

OÜ UTILITAS WIND



SAARE-LIIVI

OFFSHORE WIND FARM

ADDITIONAL AREA

ENVIRONMENTAL IMPACT ASSESSMENT

EIA report for public display, 28.09.2026



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Abbreviations used in the report

The following table presents the abbreviations used throughout this EIA report. Abbreviations that occur only once are explained in the relevant chapter when first used.

Abbreviation	Explanation
A0, E1, T1	Scenario designations used in TalTech's hydrodynamic study: A0 – scenario with no wind farms; E1 – initial area scenario; E1+T1 – combined scenario for the initial and additional areas. The designations do not correspond to the numbering of the main EIA alternatives.
AC	alternating current
ADCP	Acoustic Doppler Current Profiler – acoustic current profiler
ADLS	Aircraft Detection Lighting System – aviation safety lighting activated upon aircraft detection
AIS	Automatic Identification System – ships' automatic identification system
ALARP	As Low As Reasonably Practicable – the lowest risk level that can reasonably be achieved
AMA	area minimum altitude – minimum flight altitude for the area
AS	public limited company
CCM	Chain Cutter Module – chain saw module for cable trenching
CLV	Cable Lay Vessel – cable-laying vessel
CPT	Cone Penetration Test
CTD	conductivity, temperature, depth – conductivity, temperature and depth probe
CTV	Crew Transfer Vessel – technicians' transfer vessel
dB re 1 µPa	decibel relative to a reference pressure of 1 micropascal (underwater sound level)
DP	Dynamic Positioning
EELIS	Estonian Nature Information System
EhS	Building Code
EL	European Union
EMI	Estonian Marine Institute, University of Tartu
EMÜ	European Economic Community (in the designations of European Union directives, e.g. 92/43/EEC)
EOÜ	Estonian Ornithological Society
ERA5	European Centre for Medium-Range Weather Forecasts (ECMWF) global climate reanalysis
ERGOM	Ecological Regional Ocean Model – Baltic Sea biogeochemical model
EUROBATS	Agreement on the Conservation of Populations of European Bats
EÜ	European Community (in the designations of European Union directives, e.g. 2009/147/EC)
FFPV	Flexible Fallpipe Vessel – rock placement vessel with a flexible fallpipe
FSA	Formal Safety Assessment – IMO's systematic safety assessment methodology
GBF	gravity base foundation
GPS	Global Positioning System
HELCOM	Baltic Marine Environment Protection Commission (Helsinki Commission)
HLV	Heavy Lift Vessel – heavy-lift vessel
HOLAS	HELCOM Holistic Assessment – Baltic Sea holistic status assessment
HUB	HELCOM Underwater Biotopes – Baltic Sea underwater biotope classification system

Abbreviation	Explanation
IALA	International Organization for Marine Aids to Navigation – international organisation for marine aids to navigation (formerly the International Association of Marine Aids to Navigation and Lighthouse Authorities)
ICAO	International Civil Aviation Organization
ICES	International Council for the Exploration of the Sea
IMO	International Maritime Organization
IOW	Leibniz Institute for Baltic Sea Research Warnemünde – Baltic Sea Research Institute
IWRAP Mk II	IALA vessel traffic risk assessment modelling software
JNCC	Joint Nature Conservation Committee – the United Kingdom's nature conservation advisory body
JRCC	Joint Rescue Coordination Centre
KeHJS	Environmental Impact Assessment and Environmental Management System Act
GHG	greenhouse gas
EIA	environmental impact assessment
KOV	local authority
kV	kilovolt
kWh	kilowatt-hour
L05	sound level exceeded for 5% of the observation time (the 5% loudest situations)
LiD	Birds Directive (Directive 2009/147/EC of the European Parliament and of the Council)
LKS	Nature Conservation Act
LoD	Habitats Directive (Council Directive 92/43/EEC)
LpA,eq	A-weighted equivalent sound pressure level
MBES	multi-beam echo sounder – multibeam echosounder
MEDEVAC	medical evacuation
MPSV	Multipurpose Support Vessel
MSFD	European Union Marine Strategy Framework Directive
MTÜ	non-profit association
MuKS	Heritage Conservation Act
MVA	megavolt-ampere (unit of apparent power)
MW, GW	megawatt, gigawatt (units of power)
NAVTEX	automatic transmission system for maritime safety information
NTU	nephelometric turbidity unit – unit of turbidity
OLS	obstacle limitation surfaces
OSPAR	Commission of the Convention for the Protection of the Marine Environment of the North-East Atlantic
OSS	Offshore Substation
OÜ	private limited company
PCW	phocid carnivores in water – underwater hearing group of seals
PLGR	Pre-Lay Grapnel Run – seabed pre-clearance before cable laying
PPA	Police and Border Guard Board
PTS	permanent threshold shift – permanent increase in hearing threshold
QUONOPS	underwater noise propagation modelling software

Abbreviation	Explanation
RIV	Rock Installation Vessel – rock placement vessel
ROV	Remotely Operated Vehicle – remotely operated underwater robot
S1, S2	geographical base scenarios for maritime safety risk analysis
SAR	search and rescue
SBP	sub-bottom profiler – seabed profiler
SEL	sound exposure level
SELcum	cumulative sound exposure level
SF6	sulphur hexafluoride (insulating gas)
GDP	gross domestic product
SOV	Service Operation Vessel – service vessel
SPL	sound pressure level
SSS	side scan sonar
SWE	Saare Wind Energy OÜ (Saare Wind Energy offshore wind farm)
TalTech	Tallinn University of Technology
TTJA	Consumer Protection and Technical Regulatory Authority
TTS	temporary threshold shift – temporary increase in hearing threshold
TWh	terawatt-hour
UT	University of Tartu
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UXO	Unexploded Ordnance
VC	vibro core – vibrocoreing
VHF	very high frequency
VMS	Vessel Monitoring System – satellite monitoring system for fishing vessels
VTS	Vessel Traffic Service – vessel traffic management system
WTG	Wind Turbine Generator
WTIV	Wind Turbine Installation Vessel
ADD	Acoustic Deterrent Device
APV	historical fishing opportunity
CRM	collision risk model
D6C4, D6C5	Marine Strategy Framework Directive criteria for seabed loss and habitat condition
D11C1, D11C2	Marine Strategy Framework Directive criteria for impulsive sound and continuous underwater sound
eAIP	electronic Aeronautical Information Publication
EMF	electromagnetic field
GBS	gravity-based structure – gravity-based foundation structure
KeA	Environmental Board
LiA	special protection area (SPA)
LoA	special area of conservation (SAC)
offshore wind farm	offshore wind farm

<i>Abbreviation</i>	<i>Explanation</i>
O&M	operation and maintenance
PBR	potential biological removal – potential biologically tolerable additional mortality
PTA	Agriculture and Food Board
WAM	wave model (Wave Model)

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1. Introduction

Utilitas Wind OÜ (registration code 16171123; hereinafter the developer or Utilitas Wind) plans to develop the additional area of the Saare-Liivi offshore wind farm in the Gulf of Riga.

Utilitas OÜ submitted to the Consumer Protection and Technical Regulatory Authority (hereinafter TTJA) on 18.02.2021 an application for a superficies licence for the Saare-Liivi offshore wind farm and, on 05.07.2021, an amended application for encumbering a public body of water for the purpose of constructing an offshore wind farm. By Decision No. 1-7/21-521 of 23.12.2021, TTJA initiated the superficies licence proceedings and the environmental impact assessment (hereinafter EIA). TTJA Decision No. 1-7/23-063 of 09.03.2023 stipulated: *"Amend the Consumer Protection and Technical Regulatory Authority's Decision No. 1-7/21-521 of 23.12.2021 and relocate the area of the public body of water to be encumbered in the superficies licence proceedings initiated by that decision. Combine, into one integrated area to be encumbered in the superficies licence proceedings, the initial area of the public body of water to be encumbered in the superficies licence proceedings initiated by the Consumer Protection and Technical Regulatory Authority's Decision No. 1-7/21-521 of 23.12.2021 (excluding the unsuitable southern area) and the additional area to be encumbered set out in the application of Utilitas Wind OÜ dated 30.06.2022, and deem the superficies licence proceedings to have been initiated thereon on the basis of the application of Utilitas Wind OÜ. /---/ Assess the environmental impact of erecting the offshore wind farm in the body of water within the additional area to be encumbered for the Saare-Liivi offshore wind farm in the EIA proceedings initiated by the Consumer Protection and Technical Regulatory Authority's Decision No. 1-7/21-521 of 23.12.2021, by preparing an additional EIA programme and, if necessary, an additional EIA report together with the related additional procedural actions."*

The EIA programme for the initial area of the Saare-Liivi offshore wind farm was declared compliant with the requirements by TTJA Decision No. 16-7/21-02502-095 of 22.12.2022. By Decision No. 1-7/22-473 of 22.12.2022, TTJA initiated separate superficies licence proceedings and an EIA for the construction of the submarine cable line (export cables) required to connect the Saare-Liivi offshore wind farm to the transmission network, and joined this to the EIA proceedings for the initial area. The EIA report for the initial area of the Saare-Liivi offshore wind farm (also covering the export cables) was declared compliant with the requirements by TTJA Letter No. 16-7/21-02502-212 of 06.08.2025. By TTJA Decision No. 1-7/26-038 of 28.01.2026, a superficies licence was granted for encumbering the bed of a public body of water with structures forming part of the Saare-Liivi offshore wind farm in Areas 1 and 2 (located in the initial area of the Saare-Liivi offshore wind farm). Under the superficies licence, the following structures forming part of the Saare-Liivi offshore wind farm may be constructed in Area 1: 1) wind turbines, 2) electricity and communications cables connecting the wind turbines to one another and to the offshore substations (hereinafter inter-array cables), 3) offshore substations, and 4) the electricity and communications cables of the submarine cable line connection to the transmission network running from the offshore substations towards the coast, i.e. export cables; and in Area 2, export cables forming part of the Saare-Liivi offshore wind farm may be constructed under the superficies licence. The maximum permitted number of wind turbines was set at 80, and the maximum permitted capacity of the initial area of the Saare-Liivi offshore wind farm at 1600 MW. By TTJA Decision No. 1-7/26-037 of 28.01.2026, a superficies licence was granted for encumbering the bed of a public body of water with the export cables of the Saare-Liivi offshore wind farm. By Order No. DM-134858-29 of 28.04.2026 of the Environmental Board, environmental permit No. KL-526251 was granted for special use of water for the construction of the Saare-Liivi offshore wind farm (initial area, export cables).

In this EIA report, the term "additional area" is used hereinafter to refer to the additional area of the Saare-Liivi offshore wind farm, and "initial area" denotes the area with up to 80 wind turbines covered by superficies licence No. 1-7/26-038 and the infrastructure proposed for it; this includes export cables

running from the transmission system of the initial area to the coast, which are permitted under superficies licence No. 1-7/26-037

The EIA programme for the additional area of the Saare-Liivi offshore wind farm was declared compliant with the requirements by TTJA Letter No. 16-7/21-02502-163 of 20.10.2023¹. The maximum baseline scenario under the EIA programme covered an area of 91.2 km² and up to 92 wind turbines. As a result of the EIA studies, refinement of the technical solution, and environmental and cultural heritage considerations, main alternative 3 has become the basis for the impact assessment and final conclusions of this EIA report for the additional area of the Saare-Liivi offshore wind farm, under which up to 40 wind turbines with a total capacity of up to 800 MW are planned in the 57.1 km² additional area.

The EIA report for the additional area of the Saare-Liivi offshore wind farm focuses on the incremental impact associated with the implementation of main alternative 3 for the additional area of the Saare-Liivi offshore wind farm. The impact of the export cable system of the initial area, i.e. running from the boundary of the additional area to the substations in the initial area and from those offshore substations to the landfall point onshore, as assessed in the EIA report declared compliant with the requirements, is not reassessed in this report. The impact of the cabling proposed to connect the additional area is addressed in two scopes: as the direct impact of the proposed activity within the additional area, and, in sections 3.3 and 3.4, as part of the in-combination effect of the initial and additional areas in relation to the impact of the entire connection, including the section passing through the initial area.

The initial area is addressed in this EIA report only to the extent necessary:

- to take account of more recent known scientific information following completion of the studies of the initial area and the additional area;
- to determine the overall in-combination effect of the initial area and the additional area;
- to assess the cumulative impact of the Saare-Liivi initial area and additional area and other offshore wind farms.

Hydrogen production at sea, hydrogen production facilities and a hydrogen transport pipeline do not form part of the proposed activity assessed in this EIA. If such a solution is specified in the future, its environmental impact must be assessed in the relevant project and activity permit proceedings.

The purpose of the EIA is to identify the possible environmental impacts associated with the implementation of the proposed activity and its realistic alternatives, assess their significance, and determine the environmental measures and follow-up monitoring necessary to avoid and reduce significant adverse impacts. Environmental impact is considered to be impact on the natural environment, human health and well-being, property and cultural heritage.

This EIA report for the additional area of the Saare-Liivi offshore wind farm has been prepared by Roheplaan OÜ in cooperation with the authors of the baseline studies and subject-matter experts. The leading expert for the EIA is Riin Kutsar, EIA licence No. KMH0131. The composition of the expert group and areas of responsibility are presented in section 8.1.

This version has been prepared as the basis for the English translation for transboundary participation and is abridged compared with the full Estonian-language EIA report: only sections of significance solely within Estonia and technical-methodological sections (e.g. detailed descriptions of survey methods, construction technology and Estonian noise standards, and some repetitive figures) have been omitted or abbreviated,

¹ file:///C:/Users/Riin/Downloads/kiri_digiallkirjaga_16-7_21-02502-164.pdf

whereas all impact assessments, conclusions, environmental measures, monitoring, consideration of cumulative and transboundary impacts, and the summary of the report have been retained in full. For the abridged sections, references are provided to the full Estonian-language EIA report and the relevant baseline studies (annexes), which are available in the proceedings. The numbering of figures and tables has been kept the same as in the full Estonian-language EIA report; therefore, there may be gaps in the numbering in the abridged version. Omitted figures and tables can be found under the same number in the full report.

2. Proposed activity

2.1. Purpose and need for the proposed activity

The purpose of the proposed activity is to construct an offshore wind farm in the additional area of the Saare-Liivi offshore wind farm, including the offshore infrastructure necessary for its operation, for renewable energy generation. Under main alternative 3, which forms the basis for the impact assessment, up to 40 wind turbines with a total capacity of up to 800 MW will be constructed in the 57.1 km² additional area.

The proposed activity supports increasing electricity generation from renewable energy sources, reducing carbon emissions from the electricity system, and strengthening energy security and security of supply. The European Union's revised Renewable Energy Directive sets a binding renewable energy share at Union level of at least 42.5% by 2030, with the objective of striving towards a 45% share. Estonia submitted its final updated National Energy and Climate Plan to the European Commission in 2025².

The strategic basis for the selection of the project location is the Estonian Maritime Spatial Plan adopted on 12.05.2022, under which the region of the additional area has been designated as suitable area No. 1 for wind energy development. The suitability established by the spatial plan does not replace project-level environmental impact assessment: in this EIA, the compliance of the proposed activity with the conditions of the spatial plan is verified and the environmental impact of the specific solution is assessed.

2.2. Location of the proposed activity

The proposed additional area of the Saare-Liivi offshore wind farm is located in suitable area No. 1 designated for wind energy development under the Estonian Maritime Spatial Plan³ (adopted by Order No. 146 of 12.05.2022) (see Figure 2.2-1), adjoining the initial area of the Saare-Liivi offshore wind farm, the location of which was determined by the county-wide spatial plan for the marine area adjoining Pärnu County and refined during the EIA and studies. Accordingly, the additional area is governed by the guidelines and conditions laid down in the Estonian Maritime Spatial Plan, whereas the conditions for the initial area derived from the Pärnu maritime spatial plan.

If both are implemented, the initial area and the additional area of the Saare-Liivi offshore wind farm would likely constitute a single integrated wind farm. Accordingly, in that case, condition No. 7 set out in the Estonian Maritime Spatial Plan for wind energy development areas would not apply, under which, in order to mitigate potential wake effects, the minimum distance between wind farms is *approx.* 8 times the rotor diameter of a turbine in the later-added wind farm, with a minimum of 2 km. The condition in question is presumably intended to protect the developer of the earlier wind farm, but in the present case the applicant for the superficies licence for the initial area and the additional area is the same; moreover, it is questionable whether that condition applies in a situation where the initial area is not located within the area covered by the Estonian Maritime Spatial Plan).

² Directive (EU) 2023/2413 of the European Parliament and of the Council of 18.10.2023 amending Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources. https://energy.ec.europa.eu/strategy/energy-union/national-energy-and-climate-plans_en

³ Estonian Maritime Spatial Plan. 2022. Adopted by Order No. 146 of the Government of the Republic of 12.05.2022. <https://www.riigiplaneering.ee/mereala-planeeringud/uleriigiline-mereala-planeering>

⁴ Estonian Maritime Spatial Plan. Explanatory memorandum. Adopted by Order No. 146 of the Government of the Republic of 12.05.2022. <https://www.riigiteataja.ee/akt/317052022002>

The additional area of the Saare-Liivi offshore wind farm is located in the coastal water body of the central part of the Gulf of Riga, approximately 23 km from Kihnu Island, more than 20 km from Ruhnu Island, c. 40 km from the coast of Saaremaa, 48 km from the coast of Häädemeeste and 37 km from the coast of Tõstamaa. Based on depth data from the Transport Administration, the sea depth in the additional area (main alternative 3) ranges from approximately 23.8 to 41 m.

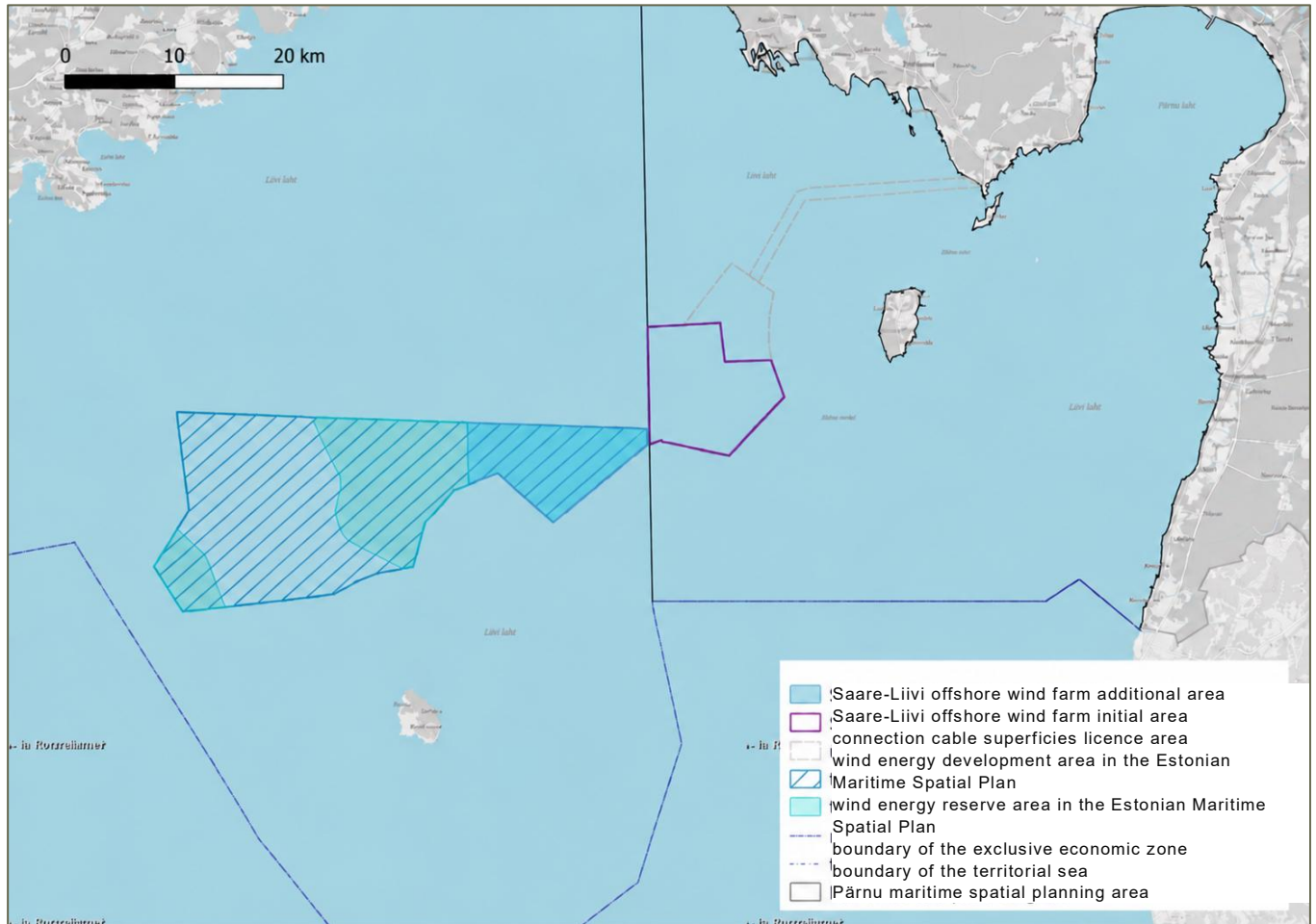


Figure 2.2-1. Location of the initial area of the Saare-Liivi offshore wind farm and the additional area in accordance with the EIA programme

2.3. Consideration of alternatives

In this EIA report for the additional area, a distinction is made between the **main alternatives** and **technical alternatives** of the proposed activity. The main alternatives describe the spatial extent of the wind farm development area and the maximum number of wind turbines proposed within it. The technical alternatives address, among other things, wind turbine capacity and dimensions, foundation types, installation technologies and other technical solutions.

According to the EIA programme declared compliant by letter No. 16-7/21-02502-163 of the Consumer Protection and Technical Regulatory Authority dated 20.10.2023, up to 92 wind turbines were planned for the 91.2 km² additional area to be encumbered of the Saare-Liivi offshore wind farm. This maximum solution under the EIA programme is treated in this EIA report for the additional area as **main alternative 1** (see Table 2.3-1).

During the EIA studies and the refinement of the technical solution, it became apparent that not the entire additional area of the Saare-Liivi offshore wind farm (within the meaning of Decision No. 1-7/23-063 of the Consumer Protection and Technical Regulatory Authority of 09.03.2023) is suitable for the construction of turbines. The western part, which was partly unsuitable from a construction-geological perspective and also due to trawling and navigation, was initially excluded from the development area, resulting in an area of 58.7 km² and allowing 50 turbines to be placed in the area (**main alternative 2**). Following the cultural heritage studies, the location of the wreck Nimetu-548, together with a 1 km wide buffer zone, was excluded from the boundaries of the additional area as an area to be excluded for the protection of cultural heritage. As a result, the reduced spatial extent of the wind farm became 57.1 km² with 40 turbines, which is treated in this report as **main alternative 3** (see Table 2.3-1 and Figure 2.3-1).

Table 2.3-1. Main alternatives for the additional area considered in the EIA report

Main alternative	Area	Maximum number of wind turbines	Treatment in the EIA report
Main alternative 1	91.2 km ²	up to 92	Maximum solution under the EIA programme. The fieldwork for several baseline studies and the description of the existing environment cover this area or its immediate surroundings.
Main alternative 2	58.7 km ²	up to 50	Larger-scale development solution for the reduced development area. Used as technical input for several studies or impact calculations.
Main alternative 3	57.1 km ²	up to 40	Refined solution forming the basis for the EIA impact assessment and final conclusions, in which the layout was optimised after the final extent of the Saare-Liivi initial area had become clear (to avoid wind losses, constraints identified during the studies, etc.). Technical alternatives are generally compared within this development scale.

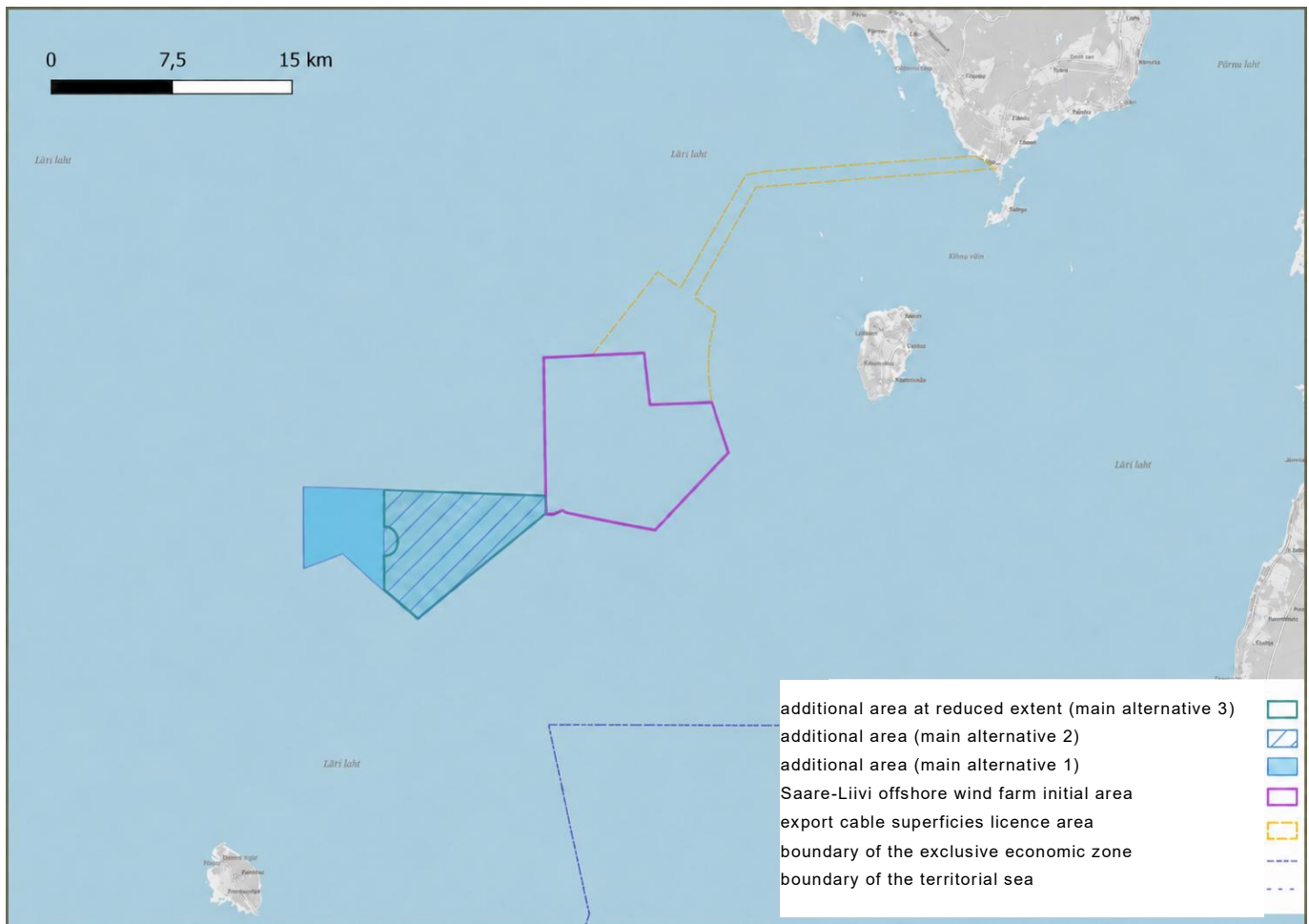


Figure 2.3-1. *Spatial alternatives for the additional area of the Saare-Liivi offshore wind farm*

Main alternative 3, as developed during the EIA process for the additional area, is the proposed activity solution that forms the basis for the impact assessment, comparison of alternatives and final conclusions of this EIA report. Main alternative 3 takes into account the study results and the refined technical solution of the project and represents the realistic maximum development scale of the additional area at the time of preparation of this EIA report.

The spatial extent of the baseline studies and the number of turbines used in the studies have not been uniform across all impact areas. Some fieldwork and studies of the existing environmental status covered the broader spatial extent of main alternative 1, whereas several impact modelling exercises used a scenario with 50 turbines (main alternative 2). Accordingly, each impact chapter specifies separately the spatial extent and development scale for which the study or modelling was prepared and how the results are applicable to main alternative 3.

Calculations carried out for a larger spatial extent or a higher number of turbines are treated as a conservative starting point for main alternative 3 only where the impact depends proportionally on the development scale. If the impact depends on the uneven spatial distribution of receptors, the specific layout of the turbines or a non-linear impact mechanism, the applicability of the results is substantiated separately in the relevant impact chapter.

Among the technical alternatives, the assessment covers different foundation types for the turbines, different turbine heights (including rotor diameter), the possible layout of the offshore wind farm, including the possible location of export cables (Table 2.3-2). Where a specific topic area requires

assessment of different technical alternatives, a comparison of the technical alternatives is also carried out in accordance with the impact significance scale (Table 2.3-3).

Table 2.3-2. *Technical parameters of the proposed additional area of the Saare-Liivi offshore wind farm and the technical alternatives considered*

PARAMETERS	INDICATORS ASSESSED	
	TECHNICAL ALTERNATIVE 1 (A) – 15 MW	TECHNICAL ALTERNATIVE 2 (B) – 20 MW
Number of offshore substations	1	1
Total capacity of the wind farm	Up to 600 MW	Up to 800 MW
Rated power of the wind turbines	15 MW	20 MW
Annual output of the offshore wind farm	Approximately up to 2.7 TWh	Approximately up to 3.5 TWh
Wind turbine rotor diameter	236 m (of the models currently in production, a wind turbine with a rotor diameter of 236 m is likely)	280 m
Wind turbine tower height	up to 157 m	up to 170 m
Maximum wind turbine tip height	up to 275 m	up to 310 m
Clearance between the blade tip and the water surface	Approximately 30–40 m	Approximately 30–40 m
Distance between wind turbines	At least 4–6 times the rotor diameter, at least 1 km	
Foundation type(s)	Monopile foundation, gravity base foundation	
Gravity base foundation base diameter, m	up to 50 m	up to 50 m
Monopile foundation pile diameter	9–12 m	12–18 m
Foundation installation methodology	Installation on a prepared seabed (gravity base foundation), drilling or pile-driving (monopile foundation)	
Export cables, km	In the additional area <i>approx.</i> 6 km of route (up to 2 cables, <i>approx.</i> 12 km of cables in total). From the boundary of the additional area, the export cables run to the offshore substations of the initial area and from there along the export cable route corridor of the initial area to land; the total length of the marine route from the offshore substation of the additional area to the landfall point is <i>approx.</i> 50 km per cable (<i>approx.</i> 100 km for two cables in total). Two cables with a transmission capacity of 400 MW. Expected to be up to 330 kV AC.	
Inter-array cables, km	Approximate total length <i>approx.</i> 66 km; 66 kV AC; where possible up to 132 kV AC.	

Under the conditions set out in Section 5.6.5 of the Estonian marine area plan, wind turbines with foundation solutions whose environmental impacts are equivalent to or lower than those associated with the construction of wind turbines on gravity base foundations are to be constructed in areas suitable for wind energy development. The final foundation solution is permissible within the assessed limits of the

proposed activity only if its impacts related to seabed occupation, sediment relocation, underwater noise, seabed habitats, material use, greenhouse gas emissions and decommissioning are, as a whole (in combination of different impact sources), equivalent to or less than those of a gravity base foundation and/or if the greater impact in a specific impact area has been duly avoided and mitigated. The comparison is presented in sections 2.6.2, 3.2–3.4, 3.7–3.8 and 3.11.

The conclusions of this EIA for the additional area apply provided that, in the project forming the basis for construction, the selected wind turbine parameters, foundation type, number of offshore substations and cable length remain within the range of solutions assessed in Table 2.3-2 and the impact chapters. The different parameters and possible technical solutions for the additional area of the Saare-Liivi offshore wind farm are described in more detail in the following subsections.

Table 2.3-3. *Impact significance scale used in the comparison of alternatives (i.e. change relative to the current state of the marine area)*

ASSOCIATED CONSEQUENCE/IMPACT	IMPACT SIGNIFICANCE
	-- i.e. significant negative impact
	- i.e. minor negative impact
	0 i.e. no impact, neutral
	+ i.e. minor positive impact
	++ i.e. significant positive impact
* A rating expressed with a slash, for example 0/– or –/–, indicates the possible range of impact resulting from the alternatives or uncertainty in the assessment. Where environmental measures are applicable, a distinction is made between the impact before the measures and the residual impact after implementation of the measures.	

2.4. Cumulative impacts and other activities considered

Cumulative⁵ impact is an impact on the environment arising from the in-combination effect of two or more activities or projects, which may occur if their impacts overlap spatially or temporally or affect the same environmental element or receptor. Cumulative impact may arise from the in-combination effect of activities taking place simultaneously or as a result of sequential activities and consists in the accumulation or mutual amplification of individual impacts.

Accordingly, in this EIA report, the assessment of cumulative impacts considers those projects for which sufficient information is available on the project location, extent and main technical solutions, allowing the overlap of their potential impacts with the proposed activity forming the basis of the assessment in this EIA (the additional area of the Saare-Liivi offshore wind farm) to be assessed.

Classification of projects

For the assessment of cumulative impacts, potential projects are classified into three groups according to their development and permitting stage, based on the tier definitions described in Table 2.4-1. Table 2.4-2 presents the classification of projects based on offshore wind farm superficies licence proceedings initiated by the Consumer Protection and Technical Regulatory Authority. According to the Consumer

⁵ Cumulative impacts are understood to mean the combined impact of one or more activities, which may arise from the accumulation of similar impacts from several activities, where there may be many different activities and an important aspect is the change resulting from the addition of activities.

Protection and Technical Regulatory Authority website⁶, the list was updated on 20.02.2026 (checked as at 07.09.2026), and Table 2.4-2 includes information known to have been added later.

The initial area of Saare-Liivi is not treated in this report as an external cumulative project. First, the cumulative impact of the initial area and the additional area together is determined, and then the cumulative impact of the initial and additional areas of Saare-Liivi together with other projects is assessed.

Table 2.4-1. Basis for the definitions applied in project classification

Tier	Definition	Use in the assessment
I	Established development project: The EIA report has been deemed compliant with the requirements and/or a superficies licence has been granted. <i>At the time of preparation of this EIA, there are no existing or under-construction offshore wind farms in Estonia.</i>	Included in the impact area assessment where there is a common receptor or impact pathway; use project-specific data wherever possible
II	Proposed development project with sufficient detail: the location and main technical parameters make it possible to assess at least the potential maximum impact area, although the solution may be refined during the EIA	Included in impact area screening (identification of impacts) and, where necessary, in qualitative or quantitative assessment
III	Development project at an early development or pre-development stage: the actual development scale, spatial layout or technology may change significantly as a result of studies	Generally not included in detailed cumulative assessment; may be described as context or as a future scenario

In this EIA report for the additional area, the assessment of cumulative impacts focuses primarily on Tier I and Tier II projects. Tier III projects are not included in detailed cumulative assessment, because on the basis of the available information it is not possible to reliably determine their actual impact area or assess the overlap of potential impacts with the proposed activity.

The classification into tiers reflects the sufficiency of the information available on the project for the assessment of cumulative impacts, not the significance of the project's expected environmental impact. The exclusion of a Tier III project from the detailed assessment in this EIA report does not mean that the project could not have a cumulative impact in the future; rather, it means that, on the basis of the available information, it is not possible to reliably determine the project's actual scale, spatial configuration and impact area. The project's potential cumulative impact must be analysed and assessed in each subsequent project-specific EIA report, once studies have resulted in a design solution of sufficient detail and the environmental status of the specific project and its sensitivity have been established (i.e. as a rule, a later development project must take into account the cumulative impact of an earlier development project).

