coasts of the different countries (with the exception of the Russian exclave of Kaliningrad, where there are no Natura 2000 sites). The closest Natura 2000 sites belonging to the Baltic Sea countries are Irbes saurums (Latvia), approximately 106 kilometres to the east, and Akmensrags (Latvia), approximately 127 kilometres to the south-east. Irbes saurums is designated as a protected area under the EU Birds Directive, while Akmensrags is designated as a protected area under both the EU Habitats Directive and Birds Directive. Due to the large distance to these areas, none of the areas are considered to be affected by the planned activities.

Alternatives and baseline alternative

The chosen location for the planned operation has been assessed as suitable on the basis of a comprehensive alternative study taking into account technical, environmental and economic conditions.

The baseline alternative means that the wind farm is not established and that there is no impact on the environment as a result of construction work and the presence of wind turbines and other installations during the operational phase. However, the baseline alternative also means that the significant amount of energy production from Ran wind farm would be cancelled. The baseline alternative also means that the contribution of the activity to regional development and to mitigating climate change through the transition to fossil-free energy is cancelled and that the possibility of achieving the climate objectives is reduced.

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Annexes

Annex B.1 Response to comments received in the context of the Espoo consultation

Concepts and definitions

For the convenience of the reader, specific terms and definitions have been compiled, which are used when describing the planned activities and outlining the project's conditions and expected environmental impacts.

Connecting corridor	The area or areas within which the wind farm **submarine** cables, to one or more onshore connection points, are located.
Submarine cable	Electricity cables that transmit the electricity produced by the wind farm to one or more connection points on land.
Effect	The rate of energy conversion. Generation capacity is measured in kilowatts (kW) and its multiple units; 1 000 kW = 1 megawatt (MW), 1 000 MW = 1 gigawatt (GW), 1 000 GW = 1 terawatt (TW).
Energy	The product of power and time. Energy produced is measured in kilowatt-hours (kWh) and its multiple units; 1 000 kWh = 1 megawatt-hour (MWh), 1 000 MWh = 1 gigawatt-hour (GWh), 1 000 GWh = 1 terawatt-hour (TWh).
Halocline	A boundary between water masses with two different salinities. The difference in salinity between surface water and bottom water creates a stratification that makes mixing of the different layers difficult.
Internal cable network	Network of internal electricity cables within the wind farm.
Environmental impact assessment (EIA)	A document attached to an application for authorisation. It should describe the direct and indirect environmental effects on human health and the environment and allow for an overall assessment of the impacts arising from the planned activities.
Farm area	Area where the wind farm is planned, delimited by the coordinates given in Figure 1.
Protective measure	Protective measures refer to the measures taken to avoid and minimise adverse environmental effects.
Sweden's economic zone	Sweden's EEZ is located where the maritime territorial boundary in the sea does not extend to the delimitation agreed with the neighbouring countries concerned.
Territorial waters	Sweden's territorial waters consist of the waters beyond the baseline out to 12 nautical miles from the baseline.
Total height	The height of the wind turbine up to the tip of the blade at its highest point above sea level.
Wind farm	Wind turbines, internal cable networks, transformer and converter stations, metering masts and associated parts within the farm area.

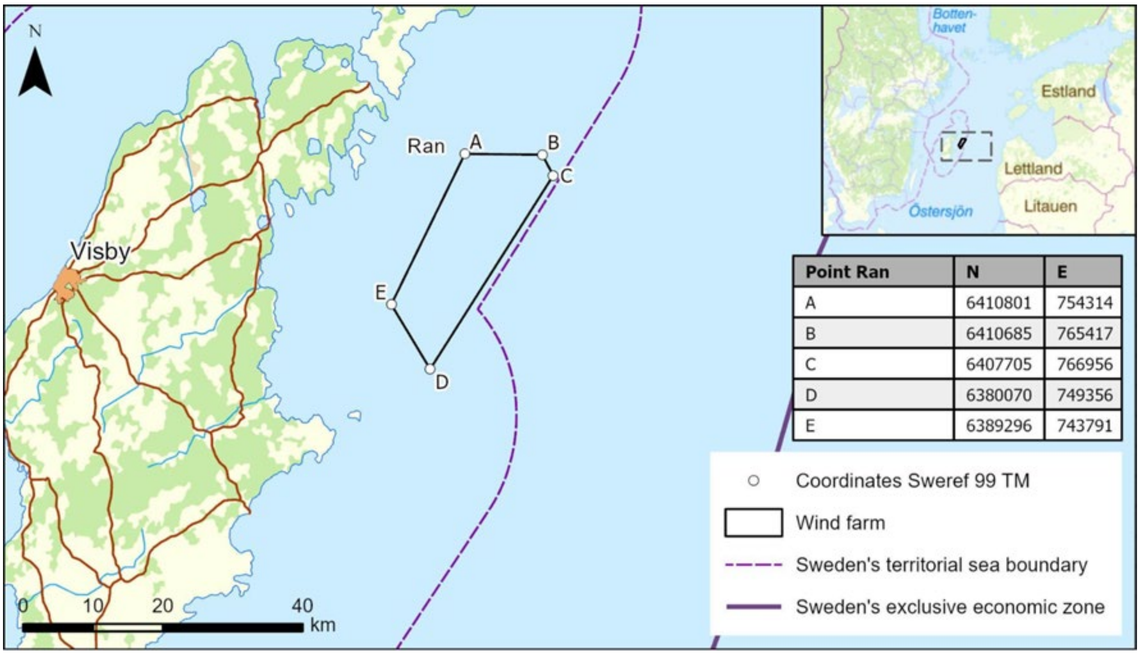
1 Introduction

1.1 Background and purpose

Ran Vindpark AB, a subsidiary of OX2 (publ.), is now planning to establish the Ran wind farm. The wind farm is located in the Baltic Proper 12 kilometres east of Gotland, within Swedish territorial waters. The location is shown in Figure 1.

The farm area is approximately 327 km² (square kilometres). When fully developed, the wind farm will comprise a total of 90-121 wind turbines with a maximum total height of 310 metres and a rotor diameter of between 240 and 280 metres.

The overall aim of the wind farm is to produce renewable electricity. The wind farm is expected to have an installed capacity of around 1.8 GW and is expected to be able to generate around 8 TWh of renewable energy per year.



Point Ran	N	E
A	6410801	754314
B	6410685	765417
C	6407705	766956
D	6380070	749356
E	6389296	743791

Figure 1. Location of the Rans wind farm and coordinates of the wind farm vertices. Base map: © [Lantmäteriet] 2023.

In view of the potential transboundary impact of the activity, a consultation procedure with affected neighbouring countries under the Espoo Convention has been initiated. This report is part of the Espoo consultation and addresses the activity and its potential transboundary impacts.

1.2 Consultation 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 co-operation to prevent transboundary environmental impacts. Sweden ratified the Espoo Convention in 1991. According to the Espoo Convention, the party responsible for an activity with a potentially significant transboundary impact must 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 affected state. For Sweden, the responsible authority is the Swedish Environmental Protection Agency. The Espoo procedure can be briefly summarised in the following overall steps:

- Notification (Article 3) - A planned activity likely to have a significant (adverse) transboundary impact must notify potentially affected parties via the responsible authority. This step has been completed.
- Preparation of the environmental impact assessment (Article 4) - To the extent that interested parties still wish to participate in consultations under the Espoo Convention, an environmental impact assessment (so-called Espoo Report/EIA) shall be prepared. Estonia and Finland have indicated their wish to participate in consultations and this report has therefore been prepared.
- Consultations on the basis of the environmental impact assessment (Article 5) are transmitted via the competent authority to the interested parties who still intend to participate in the procedure.
- Final decision (Article 6) - After consultation, a final decision on the proposed activity must ensure that due account is taken of both the outcome of the EIA and the comments received.

For Ran wind farm, the consultation process under the Espoo Convention began in December 2023, when a notification was sent via the Swedish Environmental Protection Agency to Finland, Germany, Estonia, Latvia, Lithuania and Poland. The notification included a consultation document that described the planned project and the possible transboundary impact that the activity could entail. The consultation was open from 10 January to 14 February 2024. Responses were received from all countries that received the notification, of which Estonia and Finland have indicated their continued participation in the environmental assessment process under the Espoo Convention, including the possibility to consult the present Espoo EIA. Germany, Latvia, Lithuania and Poland have announced that they do not intend to participate in a further Espoo consultation. Latvia also states that it wishes to be kept informed about the environmental assessment and transboundary impacts.

This report describes the activity and its potential transboundary impact, including in the light of comments received. The comments received have mainly concerned:

- Risks/impacts to maritime transport, navigation and marine communications
- Impact on oceanographic monitoring (impact on free-floating buoys)
- Impact on migratory birds and bats
- Impact on marine mammals
- Impact on fish/commercial fisheries
- Cumulative effects of other wind farms
- Impact of underwater noise
- Impact of submarine cables
- Impact of sedimentation
- Impacts and impact of changing air flows
- Impact due to chemical emissions
- Risk of establishment of invasive species

The consultation comments and responses to the comments (including reading references to the main document) can be found in Annex B.1.

1.2.1 Offshore wind energy

Offshore wind power off the coast of southern and central Sweden has great potential to contribute renewable electricity while existing electricity grids can be utilised efficiently. This location also strengthens the area's potential for self-sufficiency and energy stability, as the area currently has the lowest self-generation of electricity in Sweden (Lara et al. 2021).

Moreover, compared to onshore wind farms, offshore wind farms can be built with larger wind turbines of higher power. The conditions for offshore wind are also favourable, as wind speeds are higher and winds blow more evenly, contributing to more stable and efficient energy production.

2 Limitations

2.1 The activities

This report covers the effect and impact of a transboundary nature resulting from the establishment of the Ran wind farm, with associated activities and installations. Activities associated with the wind farm mainly consist of submarine cables to land, construction surveys and ship transport, and possible handling of masses. Impacts from construction surveys and transport have been considered and described in Chapter 7. None of the ancillary activities are assessed as having any transboundary impact. This is due to the nature of the follow-up activities and their location at a great distance from neighbouring countries and their limited environmental impact, which is why no special account of the impact is given in this Espoo report. In cases where it is deemed relevant, permits for the various ancillary activities will be applied for in a separate order.

2.2 Geographical delimitation

The impact assessments cover the geographical area that may be affected by the activity and deemed relevant to investigate. This includes both the direct impact area where the activity is carried out, and where physical measures are taken, and surrounding areas where an impact can be demonstrated, such as adjacent sea areas and adjacent shipping lanes. The geographical delineation varies depending on the aspect and interest being studied. The basis for the geographical delimitation is the background studies produced for each influence factor and interest. Descriptions and assessments in this report focus primarily on impacts that may be transboundary.

2.3 Environmental aspects

The environmental aspects described and assessed in this Espoo report are listed in Table 1. Environmental impacts are described for the construction phase, the operational phase and the decommissioning phase. For a description of each phase, see section 4.4. The phases assessed as relevant for each aspect are shown in the table, as well as whether impacts and impacts arise as a result of the wind farm and/or the internal cable network. Impacts can be positive or negative.

Table 1. Environmental aspects described and assessed in the Espoo report are marked with a cross, together with the phase for which they are assessed, and whether there are any transboundary impacts resulting from the wind farm and/or the internal cable network. Environmental aspects that have been assessed but are not considered to have any transboundary impact are marked with a cross in the column "not transboundary".

Aspect	**Wind farm (V)** **Internal cable network (IC)**	**Construction phase**	**Operatin g phase**	**Decommission ing phase**	**Non-transboundar y**
Climate benefits and impacts	V	X	X	X	
Benthic flora and fauna	V, IK				X
Fish	V, IK	X	X	X	
Marine mammals	V, IK	X	X	X	
Birds	V	X	X	X	
Bats	V	X	X	X	

Landscape, recreation and outdoor activities	V				X
Cultural heritage	V				X
Maritime archaeology	V, IK				X
Commercial fishing	V, IK	X	X	X	
Maritime transport	V, IK	X	X	X	
Aviation	V				X
The interests of national defence	V, IK				X
Risk and safety	V, IK	X	X	X	
Resource management	V, IK				X
Material extraction	V, IK				X
Ecosystem services	V, IK				X
Environmental quality standards	V, IK				X

3 Localisation and description of surroundings

3.1 Localisation

Ran wind farm is planned in the Eastern Gotland Sea in the Baltic Proper, within an area belonging to the Region of Gotland in Sweden. The farm area is approximately 327 km^2 in size and located approximately 12 kilometres east of Gotland, within Swedish territorial waters. The farm area consists of open sea and has no islands and is partly included in the Eastern Gotland Deep Basin. For localisation, see Figure 2. Within the Ran wind farm, the water depth varies between approximately 40 and 85 metres. The distances from the Ran wind farm to neighbouring countries are shown in the point list below.

- Latvia 126 kilometres
- Saaremaa (Estonia) 150 kilometres
- Lithuania 200 kilometres
- Kaliningrad 285 kilometres
- Poland 300 kilometres
- Finland 304 kilometres
- Bornholm (Denmark) 361 kilometres
- Germany 473 kilometres

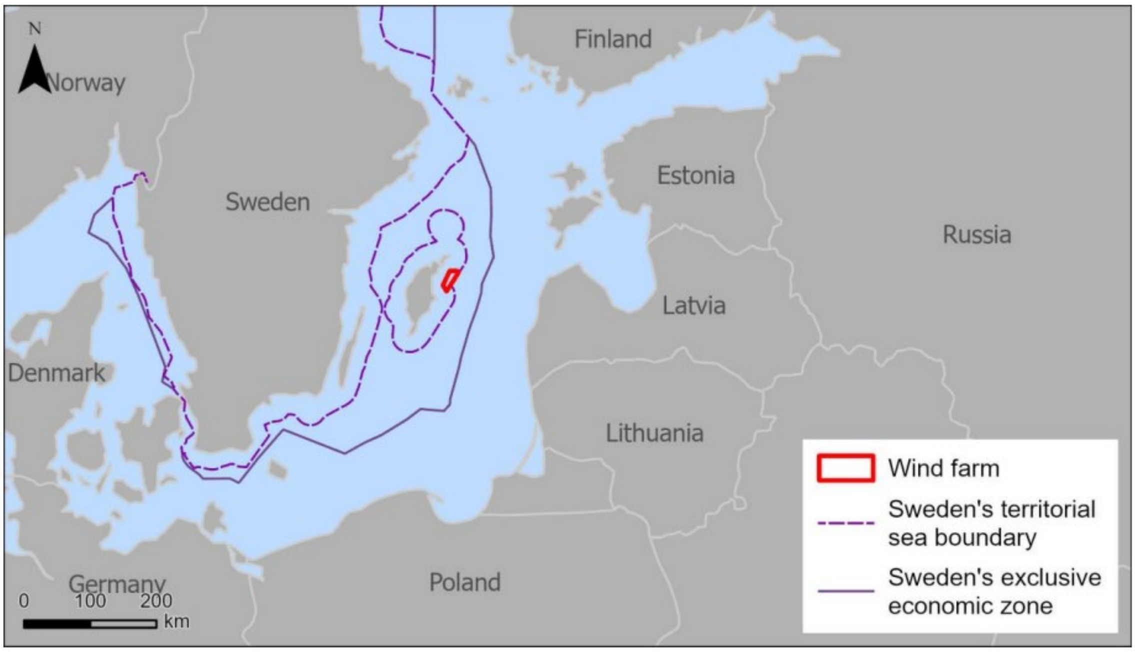


Figure 2. Location of Ran wind farm in relation to surrounding countries. Base map: © [Natural Earth] 2023.

3.2 Natura 2000

3.2.1 Natura 2000 sites

In the area around the Ran wind farm, there are designated Natura 2000 sites both on land and at sea, see Figure 3. The closest Natura 2000 sites on land designated under the Birds Directive are Asunden, Skenholmen and Ryssnäs, which are located approximately 12-18 kilometres from the wind farm. The designated species of common tern, artic tern, pied avocet and barnacle goose may be present in the Ran wind farm area for resting and foraging. Asunden, Skenholmen and Ryssnäs are also protected under the Habitats Directive with values linked to land. However, it is only the species designated under the Birds Directive that may be affected by the planned operation. The activities are not expected to cause significant disturbance to these species and no impact is expected to occur at population level. The Natura 2000 areas Uppstaig, Marpesträsk and Langhammars are also designated under the Birds Directive and are located approximately 13-81 kilometres from the Ran wind farm. However, the designated species are not expected to occur in the farm area.

Other nearby Natura 2000 sites on land designated under the Habitats Directive are Bungenäs, Sajgs, Kyllajhajdar and Furilden. At sea, the Gotska Sandön-Salvorev Natura 2000 sites (designated for, among other things, grey seals) and Hoburgs bank and Midsjöbankarna (designated for, among other things, harbour porpoises) are located north and south of the wind farm area respectively. The areas of Gotska Sandön-Salvorev (approximately 22 kilometres from the wind farm) and Hoburgs bank and Midsjöbankarna (approximately 81 kilometres away) are at such a long distance that neither designated species nor habitats are deemed to be affected by the planned activities.

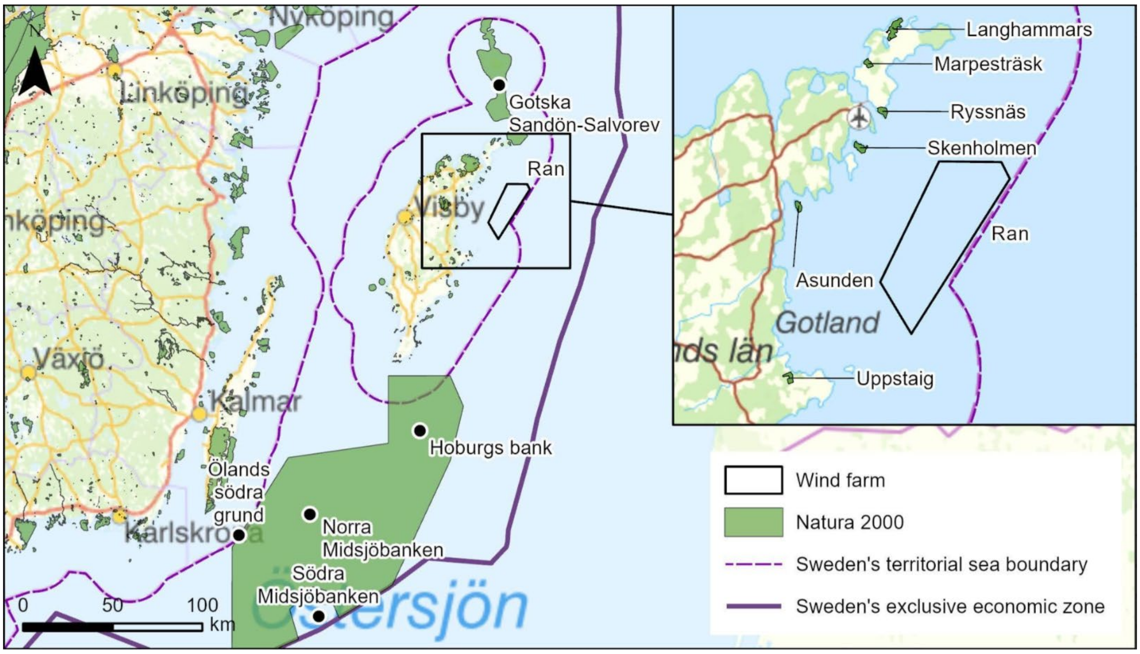


Figure 3. Overview of the location of the farm area in the Baltic Proper and Natura 2000 areas according to the Birds Directive (SPA) on the Gotland mainland and nearby islands. Base map: © [Lantmäteriet] 2021, [Basis: Swedish Environmental Protection Agency].

3.2.2 Natura 2000 sites belonging to other countries

Natura 2000 sites belonging to the countries around the Baltic Sea (apart from the Russian exclave of Kaliningrad, where there are no Natura 2000 sites) occur both at sea and along the coasts of the different countries, see Figure 4. The Natura 2000 sites of the Baltic Sea countries closest to the planned wind farm are Irbes saurums (Latvia), approximately 106 kilometres to the east, and Akmensrags (Latvia), approximately 127 kilometres to the south-east. Irbes saurums is designated as an SPA, while Akmensrags is designated as a protected area under both the EU Habitats Directive and Birds Directive.

Due to the distance between the Ran wind farm and the Natura 2000 sites, the applied activity is not considered to affect the values associated with habitats on land or seabed, which the Natura 2000 sites are intended to protect. With regard to designated species under the Habitats Directive or the Birds Directive, the assessment has been made that the applied activity is not likely to significantly affect the populations of the species that pass through or stay in the farm area. Therefore, no impact on species protected in Natura 2000 areas in other countries is assessed to occur.

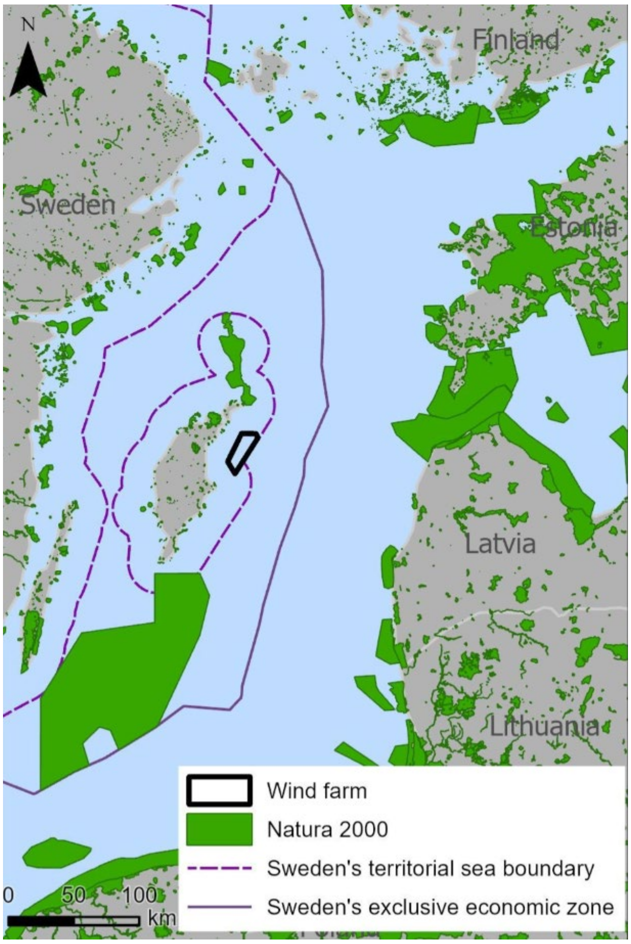


Figure 4. Map of all Natura 2000 sites in the central and southern Baltic Sea. Base map: © [Natural Earth] 2021, [Base: European Environment Agency].

3.3 Geological and depth conditions

3.3.1 Depth conditions

The water depth within the farm area varies between approximately 40 and 85 metres, with an average depth of approximately 54 metres (EMODnet), see Figure 5. The farm area does not include any islands but consists only of open sea.

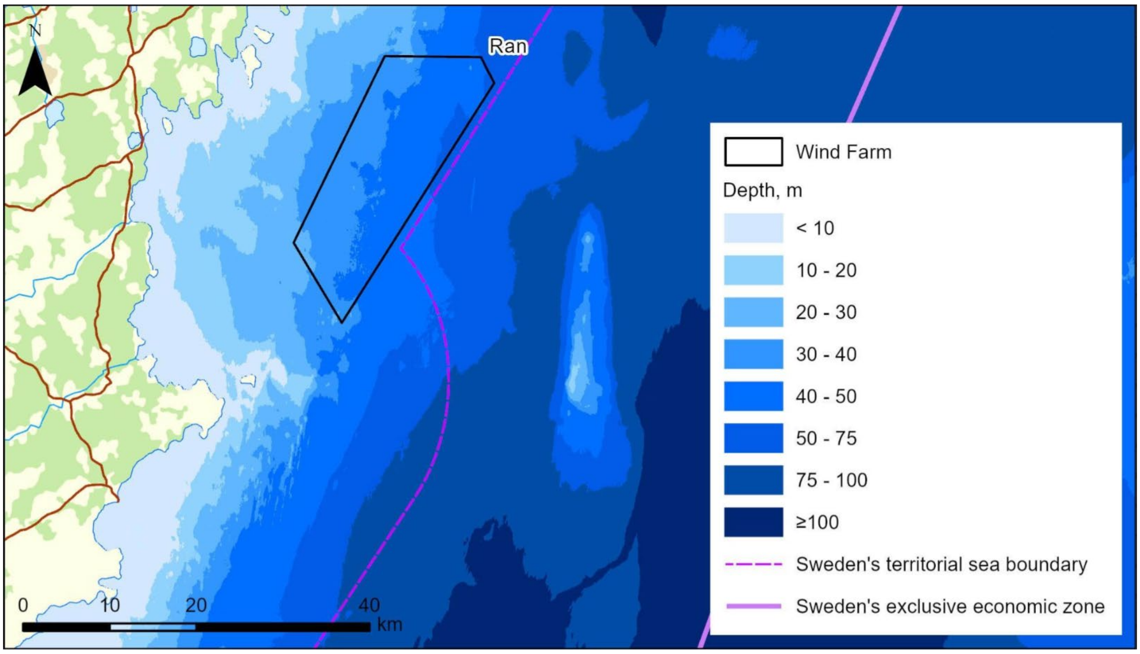


Figure 5. Depth conditions within the farm area. Base map: © [Lantmäteriet] 2022 [Base: EMODnet].

3.3.2 Bottom substrate

According to EMODnet, the bottom substrate within the farm area consists largely of mixed sediment and clay to loamy sand (Figure 6).

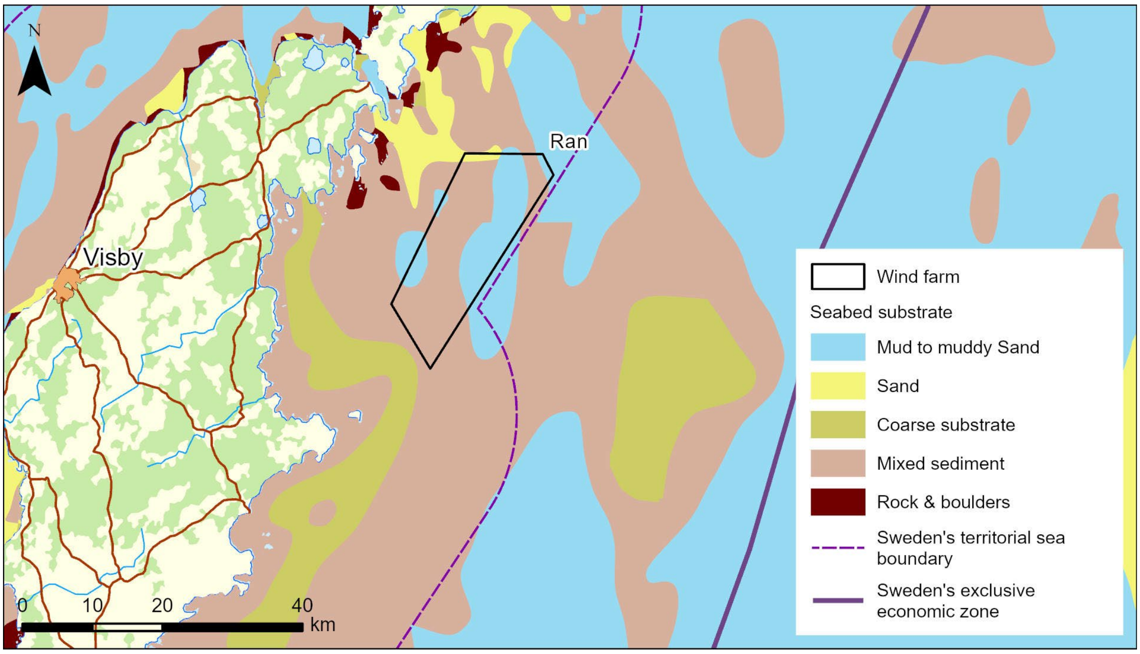


Figure 6. Bottom substrate within the farm area. Base map: © [Lantmäteriet] 2022 [Basis: EMODnet 2024].

Contamination situation in sediments

NIRAS Sweden AB carried out environmental toxin sampling in sediment within the farm area for the Ran wind farm in June 2023. Twelve stations within the farm area were investigated and 19 samples taken were sent to the laboratory for analysis of metals, nutrients, total organic carbon (TOC), polycyclic aromatic hydrocarbons (PAHs), petroleum hydrocarbons, polychlorinated biphenyls (PCBs), organotin compounds and dioxins and furans. See also Figure 7.

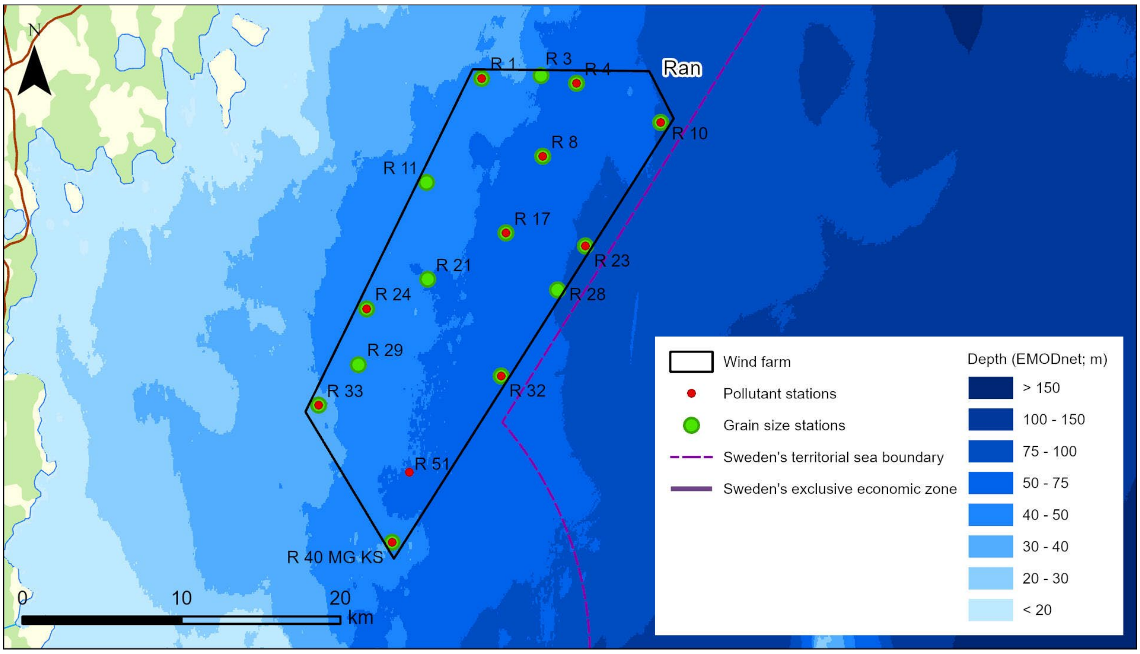


Figure 7. Map of sampling stations for pollutant stations (red) and grain size (green) within the wind farm area. Base map: © [Lantmäteriet] 2022 [Basis: NIRAS 2023, EMODnet 2024].

In general, low concentrations of metals were measured in the investigated area, but medium to high concentrations of copper, chromium, nickel and/or arsenic were measured at some sampling stations. When compared to the assessment criteria used for analysing environmental toxins, all concentrations are below the limit values at all stations.

The highest concentrations of nutrients were detected at stations R 23, R 32, R 4 and deeper sediment layers at station R 10. Phosphorus was measured between 262 - 894 mg/kg DM, which is within the expected value for the immediate area (SGU 2020). Most of the stations' bottoms are considered to be erosion bottoms and only at station R 23 was an accumulation bottom found.

As regards organic pollutants, generally low levels were measured in the investigated area. Medium levels of PAHs and tributyltin (TBT) were measured at station R 23. TBT was also found in medium levels at station R 10. At station R 23, the level of TBT was measured at 3.8 µg/kg and 7.8 µg/kg for station R 10. The limit value for TBT is 1.6 µg/kg according to SwAM's regulations (HVMFS 2019:25), which means that the limit value was exceeded at both stations by approximately 2.2 µg/kg and 4.8 µg/kg, respectively.

3.3.3 Hydrography and meteorology

Salinity, temperature and oxygen content

In the eastern Gotland Sea, where the Ran wind farm is planned, the salinity of the surface water is around 6-7 PSU (Practical Salinity Unit). The water temperature varies with the seasons, with higher temperatures during summer and lower during winter. The mean surface temperature during summer is around 18-19°C and during winter around 1-3°C (Snoeijs-Leijonmalm & Andrén 2017).

The Baltic Sea is a brackish inland sea largely characterised by a north-south salinity gradient. This is governed by an influx of salt water through the Danish straits and the Sound in the south-west and an influx of fresh water from rivers in the extensive catchment area of the Baltic Sea. The salinity gradient, with fresher water in the north becoming saltier in the south, is reflected in the distribution of species, with more typical freshwater species in the north and more saltwater species in the south (Snoeijs-Leijonmalm & Andrén 2017).