⁶ <https://ttja.ee/ariklient/ehitised-ehitamime/meretuuleparkide-hoonestusloa/alगतatud-meretuuleparkide-hoonestusloa#sihtasutus-keskkonna> (accessed on 24.07.2026)

Table 2.4-2. *Classification of offshore wind farms for the assessment of cumulative impacts (data checked as at 07.09.2026)*

Applicant	Name or area of the offshore wind farm	Status of the proceedings and the project	Key data on the proposed activity	Tier	Treatment in the EIA for the additional area of Saare-Liivi
Saare Wind Energy OÜ	Saare Wind Energy offshore wind farm	EIA programme approved on 18.10.2021; EIA report approved on 10.06.2024; superficies licence granted on 21.05.2025	Up to 100 wind turbines, up to 1400 MW, tip height up to 310 m; area to be encumbered <i>approx.</i> 197.5 km ²	I	Include in impact areas where there may be a common receptor or impact pathway, particularly in relation to birdlife
Utilitas Wind OÜ	Saare-Liivi offshore wind farm – initial area	EIA programme deemed compliant with the requirements on 22.12.2022; EIA report deemed compliant with the requirements on 06.08.2025; superficies licences granted on 28.01.2026.	Up to 80 wind turbines	I	Is treated as a source of cumulative impact for the proposed activity, i.e. the additional area
Liivi Offshore OÜ	Liivi Bay offshore wind farm	EIA programme approved on 15.04.2021; EIA report in preparation (the Environmental Board has not yet approved it)	According to the initial application, 50–160 wind turbines and up to 1000 MW; area to be encumbered <i>approx.</i> 183.19 km ² ; during the preparation of the EIA report, the solution has been refined and, based on input from the Environmental Board, must be further refined and the scale of the wind farm reduced.	II	Include in impact area screening and, in relevant areas, in substantive cumulative impact assessment
Liivi Offshore OÜ	Liivi Bay combined area offshore wind farm / areas 1 and 2	Superficies licence proceedings and EIA initiated on 06.09.2024; EIA programme prepared and published	In the EIA programme, up to 27 wind turbines, but in the TTJA initiation data up to 140 wind turbines and 2010 MW; area to be encumbered <i>approx.</i> 168.08 km ² .	III	Do not include in detailed cumulative assessment if the actual development scale, layout and technical solution have not yet been established through studies; describe as a background project if necessary
Tuul Energy OÜ	Tuul Energy offshore wind farm – Saare 2.1 and Saare 2.2	Proceedings initiated on 18.09.2024 and 24.09.2024; joint EIA programme deemed compliant with the requirements on 04.06.2025	Across the two areas, up to 160 wind turbines and 2400 MW, tip height up to 365 m; total area to be encumbered <i>approx.</i> 252.3 km ²	III	Do not include in detailed cumulative assessment if the actual development scale, layout and technical solution have not yet been established through studies; describe as a background project if necessary

Applicant	Name or area of the offshore wind farm	Status of the proceedings and the project	Key data on the proposed activity	Tier	Treatment in the EIA for the additional area of Saare-Liivi
Five Wind Energy OÜ	Wind power plant proposed near Nasva harbour	Proceedings initiated on 19.12.2019; EIA programme approved on 31.05.2022. EIA report submitted to the Consumer Protection and Technical Regulatory Authority on 30.12.2025, but the Environmental Board has not deemed the report compliant with the requirements.	According to the EIA report, a maximum of one 4 MW wind turbine near Nasva harbour, tip height <i>approx.</i> 150 m; area to be encumbered <i>approx.</i> 0.002 km ²	II	Include in impact area screening. The project is technically defined at a preliminary level, but is small in scale and is located more than 60 km from the additional area of Saare-Liivi.
Environmental Investment Centre SA	ELWIND Estonia offshore wind farm area	Proceedings initiated on 28.03.2024; EIA programme deemed compliant with the requirements on 06.12.2024	National pre-development project; 20–100 wind turbines, 400–1000 MW, tip height up to 330 m; area <i>approx.</i> 200.44 km ²	III	Do not include in detailed cumulative assessment if the actual development scale, layout and technical solution have not yet been established through studies; describe as a background project if necessary
Latvian Investment and Development Agency	ELWIND Latvia offshore wind farm area	EIA programme valid from 08.09.2023	Total capacity, depending on the technologies used at the time of project implementation, 500–1000 MW; tip height up to 350 m; area <i>approx.</i> 200 km ² .	III	Do not include in detailed cumulative assessment if the actual development scale, layout and technical solution have not yet been established through studies; describe as a background project if necessary
Estonia Offshore Wind DevCo OÜ	Liivi 1 offshore wind farm	Superficies licence proceedings and EIA initiated on 09.04.2024; EIA programme deemed compliant with the requirements on 04.11.2025	Up to 57 wind turbines, up to 900 MW, up to two substations, tip height up to 400 m; area <i>approx.</i> 77.7 km ²	III	Do not include in detailed assessment until a sufficiently defined design solution has been established through studies and the EIA
Estonia Offshore Wind DevCo OÜ	Liivi 2 offshore wind farm	Superficies licence proceedings and EIA initiated on 06.03.2024; EIA programme deemed compliant with the requirements on 04.11.2025	Up to 88 wind turbines, up to 1400 MW, up to three substations, tip height up to 400 m; area <i>approx.</i> 114.9 km ²	III	Do not include in detailed assessment until a sufficiently defined design solution has been established through studies and the EIA
Oxan Energy	Saare 1 offshore wind farm	Superficies licence proceedings and EIA initiated on 17.06.2025	Up to 60 wind turbines, up to 900 MW, up to three offshore substations, tip height up to 365 m; area <i>approx.</i> 88 km ²	III	Early development stage; describe as a background project if necessary, but do not use as a basis for detailed cumulative impact calculation
Tuuletraal OÜ	Tuuletraal multi-purpose offshore wind	Proceedings and EIA initiated on 19.12.2019	76 wind turbines, 380 MW, an offshore substation, cables and	III	The project may, in principle, be relevant due to its location and the proposed activities, but the information currently available from

<i>Applicant</i>	<i>Name or area of the offshore wind farm</i>	<i>Status of the proceedings and the project</i>	<i>Key data on the proposed activity</i>	<i>Tier</i>	<i>Treatment in the EIA for the additional area of Saare-Liivi</i>
	farm and aquaculture project		31 mussel cultivation areas; area approx. 91.15 km ²		the proceedings does not permit a reliable detailed cumulative assessment

Identification of impact areas

Not all Tier I and II projects are automatically considered in the cumulative assessment of all impact areas. For each impact area, it is assessed separately whether there may be a potential cumulative impact pathway between the project and the proposed activity.

In doing so, the following circumstances are assessed in particular:

- whether the activities affect the same environmental element or receptor;
- whether the impacts may overlap spatially and/or temporally;
- whether a plausible impact pathway exists for the impact to arise.

If at least one of the stated conditions is not met, the respective project is not considered in the cumulative assessment for that impact area.

At present, there is not sufficiently precise or comparable information on the projects' proposed construction and commissioning times. Therefore, the possibility of temporal overlap is assessed on the basis of the available information, and the uncertainty is described in the assessment of the relevant impact area. In particular for construction-phase impacts, the actual extent of cumulative impact may depend on overlap between the projects' construction schedules.

The initial area of the Liivi Bay offshore wind farm (hereinafter: the Liivi Bay offshore wind farm) is included in the assessment of cumulative impacts in impact areas where the projects may affect the same environmental element or receptor in the Gulf of Riga, or where the impacts may overlap spatially, temporally or functionally. The assessment uses the 05.02.2026 version of the EIA report for the Liivi Bay offshore wind farm⁷ and the information presented in its underlying studies, taking into account that, at the time of preparation of this EIA report for the additional area of the Saare-Liivi offshore wind farm, the report has not yet been approved (at least the Environmental Board has repeatedly declined to approve the EIA report⁸ and has indicated the need to reduce the extent of the development area and the scale of the wind farm), and that the final content and outcome of the EIA report for the Liivi Bay offshore wind farm (including the development area and scale acceptable in terms of impacts) are unknown.

The Saare Wind Energy offshore wind farm (SWE wind farm)⁹ is included in the substantive cumulative impact assessment in respect of bird collision risk. In other impact areas, no sufficiently plausible occurrence of cumulative impacts has been identified between Saare Wind Energy and the additional area of the Saare-Liivi offshore wind farm due to the distance of more than 90 km. In the EIA report for the initial area of Saare-Liivi, bird collision risk is likewise highlighted in particular as a possible cumulative impact between these projects.

The single-turbine wind power plant proposed by Five Wind Energy near Nasva harbour is excluded from the assessment of adverse cumulative impacts for the additional area of the Saare-Liivi offshore wind farm, because the project's impact is small-scale and local and the project does not affect the same local receptors as the additional area of the Saare-Liivi offshore wind farm.

⁷ <https://jvis.ttja.ee/modules/dokumendiregister/view/1098858>

⁸ <https://jvis.ttja.ee/modules/dokumendiregister/view/1018046>

⁹ <https://swe.ee/uudised-ja-materjalid/>

Table 2.4-3. Identification of impact areas of development projects for the assessment of cumulative impacts (*K* – the project is included in the cumulative impact assessment for the respective impact area; – – the project is not included because there is no sufficiently plausible common receptor, impact pathway or spatial or temporal overlap).

Impact area and possible cumulative impact pathway	Initial area of Saare-Liivi	Liivi Bay offshore wind farm	SWE offshore wind farm	Nasva harbour wind power plant	Result and reasoning
Hydrodynamics, currents and wave action	K	K	–	–	The Liivi Bay offshore wind farm area is located within the same hydrodynamic system of the Gulf of Riga, and the wind farms' impacts on currents, wave action and water exchange may overlap functionally. The SWE offshore wind farm and the Nasva harbour wind power plant are located outside the relevant impact area, and their impacts do not cumulate with those of the additional area of Saare-Liivi.
Physical and biogeochemical properties of the water column	K	K	–	–	The Saare-Liivi and Liivi Bay offshore wind farms may affect the same marine environment of the Gulf of Riga, including water column mixing, water transport and biogeochemical processes. In the latest version of the EIA report for the Liivi Bay offshore wind farm, these impacts of the initial area of Saare-Liivi have been addressed in the context of cumulative impact.
Construction-related suspended matter and sediment redistribution	K	K	–	–	A possible in-combination effect of the Saare-Liivi offshore wind farm and the Liivi Bay offshore wind farm may manifest itself in the temporal overlap of construction works and as an additional sediment and suspended matter load on the marine environment of the Gulf of Riga. Based on the impact assessments carried out, the SWE offshore wind farm and the Nasva harbour wind power plant are not located within the same impact area for suspended matter dispersion as the additional area of Saare-Liivi. The exclusion of the SWE offshore wind farm is based on the modelled extent of suspended matter dispersion: due to the distance of more than 90 km, the construction-phase suspended matter plumes and the impact areas of sediment load do not overlap.
Nutrients and pollutants released from sediments	K	K	–	–	The Saare-Liivi offshore wind farm and the Liivi Bay offshore wind farm may affect the status of the same water body. The assessment must distinguish between the overlap of local suspended matter plumes and the overall additional load on the marine environment of the Gulf of Riga.
Seabed geology and sediments	K	–	–	–	The direct impact on seabed geology is predominantly specific to the project area. The total volume of sediment removal, dumping and physical alteration is addressed under suspended matter and seabed habitats.
Seabed biota and habitats – habitat loss and disturbance	K	K	–	–	Cumulative impact may manifest itself as repeated loss and disturbance of the same habitat type or functional seabed habitat in different development areas. The total area of habitat loss and disturbance and the overlap of the affected habitat types must be assessed. In the case of the SWE offshore wind farm, there is no common

<i>Impact area and possible cumulative impact pathway</i>	<i>Initial area of Saare-Liivi</i>	<i>Liivi Bay offshore wind farm</i>	<i>SWE offshore wind farm</i>	<i>Nasva harbour wind power plant</i>	<i>Result and reasoning</i>
					cumulative impact, because seabed habitat loss and construction-phase disturbance are local (impact area of up to a few kilometres from the infrastructure) and do not extend over a distance of more than 90 km; nor does this concern the same patch of seabed habitat.
Seabed biota – addition of artificial substrate and reef effect	K	K	–	–	The foundations of the Saare-Liivi offshore wind farm and the Liivi Bay offshore wind farm may introduce significant quantities of hard artificial substrate into the Gulf of Riga and affect the structure of seabed biota and species distribution (see section 3.4.6).
Fish fauna – spawning grounds, feeding areas and habitats	K	K K	–	–	The Saare-Liivi offshore wind farm and the Liivi Bay offshore wind farm development projects may affect the same fish community of the Gulf of Riga and the same fish stocks, including Baltic herring assemblages. Possible common impact pathways are habitat disturbance, suspended matter, seabed alteration and construction-phase and operational-phase disturbance (see section 3.8.6). The SWE offshore wind farm is located in a different part of the marine area and does not affect the same spawning areas of the Gulf of Riga or local populations of the fish fauna; nor is there a common impact pathway via underwater noise, as the noise impact areas do not overlap.
Fish fauna – underwater noise	K	K	–	–	An in-combination effect of the Saare-Liivi offshore wind farm and the Liivi Bay offshore wind farm may arise primarily where the construction periods overlap. The assessment must take into account foundation types, construction schedules and noise mitigation measures. Operational noise from the additional area of Saare-Liivi and the Liivi Bay offshore wind farm does not cumulate (see sections 3.8.4 and 3.8.6). The noise impact areas of the SWE offshore wind farm and the Nasva harbour wind power plant do not overlap with the impact area of the additional area of the Saare-Liivi offshore wind farm.
Seals – construction-phase underwater noise and disturbance	K	K	–	–	The Saare-Liivi offshore wind farm and the Liivi Bay offshore wind farm development projects may affect the same grey and ringed seals moving in the Gulf of Riga, and their construction-phase disturbance areas may overlap temporally or functionally. The SWE offshore wind farm development project is located more than 90 km away, and its local noise and disturbance areas do not overlap with the impact area of the additional area of the Saare-Liivi offshore wind farm (see section 3.7.6). The impact of the single additional turbine at the Nasva harbour wind power plant is local.
Seals – operational habitat use, noise	K	K	–	–	An in-combination effect of the Saare-Liivi offshore wind farm and the Liivi Bay offshore wind farm may alter seal movement and habitat use. Although the same Baltic Sea population is involved in the case of the SWE offshore wind farm, there is

<i>Impact area and possible cumulative impact pathway</i>	<i>Initial area of Saare-Liivi</i>	<i>Liivi Bay offshore wind farm</i>	<i>SWE offshore wind farm</i>	<i>Nasva harbour wind power plant</i>	<i>Result and reasoning</i>
					no sufficiently plausible pathway for a spatial in-combination effect to arise with the additional area of Saare-Liivi. Although this concerns the same Baltic Sea seal population, the impact areas of the additional area of Saare-Liivi and the SWE offshore wind farm do not overlap and, on the basis of telemetry data, no plausible common impact pathway arises between them through sequential avoidance or a barrier effect (see section 3.7.6).
Birds – loss of and displacement from staging and feeding areas	K	K	–	–	The Saare-Liivi offshore wind farm and the Liivi Bay offshore wind farm development projects partly affect the same marine bird fauna of the Gulf of Riga and may cause a cumulative reduction in, or displacement from, staging and feeding areas. The SWE offshore wind farm is located outside the impact area of the same functional habitat of marine birds (i.e. feeding areas). The exclusion of the SWE offshore wind farm from the assessment of the cumulative reduction in staging and feeding areas is based on the fact that the displacement impact area is limited to the wind farm area and its immediate buffer and that no common staging or feeding areas with the additional area of Saare-Liivi were identified (see section 3.5.6).
Birds – barrier effect and changes in movement routes	K	K	–	–	The Saare-Liivi offshore wind farm and the Liivi Bay offshore wind farm may together constitute a more extensive barrier to birds moving in the Gulf of Riga. Due to the distance of the SWE offshore wind farm, there are insufficient grounds for considering it in the assessment of the barrier effect of the additional area of Saare-Liivi. A barrier effect arises only if the wind farms are located one after another on the same migration route; because of the distance of more than 90 km and the different locations, no such sequential obstacle arises in the case of the Saare Wind Energy offshore wind farm (see section 3.5.6).
Birds – collision risk	K	K	K	–	Individuals of the same migratory population may pass through several offshore wind farms, and collision risk may accumulate across projects. In the EIA report for the initial area of the Saare-Liivi offshore wind farm, bird collision risk has been identified as the main possible cumulative impact with the SWE offshore wind farm.
Bats – migration and collision risk	K	K	–	–	The Saare-Liivi offshore wind farm and the Liivi Bay offshore wind farm development projects are located in the same Gulf of Riga area and may affect the same bats moving over the sea or migrating. The SWE offshore wind farm and the Nasva harbour wind power plant are located in a different spatial context, and there is no sufficiently clear common cumulative impact to justify including them. The SWE offshore wind farm and the Nasva harbour wind power plant are not located on the same migration corridor crossing the Gulf of Riga that is addressed in section 3.6;

<i>Impact area and possible cumulative impact pathway</i>	<i>Initial area of Saare-Liivi</i>	<i>Liivi Bay offshore wind farm</i>	<i>SWE offshore wind farm</i>	<i>Nasva harbour wind power plant</i>	<i>Result and reasoning</i>
					bat migration over the sea is concentrated along migration corridors, and objects outside them do not affect the same individuals.
Visual impact and seascape	K	K	–	–	The Saare-Liivi and Liivi Bay offshore wind farms may be visible simultaneously or in succession from the same viewpoints on Kihnu and the Pärnu coast and increase the proportion of the view occupied by turbines. In the latest version of the EIA report for the Liivi Bay offshore wind farm, cumulative visual impact has been addressed separately in relation to the initial area of the Saare-Liivi offshore wind farm (see section 4.1.5).
Environmental noise	K	K	–	–	The operational noise from the Saare-Liivi and Liivi Bay offshore wind farms may combine at the same receptors, particularly near Kihnu Island (see section 4.2.3). The SWE offshore wind farm and the Nasva harbour wind power plant do not affect the same noise-sensitive receptors.
Fisheries – use of and access to fishing grounds	K	K	–	–	An in-combination effect of the Saare-Liivi and Liivi Bay offshore wind farms may reduce the marine area used for fisheries, alter fishing routes and increase construction-phase and operational restrictions on the same fisheries sector (see section 4.3.2). The SWE offshore wind farm does not affect the same fishing grounds or the same fishing community, and therefore there is no common cumulative impact through the loss of space available to fisheries and changes in fishing routes (see section 5.3.2).
Tourism and recreation	K	K	–	–	Possible cumulative impact arises primarily from visual change, changes in the conditions for movement at sea and changes in the perceived environment of the Kihnu area (see section 4.3.3). The SWE offshore wind farm and the Nasva harbour wind power plant do not affect the same tourism and recreation area.
Local community and living environment	K	K	–	–	The Saare-Liivi and Liivi Bay offshore wind farm development projects may affect the same communities on Kihnu and the Pärnu coast through visual impact, marine use, fisheries and economic changes (see section 4.3).
Vessel traffic and maritime safety	K	K	–	–	The joint spatial configuration of the Saare-Liivi and Liivi Bay offshore wind farms may alter vessel traffic corridors, the movement of small craft, safety zones and rescue operations. In the latest version of the EIA report for the Liivi Bay offshore wind farm, the cumulative impact of the initial area of Saare-Liivi on vessel traffic has been assessed separately (see section 6.1.3).
Air traffic and search and rescue flights	K	K	–	–	In the EIA report for the Liivi Bay offshore wind farm, the need to assess possible cumulative impact on Ruhnu–Pärnu visual flights, medical evacuation and rescue operations arising from the addition of further wind farms has been identified (see section 6.2).

<i>Impact area and possible cumulative impact pathway</i>	<i>Initial area of Saare-Liivi</i>	<i>Liivi Bay offshore wind farm</i>	<i>SWE offshore wind farm</i>	<i>Nasva harbour wind power plant</i>	<i>Result and reasoning</i>
Navigation, communication and surveillance systems	K	K	–	–	The joint spatial extent of the Saare-Liivi and Liivi Bay offshore wind farms may affect the functioning of radars and navigation and communication systems. The impact must be addressed in the later stages of developing the technical solution for the additional area (detailed design), taking into account the data available on other projects. See section 6.3.
Underwater cultural heritage	K	–	–	–	The impact is object-specific and is generally limited to specific foundations, cables and construction areas. If the development projects do not affect the same object of cultural value or group of objects, there is no cumulative impact pathway (see section 5.1.6).

The development projects taken into account in the assessment of cumulative impacts are shown in Figure 2.4.-1.

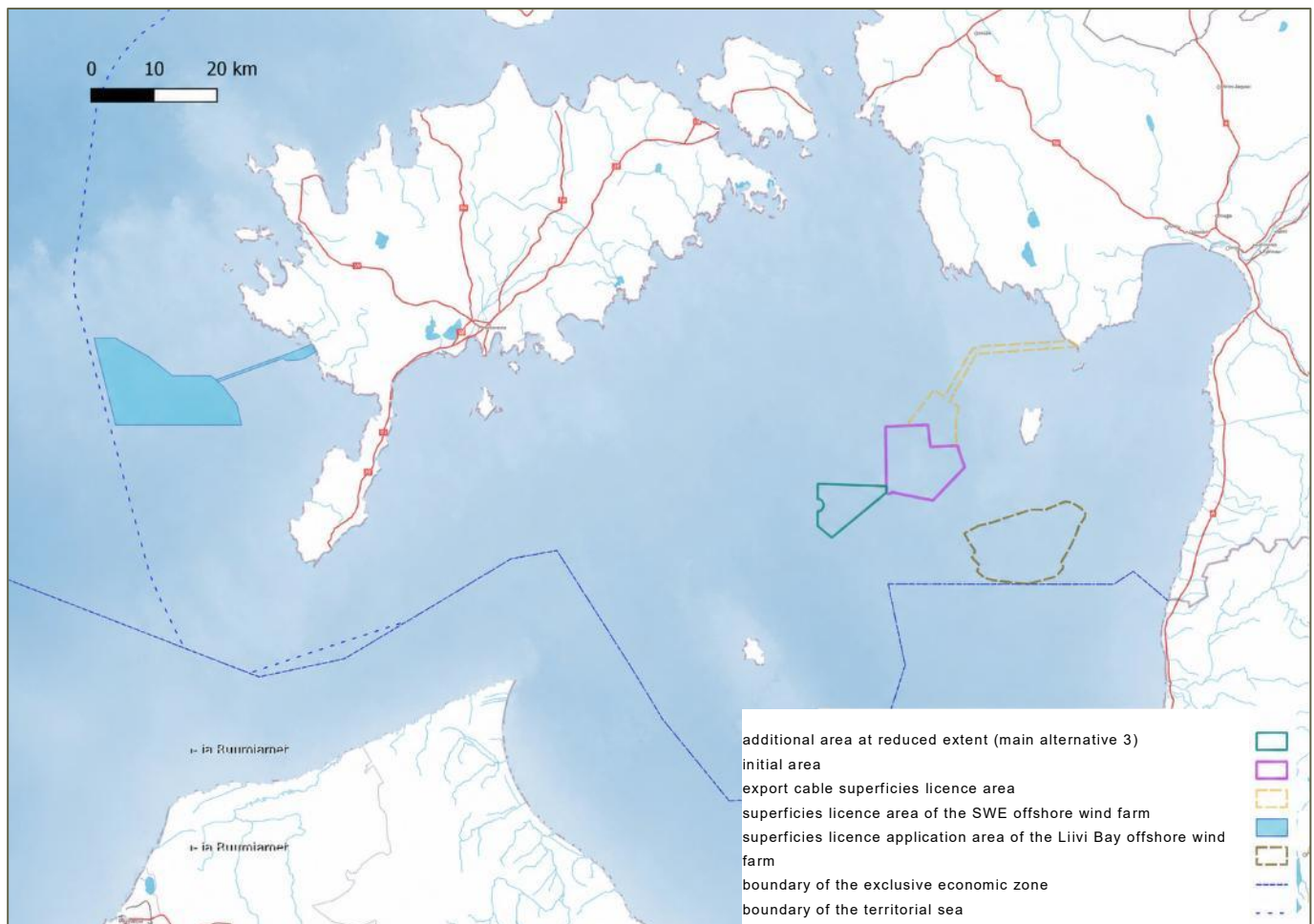


Figure 2.4-1. Additional area of the Saare-Liivi offshore wind farm (main alternative 3) together with the initial area and the projects included in the cumulative impact assessment (SWE offshore wind farm, Liivi Bay offshore wind farm)

Cumulative impact assessment

Cumulative impact is assessed by impact topic in relation to those projects that, following the preceding screening (Table 2.4-3), have been included in the assessment of the respective impact topic.

The assessment analyses, in particular:

- the accumulation of possible impacts;
- possible changes in the extent, duration and intensity of the impact due to in-combination effects with other activities;
- the need for additional mitigation measures or inter-project coordination.

Cumulative impacts are assessed by impact topic in the corresponding impact assessment chapters of this EIA report. The results of the assessment, including the significance of the cumulative impact, the uncertainty of the assessment, and any possible need for inter-project coordination, mitigation measures and monitoring, are consolidated in the summary table presented in section 7.5.

2.5. Transmission system and cable locations

To operate the offshore wind farm and feed the electricity generated into the electricity grid, it is essential to construct a submarine cable system and a connection to the transmission network. The turbines in the additional area will be connected by inter-array cables to the offshore substation in the additional area. From there, up to two parallel export cables run to the boundary of the additional area; the length of each route section within the additional area is approximately 6 km, i.e. the total installed length of the two cables within the additional area is approximately 12 km. From the boundary of the additional area, one cable continues to one offshore substation in the initial area and the other to the other offshore substation, or directly to the coast. From the offshore substations in the initial area, the electrical energy is transmitted to the onshore landfall point. The export cable system located within the initial area has been assessed in the EIA report for the initial area. Accordingly, no separate new landfall corridor is planned for the additional area. The impact of the export cable route passing through the initial area is addressed in this report as part of the in-combination effect of the initial and additional areas in sections 3.3 and 3.4.

To transmit up to 800 MW of capacity from the additional area, up to two export cables, each with a transmission capacity of up to 400 MW, will be installed. The expected rated voltage of the export cables is up to 330 kV AC.

As required, the export cable will be laid on the seabed surface or buried in the seabed. Possible methods of cable installation at sea are listed in section 2.7.2.

2.6. Technical description of the offshore wind farm

2.6.1. Wind turbine

This project envisages the use of wind turbines installed on the seabed (*bottom-fixed*). Wind turbines based on floating foundations are not planned as part of this project. A wind turbine consists of a foundation installed on the seabed, a tower, a nacelle with drivetrain systems and a generator, and a rotor with blades (Figure 2.6-1).

In the additional area of the Saare-Liivi offshore wind farm, foundations installed on the seabed will be used; the use of floating foundations is not planned. The specific wind turbine model to be used in the Saare-Liivi offshore wind farm has not yet been selected.

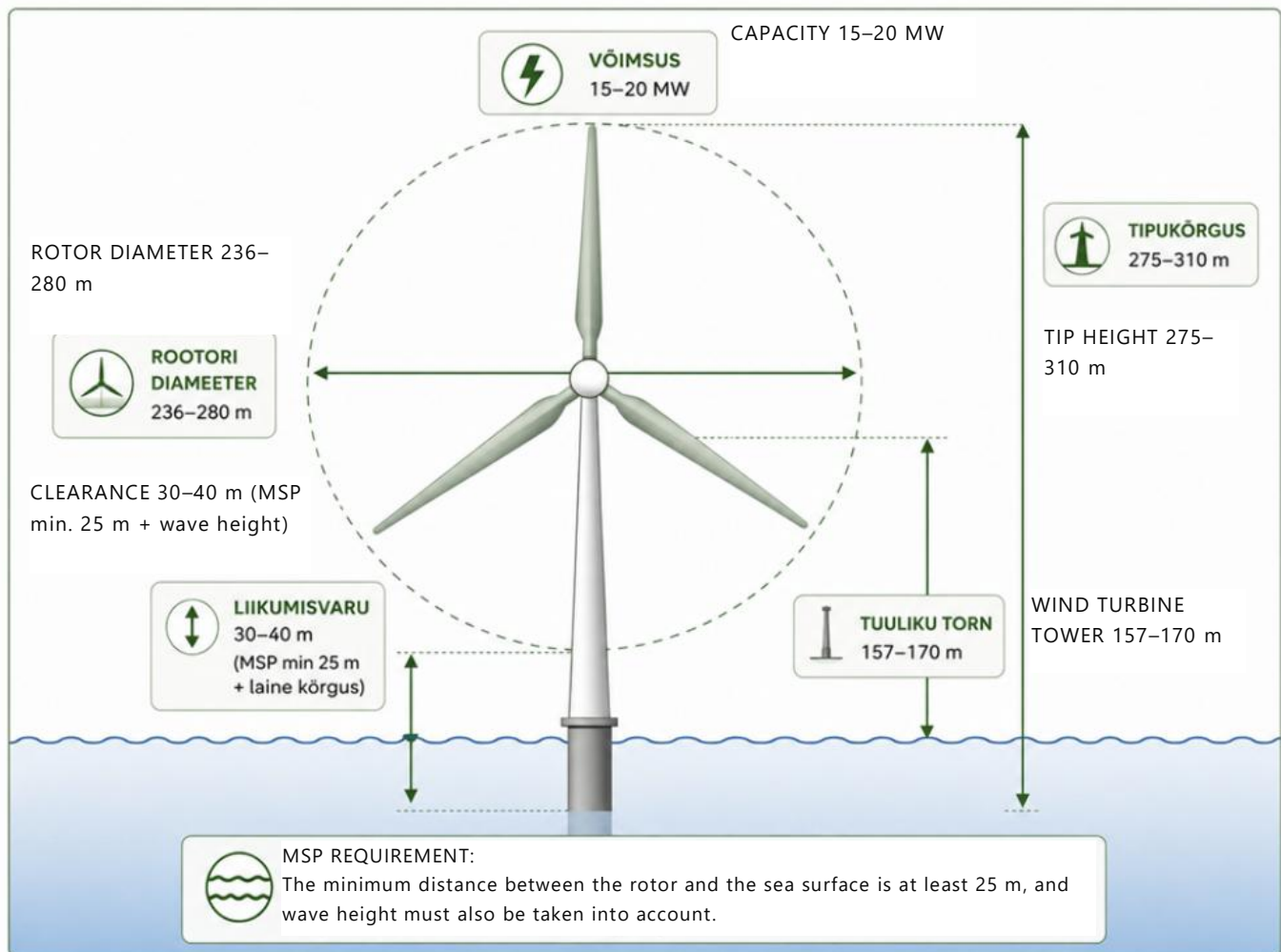


Figure 2.6-1 Illustrative dimensions of a wind turbine

Offshore wind turbine technology continues to develop; therefore, the EIA considers the maximum-size offshore wind turbine likely to be in use by the time the offshore wind farm is constructed. The developer assumes that by the time the offshore wind farm is constructed, the largest wind turbines ready for use will have a rotor diameter of 236–280 metres (wind turbines with an approximate capacity of 15–20 MW) and, consequently, a maximum blade tip height above sea level of *ca* 275–310 metres. The clearance between the blade tip and the water surface is *approx.* 30–40 metres.

The typical colour of wind turbines, including towers and blades, is light grey. In accordance with international standards, the parts of the foundations protruding above the water may require yellow marking from sea level up to a height of approximately 15–25 metres. Structures attached to the foundations (access ladders, platforms, etc.) are also usually painted either yellow or light grey. The exact marking requirements will be determined in consultation with the authorities and in accordance with national and international requirements. As a rule, wind turbines are equipped with lighting or markings so that they can be identified from aircraft and vessels. Depending on the final layout of the offshore wind farm in relation to traffic routes, there may be additional maritime safety markings. Wind turbines may also be equipped with radar, a fog signal and an automatic identification system. The detailed solutions will be defined in cooperation with the authorities once the size and final layout of the turbines are clear.

The leading edges and protective coatings of wind turbine blades wear during operation due to rain, hail, sea salt and other environmental factors. As a result of leading-edge erosion, particles of coating and composite material may be released into the environment. In discussions on wind farms, it has been

speculated that microplastics and bisphenol A¹⁰ may be released from wind turbine blades. The quantity and composition of the material released depend on the turbine model selected, the blade coating material, the leading-edge protection solution, weather conditions, and the frequency of maintenance and repairs.

The material composition and wear rate of the blades depend on the specific model and surface protection system. The project-specific assessment is based on the study described below, together with its assumptions and uncertainties; no general upper limit of material loss applicable to all turbines is set.

The quantity of microplastic particles released from wear of the blade leading edges has been estimated on the basis of the IEA 15 MW reference wind turbine (117 m long blades), combining precipitation and wind data measured in the North Sea with a fatigue-based erosion model (Caboni et al., 2025¹¹). According to the estimate, a turbine with polyurethane leading-edge protection releases on average approximately 240 g of microplastics per year, i.e. approximately 6 kg per turbine over its entire 25-year service life across all three blades combined, assuming that the leading-edge protection is renewed every five years. The calculation used the least wear-resistant of the protection systems tested; therefore, the result represents a conservative scenario. For up to 40 wind turbines, this would be on the order of 10 kg per year in the additional area.

An important benchmark for interpreting the quantity is: According to Caboni et al. (2025), the blades of all offshore wind farms in the Dutch North Sea currently release approximately 100 kg of microplastics per year, which represents less than one per mille of the total plastic load reaching the North Sea from the Netherlands (approximately 155 tonnes in 2017). The majority of this load originates from vessel paint and coating materials and from lost fishing gear.

The behaviour of the particles in the marine environment depends on the density of the material. The density range of polyurethane-based coating materials, 0.9–1.1 g/cm³, covers materials that are both lighter and heavier than water. In addition to the density of the material, the buoyancy and settling of the particles depend on the density of the local seawater, particle size and biofouling; rapid settling or a short residence time in the water column cannot be inferred from the density range alone. At the same time, several uncertainties must be taken into account: the cited estimate does not include the effects of hail or ultraviolet radiation on the ageing of the coating material, the measurement period was drier than average, and the toxicity and degradation of the released polymers in the marine environment have not been assessed.

At the present stage of the EIA, the composition of the final blade and coating material is not yet known, nor are sufficient data available for project-specific quantification of releases of possible constituents, including bisphenol A, into the environment. In the literature, the risk of bisphenol A release is associated primarily with situations where leading-edge protection is absent or inadequately maintained. Accordingly, the report does not draw the categorical conclusion that the release of particles or chemicals is entirely absent. Given the expected quantities, their order of magnitude compared with other sources of plastic loads entering the sea, and dilution in the offshore environment, no significant environmental impact is predicted on the basis of the information currently available. To minimise the environmental footprint, preference must be given, when selecting wind turbines, to wear-resistant leading-edge protection systems, and regular inspection of the blades and timely renewal of the leading-edge protection must be ensured.

¹⁰ Bisphenol A (BPA) is a chemical compound widely used in the production of plastics and resins. BPA is used mainly in the manufacture of polycarbonate plastics and epoxy resins, which are found in many everyday products.

¹¹ Caboni, M., Schwarz, A. E., Slot, H., van der Mijle Meijer, H. 2025. Estimating microplastic emissions from offshore wind turbine blades in the Dutch North Sea. *Wind Energy Science* 10, 1123–1136. <https://doi.org/10.5194/wes-10-1123-2025>

In the medium- and high-voltage electrical switchgear of turbines and wind farms, sulphur hexafluoride (SF₆) has so far mainly been used, because of the small dimensions achievable, to ensure electrical insulation and arc quenching. The use of SF₆ makes it possible to build compact equipment with a small footprint and low material and transport costs. As SF₆ is a potent greenhouse gas, more environmentally friendly solutions have increasingly been sought. One example is solutions based on clean air (so-called *dry air* or *clean air*), which provide insulation properties similar to those of SF₆ solutions at similar dimensions. In selecting turbines and medium- and high-voltage switchgear for the Saare-Liivi offshore wind farm, SF₆-free solutions are preferred. If procurement of such equipment is not possible, basic precautionary measures must be applied in connection with the use of SF₆ equipment (appropriate staff training, suitable working methods and maintenance requirements, a monitoring system, etc.). Where precautionary measures are applied, the occurrence of significant negative environmental impact associated with the installation and operation of new SF₆-filled equipment is unlikely (see Annex 3.16 for more detail).

2.6.2. Foundation type

Different foundation types are used in the construction of offshore wind turbines and substations. The most common is the monopile foundation; jacket, gravity and tripod or three-legged foundations are used considerably less often (Figure 2.6-2).

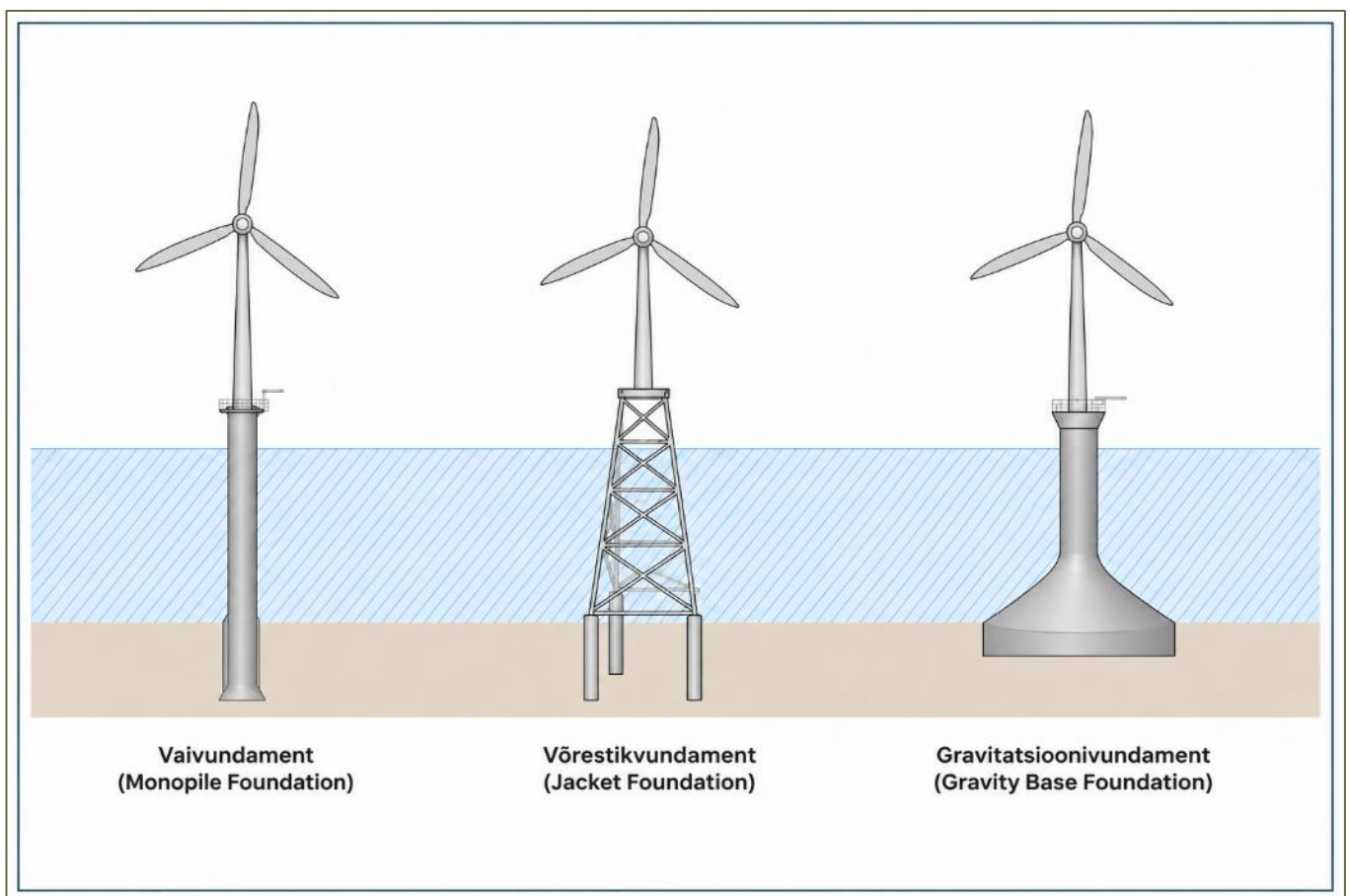


Figure 2.6-2. Illustrative types of wind turbine foundations used in offshore wind farms

The specific wind turbine and substation foundation type to be used in the Saare-Liivi offshore wind farm has not yet been selected; therefore, given the selected location, two foundation types are under consideration and assessment at the EIA report stage:

Monopile foundation or tubular foundation is currently the most widely installed offshore wind turbine foundation in the world. A tubular steel structure is installed in the seabed to a depth of tens of metres, as required. Where necessary, scour protection is added. Under North Sea conditions, a typical installation depth is approximately 30–35 m. The largest monopile foundations weigh more than 2000 tonnes and are approx. 110 m long.

The diameter of the monopile foundation is estimated at up to 18 m. For 15 MW offshore wind turbines designed to date, monopile foundation diameters have been in the range of 9–12 m, but the design conditions for monopile foundations designed to date differ significantly from those for the Saare-Liivi wind farm owing to the water depth, more complex ice conditions and geotechnical conditions characteristic of the Saare-Liivi project. The final principal dimensions of the monopile foundation are determined by the geological properties of the seabed, water depth, turbine dimensions, and local wave, ice and wind conditions. The selection of the principal dimensions of the monopile foundation also makes it possible to optimise production, transport and installation costs.

The base area of a monopile foundation with a diameter of 9 m is approx. 64 m², and for a monopile foundation with a diameter of 18 m approx. 254 m².

Gravity base foundation (GBF) consists of a crushed-stone base pad constructed on the seabed and a foundation placed on it, which is usually filled with additional ballast after installation on the seabed. Gravity base foundations are constructed either from concrete, from steel, or using both materials together. With this foundation type, no seabed drilling is carried out. Compared with a monopile foundation, a gravity base foundation requires a significantly larger seabed area. The foundation diameter can be up to 50 metres, and the base area is approximately 2000 m² and 2500 m² including the base pad. In addition, because of their large volume and weight, gravity base foundations require prior seabed preparation depending on the nature of the seabed.

2.6.3. Inter-array cables

The offshore wind farm's inter-array cables form the electrical network by which all wind turbines are connected to the offshore substation or substations. The technical parameters of the inter-array cables depend on the rated capacity of the wind turbines and their distance from the offshore substation. A communication cable is also integrated into the inter-array cables to ensure control of the electrical system.

2.6.4. Export cables

An export cable is an electrical installation by which electricity generated in the offshore wind farm is transmitted to the onshore connection point. As with the inter-array cables, communication cables are integrated into the export cables to ensure control of the electrical system. The technical parameters of the export cable, or connection cable (English *export cable*), differ from those of the inter-array cables, as significantly larger quantities of electricity are transmitted at one time. To reduce losses arising in electricity transmission, the transmission system is planned with a nominal voltage of up to 330 kV, which is also compatible with the nominal system voltage of Elering's transmission network.

The export cable route consists of two parts:

1. The marine route starts at the offshore substation in the additional area. Within the additional area, up to two export cables run along a route corridor approximately 6 km long (combined

installation length of the two cables *approx.* 12 km). From the boundary of the additional area, one cable continues to one offshore substation of the initial area and the other to the other offshore substation, and from there onwards along the export cable route corridor of the initial area to the onshore landfall point. The approximate total length of the marine route of one cable from the offshore substation in the additional area to the landfall point is *approx.* 50 km.

If the offshore wind farm in the Saare-Liivi initial area is not implemented, the connection of the additional area to the onshore system will be ensured via the same export cable route corridor passing through the Saare-Liivi initial area, and the proposed total length of the export cables serving the additional area will remain of the same order of magnitude, i.e. the approximate total length of the marine route of one cable from the substation in the additional area to the landfall point is *approx.* 50 km, and the combined installation length of the two cables in the sea *approx.* 100 km.

2. The onshore route, with an approximate length of *approx.* 28 km.

The number of export cables depends on the rated capacity of the offshore wind farm. The transmission capacity of one export cable is estimated at 400 MW. Accordingly, up to two export cables will be installed in the additional area.

Along the marine route, the export cable is installed on the seabed, either surface-laid or buried in the sediment, as required. Along the onshore route, the export cable is installed in the ground. Predominantly, the export cable is buried to a depth of 1 metre, but near shore and in places where the cable requires additional protection (e.g. near shipping routes), burial of the export cable to a depth of up to 5 metres may prove necessary. Possible methods of installing the export cable along the marine route are listed in Section 2.2.4; for the onshore route, the cables are installed either by drilling into the ground or by burial in an open trench.

The offshore wind farm will be connected to Elering's transmission network by means of a connection substation planned onshore on the 330 kV Harku – Sindi L503 overhead line. The location of the Elering and offshore wind farm substation is on the Kapa property in Malda village, Pärnu city. Pärnu city has also issued building permits for the onshore cable on 21.05.2026 and for the construction of the substation on 19.06.2026.

Possible methods of installing the export cable along the marine route are listed in Section 2.7.2.

2.6.5. Offshore substation

It is envisaged that one offshore substation will be constructed for the offshore wind farm in the additional area, in order to ensure continuous security of supply between the offshore wind farm and the onshore connection point. One or two transformers have been assumed per offshore substation. An offshore substation is a single- or multi-deck platform on which all offshore substation plant and auxiliary equipment are installed and, where necessary, a helicopter landing area is provided. It is estimated that the above-water part of one such offshore substation may have an area of 1000 m² and a weight of 2000 t. For the underwater part, either a monopile foundation or, where necessary, a gravity base foundation may be used. Like wind turbine foundations, the foundation must be protected against seabed erosion. For the installation operation of the offshore substation, a heavy-lift vessel (HLV) is used.

The footprint area of the underwater part of the offshore wind farm substation depends on the base area of the foundation used. Offshore substation foundations and offshore wind turbine foundations have

similar parameters, i.e. the maximum footprint area of the offshore substation foundation is taken to be the maximum footprint area of the turbines' gravity base foundation.

2.7. Different phases of offshore wind farm construction

This chapter provides an overview of the activities that take place during the preparatory phase of the offshore wind farm, including the cables, and during construction (i.e. construction-period activities), operation (i.e. operation of the wind farm) and decommissioning.

2.7.1. Preparatory phase

Before the offshore wind farm is designed and construction works begin, several field surveys are carried out in the marine area.

The field surveys include the following:

- Bathymetric surveys;
- Geophysical surveys;
- Geotechnical surveys.

A detailed description of the survey methods (bathymetric, geophysical and geotechnical surveys) is provided in the full Estonian-language EIA report (Section 2.7.1).

2.7.2. Construction phase

The work stages for construction of the offshore wind farm and their approximate durations are as follows:

- Geophysical and geotechnical surveys: duration 6–12 months
- Seabed preparation works for the foundations: duration approximately 12 months
- Installation of the foundations: duration 3–6 months
- Construction of the offshore substation: duration 1–2 months.
- Cable installation (offshore wind farm inter-array and export cables): duration 3–6 months
- Installation of the wind turbines: duration 6–12 months. Assembly of the wind turbines at the construction port, transport to the marine area and installation.
- Commissioning of the offshore wind farm: duration 3–6 months. Testing of the offshore wind farm systems, completion of grid connections and trial operation of the wind farm.
- Operation and maintenance of the offshore wind farm: duration 25+ years (operational phase)
- Decommissioning: duration 1–2 years (at the end of the service life). Removal of the wind turbines, foundations and cables. Restoration of the seabed to its natural state or its conversion for another purpose.

The stages and durations set out above are estimated work durations, which depend on the technical capability of the vessels selected for construction and on the applicable time restrictions for carrying out the operations.

Construction of the Saare-Liivi offshore wind farm (installation of foundations, cables, the offshore substation and wind turbines) is estimated to extend over two to three years, primarily due to winter

conditions, which make year-round construction more difficult. Construction sequence of the offshore wind farm:

- Seabed preparation works for installation of the foundations
- Installation of the foundations
- Installation of the offshore wind farm's inter-array cables
- Installation of the offshore substation for the offshore wind farm
- Installation of the export cables
- Installation of the wind turbines
- Commissioning of the offshore wind farm

A detailed description of the manufacture and transport of the main components, the types of construction and work vessels, and the wind turbine installation operations is provided in the full Estonian-language EIA report (Section 2.7.2) and in the developer's technical description (Annex 2).

INITIAL CONSTRUCTION OPERATIONS

Before construction of the offshore wind farm begins, the seabed must be prepared for the installation of components.

This usually begins with seabed clearance. In simplified terms, this is carried out using an anchor lowered to the seabed and towed behind, for example, a Multicat vessel (English *PLGR - Pre lay Grapnel Run*). In this way, the seabed is cleared, for example, of abandoned fishing nets or steel wire ropes lost by vessels and similar items. The areal extent of seabed clearance depends on the choice of foundation and the size of the area occupied by the foundation. For example, in the case of a gravity base foundation, an area the size of the foundation base pad is cleared. The wind farm cable routes are cleared as a priority in order to avoid possible damage to the cables during installation. Depending on the seabed sediment, suitable PLGR rigging (e.g. chains, wire ropes, shackles, etc.) is selected, making it possible to control how deeply the towed anchor can penetrate into the sediment.

Preparatory seabed levelling or dredging works follow seabed clearance. A dredger levels the seabed so that foundations can be installed. To ensure the safety of the cables, it may prove necessary to trench the cables into the seabed and cover them with sediment. It may also prove necessary to prepare the seabed at the wind turbine locations for installation vessels (WTIV), so that the vessel can safely support its so-called 'legs' on the seabed in order to jack itself up out of the water.

Seabed preparation also includes the removal of boulders where they cannot be avoided along cable routes or at foundation locations. Larger boulders may occur in the Gulf of Riga, and these must be taken into account when planning the wind farm. If boulders pose a construction risk at cable or foundation locations, they are removed before the foundations or cables are installed. In many cases, an MPSV is used for these works, towing a plough (English *plough*) behind it along the seabed, which diverts boulders away from the cable route. A grab is also used to lift boulders to another location. A 3D sub-bottom profiler is used to detect boulders located below the seabed.

INSTALLATION OF FOUNDATIONS

Gravity base foundation

Seabed preparation for the installation of a gravity base foundation depends on the exact location where the wind turbine is to be installed, but the most important technical constraint in the installation of a gravity base foundation is sufficient load-bearing capacity of the seabed. Where soft sediments are

present, it is most likely not possible to ensure sufficient load-bearing capacity, and the sediments must therefore be removed from beneath the foundations. In the additional area of the Saare-Liivi offshore wind farm, the thickness of the sediments varies greatly, but it is expected to be technically and economically feasible to remove sediments up to 4 metres thick. These are mostly mud or clay sediments, but depending on the properties of the bedrock, it may be necessary to remove limited quantities of the upper rock layers. The upper sediment and rock layers are removed using a dredger (English dredger). After removal of the sediments, the seabed must be levelled, any boulders present removed, and a base pad (i.e. a gravel or crushed-stone pad) constructed, on which the gravity base foundation can be installed. Gravel or crushed stone is mainly used as the base material, as it has sufficient load-bearing capacity and, owing to the relatively small particle size, these materials can also be levelled easily. For this purpose, a rock placement vessel (RIV) or flexible fallpipe vessels (English *FFPV Flexible Fallpipe Vessel*) are used. Depending on the requirements laid down in the foundation design, it may also be necessary to use underwater-operated bulldozers to level the base pad formed from the added materials. After completion of the base pad, the gravity base foundation is installed on it, after which the necessary quantity of backfill and erosion protection is added.

Table 2.7-1 *Estimated volumes of excavation and fill required for the installation of gravity base foundations (40 wind turbines + 1 offshore substation)*

	Quantity	Area (m²) per foundation	Volume (m³) per foundation	Mass (t) per foundation
Gravity base foundation	41	2000	n/a	3000–7000
Gravel or crushed-stone pad (1 m thick)	41	2500	2500	<i>approx.</i> 6750
Backfill material	41	2500	7500	<i>approx.</i> 22000
Gravity base foundation protection, i.e. erosion protection	41	2500	5000	<i>approx.</i> 14500
Material to be removed (at a thickness of <i>approx.</i> 4 m)	41	2500	10 000	<i>approx.</i> 26 000

Assuming that, due to weather conditions, it is reasonable to plan construction activities in the marine area of the Saare-Liivi project between March and October, seabed preparation for the foundations would take one to two years and would require the simultaneous operation of 2–4 vessels, depending on seabed characteristics and the final requirements for seabed load-bearing capacity.

Monopile foundation

Monopile foundations are the most commonly used offshore wind turbine foundations worldwide. A distinction is made between driven and drilled monopile foundations.

Driving is carried out using a hydraulic hammer. Alternatively, vibration or a combination of vibration and driving may be used. Use of driving technology for the installation of a monopile foundation requires very precise geological and geotechnical data on the seabed. Knowing the sediment structure of the marine area makes it possible, when designing the wind farm, to identify locations where pile driving is not possible because of the hardness of the sediment or where the pile may sink into a subsurface void.

Since a monopile foundation is tubular, sediment remains inside the pile during pile driving. Monopile foundations are mostly driven from a WTIV vessel, but HLV vessels can also be used.

Driving monopile foundations generates underwater noise, which may have a harmful effect on nearby marine life if mitigation measures are not applied. To reduce environmental impact during piling works, acoustic deterrent devices are usually used. An acoustic deterrent device is a device used to pre-emptively deter marine fauna from the construction site by means of special acoustic signals. This can be compared, for example, to the bird-scaring solutions used at airports.

Alongside deterrence measures, there are also several other methods of reducing noise, and these are often used simultaneously. One of the most common methods is the bubble curtain, which is nowadays used in a double configuration. To create a bubble curtain, hoses equipped with nozzles are installed on the seabed in one or two rings around the installation vessel. Compressed air is then pumped into the hoses, from which it exits as bubbles and attenuates the propagation of underwater sound. A multipurpose vessel (MPSV) is used to generate the bubble curtains.

If seabed geology does not allow a monopile foundation to be driven into the sediment, for example in the case of hard bedrock, drilling must be used for the installation of monopile foundations. This installation method is much slower than driving monopile foundations, but it makes it possible to install monopile foundations where driving is not possible. In addition, an advantage of drilling is the significantly lower noise level compared with driving. There are several techniques for drilling vertical shafts and installing steel piles in soils that are difficult to penetrate, which can be divided into relief drilling and vertical foundation drilling.

Table 2.7-2. *Estimated volumes of excavation and fill required for the installation of monopile foundations (40 wind turbines + 1 offshore substation) in the additional area of Saare-Liivi*

Type	Quantity	Area (m²) per foundation	Volume (m³) per foundation	Mass (t) per foundation
Monopile foundation	41	250	500	2500–4000
Monopile foundation protection, i.e. erosion protection	41	2000	3000	approx. 8500
Material to be removed (including material drilled out in the case of drilling)	41	250	6000	approx. 15000
Grouting material	41	250	300	approx. 700

DUMPING

Sediments removed from foundation locations that cannot be used beneficially on site are dumped¹² in dumping areas. During the EIA for the Saare-Liivi initial area, two dumping areas were selected: Saare-Liivi N (with an area of 3.1 km²) and Saare-Liivi S (with an area of 4.2 km²), which are located in deeper parts of the seabed where, according to the available information, there are no valuable habitats for marine life and which are as far as possible from the coast and protected areas (see Figure 2.7-1). Environmental permit KL-526251 (special use of water for the construction of the Saare-Liivi offshore

¹² *Dumping, within the meaning of the Water Act (RT I, 30.06.2023, 102), includes, inter alia, any deliberate discharge into the sea or burial on the seabed of waste or other substances or objects from a vessel, aircraft, platform or other offshore installation.*

wind farm (initial area, export cables)) has been granted for dumping, allowing 830 000 m³ to be dumped. The need for dumping in the additional area of Saare-Liivi is smaller – up to 410 000 m³, and for this purpose the dumping areas Saare-Liivi N and Saare-Liivi S approved by the above-mentioned environmental permit can be used.

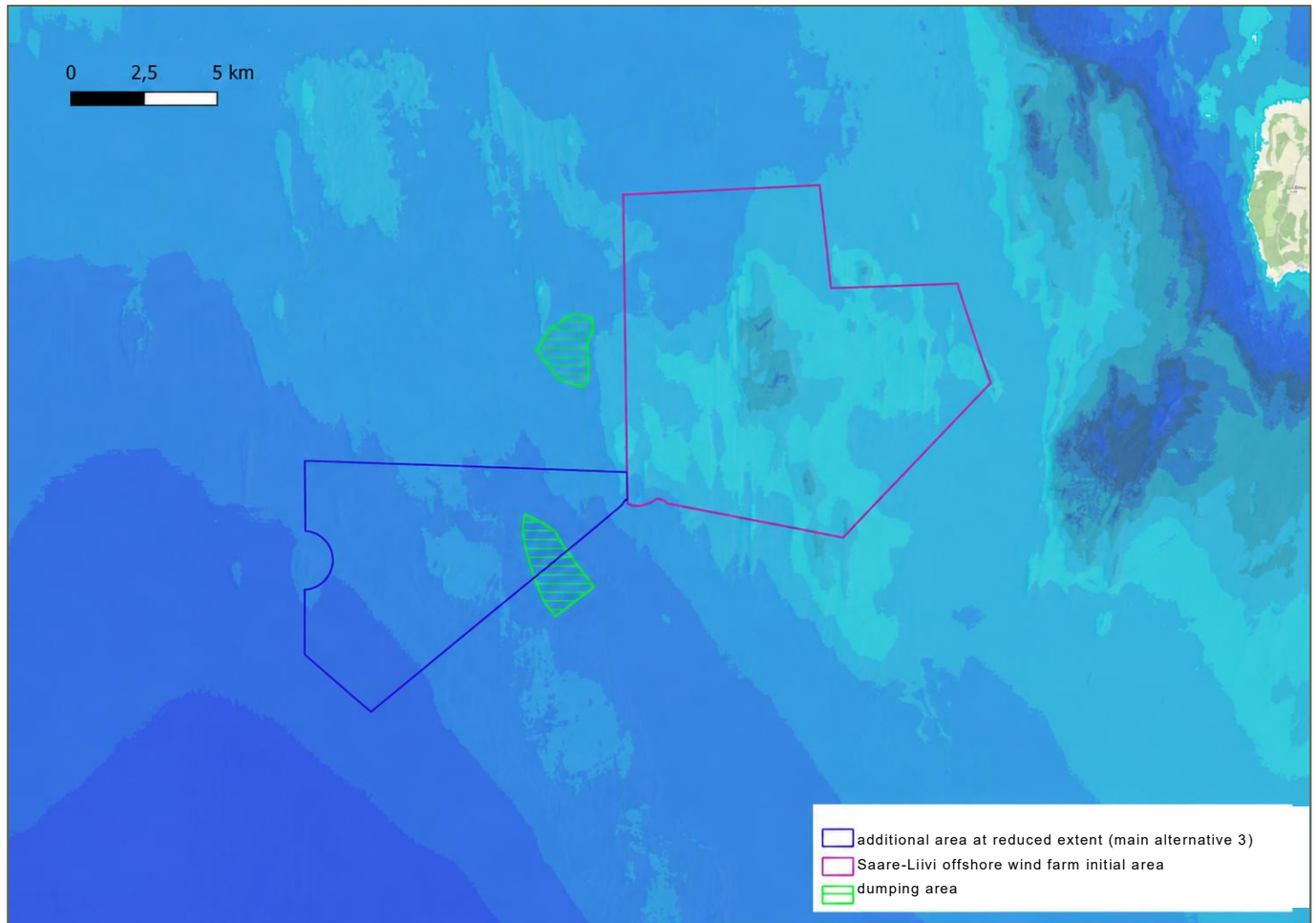


Figure 2.7-1. Dumping areas Saare-Liivi N and Saare-Liivi S

FOUNDATION PROTECTION

Moving water masses cause sediment erosion around structures installed in the sea. To prevent erosion, erosion protection is installed around the foundations. The need for this protection depends on the seabed type and environmental conditions (e.g. wave action, currents, storms) and on the geometry of the foundation. For example, a rocky seabed is considered sufficiently rigid to withstand erosive forces and therefore no separate erosion protection is needed around the structures. A sandy seabed, however, requires erosion protection to ensure the stability of the foundation throughout its service life. For example, in areas with strong currents, very deep scour holes may form around monopile foundations without erosion protection, reducing their stability.

Put simply, erosion protection consists of a layer of gravel placed on the seabed, followed by a layer of larger stones. The layers are placed around the foundation. The gravel layer prevents the larger stones from sinking into the seabed. During strong currents or storms, the layer of larger stones remains stable. The spatial extent of erosion protection on the seabed is the same as that of the gravel or crushed-stone pad.

Protection against the effects of sea ice

The Gulf of Riga is at least partially covered by ice in winter. Depending on the winter and the prevailing wind directions and strengths, both pack ice and drift ice may occur at the location of the additional area of Saare-Liivi. Formations of ridged and rafted ice, characteristic of ice movement, also occur. To protect the foundations against sea ice and sea-ice formations, an ice belt and ice-reinforced zones are added to the foundation structure. Ice reinforcements are integrated into the primary structural elements of the foundation, and sufficient erosion and corrosion allowance is added to the plating to ensure the required service life against the abrasive action of ice.

OFFSHORE WIND FARM INTER-ARRAY CABLES

Preparations required for the installation of inter-array cables

Before the installation of inter-array cables can begin, detection surveys for unexploded ordnance (UXO) and objects (e.g. boulders, other obstacles) must be carried out along the inter-array cable routes. To clear the seabed, a *pre-lay grapnel run* is lowered to the seabed, and one or, if necessary, several clearance operations are carried out by towing the anchor behind the vessel. UXO is either removed from the seabed and detonated elsewhere, or the locations where UXO is present are instead avoided in the offshore wind farm project. These steps are necessary to ensure safety during the installation of the inter-array cables.

Installation of inter-array cables

The installation of inter-array cables is carried out using specialised vessels capable of laying the cables precisely at the planned location without damaging the seabed in the process. A cable-laying vessel (CLV) is usually used for the installation of inter-array cables. Inter-array cables may weigh more than 100 kg per metre and have a diameter of 150 to 300 mm. The installation speed of inter-array cables is usually between 200 and 600 m/h, depending on the cable type, the cable route and sea and weather conditions.

Burial of inter-array cables

To reduce the risk of damage to inter-array cables due to fishing or nearby vessel traffic, the cables may be buried in the seabed. Specialised tools are often used for burial. For the installation of inter-array cables in the seabed, it has been assumed that a plough will be used in harder sediments (e.g. till) and a water jet in the case of soft sediments. A plough is a mechanical device that is towed along the seabed behind a vessel. It cuts a trench into the sediment, lays the cable in it and then covers it again with sediment. Water jet technology uses high pressure to soften the seabed sediment, allowing the cable to sink into the sediment under gravity.

If the sediment nevertheless proves more difficult than expected or the required burial depth is not achieved, the inter-array cables must be protected by other means. In most cases, inter-array cables are covered with a layer of rock, but in some cases inter-array cables are also covered with so-called concrete mattresses (English *concrete mattresses*). During burial operations using high-pressure water jets as well as the CCM method, the equipment can indicate the depth to which the inter-array cable is lowered into the trench. Such a survey carried out simultaneously with burial helps to make real-time adjustments in order to achieve the correct burial depth of the inter-array cable. After burial has been completed, a post-burial survey is usually carried out to check the final burial depth of the inter-array cable.

The quantity of material to be removed will be determined at a later stage, but it is expected to be up to 4 m³/m.

EXPORT CABLES

The export cables connecting the offshore wind farm's electricity to the transmission network are buried using the specialised cable installation equipment referred to earlier in relation to the inter-array cables. In nearshore shallow-water areas, the installation of export cables may be difficult due to vessel access and possible environmental restrictions. In these areas, the export cable is fitted with floats and guided from the cable-laying vessel to the shore. In waters close to the coast, the cable is connected to a pulling line and winched through an open trench to the connection point on land. Alternatively, the cable can be installed by directional drilling using a trenchless method. In directional drilling, a borehole is drilled from land in the required direction, running beneath the shore and seabed until the drill head exits from the seabed at the required distance. The distance at which the drill head exits depends on technical capability and environmental conditions. A cable duct is then pulled through the borehole, through which the subsea cable can in turn be pulled ashore. At present, modern directional drilling technologies make it possible to continue drilling in a controlled direction up to 1.5 km from the drilling starting point.

The minimum spacing between export cables installed in parallel is 100 metres on the offshore route and 2 metres on the onshore route. Accordingly, in the case of two parallel export cables, the overall width of the cable corridor on the offshore route is approximately 100 m. For the local burial of one export cable, a corridor about one metre wide is assumed, but during construction works, depending on the vessels and technologies used, construction activity may affect the seabed within a radius of up to 20–30 m.

THERMAL ENERGY EMITTED BY INTER-ARRAY AND EXPORT CABLES

All electrical cables heat up during operation. Because heat emission causes electricity transmission losses, the design of cables is essentially aimed at reducing heat losses. The maximum permissible temperature of high-voltage cables is 90 degrees, which means that the external temperature of the cable is up to 70 degrees¹³. The emission of heat into the surrounding environment depends both on the properties of the cable and the duration of current transmission, as well as on the properties of the sediments at the cable installation location (their temperature, thermal conductivity and thermal resistance). In seabed sediments, heat transfer can take place both by conduction (transfer of heat energy through direct contact) and by convection (transfer of heat energy through fluid movement), whereby in fine-grained sediments it appears to occur rather through direct contact and in coarse-grained sediments by convection¹⁴. In coarse-grained sediments, a shorter thermal gradient around the cable is assumed than in finer sands and mud¹⁵.

As far as is known, most benthic organisms occur in sediments up to 20 cm below the seabed¹⁶. The German Federal Agency for Nature Conservation has developed thermal guidelines for cable installation which recommend that, in seabed sediments located up to 20 cm below the seabed, the temperature increase should not exceed 2°C in order to protect benthic organisms. To comply with this recommendation, the cables must be buried sufficiently deep. The sediment layer insulates the habitats

13 Emeana, C., T. Hughes, J. Dix, T. Gernon, T. Henstock, C. Thompson, and J. Pilgrim. 2016. *The thermal regime around buried submarine high-voltage cables*. *Geophysical Journal International*, Volume 206, Issue 2. <https://academic.oup.com/gji/article/206/2/1051/2606019>

14 Emeana, C., T. Hughes, J. Dix, T. Gernon, T. Henstock, C. Thompson, and J. Pilgrim. 2016. *The thermal regime around buried submarine high-voltage cables*. *Geophysical Journal International*, Volume 206, Issue 2. <https://academic.oup.com/gji/article/206/2/1051/2606019>

15 Merck, T., and M. Wasserthal. 2009. *Assessment of the environmental impacts of cables (OSPAR Commission)*. Biodiversity Series No. 437. <https://www.ospar.org/documents?d=7160>

16 Viking Link. 2017. *Appendix I Cable Heating Effects: Marine Ecological Report*. Report VKL-07-30-J800-016 prepared for National Grid Viking Link Ltd. <https://www.commissiomer.nl/projectdocumenten/00002753.pdf?documenttitle=Appendix%20I%20-%20Cable%20Heating%20Effects%20Report.pdf>

of benthic organisms and the water column from the heating effect of the cable. Multiple cables usually require a sediment cover/depth of 0.7 m to 1.15 m, whereas single cables emit less heat and require only 0.35 m to 0.55 m of sediment cover in order to comply with the 2°C rule¹⁷.

Inter-array cables in the additional area of Saare-Liivi are generally laid on the seabed surface. If later pre-construction surveys show that currents and the mobility of seabed sediments may damage the inter-array cables, they will also be buried along all or part of their length.

The operation of offshore substations also involves the emission of thermal energy, but unlike cables located on the seabed, heat from the substations is emitted into the atmosphere and has a marginal effect on the surrounding environment.

INSTALLATION OF WIND TURBINES

Installation of wind turbines in the additional area of the Saare-Liivi offshore wind farm

No wind turbine from any manufacturer has yet been selected for the construction of the Saare-Liivi offshore wind farm. A turbine with a capacity of 15–20 MW, a maximum tip height of 310 metres and a generator height of 150–170 metres is currently under consideration. Installation will most likely be carried out using a WTIV installation vessel, and component loading operations will take place at a port yet to be determined. In 2026, a quay suitable for offshore wind farm construction was completed at Paldiski South Harbour. Liepāja port in Latvia is also planning to develop a port area suitable for offshore wind farm construction.

The **offshore substation** module is mainly constructed on land at specialised manufacturing or port areas, where steel structures are fabricated, equipment is installed and the systems undergo preliminary testing. As much of the construction and commissioning work as possible is carried out on land in order to reduce the volume of work performed offshore. The preferred approach is to assemble the entire offshore substation module as a single unit in order to reduce the volume of offshore operations. Due to constraints imposed by environmental conditions and the vessels available, the use of several offshore substation modules may also be considered.

The completed offshore substation module or modules are transported to the installation site by a heavy transport vessel or barge and lifted onto the foundation using a heavy-lift vessel. After completion of the mechanical and electrical connections, final testing and commissioning of the systems are carried out.

2.7.3. Operation phase of the offshore wind farm

Once the offshore wind farm has been completed, its operation phase begins, lasting at least 30–35 years. Operation involves continuous real-time monitoring of the functioning of the entire offshore wind farm infrastructure, regular maintenance and occasional repairs in order to ensure efficient and reliable energy production. Below is a detailed overview of the different aspects of the operation phase, with a particular focus on maintenance.

At the current stage of the Saare-Liivi offshore wind farm, no decision has yet been made regarding the maintenance vessel strategy. To decide on the strategy, an analysis is required,

¹⁷ Viking Link. 2017. *Appendix I Cable Heating Effects: Marine Ecological Report. Report VKL-07-30-J800-016 prepared for National Grid Viking Link Ltd.* <https://www.commissiomer.nl/projectdocumenten/00002753.pdf?documenttitle=Appendix%20I%20-%20Cable%20Heating%20Effects%20Report.pdf>

with inputs including, among other things, the size of the wind farm, the selected maintenance port, the operating costs of different vessel types, etc.

- Optimal location: The maintenance base should be located in a port close to the wind farm in order to minimise transport time. For servicing the wind farm by CTV, the optimal travel time is considered to be 1h. Therefore, Virtsu, Munalaid, Pärnu and Salacgriva could be suitable options for the maintenance port of the Saare-Liivi offshore wind farm. For optimal servicing of the wind farm by SOV, ports within a radius of 100 nautical miles of the offshore wind farm are considered suitable. A prerequisite, of course, is that the port can accommodate a vessel with a draught of approx. 6 m.

2.7.4. Decommissioning phase

It is assumed that the offshore wind farm will reach the end of its operation phase after about 30 years. The wind turbines, foundations, substation and other parts of the installation are decommissioned and transported ashore. The foundation locations are restored to a reasonable extent in accordance with the applicable regulations.

Decommissioning is essentially the reverse of construction-phase activities, using similar vessels. The blades, nacelle and tower of the wind turbine are decommissioned using a jack-up vessel, which removes each component, places it on a transport platform and takes it to a suitable port.

The approach to foundation removal is to remove from the sea that part which is both technically feasible and reasonable. As a general rule, installations are decommissioned if the removal of their individual structures does not result in greater environmental disturbance than leaving them in place. For example, it is technically possible to lift GBS foundations installed a couple of decades ago from the seabed. At the same time, a valuable marine ecosystem may have developed on the foundations, which may not be damaged because they function as artificial reefs.

For monopile foundations, it is rational to remove the part in the water column but leave the part in the sediment in the seabed (since pulling it out may cause significant environmental disturbance and an inert metal object in seabed sediment does not cause negative environmental impact). To remove a monopile foundation, the wall of the monopile foundation is cut through (a few metres below the seabed surface) and lifted onto a transport platform and taken to port. A metal monopile foundation can readily be either reused or recycled. As with other industrial facilities, decommissioning of the offshore wind farm is the responsibility of the offshore wind farm owner.

For inter-array and export cables, whether the cables are left on the seabed or removed depends on the decommissioning plan. In certain cases, leaving the cables on the seabed may be preferable if this results in lower environmental impact. One of the main arguments in favour of leaving cables on the seabed is that removing the cable may disturb the seabed ecosystem that has stabilised around the cable over the years. On the other hand, the materials used in the cables, such as aluminium, copper and steel, are valuable, and their removal makes it possible to reuse existing resources. The cables can be fully removed from the seabed by carrying out the reverse of the installation process. Cable design choices can improve subsequent material separation and the quality of recycling. Recycling of traditional materials such as aluminium, copper and steel is already highly efficient and widespread, but the quality and efficiency of recycling can also be improved by removing the metallic water barrier surrounding the cable core.

2.8. Underwater noise associated with the construction and operation of the offshore wind farm

This chapter is based on the study report 'Assessment of underwater noise impacts in the additional area of the Saare-Liivi wind farm, including assessment of cumulative impacts', prepared by TalTech, Structural and Fluid Mechanics research group; 2024, updated 2026 (hereinafter in this report: Underwater noise study – TalTech, 2024/26; Appendix 3.1). The aim of the study was to model the propagation of construction-phase and operational underwater noise in the Saare-Liivi offshore wind farm area and, on the basis of the modelling results, provide input for the assessment of potential impacts on seals and fish. The biological significance of the modelled sound levels is not determined in this technical chapter, but in Sections 3.8 and 3.7 on the assessment of impacts on fish and seals.

The 50-turbine layout for the additional area used in the underwater noise study corresponds to main alternative 2 as applicable at the time of the study, not to the established solution set out in this EIA report, namely main alternative 3, under which up to 40 turbines are planned for the additional area. The operational noise model is therefore used as a starting point that overestimates the number of turbines. The underwater noise study considered a modelling scenario with up to 80 turbines in the initial area of Saare-Liivi and 50 turbines in the additional area. Under main alternative 3, which forms the basis for the final impact assessment, up to 40 turbines are planned for the additional area. Accordingly, operational noise modelling for 80 + 50 turbines constitutes, in relation to main alternative 3, a conservative starting point in terms of turbine numbers, i.e. one that tends to overestimate the impact.

Noise modelling was first carried out for the existing situation.

In addition, construction-phase underwater noise associated with different foundation types (gravity base foundation and monopile foundation) and their installation methods (four in total) was modelled. Two different wind turbines with rated capacities of 15 MW and 20 MW were considered. For the monopile foundation option, pile diameters of 12 and 18 metres respectively are used. The spectra of the acoustic sources generated during pile installation are taken from the QUONOPS software database. As the largest pile diameter in the database is 15 metres, the sound spectra for 18-metre piles have been extrapolated using, among other things, the results of the report (Bellmann 2020¹⁸). The modelling covered the initial and additional areas of the Saare-Liivi offshore wind farm (Appendix 3.1, Figure 3.1-1). In addition to construction-phase noise, operational underwater noise from operating turbines was modelled for technical alternatives 1 (15 MW) and 2 (20 MW) and for the combined scenario of the initial and additional areas; the results are presented in Sections 2.8.3 and 2.8.4. In the model, waves at the sea surface are the main source of natural ambient noise. The noise maps show median underwater sound levels in the 125 Hz and 500 Hz third-octave bands. The QUONOPS software was used for the modelling.

2.8.1. Existing situation

Before assessing construction-phase noise in the additional area of the Saare-Liivi offshore wind farm, it is important to clarify the existing situation prior to the start of construction.

¹⁸ Bellmann M. A., Brinkmann J., May A., Wendt T., Gerlach S. & Remmers P. (2020) *Underwater noise during the impulse pile-driving procedure: Influencing factors on pile-driving noise and technical possibilities to comply with noise mitigation values. Supported by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU)), FKZ UM16 881500. Commissioned and managed by the Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie (BSH)), Order No. 10036866. Edited by the itap GmbH*

The marine area studied encompasses the initial and additional areas of the Saare-Liivi offshore wind farm and the adjacent parts of the Gulf of Riga. Natural underwater sound levels are presented for January and July 2024, allowing seasonal changes in ambient noise to be assessed.