As salt water has a higher density than fresh water, the water closer to the bottom is saltier than that at the surface. A permanent halocline (salt layer) exists between 60 and 80 metres depth. At the bottom, the oxygen in the water is consumed as organic matter decomposes, which is exacerbated by eutrophication in the Baltic Sea, which contributes to more organic matter ending up on the seabed. The halocline makes it difficult for oxygen exchange between oxygenated water above the halocline and oxygen-poor or oxygen-free water closer to the bottom (Hansson & Viktorsson 2023), except when the deeper water is replaced and oxygenated by large inflows of saltier and oxygen-rich water. These inflows pass through the Belt and then extend northwards through the Bornholm Basin to reach the Eastern Gotland Basin. The inflows vary in size and frequency and lead to a rise in the halocline, which then weakens between inflows and lowers again.

The farm is located in a part of the Baltic Sea that is only partially covered by ice during winters classified by SMHI as severe ice winters, in other years the area is ice-free. Ice formation is rare in the farm area, and according to SMHI's ice maps of maximum extent, no ice has occurred in the farm area in the last ten years (SMHI 2022b).

On behalf of the Company, NIRAS investigated the oxygen conditions within the Ran wind farm during August 2022 and June and September 2023. During all measurement campaigns, the oxygen conditions were generally good, with the exception of the northeastern part of the Ran wind farm, which had anoxic (oxygen concentrations of 0 ml/l) and hypoxic (oxygen concentrations below 2 ml/l) conditions in September 2023 in the bottom water below the halocline. This is likely due to variations in oxygen conditions in the Eastern Gotland Basin, where oxygen concentrations are usually lowest in autumn.

Wind and current conditions

According to the New European Wind Atlas (NEWA 2019), the annual average wind at a height of 170 metres within the farm area is approximately 9.4 m/s with a maximum wind speed of around 28 m/s. The wind direction is mainly south/south-westerly (SMHI 2022a).

The water level in the Baltic Sea is mainly influenced by air pressure and strong winds (Snoeijs-Leijonmalm & Andrén 2017). Due to weather dependency, the water level can vary rapidly under special conditions, with more than one metre difference during the same day in some locations (Snoeijs-Leijonmalm & Andrén 2017). The nearest sea level station is located in Visby harbour. The average water level in 2012-2021 at the station was +12.2 centimetres. The maximum value during the same period was +84.30 centimetres and the minimum value was -44.52 centimetres (SMHI 2022c).

Surface water currents in the Baltic Sea are the result of complex interactions between, among other things, the Coriolis effect, wind and seabed topography. The Coriolis effect means that the speed at which the Earth rotates is greatest at the equator and decreases with distance from the poles, due to the Earth's circumference being larger at the equator than at the poles. This has an impact on how the wind moves across the Earth's surface and therefore also on surface water currents.

Deep water currents lead from the straits in the south-west towards the north-east into the Baltic Sea. Deep water currents move more slowly than surface water currents and it takes about six months for salt water to travel from the straits to the Gotland Deep (SYKE 2020).

3.4 Infrastructure and plan conditions

3.4.1 Maritime transport

A major shipping route in and out of the Baltic Sea borders the eastern boundary of the Ran wind farm. Vessel movements (cargo, container, fishing, passenger, service and tanker ships, etc.) can be tracked using AIS (Automatic Identification System). AIS data from 2022 is shown in Figure 8.

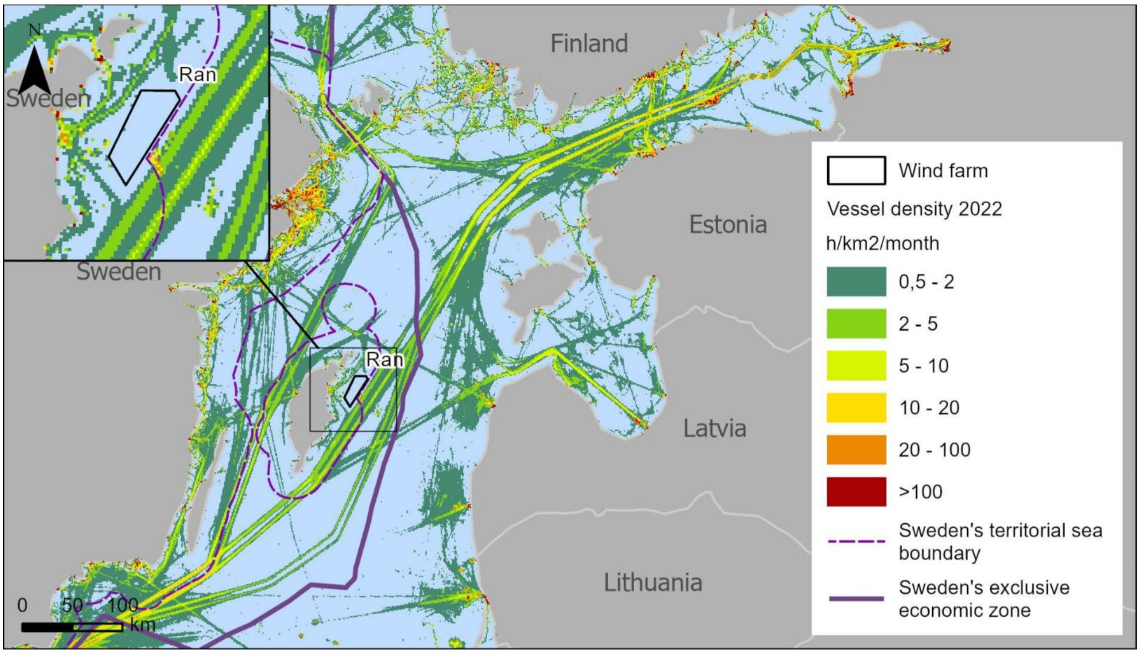


Figure 8. Map of all maritime transport in 2022 in hours per 1 x 1 kilometre square per month, and fairways in the vicinity of the wind farm. Base map: © [Lantmäteriet] 2021 [Basis: EMODnet].

3.4.2 Commercial fisheries

Pelagic fishing is mainly focused on herring and sprat (The Swedish Board of Agriculture & The Swedish Agency for Marine and Water Management 2016). The fishery is mainly carried out with pelagic trawls and is spread throughout the Baltic Sea. It is this fishery that contributes the largest catches by weight in the region (ICES 2021b, SwAM 2022). Before the fishing ban on cod came into force, the most important near-bottom fishery was bottom trawling targeting cod. In addition to cod, flounder and plaice are today important commercial species fished, concentrated in the southern and western Baltic Sea. Other species of local and seasonal economic importance are salmon, dab, brill, turbot, pikeperch, pike, perch, whitefish, eel and sea trout. Inshore fisheries (gillnets/setnets, fyke nets and other types of stationary gear) are sporadically distributed depending on the target species.

The Ran wind farm is located within the ICES marine area Baltic Sea East of Gotland. This is both a national and international fishing area where fishing quotas are regulated on an annual basis by the EU and commercial catches are reported to ICES. In the East Gotland Sea, Sweden and Latvia have since 2016 accounted for the largest share of the total catch, with approximately 40 and 34 % respectively. The catch consisted of 99 % sprat and herring. For positions of reported catch points from Sweden compared to data from Denmark, Latvia, Lithuania, Estonia, see Figure 24 in section 7.6.

The farm area lies within Sweden's territorial waters and half of it is outside the trawling limit, in other words within part of the area where trawling activity is currently most intense. However, the trawl limit is planned to be moved out to 12 nautical miles from the coast on a trial basis over a three-year period. The Swedish government has also proposed that the trawling limit, at least for parts of the coast, should be permanently moved 12 nautical miles from the coast along the entire Baltic Sea (Bill 2023/24:156). As a result, there is uncertainty about the type of commercial fishing that will be possible in the area in the future. See section 7.6 for further information.

4 Description of activities

This chapter describes the activity applied for and its main components.

The wind energy industry is subject to rapid and continuous technological development, which means that more cost-effective and environmentally efficient technologies are gradually becoming available. The detailed design of the wind farm, including the final location of the wind turbines, choice of foundations and installation techniques, will be decided prior to the construction of the wind farm to enable the use of the best possible technology. Examples of wind farm layout design, foundation and turbine design and installation methods are described below.

4.1 Overview of the components of the wind farm

Ran wind farm consists mainly of wind turbines mounted on foundations anchored to the seabed and an internal cable network connecting the wind turbines to one or more substations (or converter stations), see example in Figure 9. Erosion protection may be constructed around the foundations. In addition, submarine cables are needed to transfer the generated electricity to shore. The submarine cables are covered by another assessment.

An offshore wind farm includes the following main components:

- Offshore wind turbines
- Foundations for wind turbines
- Foundations for offshore transformer or converter stations (high voltage substations), and associated superstructures (platforms)
- Scour protection for foundations
- Submarine cables for internal cabling and communication between wind turbines
- Measuring mast
- Submarine cables for connecting the wind farm to shore

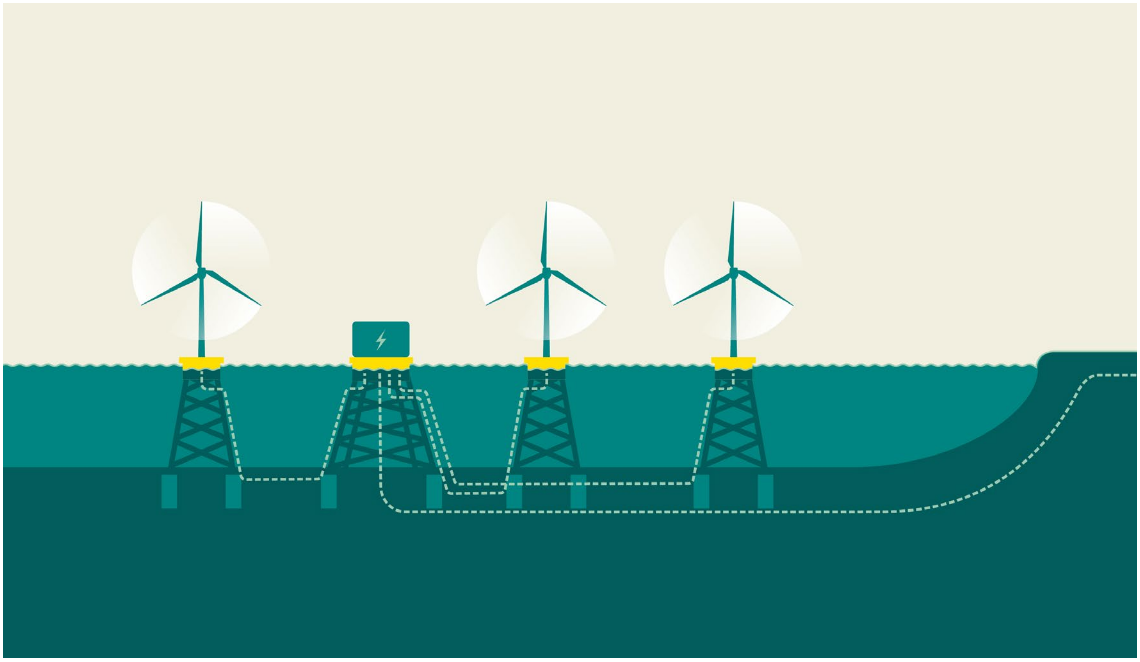


Figure 9. Example of the different parts of a wind farm. The picture shows wind turbines with foundations and cable networks [Illustration: OX2 AB 2023].

4.2 Design of the farm

The Ran wind farm area is approximately 327 km^2. At full build-out, the wind farm will comprise a total of 90-121 wind turbines with a maximum total height of 310 metres and a rotor diameter between 240-280 metres. Depending on the size of the wind turbines, the wind farm will have an installed capacity of up to 1.8 GW. Table 2 below summarises the detailed design and scope of the applied activity.

Table 2. Basic information on the farm area. Height above water is in relation to mean sea level (MSL).

Maximum number of wind turbines	121 turbines
Maximum overall height of wind turbines	310 metres
Maximum rotor diameter of wind turbines	280 metres
Expected minimum distance between wind turbines	4 rotor diameters
Clearance (lowest height of the blade tip above the water surface)	30 metres
Estimated cable length internal wiring harness	Up to 400 km
Number of high-voltage platforms	Up to 4
Surface of the wind farm	327 $kilometres^2$
Water depth	40–85 metres
Estimated total installed capacity	1.8 GW
Estimated annual electricity production	8 TWh

Wind turbines are anchored to foundations and connected by an internal cable network. The internal cable network connects the wind turbines to transformer or converter stations, which are used to transmit the electricity to shore, either by alternating current (transformer stations) or by direct current (transformer and converter stations).

Figure 10 presents examples of possible farm layouts within the Ran farm area, with 15 MW and 20 MW wind turbines respectively. The layouts show how the farm could be designed within the farm area. It should be emphasised that these are only example layouts and that the final design may be different. The number of wind turbines may therefore differ in practice from the example layouts below but will never exceed 121 turbines or a total height of 310 metres.

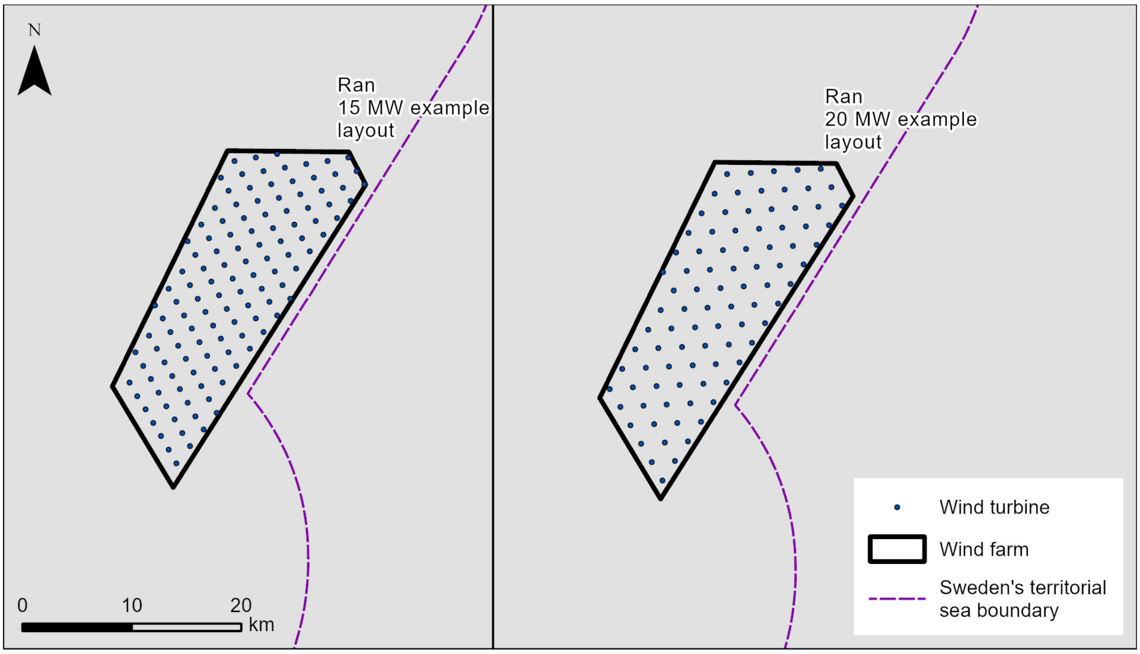


Figure 10. An example of a possible farm layout for Ran wind farm, with 15 MW wind turbines on the left and 20 MW wind turbines on the right. [Base map: © Swedish Maritime Administration 2024].

In addition, one or more masts for meteorological measurements or LiDAR, i.e. Light Detection and Ranging, as well as buoys for wave and current measurements, can be built within the Ran wind farm.

4.3 Description of the components of the activity

4.3.1 Wind turbines

A wind turbine consists of a tower, machine house and rotor blades and is installed on a foundation anchored to the seabed. The tower also contains electrical components. The main components of the nacelle are the gearbox, generator and gear motors. A transformer is located either in the machine house or in the tower. The electricity produced by each wind turbine is transmitted via an internal cable network to one or more transformer/inverter stations. The wind farm may consist of several transformer/inverter stations depending on the design and capacity.

The wind turbines in the wind farm will most likely be a traditional model with three rotor blades on a horizontal axis, see Figure 11. The rotor diameter is expected to be between 240 and 280 metres and the maximum overall height of the turbines is expected to be 310 metres above sea level. The clearance between the tip of the blade and water surface is 30 metres.

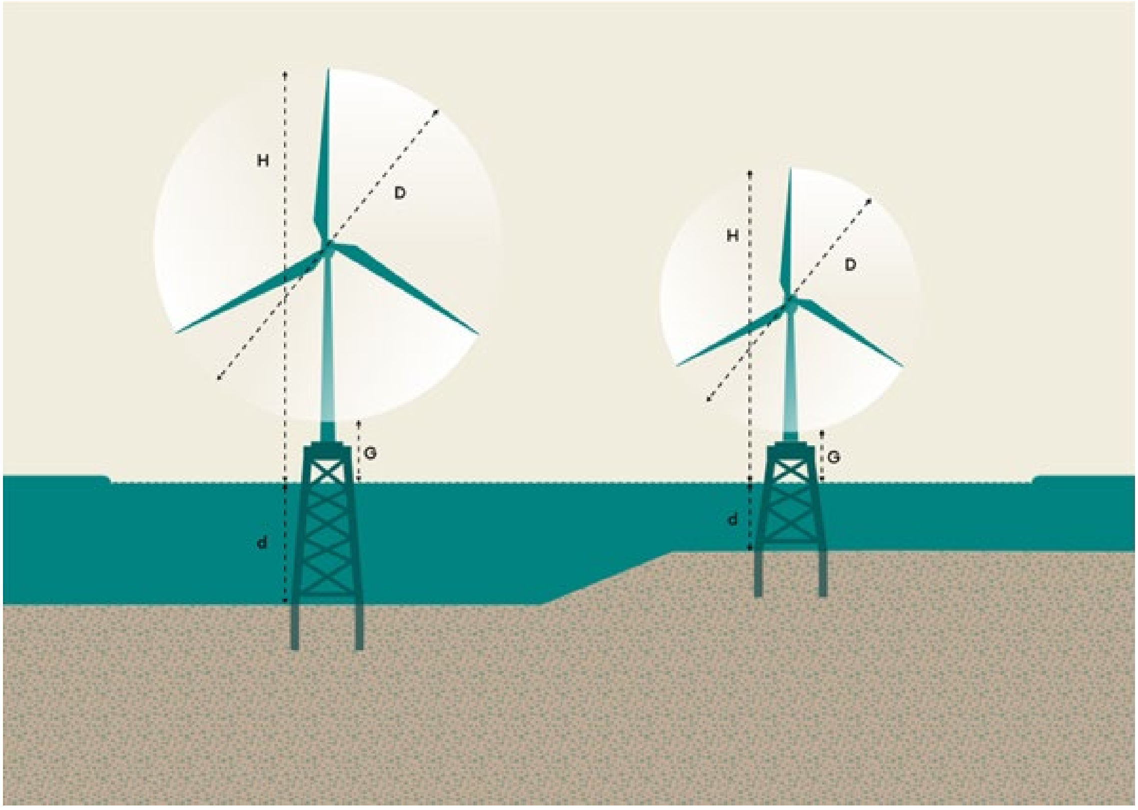


Figure 11. Example of wind turbine. D = rotor diameter, H = total height, G = clearance, d = water depth. [Illustration: OX2 AB 2023].

The wind turbines are expected to produce electricity at wind speeds from around 3 m/s and reach maximum production at wind speeds between 10 and 14 m/s. When wind speeds exceed approximately 30 m/s, the wind turbine will automatically switch off and restart automatically when wind speeds are lower.

4.3.2 Foundation

Foundations are needed to anchor platforms and wind turbines to the seabed. The choice of foundation depends on a number of factors: primarily water depth, geology, wind and wave conditions, environmental considerations and costs. In the Ran wind farm, mainly bottom-fixed foundations will be used.

Seabed foundations consist of three main parts: a lower part that secures the anchorage in or on the seabed, a part to reach above the water surface and a transition piece, which is a transition between the foundation and the tower to ensure that the tower is vertical. In connection with the foundations, an erosion protection on the seabed can be constructed to protect the foundations against the formation of erosion holes around the foundations. The need for erosion protection varies depending on waves, currents and the type of bottom sediment. The most common type of erosion protection is layers of rocks, gravel and sand of varying sizes placed around the base of the foundation. This can create reef structures that increase biodiversity.

The most common types of bedrock foundations are:

- Monopile - a steel cylinder that is piled or drilled into the seabed
- Monobucket - a monopile foundation with suction caissons called a mono bucket
- Gravity foundations of concrete or other material
- Jacket foundation with suction buckets - a jacket structure founded on three or four legs, and anchored by suction buckets
- Pile jacket foundation - a jacket structure anchored by pinpiles, smaller steel piles driven or drilled into the seabed.

Of these foundations, it is mainly monopile foundations and jacket foundations that are relevant for Ran wind farm, see pictures of these in Figure 12. The rapid development of technology also means that other types of foundations or hybrids of the presented foundations may be relevant at the time of construction, for example tripod foundations.

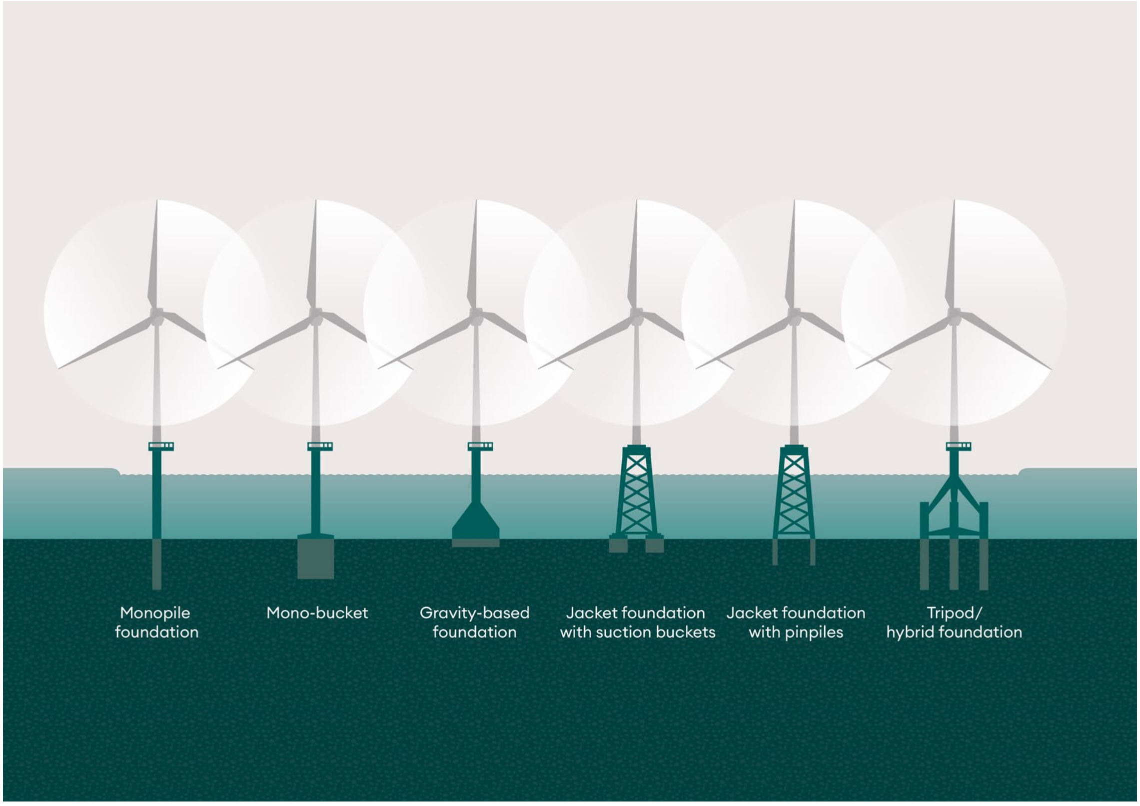


Figure 12. Foundations from left: Monopile, monopile with suction buckets, gravity-based foundation, jacket with suction buckets, jacket with pin piles and tripod foundation with pin piles. [Illustration: OX2 AB 2023].

4.3.3 High voltage platforms

One or more offshore substations (OSS) may be installed in the farm area, to which the electricity generated by the wind turbines will be transmitted via the internal cable network. From the high-voltage platforms, submarine cables run to export the electricity to connection points on land. The high-voltage platforms contain electrical equipment, including transformers that transform the voltage from the internal cable network to higher voltages. If the onshore connection is direct current, inverters are also included as part of the electrical equipment; these stations are then generally referred to as converter stations. If the electricity is transmitted directly from the wind turbines, i.e. the electricity is transmitted at the voltage level generated by the wind turbines, this results in no high-voltage platform being needed. Final arrangements will be determined later.

The high voltage platform is a platform with one or more decks, sometimes with a helipad. The platform is prefabricated and normally installed in modules on one or more foundations. The platforms are likely to be unmanned during operation.

The exact number, design and location of the platforms will be determined during the detailed design of the wind farm, based on the size and number of turbines, seabed conditions and optimal cable routing. The maximum number of platforms for Ran wind farm will be four. The platforms will be marked in accordance with applicable aviation and maritime regulations.

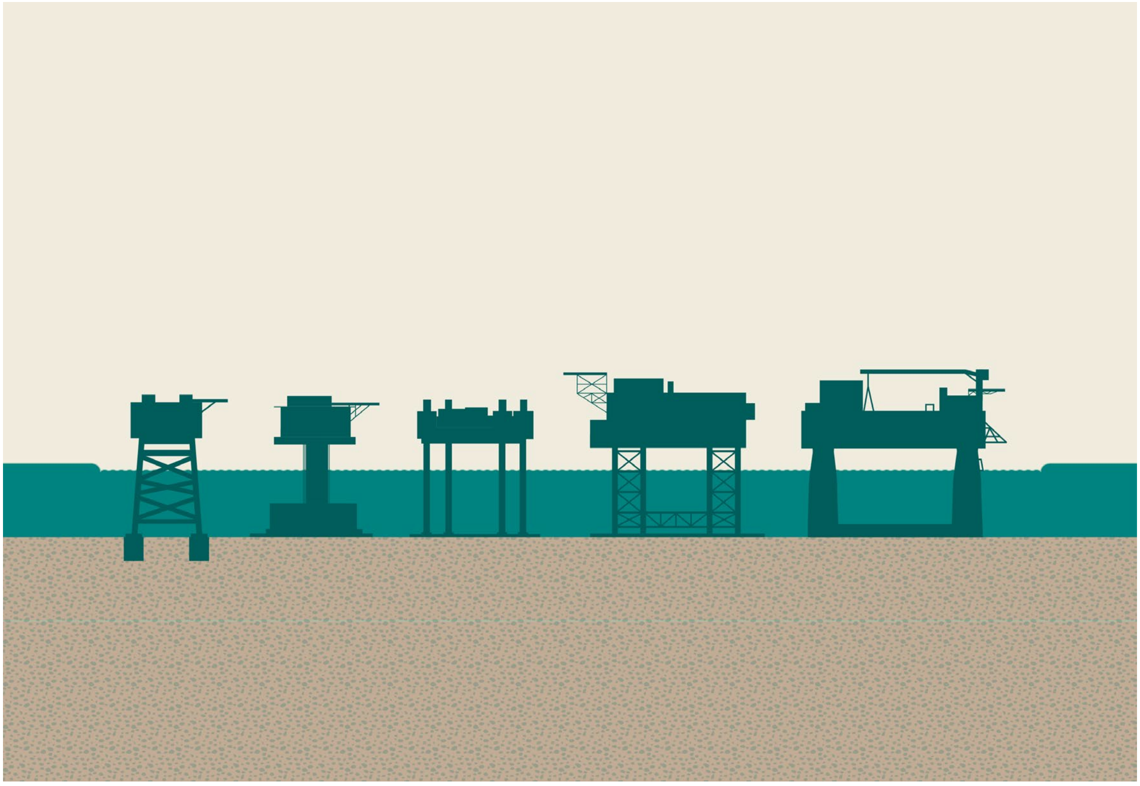


Figure 13. Examples of offshore high voltage platforms with associated foundations. From left: jacket foundation, gravity foundation, outrigger foundation, jacket foundation (with float-over installation), self-installing gravity foundation [Illustration: OX2 AB 2023].

4.3.4 Internal cable network

The internal cable network connects wind turbines to high-voltage platforms by linking individual wind turbines in groups (radials), which are then connected to the respective high-voltage platform.

For example, based on the cable technology available today, the internal cable network can consist of 66 kV cables, which can transmit a total power of around 80-90 MW per cable. This means that up to six 15 MW wind turbines can be connected along the same radial. The voltage level of internal grid cables is expected to rise to around 170 kV in the next five to ten years. This would increase the total transmission capacity of each cable, reducing the number of radials and thus the total length of cables. Other factors that can affect the length of the internal cable network are depth, geology and turbine layout. In addition to the cables connecting the wind turbines, additional cables may be established within the wind farm to create redundancy in the system and to supply power to any platforms.

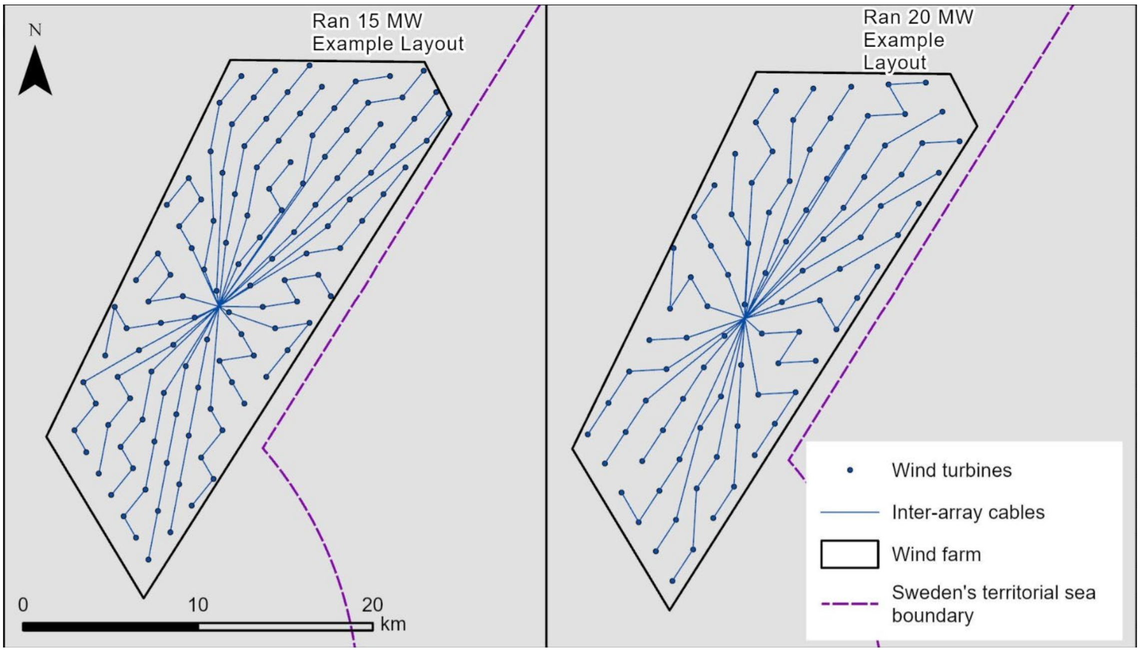


Figure 14. Example of internal cable network within Ran wind farm. The example on the left shows 121 wind turbines, with 66 kV cables and a high voltage platform. The example on the right shows 90 wind turbines. These are examples only and the layout may be subject to change [Base map: © Swedish Maritime Administration] 2024.

4.3.5 Measurements of meteorological parameters

One or more met masts may be installed to complement the available wind data from the site and to inform the detailed design and selection of turbines and layout. A met mast usually has a height roughly corresponding 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 seabed. However, the foundation of a met mast is significantly smaller than that of a wind turbine.

Data from measurement masts can also be used to monitor the conditions for different lifts during installation (e.g. when turbine blades are lifted into place), where there may be requirements for maximum wind speeds. Data can be used later in the process to monitor the production of the wind farm. In addition, data from measurement masts on wind speed, turbulence and gusts, etc. can also be used as a basis for load calculations. Load calculations are performed when dimensioning turbines, towers, foundations and anchoring.

One rapidly developing technology that has the potential to replace met masts is LiDAR. LiDAR technology uses lasers to measure wind speed over the sea surface and thus does not require a mast. The equipment can be placed either on a bottom-anchored foundation or on a floating platform. At present, this measurement technology is not certified for use as a basis for load calculations, but this is expected to be possible in the future.

4.3.6 Chemical management

In addition to gear oil, the wind turbine's machine housing contains hydraulic oils, lubricating oils and battery fluids. In addition, there are, for example, carbon dioxide or other gases in fire extinguishing equipment. In the components where oil/fluids are present, the systems are closed to prevent leakage. Should leakage occur, it is collected in dedicated collection trays that hold the full potential volume of chemicals. The waste grease generated in the lubrication process can be collected in special grease collection tanks and removed as part of the maintenance work. The total amount of oil and fluids expected to be present in a 20 MW wind turbine is approximately 20 000 litres. Please see Table 3 for chemicals that may be present in the wind farm. Note that the volumes given in the table are to some extent estimates, as some of the plant components that could be relevant for the Ran wind farm are not yet on the market, so exact data on volumes of different fluids is not available.

Table 3. Examples of volumes of chemicals that may be present in a wind turbine of current size and estimated future size and for the entire wind turbine volumes in the Ran wind farm (l=litre, kg=kilogram, m^3 =cubic metre)

Chemical products	Estimated amount per wind turbine - current size (around 15 MW)	Estimated amount per wind turbine - future size (around 20 MW)	Estimated amount - whole wind farm
Transformer oil, gear oil & hydraulic oil	15 000 l	18 000 l	1 815 000 l
Coolant (water/glycol)	35 000 l	55 000 l	4 235 000 l
Nitrogen/inert gas	70 m^3 at pressure 1 bar	90 m^3 at pressure 1 bar	8 470 m^3 at pressure 1 bar
SF6 gas (or other insulating medium/vacuum)	75kg	125kg	11 250 kg

4.3.7 Artificial reefs

Fixed structures and surfaces within the wind farm such as foundations, erosion protection and cable protection can act as artificial reefs, which can attract and favour different marine organisms.

The company is investigating the possibility of adapting foundations, erosion protection and possibly cable protection to increase the reef effect based on site-specific conditions. Stand-alone artificial structures within the farm are also being investigated as an option.

Wind turbine foundations occur throughout the water column from the bottom to the surface, creating conditions for both deep-dwelling and light-dependent species to establish themselves. The choice of foundation for the Ran wind farm depends on several factors, primarily seabed conditions such as geology and bottom topography and water depth.

Erosion protection that may be placed around the base of the foundations will create new hard bottom habitats, which may contribute to a local increase in species as animals and vegetation attach to or are attracted to the erosion protection. The most common type of erosion protection consists of a layer of smaller stones and on top of that a layer of larger stones. The need for, and design of, erosion protection varies depending on the type of foundation and bottom substrate, among other factors.

As a complement to investigating the adaptation of existing structures, such as foundations and erosion protection, the Company is investigating the possibility of placing free-standing artificial structures within the wind farm in line with the Company's nature-positive measures strategy. The free-standing structures may be placed on the seabed or form floating artificial substrates.

Final designs and solutions will be determined during detailed design at a later stage of the project.

4.4 The different phases of the project

The establishment of the wind farm will be realised in different phases. The operation is currently in the permit phase, followed by the construction, operation and decommissioning phase. This section outlines the activities of the phases.

4.4.1 Construction

The construction phase lasts for a limited time. The whole installation is expected to last for several seasons. Work at sea is avoided as far as possible during the winter period when weather conditions are less favourable. A split over several seasons may therefore be necessary. For example, foundations and cables could be installed in the initial season and the wind turbines in the following season. Alternatively, half of the wind farm could be installed and commissioned in an initial season, with the remaining part of the wind farm installed and commissioned in the following season. In total, the construction of all wind turbines is expected to take approximately one year.

Surveys prior to construction

Prior to the construction of the Ran wind farm and associated internal cable network, investigations of the seabed conditions will be carried out to further investigate the geology and sediment of the seabed. The purpose of the surveys is to obtain detailed information for the final design of the foundations and detailed design of the wind farm and cable routes, including the exact location of the wind turbines and high-voltage platforms. Geophysical surveys such as sidescan sonar (SSS) and multibeam echo sounder (MBES), as well as various forms of seismic surveys (both 2D and 3D), provide high-resolution bathymetric information on the seabed sediment and its geological composition down to about 80 metres below the seabed. The surveys also provide information on the presence of natural and artificial objects on the seabed and possible gas pockets.

Geotechnical investigations include, for example, geotechnical drilling, various types of cone penetration tests (CPT) and vibrocores. In favourable conditions, approximately six to eight CPTs can be conducted per day. A vibrocore test takes about 30-60 minutes, plus time for preparation and repositioning. Up to five to ten samples can be taken per day. Based on the results of these surveys, the company can reach conclusions about, among other things, the bearing capacity of the seabed and thus the design of foundations and the choice of installation methods. In connection with CPT, vibrocorers or drilling, measurements can be taken using thermal resistivity (thermal conductivity) or equivalent equipment. Magnetometry is carried out to ensure that construction work can be carried out without risk of, for example, finding any mines or other unexploded ordnance.

Installation

The planned order of installation of the wind farm is to first install foundations, high voltage platforms and connection cables. Then the internal cable network is installed. Finally, the wind turbines with towers, machine houses and rotor blades are assembled. As the wind turbines are installed, they are commissioned and tested before being handed over to the operating organisation after successful testing.

In connection with the installation of foundations, the selected foundation type is transported (see section 4.3.2) are transported to the relevant location, where they are placed on and driven into the seabed by piling, vibration or drilling. Prior to the installation of the internal cable network, the seabed needs to be cleared of rocks and boulders and foreign objects such as fishing nets or lines. The seabed may also need to be levelled. The cables are then laid at a depth of 1-2 metres to protect them from damage. Where cables are laid directly on the seabed, they are covered with rock or concrete mattresses or laid in pipes. Any crossing with other cables is regulated in crossing agreements that are drawn up in consultation with the cable and/or pipe owners concerned.

The main components of the wind turbines are transported by installation vessel or separate transport vessel, after which the various components are installed using a crane. In favourable weather conditions, installation work is carried out within one working day per wind turbine. Depending on the design, the transformer/inverter stations and their foundations can be towed and installed using a crane vessel or other lifting method. Alternatively, the foundations can be constructed first, after which the superstructure is lifted into place.

Traffic

During installation, the main components of the wind farm (the wind turbines, high-voltage platforms, met masts, foundations and cables) are transported to the wind farm site, positioned and installed. The main components are shipped out from the manufacturing harbour and transported either to a final assembly harbour, a so-called pre-assembly harbour, or directly to the wind farm site.

Daily transport of personnel and small components will take place from a nearby installation harbour. In addition to ship transport, helicopter transport may also occur.

During the installation of the farm, a number of installation vessels and work platforms of various types will operate in the area. It is likely that several installation operations will take place in parallel, but in different parts of the farm area.

A number of support vessels for equipment and personnel, as well as tugs, may also be required. All vessel traffic will be monitored by a *marine coordinator*. A safety zone may be established around ongoing installation works to minimise risks of collision and traffic interrupting ongoing activities.

For some works, a jack-up vessel or a jack-up platform may be used, see Figure 15. These lower their outriggers to stand on the bottom. The hull or platform itself is raised so that it stands well above the highest wave height and is therefore no longer affected by wave movements. As an alternative, semi-jack up vessels can also be used. In semi-jack up vessels, the hull remains afloat, while outriggers are lowered into the seabed to ensure stability.

Figure 15. Assembly of wind turbines with a jack-up vessel. Source: COWI.

In addition to the above-mentioned vessels, other specialised vessels may operate in the area, for example for various surveys or emergency operations. During construction, there may also be one or more smaller boats securing the installation area from other traffic.

4.4.2 Operation

Wind turbines and high-voltage platforms are remotely monitored and unmanned during normal operation. However, there is continuous maintenance of the wind farm, which requires personnel and materials to be transported there by service boat, ship or helicopter. Cables are inspected as necessary to ensure, for example, that their protection is adequate. If a cable is damaged, it is repaired by lifting the damaged section by an adapted vessel for repair, after which the cable is re-laid in the seabed using the same method as during the construction phase.

The final strategy for operation and maintenance will be determined at a later stage. It is likely that a land-based operation and maintenance base will be established. It is likely that maintenance work will primarily be carried out using Crew Transfer Vessels (CTV) or a larger Service Operation Vessel (SOV). For more extensive maintenance operations, for example where large components are replaced, outriggers may be used.

4.4.3 Decommissioning

After approximately 45 years, the wind farm is expected to have reached the end of its useful life and will then be decommissioned. Decommissioning will be carried out in accordance with the practices and legislation in force at the time of decommissioning. Wind turbines, foundations and high-voltage platforms will be dismantled and the sites where the foundations have been laid will be remediated to the required extent.

According to the current state of knowledge, the general approach is to dismantle the above-seabed components. The components may be dismantled in whole or in part if the removal of these individual structures does not have a greater environmental impact compared to the environmental benefit of the remaining components. As the technology and knowledge base is changing rapidly, the detailed decommissioning of the farm will be planned in consultation with the supervisory authority closer to the time of decommissioning.

It is likely that structures above the seabed will be decommissioned, e.g. monopile or jacket foundations may be cut a few metres below the seabed and the upper part lifted off. Some plant components may be left in place after decommissioning, such as submarine cables.

One reason for leaving some structures is that they may have become part of valuable artificial reefs. If cables need to be removed, these are exposed and then lifted up. Rock used to cover cables is likely to be left on the seabed, as are the protections used at crossings. During decommissioning, a temporary protection zone will be established around the site of the activities to protect personnel and equipment and to provide security for third parties.

4.5 Preliminary installation plan

The timetable for the Ran wind farm is shown in Figure 16 below. Several different factors may affect the timetable, which means that it may need to be adjusted during the course of the work. The schedule should therefore be considered as general and preliminary.

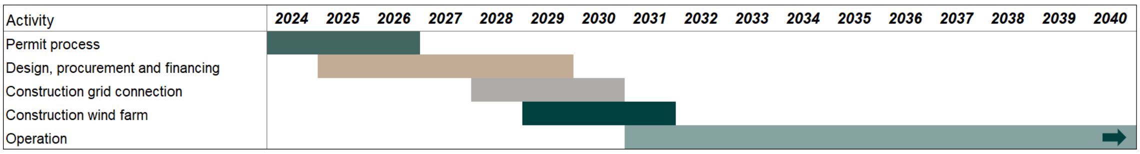


Figure 16. Preliminary timetable for Ran wind farm.

5 Prerequisites and methodology for impact assessments

5.1 Data and methods for describing the current situation

Within the framework of the project development, several different project and area-specific investigations, inventories, modelling and calculations have been carried out regarding, among other things, porpoises, birds, sound, sediment, cultural environment, maritime transport and risk, see Table 4. This has formed the basis for the environmental impact assessment prepared within the framework of the Swedish permit application to the Land and Environment Court. The other data used in the preparation of the aforementioned environmental impact assessment has consisted of existing data from various inventories and mappings carried out by, among others, the Swedish Agency for Marine and Water Management (SwAM), The Geological Survey of Sweden (SGU) and the Swedish Environmental Protection Agency, research published in scientific journals, research results, environmental reports, technical reports and knowledge and information from various authorities. This Espoo report is based on the Swedish environmental impact assessment but has been limited to describing transboundary influences, effects and impact.

The results of the investigations, inventories, modelling and calculations carried out are in good agreement with existing data from previously conducted studies, scientific articles and reports. Available data with information on the conditions and state of the area has been taken into account to the extent that it has been considered applicable and relevant to the Ran wind farm. The knowledge base produced for the Ran wind farm is therefore deemed to be sufficiently comprehensive and of sufficiently good quality to enable reliable assessments of the effects and impact of the operations to be made.

The environmental assessments have also been based on an ecosystem approach, which is an approach where it is of central importance to consider the entire ecosystem when, for example, assessing the impact of an activity or measure on the environment and surroundings. Within both the wind farm and its surrounding area, there are different types of habitats with important interactions between different species, where food preferences are of particular importance.

Table 4. Summary of the data used as a basis for impact assessments in the EIA prepared for the permit application to the Land and Environment Court.

Investigation/survey	**Dated**	**Methodology**	**Author**
Sediment modelling	2024	Modelling	IHD
Modelling underwater noise from pile driving and geophysical surveys	2023, 2024	Modelling	NIRAS
Study of underwater noise from geotechnical investigations	2024	Literature review	NIRAS
Oxygen content, salinity and temperature	2023	CTD	NIRAS
Bird survey programme	2021–2024	Boat and aerial surveys	DHI and Ottvall Consulting
Inventory of harbour porpoises	2023 (ongoing)	F-PODS	NIRAS
Inventory of marine mammals and fish	2023	eDNA sampling	NIRAS
Survey of underwater habitats (benthic flora and fauna)	2023	Video survey (GoPro Hero 8)	NIRAS

Sampling of infauna	2023	van-Veen grabber	NIRAS
Sediment survey for organic contaminants, metals and nutrients and grain size	2023	GEMAX core sampler, van-Veen grabber	NIRAS
Sound propagation air	2024	Modeling	OX2 (wind farm)
Shading	2024	Modeling	OX2
Marine archaeological feasibility study	2024	Literature review	Nordic Maritime Group
Visualisations and photomontages	2024	Installation	G sharp
In-depth analysis of landscape	2024	Modeling	Sweco
Trawl fishing	2023	Bottom trawl TV3-520x80	NIRAS
Bat survey	2021, 2023	Ultrasonic detectors	NIRAS

5.2 Methodology for impact assessments

The descriptions and assessments in this report focus on impacts that may be transboundary. Environmental aspects described and assessed in this Espoo report are listed in section 2.3. In section 6.1 the influence factors considered in the environmental assessment are presented and section 6.2 presents the influence factors considered but which have only a local impact and thus do not result in any transboundary impact. Examples of transboundary impacts are impacts on species that move across borders to other countries by air, by land or through the Baltic Sea.

A systematic approach has been used to identify and assess the potential influences, effects and impact of the activity on different environmental aspects and to describe protective measures to avoid, minimise or reduce impacts. The methodology below is used for the applied activity included in the assessment. For subsequent activities, the impact assessment is done in a more general way.

The impact assessments use the terms sensitivity, influence, effect and impact.

- **Sensitivity/value** - the sensitivity/value of the receptor to the impact in question. Thus, in the impact assessment, sensitivity/value has a bearing on the overall magnitude of the impact.
- **Influence** - the change in physical conditions caused by the implementation of the project. Examples include noise, pollutant emissions, loss of valuable natural habitats, increased transport in the area, etc. The influence can be local, regional or national and can be permanent or temporary.
- **Effect** - the change that occurs in the environment as a result of the influence. The effect is the extent or degree of the influence. Direct effects occur as a direct consequence of, for example, physical intrusion, noise or impact on water. Indirect effects occur secondarily as a result of an action. Where possible, the effect is described quantitatively.
- **Impact** - an assessment of the environmental effects on the interests affected, such as climate, human health or biodiversity. The assessment of impacts is based on the number of people affected, the significance of the environmental value and the estimated magnitude of the change. When evaluating environmental impact, the assessment is made against a comparison alternative, a so-called baseline

alternative. The baseline alternative describes the expected future development if the measures applied for are not implemented.

Once the sensitivity/value has been established, a limitation is made of the type of impact that the activity may entail. The degree of influence (effect) on the recipient that is assumed to arise as a result of the activity is then assessed. An assessment of the environmental impact for each environmental aspect is made by weighing together the sensitivity/value of the recipient and the extent of the influence (effect).

5.2.1 Description of potential influence factors

The influence factors of the activity have been identified in terms of when, where and how the activity may give rise to an influence on the identified environmental aspects. Chapter 6 describes in more detail which influence factors affect each recipient and during which phase (construction, operation, decommissioning) the influence occurs.

5.2.2 Assessment of recipient sensitivity/value

In a second step, the sensitivity and value of the receptor is assessed and described. The sensitivity or value of an environmental aspect is described in terms of the existing conditions of the area and may consist of objects and/or areas and the connections within or between them. Sensitivity/value depends, among other things, on characteristics such as size, robustness and connection to the surroundings. Beneficiaries in this case are those who may be affected by the activity and may, for example, relate to a species group, habitat type or other interests such as commercial fishing. The assessment of sensitivity/value is based on the following aspects, which are weighted together:

- The status of the beneficiary (e.g. population trends, abundance, importance of the area to the beneficiary).
- the sensitivity and adaptability of the receptor to the influence factor under consideration (e.g. sedimentation or underwater noise)
- Sensitivity of the recipient during different periods of the year, for example, the recipient may be more sensitive during mating season or migration periods.
- The protection value of the recipient.

The sensitivity/value of the beneficiary is evaluated for relevant influence factors during each phase of the activity such as construction, operation and decommissioning according to a three-point scale: low, moderate, high.

5.2.3 Magnitude and extent of the influence (effect)

The size and scope of the influence (effect) is assessed on the basis of geographical distribution, duration in time, size (magnitude) of the influence factor and probability of the influence occurring. The effect(s) that arise as a result of an influence must be related to the specific conditions of the area, i.e. which values are present and thus exposed to the influence, and its sensitivity. Thus, in an area with few values, the effects can be expected to be of a smaller scale, while in a site with high values or values with high sensitivity, the effects can be expected to be greater. The assessment of the effect is made with regard to relevant provisions, such as the Environmental Code's management provisions, accepted guideline or limit values and applicable environmental quality standards.

Negative impacts are evaluated for relevant influence factors during each phase of the activity according to the following scale: none/significant, small, moderate or large. Positive impacts are not graded but are only indicated as positive.

Table 5. Description of levels of influence significance for the recipient.

Magnitude and extent of the influence (effect)	Description of the programme
None/insignificant	The influence gives rise to no or small effects that are limited in extent, less complex and short-lived.
Small	Influences give rise to effects of a certain extent and complexity and of a certain duration.
Moderate	Influences give rise to effects that are either relatively large in magnitude or long-lasting (for example, lasting for the lifetime of the wind farm).
Large	Influences give rise to effects that are widespread and/or long-lasting, often occurring.

5.2.4 Impact assessment

For the impact assessment of the activity, the value of the sensitivity of the receptor is weighted together with the value of the magnitude and extent of the influence (effect), resulting in a joint assessment of the impact. The significance of the impact is assessed according to the scale of no/negligible, very small, small, moderate, large or very large negative impacts, or positive impacts, see Table 6.

It should be noted that the rating 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 evaluative judgement as objective as possible, the basis on which the impact was justified/assessed is presented for each habitat type and species.

Table 6. Description of levels of impact significance for the beneficiary.

The importance of consistency	Description of the programme
None/negligible	No or negligible impact on the receiver. No/low disturbance to surfaces and/or functions/populations.
Very small negative	Low impact on the receptor. Very small areas and/or functions and a very small part of the population are disturbed. No impact that is irreversible occurs.
Small negative	Small impact on the receptor. Small areas and/or functions and a small part of the population is disturbed, with no irreversible impact.
Moderate negative	Moderate impact on the recipient. Damage to surface, structures and/or functions and/or part of the population. May cause local irreversible effects, such as loss of conservation values with the impact that may require protective measures.
Large negative	High impact on the receptor. A large area, large part of structures and/or functions or large part of the population is significantly damaged, with the potential to cause significant irreversible impacts. These impacts are classified as severe, which means that changes in activities

	or the application of protective measures should be considered to minimise the impact.
Very large negative	Very high impact on the receptor. The effects are classified as very severe, which means that changes in activities or the application of protective measures should be applied to reduce the impact.

I Table 7 presents the overall scale of sensitivity/value and impact and the resulting impact.

Table 7. Evaluation matrix of the significance of impacts.

The importance of consistency		Sensitivity or value of the recipient		
		Small	Moderate	High
Magnitude and extent of the effect	Large negative	Moderate impact	Large impact	Very large impact
	Moderately negative	Small impact	Moderate impact	Large impact
	Slight negative	Very little impact	Small impact	Moderate impact
	None/ insignificantly negative	Negligible impact	Negligible impact	Negligible impact
	Positive	Positive impact	Positive impact	Positive impact

For some environmental aspects, it is less appropriate to apply the assessment methodology as described above as what is relevant is whether or not an adverse effect occurs. The environmental aspects where the assessment methodology is not fully followed are risk and safety.

5.3 Prerequisites for impact assessments

5.3.1 Assessment based on a worst-case scenario

In order to maximise the environmental impact, the Company has developed worst-case scenarios as a starting point for the impact assessments. Offshore wind power technology is undergoing rapid development, which means that it is currently difficult to predict exactly which technology is the most suitable and available at the time the wind farm is built. This requires the use of a worst-case scenario to ensure that the impact assessments cover the maximum possible impact of the Ran wind farm so that the environmental impact is not underestimated. To account for future technological developments, the final design of the wind farm will be determined during the procurement and construction of the farm.

What constitutes a worst-case varies for each environmental aspect. For some environmental aspects it is the maximum number of turbines that is crucial for assessing the greatest possible impact, while for other environmental aspects it is the size of the turbines that determines the greatest possible environmental impact. The choice of technology (type of foundation, construction method, etc.) can also be of great importance for the worst-case scenario.

The impact will therefore not be greater in any possible variant of the design of the wind farm with regard to heights and numbers as long as the wind farm remains within the scope of the assessment, i.e. at most 121 wind turbines with a maximum total height of 310 metres.

The aim is to maximise the impact and ensure that all alternative designs (distances between turbines, number of turbines and different heights, etc.) have been taken into account in the assessments of the proposed activity.

Table 8. Worst-case assumptions used in modelling/calculations for each influence factor linked to habitat/species.

Influence factor	Worst case definition for each influence factor	Recipients
Underwater noise, see section 6.1.1	The worst case for **marine mammals** occurs when piling jacket foundations with four pinpiles, with sound attenuation measures equivalent to double big bubble curtains. The worst case for **fish** occurs when piling monopile foundations with a diameter of 14 metres, with sound attenuation measures corresponding to a double biig bubble curtain and hydro sound damper. • The impact assessment is carried out for the month (March) when sound propagation is highest in the water. • The position of the foundations has been placed where the highest sound levels are expected to occur. • Soft start-up and ramp-up are applied.	Marine mammals, fish
Displacement, see section 6.1.2	Design of the wind farm: • Maximum number of wind turbines (121). • For birds, the choice of wind turbine also matters. Largest rotor (280 metres in diameter) and highest overall height (310 metres).	Birds, commercial fishing, recreation and outdoor activities
Barrier effects, see section 6.1.4	Design of the wind farm: • Maximum number of wind turbines (121). • Selection of the wind turbine with the largest rotor (280 metres in diameter) and the highest overall height (310 metres). • Clearance between water surface and lowest rotor tip is 30 metres	Birds
Collision risks, see section 6.1.3	Design of the wind farm: • Maximum number of wind turbines (121). • Selection of wind turbines with rotor size 280 metres in diameter and total height (310 metres). • The clearance between the water surface and the lowest rotor tip is 30 metres. A sensitivity assessment is made by overestimating densities of birds within or passing the wind farm.	Birds, bats
Nautical risks, see section 6.1.7	Design of the wind farm • Maximum number of wind turbines (121). • Maximum number of platforms (4).	Maritime transport

5.3.2 Protective measures

As a prerequisite for the applied activity, a number of protective measures will be taken to reduce effects and impact were deemed necessary. The protective measures that will be implemented are described in Chapter 9 and include, among other things, protective measures that have been the starting points for the impact assessments. The protective measures include methods and measures to reduce noise impacts on marine mammals, reduce collision risk for birds and bats, and signage and information to reduce the risk to maritime transport.

5.4 Uncertainties

As described above, the EIA is based on information from studies, calculations, modelling, authorities and scientific literature. The studies and calculations are based on worst-case estimates. The assessed environmental impact is based on conservative assumptions and the environmental impact is therefore not underestimated. The environmental impact can be less than assumed, but never more than described.

6 Influence factors

This chapter describes the environmental effects that the planned activity may give rise to and the influence factors and conditions that form the basis of the impact assessment. Section 6.1 describes the influence factors considered in the environmental assessment and section 6.2 presents the influence factors that are considered but which only have a local impact, and thus do not entail any transboundary impact. The influence on the environmental aspects of benthic flora and fauna, landscape, recreation and outdoor life, cultural environment and marine archaeology is deemed to be local and not transboundary. These environmental aspects have therefore been written off and will not be described further in this Espoo report. Chapter 7 describes how the changes that the planned activities may have an effect on the surrounding environment and activities.

6.1 Assessed influence factors

6.1.1 Underwater noise

Underwater noise as a result of planned activities can occur during the construction phase, the operational phase and the decommissioning phase. During the construction phase, underwater noise is expected to arise partly from work activities during installation and partly because of ship transport to and from the wind farm. Underwater noise may also arise in connection with construction surveys, for example during geophysical surveys.

During the operational phase, noise is generated by vessels in connection with the maintenance and servicing of the wind turbines, as well as underwater noise from the wind turbines themselves. Wind turbine noise originates from aerodynamic noise (rotating rotor blades) and mechanical noise originating from the construction of the wind turbines (gearbox, engine house, etc.). Transmission of sound from the air down below the water surface is limited as most of the sound is reflected at the sea surface (Richardson et al. 1995). Vibrations from the wind turbine, mainly created in the gearbox if installed in the wind turbine, are transmitted via the tower down into the foundation and spread from there as a low-frequency sound (Tougaard & Michaelsen 2018). Airborne sound is described in section 6.2.8.

During the decommissioning phase, noise corresponding to the construction phase is expected in the form of ship transport, as well as possible additional noise during dismantling/sawing of turbines and foundations.

Underwater noise can affect marine mammals and fish, depending on the loudness and duration of the sound, through behavioural impacts and/or temporary or permanent hearing loss. Behavioural impact refers mainly to avoidance behaviour, which can vary from a small change, such as a brief disturbance in foraging, to escape behaviour. The different levels of impact from behavioural change to permanent hearing loss can be put into impact levels. The impact levels used as assessment criteria for harbour porpoise, seal and fish are shown in Table 9, Table 10 and Table 11. These are presented as sound pressure level (SPL) or sound exposure level (SEL) depending on whether a single sound event or a series of sound events is relevant for the impact level. For the assessment of temporary and permanent hearing loss, cumulative SEL is used (SEL_{cum} or SEL_{C24h}).

Table 9. Weighted limits for sound levels that may cause avoidance behaviour, temporary hearing loss (TTS) and permanent hearing loss (PTS) for harbour porpoises, from Tougaard et al. 2021, NOAA 2018 and Southall et al. 2019.

Impact	**Limit value**
Avoidance behaviour	103 dB re 1μPa $(SPL)_{rms\text{-}fast}$
Temporary hearing loss, TTS	140 dB re 1μPa^2 s $(SEL)_{cum}$
Permanent hearing loss, PTS	155 dB re 1μPa^2 s $(SEL)_{cum}$

Table 10. Weighted limits for sound levels that can cause temporary hearing loss, TTS, and permanent hearing loss, PTS, for seals (harbour seal, grey seals and ringed seals), from Tougaard et al. 2021, NOAA 2018 and Southall et al. 2019.

Impact	**Limit value**
Temporary hearing loss, TTS	170 dB re 1μPa^2 s $(SEL\ )_{cum}$
Permanent hearing loss, PTS	185 dB re 1μPa^2 s $(SEL\ )_{cum}$

Table 11. Unweighted limit values for sound levels that can give rise to temporary hearing loss, TTS, and physiological damage, for fish (Andersson et al. 2016, Popper et al. 2014). Herring and cod represent all species as these are among the most sensitive to sound.

Fish species	**Limit values**	
	Temporary hearing loss, TTS	Physiological damage*
Codfish	185 dB SEL_{C24h} , unweighted	204 dB SEL_{C24h} , unweighted
Herring	186 dB SEL_{C24h} , unweighted	204 dB SEL_{C24h} , unweighted
Fish larvae and eggs	-	207 dB SEL_{C24h} , unweighted

*For example, permanent hearing loss or damage to internal organs

On behalf of the Company, NIRAS has carried out modelling and assessment of underwater noise during construction and operation (Reference Report R.2) based on knowledge of site-specific environmental conditions (e.g. bathymetry and bottom sediment composition). The modelling carried out for the assessment of underwater noise has been based on an established methodology. Modelling of the propagation of underwater noise from pile driving has been carried out for three different locations within the wind farm. The locations have been selected based on the fact that the sound propagation is expected to be greatest there, to represent a worst-case scenario. The points are spread out within the wind farm to represent variations in environmental conditions, such as bathymetry and bottom sediments, see Figure 17. Noise from geotechnical investigations has only a limited and local impact and is not considered to be transboundary, hence it is not assessed further in the Espoo report.

The assessments of the effects have been made based on two different assumed possible scenarios; installation of monopile foundations where double big bubble curtain (DBBC), Hydro Sound Damper (HSD) and soft start-up are used as protective measures, and installation of jacket foundations where double big bubble curtain and soft start-up are used as protective measures. An example of a modelled impact surface is shown in Figure 18. In this case, the worst-case avoidance behaviour of harbour porpoises is shown when piling jacket foundations with a double big bubble curtain within the farm area.

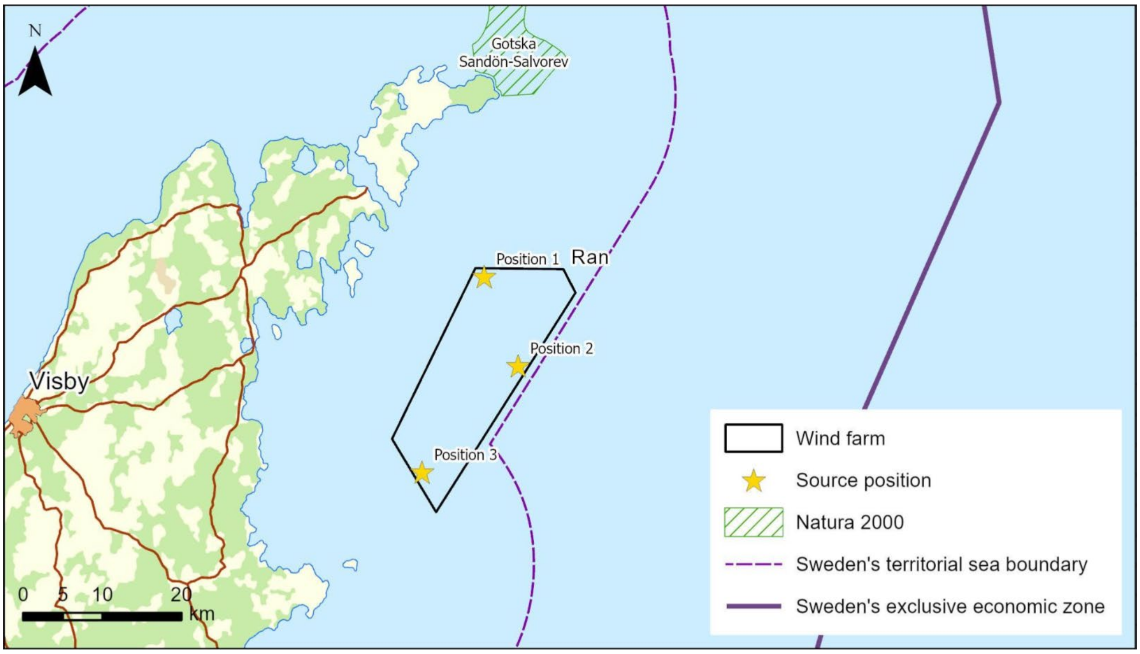


Figure 17. Source positions selected for underwater sound modelling Base map: © [Lantmäteriet] 2021, [Underlag: Niras, Naturvårdsverket 2024].

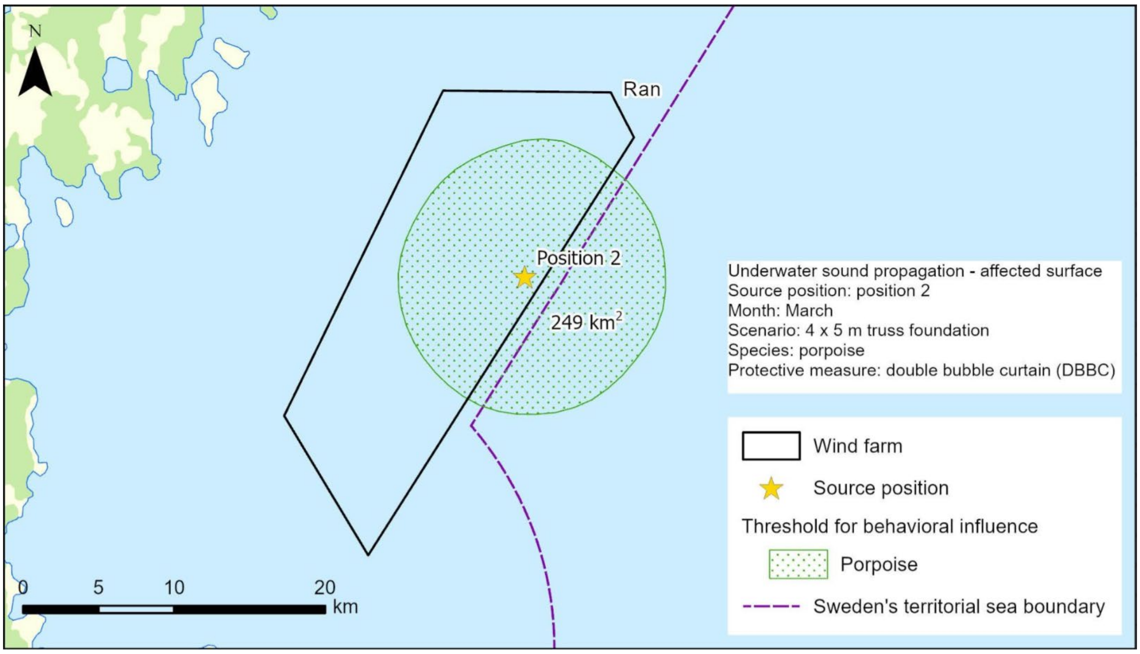


Figure 18. Example of a modelled impact area, in this case showing the worst case for avoidance behaviour of harbour porpoises (green marking) when piling jacket foundations (five metres in diameter) with a double big bubble curtain (DBBC) within the farm area [Base map: © [Lantmäteriet] 2021] 2023, [Basis: NIRAS, Reference report R.2].