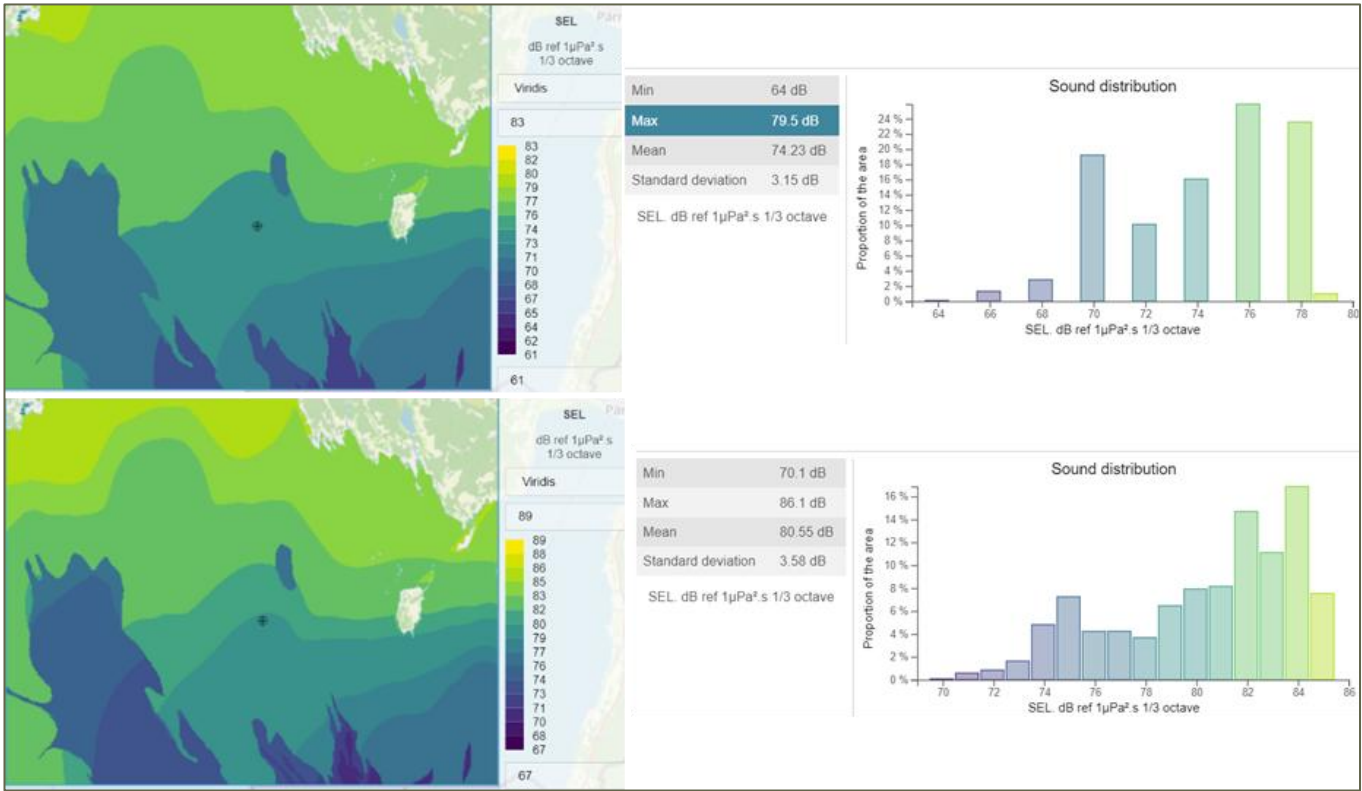


Figure 2.8-1. Modelled median levels of natural ambient sound. 125 Hz decade band at the top and 500 Hz decade band at the bottom, July 2024 (Underwater noise study – TalTech, 2024/26).

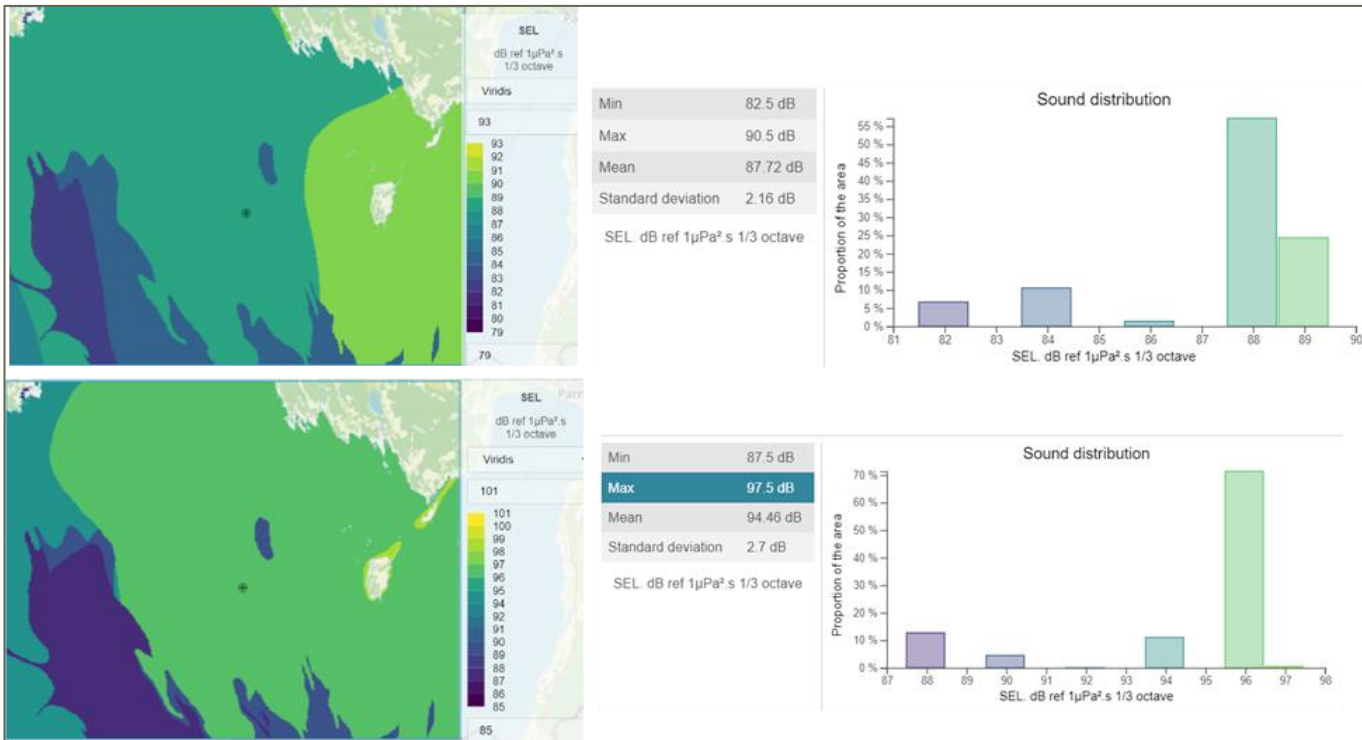


Figure 2.8-2. Modelled median levels of natural ambient sound. 125 Hz decade band at the top and 500 Hz decade band at the bottom, January 2024 (Underwater noise study – TalTech, 2024/26).

Table 2.8-1. Ambient sound levels in the initial and additional areas of the Saare-Liivi offshore wind farm (Underwater noise study – TalTech, 2024/26)

Season	0 - alternative sound level, dB re 1μPa					
	125 Hz			500 Hz		
	min	Mean	max	min	mean	max
July	64	74	80	70	81	86
January	83	88	91	88	94	98

2.8.2. Construction-phase noise

In the modelling of construction-phase noise, four technical scenarios for turbine installation during the construction period were considered. One gravity base foundation installation technology and three different possible monopile foundation installation technologies (drilling, vibro-driving and impact pile-driving) were modelled.

GRAVITY BASE FOUNDATION INSTALLATION

For assessing construction-phase underwater sound levels for the offshore wind farm, the model uses a worst-case scenario in which 7 vessels are present simultaneously in the marine area. In different parts of the marine area, dredging (A), rock placement (B), cable installation (C) and transport of the foundation by four tugboats (D) take place simultaneously. The works are carried out in July, and the noise map presents median sound levels.

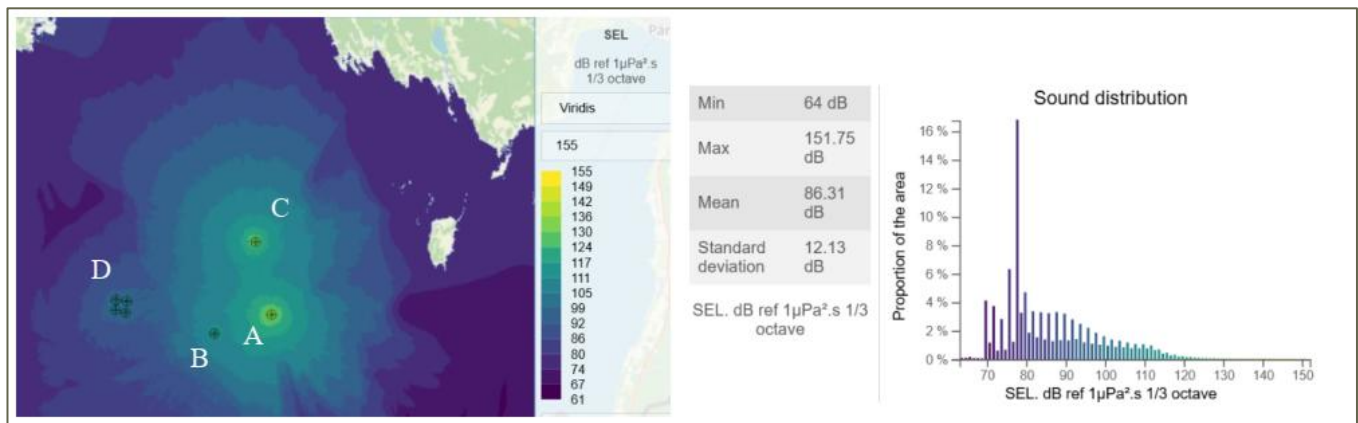


Figure 2.8-3. Modelled sound levels corresponding to the construction-phase “worst-case” scenario in the 125 Hz third-octave band. A - dredger, B - rock placement, C - cable installation and D - transport of the foundation by four tugboats.

The histograms show the distribution of sound levels. The sound level in the marine area has increased by an average of 12 dB compared with the 0 alternative. (Underwater noise study – TalTech, 2024/26).

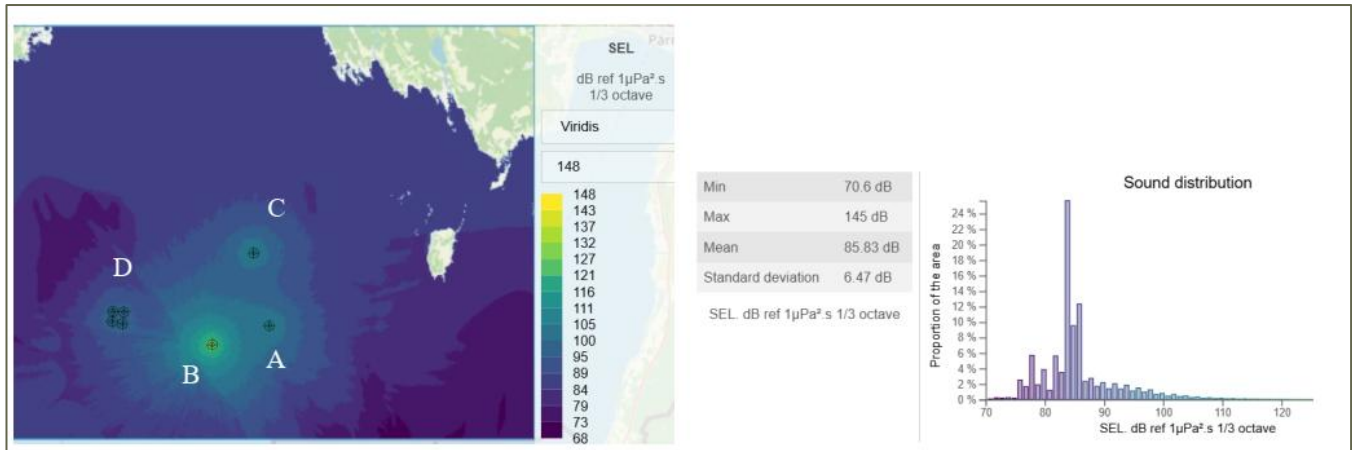


Figure 2.8-4. Modelled sound levels corresponding to the construction-phase “worst-case” scenario in the 500 Hz third-octave band. A - dredger, B - rock placement, C - cable installation and D - transport of the foundation by four tugboats.

The histogram shows the distribution of sound levels in the marine area. The sound level in the marine area has increased by an average of 5 dB compared with the 0 alternative. (Underwater noise study – TalTech, 2024/26).

By comparing the results obtained with the existing situation, it can be concluded that, due to gravity base foundation construction works, the median sound level may be higher by $86 - 74 = 12$ dB in the 125 Hz decade band and by $86 - 81 = 5$ dB in the 500 Hz decade band.

VIBRO-DRIVING OF PILES

Vibro-driving (*vibrodriving*) is a newer technology that allows faster pile installation while generally generating less noise than traditional pile-driving¹⁹. The piles are installed using a large vessel platform.

Vibro-driving is conventionally treated as a source of impulsive noise, as it operates over a relatively short period of time (3–4 hours to install a single pile). As this is a fairly strong noise source, noise from other support vessels may be disregarded in this scenario.

The modelling of pile vibro-driving was carried out for two technical solutions in which piles with diameters of 12 m or 18 m are installed near Kihnu Island.

¹⁹ <https://capeholland.com/applications/xxl-monopile-installation/>

1) VIBRO-DRIVING OF 18 m DIAMETER PILES

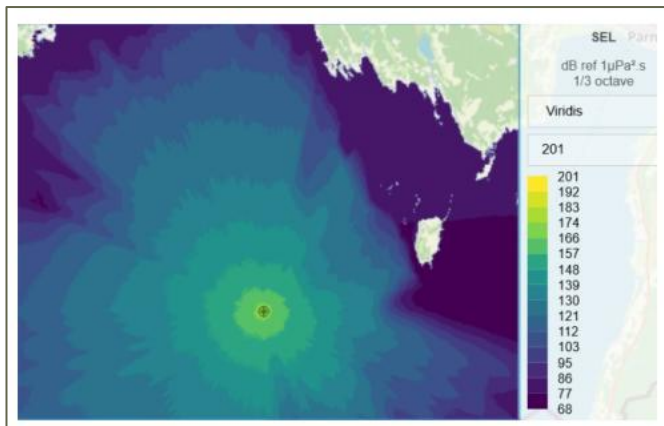


Figure 2.8-7. Modelled sound levels for pile vibro-driving in the 125 Hz decade frequency band, L05 exceedance level (for the 5% loudest sounds). A temporary threshold shift in Baltic herring may occur within a 100-metre zone (Underwater noise study – TalTech, 2024/26).

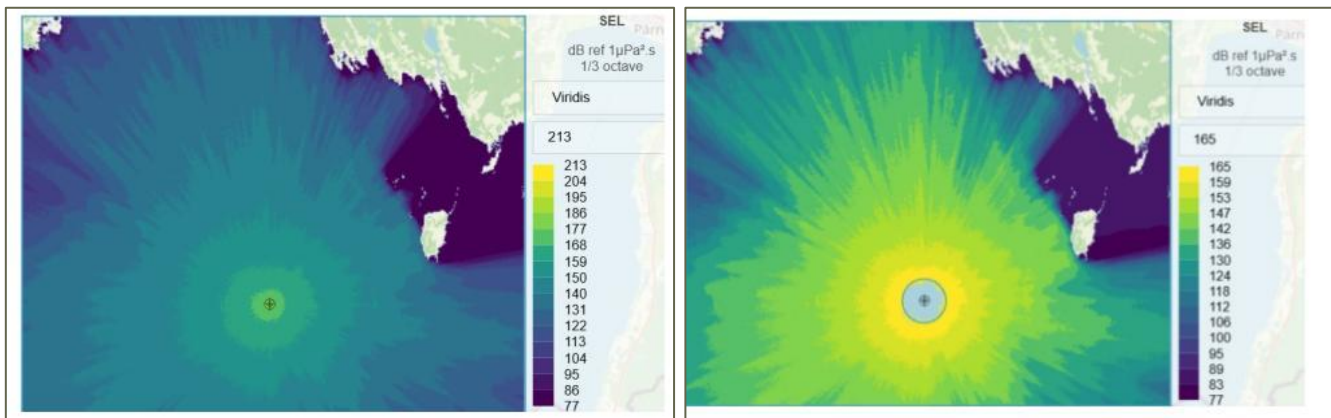


Figure 2.8-8. Modelled sound levels for pile vibro-driving in the 500 Hz decade frequency band, L05 exceedance level (for the 5% loudest sounds). On the right, the light blue circle indicates a zone with a radius of 3200 m in which a temporary threshold shift may occur in seals. A permanent threshold shift in seals may occur within a 350 m zone (Underwater noise study – TalTech, 2024).

DRILLING OF PILES

Pile drilling is also a relatively new technology that significantly reduces underwater noise emissions compared with conventional pile-driving.

Drilling is conventionally treated as a source of impulsive noise, as it operates over a relatively short period of time (3–4 hours to install a single pile). As this is a fairly strong noise source, noise from other support vessels may be disregarded in this scenario.

1) DRILLING OF 18 m DIAMETER PILES

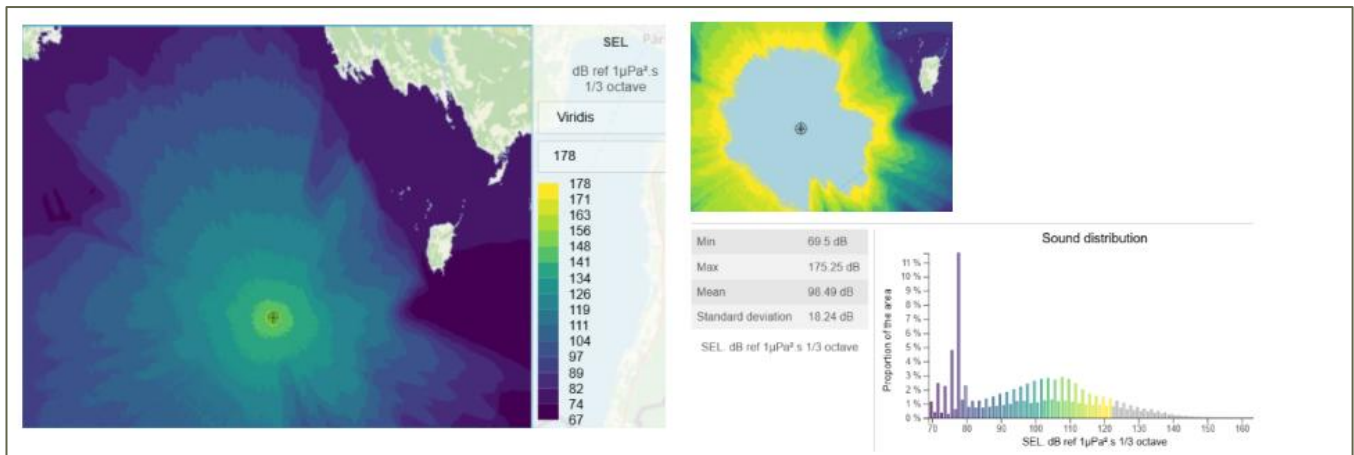


Figure 2.8-11. Modelled sound levels for pile drilling in the 125 Hz third-octave band. The histogram shows the distribution of sound levels in the marine area under assessment. In the upper figure, the area where the median sound level is higher than 118 dB (fish reaction level) is shown in light blue. No temporary threshold shift occurs in Baltic herring (Underwater noise study – TalTech, 2024/26).

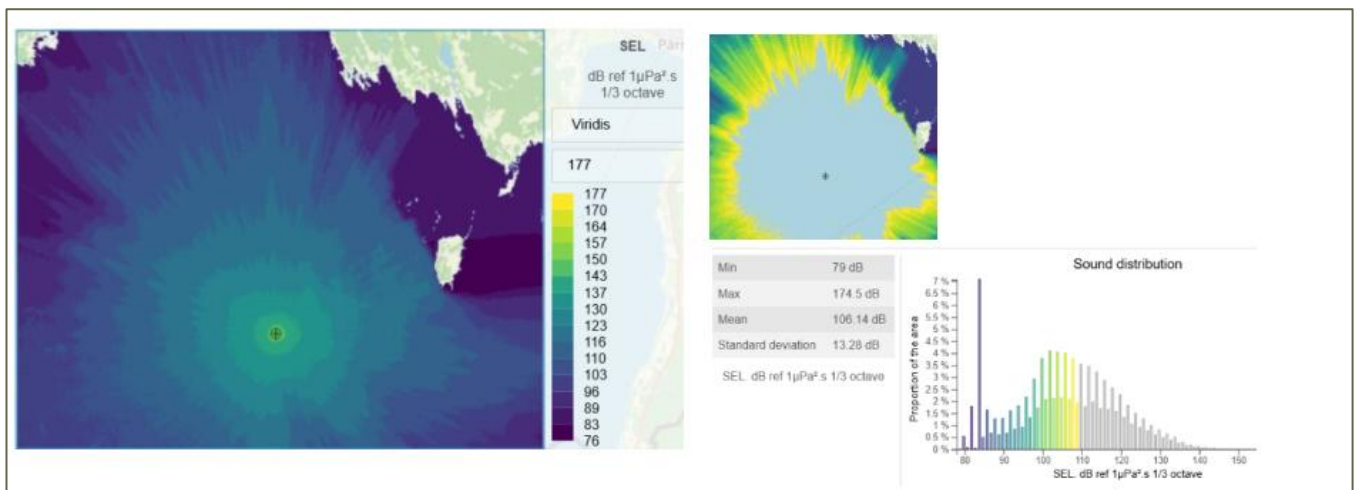


Figure 2.8-12. Modelled sound levels for pile drilling in the 500 Hz third-octave band. The histogram shows the distribution of sound levels in the marine area under assessment. In the upper figure, the area where the median sound level is higher than 110 dB (seal reaction level) is shown in light blue. A temporary threshold shift in seals may occur within a 40-metre zone (Underwater noise study – TalTech, 2024/26).

IMPACT PILE-DRIVING

During construction of the wind farm, pile-driving is the largest source of impulsive noise. The technically simplest mitigation measure for the noise impacts of impact pile-driving may be considered to be a soft start to pile-driving. Additional sound attenuation can be achieved by using a curtain of air-filled balloons (*Hydro Sound Dampers and encapsulated bubbles*). The most effective, but also costlier, mitigation measure is the generation of air bubble clouds (bubble curtain) (BBC - *Big Bubble Curtain*). The noise generated during pile-driving depends on the pile-driving technology, the hammer energy and the pile

diameter (Bellmann *et al.*, 2020²⁰). As this is a strong noise source, noise from other support vessels may be disregarded in this scenario.

1) IMPACT PILE-DRIVING OF 18 m DIAMETER PILES

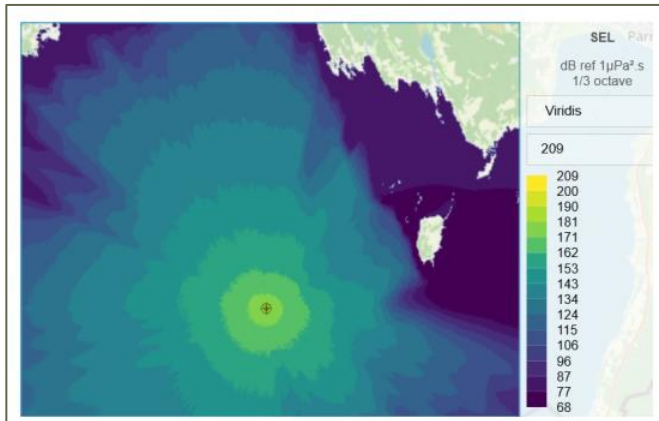


Figure 2.8-15. Modelled sound levels for impact pile-driving in the 125 Hz decade frequency band, L05 exceedance level (for the 5% loudest sounds). A temporary threshold shift in Baltic herring may occur within an area with a radius of 500 metres around the pile-driving site (Underwater noise study – TalTech, 2024/26).

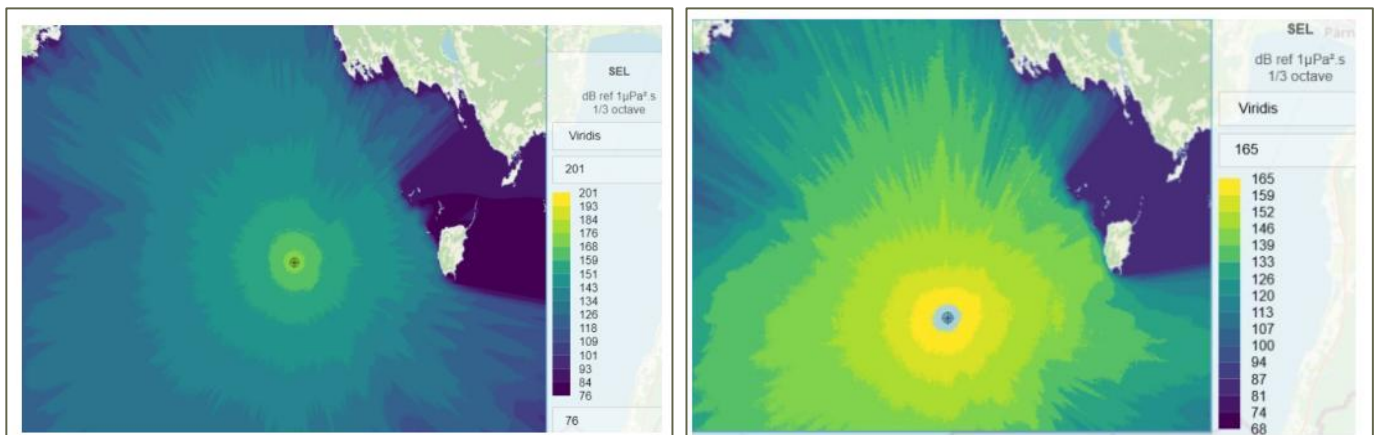


Figure 2.8-16. Modelled sound levels for impact pile-driving in the 500 Hz decade frequency band, L05 exceedance level (for the 5% loudest sounds). On the right, the light blue circle indicates a zone with a radius of 2000 m in which a temporary threshold shift may occur in seals. A permanent threshold shift in seals may occur within a 150 m zone (Underwater noise study – TalTech, 2024/26).

In summary, in terms of radiated sound, the foundation construction scenario with the lowest environmental impact would be the use of a gravity base foundation, followed by drilling of monopile foundations. The high noise levels that may accompany impact pile-driving and vibro-driving of monopile foundations near the pile being driven may cause permanent and/or temporary threshold shifts in seals (and Baltic herring) that happen to be present within the hazard zone, and mitigation measures must be applied (in more detail in the chapters assessing impacts on fish and seals, Sections 3.8 and 3.7).

²⁰ Bellmann M. A., Brinkmann J., May A., Wendt T., Gerlach S. & Remmers P. (2020) Underwater noise during the impulse pile-driving procedure: Influencing factors on pile-driving noise and technical possibilities to comply with noise mitigation values. Supported by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU)), FKZ UM16 881500. Commissioned and managed by the Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie (BSH)), Order No. 10036866. Edited by the itap GmbH.

2.8.3. Operational noise

During the operational period, the main sound sources are the wind turbines. For the purposes of assessing environmental impact during the operational period, it is conservatively assumed that both the initial area and the additional area of the Saare-Liivi offshore wind farm have been built out. For the additional area, the modelling was based on main alternative 2, under which 50 wind turbines are planned for the area (see Figure 2.8-17). Accordingly, two alternative turbine layout scenarios were modelled:

a) wind farms with 130 turbines (80 turbines in the initial area + 50 turbines in the additional area), each with a capacity of 15 MW, and b) wind farms with 130 turbines (80 turbines in the initial area + 50 turbines in the additional area), each with a capacity of 20 MW.

TECHNICAL ALTERNATIVE 2

Under technical alternative 2, the wind farms in the initial and additional areas comprise 80+50 wind turbines, each with a capacity of 20 MW.

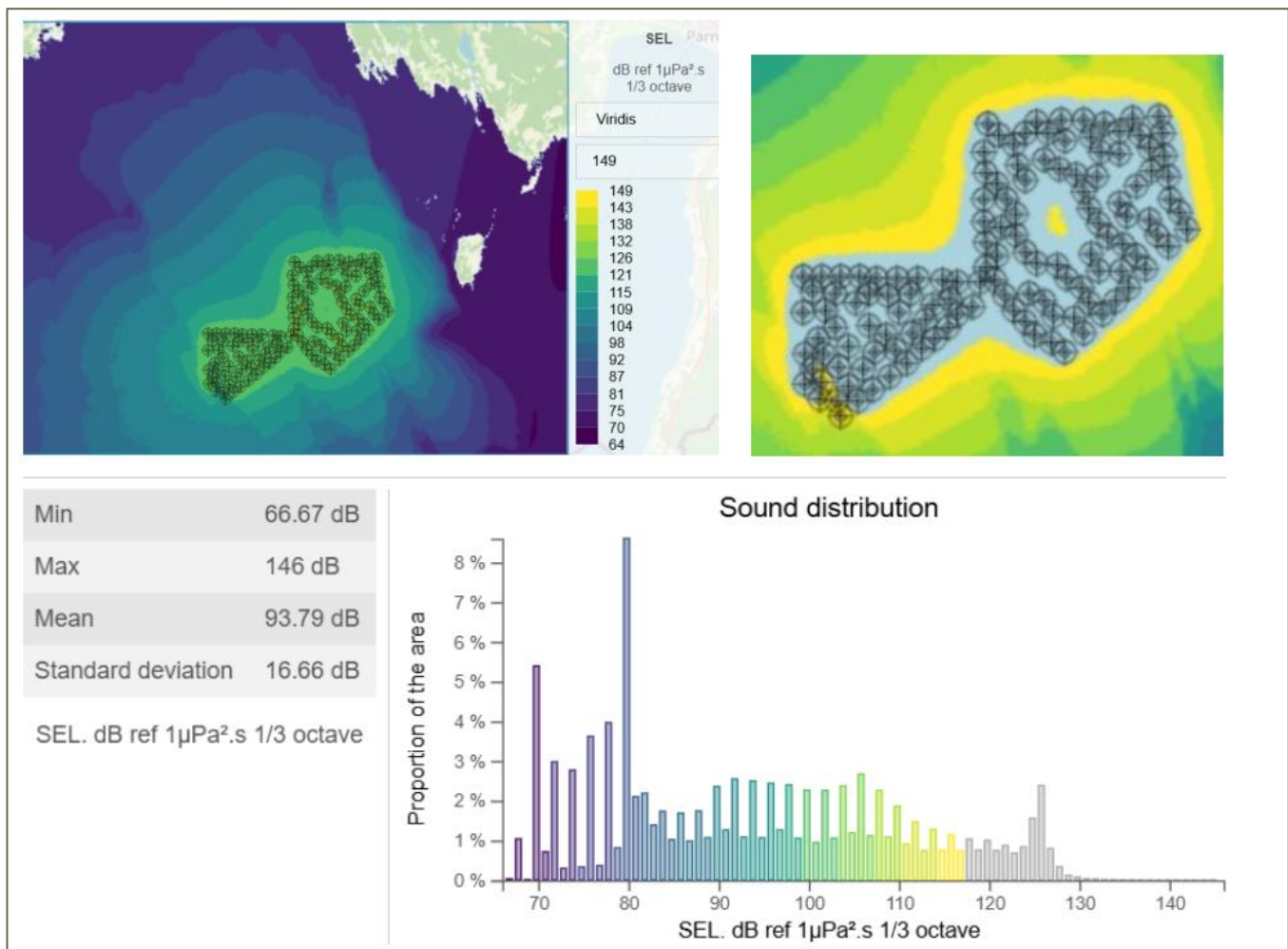


Figure 2.8-19. Modelled 125 Hz ddec sound levels for alternative 2 (20 MW) during the operational period. In the figure, the area where the median sound level exceeds 118 dB (fish reaction level) is shown in light blue. The histogram shows the distribution of sound levels in the marine area. The sound level in the marine area has increased by an average of 20 dB compared with the 0 alternative.

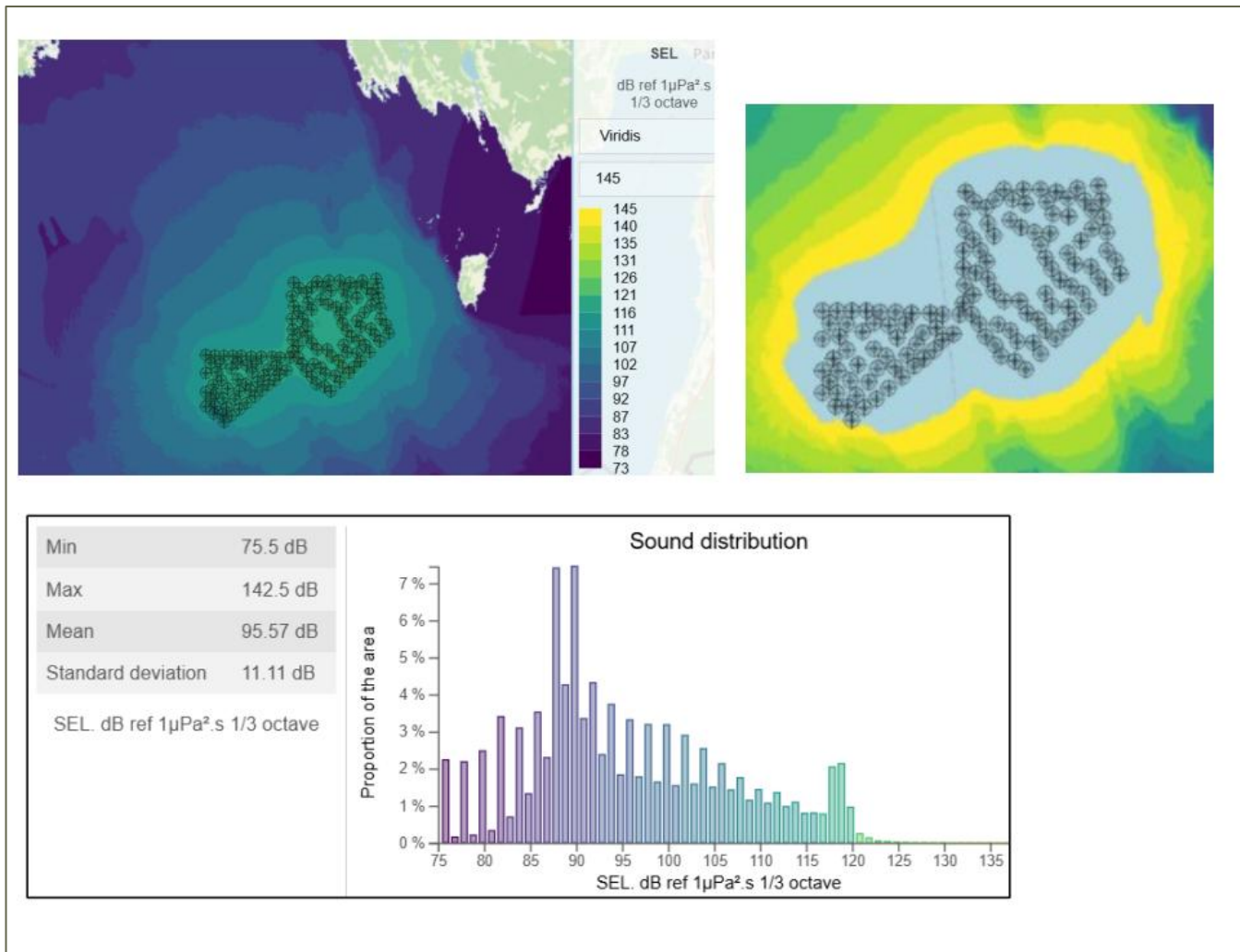


Figure 2.8-20. Modelled 500 Hz ddec sound levels for alternative 2 (20 MW) during the operational period. In the figure, the area where the median sound level exceeds 110 dB (seal reaction level) is shown in light blue. The histogram shows the distribution of sound levels in the marine area. The sound level in the marine area has increased by an average of 14 dB compared with the 0 alternative

As measurement results for the planned turbines are unavailable, the empirical formula proposed in the scientific article (Tougaard 2020²¹) was used to estimate the source sound levels. The vessel Windea la Cour²², with a length of 88 metres and a draught of 5.9 m, was modelled as the service vessel for the wind turbines.

Table 2.8-2. Description of sound sources during the operational period (Underwater noise study – TalTech, 2024/26)

Acoustic characteristics of sound sources			
Wind turbine capacity, MW	Frequency band, Hz	Wind speed, m/s	Source level, dB re 1μPa @ 1m
15 MW	16–4000	10	169

²¹ Tougaard, Jakob. 2020. "How Loud Is the Underwater Noise from Operating Offshore Wind Turbines?" J. Acoust. Soc. Am., 9.

²² <https://www.vesselfinder.com/vessels/WINDEA-LA-COUR-IMO-9769025-MMSI-218824000>

Acoustic characteristics of sound sources

20 MW	16–4000	10	172
Service vessel	16–4000	-	170

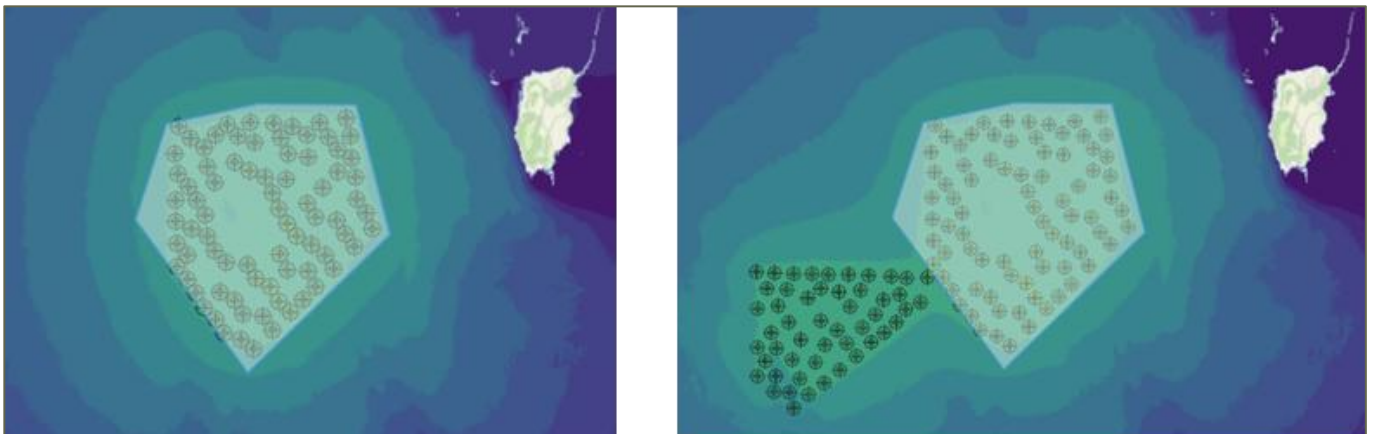
The modelling results for noise generated during the operational period by the different wind farm alternatives showed that technical alternatives 1 and 2 have similar impacts. The modelled sound levels during the operational period are significantly lower than those during construction, and the difference between technical alternatives 1 and 2 is approximately 0.1 dB, which is not distinguishable in terms of the significance of impacts. The biological significance of the modelled sound levels is assessed in Sections 3.7 (seals) and 3.8 (fish fauna).

The modelling results show the propagation of underwater sound under different construction and operational scenarios. Based on these results, the following chapters assess whether the modelled sound levels may cause significant impacts on different environmental receptors.

2.8.4. Cumulative impact

The final construction schedules for the proposed wind farms are not known, and therefore any possible temporal overlap of pile-driving cannot currently be confirmed or ruled out. For the installation of gravity base foundations, the radiated sound level, both for the installation of a single foundation and for the simultaneous installation of several foundations, is relatively low (comparable to the noise of a medium-sized vessel), and no significant cumulative impact is expected. If impact pile-driving or vibro-driving of monopile foundations overlaps with high-noise works of a neighbouring project, the developer of the additional area must, on the basis of the scheduling information available, assess the cumulative noise level and, where possible, adjust the timing of works in the additional area or apply mitigation measures. During drilling of monopile foundations, the radiated sound level is significantly lower than during pile-driving, and therefore impulsive noise mitigation measures specific to pile-driving (soft start, bubble curtain, acoustic deterrents) do not need to be applied to the same extent, although general precautionary measures are applied. The specific mitigation measures related to underwater noise are set out in the chapters assessing impacts on seals (Section 3.7.4) and fish fauna (Section 3.8.4).

During the operational period of the wind farms, each wind farm generates underwater noise within the boundaries of its own area, and neighbouring wind farms do not in practice increase the surrounding noise level. To verify this statement, it was modelled whether, and by how much, the modelled median sound pressure level in the possible offshore wind farm in the Saare-Liivi initial area changes before and



after the build-out of the additional area of the offshore wind farm. It is assumed that all offshore wind turbines have a capacity of 20 MW (a conservative approach).

Figure 2.8-21. *Saare-Liivi initial area offshore wind farm during the operational period under technical alternative 2 (20 MW), where cumulative impact is assessed. On the left – scenario 1, in which only the initial area is developed; on the right – scenario 2, in which both wind farm areas, i.e. the initial area and the additional area, are developed (Underwater noise study – TalTech, 2024/26).*

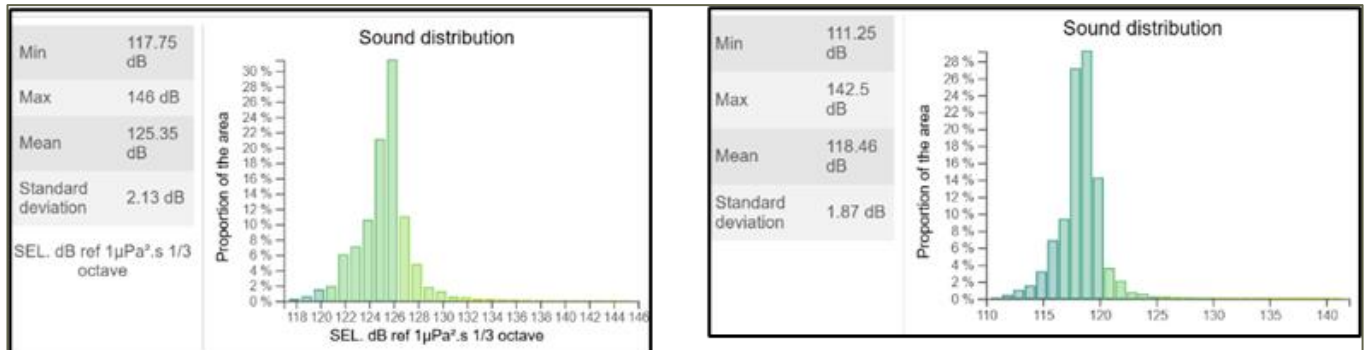


Figure 2.8-22. *Modelled sound levels during the operational period for the scenario with 80 × 20 MW turbines in the Saare-Liivi initial area: 125 Hz on the left and 500 Hz ddec on the right (Underwater noise study – TalTech, 2024/26)*

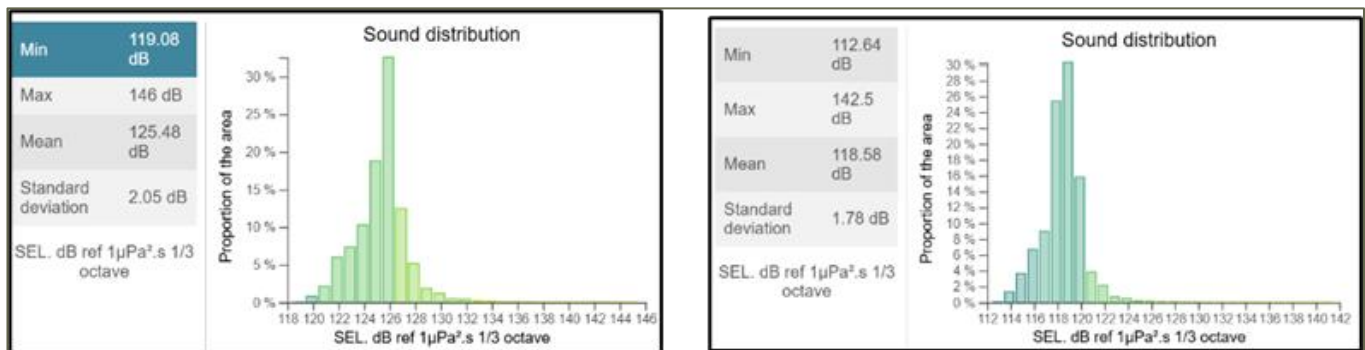


Figure 2.8-23. *Operational sound levels for the modelling scenario with 80 turbines in the Saare-Liivi initial area and 50 × 20 MW turbines in the additional area: 125 Hz on the left and 500 Hz ddec on the right (Underwater noise study – TalTech, 2024/26)*

As can be seen from the histograms presented in Figures 2.8-22 and 2.8-23, the average operational noise level under scenario 2 (initial and additional areas together) is practically the same as under scenario 1 (initial area only) (an increase of 0.1 dB). Accordingly, the modelling results show that there is no cumulative impact of operational noise between the initial area and the additional area and, based on the modelling results, the summation of operational noise from the Saare-Liivi initial area and the additional area is very small.

No significant cumulative impact with the Liivi Bay offshore wind farm is forecast either, but in the case of impulsive noise during construction (installation of monopile foundations), the in-combination effect depends on the overlap between the projects' construction schedules and the noise mitigation measures applied. The mitigation measures for the additional area and the principle of taking available scheduling information into account are set out in Sections 3.7.4 and 3.8.4.

The results of cumulative underwater noise modelling form the basis for the assessment of cumulative impact on seals and fish fauna in Sections 3.7 and 3.8.

This underwater noise assessment was based on main alternative 2 (up to 50 turbines in the additional area). During the preparation of the EIA, a smaller-scale main alternative 3 has emerged on the basis of various environmental considerations (up to 40 turbines in the additional area; see Section 2.3), and therefore the noise levels and the extent of impact areas presented in this chapter represent a conservative (upper-bound) estimate of the actual proposed scale.

3. Impact on the natural environment

3.1. Hydrometeorology and hydrodynamics

This chapter is based on the final report of the TalTech study 'Study of water quality, physical (including hydrodynamic) and biogeochemical parameters of the water column, and pollution dispersion for the EIA of the Saare-Liivi offshore wind farm' (TalTech, 2024; hereinafter the Water quality and hydrodynamics study; Annex 3.2) and on the study 'Study of cumulative impacts on hydrodynamics and the physical and biogeochemical parameters of the water column for the EIA of the Saare-Liivi offshore wind farm' (TalTech, 2024; hereinafter the Hydrodynamics cumulative impact study; Annex 3.3).

The TalTech study 'Analysis of the interaction between the Saare-Liivi offshore wind farm and the ice field'²³ was also used to describe ice conditions and assess impacts.

3.1.1. Consideration of alternatives

Hydrometeorological measurements and measurements of the existing condition of the water column covered the Saare-Liivi initial area, the 91.2 km² study area corresponding to main alternative 1 of the additional area, and their immediate surroundings. Main alternative 3 lies entirely within the studied area.

In TalTech's baseline study, three scenarios were used in the modelling:

- A0 – existing situation without the Saare-Liivi offshore wind farm;
- E1 – the configuration used in the study for the Saare-Liivi initial area;
- E1+T1 – the Saare-Liivi initial and additional areas.

The designations E1 and T1 are scenario labels from the baseline study and do not correspond to the numbering of main alternatives PA1–PA3 in this EIA report.

In the modelling configuration used in the study for the additional area, 50 wind turbines, i.e. the development scale referred to in this EIA report as main alternative 2 were used. Under main alternative 3, up to 40 wind turbines are planned for the additional area.

Therefore, in terms of the number of turbines, the modelling with 50 turbines describes a solution larger than main alternative 3, and the existing modelling results are used to assess the direction and expected order of magnitude of the impacts of main alternative 3.

3.1.2. Description of environmental status

Various hydrometeorological measurements have been carried out in the initial and additional areas of the Saare-Liivi offshore wind farm and in their vicinity. Utilitas Wind OÜ has collected data using a Lidar device on Kihnu island in 2022–2024 and in the marine area from August 2023 to August 2024. The offshore Lidar device collected the following data: wind speed and direction, current speed and direction, wave conditions, ice movement, air pressure, air temperature, water temperature (at the surface and/or bottom), precipitation.

²³ Analysis of the interaction between the Saare-Liivi offshore wind farm and the ice field. TalTech, 2024

WIND

Measurements carried out at sea confirm the observation data from the Kihnu weather station, according to which winds from the western and southern sectors prevail in the area and are also the strongest (Figure 3.1-2).

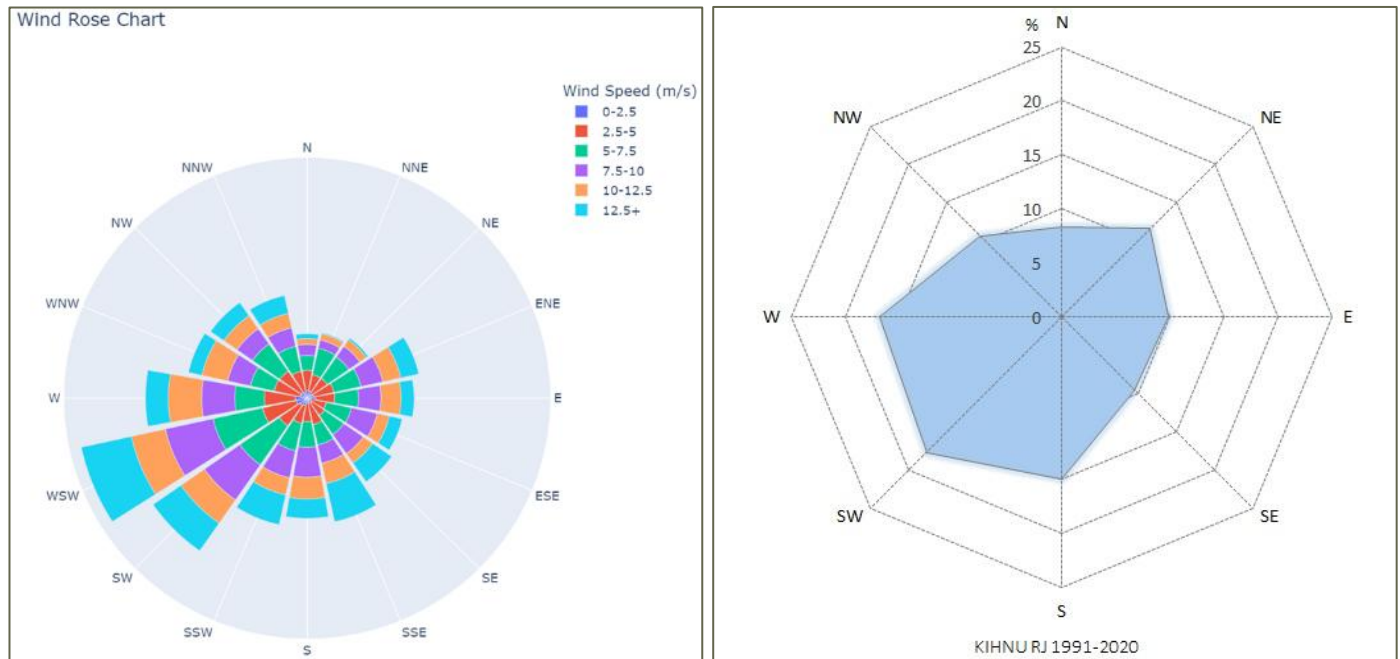


Figure 3.1-2. Wind rose for the Saare-Liivi initial area in 2023–2024 (Utilitas Wind measurements 2022–2024), on the left, and for the Kihnu weather station in 1991–2020, on the right

CURRENTS

During the autumn-winter period, barotropic (single-layer) currents occurred, which were associated with the direct and indirect effects of wind. The average current speed during the autumn-winter period was 4–5 cm/s, and the maximum hourly mean current speed was 14 cm/s (Figure 3.1-3). The currents measured during the summer-autumn period were stratified until mid-October, when the water column mixed under the influence of strong winds. The average current speed was then in the range of 5–8 cm/s, and the maximum hourly mean current speed was 26 cm/s (Figure 3.1-4).

Current direction correlated with wind direction (Figure 3.1-5). In general, the current was directed towards the NW, NE and ESE sectors in both the upper and near-bottom layers, which is consistent with the directions of the wind vectors.

Current directions are variable: the persistence parameter is 30–40% in autumn-winter and 20–30% in summer-autumn.

WAVE CONDITIONS

The wave height measured at station KW (Figure 3.1-6) did not exceed 1.5 m in terms of significant wave height (H_{sig}) from April 2023 to early July. In autumn-winter, wave events > 2 m were common. The highest $H_{sig} > 3.6$ m was recorded in early October 2023, when the hourly wind speed during the event was 19–20 m/s. On the basis of the scientific literature and wind statistics, it may be assumed that even higher waves may occur in the area. The highest waves occur with southerly, westerly and south-westerly

winds. According to Copernicus reanalysis data, there were four storms in the area during the period 1993–2022 when Hsig may have been around 5 m.

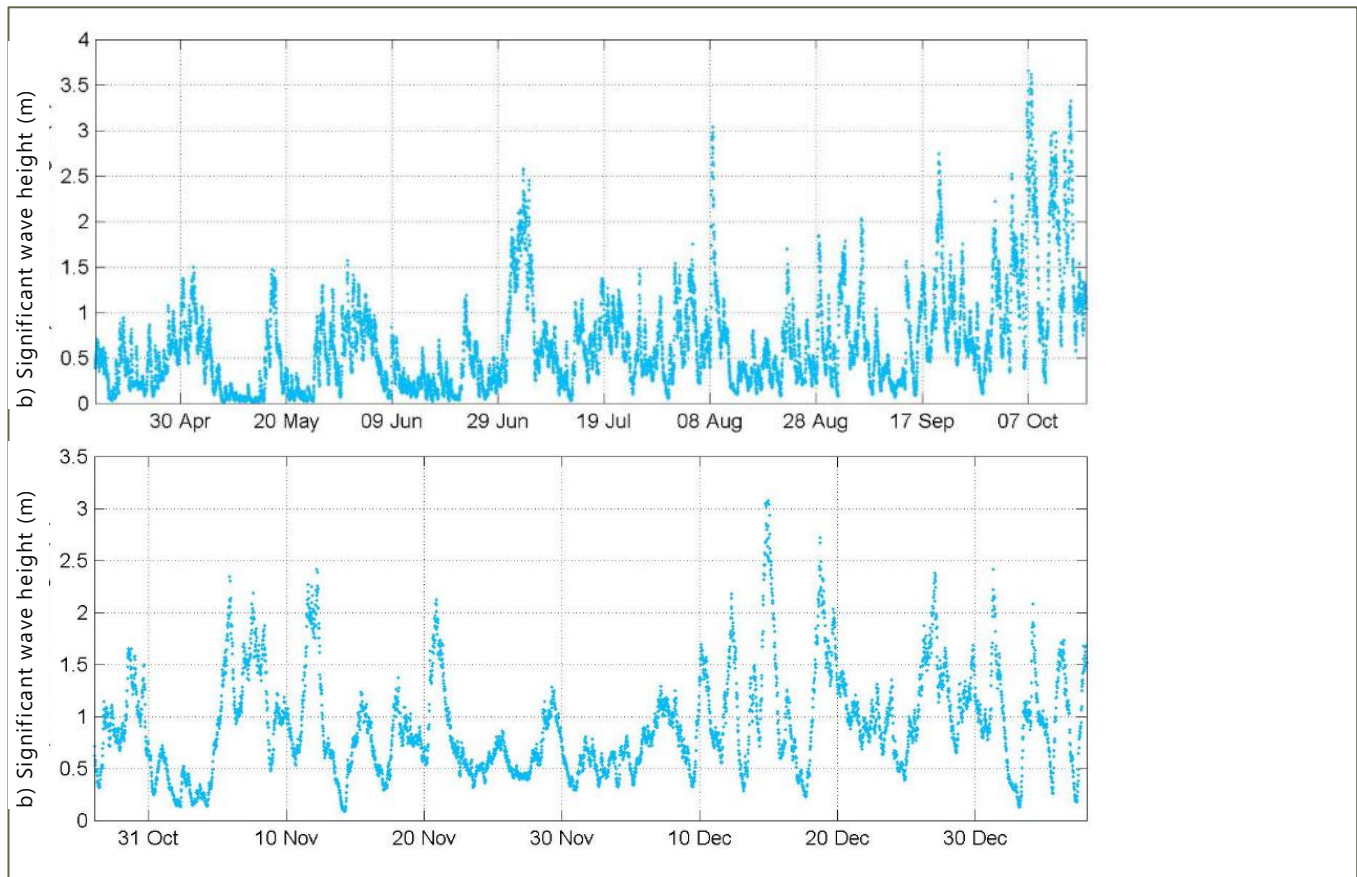


Figure 3.1-6. Significant wave height from 30.04.2023 to 31.01.2024

PHYSICAL PROPERTIES OF WATER

To clarify stratification, measurements of water parameters were carried out at station KW over the course of a year (Figure 3.1-8). By the end of October 2022, the water column at station KW was fully mixed, and there were no major differences in the parameters between the surface and bottom layers. By mid-January, a weak temperature and salinity transition layer had formed at around 10 m depth at station KW. Slightly cooler and less saline water was present in the surface layer. From April to September, a appreciable vertical gradients occurred in the water column parameters. During the stratified period, the lower layer is colder, more saline, richer in nutrients and has a lower oxygen content. Temperature and salinity were 11.4 °C and 6.2 g/kg, respectively. By October 2023, the water column had mixed again, and there were no major vertical gradients in the parameters at either station; temperature was approximately 9°C, salinity approximately 6 g/kg, chlorophyll approximately 2 mg/m³ and oxygen approximately 10 mg/l. The measurement data show that seasonal hypoxia may occur in the deep layer of the development area.

Measurements carried out in the surface layer show that coastal processes such as upwelling or the spread of river water do not have a direct strong influence on the initial and additional areas. Continuous measurements showed that water properties in the area are significantly influenced by vertical mixing events, basin-scale tilting of transition layers and advection.

ICE CONDITIONS

The Gulf of Riga is at least partially ice-covered every winter. As soon as the first sub-zero temperatures arrive, ice begins to form in shallow, isolated bays. Both fast ice and drift ice occur in the Gulf of Riga. Fast ice occurs in coastal areas and archipelago areas where the depth is less than 15 metres. Fast ice forms at the beginning of the ice season and persists until the melt period. Drift ice is inherently dynamic because it is influenced by winds and currents. Depending on the year, the ice season in the Gulf of Riga begins between the end of November and mid-January. The length of the ice season, which may last until the end of April, is 3–5 months.

In cold winters, the first sea ice usually begins to form in early December. Maximum ice cover is usually reached in February or March, and sea ice persists until the end of April (early May). In average winters, the first ice usually forms in late December or early January. In such winters, ice persists until mid-April, covering coastal areas and archipelagos for less than 70% of the duration of the ice season. In warm winters, almost the entire gulf is ice-free for most of the time. Only shallow coastal areas are ice-covered, and even those for less than 50% of the duration of the ice season.

In addition to the year-to-year differences in ice cover, there are also significant spatial differences between different areas of the Gulf of Riga. The open part of the Gulf of Riga is ice-covered for no more than 20% of the ice season. In cold winters, almost the entire Gulf of Riga becomes ice-covered. The northern part (the West Estonian archipelago and Pärnu Bay) is covered with ice for more than 60% of the ice season, whereas the rest of the area is ice-covered for up to 30% of the ice season.

Based on Copernicus Marine Service (CMEMS) model data for 1993–2021, ice occurred in the region of the Saare-Liivi initial and additional areas in every year except the winter of 2020 (Figure 3.1-11). On average, ice formed on 15 December and disappeared completely on 11 April. The earliest date of ice formation during the analysed period was 12 November (in the winter of 2016/2017), and the latest date of ice disappearance was 1 May (in the winter of 1995/1996). The average length of the ice period in 1993–2021 was 101 days (maximum 155 days, in the winter of 1993/1994).

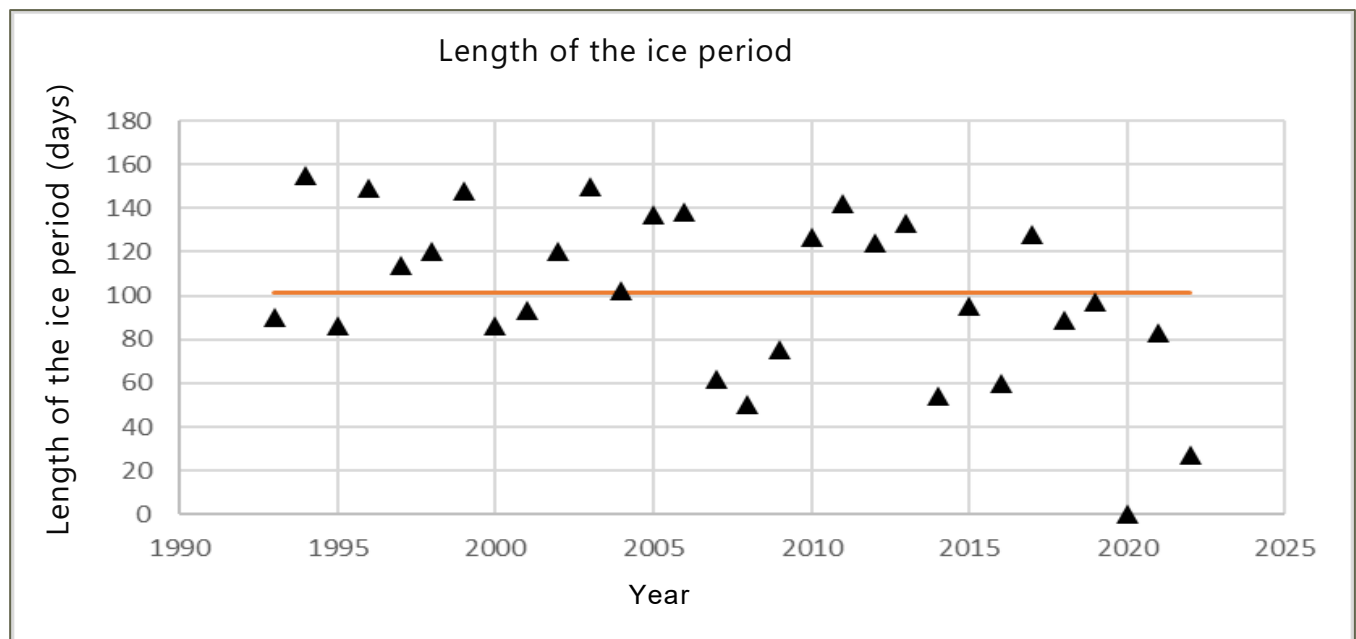


Figure 3.1-11. Length of the ice occurrence period in 1993–2021 according to Copernicus Marine Service data for the initial and additional areas. The orange line indicates the average length of the ice period for 1993–2022.

Figure 3.1-11 shows that the length of the ice period has decreased over the years and, since 2014, the length of the ice period has generally been shorter than the average for the last 30 years (101 days).

3.1.3. Impact assessment

The following numerical modelling results describe the E1 and E1+T1 configurations used in the baseline study. These are not precise forecasts of the impacts of the implementation of main alternative 3 for the additional area but describe the direction and possible order of magnitude of the impacts. For the numerical results, the scenario labels from the baseline study are retained, and their correspondence to the main alternatives in this report is set out in Section 3.1.1.

CURRENTS

To describe the average surface circulation of the Gulf of Riga, long-term model results for the period 2011–2019 and time averages of surface-layer current and salinity were used. In general, circulation in the southern part of the Gulf of Riga is anticyclonic – flow along the western part of the Gulf of Riga is directed northwards and along the eastern part southwards. The anticyclonic flow is particularly strong during the summer period (June–August, i.e. JJA), when current speeds along the coast are also higher and the anticyclone in the southern part is clearly distinguishable (Figure 3.1-12). During the winter period (December–February, i.e. DJF), the average surface-layer circulation is related to the wind regime – flow is predominantly towards the north-east (the most frequent winds in the Baltic Sea are south-westerlies), and no anticyclonic gyre forms/can be distinguished. In addition, during the winter period, strong northward flow is observable in the eastern part of the gulf, as well as dominant water transport through Suur Strait into Väinameri and from there onwards into the open Baltic Sea.

The temporal course of the spatial average of current speed is shown in Figure 3.1-13. The construction of wind turbines in the initial and additional areas reduces both parameters appreciably in the autumn–winter period, and somewhat less in the spring–summer period. The monthly mean surface-layer current speed may decrease by up to 2.5 cm/s. A reduction in current speeds in the area affected by the wind turbines is expected, because the wind stress exerted on the sea decreases. Compared with natural variability, the change is rather modest.

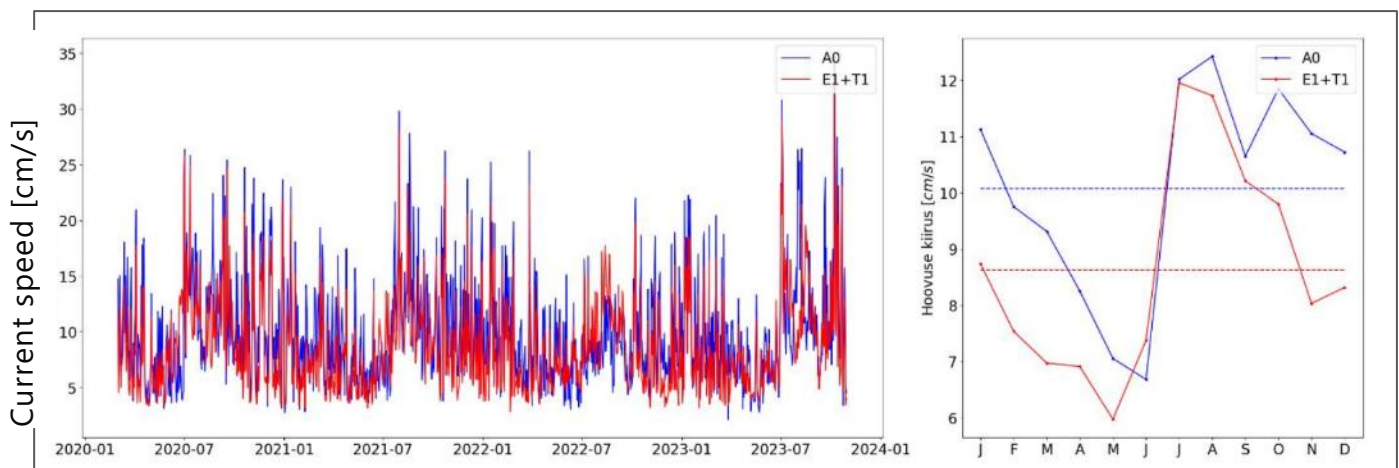


Figure 3.1-13. Temporal course of surface-layer current speed across the entire E1+T1 area (left) together with the seasonal cycle (right) for alternatives A0 and E1+T1 (initial + additional area)

WAVE CONDITIONS

A reduction in wind speed causes a decrease in wave energy downwind of the wind turbines in the initial and additional areas. The shadow effect created by the wind turbines is more modest at higher wind speeds, and therefore at wind speeds of ≥ 13 m/s the effect on wave height remains very modest. At lower wind speeds as well, below 7 m/s, the effect is relatively small. The effect is greater at intermediate wind speeds. At intermediate wind speeds, significant wave height decreases by at least 5 cm, and in places by nearly 10 cm. The effect on the long-term mean wave height field is significantly smaller, because an appreciable effect occurs only when the sea point under consideration lies downwind of the wind turbines and the wind speed is within the favourable impact range described above. The effect is somewhat greater to the east and north-east of the initial and additional areas, because the prevailing winds blow from the south-west and west. The average change in wave height caused by the wind turbines in the initial and additional areas is shown in Figure 3.1-14.

With winds blowing from land, wave height recovers at a certain distance after leaving the impact area of the wind turbines in the initial and additional areas. A marginal effect (up to a reduction of a couple of cm in significant wave height) may, in the favourable speed range and with winds from the western sectors, extend as far as the Kihnu coast. The average reduction in significant wave height on the Kihnu coast is likely to be undetectable.

Overall, it must be noted that the variability of natural factors affecting the wave climate is considerably greater than the effect of the wind turbines in the initial and additional areas. Because the wind generating waves is variable, the average reduction in significant wave height within the wind farm is up to a couple of cm. Taking into account the area's average significant wave height of ca 0.65–0.75 m, wave height within the wind farm decreases on average by up to 3%. Considering the Gulf of Riga as a whole, the effect is modest.

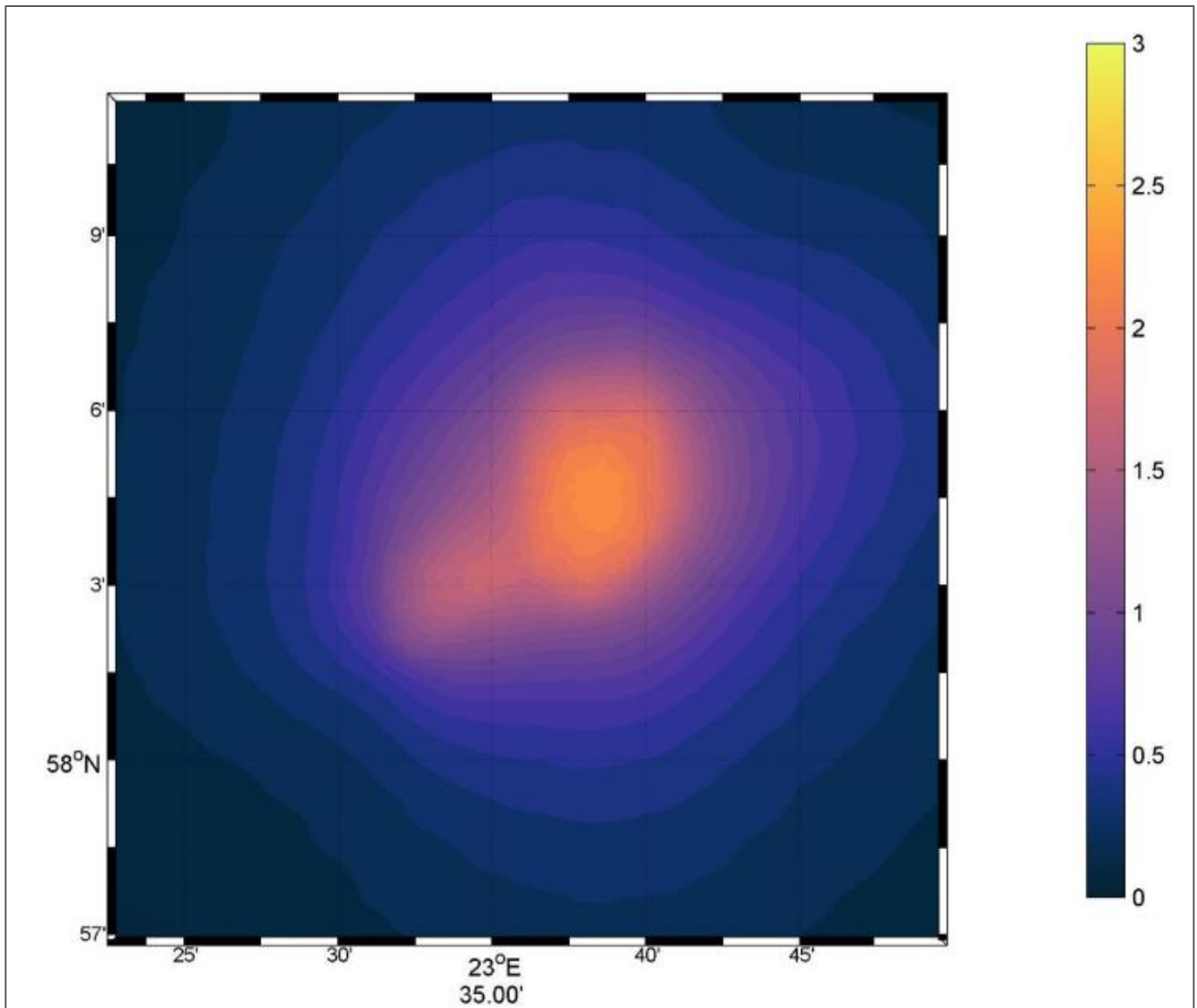


Figure 3.1-14. Average change in wave height (cm) in the initial and additional areas when wind turbines are placed there. In the calculation, ERA5 wind data for 1992–2021 have been used (Hersbach et al., 2020), but ice cover has not been taken into account. Therefore, the figure shows the maximum effect. In years with more ice, the effect may be even smaller.

PHYSICAL PROPERTIES OF THE WATER COLUMN

Habitat conditions in the water column are determined by the distributions of temperature, salinity, oxygen, nutrients, turbidity and other substances. Stratification and the vertical and horizontal gradients of substances are important. Based on the measurements, it can be concluded that (sub)mesoscale horizontal gradients do occur in the additional area, but the gradients of long-term mean fields are modest within the additional area.

In addition to the weakening of currents, a change in vertical mixing affects the properties of the water column. Vertical mixing, in turn, is a process that directly or indirectly affects all components of the marine system, because vertical mixing enables transport between the surface and deep layers of the sea. This transport partly defines the properties of both layers, which in turn determine habitat conditions in the pelagic zone. For example, vertical mixing plays an important role in the salinity of the Baltic Sea and the Gulf of Riga. The saline water mass arriving from the North Sea sinks into the lower layers of the sea and

mixes with the fresher surface water. Away from river mouths, the vertical transport of nutrients is important for primary production, because during the biologically active season nutrients in the upper sea layer are consumed until the limiting nutrient (phosphorus or nitrogen) is exhausted. Among other things, a reduction in vertical mixing promotes oxygen deficiency in the bottom layer. An increase in vertical mixing reduces the strength of stratification.

In recent years, several studies have demonstrated the importance of the effects of wind farms on vertical mixing and water-column habitats. On the one hand, turbine support structures cause additional mixing in the water column and weaken stratification²⁴. On the other hand, a reduction in wind stress at the sea surface reduces vertical mixing²⁵.