Results from the sound propagation modelling carried out have shown that, due to the large distances involved, underwater noise will not propagate into the waters of neighbouring countries during any project phase and thus not cause any transboundary effects. However, underwater noise may temporarily affect fish and marine mammals travelling across borders and therefore impacts due to underwater noise are assessed for these receptors in section 7.2 and section 7.3.

6.1.2 Displacement

Birds and commercial fisheries can be affected by wind farms through displacement. Displacement occurs as a result of environmental disturbances such as operating wind turbines (presence of turbines, noise and lighting) or vessels. For example, disturbance to birds' foraging or roosting areas can result in displacement by foraging and roosting elsewhere. This can lead to a reduction in the habitat of bird species. Commercial fisheries may be affected by displacement by limiting the accessibility of the area to commercial fishermen.

Impacts on birds resulting from the planned activities are described in section 7.4 and for commercial fisheries in section 7.6.

6.1.3 Collision risk

The establishment of wind turbines that interfere with natural movement patterns can pose a collision risk. Collision risk for birds and bats refers to the risk of these species colliding with the rotor blades of wind turbines. The risk of collision for birds and bats depends, among other things, on the design of the wind turbines, such as swept area and rotation speed, the height between the rotor blade and the water surface (clearance), the height at which they fly, the avoidance behaviour of the animal, flight speed, the number of passing individuals and weather conditions. Based on published studies, it is shown that bats mainly fly at a low height (<10 metres) above water, but in occasional observations bats have also moved around the hub height of wind turbines (Ahlén et al. 2009, Rydell & Wickman 2015, Brabant et al. 2019).

Birds and bats that do not generally avoid the wind farm may be attracted to artificial light from wind turbines when migrating or foraging. Artificial light sources can also attract insects, which in turn attract foraging birds and bats. Artificial light can thus increase the risk of collision (Voigt et al. 2017, Voigt et al. 2018). Birds may be attracted to other types of offshore platforms and wind turbine platforms where they land to rest. In poor weather conditions with low visibility and fog, the risk of collision may increase.

In section 7.4 and section 7.5 describe the impacts of the planned activities on birds and bats respectively.

6.1.4 Barrier effects

Barrier effects mean that physical structures can constitute an obstacle to various species or neighbouring activities. This means that the wind farm may limit parts of the marine area's accessibility.

For birds, barrier effects mean that they may have to fly around the wind turbines, thus increasing their flight distance. Those birds that perceive wind farms as a barrier in the landscape are at risk of increased energy consumption during either migration or during transport to and from foraging, nesting and resting sites because of the barrier effect. These changes in flight behaviour can range from a minor adjustment in flight direction to avoiding an entire wind farm.

For migrating birds, the barrier effect may mean that the total distance to the final destination is longer. However, the additional energy expenditure that may occur when birds take a different flight path around wind farms represents a marginal impact over the entire migration distance and is of no biological significance (Fox & Petersen 2019, Krijgsveld et al. 2011).

The sensitivity of a species to barrier effects also depends on their natural migration and resting behaviours. Species that can rest on the surface of the water are less sensitive to disturbance along the migration route because they can rest and in many cases forage if they encounter circumstances that prevent them from reaching their destination. Those species that are reluctant to fly over open water and cannot rest on the water surface have a higher sensitivity to barrier effects as they may be forced to change their route or perish. The sensitivity is a combination of the length of the migration route and natural migration and resting behaviour.

In section 7.4 describes the impact of the planned activities on birds.

6.1.5 Changing fishing pressure and fish availability

During the operational phase, reduced fishing pressure on a localised area of the sea may have positive effects on fish stocks, leading to an increase in fish availability within the wind farm and its vicinity. During the construction phase, underwater noise or sediment dispersion may negatively affect commercial fish species populations for a limited time, for example by disturbing spawning, which could lead to a change in fish availability. As the evolution of fish populations influences stock estimates and fishing quotas, commercial fisheries may therefore also be affected by changes in fishing pressure and fish availability as a result of wind farm construction.

In section 7.6 describes the impacts of the planned activities on commercial fisheries.

6.1.6 Carbon dioxide emissions

The wind farm generates carbon dioxide emissions during its lifetime, but also provides a climate benefit through the generation of renewable electricity. In section 7.1 the impact of planned activities on climate benefits is described.

6.1.7 Nautical risks

In a so-called HAZID (HAZard IDentification workshop) a number of nautical risks have been identified. Nautical risks can include collisions between vessels, grounding, allision or radar interference. Allision primarily refers to a vessel coming into conflict with the wind farm, i.e. accidentally steering or drifting into the wind farm. However, allision does not necessarily mean that the vessel collides with a wind turbine. The impact of nautical risks is assessed in section 7.8.

6.2 Demarcation of influence factors

6.2.1 Sediment and pollutant dispersion

The planned activities may, mainly during the construction phase, give rise to sediment suspension and sedimentation. In order to show the sediment dispersion that occurs during the drilling of foundations and flushing of cables, as well as the subsequent sedimentation, DHI, on behalf of the Company, has produced a sedimentation modelling based on conservative assumptions (worst case).

The sediment dispersion modelling carried out shows that sediment dispersion is localised and mainly limited to the immediate vicinity of the farm area. The magnitude and extent of the effect is assessed as insignificant with respect to the instantaneous dispersion of suspended sediment (duration and dispersion of sediment plumes). Adult fish are expected to avoid areas with temporarily high concentrations of suspended sediment. For eggs and larvae, mortality is already very high during the pelagic phase and the possible localised and temporary impact of suspended sediment is assessed to have an insignificant impact at the population level. In summary, the impact is assessed to be insignificant and no impact at the population level occurs, therefore no transboundary impact is assessed to occur. As sediment dispersion is limited, the dispersion of contaminants from/in sediment is also limited. With the same assessment as above, no transboundary impact regarding the spread of pollutants is deemed to arise either.

The magnitude and extent of the effect is assessed to be insignificant also for marine mammals in terms of both sediment and contaminant dispersion as it is localised and temporary. Harbour porpoises mainly use their echolocation when hunting, which means that they can hunt even in turbid water and at night. Seals are adapted to a life in coastal waters where they are often exposed to turbid water. Any contaminants present are rapidly diluted in the water column through natural mixing. The possible spread of contaminants is therefore not expected to affect porpoises or seals. Overall, no transboundary impact is assessed to occur for marine mammals linked to sediment and contaminant dispersion.

Furthermore, no transboundary cumulative effects are considered to arise in relation to sediment and contaminant dispersion, either for fish or marine mammals. Impacts from sediment and contaminant dispersion are therefore not further described in the report.

6.2.2 Physical impacts on the seabed

Physical impact on the seabed refers to direct interventions in the seabed including the utilisation of seabed area. The planned wind farm will permanently occupy the seabed within the wind farm area. The amount of seabed area will depend mainly on the type of foundations that will be used, the number of wind turbines and the amount of erosion protection that will be installed.

Physical impacts on the seabed mainly arise from the construction of foundations and internal cable networks and jack-up vessels. The majority of the physical impacts associated with the installation of the inner cable network are temporary, as the seabed substrate is expected to return to (near) its original state, and any seabed flora and fauna can re-establish themselves once the cables are laid. It is estimated that the maximum seabed area that will be affected by the establishment of the wind farm is approximately 6.3 km^2. This corresponds to approximately 1.93% of the total area of the wind farm of 327 km^2.

No transboundary impacts arise from physical impacts on the seabed; therefore, it is not described further.

6.2.3 Reef effect

The establishment of wind farm foundations within the wind farm area means that artificial reefs can be formed as a result of foundations providing a hard bottom environment. The formation of artificial reefs is often used as a method to increase the number of fish in certain marine areas (Öhman 2006). The species that establish foundations vary depending on the natural conditions of the area (e.g. salinity, substrate and depth) and the construction of the foundations. What is unique about wind turbines compared to naturally occurring reef types is that the structure penetrates the entire water column from the surface to the bottom. This means that the impact is not only on the bottom but also creates a habitat where there would otherwise be open water.

Figure 19 shows an overview of the possible establishment of the species that may be present at an artificial reef created at a wind farm foundation (Degraer et al. 2020).

OX2 is investigating the possibilities of designing foundations, erosion protection and possibly cable protection to increase the reef effect based on site-specific conditions. Stand-alone artificial structures within the farm are also being investigated as an option. As the positive impact in terms of reef effects on the species that can establish themselves and on the ecosystem is assumed to be mainly localised, no transboundary impact is deemed to arise, and it is therefore not described further in this report.

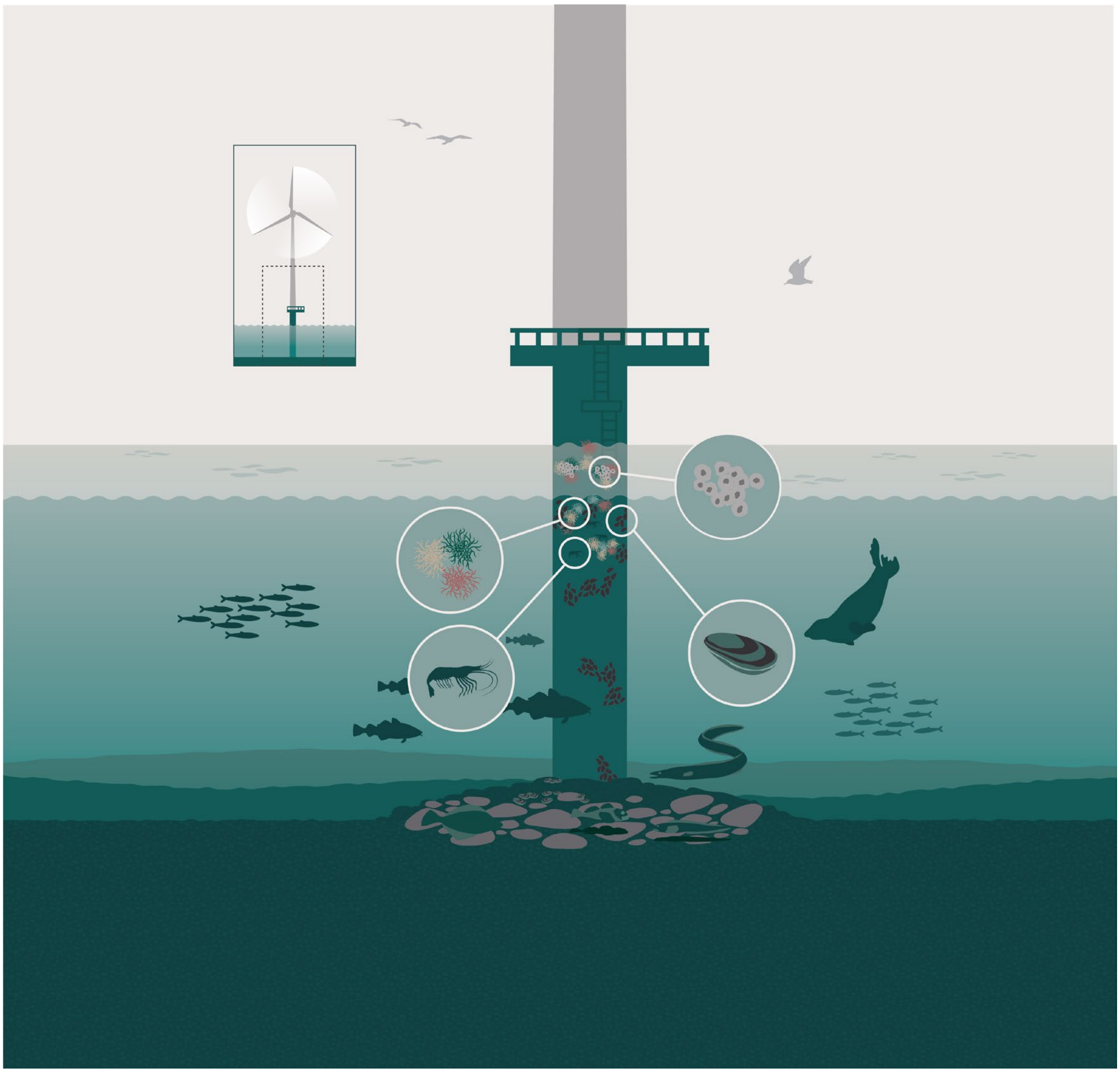


Figure 19. Overview of the reef effect at offshore wind turbines distributed over the entire water column from the bottom to the surface. The figure shows a schematic picture of the reef effect and is not fully representative of the species that occur in the area [Illustration: OX2 AB 2023].

6.2.4 Hydrographic changes

Hydrographic changes involve impacts on current, mixing and wave conditions.

Hydrographic changes in the form of altered current, wave, mixing and substrate conditions can, depending on the nature and extent of the changes, potentially affect the surrounding aquatic environment. Impacts occur during the operational phase, both locally around the foundations and in the area in and to leeward of the wind farm, where wind speed near the water surface is reduced. Restructuring of the seabed can result in altered hydrodynamics, which in turn can lead to a change in the seabed substrate at the site (Hammar et al. 2009).

The upper part of the water mass above the halocline is the part directly affected by the wind, and thus also by the weakened wind behind wind farms, i.e. the windbreak. The impact of the wind wake on the water surface can be expected to be greatest a few kilometres downstream of the wind farm. For example, a maximum reduction in wind speed of around 10 % has been observed in the central parts of a windbreak 5 kilometres downstream of a wind farm in the North Sea (Gandara & Harris 2012).

A wind farm can affect wave conditions by reducing the wave energy in the area and by a wake effect that contributes to a reduction in wave height (Gandara & Harris 2012). This can lead to impacts on sediment transport along sandy coastlines. Restructuring of the seabed can result in altered hydrodynamics, which in turn can lead to a change in the bottom substrate at the site (Hammar et al. 2009). However, the impact is deemed to be small and not to lead to any significant change in the aquatic environment.

Studies in Denmark show that the hydrographic changes resulting from an operating wind farm are minimal and very localised due to the large distances between the turbines (Dong Energy et al. 2006). OX2 has carried out modelling for previous offshore wind projects which shows that the impact of foundations on currents is limited to a very small part of the total extent of the wind farm.

No transboundary impacts are expected to arise from hydrographic changes and are therefore not described further.

6.2.5 Alien species

In connection with the establishment of the wind farm, hard bottom surfaces are added in the form of foundations in an area that is partly naturally made up of soft bottoms. Such structures are well known to attract many aquatic animals. In addition to the positive effect of rich fauna, there is also a risk that they may facilitate the establishment of non-native species (Kerckhof et al. 2012).

There are installation and cargo vessels that use ballast water. For international vessels, the ballast water may pose a risk of spreading alien species. However, most components will be shipped from a final assembly harbour in the Baltic Sea directly to the farm area, so any risk of spreading non-native species associated with these shipments can be dismissed. Some components may nevertheless be shipped from international manufacturers directly to the farm area. All vessels travelling through international waters are subject to the Ballast Water Management Convention[1] , which was established to prevent the spread of harmful aquatic organisms from one region to another.

Due to the brackish conditions of the Baltic Sea, the area of the wind farm is not an optimal environment for most marine and freshwater species. The likelihood of the activity contributing to the introduction of non-indigenous species is considered low and the magnitude and extent of the effect is considered insignificant. Considering the Ballast Water Management Convention and applicable regulations, no transboundary impact is deemed to occur. The impact of alien species is therefore not described further.

6.2.6 Electromagnetic fields

Within Ran wind farm, an internal cable network will be built. Submarine cables to land will also be laid from the wind farm. Electric and magnetic fields, collectively referred to as electromagnetic fields, are generated around power cables. Around submarine cables, the electric field is shielded by the cables' insulation and by the depth at which the cable is laid. The field decreases in strength with increasing distance from the cable.

Most fish species have the ability to sense magnetic fields (Öhman et al. 2007), whereupon the geomagnetic field is used for navigation (Putman et al. 2013, 2014; Naisbett-Jones et al. 2017). This is reflected physiologically by the fact that fish may have magnetic material in their bodies (Walker 1984, Hanson et al. 1984, Hanson & Westerberg 1987).

The impact of electromagnetic fields from the internal cable network is assessed to be localised within the wind farm area and is not expected to affect fish at the population level, therefore no transboundary impact occurs.

6.2.7 Visual change

An offshore wind farm has no physical impact on cultural heritage and landscape on land. The impact that may occur is visual.

[1] International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004

At a distance greater than 39 kilometres from the wind farm, the wind turbines are not visible at all. The distance to other countries is greater than this, which is why no transboundary visual impact occurs. The impact on landscape and cultural heritage is therefore not described further in this Espoo report.

6.2.8 Airborne sound

Operating wind turbines emit two types of airborne noise: mechanical (from generators, for example) and aerodynamic (from the movement of the rotor blades in the air).

The results of the noise calculations show that the impact is limited and localised. The noise level decreases with distance from the wind turbines. The distance to other countries is so great that no airborne sound is expected to reach them. The distance to the seals' haul-out sites is also too great for seals to be affected by airborne sound from the wind turbines. Harbour porpoises only come up to the surface of the water to breathe and are under water for the rest of the time. They are therefore not expected to be affected by airborne sound. There is no transboundary impact for airborne sound, therefore airborne sound is not further described in this report.

6.2.9 Shading

Wind turbines create shadows and reflections from their towers and rotor blades.

Shadow calculations have been produced by the Company to describe the shadow impact of the wind farm. The results show that the shadows do not extend beyond the neighbouring areas of the wind farm. The shadowing influence factor will therefore not contribute to a transboundary impact and is not described further in this report.

6.2.10 Marine litter

Marine litter originates from both land and sea-based activities and can be dumped deliberately or accidentally.

When it comes to offshore wind farms, marine debris such as lost fishing gear can create an indirect impact on marine life in the area by getting caught in foundations, mooring lines or cables.

Before construction of Ran wind farm, the area will be cleared of any marine debris and since fishing in the area around Ran has been very limited in recent years, there is very little risk of new ghost fishing gear getting caught in structures and foundations in the wind farm. The influence factor marine litter will therefore not be described further in this report.

7 Transboundary effects and impacts

This chapter describes the effects and impacts of the planned activities assessed as potentially transboundary.

7.1 Climate benefits and impacts

Overall impact assessment

During its lifetime, from construction to decommissioning, Ran wind farm will have some climate impact. During the construction and decommissioning phase, greenhouse gas emissions will occur, for example from the manufacture of components and from transport. However, the climate benefit of the fossil-free energy production that the wind farm entails during operation is expected to far outweigh the impact that occurs during the construction and decommissioning phases.

Overall, Ran wind farm is deemed to have a positive impact on the climate as it contributes significantly to the transition to fossil-free energy production and large-scale reduction of carbon dioxide emissions. This positive impact is considered to extend across borders because the climate has no national boundaries and because it contributes to the common climate goals. Ran wind farm can contribute to the European electricity supply and thus reduce the use of fossil fuels through electricity exports to Europe.

7.1.1 Prerequisites

Greenhouse gas emissions, energy use and natural resource management are global phenomena that have global effects. The impact of the wind farm on these phenomena, both positive and negative, is therefore transboundary.

During its lifetime, from construction to decommissioning, the wind farm will have a certain carbon footprint. During the construction and decommissioning phases, greenhouse gas emissions occur, for example from the manufacture of components and from transport. By conducting a life cycle analysis, the wind farm's carbon dioxide equivalent emissions per kWh of electricity produced can be calculated and compared with those of other power sources.

An offshore wind farm such as Ran can be assumed to generate around 7.3 g CO2e/kWh. In comparison, emissions from fossil electricity generation for coal are between 740-1689 g CO2e/kWh, oil 510-1170 g CO2e/kWh and natural gas 290-930 g CO2e/kWh (Swedish Energy Agency 2021).

7.1.2 Impact

Table 12 shows which influence factor for transboundary impacts has been assessed and in which phase.

Table 12. Assessed influence factor for transboundary climate impacts and which phase(s) this may occur.

Influence factor	Activities	Construction phase	Operating phase	Decommissioning phase
Carbon dioxide emissions	Wind farm	X	X	X

The activities contributing to greenhouse gas emissions from construction to decommissioning of the wind farm will be limited in time and scope. However, the climate benefits of the renewable energy production generated by the wind farm during operation, by contributing to electrification and displacing coal and gas power through electricity exports, are expected to far outweigh the impact during the construction and decommissioning phases.

Ran Wind Farm is expected to have a very high climate benefit during the operational phase and no significant climate impact from greenhouse gas emissions is expected to arise. This is because no significant additions of greenhouse gases to the atmosphere are generated during the operational phase during the actual electricity production. The positive climate benefit is considered to extend across borders as the climate has no national borders and by contributing to the common climate goals. Ran wind farm can contribute to the European electricity supply and thus reduce the use of fossil fuels through electricity exports to Europe.

In an overall assessment of the impacts arising throughout the life cycle of Ran wind farm, the wind farm has a positive impact with regard to climate, resulting in positive transboundary impacts throughout the operational phase of the wind farm.

Table 13. Assessed impact on climate change. *Receiver means the atmosphere that receives the CO_2 emissions generated.

Influence factor	Sensitivity/value of the recipient*	Effect	Impact
Reduced CO2 emissions	High	Positive	Positive

7.2 Fish

Overall impact assessment

The establishment of the wind farm may give rise to impacts on fish during all phases. However, only the impact on fish due to underwater noise is assessed as potentially causing transboundary impacts.

During the construction phase, with protective measures in place, it is assessed that there will be mainly a localised impact on fish due to underwater noise from pile driving. The same assessment is made in relation to the decommissioning phase even if piling does not take place during this phase, which is mainly due to the fact that the final decommissioning method is not yet established. The geographical extent of the impact is small and temporary, and the area is not considered to be of particular importance for fish. The impact is assessed as insignificant as no impact at population level is expected. The transboundary impacts are therefore deemed to be negligible during these phases.

During the operational phase, the transboundary impacts on fish are also deemed to be negligible. This is because the underwater noise created by the establishment of the wind farm does not add any additional impact over and above the already existing noise level in the Baltic Sea that arises from maritime transport.

This section describes the prerequisites, impact and consequences within Ran wind farm and the potential transboundary impacts that may arise. The section is based on data from ICES, HELCOM, SwAM and own surveys (eDNA and sample fishing) from 2022-2023. The information in this section is a summary of the investigation regarding fish that has been carried out within the project (Reference report R.1).

7.2.1 Prerequisites

The Baltic Sea is a distinctive and relatively young sea (Lass & Matthäus 2008) with a limited diversity of fish species. The sea is strongly regulated by a salinity gradient which is reflected in the fish fauna. The salinity gradient in the sea has a significant impact on the fish fauna (Frelat et al. 2018), which means that the southern and western parts of the Baltic Sea contain the largest number of fish species. In the offshore environments of the Baltic Proper (where the farm area is located), the fish community is dominated by the presence and interaction of three marine species: cod, herring and sprat. These three species have historically been, and still are today, the most important species for commercial fishing, which in turn has affected the stock levels of these species.

Fish species

Herring and European sprat are the dominant species in the BITS surveys in ICES sub-area 28, accounting for 59 % and 39 % of the catch per effort over a 20-year period. After herring and sprat, the ten most common species were European flounder/Baltic flounder, shorthorn sculpin, cod, three-spined stickleback, viviparous eelpout, several species of gobies, lumpfish and snakeblenny. European flounder and Baltic flounder are so similar that they are not distinguished in the BITS surveys. Outside of the 10 most common species, other species were caught in relatively low numbers (0.33%).

During eDNA sampling in August 2022 and in June and September 2023, 20 different fish taxa were detected. eDNA of three-spined stickleback, herring and European sprat was present in the majority of samples during all sampling events. Eelpouts and cottids were also frequently present in the samples. In August 2022, eDNA from three-spined stickleback was present in all samples. During sampling in 2023, European sprat dominated in June, while three-spined stickleback dominated in September. The remaining fish taxa were detected during varying and limited periods in the Baltic Sea.

During the two test fishing sessions conducted with survey trawls in the Ran wind farm area in June 2023, approximately 7,600 individuals were caught and approximately 200 individuals were caught in September 2023. The most common species found in the catches in June 2023 were fourhorn sculpin, viviparous eelpout and herring, while in September 2023 it was herring, cod and fourhorn sculpin.

The cod (Vulnerable; VU) and fourbeard rockling (Near Threatened; NT) are two fish species detected in the surveys within or adjacent to the Ran wind farm area. They are listed in the Red List of Threatened species, which is based on the IUCN guidelines used to assess the status of a species (IUCN 2001). Cod is red-listed and was found using all three monitoring methods (BITS, eDNA and sample fishing). Fourbeard rockling was only found in the NIRAS sample fisheries but was not among the ten most abundant species.

Cod in the Baltic Sea is managed as two distinct stocks: the western stock with its main spawning area in the Bay of Kiel, Fehmarn Belt and Mecklenburg Bay and the eastern stock with its main spawning area around the Bornholm Deep (Hüssy 2011). In the remaining parts of the eastern Baltic Sea, cod abundance is generally lower (Köster et al. 2017, ICES 2021a). Red listing is based on reduced geographical distribution and/or deterioration in habitat quality, actual or potential exploitation of the species and negative impact (SLU Artdatabanken 2024). The establishment of Ran wind farm is not expected to affect the status of cod on the Swedish red list.

Fourbeard rockling is a marine species that also occurs and spawns in the southern Baltic Sea, mainly in and around the Bornholm Deep (Dembek et al. 2019). The red listing is based on an ongoing or expected decline in the species' population. The decline relates to the number of reproductive individuals and is largely based on fish in the Baltic Sea, which constitute the majority of the population. The wind farm is not expected to affect the status of the fourbeard rockling on the Swedish Red List.

HELCOM (2021) has modelled high probability and potential spawning areas for five fish species (cod, European sprat, herring, European flounder and Baltic flounder) with a wide distribution, which are considered to be of importance for the ecology of the Baltic Sea and of value for commercial fisheries. The farm area overlaps with potential and high probability spawning areas for European sprat, but the farm area represents only a very small part of the potential spawning area for European sprat. This is due to the fact that European sprat have expansive spawning areas throughout the Baltic Proper. Spawning areas for herring, cod, European flounder and Baltic flounder are not located within the designated farm area, however there are potential spawning sites for herring and Baltic flounder near the coast of Gotland.

7.2.2 Impacts

This section describes the identified transboundary influence, effects and impacts on fish. Table 14 describes the identified influence factor during construction, operation and decommissioning.

Table 14. Assessed influence factor for transboundary impacts during the construction, operation and decommissioning phases of the wind farm.

Influence factor	**Activities**	**Construction phase**	**Operating phase**	**Decommissioning phase**
Underwater noise	Wind farm	X	X	X

Construction phase

Underwater noise during the construction phase may be generated during surveys as well as during construction works, specifically pile driving. Geophysical surveys are planned for the Ran wind farm. Geophysical surveys generate sounds that have been shown to affect fish (Slotte et al. 2004, Duarte et al. 2021). However, the work related to surveys and pile driving is carried out for a limited period of time and with protective measures, such as soft start-up to prevent fish from being in the vicinity. Furthermore, the noise generated from vessels can also prompt fish to swim away from the area before work starts. Calculations have shown that the noise impact of pile driving is more widespread and extensive than the geotechnical and geophysical investigations. Therefore, the impact of pile driving will be described in the following, as it constitutes a worst-case for underwater noise during the construction phase.

Fish are generally equipped with an evolved sense of hearing (Popper et al. 2019). Key organs for perceiving sound are the ear, swim bladder and lateral line. The ability to hear is utilised by fish, for example, to detect a predator, search for food, orientate themselves and to communicate. Hearing ability varies between species and depends on the anatomy of the auditory organs.

Elevated sound levels can interfere with the natural behaviour of fish and cause stress reactions (Slotte et al. 2004, Smith et al. 2004, Wahlberg & Westerberg 2005, Bruintjes & Radford 2013, de Jong et al. 2020). Proximity to loud sounds can cause temporary threshold shift (TTS) and, if loud enough, can lead to physiological damage (Breitzler et al. 2020). The impact of underwater noise on fish depends on factors such as sound propagation and the sensitivity of the species concerned.

The underwater noice modelling performed by NIRAS (Reference Report R.2) shows that adult cod situated between <200 metres and 2.4 kilometres from the pile driving position at start-up are at risk of suffering from TTS, while the equivalent for herring was 200 metres up to 2 kilometres. For juvenile and adult cod and herring to be at risk of physiological damage during pile driving, they must be within 200 metres of the pile driving source. However, it is considered unlikely that fish would be in such close proximity to the foundations following a soft start-up and ramp-up (van der Knaap et al. 2022, Neo et al. 2016). Consequently, serious physical injuries from pile driving noise are not expected to occur in adult fish.

The sound modelling carried out has shown that the pile driving sounds will not reach known spawning areas for herring and cod, and therefore will not damage their eggs and larvae. In the case of European sprat, they spawn in the planned farm area, which means that their eggs and larvae may be present in the area Nevertheless, the area within which pile driving sounds of sufficient intensity to cause damage can be heard is limited (875 metres radius from pile driving position, 2.4 km^2). The area is not considered to be of particular importance for sprat spawning, given that European sprat spawn in extensive areas of the Baltic Sea. Therefore, no impact is expected to occur at the population level on the eggs and larvae of these species.

The spread of underwater noise is expected to be limited and localized, given the implementation of the proposed protective measures. Furthermore, the construction works will be ongoing for a short period. The proposed protective measures (DBBC, HSD and soft start-up and ramp-up) minimise the risk of fish being present within the impact area of sound levels that can cause TTS when pile driving takes place. However, it cannot be excluded that individual fish, such as larvae and eggs, will be within the impact area. Given that individual fish are capable of traversing national territorial boundaries, there is a possibility of transboundary impacts.

The value of the receptor in and around the farm area is deemed to be low with regard to the conservation value of fish species, and the same assessment is made for the importance of the area for species with higher conservation value. The geographical extent of the impact is limited and temporary, and the area is not deemed to be of particular importance for fish. The magnitude and scope of the impact is therefore assessed as insignificant as no impact at population level is expected. The overall transboundary impacts are assessed to be negligible.

Table 15. Assessed transboundary impact on fish during the construction phase.

Influence factor	**Sensitivity/value of the recipient**	**Effect**	**Impact**
Underwater noise	Small	Insignificant	Negligible

Operating phase

It has been demonstrated that wind turbines can emit sounds that can be perceived in the water. The sound can originate from the mechanics of the turbine housing or be attributed to wind-induced vibrations in the tower (Kikuchi 2010, Pangerc et al. 2016, Tougaard et al. 2020). As noted above, fish can be affected by sound in different ways, particularly at higher sound levels. However, the sound levels emitted by operational wind turbines are typically lower than those produced by vessels operating within the same frequency range (Tougaard et al. 2020). It is anticipated that noise emitted by wind turbines at frequencies perceived by the majority of fish species will be predominantly below pre-existing background noise levels during operation. In several studies, it has been found that the investigated species did not exhibit any obvious negative behavioural changes when exposed to sound levels corresponding to those emitted by operating wind turbines (Wahlberg & Westerberg 2005, Båmstedt et al. 2009). Wahlberg and Westerberg's (2005) conclusion is that sound from an operating wind turbine does not lead to long-term avoidance or physiological damage.

During the operational phase, some boat traffic will be added in the area as part of the operation and maintenance of the wind turbines and platforms. This additional boat traffic is deemed to be of minor significance in terms of impact on fish as there is already intensive boat traffic in the Baltic Sea due to fairways and to some extent fishing vessels. As a result, the additional boat traffic will not result in any additional or greater impact on fish beyond the impact which arises from the existing boat traffic in the Baltic Sea.

The evaluation of the impact of noise during operation is based on fish species that may be present in the area, with greater consideration given to species with a high capacity for sound perception. Behavioural impacts have also been considered in the assessments. Several fish species in and around the farm area have a good ability to perceive sound. The value of the receptor in and around the farm area is assessed as low with regard to the conservation value of the fish species, and the same is true regarding the importance of the area for species with higher conservation value. The sensitivity/value of the recipient is therefore assessed as low. The magnitude and extent of the effect is assessed as insignificant as there is already relatively high background noise in and around the farm area, which means that the sounds generated by the wind farm will not be as prominent, and the fish are also accustomed to higher sounds. The transboundary impact is therefore considered to be negligible.

Table 16. Assessed transboundary impact on fish during the operational phase.

Influence factor	Sensitivity/value of the recipient	Effect	Impact
Underwater noise	Small	Insignificant	Negligible

Decommissioning phase

During the decommissioning phase, the wind turbines will be dismantled, and the foundations will either be fully or partially removed or left in place. Decisions on decommissioning measures will be taken closer to the time of decommissioning in consultation with the supervisory authority regarding sub-seabed structures (parts of foundations and cables) and erosion protection.