The temporal course of the mean mixed layer thickness, together with the seasonal cycle, is shown in Figure 3.1-17. The greatest effect of the wind turbines in the additional area on mixed layer thickness occurs in the spring-summer period, when the construction of the wind turbines reduces mixed layer thickness by up to 2 metres. A reduction in mixed layer thickness in spring may lead to an earlier and more intense spring bloom. For example, it has been found that, in the open Baltic Sea, owing to higher surface-layer temperatures over recent decades, the period during which the mixed layer is sufficiently thin for effective plankton growth has increased, which in turn has extended the period of higher biological productivity in the upper sea layer (Kahru *et al.*, 2016)²⁶. Given the uncertainty of the simulations, it is not possible to reliably provide a quantitative estimate of how much a change in mixed layer thickness could affect the spring bloom or primary production as a whole, but the potential for change exists.

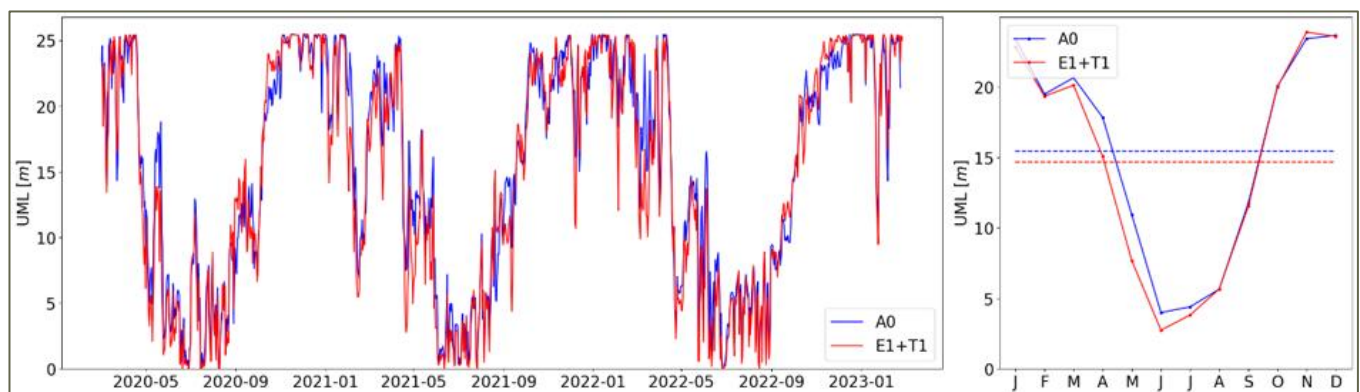


Figure 3.1-17: Temporal course of upper mixed layer thickness in 2020–2023 for the 0 alternative (A0 in the figure) and the initial + additional area (main alternative 2) (E1+T1 in the figure), together with the seasonal cycle for the same period (right)

ICE CONDITIONS

The TalTech study “Analysis of the interaction between the Saare-Liivi wind farm and the ice field”²⁷ has been used to describe ice conditions.

The wind turbines and structures of offshore wind farms affect wind conditions in the area, as well as ice formation and movement. The heating and cooling of wind turbines differs from that of seawater,

²⁴ Grashorn and Stanev, 2016

²⁵ Christiansen *et al.*, 2023

²⁶ Kahru, M., Elmgren, R., Savchuk, O.P., 2016. Changing seasonality of the Baltic Sea. *Biogeosciences* 13, 1009–1018. <https://doi.org/10.5194/bg-13-1009-2016>

²⁷ Analysis of the interaction between the Saare-Liivi offshore wind farm and the ice field. TalTech, 2024

affecting ice formation and melting processes. Seabed-fixed wind turbines create channels in the drifting ice field, and the ice breaks into smaller pieces that form ridges along the edges of the ice channels or against the turbine foundations. During the freezing and thawing of the channels, accumulations of rafted and ridged ice form. Under the influence of wind and currents, the disturbed ice field drifts away from the wind farm and may reach nearby shipping channels, other offshore structures and coastal areas.

In the study examining the interaction between the wind farms in the Saare-Liivi initial and additional areas and the drifting ice field, the ice-rich winter of 2011 was used as the basis and point of comparison, as a conservative case. First, the forces exerted by the ice field on a single wind turbine were modelled. The forces obtained were then applied to the ice field following the principle of interaction. The main results of the study were as follows:

1. **Changes in ice drift.** The wind farms located in the initial and additional areas, by obstructing free ice drift, alter the drift of ice masses and the spatial distribution of the ice field, as well as the location and geometry of openings in the ice. The effect of the wind farms is greatest in hindering the drift of the ice field forming in the north-eastern part of the gulf, in the immediate vicinity of the wind farms. The coastal waters between Kihnu and Saaremaa are affected the most, where ice trapped in the wind farm may keep the ice field intact, thereby reinforcing the landfast ice mass and keeping it close to the shore (Figure 3.1-18). When ice becomes trapped in the wind farms, ice thickness increases both within the wind farms and at their edges, i.e. ice ridging occurs (example in Figure 3.1-19). When ice becomes trapped in the wind farms, open water forms in their lee (Figure 3.1-20).
2. **Spread of ridged ice caused by the wind farms in the initial and additional areas.** In the wind farm area, owing to the obstruction caused by the wind turbines, a longer ice period and thicker ice cover can be expected as a result of both ridged ice trapped behind the wind turbines and ice growth retained within the wind farm area. Due to winds, the ridged ice formed at the wind turbines may accumulate and undergo renewed ridging. The greatest effect occurs during strong easterly winds, when the ice field formed along the eastern coast of the Gulf of Riga breaks up and drifts offshore. If the ice field becomes trapped in the wind farm, new ice ridges may form at the edges of the wind farm. In a breaking-up and moving ice field, accumulated ridged ice fields may also be carried into the eastern and southern parts of the gulf.
3. **Spread of ridged ice formed at the wind turbines to shipping routes and small islands.** In ice-rich winters, such as 2011, which was used as the basis for the modelling, ridged ice in the drifting ice field, deformed by the wind farms in the initial and additional areas, may reach the western and southern coasts of Ruhnu Island and the western and north-western coasts of Kihnu Island. The coasts mainly affected are those facing the wind farms (Figure 3.1-22). On both islands, ridged ice is more prevalent on the west coast than on the east coast. In the case of Ruhnu Island, this indicates the importance of earlier ice-drift events, because ice carried into the vicinity of the island by westerly winds can do so only if it has previously drifted, under easterly winds, from the wind farm into the sea area west of the island. In the case of Kihnu, ice is transported to the coast and nearby islets mainly by north-westerly winds. Drift ice reaches the southern and south-western coast of the island, similarly to Ruhnu, in cases where ice masses deformed in the wind farm have previously been transported by easterly and northerly winds to areas west of the island. Whereas persistent landfast ice, which prevents the spread of deformed ice, plays an important role on the west coast of Kihnu, in the case of Ruhnu all nearshore waters and coasts are affected relatively evenly. Easterly winds are required for the deformed ice field to move behind Ruhnu. By contrast, in winters with little ice, landfast ice occurs along the edges of the Gulf of Riga, and Ruhnu Island remains practically unaffected by ice and probably also by wind-farm-affected ice.

3.1.4. Environmental measures

MITIGATION MEASURES

The modelled changes in currents, wave conditions and sea ice are local and remain significantly smaller than the natural variability of the Gulf of Riga. Therefore, no separate mitigation measures are required to reduce these impacts.

ENVIRONMENTAL MONITORING

Follow-up assessment is required to verify the model predictions. For at least one year before the construction of the wind farm in the additional area and for one year after it is commissioned, the following must be carried out:

- measure current speed and direction;
- measure chlorophyll-a, temperature and salinity in the upper water layer from the disappearance of the ice cover until autumn;
- measure oxygen, temperature and salinity in the near-bottom layer from May to October.

Measurements must be taken at least one station located within the impact area of the wind farm in the additional area and at one reference station with comparable natural conditions outside the impact area. The exact location, timing and methodology of the monitoring must be agreed with the Environmental Board before measurements begin and, where possible, aligned with the monitoring of the offshore wind farms in the initial area and the Gulf of Riga. If the monitoring described has already been carried out in any of the above-mentioned offshore wind farm areas and the model predictions have been validated, monitoring of the additional area may be dispensed with, subject to agreement with the Environmental Board.

When organising winter navigation and ice management, the extent, concentration, drift and ridging of the ice cover, as well as the impact of any icebreaking operations on the ice cover, must be monitored.

3.1.5. Summary

Based on the modelling results, implementation of main alternative 3 for the additional area of the Saare-Liivi offshore wind farm does not cause a significant change in the general circulation, water exchange, wave climate or ice conditions of the Gulf of Riga. The impacts manifest predominantly as local changes in the additional area of the Saare-Liivi offshore wind farm and its immediate surroundings.

If the Saare-Liivi initial and additional areas are developed, the mean surface-layer current speed may decrease by approximately 2–2.5 cm/s in the autumn-winter period and generally by less than 1 cm/s in summer. The mean significant wave height within the wind farms may decrease by up to approximately 3%. According to the model, the effect on the long-term mean wave height at Kihnu and other coastal areas is very small, and no significant change in coastal processes is forecast.

In the additional area, the thickness of the upper mixed layer may decrease in spring and summer. The exact effect of the change on primary production and oxygen conditions in the near-bottom layer cannot be quantitatively assessed, but the potential for change exists; this is assessed together with the impact on seawater quality in section 3.3.

In cold winters, the wind turbines in the initial and additional areas may locally affect ice drift, ice concentration and the distribution of ridged ice. Based on the existing modelling, no significant adverse impact on coastal processes is forecast, but changes in ice conditions must be taken into account when organising winter navigation.

Overall, the impact of main alternative 3 for the additional area on the hydrodynamics and wave conditions of the Gulf of Riga is assessed as neutral to minor negative (0/–). No significant adverse impact is anticipated.

Table 3.1-1. *Impact associated with planning the wind farm and its significance*

Associated impact	Significance of the impact before measures	Measures and final assessment
Impact on hydrodynamics during the construction and decommissioning phase	0	No measures are required. Residual impact 0
Operational impacts		
Local changes in current speed and water transport	0/–	No mitigation measures are required; monitoring to verify the model results
Local changes in wave conditions and coastal processes	0/–	No significant impact on the coast; residual impact 0/–
Change in mixed layer thickness and stratification	0/–	Water-column monitoring; biogeochemical consequences in section 3.3
Change in ice concentration, drift and ridging	0/–	Monitoring of winter navigation and ice conditions; residual impact 0/–

Scale used in the EIA report for significant environmental impact: - minor negative impact, -- significant negative impact, 0 - no impact, neutral, + minor positive impact, ++ significant positive impact

3.1.6. Cumulative impact

HYDRODYNAMICS

In the cumulative impact study, the then-current 120-turbine design for the Saare-Liivi initial area, the 50-turbine design for the additional area and the 67-turbine design for the Liivi Bay offshore wind farm were modelled, i.e. 237 wind turbines in total. This is a study scenario, not the final development scale proposed at the time of preparation of this report. A superficies licence has been granted for the Saare-Liivi initial area for the construction of up to 80 wind turbines, and main alternative 3 for the additional area includes up to 40 wind turbines. According to current information, the alternatives currently under consideration for the Liivi Bay offshore wind farm include 50–84 wind turbines. Thus, according to the current project designs, the total number of turbines across the three areas would be approximately 170–204, i.e. lower than in the modelled design.

The impacts of the three possible development areas on hydrodynamics and on the physical and biogeochemical parameters of the water column were assessed cumulatively. The modelling showed the following:

- The construction of the three offshore wind farms (the Saare-Liivi additional and initial areas and the Liivi Bay offshore wind farm) is likely to entail a cumulative impact on current fields. The circulation of the Gulf of Riga as a whole does not change, but local changes in current structure occur. The larger changes would occur in surface-layer currents. Within the wind farm areas, surface-layer current speeds decrease and water transport through the parks is reduced. At the edges of the wind farms, especially in summer, stronger surface currents form to compensate. Thus, the kinetic energy of surface-layer currents within the wind farm areas tends to decrease and tends to increase in the immediate surroundings of the wind farms. During the winter period, surface currents within the wind farm areas also slow somewhat, but the changes around the wind farms are more modest. Changes in bottom-layer currents are smaller than those in the surface layer. The interaction is directed primarily from the Liivi Bay offshore wind farm towards the Saare-Liivi additional area: according to the study simulations, surface-layer current speeds and kinetic energy in the additional area decrease further precisely when the Liivi Bay offshore wind farm is in operation, whereas the effect of the other areas on the surface-layer kinetic energy in the Saare-Liivi initial area remains modest. In summer, the changes remain on average below 1 cm/s. In winter, changes in the mean bottom-layer current speed in the Saare-Liivi initial and additional areas reach close to 1 cm/s.
- The construction of the three offshore wind farms (the Saare-Liivi additional and initial areas and the Liivi Bay offshore wind farm) entails a small cumulative impact on the wave field. The cumulative impact on wave conditions is greatest with winds blowing in a north-west–south-east direction at speeds of 7–10 m/s. Such winds occur in the area approximately 7% of the time. At the coast of Kihnu, the mean wave height may decrease by 1–2 cm when all three offshore wind farms are present. A minor cumulative impact may also occur on the Häädemeeste-Ikla-Ainaži coast in westerly and north-westerly winds. The mean impact on wave height there remains modest, at less than 1 cm. According to the study, the transboundary environmental impact on wave conditions is mainly associated with the Liivi Bay offshore wind farm: under favourable winds, wave height near the state border may decrease by 10 cm or slightly more, while the additional contribution of the Saare-Liivi initial and additional areas is limited on average to a couple of centimetres. Within the wind farms, significant wave height decreases on average by 4–6% when all three development areas are present. The variation in natural factors affecting wave climate is considerably greater than the impact of the wind farms. Considering the Gulf of Riga as a whole, the impact is not significant.
- The wind farms (the Saare-Liivi additional and initial areas and the Liivi Bay offshore wind farm) do not alter the salinity distribution in the Gulf of Riga. A local impact can be detected in the vicinity of the wind farms. Salinity decreases in the wind farm areas, and this change is most pronounced when all areas are present. Changes in salinity are stronger under stratified conditions. During the stratified period, surface-layer salinity tends to decrease in the wind farm areas, but tends to increase in the immediate surroundings of the wind farms. It may be assumed that such trends are related to weaker transport within the wind farm areas and to stronger currents forming around the wind farms as compensation, bringing more saline water there. A reduction in vertical mixing may also contribute to some extent to the decrease in surface-layer salinity. Similarly to the surface layer, bottom-layer salinity in the wind farm areas also decreases slightly in summer. By contrast, to the south-west of the wind farms, in the deeper area from which more saline water should be transported to the wind farm areas, salinity increases. During the winter period, the patterns of salinity change are highly variable, but the general tendency is similar to that in the stratified period, i.e. salinity within the wind farm areas tends to decrease slightly and to increase slightly away from the wind farms. Compared with the seasonal and short-

term variability of salinity under existing conditions, the impact of the wind farms is not significant, being limited to up to 10% of the aforementioned variability.

- The thickness of the mixed layer decreases within the wind farm areas (the Saare-Liivi additional and initial areas and the Liivi Bay offshore wind farm), and this change is greatest when both the initial and additional areas and the Liivi Bay offshore wind farm are constructed. As a result of the interaction between the wind farms, an area forms to the south and south-west of Kihnu where mixed layer thickness decreases. Further from the wind farm areas, to the south-west and south, mixed layer thickness increases. The latter may be explained by the formation of a convergence zone. If the current in the prevailing flow direction is slowed by the wind farms, a convergence zone forms in front of the obstacle. The decrease in mixed layer thickness in this area occurs in late winter and spring, and to some extent also in summer. According to the study, the area in which mixed layer thickness changes by at least 0.5–1 m increases non-linearly with the addition of the third wind farm, indicating the cumulative nature of the impact of multiple wind farms.

Thus, cumulative impacts are manifested primarily locally in the intensification of changes in currents, wave conditions and water-column properties in areas where the zones of influence of different offshore wind farms overlap. Even with the in-combination effect of several wind farms, the general hydrodynamic functioning of the Gulf of Riga does not change and no significant impact occurs.

The cumulative impact assessment showed that from July to September the oxygen content of the near-bottom layer may decrease, and the area with an oxygen decrease of more than 0.3 ml/l increases several-fold when the Liivi Bay offshore wind farm is added to the Saare-Liivi initial and additional areas. The significance of this impact and the need for monitoring are discussed in section 3.3.

ICE CONDITIONS

The cumulative impact on ice conditions was modelled for the Saare-Liivi initial and additional areas in combination with the proposed Liivi Bay offshore wind farm. The addition of the Liivi Bay offshore wind farm does not entail significant changes in the large-scale behaviour of the ice field, although local and temporal changes do occur. In the offshore area to the south of the wind farms, the number of ice days decreases. In the Pärnu Bay area, the wind farms virtually do not increase the average number of ice days (Figure 3.1-24, top right). Nor do the wind farms significantly alter the number of ice days in other coastal areas, although there are some day-to-day variations in the amount of ice. Mean ice thickness (Figure 3.1-24, middle row) increases somewhat in the sea area to the west and north-west of the wind farms, whereas in the coastal sea to the south and north-east mean ice thickness changes little and tends rather to decrease. Mean drift speed (Figure 3.1-24, middle row) decreases in the vicinity of the wind farms, while in certain areas a slight increase in drift speed can be seen.

Also in the case of the three offshore wind farms (the Saare-Liivi additional and initial areas and the Liivi Bay offshore wind farm), the ridged ice field moves throughout the Gulf of Riga, but the extent of the ridged ice field is significantly greater. Ice fields deformed by the wind farms occurred most frequently in the immediate vicinity of the wind farms. Through the drift of the ridged ice field, the impacts of the wind farms are observable up to 100 km from the areas, but ridged ice fields caused by the turbines generally do not reach mainland coastal areas. Ice floes originating from the wind farms spread towards the south of the gulf, while to the north and north-east the deformations extended as far as the edge of the mainland fast ice, which prevented the ridged ice from reaching the shore. On the coasts of the eastern and south-eastern parts of the gulf, where there was persistent fast ice, the impacts of the wind farms were not significant. At the end of the ice period, the remaining ice field, and thus also the ridged ice, becomes concentrated in the southern part of the Gulf of Riga.

On the Pärnu–Ruhnu shipping route, ice behaves similarly with the three offshore wind farms (the Saare-Liivi additional and initial areas and the Liivi Bay offshore wind farm) as with the two offshore wind farms (the Saare-Liivi additional and initial areas) (see section 3.1.3). In the southern part of the Gulf of Riga (Figure 3.1-25, centre), some ridged ice occurs from the beginning of February. As the ice period progresses, the ridged ice shifts from the western direction of the section shown towards the south-east, in the direction of Riga.

In the north, east and south coastal areas (Figure 3.1-25, bottom), ridged ice generated by the wind farms (the Saare-Liivi additional and initial areas and the Liivi Bay offshore wind farm) practically does not arrive due to the presence of fast ice, and this section is characterised by fast ice throughout the ice season. At the end of the ice season, however, in the second half of April (Figure 3.1-25, bottom right), the ridged ice field may be driven ashore on the Gulf of Riga coast immediately south and south-west of Ruhnu Island. The ridged ice field created by the wind farms moves into the vicinity of Ruhnu from mid-February onwards, and the most intensive movement of ridged ice takes place in March. Due to the fast ice near the coast, the entire ridged ice field does not move onto the Ruhnu coast. The ridged ice that has moved close to the coast would probably not differ significantly from naturally formed ridged ice near Ruhnu.

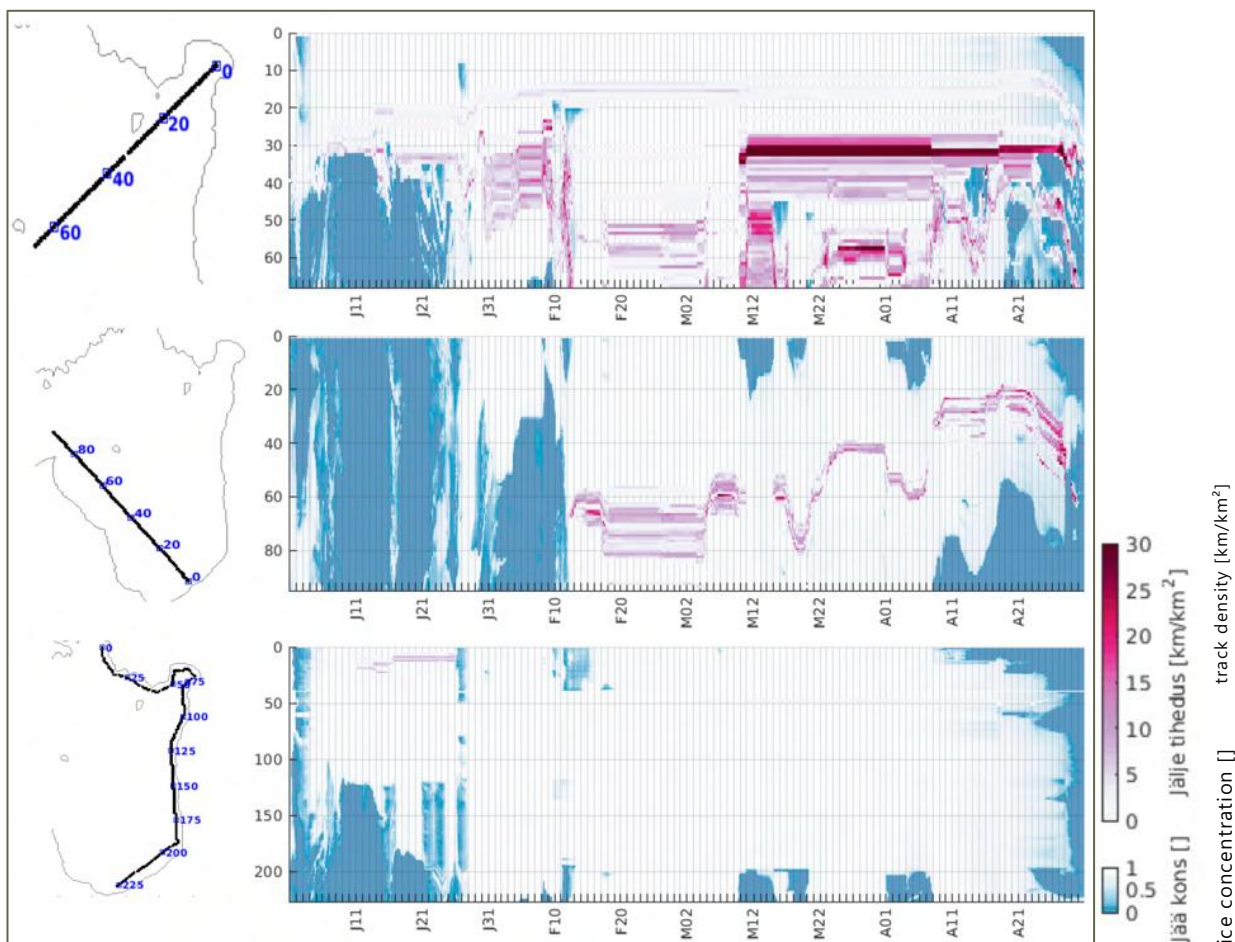


Figure 3.1-25. Drift of deformed ice on the Pärnu-Ruhnu shipping route (top), in the southern part of the Gulf of Riga (centre) and in the north, east and south coastal areas (bottom).

3.1.7. Uncertainty/knowledge gaps

The assessment of hydrodynamics and water-column conditions is based on TalTech measurements carried out from a research vessel, at buoy stations and with a glider. Continuous measurements focused

primarily on the vicinity of measurement station KW, while vessel- and glider-based measurements provided information on the spatial variability of the area. The measurement dataset makes it possible to describe the conditions during the study period and the main spatial and temporal changes, but when considering the detailed spatial variability of the entire additional area, the location and density of the measurements must be taken into account. As the measurement period covered one annual cycle, the data do not fully reflect the interannual variability characteristic of the Gulf of Riga or the rarely occurring extreme conditions.

The cumulative impact modelling covered three development areas with a total of 237 turbines (120 in the initial area, 50 in the additional area and 67 in the Liivi Bay offshore wind farm). As the number of turbines in the Saare-Liivi initial area has been reduced to 80 according to the superficies licence and to 40 in the additional area according to this EIA report, the actual number of turbines in the three areas will, depending on the alternative implemented for the Liivi Bay offshore wind farm, range from 170–204. The modelled cumulative scenario is therefore more extensive than the actual design.

Forecasting ice conditions entails greater uncertainty compared with other hydrodynamic indicators, as ice concentration, drift and ridging depend on the weather conditions of the particular winter. Modelling a single ice-rich winter does not describe the full range of possible interannual variability, but it makes it possible to assess the change arising under ice-rich winter conditions compared with the 0-alternative.

The identified knowledge gaps do not prevent assessment of the impacts of main alternative 3, nor do they alter the conclusion that no significant change in the general circulation or wave climate of the Gulf of Riga is predicted.

3.2. Seabed geology

This chapter is based on the geophysical, geotechnical and seabed sediment investigations carried out in 2022–2025 for the initial and additional areas of the Saare-Liivi offshore wind farm, and on the feasibility analysis prepared by the developer. An overview of the investigations is provided in Table 3.2-1.

The investigations make it possible to describe the geological structure of the seabed, the distribution of soft sediments, possible gas pockets, buried depressions and preliminary constraints on foundation installation. Investigations at EIA level do not replace the detailed engineering-geological investigation of the locations of each turbine, the offshore substation and the jack-up legs of the installation vessel, which will be carried out as part of the detailed design.

3.2.1. Consideration of alternatives

Geophysical and geotechnical seabed investigations covered a 91.2 km² study area for the main alternative 1 of the additional area. As a result of the investigations, thicker soft clayey sediments and local geological hazards were identified in the western part of the area. Taking trawling and navigation into account as well, the western part was excluded from the further development design, resulting in main alternative 2 with an area of 58.7 km².

Following underwater cultural heritage investigations, the area was further reduced to 57.1 km², resulting in main alternative 3. Main alternative 3 lies entirely within the geophysically and geotechnically investigated area.

The data collected at EIA level are sufficient to identify geological constraints and potential hazards. To determine the final foundation type, the exact layout of the turbines and the substation, and the installation technology, site-specific geotechnical investigations are required and will be carried out at the detailed design stage.

3.2.2. Description of environmental status

Several preliminary geotechnical and geophysical investigations have been carried out in the Saare-Liivi initial and additional areas (Table 3.2-1). In 2022, 38 samples were taken from seabed sediments in the Saare-Liivi initial area and along the export cable route, and in 2023, 20 sediment samples were taken in the Saare-Liivi additional area (Figure 3.2-1). One purpose of taking these samples was to calibrate the geophysical data and correlate backscatter at certain frequencies with particular soil types. In addition, in 2024 soil samples were taken at 100 locations distributed evenly across the initial and additional areas and the export cable route.

During the geotechnical investigations carried out in 2024, CPT (*cone penetration test*) and VC (*vibro core*) methods were also used, with the aim of obtaining direct information on lithology and soil to a depth of approximately 6 m. In total, investigations were carried out at 35 locations (Figure 3.2-2). The VC system takes a soil sample and brings it up from the seabed; the CPT method drives a probe into the soil until it reaches its prescribed depth or encounters sediments it cannot penetrate. To identify deeper layer boundaries (more than 20 m), seismo-acoustically collected data were used (e.g. a sub-bottom profiler).

GEOPHYSICAL AND GEOTECHNICAL CONDITIONS

In 2021, the Geological Survey of Estonia prepared an overview of the existing marine geological dataset for offshore wind farm planning²⁸. The study notes that there are no precise data on the depth/relief of the bedrock for wind energy development area No. 1 designated by the Estonian marine area plan, and that the area is characterised by extensive variation and undulation in the upper surface of the moraine, typical of bedrock depressions (the Gulf of Riga is a bedrock depression of glacial origin) and basin-like structures. In addition to the variable moraine surface, the total thickness of the younger surficial layers covering it may also vary greatly. Over much of wind energy development area No. 1 located in the Gulf of Riga, the cover above the moraine is characterised by considerable thickness (> 20–35 m), with the majority of these sediments consisting of Baltic Ice Lake sediments and the overlying Joldia Sea–Ancyclus Lake clayey sediments. The study recommended carrying out a thorough geological investigation before planning the wind farms.

According to the bathymetric data used, the water depth in the wider study area corresponding to main alternative 1 is approximately 22–41 m. Within main alternative 3, on which the impact assessment is based, the water depth according to Transport Administration data is approximately 23.8–41 m (Figure 3.2-3).

²⁸ Ees Geological Survey of Estonia, 2021. Overview of the existing marine geological dataset for offshore wind farm planning.

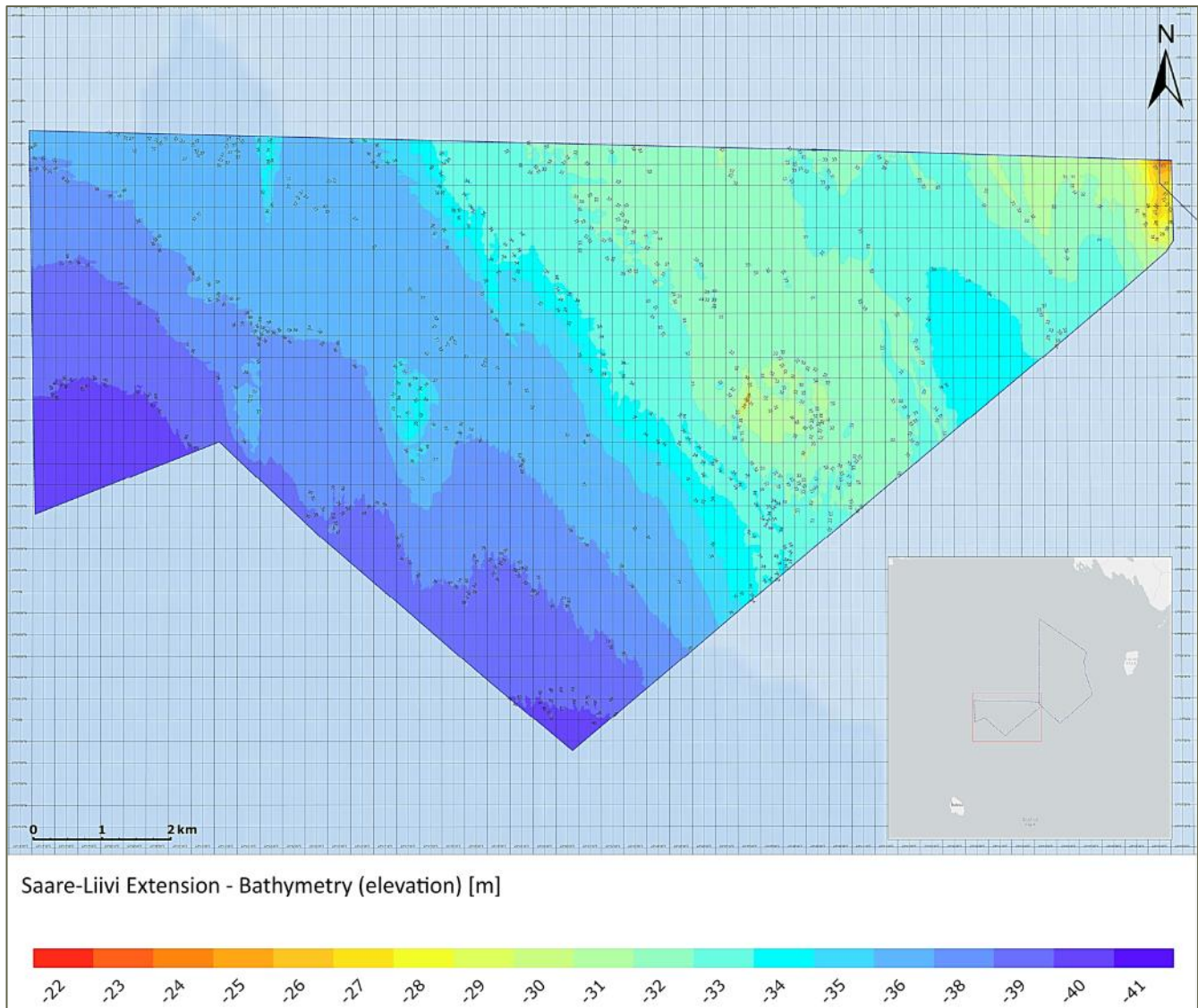


Figure 3.2-3. Bathymetry of the Saare-Liivi offshore wind farm additional area (main alternative 1) (water depth in metres)

Ramboll's²⁹ study found that the additional area essentially comprises three geological units. The first of these consists of soft sediments (i.e. varved clay and other soft clayey sediments) (see Figure 3.2-4). Varved clay occurs locally, especially in the north-western part of the additional area; clay occurs practically throughout the additional area. Within the soft sediments, certain hazards arising from the geological structure have been identified locally using seismo-acoustic methods: depressions or hollows covered by gas and sediments, i.e. buried depressions (see Figure 3.2-5). From the seismic profiles, markers characteristic of gas were interpreted in the clayey sediments of the Saare-Liivi additional area. More specifically, strong reflections of seismo-acoustic energy, bright spots and crater-type seabed structures indicate the presence of gas. In addition, the sound-wave depression (*push-down*) effect and information-free sections, i.e. acoustic blanking, indicate the occurrence of gas pockets.

The occurrence of gas pockets in the soil locally affects the load-bearing capacity of the soil and poses risks to construction activities. Since the identified gas pockets are relatively small and local in extent, it is on technical grounds possible to modify the seabed at those locations so that it is suitable for bearing

²⁹ Saare-Liivi main and extension G&G interpretations report, Ramboll Polska Sp. z o.o. 2024

foundations, but this may not be rational on economic grounds. It is important to note that, despite the characteristic markers indicating the presence of gas, the signals obtained regarding the presence of gas within the Saare-Liivi additional area are of low reliability. The distribution of buried depressions is uneven, but at least one clay-filled hollow cuts across the northern part of the additional area in a north-west-south-east direction. The presence of buried depressions indicates uneven load-bearing capacity of the soil, because the depressions are filled with sediments whose properties differ from those of the underlying soil. Depending on the size and nature of the depressions, it is on technical grounds possible to make them suitable for bearing a turbine foundation by excavating and infilling the seabed. From a construction perspective, buried depressions pose a hazard to jack-up vessels. The investigation results show that the occurrence of hazards arising from the geological structure is local and that potentially hazardous areas can be avoided both during design and during construction.

It is also possible to identify older depressions whose infill material is not clay but moraine. Their locations are currently uncertain and will be specified in the course of further investigations.

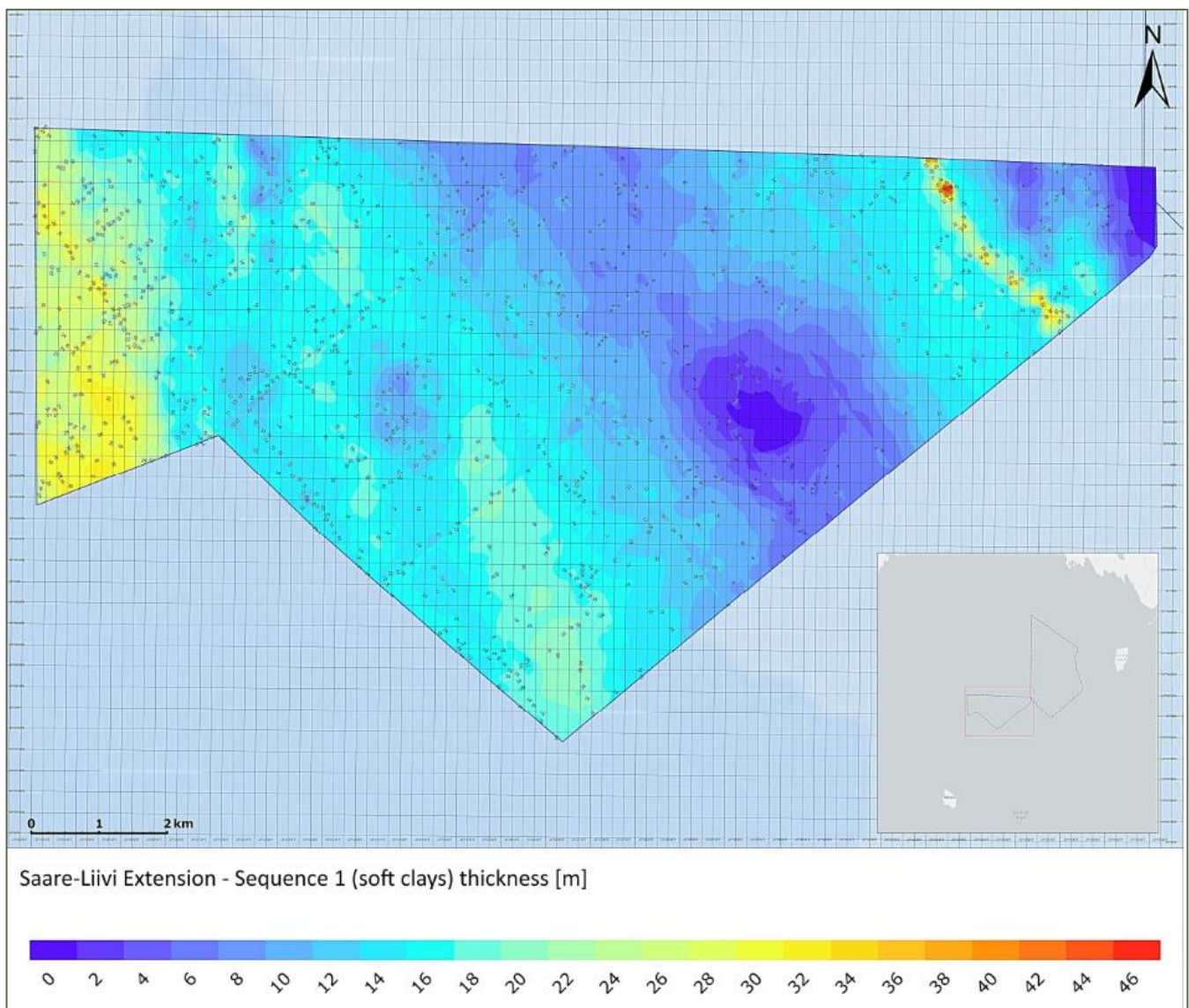


Figure 3.2-4. Thickness of the clay-layer unit in the Saare-Liivi offshore wind farm additional area (main alternative 1)

The second geological layer in the additional area is moraine (see Figure 3.2-6). Moraine is certainly present in the southern and western parts of the additional area, but possibly also more widely beneath the younger clay layers.

The oldest and deepest layer geologically present in the additional area is the bedrock geological unit. The bedrock in the additional area of the Saare-Liivi offshore wind farm probably dates from the Lower Devonian. Based on the boreholes nearest to the Saare-Liivi offshore wind farm additional area (see Figure 3.2-7) (Kihnu and Seliste) and two boreholes drilled in Latvian marine waters, the youngest bedrock strata are presumed to belong to the Lower Devonian Pärnu and Narva stages.

SEDIMENT COMPOSITION

To determine the grain-size distribution, heavy metals, total petroleum hydrocarbons, nutrients and other elements of seabed sediments, 20 sediment samples were taken from the additional area by the University of Tartu on 11.07.2023. The analysis results were compared with the limit values established for hazardous substances in soil (Regulation No 26 of the Minister of the Environment of 28.06.2019, 'Limit values for hazardous substances in soil'³⁰). In the area of main alternative 3, the content of heavy metals and petroleum hydrocarbons in the samples was generally significantly below the target value and the sediments were in good condition. At points UTIL882, UTIL 887, UTIL 897, UTIL 911 and UTIL 972, vanadium exceeded the target value. Since vanadium present in seawater is adsorbed in sediments, the exceedance of the target value is presumably of natural origin. Pursuant to section 4 of the above-mentioned Regulation of the Minister of the Environment, *'the target value indicates a content of a hazardous substance in soil at or below which the condition of the soil is considered good'*.

Grain-size analysis (Annex 3.13) provides input for suspended matter dispersion modelling. The finer the fraction, the more suspended matter is generated. Water movement sorts the sediments so that fine-grained sediments occur in deeper parts (depressions) and coarser sediments in shallower areas (elevations).

3.2.3. Impact assessment

ENGINEERING GEOLOGY

In the feasibility analysis³¹ of the offshore wind farm in the Saare-Liivi additional area, the suitability of the anticipated geological conditions for the construction of both gravity-based and monopile foundations was examined. Preliminary results show that both gravity-based and monopile foundations are suitable for the additional area.

As described in Section 3.2.2 of this EIA report and in Figures 3.2-3 to 3.2-4, clay occurs in the western part of the additional area, where gas pockets may also occur. Buried depressions have also been identified. The identified gas pockets are relatively small and local in extent, and it is on technical grounds possible to modify the seabed at those locations so that it is suitable for bearing foundations, but this may not be rational on economic grounds. The presence of depressions indicates uneven load-bearing capacity of the soil, because the depressions are infilled with sediments whose properties differ from those of the underlying soil. Depending on the size and nature of the channels, it is on technical grounds

³⁰ RT I, 04.07.2019, 65242.22

³¹ Saare-Liivi wind farm pre-FEED, Ramboll Polska Sp. z o.o. 2023

possible to make them suitable for bearing a turbine foundation by excavating and infilling the seabed. From a construction perspective, buried depressions pose a hazard to jack-up vessels.

The constraints on the use of foundation solutions arising from engineering geology are as follows:

1. the construction of a monopile foundation is not technically or economically feasible where the bedrock lies deeper than 40 m below sea level;
2. the construction of a gravity-based foundation is not technically or economically feasible where the thickness of the soft seabed sediment layer overlying the bedrock exceeds 4 m or the bedrock lies deeper than 40 m below sea level.

In summary, where the soft sediment layer exceeds 4 m in thickness or the bedrock lies at a depth of more than 40 m, the use of gravity-based and monopile foundations may be regarded as technically and economically unsuitable. Under such seabed conditions, the area must be regarded as unsuitable for the respective foundation type. In addition, it must be taken into account that compensating for unfavourable seabed conditions by using larger foundations or extensive sediment removal would increase both construction costs and the impact on the marine environment.

COASTAL PROCESSES

In the nearshore zone, waves transport material. Waves lift material into the water column and also transport it along the shoreline. Depending on the nature of the shoreline, erosion or accumulation of material occurs there. Modelling of wave height changes caused by the Saare-Liivi offshore wind farm additional area showed that wave height within the additional area decreases on average by up to 3%, and the effect is modest when considering the Gulf of Riga as a whole. Thus, the Saare-Liivi offshore wind farm additional area does not cause changes in coastal processes in the region. In cold winters, the Saare-Liivi offshore wind farm additional area may increase ice ridging and the formation of ice-ridge berms near the coasts of the islands of Kihnu and Ruhnu, and ice shove may redistribute material along the coast, but this is not inherently different from the natural processes that normally shape the coast.

3.2.4. Environmental measures

MITIGATION MEASURES

On engineering-geological grounds, the western part of the additional area must be excluded as a location for turbines, as the thickness of clayey sediments exceeds 4 m there and additional hazards occur in the form of gas pockets and buried depressions. By excluding the geologically less favourable western part, a significant avoidance measure has already been integrated into the project's spatial layout. Main alternative 3 does not include the aforementioned western part.

During final design, an engineering geological investigation must be carried out at the location of each turbine and offshore substation to select the foundation type and installation solution.

ENVIRONMENTAL MONITORING

Operational monitoring

During operation of the offshore wind farm, regular monitoring of the technical condition of turbine foundations and cable routes must be provided for.

3.2.5. Summary

Within main alternative 3, no general geological obstacle has been identified that would preclude the construction of bottom-fixed wind turbines. However, the thickness of soft sediments, the depth of the bedrock, lithology and the load-bearing capacity of the soil vary locally, and buried depressions and possible indications of shallow gas occur.

The installation of foundations (for turbines and the substation), cables and foundation protection locally alters the structure and microrelief of the upper sediment layer of the seabed. The change is permanent at the immediate location of the structures and predominantly temporary in areas associated with construction. Its impact on seabed habitats is assessed in section 3.4, and the impacts of sediment movement and suspended matter in section 3.3.

The predicted change in wave conditions is small (less than 3%) and, based on the information available, does not cause a significant change in coastal processes.

If main alternative 3 is implemented, the impact on seabed geology and morphology will be neutral to slightly negative (0/–).

Table 3.2-2. *Impact associated with the planned wind farm and its significance*

Associated consequence/impact	Impact significance	Need for mitigation measures, final impact significance
Wind farm construction and decommissioning		
Engineering geology	-	Avoid the western part of the additional area (main alternative 1) for turbine and substation locations. Taken into account. Residual impact: 0
Impact on coastal processes	0	-

Scale of significant environmental impact used in the EIA report: - slight negative impact, -- significant negative impact, 0 - no impact, neutral, + slight positive impact, ++ significant positive impact

3.2.6. Cumulative impact

The geotechnical properties of the seabed and the feasibility of constructing a specific foundation are location-specific and, in that sense, no cumulative impact arises between different offshore wind farms.

However, cumulative impact may arise from the aggregate extent of physical alteration of the seabed, sediment removal, the use of fill material and foundation protection, and cable burial. These impacts are assessed quantitatively in the context of seabed loss and disturbance in section 3.4, and in the context of sediments and suspended matter in section 3.3.

According to cumulative modelling of the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm, average wave height near the coast of Kihnu may decrease by 1–2 cm and by less than 1 cm along the Hädemeeste–Ikla–Ainaži coast. The change remains substantially smaller than the natural variability of wave conditions and is not expected to cause a significant change in coastal processes or shoreline development.

3.2.7. Uncertainty/knowledge gaps

At the EIA stage, the exact locations of the turbines, offshore substation, cables, the support legs of jack-up installation vessels and temporary work areas have not yet been definitively determined. The thickness and strength of soft sediments, the depth and lithology of the bedrock, the geometry of buried depressions, the occurrence of possible gas pockets and the installability of piles also require location-specific refinement.

These knowledge gaps do not prevent the assessment of the overall environmental impact of main alternative 3, nor do they indicate that the area as a whole is technically unsuitable. However, at the EIA stage they do not allow final selection of the foundation type or confirmation of the exact location of each turbine position. At a later design stage, an engineering geological investigation will be carried out at the location of each specific turbine and substation, as required for engineering purposes (detailed foundation design).

3.3. Marine water quality

This chapter is based on TalTech's studies "Study of water quality, physical, including hydrodynamic, and biogeochemical parameters of the water column, and pollution dispersion within the EIA of the Saare-Liivi offshore wind farm" (TalTech, 2024; Annex 3.2) and "Study of the cumulative impacts of hydrodynamics and the physical and biogeochemical parameters of the water column within the EIA of the Saare-Liivi offshore wind farm" (TalTech, 2025; Annex 3.3).

3.3.1. Consideration of alternatives

The fieldwork for the baseline water quality study covered a study area broader than the site of the additional area main alternative 1. In the impact modelling, the Saare-Liivi initial and additional area were considered, with 50 turbines assumed in the additional area (study scenario T1; main alternative 2 in this report). Under main alternative 3 for the additional area, up to 40 turbines are planned; therefore, the solution modelled with 50 turbines is used as a conservative reference scenario.

In TalTech's baseline study, three scenarios were used in the modelling:

- A0 – the existing situation without the Saare-Liivi offshore wind farms;
- E1 – the configuration used in the study for the Saare-Liivi initial area;
- E1+T1 – the Saare-Liivi initial and additional areas.

The designations E1 and T1 are scenario labels from the baseline study and do not correspond to the numbering of main alternatives PA1–PA3 in this EIA report. When constructing gravity-based foundations, the amounts of suspended matter generated, sediment moved and potentially mobile phosphorus depend on the number of turbines to be installed. Therefore, based on the modelling results for the 50-turbine solution, it is also possible to estimate the corresponding quantities for the 40-turbine solution.

3.3.2. Description of environmental status

The additional area is located in the central Gulf of Riga coastal water body. The Gulf of Riga is a seasonally stratified, semi-enclosed sub-basin of the Baltic Sea, separated from the open Baltic Sea by

shallow straits. According to the Environmental Agency³², the overall status of the water body is poor. The overall status is poor in terms of chemical status based on 2021 monitoring; good chemical status has not been achieved due to cadmium and bromodiphenyl ether concentrations in biota. The ecological status of the central Gulf of Riga coastal water is assessed on the basis of the phytoplankton and benthic invertebrate quality elements; according to 2021 monitoring data, the central Gulf of Riga coastal water is in moderate status for phytoplankton and benthic invertebrates. Poor water quality is caused primarily by the overall eutrophication level of the Baltic Sea and the high values of the relevant indicators.

Water quality measurements were carried out in the additional area from a research vessel and using a glider. Profile measurements of water column parameters (temperature, salinity, dissolved oxygen, turbidity, chlorophyll-a concentration and nutrients) were carried out at station "KR" (location 58.00560°N 23.43360 °E, mean depth 37 m) in different seasons of 2023 (13.04., 1.06., 13.07., 26.08., 31.10.) (Figure 3.3-1).

A detailed overview of the measurement results (vertical profiles measured from the research vessel, glider measurements, laboratory analyses of nutrients and horizontal distributions) is presented in the baseline study (TalTech, 2024; Annex 3.2) and in the full Estonian-language EIA report (Section 3.3.2). In summary, the water column of the additional area is characterised as follows.

Oxygen conditions in the water column were relatively good during the measurement period, but in the near-bottom layer the oxygen concentration was still below saturation, at 6–7 mg/l.

The shallow straits hinder the spread of the deep-layer water mass from the open Baltic Sea into the Gulf of Riga, and therefore there is no permanent stratification here. This morphological peculiarity largely determines the characteristics and hydrodynamics of the Gulf of Riga water column. In the water balance of the Gulf of Riga, in addition to water exchange through the straits, rivers and exchange with the atmosphere play an important role.

In winter, the water column of the Gulf of Riga mixes down to the bottom. In spring, an initial weak stratification develops as fresher surface water spreads (Stipa *et al.*, 1999). By summer, the temperature difference between the upper and near-bottom layers contributes more to stratification, i.e. the vertical density gradient, while the contribution of salinity is smaller. The density gradient also determines the other characteristics of the water column. In summer, the surface water mass is warm, fresher and nutrient-poor. The deep layer is cooler, with slightly higher salinity and nutrient concentrations, and lower oxygen levels. Various processes (for example, the spread of river water, the spread of water lenses entering through the straits, and upwelling events) give rise to smaller-scale spatial variability in the gulf, which is also visible in water characteristics (Liblik *et al.*, 2017; Lips *et al.*, 2016b). Although no permanent oxygen deficiency occurs in the Gulf of Riga, an oxygen deficit develops from spring onwards, and by autumn the oxygen concentration in the deep layer of the gulf falls to hypoxic levels (Liblik *et al.*, 2023).

Good marine environmental status has not been achieved in the Gulf of Riga, including in terms of the parameters describing eutrophication (HELCOM, 2023). Excessive nutrient input from the catchment area remains a problem, but the release of phosphorus from the sediment (Savchuk, 2002), which is more intense under oxygen-poor conditions (Aigars *et al.*, 2015; Stoicescu *et al.*, 2022), also plays an important role.

³² <https://keskkonnaportal.ee/et/teemad/vesi/pinnavesi/pinnaveekogumite-seisundiinfo>

3.3.3. Impact assessment

BIOGEOCHEMICAL PROPERTIES OF THE WATER COLUMN

Studies have shown that during operation offshore wind turbines may cause changes in vertical mixing in the water column and thereby affect biogeochemical processes occurring in the sediments, which in turn may be manifested in changes in the concentrations of nitrogen and phosphorus compounds in the marine area. Temperature, salinity, oxygen and nutrient content, turbidity, and the movement of substances in the water column, however, affect living conditions in the water body.

For biogeochemical modelling, the ERGOM (*Ecological Regional Ocean Model*) model developed by the Baltic Sea Research Institute (IOW) was used. The spatial averages of winter nutrient concentrations and summer total nutrient and chlorophyll concentrations for the initial and additional area are shown in Figure 3.3-8, and the temporal variation of total nutrient and chlorophyll concentrations together with the seasonal cycle is shown in Figure 3.3-9. The basin-scale distributions are similar to those for the zero alternative and the initial area, i.e. the greatest influence in the Gulf of Riga derives from riverine loading. In the case of phosphates, the flux from the sediment into the water column also plays a role. Local changes in chlorophyll and total nutrient concentrations are similar to those when only the initial area is implemented. With the initial and additional area, changes of the same order of magnitude occur over a larger area.

Mean distributions and time series of near-bottom oxygen content for the combined solution of the Saare-Liivi initial and additional area (E1+T1) are presented in Figures 3.3-10–3.3-12. The magnitude of the changes is similar to that in the initial area scenario, but the changes are manifested over a larger area.

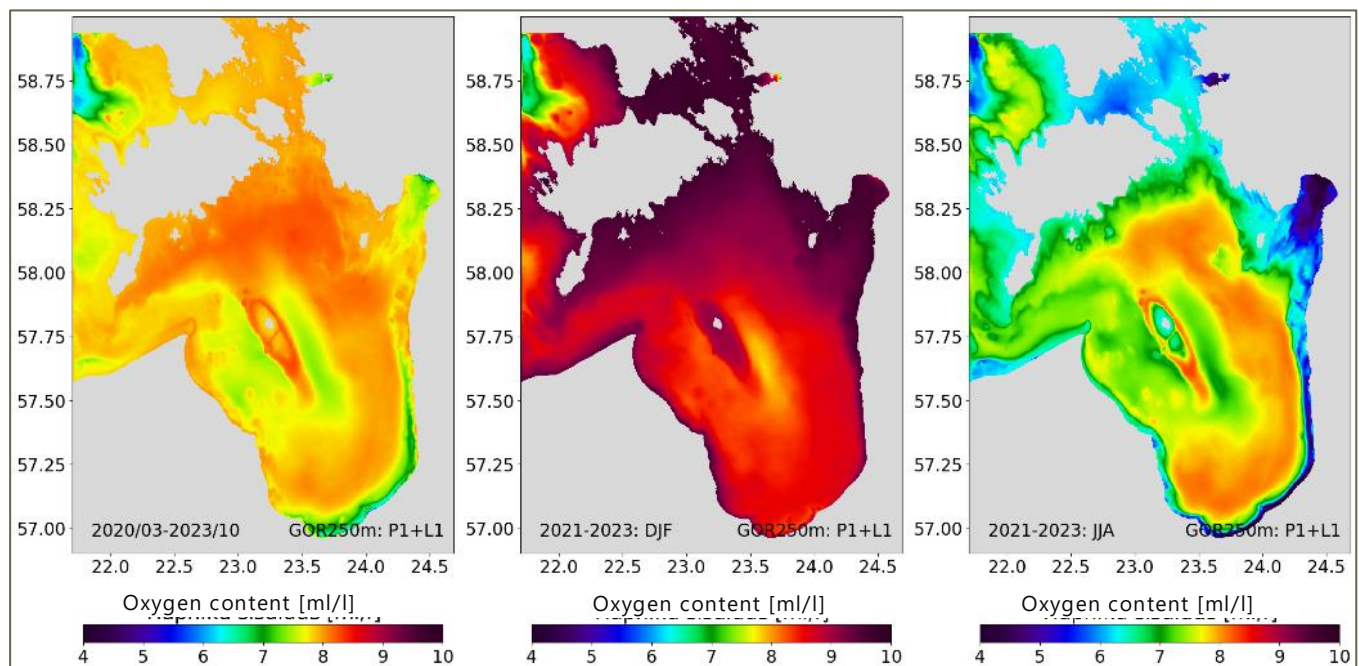


Figure 3.3-11. Mean near-bottom oxygen content for the entire period (left) and for the winter and summer periods for the initial and additional area (P1+L1 in the figure)

SUSPENDED MATTER DISPERSION

During the construction phase of the wind farm, suspended matter is generated during the construction of foundations, the dumping of removed material, and the installation of inter-array and export cables (see Sections 2.6.3, 2.6.4 and 2.7.2). The impact of seabed disturbances (movement of sediments and suspended matter) on water quality depends on the amount of sediments released into the water column (see Section 2.7.2), their properties (see Section 3.2.2), and the prevailing hydrodynamic conditions (see Section 3.1.2). These impact sources are considered separately below. In Subsection 4.5.2 of TalTech's study (2024; Annex 3.2), the impacts associated with the construction of foundations and inter-array cables were assessed, and in Subsection 4.5.3 the impact of export cable installation was assessed.

To model the dispersion of suspended matter released during the relocation of seabed sediments in construction works in the additional area, the IOW sediment model was used via the FABM interface, similarly to the ERGOM biogeochemistry model. The summer periods of 2018 and 2019 were used in the modelling, with wind speed and direction distributions close to average seasonal conditions. The impact of the cables was modelled under both summer and winter conditions. The model current field was validated against measurements carried out in the area (see Section 3.1 and Annexes 3.2 and 3.3).

Based on grain-size composition analyses of seabed sediments, the sediments were divided into three types: mud/silt, sand and coarse-grained sediments. Of these, the settling velocity of the slowest-settling material (mud/silt) is 50 m/day, and that of fine-grained sand 200 m/day. The settling velocities of the other sediment types (sand, gravel) are considerably higher, meaning their dispersion is local. For sediment removal, the developer provided as input the assumption that 10 000 m³ of material would be moved at one foundation location, of which 10% would enter the water column, and that the composition of the suspended matter at the location considered corresponds to the spatially interpolated grain-size distribution of the sediment (Table 3.3-2). For cables, the movement of 4 m³ of sediments per metre has been assumed, of which 0.4 m³ is considered suspended.

Table 3.3-2: Maximum total possible amount of sediments for 50 turbines, gravity base foundation

Sediment type	Amount (m³)	%
Mud/Silt	13 000	26
Fine-grained sand	16 000	32
Coarser-grained sediments	21 000	42
Total	50 000	

Construction of foundations and inter-array cables

In Subsection 4.5.2 of TalTech's study (Annex 3.2), both the construction of gravity base foundations and the installation of inter-array cables in the additional area (main alternative 2) were considered. Due to the technology used (see Section 2.7), the solution involving the installation of gravity base foundations has the largest volume of sediment movement and therefore represents an assessment of the worst possible scenario. When installing monopile foundations, a technology is used in which the generation of suspended matter is significantly lower. In modelling suspended matter dispersion, 50 turbine positions were taken into account. In main alternative 3, up to 40 turbines and one substation are planned; therefore, the modelled sediment volume and the resulting suspended matter represent a conservative estimate for main alternative 3.

When constructing gravity base foundations in the additional area (alternative 2), suspended matter concentrations above 5 mg/l extend to a maximum distance of up to 10.2 km after 6 h of dispersion, and up to 4.8 km from the source 24 h after release.

Suspended matter dispersion during cable installation in the additional area is somewhat more limited. Under summer conditions, settling is rapid. 6 h after the suspended matter enters the water column, the maximum extent of the 5 mg/l concentration is 4.6 km from the source; within 12 h, such a high concentration occurs only 700 m away, and after 24 h the concentration is below 5 mg/l. Under winter conditions, during cable installation the maximum extent of the 5 mg/l concentration is 3.3, 5.5 and 5.7 km, respectively, 3 h, 6 h and 12 h after the particles enter the water column.

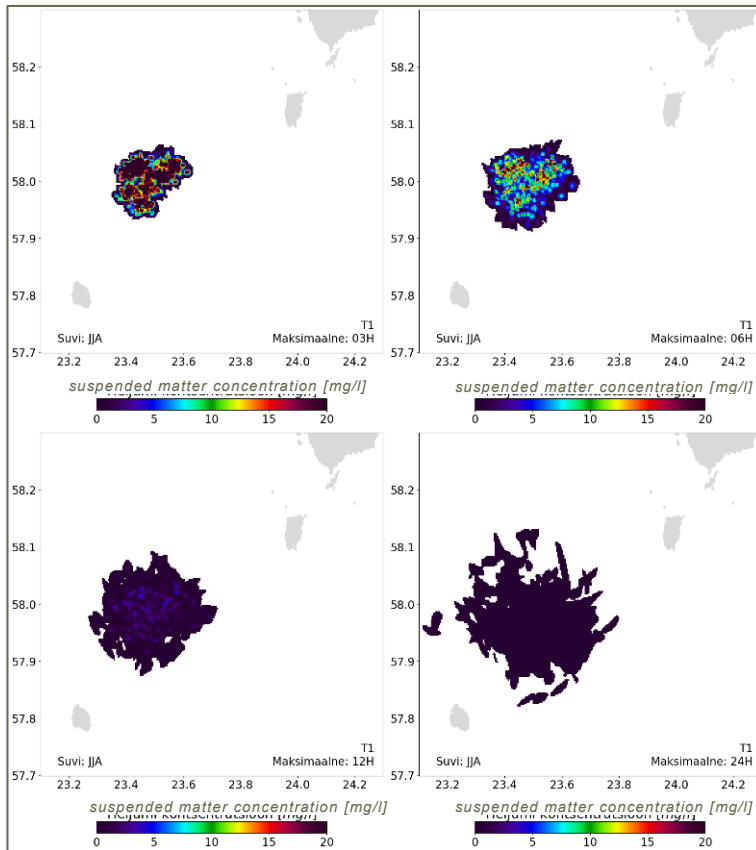


Figure 3.3-13 Maximum suspended matter concentration in each grid cell at a depth of 1 m under summer conditions after 3-, 6-, 12- and 24-hour dispersion in the additional area (main alternative 2) during the construction of wind turbine foundations. The period June-August 2019 was modelled.

The modelling shows that changes do occur in the additional area of the wind farm (main alternative 2) and its immediate surroundings, but taking into account the openness of the area and the natural variability of suspended matter content, there is no basis for assuming that this constitutes a significant long-term negative impact. Dispersion to conservation areas is unlikely, because the additional area (main alternative 2) is located more than 20 km from them.

Installation of the export cable

In Subsection 4.5.3 of TalTech's study (2024; Annex 3.2), the impact of export cable installation was modelled along the full extent of the connection from the offshore substation in the additional area to the landfall point. For cables, the movement of 4 m³ of sediments per metre has been assumed, of which 0.4 m³ is considered suspended. In the solution proposed under main alternative 3, two cables of

approximately 6 km each run from the offshore substation in the additional area to the boundary of the additional area (the total length of cable to be installed in this section is approximately 12 km). From the area boundary onwards to the landfall point, the export cable system and corridor assessed in the EIA report for the initial area are used: from the area boundary, one cable continues to one offshore substation of the Saare-Liivi initial area and the other to the other one; from there onwards, the export cable system and corridor of the initial area are used up to the landfall point. No new separate landfall corridor is planned. The modelled combined solution covered this entire wider connection, and on that basis the impact of the export cables of the additional area can be assessed.

The modelled **maximum** distributions **for the winter** period of suspended matter generated by export cable installation are shown in Figure 3.3-17 (both mean and maximum distributions for the winter and summer periods are presented in Figures 4.5.3.1 to 4.5.3.8 of Annex 3.2). The highest mean and maximum suspended matter concentrations at a depth of 1 m below the water surface persist only for a short time. For a certain period (*ca* half a day), the area does increase, but concentrations decrease, and after 24 h the area covered by suspended matter is significantly smaller. Concentrations and dispersion are greater under winter conditions. Under summer conditions, dispersion is more limited and settling is faster. Under summer conditions, concentrations above 5 mg/l extend to a maximum distance of 6.0 km, 7.8 km and 4.8 km after 3 h, 6 h and 12 h, respectively. Under summer conditions, the concentration falls below 5 mg/l within 24 h.

Under winter conditions, the extent of water with a concentration of at least 5 mg/l is 4.7, 5.0, 10.7 and 12.7 km after 3, 6, 12 and 24 h, respectively, and the concentration falls below 5 mg/l within 48 h. Therefore, under winter conditions, suspended matter dispersion during export cable installation is longer-lasting and more extensive compared with other works. The average suspended matter content measured over the period 17.05.2024-26.08.2024 was 3.8 mg/l. Thus, under favourable conditions, the suspended matter content generated by the works may exceed the average natural content relatively far from the source. These relatively far-reaching dispersions are likely associated with currents along the coast, which are stronger than offshore in the wind farm area. The impact of export cable installation in the additional area is therefore local and temporary. As the export cable for the initial area will likely be installed before the export cable for the additional area, in reality the impacts of export cable installation in the two areas will not cumulate, i.e. the simultaneous suspended matter load will be significantly lower than in the modelled combined solution.

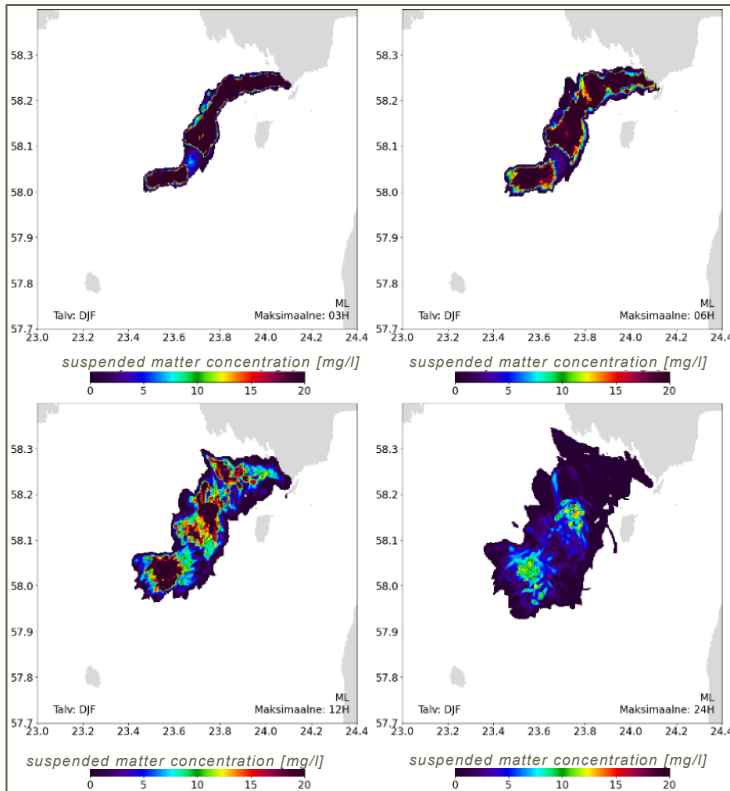


Figure 3.3-17. Maximum suspended matter concentration in each grid cell at a depth of 1 m during export cable installation in the additional area, initial area and export cable development area under winter conditions after 3-, 6-, 12- and 24-hour dispersion. The period December-February 2018/2019 was modelled.

Suspended matter dispersion associated with dumping

In the baseline study, suspended matter dispersion was modelled for two possible gravity base foundation installation scenarios: dumping of sediments at a dumping area and dumping directly adjacent to the foundations (Annex 3.2, Section 4.5.4). In practice, dumping does not take place directly adjacent to gravity base foundations – sediments are dumped at dumping areas. Therefore, only dumping at a dumping area is considered in the EIA report. When installing monopile foundations, dumping takes place only if the material to be dredged cannot be beneficially used for scour protection of the monopile foundations.

For both the initial area and the additional area, the dumping areas Saare-Liivi N and Saare-Liivi S designated in the water permit for the initial area are used (Figure 2.7-1). Dumping at the dumping areas was modelled for main alternative 3 of the initial area for the construction of 80 turbines over a 16-month period. Construction of 40 turbines and a substation under main alternative 3 of the additional area will last for a somewhat shorter period, so this is a conservative assessment in the context of main alternative 3 of the additional area.

For the removal of sediments and their dumping at the dumping areas (Figure 2.7-1), it was assumed that the material would be dumped equally between the two areas over two years from March to October. Material is taken to the dumping area every three days. Figure 3.3-19 presents the spatial distributions of the sediment layer resulting from dumping at the dumping areas. Compared with settling caused by natural resuspension, the impact of dumping is spatially limited, but the local impact is stronger.

When dumping at the dumping areas, suspended matter (Figure 3.3-20) remains in the upper layer of the sea for a limited time; after 12 h, most of the suspended matter has sunk from the surface layer into the lower layers of the water column. In the near-bottom layer distributions, mean concentrations above 5 mg/l can be seen 3 h after dumping. Dispersion and the extent of spread are greater in the lower-layer distributions. Most of the suspended matter settles within 24 h. Also, under favourable conditions, concentrations in the surface layer may be considerably higher than average in the first hours after dumping (Figure 3.3-8). If the works are carried out with dumping every three days, there is an appreciable impact on the transparency of the water column during the first half-day. During the remaining two and a half days, the impact is limited. If dumping is carried out at shorter intervals, the intensity of the short-term impact is lower (concentrations are lower), but the period during which the impact occurs is longer. From the perspective of the final sedimentation load, there is no major difference whether smaller volumes are dumped more frequently or larger volumes less frequently; the exact dumping schedule will be determined in the organisation of the works and adjusted on the basis of monitoring if necessary, because the concentration of suspended matter and the duration of disturbance are influenced by timing, not by the frequency of dumping and the volume of material dumped at one time (Section 3.3.4).

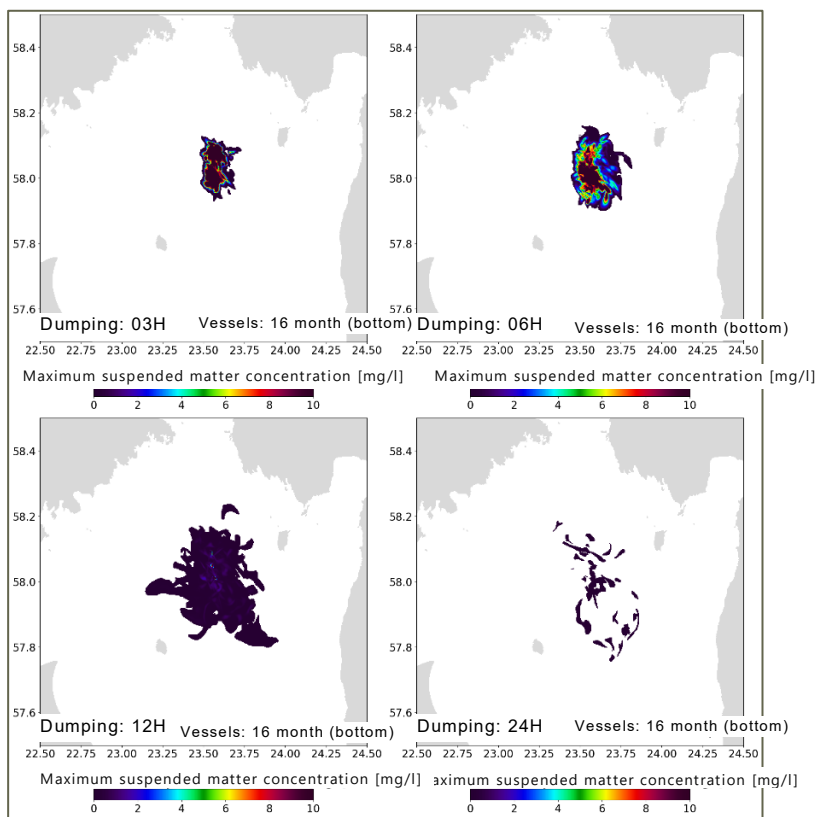


Figure 3.3-20. Maximum surface-layer suspended matter concentration when using two dumping areas

Overall, during the construction period, dumping works result in an increase in suspended matter concentration, a reduction in water transparency and sediment deposition on the seabed. If dumping works are carried out, for example, every three days, increased suspended matter concentrations and reduced water transparency in the water column are estimated to occur for approximately 1/6 of the 16-month work period. Sedimentation is most intensive around the dumping areas, and sedimentation exceeding the natural sedimentation load is mainly confined to those areas and their vicinity. The impact on shallow marine areas is minor, and the impact on protected areas is negligible.

Oil pollution dispersion

For modelling oil pollution dispersion, areas with an elevated shipping accident risk identified in the expert assessment by TalTech Eesti Mereakadeemia were selected. In terms of the timing of the accident and the volume of pollution released into the sea, the worst possible scenario was selected. Periods were selected in which westerly winds predominated, favouring the rapid dispersion of the pollution towards the coast. The pollution was defined as 10 m³ of fuel oil. According to HELCOM's oil slick database, the largest slick detected in the Gulf of Riga had a volume of 2.25 m³. The modelling was carried out for two different scenarios: the first dispersion starting at midnight on 2019-09-11 (hereinafter pollution 1) and the second starting at midnight on 2019-09-12 (hereinafter pollution 2). Dispersion was modelled over a two-day period. 1000 particles were released, each representing 0.01 m³ of oil, and various oil-specific processes such as dispersion and evaporation acted on them. Thus, the volume/mass of oil represented by a particle could change during the simulation.

In the first scenario, the oil slick dispersed north/north-east from the starting point, and most particles beached on the coast of mainland Estonia. Very few particles reached Kihnu island. Under the second scenario, the oil slick dispersed more towards the east, and a large number of particles reached the coast of Kihnu island and the mainland east of the starting point. By the end of the simulation, 0.0005 m³ and 0.02 m³ of oil, respectively, had reached the coast. The arrival of such a small volume on the shore is explained by the dispersion of the oil into the water column and evaporation. Most of the oil breaks up into smaller droplets and disperses in the water column, where the oil can no longer be distinguished from the water.

In both scenarios, within 10 h, about 80% of the oil dispersed into the water column and about 14% evaporated. This means that, although many virtual markers drift ashore (see Figure 3.3-21), they do not contain significant amounts of oil. The comparison between the two scenarios shows that the direction of pollution dispersion depends on the meteorological conditions prevailing in the specific period.

The probability of oil pollution spreading to conservation and protected areas is shown in Figure 3.3-22. Over the entire analysis period, the largest number of particles reached the Pärnu Bay conservation area from point P3 (39%); similar values were also recorded at other points on the eastern side of the additional area. Due to the location of the additional area, the dispersion of particles to conservation areas was greater in the autumn-winter period.