The impact of noise during the decommissioning phase is expected to be less than during the construction phase, as piling of foundations does not occur during this phase. The decommissioning methodology has yet to be established; hence the assessments are based on a conservative scenario, i.e. that decommissioning gives rise to the same noise levels as during construction. The noise impact is expected to come mainly from the dismantling of the wind turbines and increased ship traffic in connection with this. As described above, the area is already exposed to a high background noise level today due to maritime transport, which means that the additional sounds due to the wind farm will not be as prominent, in addition to the fact that the fish are used to higher sounds. Sound impacts that exceed current background levels will be very local and transient with, at most, a small negative impact on fish. As individuals of fish can move across countries' territorial boundaries, there is a risk of transboundary impacts.

The sensitivity/value of the recipient is assessed to be equivalent to that assessed during construction, small. The magnitude and effect of the impact are assessed as insignificant, with no risk of impact at population level. The transboundary impact for noise during decommissioning is therefore assessed to be negligible.

Table 17. Assessed transboundary impact on fish during the decommissioning phase.

Influence factor	Sensitivity/value of the recipient	Effect	Impact
Underwater noise	Small	Insignificant	Negligible

7.3 Marine mammals

Overall impact assessment

Four species of marine mammals may occur within the wind farm area; harbour porpoise, harbour seal, grey seal and ringed seal.

The park area is not considered to be an important habitat or breeding area for harbour porpoises, as data shows that it is rare for harbour porpoises to be in the area and there is nothing to suggest that Ran wind farm is more important as a foraging area than the surrounding waters. The park area is not considered to be an important habitat for harbour seals, grey seals or ringed seals, as it is regarded as a less significant foraging area in comparison with Gotland's coastal waters.

Ran Wind Farm is not assessed to affect marine mammals at the population level, or impede their ability to reach a favourable conservation status, at either the local or biogeographical level, which is why the transboundary impacts are assessed as negligible. The primary local impact is the generation of underwater noise during the construction phase, which may prompt marine mammals in the vicinity of the wind farm to avoid the park area, resulting in a localised and temporary loss of habitat. It is not anticipated that noise generated during the construction, operation and decommissioning phases will reach the territorial waters of other countries.

During the construction phase, local impacts on marine mammals are expected to arise mainly from underwater noise generated during geophysical surveys and piling of foundations. This noise may prompt marine mammals to avoid the area. To minimise impacts, protective measures will be implemented, such as acoustic mitigation methods, soft start-up and silencing equipment such as double bubble curtains or similar. For all influence factors during this phase, the transboundary impacts are assessed to be negligible for seals and harbour porpoises.

During the operational phase, the impact of underwater noise on marine mammals is assessed to be insignificant at the population level and the transboundary impact is assessed to be negligible. Underwater noise during the operational phase consists mainly of operational noise from wind turbines and vessel noise from maintenance vessels. It is anticipated that the additional vessel traffic generated by the Ran wind farm will contribute to a negligible increase in underwater noise from vessels compared to existing vessel traffic in the adjacent shipping lanes.

During the decommissioning phase, the local impact on marine mammals is assessed to be similar to that of the construction phase but to a significantly lesser extent as no piling will occur. The transboundary impacts during the decommissioning phase are deemed to be negligible for seals and harbour porpoises. If decommissioning involves the total removal of foundations and the like, the wind farm area will revert to a scenario similar to the baseline alternative, where no impact from the wind farm occurs for marine

This section describes the occurrence of marine mammals in the wind farm area and the assessed impact of the proposed activities from a transboundary perspective. Transboundary impacts are considered to occur if the extent of the impact has an effect at the population level, or if the impact extends across national borders. The information in this chapter is a summary of the marine mammal assessment carried out within the project (Reference Report R.3).

7.3.1 Prerequisites

Porpoises

There are two populations of harbour porpoises in the Baltic Sea that are genetically distinct from each other: the Belt Sea population and the Baltic Sea population. Only harbour porpoises from the Baltic Sea population are expected to occur within the farm area. The harbour porpoise is a protected species under Annexes 2 and 4 of the EU Habitats Directive. The Baltic Sea population has been estimated to consist of approximately 500 individuals (SAMBAH 2016) and is listed as critically endangered (CR) according to the Swedish Red List (SLU Artdatabanken 2020). Bycatch and environmental toxins during the 20th century are believed to be the cause of the sharp decline in the population. Today, bycatch is still a threat to the population along with underwater noise and reduced access to prey.

A European collaborative project (SAMBAH 2016) modelled the distribution of the species in the Baltic Sea between 2011 and 2013, using sound detectors (C-PODS) that recorded the high-frequency clicks of harbour porpoises. The study identified key areas with higher densities of harbour porpoises in different seasons. The results show that harbour porpoises congregate around the offshore banks of Hoburgs Bank and Midsjöbankarna in the Baltic Proper during May-October, while they are more dispersed across large parts of the Baltic Sea during November-April (see Figure 20. This study contributed to the designation of Hoburgs bank and Midsjöbankarna as a Natura 2000 site, where harbour porpoise is a designated, targeted species (Länsstyrelsen Gotland & Länsstyrelsen Kalmar 2021). The Natura 2000 area Hoburgs bank and Midsjöbankarna is located approximately 81 kilometres southwest of the farm area.

Ran wind farm overlaps to some extent with an area that, based on the SAMBAH study, was identified as important for harbour porpoises during the spring (February-April), see Figure 20. These important areas are based on modelling of the probability of detection of harbour porpoises, so the boundaries of the important areas should not be seen as completely accurate, as in reality, harbour porpoises move more widely rather than restricted within defined areas.

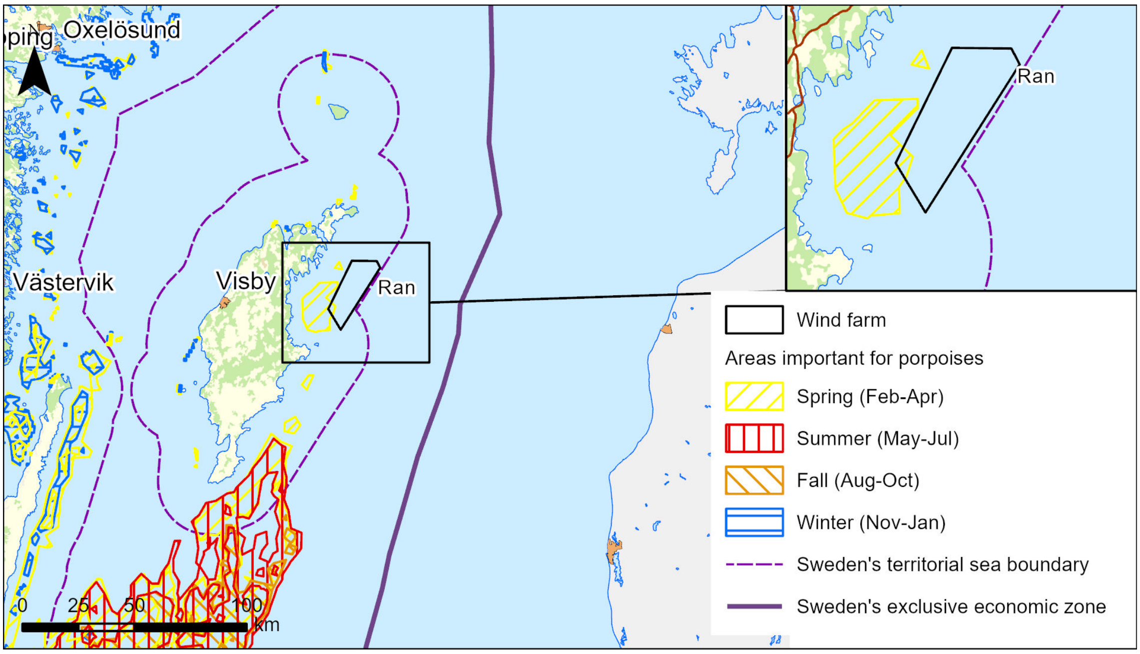


Figure 20. Important areas for harbour porpoises in the vicinity of the farm, by season. Base map: © [Lantmäteriet] 2021, [basis: Carlström and Carlén, 2016].

The presence of harbour porpoises has been studied using harbour porpoise detectors in the farm area from June 2023 and is still ongoing. The results of the survey so far show that there has been only one detection of harbour porpoise (Reference Report R.3). eDNA sampling has also been carried out, but no harbour porpoises have been detected at any of the sampling events.

Seals

There are three species of seal in the Baltic Sea: grey seal, harbour seal and ringed seal. Of the three species, grey seals are the most likely to occur in the farm area, but sporadic individuals of the other two species may also occur in the area. All three species are protected under Annexes 2 and 5 of the Habitats Directive. When analysing eDNA samples from June 2023, there was a weak hit of grey seals at one of 20 stations. The September 2023 sampling detected grey seals at five out of 20 stations and a weak hit on ringed seals at one station. All eDNA detections were made along the western/south-western boundary of the Farm area, and no other marine mammals were detected (Reference Report R.3).

Grey seals

Grey seals are the most common seal species in the Baltic Sea. The population is assessed as viable (LC) according to the Swedish Red List (SLU Artdatabanken, 2020). Documented land-based haul-out sites where grey seals change fur are found on both Öland and Gotland. The haul-out site closest to the Ran wind farm is located along the east coast of Gotland, approximately 13 kilometres from the farm area. Grey seals are a designated species in the conservation plan for the Natura 2000 site Gotska Sandön-Salvorev and can move long distances from their haul-out sites (see section 3.2).

Harbour seal

Harbour seals are divided into two sub-populations in the Baltic Sea: the south-western Baltic Sea and The Kalmar Strait. It is individuals from the Kalmar Strait population that could possibly occur within the Ran wind farm area. This subpopulation is estimated to consist of approximately 3,000 individuals (HELCOM 2023a) and is listed as vulnerable (VU) according to the Swedish Red List (SLU Artdatabanken 2020). Based on survey data between 2003 and 2021, the Kalmar Strait population has increased annually by 9.9 % (HELCOM 2023a). The nearest known haul-out sites for harbour seals are along the east coast of Öland at a distance of just over 170 kilometres from the farm area (HELCOM 2023a). The species is relatively stationary and does not usually move great distances from the haul-out sites, so the likelihood of its occurrence in the farm area is considered to be small.

Ringed seals

The Baltic Sea population of ringed seals consists of three subpopulations: the Gulf of Bothnia, the Gulf of Finland and the Gulf of Riga including Estonian coastal waters. Single individuals from the latter subpopulation may potentially occur in and around the farm area during the ice-free period (HELCOM 2023b, SLU Artdatabanken 2023). The population trend of ringed seal differs between the subpopulations. In the Gulf of Bothnia, the population is growing slowly and is estimated at around 20 000 individuals. Neither in the Gulf of Finland nor in the Gulf of Riga and Estonian coastal waters has a positive population trend been observed, and the population in the Gulf of Finland is estimated at only about 100 individuals. The population in the Gulf of Riga and Estonian coastal waters is estimated to be around 1 500 individuals (HELCOM 2023b). A reduced ice season due to climate change poses a major threat to the population of ringed seals as the species depends on stable sea ice for reproduction. The ringed seal is classified as viable (LC) on the Swedish Red List but as vulnerable (VU) on the HELCOM Red List (HELCOM 2013).

7.3.2 Impact

This section describes the identified impacts and assesses transboundary impact on marine mammals. The following influence factors during construction, operation and decommissioning have been identified, see chapter 6 for further description.

Table 18. Assessed influence factor for transboundary impacts during the construction, operation and decommissioning phases of the wind farm.

Influence factor	**Activities**	**Construction phase**	**Operating phase**	**Decommissioning phase**
Underwater noise	Wind farm	X	X	X

For a more detailed description of marine mammals, their occurrence in the Baltic Sea, influence factors and inventories carried out, see Reference Report R.3.

Construction phase

The primary source of potential transboundary impacts on marine mammals is underwater noise. To assess the potential impact of the wind farm on marine mammals, site-specific underwater noise modelling has been carried out for those activities that may generate high levels of underwater noise, such as geophysical surveys and foundation pile driving.

Impact assessments assume the use of protective measures. The following section presents the impact assessments carried out in the light of the implementation of the proposed protective measures. The protective measures are described in more detail in Chapter 9.

Underwater noise

Geophysical surveys

Prior to the installation of foundations and cables, geophysical surveys of the seabed must be conducted. These surveys generate underwater noise. The modelling of the underwater noise from geophysical surveys shows that the impact distances for hearing loss are limited (up to 875 metres for TTS). It is probable that the underwater noise from the survey vessel itself will cause marine mammals potentially present in the area to avoid the immediate vicinity of the vessel. When geophysical and seismic surveys are conducted, protective measures such as soft start-up will be implemented to avoid impacts on marine mammals. Where possible, hull-mounted survey equipment will be used. This will allow harbour porpoises to move away from the area well in advance of the equipment starting up or running at full power. This means that porpoises are not at risk of being exposed to PTS or TTS, but that the impact is deemed to consist solely of temporary avoidance behaviour around the equipment. Seals are considered to be less sensitive to noise impacts than porpoises and therefore the modelled impact distance for porpoises can also be used as a conservative assumption for behavioural impacts on seals.

The geographical extent of the impact is small and temporary. The investigated area is not considered to be of particular importance for harbour porpoises or an area where harbour porpoises are regularly present. The magnitude and extent of the effect is assessed as insignificant in a transboundary perspective, with no risks to the population in either the short or long term. The geophysical surveys are therefore assessed to have negligible transboundary impact on harbour porpoises.

The sensitivity of seals to underwater noise is considered to be lower compared to harbour porpoises. No sound impact from the surveys will reach the seals' haul-out sites. When soft start-up and ramp-up are applied, the sensitivity of seals is assessed to be low to impacts from the geophysical surveys. The area is not considered to be a more important area for seals than the surrounding waters. The extent of the impact is insignificant at the population level. The geophysical surveys are therefore deemed to have negligible transboundary impact on seals. Overall, the geophysical surveys are assessed to have only negligible transboundary impact on marine mammals.

Vessel traffic

During the construction phase, vessel traffic will increase both within and around the farm area. Both smaller, faster boats and larger, slower vessels are expected to be used during the installation work. Underwater noise from vessels is mainly generated by the propeller.

Results from research indicate that short-term behavioural changes, such as avoidance behaviour, can occur as a result of vessel traffic. For example, the harbour porpoise's reaction is affected by the speed of a boat (Wisniewska et al. 2016, Dyndo et al. 2015, Bas et al. 2017). This means that the porpoise's sensitivity to ship traffic is considered to be low for ship traffic that is slow-moving and thus more predictable for porpoises, which in these cases have time to avoid the sound. This includes large vessels for cable laying and pile driving among others. For smaller and fast boats that can operate more unpredictably, the sensitivity is considered to be moderate as the boats can cause behavioural impacts and possibly avoidance. However, the area is surrounded by shipping lanes, so marine mammals in the area are considered to be accustomed to a certain level of vessel noise. The increase in vessel traffic within the farm area as a result of the construction works is considered to be limited in relation to the existing traffic.

Sensitivity to impacts from vessel traffic is assessed to be moderate for harbour porpoises according to the worst-case. The farm area is not considered to be of any particular importance for harbour porpoises, as previously described. The impact from vessel traffic is also very local and temporary. The magnitude and extent of the effect is deemed to be insignificant in a transboundary perspective, with no risks to the population in either the short or long term. Overall, vessel traffic is deemed to have only negligible transboundary impact on harbour porpoises.

For seals, sensitivity to impact from vessel traffic is deemed to be low as there are no haul-out sites in or near the farm area. The farm area is not considered to be a more important area than the surrounding waters for seals, and the impact from vessel traffic is very local and temporary, which is why the magnitude and extent of the effect at population level is considered to be insignificant.

Positioning system

Positioning systems are used to position free-standing or towed equipment during surveys. Positioning systems may also be required for civil engineering works that require accurate positioning, for example when laying electrical cables. Measurements of underwater sounds during surveys in the North Sea have shown that they can emit frequencies and levels that are within the hearing range of harbour porpoises and seals (Pace et al. 2021).

To avoid the risk of positioning systems causing PTS and TTS in marine mammals, soft start-up will be applied before the use of positioning systems operating at a sound frequency below 200 kHz. The timing of the soft start will be adjusted to allow marine mammals to move away from the area in a timely manner. This means that the impact is limited to temporary avoidance behaviour while the equipment is in use.

The sensitivity of harbour porpoises to the impact of positioning systems is assessed as moderate. The sensitivity of seals to the impact is assessed as low. The magnitude and extent of the effect is assessed to be insignificant at population level. This results in negligible transboundary impact on marine mammals.

Pile driving

During the installation of the wind farm, underwater noise affecting marine mammals may arise from the construction of the different components of the wind farm, mainly during the installation of wind turbine foundations, substations and platforms. Underwater noise from foundation piling can potentially induce TTS or PTS, avoidance behaviour, and mask marine mammal communication and echolocation. The degree of hearing loss depends on the intensity and duration of sound exposure. Piling of jacket foundations is the method with the highest noise impact with available protective measures and therefore represents the worst case in relation to marine mammals. Without protective measures, monopiles have the highest noise impact.

The propagation of underwater noise during foundation installation by pile driving has been modelled (Reference Report R.2). The results of the modelling show that a harbour porpoise needs to be within 975 metres of the pile-driving site to be at risk of TTS and less than 200 metres to be at risk of PTS (Reference Reports R.2 and R.3). However, studies in wind farm construction have shown that the presence of harbour porpoises is reduced even before pile driving has started by them avoiding areas with high activity/presence of construction vessels and similar and avoiding areas with high noise levels (Rose et al. 2019, Benhemma-Le Gall et al. 2021). As a result, harbour porpoises can be expected to move away from the pile driving area even before the soft start-up begins, resulting in a temporary loss of habitat. The likelihood of a harbour porpoise being within 975 metres of the piling site is considered very low. Soft start-up, together with other protective measures (silencing and acoustic mitigation methods) are considered sufficient to ensure that neither PTS nor TTS thresholds are exceeded. Taking into account both the low densities of harbour porpoises in the area and the proposed protective measures, there is no risk of adverse impact.

Hoburgs Bank and Midsjöbankarna are the only known breeding area for Baltic Sea porpoises. Reproduction takes place during summer and Baltic Sea porpoises are generally more sensitive to behavioural impacts during this period. The distance from Ran wind farm to the Natura 2000 site is 81 kilometres, therefore noise levels that could give rise to behavioural impacts are completely avoided within the Natura 2000 site. Due to the distance to the Natura 2000 site, the sensitivity of harbour porpoises to behavioural impacts is assessed as moderate.

The impact that may occur with the proposed protective measures is that the harbour porpoises will have a temporary and limited loss of habitat as they avoid areas with higher noise levels. However, the area where Ran wind farm is located is not considered to be of any particular importance for harbour porpoises, which is why a temporary and limited loss of habitat is not considered to have any impact on either an individual or population level. As the sensitivity of harbour porpoises to underwater noise is moderate and the extent of the impact at population level is assessed as insignificant, the pile driving has negligible transboundary impact for harbour porpoises.

It is anticipated that seals will avoid the immediate vicinity during pile driving, a phenomenon that has been documented in numerous studies (Russell et al., 2016). Nevertheless, seals are regarded as being less susceptible to the effects of noise than harbour porpoises. They are capable of maintaining their heads above the water surface if the noise is sufficiently loud, which also serves to reduce their sensitivity to disturbance. It can therefore be reasonably assumed that the modelled impact distance for harbour porpoises represents a conservative estimate of the potential behavioural impact on seals. The behavioural impacts are most significant for seals during the period of suckling their pups and spending a considerable amount of time on land. The nearest seal haul-out site is situated approximately 13 kilometres from the farm area and noise generated from the construction works is not expected to affect the seals at the haul-out site. No sound levels that could give rise to behavioural impacts are expected to reach the Natura 2000 area Gotska Sandön-Salvorev, where grey seals are a designated species. The farm area is not considered to be of greater importance to seals than the surrounding waters. The overall sensitivity of the seals to underwater noise from pile driving is assessed as low. The magnitude and extent of the effect, namely the temporary loss of habitat, is assessed to be insignificant at the population level. This is because the area is not of particular importance to seals. It is thus concluded that the pile driving will have an insignificant transboundary impact on seals.

Overall assessment - construction phase

The spread of underwater noise is expected to be limited and local with the proposed protective measures. Furthermore, construction works are ongoing for a short period. The proposed protective measures (DBBC, HSD and soft start-up and ramp-up) minimise the risk that marine mammals will be within the impact area of sound levels that can cause TTS when pile driving takes place. However, it cannot be excluded that occasional individuals of seals may be present within the impact area. The likelihood of harbour porpoises being present within the impact area is assessed to be low. Underwater noise is not expected to reach the economic zones of neighbouring countries.

The sensitivity of the receptor to underwater noise in and around the farm area is assessed as low to moderate. The magnitude of the impact is assessed as insignificant during the construction phase with no risk of impact at population level. Overall, the impact during the construction phase is assessed as negligible. Please see Table 19.

Table 19. Assessed transboundary impact based on impacts on marine mammals during the construction phase.

Influence factor	**Animals**	**Sensitivity/value of the recipient**	**Effect**	**Impact**
Underwater noise	Porpoises	Moderate	Insignificant	Negligible
	Seals	Small	Insignificant	Negligible

Operating phase

Sound

Wind power in operation emits two types of noise; mechanical and aerodynamic, see section 6.1.1 and 6.2.8. The aerodynamic sound constitutes the dominant part of the sound from a wind turbine. The transmission of aerodynamic noise into the water column is limited as most of the noise is reflected away at the water surface.

As harbour porpoises only come up to the water surface to breathe, aerodynamic noise from the wind farm is expected to have a negligible impact on harbour porpoises in the area. Seals spend more time above the water surface, but the aerodynamic noise is not expected to have a significant impact as the wind farm is located offshore far from the seals' haul-out sites where they spend a longer time above the surface.

The noise from turbines is the main sound transmitted into the seabed through vibrations that can then propagate into the surrounding water. A conservative calculation of underwater noise from the planned wind turbines has been carried out, where hearing loss for harbour porpoises and seals is considered unlikely. Even if the combined underwater noise from the nine nearest wind turbines is taken into account in the calculation, hearing loss and behavioural impacts are considered unlikely (Reference Report R.2). Sensitivity to underwater noise from the wind turbines is therefore assessed as low for both harbour porpoises and seals.

Underwater noise associated with operations during the operational phase also arises from ship transport of personnel and equipment. During the operational phase, temporary underwater noise also arises from ship transport of personnel and equipment during servicing. However, the additional ship transport as a result of the Ran wind farm is only expected to contribute to a negligible increase in underwater noise in relation to what is produced from existing shipping lanes. The size and scope of the impact on harbour porpoises from sound linked to both ship transport and sound from wind power during the operational phase is assessed overall as insignificant and locally limited. As the sensitivity of harbour porpoises to underwater noise is moderate, the transboundary impacts are assessed as negligible.

For seals, sensitivity to noise from ship transport and to noise from wind power in operation is assessed as low, as no haul-out sites are located within or near the wind farm area. Overall, underwater noise during the operational phase is assessed to have negligible transboundary impacts on seals.

Overall assessment - operational phase

Overall, the sensitivity of harbour porpoises to underwater noise is assessed as moderate and that of seals as low. The magnitude and extent of the effect during the operational phase is assessed to be insignificant and the transboundary impacts on marine mammals during the operational phase are thus assessed to be negligible. Please see Table 20.

Table 20. Assessed transboundary impact on marine mammals during the operational phase.

Influence factor	**Animals**	**Sensitivity/value of the recipient**	**Effect**	**Impact**
Underwater noise	Porpoises	Moderate	Insignificant	Negligible
	Seals	Small	Insignificant	Negligible

Decommissioning phase

During the decommissioning phase, underwater noise may occur. The local impact that may occur in terms of underwater noise is essentially the same as in the construction phase, but on a much smaller scale and extent. This is mainly due to the fact that no pile driving will occur during the decommissioning phase. Decommissioning will be carried out in accordance with the practices and legislation in force at the time of decommissioning, see section 4.4.3.

During decommissioning, the number of vessels in the wind farm area is expected to be similar to that during the construction phase. The main impact on marine mammals in terms of vessel traffic is the underwater noise generated, which could mask marine mammal communication and also affect their behaviour. Intense activity in the vicinity of the dismantling of individual wind turbines is likely to result in harbour porpoises in particular avoiding the site of the work during the short periods of time when the foundations are being dismantled. However, this is unlikely to be to the same extent as during the construction phase.

Overall assessment - decommissioning phase

Decommissioning works may result in the temporary avoidance of the farm area by any marine mammals that may be present. Overall, the sensitivity of marine mammals to underwater noise during the decommissioning phase is assessed to be moderate to low. The magnitude and extent of the local impact for all influence factors during the decommissioning phase is assessed to be insignificant at population level for marine mammals. The transboundary impacts will therefore be negligible, see Table 21.

Table 21. Assessed transboundary impact on marine mammals during the decommissioning phase.

Influence factor	Animals	Sensitivity/value of the recipient	Effect	Impact
Underwater noise	Porpoises	Moderate	Insignificant	Negligible
	Seals	Small	Insignificant	Negligible

7.4 Birds

Overall impact assessment

The migration over the Baltic Sea is extensive during spring and autumn, when a number of seabirds, most notably geese, ducks and loons, as well as nocturnal migratory birds may pass through Gotland during migration. A number of these species may also migrate across the Ran wind farm area. All the species considered in this report move across borders between the territories of different countries.

Collision risks for the bird species concerned have been calculated based on information on the technical characteristics of the wind turbines as well as the physiological characteristics of the birds, their behavior in relation to the wind turbines, flight height, flight speed and the number of passing individuals. The calculations are based on a worst-case scenario. For all assessed bird species and species groups, the effect of collision risk is assessed to be insignificant and the impact negligible.

For diving ducks and loons, displacement may occur. However, the effect is deemed to be insignificant as these species occur at low densities and the importance of the area as a foraging area is low, which is why the impact of the displacement effect is deemed to be negligible.

Barrier effects may also arise for those species that exhibit avoidance behavior in relation to wind turbines. The detour that these birds choose to take results in higher energy consumption. In the context of the entire migration route, the additional energy required when birds take a different migration route will only entail a negligible impact.

The overall impact assessment is that the impacts for all influence factors are negligible in the construction, operation and decommissioning phases. This also applies to the transboundary impacts. As a protective measure, the rotor blade will have a clearance distance of 30 metres between the bottom tip of the rotor blade to the water surface which has been considered in the impact assessment. The planned project will not come into conflict with the Birds Directive. This means that nesting populations from other countries are not at risk of being significantly affected and that there will be no impact at population level.

This section describes the occurrence of birds in the wind farm area and the assessed impact of the planned activities from a transboundary perspective. The information in this chapter is a summary of the bird survey carried out within the project (Reference Report R.4).

7.4.1 Prerequisites

A total of 174 bird species are regularly found breeding on Gotland (Ottosson et al., 2012), with the number of bird pairs estimated at approximately 800,000. This corresponds to just over 1 % of the breeding bird population in Sweden. The majority of birds that breed on Gotland are only present on the island during the summer months, while approximately 20% of the birds are found on Gotland throughout the year. Additionally, birds arrive from the north to spend the winter on Gotland or in the waters off the island's coasts. Many of these wintering birds are seabirds that forage in shallower waters as long as there is no ice.

Some bird species may be present in the Ran wind farm farm area for foraging or flying through. Among breeding birds on Gotland, relatively few species regularly forage further out to sea. Due to the depth conditions, the area of the Ran wind farm harbours poor conditions for bird species that forage on the seabed. Bird species that dive for fish in the open water, on the other hand, are not dependent on the depth of the seabed. Gulls and terns from breeding colonies along the north-eastern coasts of Gotland, as well as other fish-eating bird species, can therefore be expected to occur in the area of Ran wind farm for resting or foraging.

A significant proportion of seabirds undertaking the annual migration to the Russian tundra for breeding purposes traverse a wide area of the Baltic Sea, extending from the Gulf of Finland in the north to the coasts of Germany and Poland in the south. This migratory route is known as the Arktika. Within this wide area, it is difficult to delineate species-specific flight paths that the birds always follow year after year. In general, however, the migration routes through the Ran wind farm are not considered to be part of the main routes for most of the species that pass through Gotland in the spring, but there are bird species that can migrate through the area in large numbers, such as barnacle goose. In the autumn, more migratory seabirds are expected to pass through the farm area and surrounding areas as they follow Gotland's east coast in a more south-westerly direction.

7.4.2 Impact

This section describes the identified transboundary influence, effects and impact for birds. I Table 22 describes identified transboundary influence factors during construction, operation and decommissioning.

Table 22. Influence factors assessed during the construction, operation and decommissioning phases of the wind farm.

Influence factor	Activities	Construction phase	Operating phase	Decommissioning phase
Collision risk	Wind farm	X	X	X
Displacement effect	Wind farm	X	X	X
Barrier effect	Wind farm	X	X	X

The potential transboundary impacts of the wind farm on birds are categorised into three influence factors: collision risk, displacement and barrier effect. These are described in more detail in Chapter 6. All assessments of impacts on bird species are based on the data and investigations compiled and presented in Reference Report R.4. For more detailed assessments and accounts, reference is therefore made to Reference Report R.4.

For each influence factor, a number of reference species are assessed to provide a summarised but representative picture of the impacts that occur. The selection is based on the documented sensitivity of the species to wind power, occurrence in the relevant area, population trends and behaviour. The selection has also taken into account which species may move across borders. The impact assessments have been based on a worst-case scenario, see section 5.3.1. This means that the impact assessments take into account the highest possible impact. Selected species and the influence factors affecting them are presented in Table 23 below. For full details of the impacts on all species included in the assessment, it is referred to Chapter 7 of Reference Report R.4.

Table 23. Overview of the reference species assessed by influence factor.

Influence factor	**Species/species groups**
Collision risk	Geese (migratory barnacle goose and brant goose) Migratory mute swan Migratory and wintering long-tailed ducks Migratory eider Shoveler (eurasian teal and pintail) Foraging and migrating gulls Great Cormorant Migrating crane and heron Migratory birds of prey Nocturnal migratory small birds
Displacement effect	Wintering diving ducks Wintering loons
Barrier effect	Geese (migratory barnacle goose and bar-headed goose) Migratory mute swan Migratory diving ducks Migrating loons Migratory and wintering auks Migratory waders Migratory grebes Migrating crane and heron

Construction phase / Decommissioning phase

It is possible that birds may be temporarily displaced by increased vessel traffic in connection with the assembly and dismantling of wind turbines, both during the construction and decommissioning phases. However, it should be noted that both phases are temporary, and that the risk of negative impacts from displacement is reduced when taken into account the mobility of birds (Bergström et al. 2022). The risk of impact due to barrier effects is initially very limited but increases as more wind turbines are completed. Similarly, the barrier effect decreases as the wind farm is dismantled. It is only in the final phase of construction, when the wind turbines occupy an increasingly large part of the farm area, that barrier effects for migratory birds may gradually arise in connection with the commissioning of the turbines. It is mainly during the operational phase that there is a potential risk of impact on birds through collision risk. Effects on birds during the construction and decommissioning phases have been assessed to be insignificant and lead to negligible transboundary impacts.

Operating phase

Collision risk

The expected number of birds at risk of colliding with the rotor blades of the wind turbines has been calculated by modelling the risk of collision in accordance with the Band model. The model calculates the collision risk based on the technical characteristics of the wind turbines as well as the birds' physiological characteristics, behaviour in relation to the wind turbines, flight height, flight speed and the number of passing individuals. Species such as mute swans, long-tailed ducks, shovelers and cormorants generally fly at low altitudes below the rotor blades. Geese, eider, crane and grey heron are species that vary in their flight height. Seagulls are generally attracted to wind farms but adapt their flight to avoid the turbines. Birds of prey show no significant avoidance of wind farms. The reference species the white-tailed eagle, rarely travels that far out to sea as the distance from the nearest nesting site is probably too great. According to the modelling carried out, a larger number of individuals of nocturnal migratory small birds are at risk of collision, but this does not give rise to any impact at population level. The collision risk modelling carried out shows that the collision risk is low for all species. Since the impact is negligible for all species, the transboundary impact is therefore deemed to be negligible for the populations that breed in other countries and may pass through the wind farm.

Displacement

The activities have been assessed as having the potential to cause displacement for diving ducks, including scaups, common scoters, and long-tailed ducks, as well as loons that originate from other countries and winter in the sea off the north-east coast of Gotland. The depths within the farm area are, however, considered to be predominantly too great for the area to provide suitable foraging sites for these species. Consequently, the densities of diving ducks and loons are considered to be low in the area. Any displaced individuals will be able to rest in other areas along the eastern coast of Gotland. The effect is deemed to be insignificant and the transboundary impact negligible for all species.

Barrier effect

Barrier effects are assessed as potentially impacting migrating geese, mute swans, diving ducks, loons, auks, grebes, waders, cranes and herons. These species exhibit clear avoidance behaviour during migration, which means that they choose to fly alternative routes and are thus affected by higher energy consumption. Geese, mute swans, diving ducks, loons, auks and grebes may roost at sea if necessary. Waders rarely rest at sea but migrate at high altitude and are therefore less affected by barrier effects. Species such as cranes and herons do not roost at sea, but the flight distance increases marginally for these species.

In terms of the entire migration route, the additional energy required when the birds take a different flight path represents a negligible impact for all species. The effect is assessed to be insignificant and the impact negligible for all species, which is why the transboundary impacts are assessed to be negligible for the populations breeding in other countries.

7.5 Bats

Overall impact assessment

The bat species nathusius's pipistrelle has been noted in the park area in connection with inventories carried out. It can therefore not be ruled out that the establishment of Ran wind farm may have an impact on migratory bats. However, only long-distance migratory bat species may be affected in such a way that transboundary effects arise.

Bats are only expected to be affected as a result of increased collision risk during the operational phase. A survey programme will be conducted by the company during the initial three-year operational phase and, if necessary, the rotor blade speed can be reduced in order to reduce the risk of collision. The overall assessment is therefore that the impact on bats is negligible. As a result, the transboundary impacts on bats will be negligible.

This section describes the conditions, effects and impact within Ran wind farm and the possible transboundary impacts that may arise. The section is based on data from SMHI, NORA 3 and surveys carried out by the company (inventories from 2021-2023). The information in this section is a summary of the investigation regarding bats that has been carried out within the project (Reference Report R.5).

Only long-distance migratory bat species are described in this section, as these are the ones that are considered to be potentially affected across borders.

7.5.1 Prerequisites

In Sweden, at least two long-distance migratory bat species occur, the nathusius's pipistrelle and the common noctule, which migrate south to the continent in autumn and then fly back to Sweden over the Baltic Sea in spring (Ahlén et al. 2009, Rydell et al. 2014). The nathusius's pipistrelle has been shown to move by flying between islands from the Finnish coast to the Swedish coast (Schneider & Fritsén 2020) and the Baltic-Gotland route may be used as a migration route (Gaultier et al. 2020). The majority of European bat species alternate between summer and winter colonies, with migration routes varying in length (Dietz et al. 2007). Spring migration occurs mainly from mid-April to mid-June and autumn migration from August to September. The autumn migration of bats at sea appears to occur at least one month later than the time of autumn migration recorded at onshore wind turbines.

The current state of knowledge regarding the impact of onshore wind power on bat species is considerably more extensive than that pertaining to offshore wind power, both at the international and national levels in Sweden. However, a known influence factor of wind power on bats is the risk of collision with the rotor blades of wind turbines (Rydell et al. 2011). Not all bat species are at the same risk of collision with wind turbines as the risk depends on the species' flight behaviour and propensity to forage at wind turbines (Rydell et al. 2017), see also section 6.1.3 for further details on bat behaviours that may lead to collision.

In a study at a wind farm located approximately 23-49 kilometres off the coast of Belgium, it has been shown that 90 % of bat activity occurs when the wind speed is below 6 m/s and at a temperature above 13 degrees (Brabant et al. 2021). Single registrations could be made at wind speeds up to 13 m/s. This shows that bats also fly in stronger winds, but that activity is significantly higher when the wind speed is low, and the temperature is high. A further study has been conducted on three offshore wind farms on the Dutch coast, showing similar results to the aforementioned study, where the greater activity (67 %) occurred below 5 m/s and at a temperature above 15 degrees, the activity was 89 % (Lagerveld et al. 2021).

A bat inventory has been carried out by NIRAS within the farm area of the Ran wind farm during June and September 2023. The inventory was carried out with an autobox that automatically records all high-frequency sounds that occur. Based on the sound files, the bat species nathusius's pipistrelle could be noted and identified during the inventory that took place in June. An earlier inventory using the same methodology was also carried out in September 2021 in the farm area of Pleione energy farm, which is located about 20 kilometres southeast of Ran wind farm. Based on the sound files, only one bat species was noted and identified, which was the nathusius's pipistrelle. Further bat inventories have been carried out by Ottvall consulting during spring and autumn 2022 and 2023 out on the open sea east of Gotland, whereby ten registrations of the bat species nathusius's pipistrelle were noted and one registration of an indeterminate bat species.

The company will carry out a three-year survey programme to investigate the presence of bats in the farm area and to investigate the impact of Ran wind farm on bats during the operational phase. The survey programme will run for three years from the time the Ran wind farm becomes operational. Furthermore, the wind turbines will be equipped with detection and equipment to enable operational control of wind turbines. Operation control of the wind turbines can be applied if deemed necessary to protect bats during spring and autumn migration between sunset and sunrise when there is an increased risk of collision (during low winds (less than 6 m/s) and temperatures above 14 degrees). The proposed permit condition for operational control, which is based on wind and weather data, is considered adequate to provide protection for bats.

7.5.2 Impact

During all phases of the wind farm, only long-distance migratory bat species are assessed as these are the species that could be affected across borders.

Table 24. Assessed influence factor for bats during the construction, operation and decommissioning phases of the wind farm.

Influence factor	**Activities**	**Construction phase**	**Operating phase**	**Decommissioning phase**
Collision risk	Wind farm	X	X	X

Construction phase / Decommissioning phase

No transboundary impacts are expected to occur on bats during the construction and decommissioning phase as the risk of bats colliding with fixed installations is minimal.

Operating phase

The long-distance migratory bat species are classified as high-risk species, and this is generally characterised by the fact that they to a greater extent fly at the height of the rotor blades and its swept surface. The sensitivity/value of the receptor is thus assessed as high for these bat species.

During the operational phase, the rotor blades of the wind turbines pose a risk of collision for bats migrating within or near the farm area. The proposed protective measures ensure that no such impacts occur and therefore the transboundary impacts are negligible, see Table 25.

Table 25. Assessed transboundary impact on bats during operational phase.

Influence factor	**Sensitivity/value of the recipient**	**Effect**	**Impact**
Collision risk	High	Insignificant	Negligible

7.6 Commercial fishing

Overall impact assessment

In summary, fishing activity is greatest in the north-eastern part of the Ran wind farm with trawl tracks in a north-south direction, running parallel to the coast of Gotland and following the bottom topography. In a worst-case scenario, it is estimated that this trawl fishery will not be able to operate during the construction and operational phases, but will need to be relocated to areas some ten kilometres to the east or north. Even when decommissioning is completed, in a worst-case scenario, parts of the wind farm area may be inaccessible to demersal fishing with bottom trawls in cases where parts of foundations, buried cables and pipelines and erosion protection are left in place after decommissioning. However, pelagic fishing for herring and sprat is likely to resume, as the positions of the foundations will be known even after dismantling, and the foundations will be separated by about one kilometre.

The establishment of wind power will mainly have a local effect on Swedish commercial fishing through displacement, which can be relocated to the surrounding area. As foreign vessels rarely use the area for commercial fishing, the transboundary impacts are deemed to be negligible to very small.

This section describes the commercial fishing around the wind farm area and the assessed impact of the proposed activities from a transboundary perspective. From a transboundary perspective, the assessments have only been made on the basis of an impact on international fishing, where Swedish fishing is not taken into account. The information in this section is a summary of the investigation into commercial fishing that has been carried out within the project (Reference Report R.6).

7.6.1 Prerequisites

Ran wind farm is located in the Eastern Gotland Sea within ICES sub-area 27.3.d.28.2, see Figure 21. Fishing activity is highest in the north-eastern part of Ran wind farm. Commercial fishing in the Baltic Sea is mainly regulated by fishing quotas set annually by the EU, but also by national rules on closed seasons, no-fishing zones and gear bans (Bergenius et al. 2018). There has been a sharp decline in the most fished species, herring and cod, over the last ten years. For cod, a fishing ban was introduced in 2019 in the Eastern and Central Baltic Sea and in 2022 the ban was extended to the entire Baltic Proper. Sprat is the only commercial species where quotas are relatively stable.

Pelagic fishing is conducted with similar equipment and methods regardless of the fishing nation. Thus, high-resolution geographical data from the most active fishing nations should provide a representative picture of the fishing activities around Ran wind farm. By analysing ICES commercial fisheries data in sub-area 27.3.d.28.2 (Eastern Gotland Sea), Sweden, Latvia, Denmark, and Lithuania were identified as the most active fishing nations in the area (see Figure 22) and have accounted for an average of 90% of the catches over the last decade. An analysis of VMS data shows that only Sweden, Denmark and Finland have fished within Ran in the years 2019-2021 and that Sweden landed 90 % of the herring and sprat catches (see Figure 23). Germany, Poland and Estonia did not provide data from which landing positions could be derived either. Apart from Sweden, Denmark and Finland are the most likely countries to fish in the area. See Figure 24.

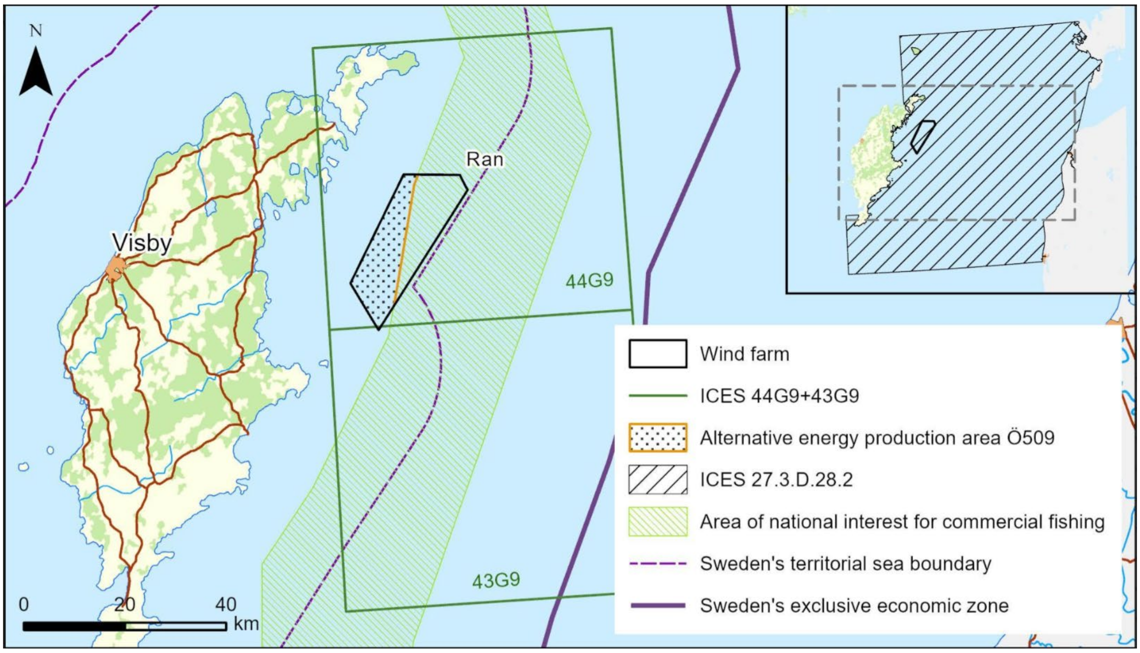


Figure 21. Map of Ran wind farm for commercial fishing and relevant ICES areas used in the analysis of commercial fishing data. Base map: © [Lantmäteriet] 2021, [basis: SwAM 2023a, ICES 2022].

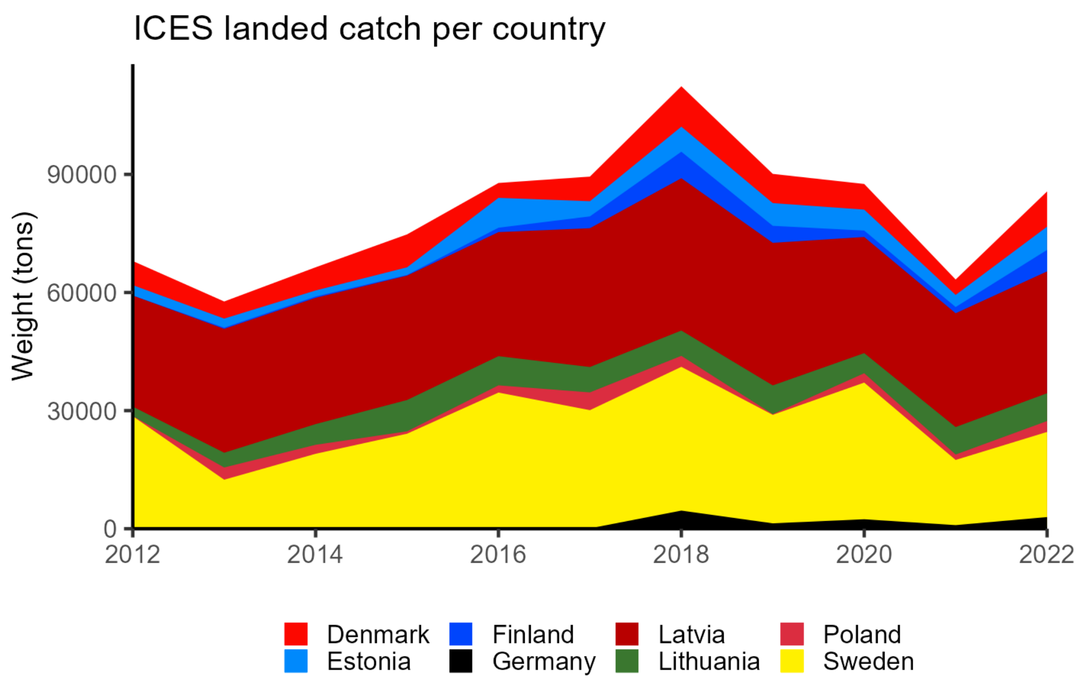


Figure 22. Total weight of landed catch in tonnes for ICES subdivision 27.3.d.28.2 by catching country

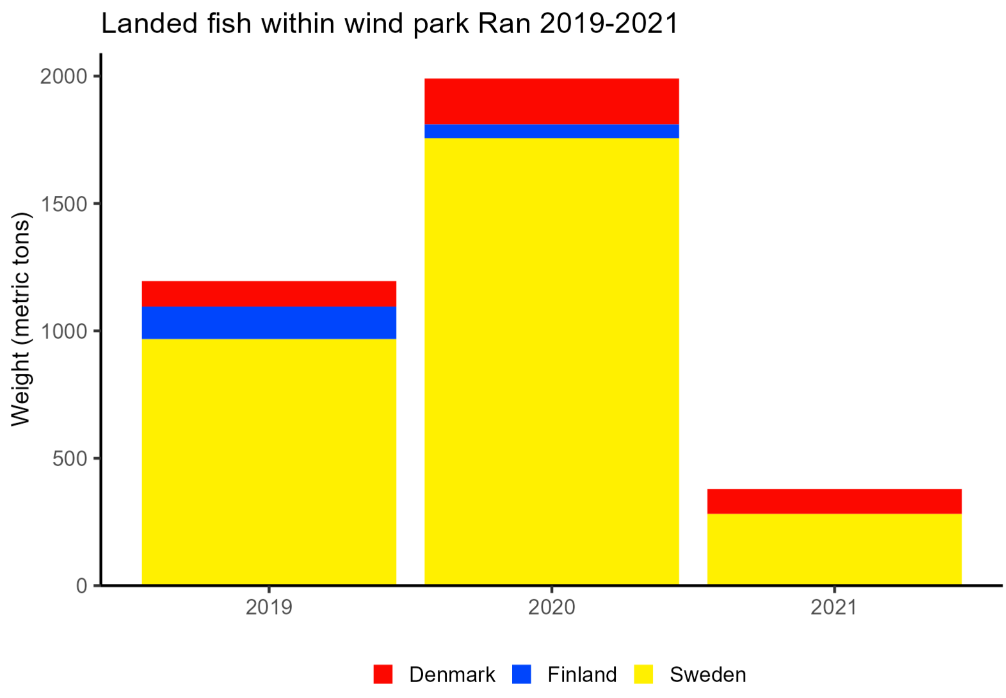


Figure 23. Aggregated catch data based on VMS data obtained from Sweden, Denmark, Finland, Latvia, and Lithuania. There were no landings within the wind farm area for Latvia and Lithuania. Germany is not included in the graph as only VMS data without associated catch data was delivered with coordinate resolution. Finnish landings have been estimated on the basis of the number of trawl hours in Ran combined with the average Finnish catch per trawl hour in ICES statistical rectangles 43G9 and 44G9.

The larger area, ICES sub-area 27.3.d.28.2 (Eastern Gotland Sea), was surveyed in 2012 - 2020.

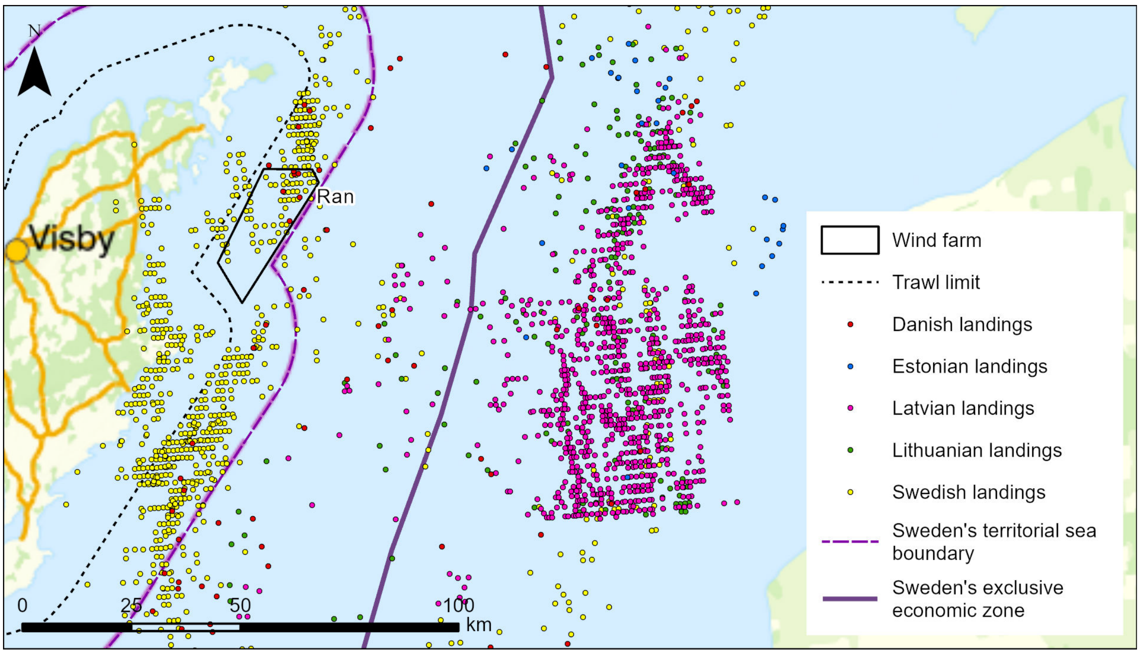


Figure 24. Positions of reported catch points from Sweden compared to data from Denmark, Latvia, Lithuania, Estonia. Data corresponds to the period 2019-2021. VMS data was received from Germany and Finland for their fishing vessels but no position-specific data on landings in the area. The data showed that German vessels did not fish in the vicinity of Ran, while Finnish vessels fished to a similar extent as the Danish ones.

7.6.2 Impact

This section describes the identified impacts and effects on commercial fisheries. The impacts on commercial fisheries are described on the basis of a worst-case scenario where no trawling is possible in the farm area during the construction, operation and decommissioning phases. During the construction phase, a temporary protection zone of at least 500 metres will be established, while construction and maintenance works from installation vessels are carried out. Also, during the operational phase, the corresponding protection zone may be temporarily established in case of repair activities, where larger vessels, such as jack-up vessels or crane vessels, are involved. The worst-case scenario for commercial fisheries is that no fishing, by any method, may take place within these protection zones. Furthermore, it has been assumed that certain protective distances around foundations and anchorages will need to be established during the operational phase where no fishing, regardless of method, may take place within these distances. Impact on commercial fishing mainly occurs during the operational phase when all wind turbines are up and running, but commercial fishing may also be affected to some extent during the construction and decommissioning phases. The influence factors that affect fishing are displacement and changes in fishing pressure and access to fish, see Table 26.

Table 26. Assessed influence factors regarding transboundary impacts during the construction, operation and decommissioning phases of the wind farm.

Influence factor	**Activities**	**Construction phase**	**Operating phase**	**Decommissioning phase**
Displacement	Wind farm	X	X	X
Changes in fishing pressure and fish availability	Wind farm, internal cable network	X	X	X

Construction phase

Physical impacts on fish, for example from noise, may to a lesser extent affect commercial fisheries indirectly by influencing how fish move in and around the wind farm area. In general, underwater noise during pile driving is the impact that has the greatest potential to harm or scare fish away from the area (see previous section 7.2 and Isæus et al. 2022). Fish may avoid a larger area during active pile driving, but since pelagic trawl fishing is done by actively locating fish with e.g. sonar, fishing boats are expected to follow the shoals. Thus, any effects on commercial fisheries are expected to be local and short-lived. Overall, the sensitivity of commercial fisheries from a transboundary perspective to changes in fishing pressure and the availability of fish during the construction phase is deemed to be low. The effect is assessed as insignificant and the impact therefore negligible.

During the establishment of the wind farm, a protective distance of 500 metres will be established around the work vessels. Parts of the farm area will therefore have limited access for a short period. This means that fishing (which is mainly conducted by Sweden in the area in question) during the construction phase will not be possible in the limited parts of the farm area where work is underway. The sensitivity of commercial fishing to displacement during the construction phase is assessed as low. The transboundary effect is assessed as insignificant and the transboundary impact as negligible, see Table 27.

Table 27. Assessed transboundary impact on commercial fisheries during the construction phase.

Influence factor	**Sensitivity/value of the recipient**	**Effect**	**Impact**
Changes in fishing pressure and fish availability	Small	Insignificant	Negligible
Displacement effect	Small	Insignificant	Negligible

Operating phase

Fishing opportunities within the area of the planned wind farm are affected differently depending on the fishing method. As a worst-case scenario, no trawling, either pelagic trawling or bottom trawling, is deemed to be possible within the farm area due to safety risks, as the equipment can get caught in and destroyed by erosion protection and internal cable networks. It can be noted that the trawl limit is planned to be moved out to 12 nautical miles from the coast, so there is uncertainty about what type of commercial fishing will be possible in the area at all in the future (see section 3.4.2).

Pelagic fishing is generally more dynamic in time and space than demersal fishing. The fishing that occurs in the farm area today is large-scale and is mainly conducted with pelagic trawlers that land large amounts of fish (100s of tonnes) a couple of times a year, mainly fished in the north-eastern part of the wind farm. There are thus favorable conditions to redistribute the pelagic fishing that takes place in the farm area today to neighbouring areas. Based on the very limited international fishing activity in the farm area, the sensitivity of commercial fishing to displacement from the fishing area during the operational phase is deemed to be small. The transboundary effect is deemed to be insignificant to small and the transboundary impact will therefore be negligible to very small.

During the operational phase, physical impact on fish such as operational noise can indirectly affect commercial fisheries by influencing fish movement patterns within the farm area. However, current research shows that operational noise at constructed wind farms does not significantly affect fish. If reduced fishing pressure occurs during the operational phase, it may in the long run improve the stock status of some commercially important fish species, such as cod, which in the long run could also benefit commercial fisheries in neighbouring areas (Goñi et al. 2008; Langhamer 2012; Reubens et al. 2013b). This is described in marine conservation ecology as 'spill-over effects' (Hüssy et al. 2016). Spill-over effects occur when a no-take area favours the fisheries (or conservation status) of species in adjacent areas.

Overall, the sensitivity of transboundary commercial fisheries to changes in fishing pressure and fish availability during the operational phase is assessed as low. The effect is assessed as insignificant. The transboundary impact during the operational phase is therefore assessed as negligible.

Table 28. Assessed transboundary impact on commercial fisheries during the operational phase.

Influence factor	Sensitivity/value of the recipient	Effect	Impact
Changes in fishing pressure and fish availability	Small	Insignificant	Negligible
Displacement	Small	Negligible-small	Negligible - Very small

Decommissioning phase

When the wind farm is decommissioned, consideration will need to be given to how the occurrence of different species has developed during the wind farm's operational phase. Overall, the sensitivity of commercial fisheries to changes in fishing pressure and the availability of fish during the decommissioning phase is assessed as small. The effect on commercial fisheries in this regard is assessed as insignificant, resulting in negligible transboundary impacts.

The impact on commercial fisheries and other activities during the decommissioning phase is similar to the construction phase but partly reversed. During the decommissioning phase, a protective distance will need to be established, as during the construction phase. Even when decommissioning is completed, in a worst-case scenario, parts of the wind farm may be inaccessible to demersal bottom trawl fishing in cases where parts of foundations, buried cables and erosion protection are left in place after the decommissioning. Pelagic trawls/gears towed close to the seabed are therefore at risk of being damaged by contact with structures left behind after decommissioning. However, it is likely that pelagic trawl fishing will be able to resume in some parts of the farm area once decommissioning has been completed, as the foundations will be separated by approximately one kilometre and their positions will be known also after they have been dismantled. The sensitivity of commercial fisheries to displacement from fishing areas during the decommissioning phase is therefore assessed as low and the effect as insignificant to small negative. This entails negligible to very small negative transboundary impacts, given that it is mainly Swedish vessels that fish in the area at present, see Table 29.

If the foundations are completely removed, the area will revert to the baseline alternative, which means that access for commercial fishing will be the same as before the wind farm was established.

Table 29. Assessed transboundary impact on commercial fisheries during the decommissioning phase.

Influence factor	Sensitivity/value of the recipient	Effect	Impact
Changes in fishing pressure and fish availability	Small	Insignificant	Negligible
Displacement	Small	Insignificant - small	Negligible - Very small

7.7 Risk and safety

Overall impact assessment

In addition to risks related to maritime transport, the planned wind farm may give rise to other unplanned risks and events during the construction, operation and decommissioning phases. The risks may consist of environmental risks (e.g. spills of oil or other chemicals), accident risks (e.g. towers falling) and risks resulting from external events (e.g. extreme weather conditions). Risks that the activity may give rise to will be continuously managed and minimised through, among other things, risk analyses and the implementation of various protective measures and procedures. The applied project is therefore not considered to give rise to any unacceptable risk from a transboundary perspective.

Risks caused by external events such as extreme weather and climate change are managed through adaptation (e.g. by customizing the design of the wind farm in such a way that it can withstand extreme weather), as well as through risk-conscious planning of the activity and risk analyses. Taking into account the proposed protective measures, as well as the documents and procedures that are developed in the further process, the applied project is not considered to give rise to any unacceptable risk in terms of general risks, environmental risks and risks with external events. Ran wind farm is not considered to entail any negative transboundary impact with regard to risk and safety as protective measures are taken during the construction, operation and decommissioning phases to avoid the release of chemical products. Moreover, protective measures shall be taken in the event that unexploded ordnance is found and protective distances shall be used from neighbouring infrastructure.

This section describes how the Company works and will continue to work with issues relating to safety, as well as the typical risks associated with the construction, operation and decommissioning of an offshore wind farm, and which may have an impact from a transboundary perspective. It also provides examples of risks that may arise in the context of its activities.

In general terms, risks in major construction projects can be divided into health, environmental and property risks. Economic risks are not covered in this report.

The risk of damage to property mainly concerns the installation itself and can often arise from the handling of heavy components. However, accidents such as allision can also affect third parties.

Table 30 illustrates various general examples of the risks that may arise in the context of the activity, and which are considered to have a transboundary impact. Examples of measures to avoid the risk materialising are given in brackets. Note that the summary illustrates different examples of possible risk events, not their cause.

Table 30. Examples of risks and measures.

Category	Example of risk (proposal for action)
Environment	• Oil and chemical spills (emergency preparedness)
Accidental risks	• Falling towers (certification, control during manufacture, installation and operation) • Machinery casings falling (certification, control during manufacture, installation and operation) • Blade loosening (certification, control during manufacture, installation and operation) • Wind turbine part loosening (certification, control during manufacturing, installation and operation) • Fire, overheating, short circuit (detectors, extinguishing system)
External events	• Extreme weather • Unexploded ordnance • Maritime risks/collisions (covered in section 7.8) • Antagonistic threats

7.7.1 Environmental risks

Spills of oil or other chemical products can occur from vessels and from the various components of the installation. The oils and other chemical products contained in the wind turbines need to be replaced or refilled regularly, but at long intervals in some cases. There is a risk of a spill during these operations. The likelihood of a major spill from a vessel within the wind farm is considered to be small, as the wind farm area is expected to be used mainly by service and maintenance vessels and recreational boats to a small extent.

Minor spills of oil or other chemical products could occur during maintenance of the turbines, however, it should be noted that the wind turbines and other components are designed with, for example, spill trays and/or other means of collecting any spills. The wind farm will have equipment such as bilges for handling such spills. In the event of a fire, collision or other external physical impact, major spills of diesel or transformer oil may occur. Tanks containing diesel and environmentally hazardous oils will be fitted with leakage protection that can handle the entire contents of the tank, which means that the likelihood of a major spill to the aquatic environment is considered low, which is why the risk of transboundary impact in this respect is considered low.

In order to prevent the risk of accidents and limit the impact in the event that an accident occurs, a contingency and rescue plan will be drawn up in consultation with the Coastguard and others. The plan will describe, among other things, accessibility in the event of an accident or spill, as well as the possibility of cleaning up oil spills or spills of other chemical products that may have an impact on the environment.

In the event of a wind turbine collapse, the hydraulic oil and coolant of the wind turbine could potentially leak. Gearbox oil (if the wind turbine has a gearbox) will most likely remain in the gearbox, as the gearbox casing is usually made of cast iron. Hydraulic oil, transformer oil (if used) and gearbox oil (if used) can be biodegradable, as can coolant.

7.7.2 External events

Unexploded ordnance

According to the Swedish Armed Forces' mapping of risk areas, there are unexploded munitions and other ordnance in the farm area. The possible presence of unexploded munitions (UXO) will be mapped as part of the detailed designing. Identified objects are either avoided by taking them into account when placing wind turbines and cables or neutralised before any work is carried out.

Prior to installation works, a final check of conditions is made to ensure that there is no unexploded ordnance at the specific location where a support leg vessel is positioned, where a foundation is placed or where a cable is laid down. Various forms of bottom preparation are then carried out before the foundation is established at the site. If unexploded ordnance or chemical warfare agents are found during seabed surveys prior to installation work, the relevant authorities are notified immediately. If it poses a risk to the installation work, an assessment is made, in consultation with the supervisory authority and the Swedish Armed Forces, of whether the object should be moved or blown up under controlled conditions. Alternatively, the object can be avoided by choosing a different foundation position or cable route. In the event of relocation or blasting of objects, appropriate protective measures shall be taken to minimise the impact on marine mammals, fish and seabirds likely to be in the area. Appropriate protective measures are developed in co-operation with the relevant authorities and therefore the risk of negative transboundary impacts is assessed as low.

Nord Stream and other infrastructure

Nord Stream 1 and Nord Stream 2 pass to the east of the farm area, approximately 7.6 km from the farm area. In total, Nord Stream 1 and 2 consist of four pipelines. At present, three of the four pipelines are out of service. The existing gas pipelines will be taken into account when constructing Ran wind farm and future export cables. The company will also consider other nearby cables and will take appropriate protective measures to avoid damaging existing infrastructure.

7.7.3 Risk management work

In future work, the Company will continue to work on risk management and risk minimisation. This work is described in general terms below.

HSSE Management Proceedings of the project

The company has initiated the preparation of Health, Safety, Security and Environment (HSSE) Management Proceedings, which describe how the project will plan, manage, monitor and co-ordinate health, safety and environmental issues throughout the design, construction and commissioning phases of the wind farm.

Contingency and rescue plan

The company will draw up a contingency and rescue plan in consultation with the relevant authorities well in advance of the construction phase.

Risk register

An important part of the HSSE work is to continuously identify all risks and record them in a project-specific risk register; a detected risk should be evaluated and accompanied by an action. This register should describe, among other things, risk events and their underlying causes, which may be a chain of events or several parallel events, the probability and consequence of the risk events, various measures and the effect of the measures on probability and consequence, as well as who is responsible for managing the risk and when it should be managed.

It is important to start work on risk analysis early in the project development. Already during the design of components or when designing a work step, an assessment should be made of the risks that the component or step may give rise to and the protective measures that can be taken. Procurement ensures that suppliers understand and respect the high-risk awareness of the project. Procedures should be continuously checked also among suppliers and their subcontractors, including during the manufacturing of components.

Controls, RAMS, Toolbox talk

During the manufacturing of components, documented checks will be performed continuously. The finished component will be examined in a Factory Acceptance Test (FAT) and after delivery in a Site Acceptance Test (SAT). The finished installation is checked and reconciled against a so-called Reference Turbine before test operation begins.

A risk assessment (RAMS, Risk Assessment Method Statement) is carried out prior to various work steps, identifying various potential risks and clearly describing how the step is to be carried out. Just before a work step is started, a so-called "toolbox talk" is held, where the step is reviewed together and the risks that may exist. After the work has been carried out, a follow-up must take place and any deviations, including incidents that have not led to an accident, must be reported.

Education and training

Individuals involved in the construction and operation of the activity will have relevant education and training adapted to offshore wind, for example coordinated by the Global Wind Organisation.

Prior to the marine part of the installation, a workshop is conducted, where possible risk events are identified, proactive measures are developed, and action plans are drawn up. The results are summarised in a risk binder, which clearly describes the measures to be taken for the various risk events and by whom. In the event of an accident, there should then be an easily accessible guide on what to do.

Monitoring systems

In addition to the preventive measures and procedures mentioned above, a number of automatic monitoring and control systems will be used within the wind farm. The ongoing maintenance is focused on preventive maintenance, where various monitoring systems and sensors are used to obtain early information about damage to the wind turbines and thus be able to take remedial action before the damage becomes too serious. In addition to reducing downtime, this also means that leaks etcetera can be detected before any emissions occur.

7.7.4 Executive summary

Taking into account the proposed protective measures in this report, the Reference Reports R.7.A; R.7.B; R.7.C and the forthcoming documents and procedures required by the legislation to be developed within this process, the applied activity is not considered to give rise to any unacceptable risk from a transboundary perspective.

7.8 Maritime transport

Overall impact assessment

Ran wind farm is located between three shipping lanes, but outside established routes.

The risks in relation to maritime transport have been assessed within the framework of a nautical risk analysis. When evaluating the risks identified, no unacceptable risks were found. All assessed risks have been classified as acceptable or as ALARP. For risks classified as acceptable, the risks are considered to be so low that no protective measures need to be taken. For risks classified as ALARP, the risks are considered tolerable if reasonable precautions are taken.

The distance between the maritime traffic and the wind farm means that there is plenty of room for vessels to navigate safely even when the wind farm is built. This applies to both current and future traffic scenarios. The wind farm does not affect the conditions for navigation within or near any traffic separation zone, nor does it affect the possibilities for maritime traffic to follow straight courses in shipping lanes between traffic separations. Ports are therefore not affected.

Vessel traffic through the farm area is currently limited to two vessels per day. Passage through the wind farm, for example for fishing vessels, will still be possible after its establishment. For those vessels that choose a different route, the journey may be slightly longer, but the effect is considered negligible.

Overall, the sensitivity of maritime transport in the area is assessed to be moderate for all phases of the wind farm: construction, operation and decommissioning. Taking into account the protective measures taken, such as the development of a contingency and rescue plan and the appointment of a marine coordinator, the effect on maritime transport during all phases of the planned wind farm is deemed to be slightly negative. The transboundary effect on maritime transport is assessed to be the same as in Swedish waters, which overall means that Ran wind farm is assessed to have small negative transboundary impact for maritime transport.

The section describes the maritime transport around the wind farm area and the assessed impact of the planned activities from a transboundary perspective. The information in this chapter is a summary of the nautical risk analysis and traffic analysis produced within the project (Reference Reports R.7 and R.8).

7.8.1 Prerequisites

A traffic analysis and a nautical risk analysis have been carried out according to PIANC's[2] methodology step 1 (a first step that provides general safety distances based on a standardised calculation method) and step 2 (an in-depth nautical risk analysis that provides answers to whether the distances that exist between wind turbines and passing vessels give rise to risks that cannot be accepted) (PIANC 2018).

A number of risks have been identified based on the results of the traffic analysis, information on accidents, possible navigation disruptions and comments received in the consultation. Recommendations from the Swedish Transport Agency and the Swedish Maritime Administration (Transportstyrelsen & Sjöfartsverket 2023) and literature studies have also been used to identify relevant risks. In addition, a so-called HAZID[3] workshop has been conducted.

[2] The World Association for Waterborne Transport Infrastructure (PIANC), MarCom WG Report NO. 161, 2018.

[3] Hazard Identification - risk identification

The identified risks have then been analysed based on accepted international guidelines and taking into account the recommendations of the Swedish Maritime Administration and the Swedish Transport Agency for the design and establishment of offshore wind power (Maritime Safety Committee 2018, PIANC 2018, Swedish Transport Agency & Swedish Maritime Administration 2023). The risks have been classified on the basis of the scale acceptable, tolerable (if technically and economically reasonable measures are taken, also known as ALARP[4]) or unacceptable.

The impact and risk assessment has been based on a worst-case scenario. In relation to maritime transport, such a scenario assumes that the largest number of foundations are constructed, i.e. 121 wind turbines and four platforms. The assessment of the impact on national maritime traffic is also applicable to international traffic and thus the national impact is consistent with the transboundary impact.

Shipping lanes

Ran wind farm is located between three shipping lanes, *Öland's southern cape - Gulf of Finland*, *Salvorev - Slite* and *Slite - Öland's southern cape*, see Figure 25.

[4] ALARP - As low as reasonably practicable

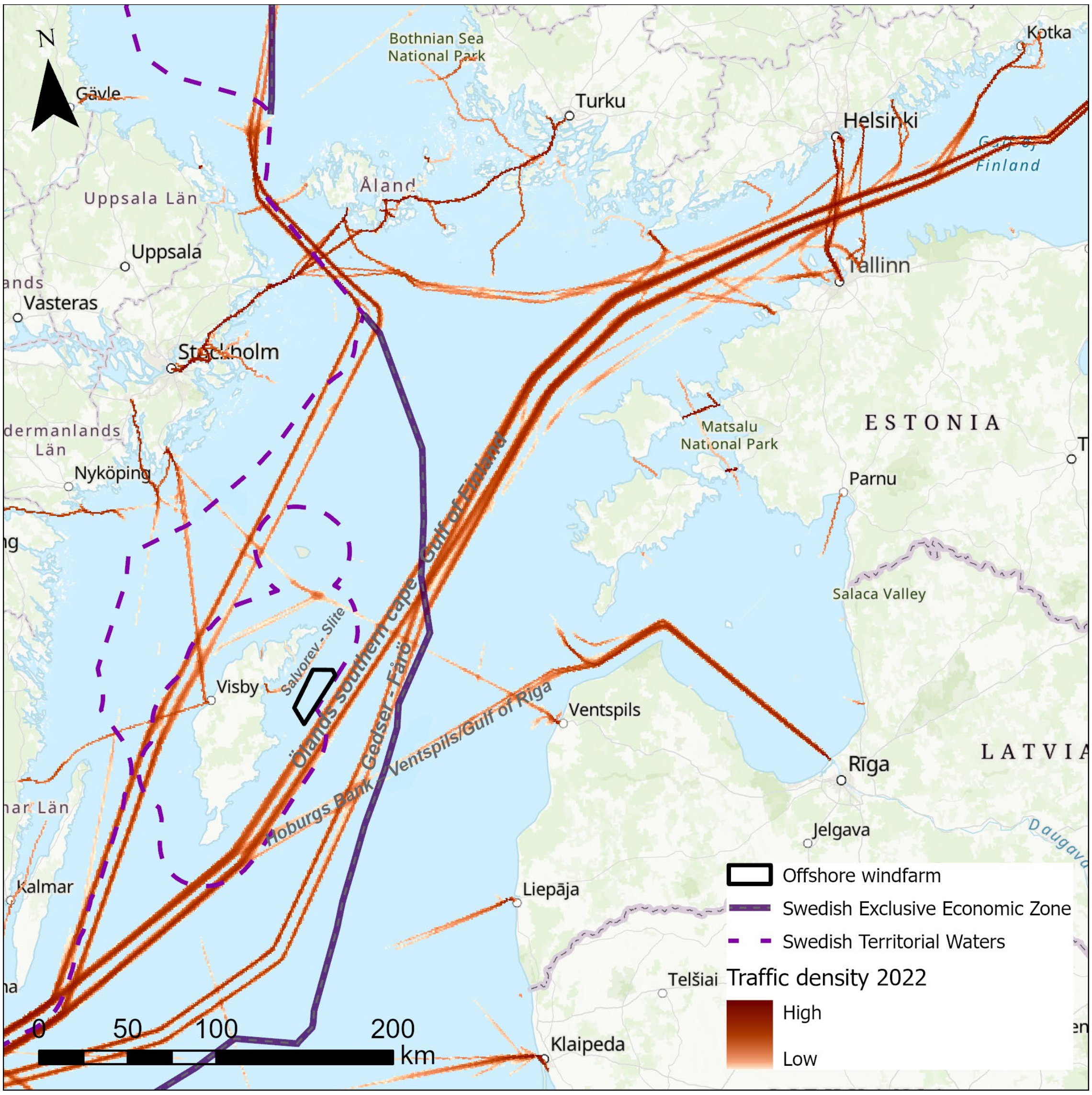


Figure 25. Shipping lanes and traffic density at Ran wind farm. Base map: © [Lantmäteriet] 2021, [Basis: EMODnet 2024).

Vessel types and lengths

Vessel types and traffic flows within the planned wind farm and in its vicinity have been analysed using AIS data for the period February 2022 - February 2023 (hereafter referred to as the reference period).

The vast majority of vessels travelling in the area are cargo vessels. In addition, there are mainly passenger ships, followed by pleasure boats and fishing boats. Most vessels are 80-210 metres long with an average length of 148 metres. The longest vessel passing in the vicinity of Ran wind farm, the passenger ship MSC Preziosa, is 333 metres long and passed the *southern cape of Öland - Gulf of Finland* eight times during the reference period.

Vessels larger than 200 metres mainly operate on *the southern tip of Öland - Gulf of Finland*. Ship passages with a ship length of less than 100 metres are generally evenly distributed between the different lanes.

Traffic flows

The traffic analysis shows that relatively few vessels operate in the shipping lanes around the Ran wind farm, compared with lanes further south, for example. Traffic east of Gotland is mainly concentrated in the lanes from *the southern tip of Öland to the Gulf of Finland* and the deep-water route *from Gedser to Fårö*, which is located further east. Some concentration can also be seen in other lanes, such as the *Salvorev - Slite* and *Slite - southern tip of Öland*. Traffic in the various lanes in the vicinity of the Ran wind farm averages 1-26 passages per day. The majority of vessel passages take place outside the wind farm area.

There were 5,600 vessel passages recorded within a 5 M (nautical mile, 1 nautical mile = 1,852 metres) buffer zone from the farm area and 687 passages through the farm area during the reference period.

Safety distance

The recommended safety distance according to PIANC's methodology step 1 has been calculated to 1.09 M (approximately 2.1 kilometres) for the ship route *Öland's southern cape - Gulf of Finland*, 0.7 M (approximately 1.3 kilometres) for *Salvorev - Slite* and 0.71 M (approximately 1.3 kilometres) for *Slite - Öland's southern cape*. In addition, there is a safety zone around the foundations of 50 metres (0.03 M), giving total safety distances of 1.12 M, 0.73 M and 0.74 M respectively.

The distance from the outer edge of the recommended traffic route[5] to the nearest wind turbine in the example layout is 4.92 M (approx. 9.1 kilometres) for *Öland's southern cape - Gulf of Finland*, 2.22 M (approx. 4.1 kilometres) for *Salvorev - Slite* and 3.94 M (approx. 7.3 kilometres) for *Slite - Öland's southern cape*, see Figure 26.

The recommended safety distances according to PIANC (2018), 1.12 M, 0.73 M and 0.74 M respectively including the safety zone of 50 metres (0.03 M), are met with a good margin for the example layouts. When finalising the layout, a complementary risk analysis will be performed according to PIANC methodology step 2 to ensure that the final layout does not pose unacceptable levels of risk.

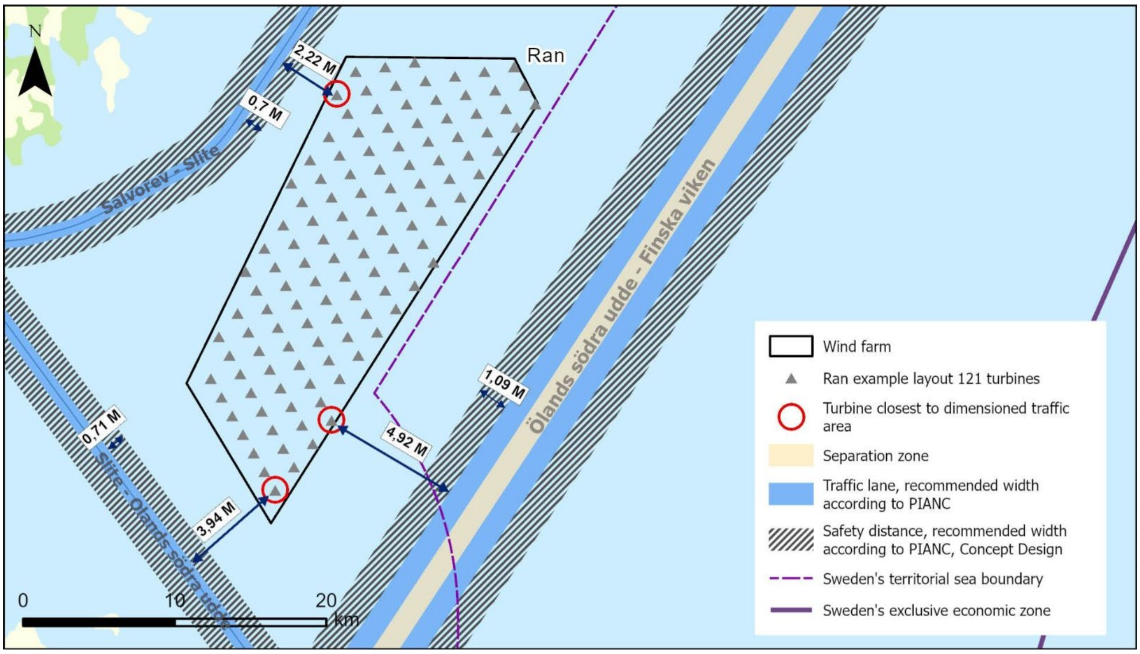


Figure 26. Distance from the outer edge of the recommended traffic lane to the nearest wind turbine and recommended safety distances for each shipping lane. The figure shows an example layout of the wind turbine locations within the farm area. Base map: © [Lantmäteriet] 2022, [Basis: PIANC 2018].

[5] PIANC (2018) provides recommendations on how wide a traffic lane or several traffic lanes should be to be able to handle a certain volume of traffic in a shipping lane with good maritime safety in accordance with international recommendations. These have also taken into account and been based on where the actual shipping takes place (compare lanes that are regularly used, according to PIANC), which has been calculated and analysed based on AIS data.

7.8.2 Impact

This section describes the identified impacts and implications for transboundary impacts for maritime transport. Table 31 shows which influence factors have been assessed and in which phase.

Table 31. Assessed influence factor for maritime transport and during which phase(s) this may occur.

Influence factor	**Activities**	**Construction phase**	**Operating phase**	**Decommissioning phase**
Nautical risks	Wind farm	X	X	X

Construction phase

Maritime traffic to and from the site during the construction phase will consist of vessels of varying sizes, such as installation vessels, transport vessels, various specialised vessels and smaller boats for personnel transport and surveillance.

The port used for the installation will be used for the transport of personnel and small components. Transport to and from this port may require crossings of existing shipping lanes during periods when installation work is in progress. If the transport takes place along existing shipping lanes, crossings of lanes can be minimised. The additional maritime traffic associated with the construction phase of the Ran wind farm is estimated to be just over 1,600 voyages over five years.

For the construction phase, the risks are considered to be linked to the increased traffic intensity to the farm area, where the crossing of shipping lanes is the most critical risk factor. The risk of collision between work vessels and ships in established shipping lanes is classified as ALARP, which means that protective measures need to be taken. A supplementary risk analysis will be carried out prior to the construction phase and several different protective measures will be implemented to reduce identified risks, for example, the wind farm will have a so-called marine coordinator, who controls and coordinates all marine operations. Furthermore, relevant maritime stakeholders will be informed well in advance of the construction works and the areas affected. Given the proposed protective measures, no unacceptable risks to maritime transport are expected to arise during the construction phase.

The sensitivity of maritime transport in the area affected by the planned wind farm is assessed as moderate due to the proximity to established shipping lanes. With the protective measures taken, the effect during the construction phase is assessed as a small negative. The transboundary impact regarding maritime transport is assessed to be the same as in Swedish waters, as maritime traffic moves between national borders, which overall results in small negative transboundary impacts (Table 32).

Table 32. Assessed transboundary impact on maritime transport during the construction phase.

Influence factor	**Sensitivity/value of the recipient**	**Effect**	**Impact**
Nautical risks	Moderate	Small negative	Small negative

Operating phase

General

Ran wind farm will be established outside designated shipping lanes. The safety distance between maritime traffic and Ran wind farm means that there is plenty of space for vessels to navigate safely even when the wind farm is built. Vessels will still be able to utilise the entire space in the recommended traffic lanes and additional space outside, without falling below the safety distance according to PIANC (2018).

The wind farm does not affect the conditions for navigation in or near any traffic separation zone, nor does it affect the ability of maritime traffic to steer a straight course in the shipping lanes between traffic separations. Accessibility to ports is therefore not affected.

Vessel traffic through the farm area is currently limited to two vessels per day. Passage through the wind farm, for example for fishing boats travelling between a port and a fishing area, will continue to be possible after its establishment. For those vessels that choose a different route, the journey may be slightly longer, but the effect is considered negligible.

During the operational phase, the risk of collision, interference with ship radar and effect on search and rescue operations has been classified as ALARP from certain aspects, which means that reasonable measures need to be taken to make the risk acceptable. These risks are therefore addressed in more detail below.

Collision

Collision in this case means that a vessel passing through the wind farm inadvertently steers into the wind farm and collides with a wind turbine or, due to technical failure, loses manoeuvrability and drifts into a wind turbine. It can also mean that vessels passing through the wind farm collide with a wind turbine, for example in poor visibility. To reduce these risks, several measures will be taken, see chapter 9.

Interference with radar and navigation systems and search and rescue operations

Radar interference can potentially occur for traffic passing Ran wind farm at a distance closer than 1.5 M (about 2.8 kilometres) to the wind farm but is generally limited to the absolute vicinity of the wind turbines (0.25 M or about 0.5 kilometres). Radar interference is a well-known phenomenon in commercial traffic and occurs in more places than at wind turbines. There are routine measures to minimise interference. In addition, large vessels are equipped with several systems for gathering information for safe navigation. Interference with equipment is not expected to jeopardise the ability of vessels to navigate safely. Offshore wind turbines may adversely affect rescue operations due to radar and communication interference and due to the physical obstructions posed by wind turbines. However, searches can also be facilitated by the high visibility of the wind farm and the fact that wind turbines have unique numbers that can serve as a reference point for those in distress.

Ship collision and grounding

The establishment of Ran wind farm is not expected to have a significant impact on traffic patterns outside the wind farm area. This means that the risk of collisions and grounding is not affected by the establishment.

Other risks

The ice formation in the area is generally limited due to the winter conditions in the specific farm area. Ice formation around Ran wind farm is therefore not expected to affect the accessibility of vessel traffic in the surrounding shipping lanes.

The risk of falling objects, blade throwing or similar causing a serious accident on passing merchant vessels or recreational boats is considered to be low, as blade throwing in wind power accidents is generally short and distances to places where vessels pass are long.

Helipads may be present within the wind farm or on maintenance vessels. These and the helicopters utilised in the wind farm can be used to improve the conditions for sea rescue and are part of the internal rescue plan.

The use of helicopters for airborne search and rescue (SAR) operations in an area with wind turbines may involve increased risks, but the risks are calculated risks to rescue people in distress. However, the availability of usable helicopters is likely to increase, as well as the availability of vessels, rescue equipment and trained and co-trained personnel.

Overall assessment - operational phase

Overall, no unacceptable risks have been identified for the operational phase. All assessed risks have, given conservative analysis assumptions, been classified as acceptable or as ALARP. Protective measures to reduce the risk of the scenarios classified as ALARP will be implemented.

The sensitivity of maritime transport in the area affected by the planned wind farm is assessed as moderate due to the distance to established shipping lanes. With the protective measures taken, the effect during the operational phase is assessed as small negative. The transboundary impact regarding maritime transport is assessed to be the same as the impact in Swedish waters, as maritime traffic moves between national borders, which overall results in small negative transboundary impacts (Table 33).

Table 33. Assessed transboundary impact on maritime transport during the operational phase.

Influence factor	**Sensitivity/value of the recipient**	**Effect**	**Impact**
Nautical risks	Moderate	Small negative	Small negative

Decommissioning phase

During the decommissioning phase, the foundations and other components of the wind farm will be removed. According to the current state of knowledge, the decommissioning phase of the planned wind farm is generally expected to be the reverse of the construction phase. When the wind farm is decommissioned, all maritime traffic will gradually be able to use the entire area covered by the wind farm again without hindrance.

As during the construction phase, the risks are considered to be linked to the increased traffic intensity to the farm area and then the need to possibly cross shipping lanes.

The sensitivity of maritime transport in the area affected by the planned wind farm is assessed to be moderate due to the proximity to established shipping lanes. With protective measures in place, the effect during the decommissioning phase is assessed as small negative. The transboundary impact regarding maritime transport is assessed to be the same as in Swedish waters, as maritime traffic moves between national borders, which overall results in small negative transboundary impacts (Table 34).

Table 34. Assessed transboundary impact on maritime transport during the decommissioning phase.

Influence factor	**Sensitivity/value of the recipient**	**Effect**	**Impact**
Nautical risks	Moderate	Small negative	Small negative

8 Cumulative effects

Cumulative environmental effects describe how an acitivity, together with other past, present or future activities, affects the environment in an area. Cumulative effects can occur when several different effects interact with each other, both when different types of effects from one and the same activity interact or if effects from different activities interact. Cumulative effects can, for example, be the impact on birds, fish and marine mammals from different types of activities within a relevant geographical area. The cumulative effects of the planned Ran wind farm in combination with potential impacts from neighbouring projects are thus described here. No wind farms or projects from other countries may be cumulatively affected by the applied activity.

A starting point for the assessment of cumulative effects is that the existing and permitted activities in the vicinity of the farm area, which can potentially affect the same environmental aspects as the wind farm in question, are included. On 4 November 2024, the Government announced that it was rejecting 13 applications for permits for offshore wind projects in the Baltic Sea. It is therefore unlikely that these projects will be realised. Pleione energy farm, which OX2 and Ingka are planning, has been considered in the Company's cumulative assessment, see Table 35, Figure 27 and Figure 28. In the application for a Natura 2000 permit that the Company has submitted, the Aurora wind farm and Neptunus energy farm, which are planned by OX2 and Ingka Investments, were also considered. This has been done despite the rejection decisions for the farms in question, indicating that the Company's cumulative assessments are very conservative and take into account a worst-case scenario where the rejected windfarms will be established, albeit this is highly unlikely.

Aurora wind farm and Neptunus energy farm were included on the basis that cumulative effects with Ran wind farm could have a potential impact on birds in the Natura 2000 sites of Asunden, Skenholmen and Ryssnäs. However, the assessment showed that no cumulative effects occur. Other ongoing activities assessed for cumulative effects are maritime transport and commercial fishing. Nord Stream is located at such a distance that no cumulative effects are expected to occur with Ran wind farm.

The environmental aspects where a cumulative effect is expected to occur are described in more detail below.

Table 35. Existing and planned wind farms in the vicinity of Ran wind farm for which cumulative effects are assessed.

Wind farm/operation	Status of the project	Distance and direction from Ran wind farm (kilometres)	Project type
All onshore wind turbines on Gotland	In operation	13 V-75 SW	Onshore
Pleione	Under development	20 SE	Offshore
Bockstigen 1	In operation	79 SW	Offshore
Kårehamn	In operation	140 SW	Offshore

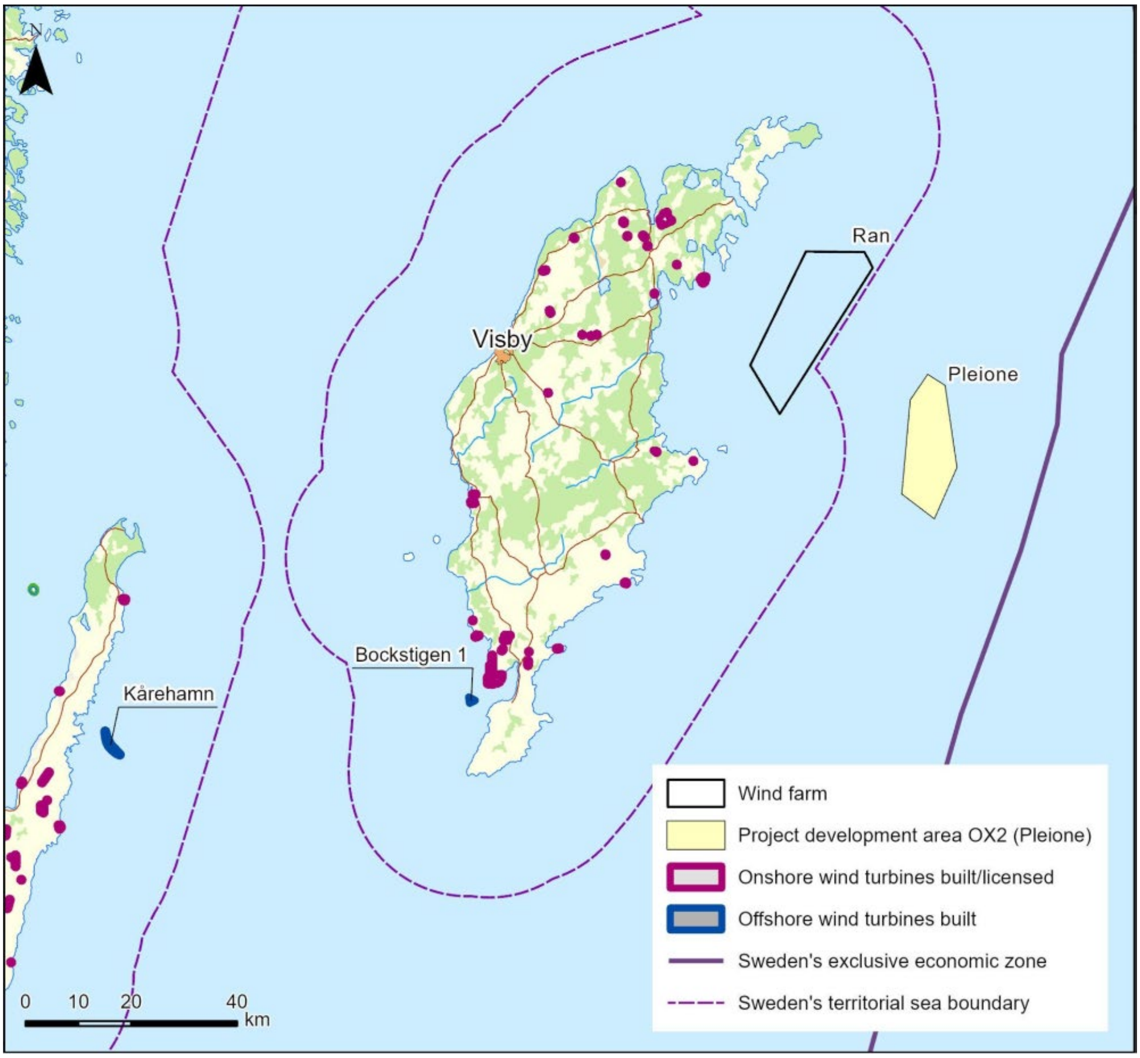


Figure 27. The farm areas for Ran wind farm and OX2's neighbouring project development area, Pleione energy farm, existing offshore wind farms, existing onshore wind farms. Base map: © [Lantmäteriet] 2021, [Basis: County Administrative Board 2024; SGU 2024].

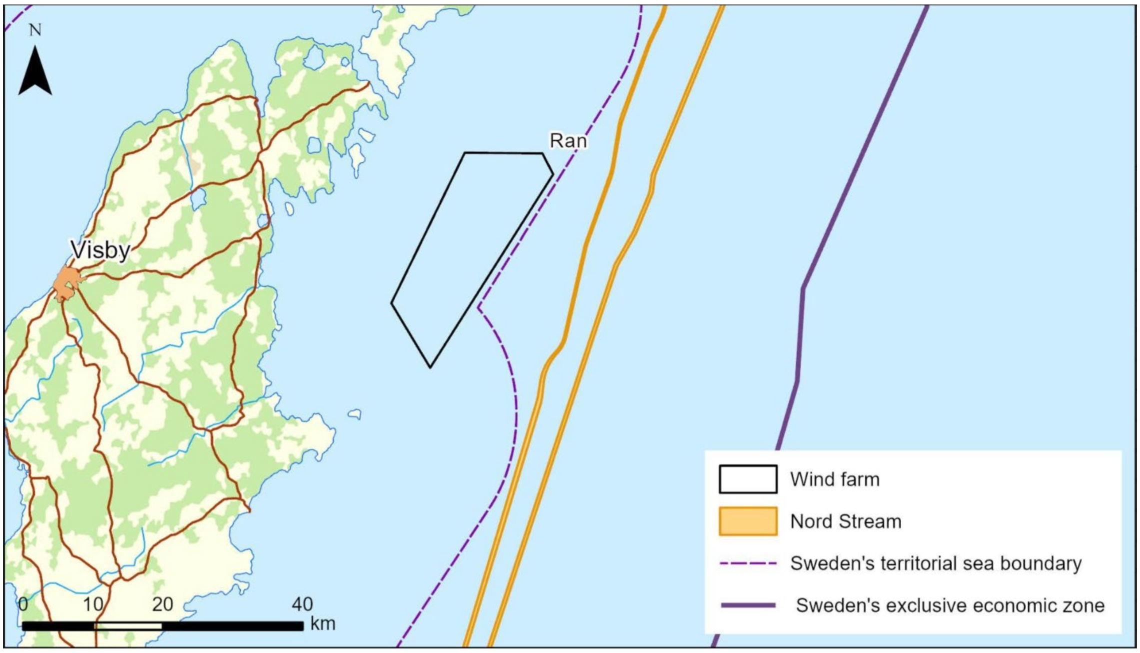


Figure 28. The farm area for Ran wind farm and the Nord Stream 1 and 2 gas pipelines. Base map: © [Lantmäteriet] 2021, [Basis: SGU 2024].

8.1 Construction phase

The construction phase of Ran wind farm is expected to overlap with the construction phase of Pleione energy farm. However, piling will not be carried out in Ran wind farm and Pleione energy farm at the same time. As a result, there will be no cumulative effects of underwater noise from pile driving between the two farms.

Construction work also means an increased presence of vessels and activity in the farm areas. The adjacent shipping lanes already give rise to underwater noise and the additional traffic in the area during the construction phase for Ran wind farm and Pleione energy farm is only expected to contribute to a very limited increase in underwater noise from vessels, in limited areas and for a limited period of time. Nor is the increased traffic expected to entail an increased risk of grounding or collision. The frequency of allision, i.e. a ship steering or drifting into a wind turbine, is expected to increase marginally if both wind farms are constructed. The cumulative effects on vessel traffic are assessed to be negligible overall. Thus, there are negligible transboundary impacts regarding the cumulative effects on vessel traffic.

The cumulative effects on bats and birds during the construction phase are assessed as insignificant as the impact of Pleione energy farm and the existing wind farms and the wind farm itself are assessed as insignificant during these phases, which is why negligible transboundary impacts are assessed to occur.

During the construction phase, an additive effect may occur for commercial fishing by restricting boat traffic and fishing in different areas at the same time. However, the farm areas for the existing wind farms Bockstigen 1 and Kårehamn do not constitute significant fishing areas and even within Ran wind farm and Pleione energy farm, fishing pressure is relatively low. Since the entire wind farm is not being constructed at the same time, the protection zones around the work areas will be smaller in terms of both time and area. As the wind farm and the energy farm are so far apart, the loss of these fishing areas is not expected to affect the possibility of relocating fishing to intermediate areas. Swedish fishing within Ran may need to be relocated eastwards, which could lead to increased Swedish fishing pressure in areas where other nations currently conduct their main fishing, causing increased competition. The development of both Ran wind farm and Pleione energy farm could make such a relocation of commercial fishing more difficult and thus give rise to a greater negative impact than either farm alone. Given that foreign vessels very rarely fish in the wind farm area where there is a temporary loss of fishing areas, the transboundary cumulative effects will be very small for commercial fishing.

8.2 Operating phase

8.2.1 Fish and marine mammals

Adjacent shipping lanes already give rise to underwater noise today and the additional traffic (during maintenance) as a result of the establishment of Ran wind farm and Pleione energy farm are deemed to contribute to a negligible increase in underwater noise from the wind farm and from vessels compared with existing traffic. The cumulative transboundary effects that may arise for fish and marine mammals from underwater noise in the operational phase are therefore assessed as negligible.

8.2.2 Bird

Cumulative effects with other wind farms may lead to increased risk of collisions, displacement and barrier effects. The birds passing Ran wind farm may also pass Pleione energy farm, Bockstigen 1, Kårehamn and onshore wind farms located on Gotland. The cumulative effects arising from an increased collision risk are not considered to be of such magnitude that it risks affecting the maintenance of viable bird populations, not least because the Pleione energy farm will also apply the necessary protective measures to reduce the collision risk. The offshore wind farms Bockstigen 1 and Kårehamn are located within the same migration route as Ran wind farm, which entails a longer flight distance for birds passing through the migration route. However, the increased energy consumption required has an insignificant impact on the bird species in relation to the total flight distance. Birds that are nesting, roosting or wintering, i.e. spending a longer time in a certain area, are more likely to be killed by collisions with wind turbines than those that only pass the area actively flying during migration (Rydell et al. 2011). Displacement can also pose a risk to resting and wintering birds. Breeding and wintering populations at the onshore wind farms and Pleione energy farm are not expected to occur in the Ran wind farm area to any great extent.

Cumulative effects of onshore wind power are not expected to occur for bird species that rest on Gotland during migration. The impact on seabirds such as diving ducks, swimming ducks and auks is therefore considered to be negligible. For guillemots, displacement from wind farms is very tangible (Garthe et al. 2023). However, the densities of wintering common guillemots in the relevant part of the Baltic Sea are low and are therefore not considered to risk cumulative effects together with the offshore wind farms. The cumulative effects during the construction and decommissioning phases are assessed as insignificant as the impact of the wind farm itself is assessed as insignificant during these phases.

The assessment of the impact of cumulative effects takes into account the farms that have been assessed as being able to contribute to cumulative effects with the activity applied for, i.e. neighbouring farms that have been built and are located in the same migration path as Ran wind farm. As previously stated, the assessment shows that there are no cumulative effects. It is therefore concluded that Ran wind farm does not contribute to cumulative effects with other wind farms, with regard to assessed bird populations from other countries.

8.2.3 Bats

Multiple wind farms can potentially have a cumulative effect in terms of increased collision risk for bats. The design of the planned wind farms has not been finalised, but they will be designed so that precautionary measures are applied to reduce the risk of collisions. The planned precautionary measures at Ran wind farm and Pleione energy farm entails that the windfarms, neither individually nor together, will affect the maintenance of bat populations from a transboundary perspective. As a result, negligible transboundary impacts are considered to occur in terms of cumulative effects.

8.2.4 Commercial fishing

If both Ran wind farm and Pleione energy farm are built, the area of free accessible fishing grounds will be reduced by an order of magnitude corresponding to less than one per cent of the central Baltic Sea. The loss of these fishing areas is expected to mainly affect the Swedish commercial fisheries that are most active in these areas today. The direct impact on international commercial fisheries (mainly Denmark, Latvia, Lithuania and Finland) is expected to be very small. However, it is expected that the Swedish fisheries that are currently conducted mainly in Ran will need to be relocated eastwards, which could lead to increased Swedish fishing pressure in areas where other nations currently conduct their main fishing. This in turn could cause increased competition. Expansion of both Ran and Pleione would also make such a relocation of fishing activity more difficult and give rise to a greater negative impact than that caused by each farm. If a relocation of the trawl limit along the Swedish coast takes place before then, as proposed by the government, Swedish commercial fishing will already have relocated away from Ran. The cumulative effects on transboundary commercial fishing are therefore considered to be very small.

8.3 Decommissioning phase

The decommissioning phase of Ran wind farm is so far in the future that, at the time of writing, it is not possible to predict what other measures or activities may coincide with the decommissioning of Ran wind farm and thus contribute to cumulative effects. It is therefore not possible to assess the transboundary implications of the potential cumulative effects for this phase.

9 Protective measures and monitoring

9.1 Protective measures

The following protective measures will be implemented in the context of the planned activities and have either been included as a prerequisite in the impact assessment or have been added as a result of the impact assessments. Within the framework of the impact assessments produced, an assessment has been made of which protective measures are justified on the basis of the transboundary impacts of the activity on the various aspects concerned.

Location and design

- The precise location of wind turbines and platforms shall be determined after consultation with the relevant authorities.
- The design of the wind farm (the location of the wind turbines and platforms and the location of the internal cable network) will be adapted to the appropriate and available technology at the time, the site conditions in terms of wind, waves, water currents and geological characteristics, as well as taking into account environmental values and other interests.
- Wind turbines, metering masts and platforms shall be marked with obstruction markings in accordance with the regulations in force at the time.
- Simultaneous piling in the Pleione and Ran farms has been ruled out.

Underwater noise

- For the protection of marine mammals and fish, soft-start shall be applied before the use of equipment operating at a sound frequency below 200 kHz and potentially causing hearing loss to marine mammals and fish. The soft-start shall be specifically designed for the source strength to be used so that marine mammals and fish have time to swim away from areas where the sound levels could potentially cause hearing loss.
- In case of interruptions of more than 15 minutes in surveys or when using equipment that may cause hearing loss in marine mammals and fish, the survey should be restarted with a soft start.
- For the protection of harbour porpoises, equipment for side-scan sonar and multibeam sonar surveys should operate at a sound frequency above 200 kHz.
- Wherever possible, hull-mounted equipment should be used for surveys.
- Protective measures shall be used during any blasting operations to minimise the impact on marine mammals.
- In order to guarantee the absence of harbour porpoises in the vicinity of the pile-driving site and to prevent them from being deterred to an unnecessarily large distance, acoustic methods that remove porpoises shall be employed.
- The period of soft start-up and ramp-up, together with other protective measures, shall be sufficient to protect harbour porpoises from underwater noise from the piling that exceeds the thresholds for permanent hearing loss (PTS) and temporary hearing loss (TTS) for harbour porpoises.
- For pile driving, sound attenuation equipment with a performance equivalent to Double Big Bubble Curtain (DBBC), or Double Big Bubble Curtain and Hydro Sound Damper shall be used depending on the foundation.
- To reduce noise levels for the protection of harbour porpoises, one foundation at a time should be constructed during the construction of the wind farm.
- Monitoring of sound during the piling control programme should be carried out at several distances within a 9.4 km radius of the piling site to ensure that sound propagation does not exceed the modelled impact distances.

Maritime transport and safety

- Wind turbines shall be equipped with an emergency stop function. Emergency shutdown procedures for wind turbines shall be developed and made available.
- The Company will maintain a dialogue on risks with relevant shipping operators, such as shipping companies whose vessels regularly operate in the area around the wind farm.
- A contingency and rescue plan, which will prepare the organisation for possible emergencies, should be developed and available.

- A marine coordinator will be in place to control, coordinate and monitor marine operations during the construction phase and major operations. During construction, operation and decommissioning, monitoring of vessel traffic in the wind farm and the surrounding area will be carried out, using radar and AIS, among other means.
- A specific risk analysis for the construction and operation phase of the wind farm shall be developed. The results shall be incorporated into the company's procedures and into the contingency and rescue plan.
- In order to increase the visibility of the wind farm to maritime traffic, some wind turbines will be marked with AIS and/or Racon.
- Mist-nozzles shall be installed on all wind turbines, or on selected wind turbines.
- Wind turbines shall be equipped and labelled with a unique ID to facilitate rescue operations.
- Vessels used for servicing and maintenance shall be fitted with equipment to contain and minimise any release of substances hazardous to the environment and/or health.
- Prior to finalising the design of the wind farm, a complementary nautical risk analysis and radar interference assessment shall be carried out. Possibilities for rescue operations and navigation in the wind farm shall be considered.
- In the case of major maritime operations, 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 Company must inform the authorities of the timetable and execution well in advance of the construction work and consult with the Swedish Maritime Administration and the Swedish Transport Agency on measures to improve maritime safety and equipment needed to reduce the risk of radar interference.
- In connection with construction work, the operator must produce a nautical risk analysis and action plan so that vessel traffic to and from areas where construction work is being carried out does not pose a risk to other vessels. If necessary, comments on the risk analysis and action plan can be obtained from the Swedish Transport Agency.
- In order to avoid risks related to maritime transport, 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. Vessels that risk navigating incorrectly in relation to the wind farm shall be warned. Continued monitoring shall take place during the operational phase.

Chemicals and waste

- Equipment for collecting spillages of oil and other liquid chemical products from wind farm components shall be provided.
- Waste, both solid and liquid, must be handled, sorted and stored in such a way that there is no risk of pollution or other nuisance and transported to land for disposal.

Birds and bats

- For the protection of birds and bats, the clearance between the water surface and the rotor blades shall be set at 30 metres, to reduce the risk of collision.

Risk and safety

- Wind turbines and platforms with tanks containing diesel or environmentally hazardous oils are equipped with leakage protection to prevent the release of environmentally hazardous substances into water. The leakage protection must be able to handle the entire contents of the tank.
- Leakage alarms with optical and acoustic signals should be located in connection with likely leakage points. Detailed scope, design and locations will be investigated at a later stage.
- Automatic fire detection and extinguishing systems shall be provided in connection with locations with an increased risk of fire. Detailed scope, design and locations will be investigated at a later stage.
- The company also takes into account existing cables/pipes and undertakes to apply appropriate protective measures in order not to damage existing infrastructure.
- Good safety practices and compliance with applicable rules, regulations and practices for helicopter operations shall be ensured.
- Prior to the installation of cables/pipes that cross each other, thorough investigations must be carried out and appropriate measures taken to reduce the risk of a leak occurring. Prior to the operational phase, a risk analysis must be carried out to investigate the need for protection against physical damage.
- Trained and equipped lifesaving capability within the internal organisation, as part of the maintenance vessel's own capability when working within the farm, shall be ensured.
- Wind turbines and platforms must be marked in accordance with the Swedish Transport Agency's and the Swedish Maritime Administration's regulations or in accordance with industry standards.

- Measures against radar interference shall be ensured. The installation of reference buoys, in established traffic lanes, and other measures to reduce the risk of radar interference are considered and decided on before the final design of the wind farm.
- Staff and contractors working on wind farm installations shall have the necessary training.

9.2 Monitoring programmes and survey programmes

The company will establish a monitoring programme for the planned activities after consultation with the supervisory authority once the permit has gained legal force. The purpose of the monitoring programme is to show how the permit conditions are met.

The monitoring of noise generated by foundation piling will constitute a significant component of the monitoring programme. Based on the sound modelling, the company has committed to not exceeding the behavioural impact threshold for harbour porpoises at a distance of 9.4 kilometres from the pile-driving site. The modelling will be followed up with actual sound measurements to verify the results of the sound modelling and ensure that the threshold is met and that marine mammals are not exposed to TTS or PTS sound levels. The monitoring programme will also include procedures in case the threshold is exceeded, for example how the operator will identify the cause of the exceedance and take corrective action to prevent further exceedances.

In addition to the proposed protective measures, the Company has, as an additional precautionary measure, undertaken to implement operational control of the wind turbines to reduce the risk of collision for birds and bats that could potentially pass through the farm area. The operational control system may comprise, for instance, ultrasonic detection, horizontal radar and vertical radar. This is to determine the flight height and the frequency and trajectory of bats. The wind turbines can also be equipped with additional cameras for daylight and/or night vision. Image analysis and artificial intelligence, for example, can help by feeding the information to the wind turbines and farm's SCADA (control) systems, which then adjust the rotation speed of the turbines concerned according to predetermined parameters. Once the birds and/or bats have passed the wind turbine, operation returns to normal.

A three-year survey programme will be conducted for nocturnal migratory small birds and bats, respectively. The survey programmes will be designed following consultation with the relevant authorities. The objective of the survey programme for nocturnal migratory birds is to investigate the movement patterns of the species through the wind farm and the risk of collision. Additionally, the programme aims to ensure that the proposed operational control for nocturnal migratory birds is appropriately designed. The survey programme for bats has two main objectives: to investigate the presence of bats in the wind farm and the risk of collision, and to determine whether there is a need for operational control for bats. If such a need is identified, the programme will also assess whether the operational control is appropriately designed.

10 Alternatives

The alternative report describes the alternatives studied for the operations, as well as the choices that have been made with regard to environmental impacts and other criteria. In line with practice, a starting point for the options studied has been that they should fulfil the purpose of the activity, see section 1.1.

The baseline alternative is described in section 10.3 and refers to the effects that are expected to occur or not occur if the activity applied for does not materialise.

10.1.1 Starting points for localisation

In selecting a site for an activity that uses an area of land or water, it is essential to choose one that is suitable for the purpose to be achieved, with the least possible intrusion and inconvenience to human health and the environment (the localisation principle). The selection of the location for the activity was based on a comprehensive localisation study. The final choice of offshore design areas by OX2 was the result of a systematic evaluation based on fundamental economic and technical conditions, such as wind conditions and water depth. Additionally, various selection criteria were considered, including anticipated environmental effects, which led to the elimination of less suitable locations.

The localisation study has accorded particular attention to sensitive species that are typically expected to be affected by energy and wind farms. It has constituted a central starting point for OX2 in its endeavour to avoid, as far as possible, the areas where sensitivity with regard to marine species and habitats is greatest. In order to avoid any potential negative impact on the most valuable areas with regard to existing natural values and the marine environment, a crucial limitation for the localisation study has been that possible farm areas should be situated outside Natura 2000 areas.

10.1.2 Alternative localisations

Ran wind farm is situated in an area that has been identified as having optimal conditions for the development of wind and energy farms, as outlined in section 10.1.3. Figure 29 illustrates the Company's alternative locations for the establishment of offshore wind farms and energy farms in southern Sweden, including both selected and deselected locations. It should be noted that the selected sites for OX2's other planned projects, namely the Galene, Triton and Aurora wind farms and Neptunus and Pleione energy farms (indicated by green stars on the map below), are not alternative locations for Ran wind farm. Rather, they have been developed on the basis of the same analysis. In order to achieve the desired reduction in greenhouse gas emissions, a portfolio of renewable and fossil-free energy sources is required. This may take the form of multiple energy and/or wind farms, as exemplified by Ran wind farm and the other selected projects. It is therefore evident that these projects are not mutually exclusive, but rather constitute an integral part of a larger, interconnected energy system. The selected wind farms have been deemed suitable locations in terms of their impact on human health and the environment, as well as the possibility of establishing an economically viable business based on the need for fossil-free energy.

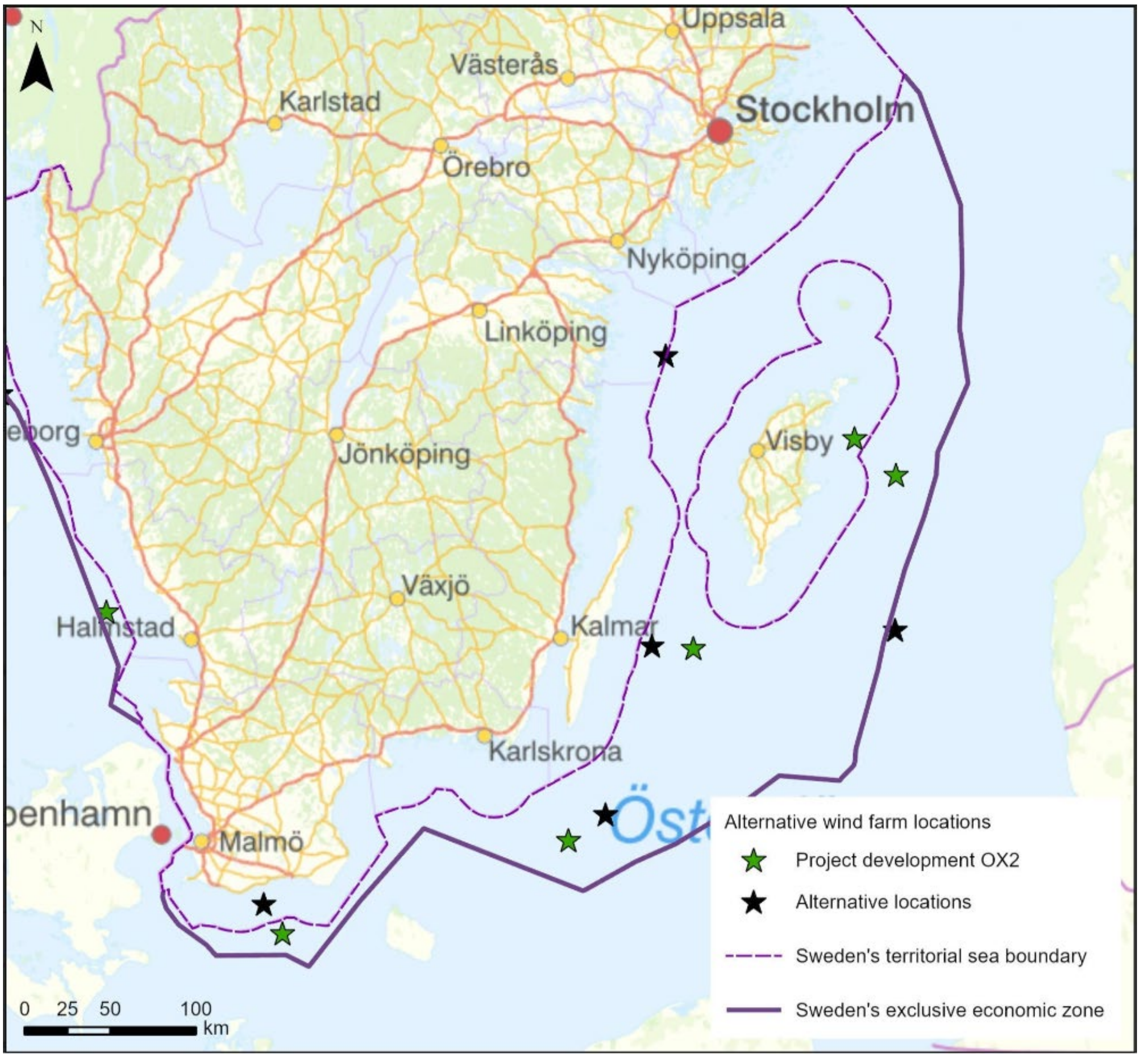


Figure 29. Alternative locations in southern Sweden. Rejected locations are marked with black stars. Locations where OX2 has chosen to proceed with applying for permits for energy and wind farms are marked with green stars. Base map: © [Lantmäteriet] 2021.

10.1.3 Selected alternative: Ran wind farm

Within the framework of the localisation study, a number of natural limitations arose in relation to existing protected areas and other designated interests. In addition, consideration of the expected environmental impact, various possibilities for connections and overall technical conditions have resulted in the chosen localisation for Ran wind farm. The farm areas for Ran wind farm and Pleione energy farm are the alternatives in the area that have the best conditions for the establishment of wind and energy farms.

The planned wind farm is located in an area where the natural values are limited, mainly due to the depth of the water in conjunction with a diverse bottom substrate. In the shallower areas, however, there are elevated natural values in the form of inter alia blue mussel banks.

Investigations conducted on behalf of the company, in addition to previous studies, have demonstrated that the occurrence of harbour porpoises (Baltic Sea population) is exceedingly low within the area encompassed by the proposed wind farm. Furthermore, the region is not regarded as a significant habitat for fish. The depth conditions in the Ran wind farm area render it unsuitable for seabed foraging birds. However, gulls and terns diving for fish in the open water may forage in the area in low numbers during the breeding season. The area may be passed by migrating birds, but the farm area is not considered to be part of the main routes for the majority of bird species passing through Gotland during spring and autumn migration.

The planned wind farm does not overlap with any designated national interests for the natural or cultural environment, nor does it affect any defence interests to a significant extent. Furthermore, the wind farm does not overlap with any Natura 2000 sites or nature reserves. The nearest Natura 2000 site is situated approximately 12 kilometres away. The farm area does not overlap with any fairways or shipping lanes. However, it does overlap with a national interest for outdoor recreation, which follows the entire coast of Gotland, and partly with a national interest for commercial fishing.

The dimensions of the available area also allow the construction of a substantial wind farm, which offers advantages in terms of climate and the environment, as well as technical and economic considerations. The location of the wind farm, situated 12 kilometres east of the coast of Gotland, will result in a reduced visual impact in comparison to the existing wind turbines on Gotland, whether situated on land or in the sea closer to the coast. However, this will be offset by an increased visual impact in comparison to a location further out to sea. The proximity to Gotland offers the potential for the wind farm to be constructed and connected to Gotland in the near future. The depth of the water allows for the construction of the wind farm using current technology, while the connection to land is simplified and more resource- and cost-efficient. The location of the wind farm outside Gotland is advantageous for several reasons. Firstly, it can effectively contribute to Gotland's self-sufficiency in electricity. Secondly, it can enable climate change adaptation for the industries located on the island, including the lime and cement industry, and along the mainland coast.

10.2 Alternative design

A variety of alternative designs for the planned wind farm have been subjected to analysis within the context of the project development. Based on this analysis, a careful balance has been struck and the design of the wind farm has been adjusted accordingly. One fundamental premise has been that the wind farm and its design must be optimised based on a balance of competing interests. The overarching objective is to maximise renewable energy production and its associated climate benefits, while minimising the negative impact of the planned activities on various existing interests, such as protected areas, species and habitats. The environmental assessment process, which entailed the preparation of comprehensive environmental studies and consultations, was conducted in an iterative manner concurrent with the design of the farm and its planned facilities and activities.

However, potential design alternatives comprising different combinations of the number of installed wind turbines and platforms, as well as varying outputs and heights for the individual wind turbines, are within the scope of the design scenarios presented in chapter 4. It is necessary to allow flexibility in the design of the wind farm to ensure that the best possible technology is used at the time of construction and to ensure optimal utilisation of resources at the site.

10.3 Baseline alternative

The baseline alternative means that the activity applied for will not be realised. This means that Ran wind farm will not contribute to Sweden's and Europe's requirement for a significant increase in the production of electricity from renewable sources. This will have a detrimental impact on a number of factors, including the reliability of the electricity supply, the conditions necessary for a transition in society and industry, and the climate. In such a scenario, energy production would have to be sourced from alternative means, including imports, onshore wind and solar power, or nuclear power. The baseline alternative also entails the forfeiture of the prospective long-term climate and environmental benefits that would otherwise accrue from the proposed activity. A baseline scenario in which Ran wind farm is not constructed and other fossil-free power generation is not expanded to an adequate degree is predicted to precipitate significant adverse climate change. Furthermore, the baseline alternative entails that there are neither adverse nor beneficial impacts for the interests and environmental aspects associated with the construction, operation and decommissioning of the wind farm.

11 Overall assessment of the transboundary impacts

Ran wind farm makes a positive contribution to Sweden's and the EU's environmental objectives, which include handing over a sustainable society to the next generation. Furthermore, Ran wind farm is anticipated to play a pivotal role in Sweden's and Europe's transition towards renewable energy sources, thereby assisting in the fulfilment of Sweden's and Europe's climate objectives. It is anticipated that the wind farm will have a long-term positive impact with regard to the replacement of fossil electricity production, thereby facilitating a significant reduction in greenhouse gas emissions on a large scale. It is anticipated that the project will have a favourable impact on the climate in neighbouring countries. It is essential to consider the potential long-term positive impacts in relation to the transient and time-limited negative impacts that may arise in most cases.

The influence and impact assessments are based on a worst-case approach. The assessments are based on assumptions about a design scenario that takes into account, with a significant margin, what could be the greatest impact on the environment. This approach allows the wind farm to be designed within the limits set by the permit. This approach has been used to cover all cases with minor effects and impact. Thus, environmental impacts can be less extensive but not more extensive than described in this Espoo report.

The location of the Rans wind farm does not overlap with any protected area. The distance between the wind farm area and surrounding Natura 2000 sites is considerable, and as a result, it can be concluded that the operation will not have an impact on these sites.

The impacts on fish and marine mammals are primarily associated with the construction phase, although the decommissioning phase also has an influence. The primary influence factor affecting these species is underwater noise, which occurs during the installation and removal of foundations. The construction phase will be of limited duration, and protective measures will be implemented to minimise the effect on marine mammals and fish. It is concluded that the potential transboundary impacts on fish and marine mammals during the construction and decommissioning phases are negligible. This is due to the fact that the effect is assessed to be insignificant and that there is no risk of population-level impacts. Furthermore, negligible transboundary impacts are anticipated for fish and marine mammals during the operational phase. This is due to the fact that the underwater noise generated by the wind farm and operation and maintenance boats is comparatively lower and temporary, particularly in comparison to the existing noise level from various sources, including boat traffic in the Baltic Sea.

No populations of birds or bats will be affected by the planned operations. The Company has undertaken to take protective and precautionary measures to limit the impact further. Thus, there will be negligible transboundary impacts.

The construction of the wind farm will result in a reduction in the availability of fishing grounds for commercial fishing activities. Nevertheless, fishing in the vicinity of the wind farm is already constrained by the prevailing restrictive fishing quotas. Furthermore, there are promising prospects for the redistribution of pelagic fishing to alternative regions. This is due to the fact that fishing activities in or in the vicinity of the area are characterised by a relatively high level of intensity, particularly with regard to pelagic trawling, while bottom trawling is virtually non-existent. The current research indicates that operational noise at constructed wind farms does not have a significant impact on fish. It is possible that additional local reef effects and reduced fishing pressure within the wind farm area may, over time, lead to an improvement in the stock status of some commercially important fish species, such as cod. This could, in turn, have a beneficial impact on commercial fisheries in neighbouring areas. The potential impacts on commercial fisheries mainly affect Swedish commercial fisheries. Given the limited international commercial fishing in the area, the transboundary impacts in terms of displacement and changes in fishing pressure and availability of fish are assessed to be very small negative and negligible, respectively.

The operation is not considered to pose any unacceptable risks. 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 minimisation by producing a risk analysis early in the process that is continuously monitored. Additionally, a contingency and rescue plan will be developed.

The wind farm is situated between three shipping lanes. However, in comparison to other shipping lanes situated further south, the number of vessels operating within these lanes is relatively low. A number of measures will be implemented to ensure the safety of navigation and to mitigate potential risks. These include the control and coordination of all marine operations, the monitoring of vessel traffic, the designation of a protection zone during construction works, and the maintenance of safety distances between wind turbines and shipping lanes. It is anticipated that the implementation of the planned safety measures will result in a notable reduction in the probability of accidents. The final design of the wind farm and the subsequent implementation of the requisite protective measures to ensure optimal maritime safety will be conducted in consultation with the relevant maritime authorities. The application of the proposed protective measures is expected to result in very small negative transboundary impact on maritime transport. The distance between maritime traffic and the wind farm is such that there is ample opportunity for vessels to navigate safely even in the event of the wind farm's construction.

Overall, it is assessed that there could be negligible to very small negative and small negative transboundary impacts on commercial fisheries and maritime transport respectively, and positive transboundary impacts on climate.

Table 36 below presents the magnitude of the transboundary impacts for each recipient/aspect. For a more detailed description of the above transboundary impacts for each environmental aspect, see Chapter 7.

Table 36. Summary of the assessed transboundary impacts of the activity arising for each recipient/aspect during all phases. The impact assessment assumes that the proposed protective measures are implemented.

Recipient/aspect	Transboundary impact
Climate benefits and impacts	Positive
Fish	Negligible
Marine mammals	Negligible
Birds	Negligible
Bats	Negligible
Commercial fishing	Negligible - Very small negative
Risk and safety	No unacceptable risks
Maritime transport	Small negative

12 Expertise

12.1 OX2 project organisation

The OX2 project organisation for the Ran wind farm has many years of knowledge of wind power. The people below have been involved in the preparation of the current permit application, project design and project planning.

Name of the organisation	Role in projects	Experience
Elina Cuéllar	Project manager	Elina is a trained marine biologist and has previous experience as a seabed surveyor for the UK Maritime and Coastguard Agency (MCA) and for the Nord Stream project in the Baltic Sea. Elina has been involved in the development of several offshore wind and energy farm projects in the Baltic Sea, the wind farms Storgrundet, Ran and Aurora as well as the energy farm Neptunus and Pleione. In addition to development, Elina has as a sub-project manager in permitting, replaced Svenska Kraftnät's 400 kV submarine cables *"Öresundskablarna"*, which runs between Skåne and Zealand.
Kristina Nilsson Bromander	Deputy Project Manager	Kristina holds a Master of Science in Sustainable Energy Engineering from KTH Royal Institute of Technology and has worked on the development of several offshore wind and energy farm projects. Kristina has previously worked with project management and sales of large-scale power transmission projects at ABB (now Hitachi), including the connection of offshore wind farms in Germany, the UK and China.
Clara Lundberg	Junior project manager	Clara is an environmental scientist and economist. Clara has been involved in the preparation of the Ran wind farm and Pleione energy farm permit applications.
Hans Ohlsson	Authorisation specialist	Hans has 25 years of experience in offshore project development. Hans has been and is involved in several permit applications in

Name of the organisation	Role in projects	Experience
		Sweden. Hans also worked with the technical parts of the Swedish Nature Conservation Agency's research programme Vindval regarding the impact of wind power on marine life and within the Norwegian Research Council to assess various innovations. Hans has also previously worked with and had responsibility for Swedish wind power research during the mid-90s.
Fredrik Wibling (on parental leave)	Technical project manager	Fredrik has 15 years of experience in project management within large complex projects on different continents, mainly in wind power, high voltage and offshore industry. Fredrik has previously worked at ABB HVDC (BorWin1, DolWin1, DolWin2, NEA800), Bassoe (MWP Mark 2, BT-3500-2, BT-4000) and Vattenfall (Limfjord and Klevberget).
Emily Garney	Technical project manager	Emily has a master’s degree in Ecosystem Engineering (Environmental Engineering) specialising in energy systems. Emily has worked at OX2 on offshore wind farms since 2021, prior to which Emily worked at the consulting firm AFRY with electricity network permits for transmission and distribution networks in Sweden.

12.2 Experts on behalf of OX2

Name of the organisation	Education and training	Experience
Petra Adrup, Structor, EIA coordinator	Biology Phil Mag	Petra has more than 25 years' experience of working with permit assessments and EIA. Petra has worked with and been responsible for permit assessments including the preparation of EIA in a number of large and complex projects including urban development, energy supply, infrastructure, industry and ports. Petra is currently working on the permit assessments for several other of OX2's offshore wind

Name of the organisation	Education and training	Experience
		farms; Triton wind farm and Pleione energy farm.
Lovisa Sandström Lundh, Structor, EIA Coordinator	Master of Science in Environmental and Water Engineering, Uppsala University	Since 2016, Lovisa has been working with permit assessment, environmental assessment and EIA. Lovisa has worked with and been responsible for permit assessments, including the preparation of EIAs, in projects including urban development, water activities and environmentally hazardous activities. Lovisa is currently also working on the permit assessment for the Pleione energy farm.
Felicia Arnsbjer, Structor, EIA officer	Bachelor of Science. Environmental Science, Linköping University	Felicia has worked with environmental assessment in authorisation processes since 2022. Among other things, Felicia is currently working on the permit assessments for OX2's Pleione offshore energy farm.
Isabell Persson, Structor, EIA officer	M.Sc. Environmental Engineering and Sustainable Infrastructure, Royal Institute of Technology	Isabell has worked with environmental assessment in permit processes since 2022. Isabell is currently working on the permit assessments for OX2's offshore wind farms Triton and Ran, as well as on the permit application for the export cables for the Galene wind farm.
Michael Wzdulski, Structor, EIA Officer	M. Sc Strategic Leadership towards Sustainability, Blekinge Institute of Technology	Michael has experience as a project manager and consultant in assignments related to the environment and water since 2013. Among other things, he has worked as a project manager at a water protection association, an investigative engineer at a water company, and a strategist in the public sector. Michael has worked with local action programmes for water, project management, environmental monitoring in water, GIS and water management.
Mrs Roos van der Spoel, Structor, SME Officer	Bachelor of Science in Biology, Uppsala University	Since 2016, Roos has worked on licensing issues relating to environmentally hazardous activities, environmental assessment and EIA, among other things. Roos is currently working on the licensing

Name of the organisation	Education and training	Experience
		assessments for OX2's Pleione offshore energy farm and submarine cables from the Galene wind farm.
Kajsa Andersson, Structor	Master's degree in Biology, Stockholm University	Kajsa works as an environmental consultant, quality manager and project manager in environmental assessments, mainly in large-scale energy projects. Kajsa is often responsible for coordination and assessments regarding birds, species protection and natural environment.
Carina Lundgren, Structor	B Sc. Environment and Health Protection, Umeå University	Carina is a project manager and environmental consultant working with authorisation issues for complex projects. She has extensive knowledge of environmental assessments, consultation processes with authorities, EIA and the environmental and authorisation process under the Environmental Code.
Alva Jakobsson, Structor	M.Sc. Environmental Science with specialisation in applied climate strategy, Lund University	Alva works as an environmental consultant in environmental assessments and permit cases, with a special focus on impact assessment linked to climate aspects. Alva works mainly with wind and solar projects.
Katarina Helmersson, Structor, Deputy EIA Coordinator (on parental leave)	Master of Science in Natural Resources Engineering in Environment and Water, Luleå University of Technology	Since 2020, Katarina has worked with permit cases (incl. EIA), primarily in offshore wind power. Katarina is currently working on the permit assessments for several other of OX2's offshore wind farms; Triton wind farm and Pleione energy farm. Katarina has also worked on the permit application for the export cables for the Galene wind farm.
Jennifer Voghera, Structor, EIA Officer (on parental leave)	Master of Civil Engineering in Environmental Engineering and Sustainable Infrastructure, Royal Institute of Technology	Jennifer has been working with environmental assessment and EIA of plans and authorisations since 2015. She has worked with large infrastructure projects for road and railway projects, but also water activities and environmentally hazardous activities.

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