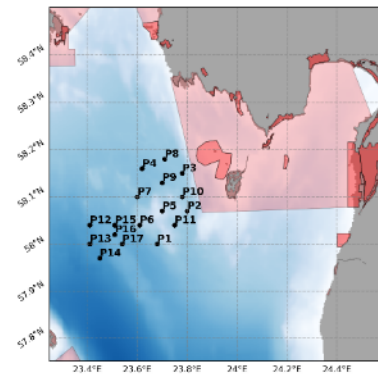
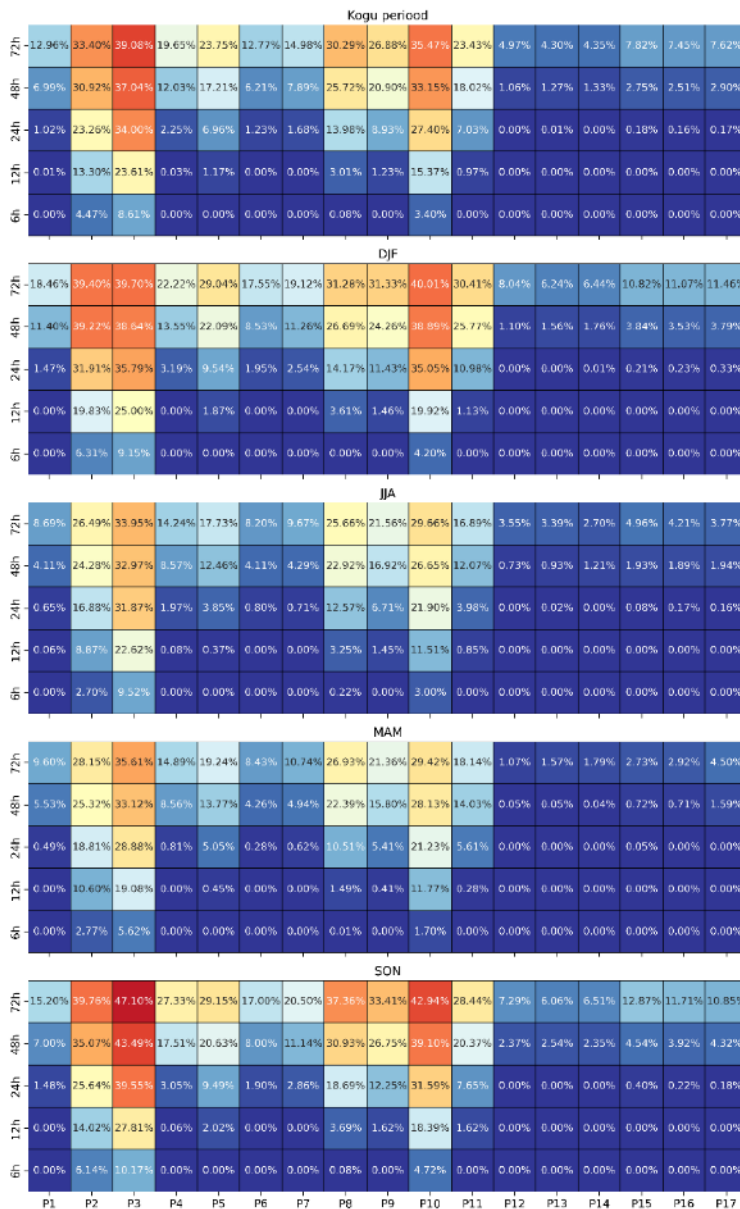


Figure 3.3-22. Probability of oil pollution reaching conservation and protected areas over the entire period and by season. In the figure on the right, conservation areas and protected areas are shown as light red and dark red areas, respectively.

Nutrients released from sediments

One of the biggest environmental problems in the Baltic Sea is eutrophication, caused by excessive inputs and accumulation of nitrogen and phosphorus in the marine environment. Although nutrient loading has been reduced, the problem of eutrophication still remains. According to integrated eutrophication indicators, the Baltic Sea is predominantly in poor condition, and the Gulf of Riga³³ is also in poor condition. Depending on the season and area, the nutrient limiting primary production in the Gulf of Riga may be either phosphorus or nitrogen³⁴ (Seppälä *et al.*, 1999; Tamminen and Seppälä, 1999).

³³ HELCOM: Eutrophication. Thematic assessment 2016–2021. Third HELCOM holistic assessment of the Baltic Sea, *Balt. Sea Environ. Proc.*, 192, 2023.

³⁴ Tamminen, T. and Seppälä, J.: Nutrient pools, transformations, ratios, and limitation in the Gulf of Riga, the Baltic Sea, during four successional stages, *J. Mar. Syst.*, 23(1–3), doi:10.1016/S0924-7963(99)00052-4, 1999.

Annually, on the order of 2000–2600 tonnes of phosphorus and 90 000 – 120 000 tonnes of nitrogen enter the Gulf of Riga, a significant proportion of which is anthropogenic and comes from land. According to HELCOM data, the actual total external input to the Gulf of Riga in 2023 was 121 578 tonnes of nitrogen, including 8 159 tonnes from the atmosphere, and 2 618 tonnes of phosphorus, including 93 tonnes from the atmosphere (HELCOM, 2026). These actual amounts for a single year differ from the normalised trend estimates used in assessing the load targets.

The development activity takes place in the central Gulf of Riga coastal water body, into which no water or substances arrive directly from land, except for a small amount from Ruhnu. Approximately 3 800 tonnes of nitrogen and 57 tonnes of phosphorus enter the coastal water body annually from neighbouring areas (Tallinn University of Technology, 2025³⁵). These amounts describe the exchange of substances between the coastal water body and neighbouring areas and are not equivalent to the external load of the Gulf of Riga as a whole. According to the Baltic Sea Action Plan, the maximum acceptable phosphorus load for the Gulf of Riga is 2 020 t/a and the nitrogen load is 88 417 t/a (HELCOM, 2021). HELCOM's 2023 normalised trend estimate was approximately 105% of the respective load target for phosphorus and 104% for nitrogen. Due to statistical uncertainty, fulfilment of the phosphorus target could not be assessed unequivocally; the nitrogen target was not met. The normalised waterborne nitrogen load increased by approximately 3% per year over the period 2012–2023 (HELCOM, 2026).

Over time, phosphorus and nitrogen have also been buried in sediments. Soft sediments contain a considerable amount of phosphorus, which substantially affects eutrophication in the Baltic Sea. The release of phosphorus from sediments into the water column is greater under oxygen-deficient conditions³⁶, which also occur seasonally in the deeper layers of the Gulf of Riga³⁷. The phosphorus flux from the sediment is probably the reason why, despite reductions in land-based loading, concentrations in the water column have not decreased and values are still higher than those corresponding to good environmental status³⁸. The release of phosphorus from the sediment into the water column is more pronounced specifically in the deeper central part of the gulf.

A considerable number of surface sediment samples have been collected from the offshore wind farm area of the Saare-Liivi additional area (and also the Saare-Liivi initial area), and the total phosphorus and total nitrogen concentrations per dry mass have been determined.

The total phosphorus concentrations were above the determination limit (100 mg/kg) in all samples and differed by area. In the southern part of the initial area, concentrations are lower (120–400 mg/kg), while in the northern part they are somewhat higher (500–600 mg/kg). The highest values (> 900 mg/kg) were obtained west of the westernmost turbines of the additional area, in a deeper sea area. This distribution is broadly consistent with earlier measurements (Ausmeel, 2022; Geological Survey of Estonia, 2022; TTÜ Marine Systems Institute, 2021a, 2021b), according to which the highest values were obtained in the deeper parts of the gulf, where organic matter has accumulated. A distinction is made between non-mobile and mobile phosphorus fractions. Unlike the former, phosphorus in mobile forms can, under favourable conditions, be released from the sediment into the water column and be available for primary production. Both the total phosphorus concentration and the share of mobile phosphorus correlate with the organic matter content in the sediment (Tallinn University of Technology, 2025). The highest

35 Tallinn University of Technology, 2025. *Secondary pollution from seabed sediments and assessment of the share of internal marine loading in the total nutrient load, and determination of maximum permissible pollution loads for coastal water bodies. Final report.*

36 Aigars, J., Poikane, R., Dalsgaard, T., Eglite, E. and Jansons, M.: Biogeochemistry of N, P and SI in the Gulf of Riga surface sediments: Implications of seasonally changing factors, *Cont. Shelf Res.*, 105, 112–120, doi:10.1016/J.CSR.2015.06.008, 2015.

37 Liblik, T., Stoicescu, S.-T., Buschmann, F., Lilover, M.-J. and Lips, U.: High-resolution characterization of the development and decay of seasonal hypoxia in the Gulf of Riga, Baltic Sea, *Front. Mar. Sci.*, 10, 438, doi:10.3389/FMARS.2023.1119515, 2023.

38 HELCOM: *Eutrophication. Thematic assessment 2016–2021. Third HELCOM holistic assessment of the Baltic Sea*, *Balt. Sea Environ. Proc.*, 192, 2023.

concentrations of mobile phosphorus in Estonian marine areas occur in accumulation areas, primarily in the deeper parts of the sea. By contrast, concentrations are lower in sediments of nearshore transport areas (Tallinn University of Technology, 2025). The share of mobile phosphorus is higher in the surface layer of the sediment and lower in the deeper part of the sediment profile (Tallinn University of Technology, 2025; Ausmeel, 2022). In a recently published study (Tallinn University of Technology, 2025), the phosphorus content and the share of mobile phosphorus in sediment were analysed across the entire Estonian marine area. It was found that stable phosphorus forms predominate in the surface sediment layer (0–1 cm) across the vast majority of the marine area. The exception was the deep-water area of the Gulf of Riga, where the share of mobile phosphorus in the surface sediment was higher than that of the stable form. A sediment sample profile taken from the deeper part of the Gulf of Riga shows that the share of mobile phosphorus is higher only in a surface layer a few cm thick. From a depth of 5 cm in the sediment layer onwards, the share of mobile phosphorus is approximately 30% (Ausmeel, 2022). In subsequent calculations, a conservative share of mobile phosphorus of 40% is used, based on sediment profiles described in earlier studies (Ausmeel, 2022). It cannot be ruled out that in the surface layer of the sediment the share of mobile phosphorus may locally exceed 40%, but this is unlikely as an average for the entire mass of sediment to be moved, because both the share of the mobile fraction and the total phosphorus concentration are lower in the deeper part of the sediment profile than in the surface layer (Ausmeel, 2022; Geological Survey of Estonia, 2022).

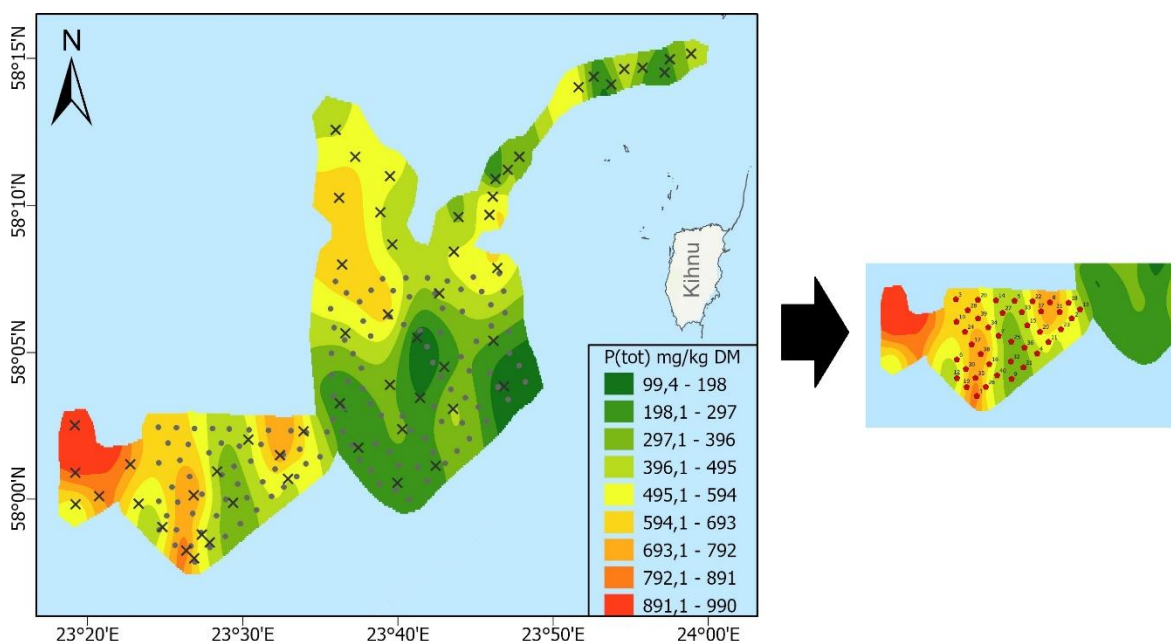


Figure 3.3-23. Total phosphorus concentration (mg/kg) in seabed sediment on a dry-weight basis. Crosses indicate the locations of the sampling points. Dots indicate the locations of the turbines. At the time of the EIA process for the initial area, 50 turbines were planned for the additional area (left-hand panel), but by the time the EIA for the additional area was prepared, 40 turbines were considered (right-hand panel). In addition, 1 offshore substation will be constructed in the additional area.

The spatial distribution of total nitrogen was similar to that of total phosphorus, but at many locations the concentrations were below the determination limit. In the southern part of the initial area, most concentrations were below the determination limit; in the northern part, they ranged from 300–600 mg/kg. In the additional area, concentrations were of the order of 500–1100 mg/kg. The total nitrogen concentration in the Gulf of Riga correlates well with the total organic carbon concentration, indicating that nitrogen in the sediment is mostly of organic origin (Eesti Geoloogiateenistus, 2022), i.e. most of the nitrogen resuspended into the water column is not available for primary production. Considering the magnitude of the external nitrogen load and the Redfield ratio, according to which nitrogen and

phosphorus are consumed during primary production at a ratio of 16:1, it may be concluded that the transport of nitrogen into the water column resulting from resuspension is negligible.

For the initial area, 80 turbines and 3 offshore substations are assumed, giving a total of 83 foundations. Assuming a volume of 10 000 m³ of sediment to be dredged per foundation, the calculated volume for the initial area is 830 000 m³. For the additional area, 40 turbines and 1 offshore substation are assumed, giving a total of 41 foundations and, with the same unit volume, 410 000 m³ of sediment. Assuming a marine sediment density of 1200 kg/m³ and a water content of 65% (Ausmeel, 2022; Eesti Geoloogiateenistus, 2022), and taking the share of mobile phosphorus to be *approx.* 40% (Ausmeel, 2022). It is also assumed that the phosphorus concentrations obtained from the surface sediment layer are representative of the entire mass to be dredged. **This approach is more likely to overestimate than underestimate the mass of phosphorus released, because it has been found that concentrations are higher in the upper part of the sediment profile and lower in the lower part** (Eesti Geoloogiateenistus, 2022). In the initial area study, the interpolated average total phosphorus concentration for the 80 turbine locations was 342 mg/kg. In the present calculation for 83 foundations, the same concentration is also used for the sediments at the three offshore substations as a proxy assumption; it is not treated as a measurement or interpolation result obtained from 83 locations. The dry mass of the sediment in the initial area is 348 600 t, the total phosphorus stock is 119.22 t, and the mobile phosphorus stock, assuming a 40% share, is approximately 48 t. For the calculation for 40 turbines and 1 offshore substation in the additional area, an average total phosphorus concentration of 562 mg/kg dry matter is used. The dry mass of the sediment is 172 200 t and the total phosphorus stock is 96.78 t. With a 40% share of mobile phosphorus, the potentially releasable amount is 39 t. If it is assumed that all phosphorus entering the water column is mobile, its mass would be approximately 97 tonnes. At the same time, such a scenario, in which 100% of the phosphorus entering the water column is mobile, is not realistic in the light of existing studies.

It has been estimated that 18 700 tonnes of phosphorus move annually from the sediment into the water column in the Gulf of Riga (Savchuk, 2002). If this estimate describes a phosphorus flux leaving the sediment that is comparable with the present calculation, the potentially releasable amount of mobile phosphorus for the 83 foundations in the initial area, 49 t, and the amount for the 41 foundations in the additional area, 39 t, account for approximately 0.26% and 0.21%, respectively, of one year's background flux. The amount for both areas combined is 87 t, i.e. 0.47% of one year's background flux. If the construction works in both areas take place during the same two-year period and the release of phosphorus is evenly distributed between the years, the corresponding annual shares are 0.13% in the initial area, 0.10% in the additional area, and 0.23% in total. This is a calculated distribution; the actual temporal pattern of release depends on the schedule of the works and environmental conditions. Savchuk's (2002) estimate is subject to uncertainty. The comparison indicates that the potentially releasable amount of phosphorus associated with the construction works represents a small share of the total annual phosphorus flux from sediment in the Gulf of Riga, but does not allow local or short-term effects to be ruled out. The release of phosphorus from sediment is strongly linked to oxygen conditions (Aigars et al., 2015; Eglite et al., 2014; Stoicescu et al., 2022), which in turn show strong seasonal and interannual variability (Liblik et al., 2023; Stoicescu et al., 2022). It has been shown (Aigars et al., 2015) that the release of phosphorus from sediment into the water column can be around twenty times higher under oxygen-poor conditions than at high oxygen concentrations. Thus, the release of phosphorus from sediment is highly variable in time and space.

Sediment is also suspended into the water column during cable burial. The amount of suspended matter generated depends on the installation technology, which is not yet known. It is clear that the sediment does not need to be brought to the water surface, i.e. most of the sediment remains on the seabed or in the near-bottom layer. In earlier assessments of the effects of dredging works (e.g. Balticconnector, the Loode-Eesti offshore wind farm), modelling used the assumption that approximately 10% of the dredged sediment enters the water column. Monitoring of suspended matter dispersion during Balticconnector

installation did not show that the modelling had underestimated the dispersion of suspended matter. In modelling the dispersion of suspended matter generated by dredging at Paldiski harbour, it was assumed that 1% of the mass enters the water column, and the modelling results were in relatively good agreement with *in-situ* measurements and measurement results obtained by remote sensing (Sipelgas et al., 2006). Thus, 10% of the volume is rather a pessimistic estimate. The total volume of sediment moved during burial of the cable routes is approximately 2.08 million m³. Assuming 10%, the volume of sediment entering the water column during cable installation is approximately 208 000 m³, and at 1% it is 21 000 m³. Compared with the volume of sediment dumping associated with the construction of turbine foundations (initial area and additional area together approx. 1.24 million m³), the potential effect on the release of phosphorus from sediment arising from cable burial is considerably smaller.

Overall, compared with the background phosphorus flux from sediment into the water column and its variability, the transport of phosphorus from sediment into the water column associated with the construction of turbine foundations is modest at the scale of the entire Gulf of Riga. A local effect in the form of slightly more intensive primary production may occur. Whether this effect can be detected in nature against the background of other variability must be shown by construction-period monitoring of suspended matter dispersion, during which it is also recommended, *inter alia*, to measure total phosphorus, total nitrogen, phosphates, nitrates+nitrites and chlorophyll *a*.

3.3.4. Environmental measures

MITIGATION MEASURES

To reduce impacts on marine water quality and to prevent pollution incidents and limit their consequences, the following measures must be implemented during the design, construction and operation of the additional area:

- Material removed from beneath the foundations and not used on site must be taken to a dumping area authorised by the environmental permit.
- In the event of an oil spill, this would be an accident the probability of which is extremely low, but its occurrence cannot be completely ruled out. By its nature, an accident in the wind farm does not differ from any other accident involving ships, whether in port or at sea. For the rapid clean-up of a potential oil spill, a pollution response plan similar to those in place at ports is required.
- When selecting wind turbines, preference must be given to wear-resistant leading-edge protection systems, and regular inspection of the blades and timely renewal of the leading-edge protection must be ensured.
- Before construction works begin, a plan for the prevention of and pollution response to marine pollution incidents must be prepared.

If construction-period monitoring shows a greater impact on marine water quality than assessed, the intensity and timing of works in the additional area must be adjusted.

ENVIRONMENTAL MONITORING

To verify the effects of the construction and operation of the additional area, a water column monitoring programme must be implemented, aligned with the impact-area and reference-area monitoring under Section 3.1.4. During monitoring, total phosphorus, total nitrogen, phosphates, nitrates and nitrites, and

chlorophyll a must be measured, and the results assessed on the basis of the relevant indicators for the coastal water body in the central part of the Gulf of Riga³⁹.

According to the phosphorus study, construction-period monitoring must show whether the effect on marine water quality associated with sediment movement is detectable against the background of natural variability. To verify this, measurements of the above-mentioned water quality indicators must be integrated with monitoring of suspended matter dispersion, with their timing aligned to the seabed works and the dispersion of suspended matter. To distinguish the effects of the works from natural variability, the results must be compared with pre-construction baseline data and reference-area data.

During the construction phase, it is recommended that water column parameters be measured up to twice per month and at sufficient spatial resolution. The exact monitoring frequency and measurement points shall be determined in the monitoring plan, taking into account the locations and intensity of the works and the need to distinguish the effects of the works from natural variability. The recommendation concerns the measurement frequency; implementation of the water column monitoring programme and measurement of the parameters required therein are mandatory.

Additional monitoring of possible changes in water column stratification and the use of turbine foundations as permanent monitoring platforms are recommended.

3.3.5. Summary

Based on the modelling results, the construction of the additional area of the Saare-Liivi offshore wind farm entails a local and temporary increase in suspended matter concentration, a reduction in water transparency and an increase in sedimentation load. The extent and intensity of the impact depend on sediment texture, the location of the works, the season and the technology used. Under the solution proposed by the developer, material removed from beneath the foundations and not used on site is taken to a dumping area authorised by the environmental permit. The impact of the export cables has been assessed in the TalTech study (2024) for the entire connection from the additional area offshore substation to the landfall point; the modelled overall solution is conservative with respect to main alternative 3 for the additional area.

Under main alternative 3, the calculated mass of total phosphorus in the sediment to be moved is approximately 97 tonnes. According to the published study on the Gulf of Riga (Tallinn University of Technology, 2025) and assuming a 40% mobile share based on the literature, the potentially releasable stock is approximately 39 tonnes; 97 tonnes corresponds to the comparison scenario of 100% mobility, which existing studies do not support as a realistic release. These amounts do not in fact equal the load reaching the water column as dissolved phosphate: some of the phosphorus remains bound to particles, settles, or is bound again into the sediment.

Based on the existing modelling, no deterioration is forecast in the general nutrient regime of the Gulf of Riga or in the status class of the coastal water body in the central part of the Gulf of Riga.

Operation of the wind farm may locally affect water column mixing, the seasonal dynamics of chlorophyll and near-bottom oxygen content. No significant change is forecast at the basin scale of the Gulf of Riga, but the effect must be verified by follow-up monitoring under Sections 3.1 and 3.3.

³⁹ Lips, U., Väli, G., Luik, S.-T., Rünk, N., Heinsalu, A., Alliksaar, T., Liiv, M. *Secondary pollution from seabed sediments and assessment of the share of the marine internal load in the total nutrient load, and determination of the maximum permissible pollution loads for coastal water bodies. Tallinn University of Technology, 2025*

Overall, the impact of main alternative 3 on marine water quality is assessed as minor negative (–) before measures and, with the implementation of measures, including adjustment of the works on the basis of monitoring results, as neutral to minor negative (0/–).

Table 3.3-3. Impact associated with planning the wind farm and its significance

Associated consequence/impact	Significance of the impact before measures	Need for mitigation measures, final impact significance
Wind farm construction and decommissioning		
Suspended matter dispersion	0/–	Construction-period monitoring of suspended matter dispersion Water column monitoring
Transport of phosphorus from sediment into the water column	0/–	Water column monitoring
Cable construction		
Suspended matter dispersion	0/–	Construction-period monitoring of suspended matter dispersion
Wind farm operation		
Oil pollution risk	0/–	Pollution response plan

Scale of significant environmental impact used in the EIA report: – slight negative impact, -- significant negative impact, 0 - no impact, neutral, + slight positive impact, ++ significant positive impact

3.3.6. Cumulative impact

When assessing and modelling cumulative impacts, main alternative 2 of the initial area of the Saare-Liivi offshore wind farm with 120 turbines and main alternative 2 of the additional area with 50 turbines were considered in combination with the Liivi Bay offshore wind farm with 67 turbines, i.e. 237 turbines in total. The EIA report for the Liivi Bay offshore wind farm presents three alternatives: 84, 67 and 50 turbines, and modelling was carried out only for the 67-turbine alternative, concluding that the impacts of all three alternatives on water quality are the same. Accordingly, the modelled 67-turbine alternative of the Liivi Bay offshore wind farm has also been taken into account here. At the same time, in the superficies licence for the initial area of the Saare-Liivi offshore wind farm, the number of turbines has been reduced to 80 (main alternative 3); Section 8.1 of the EIA report for the Liivi Bay offshore wind farm identifies alternative 3, with 50 turbines, as the best possible, i.e. lowest-impact, alternative. Accordingly, depending on the alternative implemented for the Liivi Bay offshore wind farm, the number of turbines across the Saare-Liivi initial and additional areas and the Liivi Bay offshore wind farm could in reality range from 170 to 204. The modelled 237-turbine variant is therefore an overestimate compared with the actual situation.

The cumulative impacts of the Saare-Liivi initial and additional areas and the Liivi Bay offshore wind farm on hydrodynamics and on the physical and biogeochemical parameters of the water column were assessed. The modelling showed the following:

- The wind farms in question do not cumulatively alter the basin-scale distribution of salinity in the Gulf of Riga. A local impact can be detected in the vicinity of the wind farms. Salinity decreases in the wind farm areas, and this change is most pronounced when all areas are present. Changes in salinity are stronger under stratified conditions. During the stratified period, surface-layer salinity in the wind farm areas tends to decrease, but tends to increase in the immediate vicinity of the wind farms. It may be assumed that such trends are related to weaker transport within the wind farm areas and to stronger currents forming around the wind farms as compensation, bringing

more saline water there. A reduction in vertical mixing may also contribute to some extent to the decrease in surface-layer salinity. Similarly to the surface layer, bottom-layer salinity in the wind farm areas also decreases slightly in summer. By contrast, to the south-west of the wind farms, in the deeper area from which more saline water should be transported to the wind farm areas, salinity increases. During the winter period, the patterns of salinity change are highly variable, but the general tendency is similar to that in the stratified period, i.e. salinity in the wind farm areas tends to decrease slightly and to increase slightly away from the farms. Compared with the seasonal and short-term variability of salinity under existing conditions, the impact of the wind farms is modest and is limited to up to 10% of the above-mentioned variability.

- The wind farms do not cumulatively alter the basin-scale distributions of biogeochemical parameters (nutrients, total matter, chlorophyll, oxygen content) in the Gulf of Riga. Surface-layer chlorophyll content in the wind farm areas increases somewhat in late winter and early spring, and in summer. The spring bloom may occur slightly earlier. No sharp increase in the effect on chlorophyll content was detected as wind farms were added.
- From July to September, the oxygen content of the near-bottom layer decreases in the wind farm areas and to their south-west and west. The area affected by a reduction in oxygen content (>0.3 ml/l) increases sharply when the Liivi Bay offshore wind farm is added.
- Even if works generating suspended matter take place simultaneously in several areas, suspended matter originating from those areas does not accumulate in the water column at the same time to any appreciable extent. Across the Gulf of Riga as a whole, the construction of three wind farms (compared with the construction of one wind farm) results in the generation of suspended matter and a reduction in water column transparency over a larger area. Likewise, sedimentation exceeding the natural background occurs over a larger area when more than one wind farm is constructed. The cumulative sedimentation of suspended matter generated during the construction of the Liivi Bay offshore wind farm, together with material originating from the initial and additional areas of the Saare-Liivi offshore wind farm, is very small. Suspended matter in the water column from different development areas does not accumulate together, and the cumulative sedimentation of suspended matter originating from different areas in the same area is also modest.
- The effect on wave conditions is cumulative only under certain wind directions. The effect of the three wind farms on currents is cumulative, since turbines in one wind farm may affect currents in the area of another wind farm. Currents weaken inside the wind farms but strengthen at their edges. The effect on water column properties is likewise cumulative. Salinity decreases in the wind farm areas and increases in the peripheral areas. The thickness of the mixed layer decreases west and south of Kihnu, but increases to the south-west of the farms, towards the open sea. The decrease in the thickness of the mixed layer in spring west and south of Kihnu may trigger a somewhat earlier spring bloom. From July to September, the oxygen content of the bottom layer decreases slightly. The area affected by a reduction in oxygen content (>0.3 ml/l) increases sharply when the Liivi Bay offshore wind farm is added to the Saare-Liivi initial and additional areas. The spatial accumulation of suspended matter from different areas, and of its sedimentation, is marginal and therefore the impact is insignificant.

To verify cumulative impacts, monitoring in accordance with Section 3.3.4 must be implemented in the additional area. When tracking the development of the in-combination effect, monitoring data collected since the construction of the first wind farm in the area will also be used where possible. If the Saare-Liivi initial area is constructed before the additional area, the likelihood of complete temporal overlap of foundation, dumping and cable works will be reduced. TalTech's 2024 cable model covered the connection from the additional area offshore substation via the initial area offshore substations to the landfall point; therefore the in-combination effect of export cabling has been taken into account in the model's base scenario. Even assuming simultaneous works, the spatial accumulation of suspended matter remained limited, and no significant impact on protected areas is forecast.

Cumulative construction-period phosphorus loading depends primarily on the temporal overlap of dredging and dumping works in the Saare-Liivi initial and additional areas and at the Liivi Bay offshore wind farm.

According to the modelling, suspended matter plumes originating from different development areas do not accumulate to a spatially significant extent, but moving sediments adds a temporary load to the same nutrient system of the Gulf of Riga. The limited spatial overlap of suspended matter does not in itself preclude nutrient loads being additive. Given the order of magnitude of the load, the duration of the works and the basin-scale modelling, no significant cumulative impact is forecast; local effects will be controlled by water column monitoring and, where necessary, by adjusting the works (Section 3.3.4).

3.3.7. Uncertainty/knowledge gaps

The main uncertainties in the marine water quality assessment relate to the final project design, the phosphorus fractions in the sediments and the natural variability of the Gulf of Riga. At the EIA stage, the exact locations of the turbines and offshore substation, the foundation type to be selected, the actual volume and depth of sediment to be removed, the dumping solution, and the construction schedule are not yet finally known.

Total phosphorus was determined in the sediment samples, but not the mobile phosphorus fraction. Accordingly, both a 40% mobile proportion and a separate comparison scenario with 100% mobility were used. The calculated mass of mobile phosphorus represents the potentially releasable stock, not the load that actually reaches the water column as dissolved phosphate, and it is treated as a conservative calculation basis.

The modelling of suspended matter dispersion covered the up-to-50-turbine configuration current at the time of the study and the entire route of the connection cable from the additional area offshore substation via the initial area offshore substations to the landfall point. The modelled solution is conservative relative to the up-to-40-turbine solution under main alternative 3. Uncertainty in the modelling arises primarily from the spatial variability of sediment properties, the actual generation of suspended matter associated with the technology used, and the temporal and spatial sequencing of the works.

The seasonal and interannual variability of nutrient content, water column stratification and near-bottom oxygen content in the Gulf of Riga is high, which may make it difficult to distinguish the impact associated with the construction works from natural variability. Based on the available data and impact assessment, the construction and operation of main alternative 3 are nevertheless not expected to cause significant deterioration in either the overall nutrient regime of the Gulf of Riga or the status class of the coastal water body of the central Gulf of Riga. To verify the impact forecast, the water column monitoring described in Section 3.3.4 will be implemented, linking construction-period monitoring of suspended matter dispersion with measurements of nutrients and chlorophyll *a*, and comparing the results with data on the pre-construction condition and the reference area. If monitoring shows a greater impact on marine water quality than assessed, the intensity and timing of works in the additional area must be adjusted.

3.4. Seabed biota and habitats

This chapter is based on the study carried out by UT Estonian Marine Institute, "Seabed study, artificial substrate colonisation study and water quality study in the Saare-Liivi offshore wind farm area" (prepared by UT Estonian Marine Institute, 2026), and on its special part, Report 5: study of seabed biota and habitats in the Saare-Liivi additional area, Appendix 3.4.

In addition, artificial substrate colonisation study/experiments were carried out in the initial area of the Saare-Liivi offshore wind farm⁴⁰ as one component of the seabed study, in order to clarify the impact on the surrounding environment associated with the colonisation of the artificial substrate created by wind turbine foundations during construction of the wind farm. The results of the experiment are reported in the EIA report for the Saare-Liivi initial area⁴¹. The experiment was not extended to the additional area of the Saare-Liivi offshore wind farm and, in making the assessments, repetition of the experiment is not necessary, since it is the same body of water and the environmental conditions are expected to be similar. The conclusions of the study can be applied to the additional area.

In assessing possible impacts, the primary focus is on long-term impacts that alter the structure and function of seabed biota and habitats in the study area. The short-term impacts of constructing the wind farm occur primarily during the construction phase and are generally reversible. The impacts on seabed habitats and seabed biota are assessed separately. Potential impacts associated with the so-called 'reef effect' are also assessed.

3.4.1. Consideration of alternatives

The fieldwork for the seabed biota and habitats study and the modelling of the distribution of biota and habitats were carried out within the study area corresponding to main alternative 1 of the additional area. Calculations of seabed loss, disturbance and the addition of artificial substrate were prepared for the indicative layout of main alternative 3, under which up to 40 wind turbines and one offshore substation are planned within an area of 57.1 km².

Main alternative 3 lies entirely within the area studied in detail. For disturbance buffers and parts of the dumping area extending beyond the study area mapped in detail, nationwide modelled data on the distribution of seabed habitats were used. For such areas, the spatial accuracy of the assessment is lower than that of the mapping based on fieldwork carried out in the project area.

⁴⁰ Report 3: artificial substrate colonisation study (hereinafter Colonisation Study – UT Estonian Marine Institute, 2024), Appendix 3.6 to the main EIA report

⁴¹ Utilitas Wind OÜ. 2025. Environmental impact assessment report for the Saare-Liivi offshore wind farm with appendices. Found to comply with requirements on 06.08.2025.

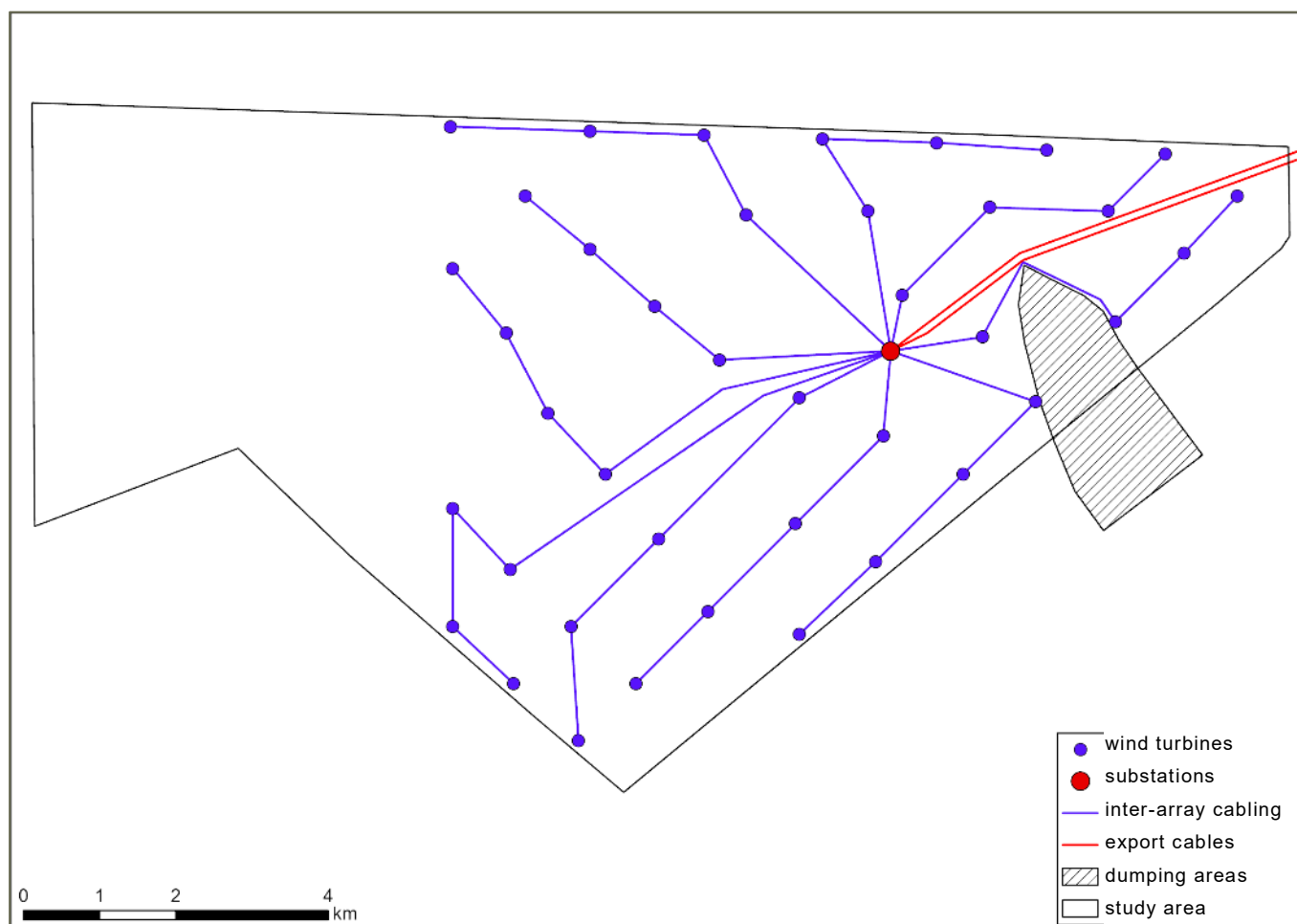


Figure 3.4-1 The spatial extent of the entire study area, i.e. main alternative 1 of the additional area, and the location of the wind farm infrastructure and dumping area forming the basis for the assessment, i.e. main alternative 3 (UT Estonian Marine Institute, 2026 – Report 5)

As technical alternatives, two foundation solutions – gravity base foundation and monopile foundation – are considered and assessed, together with the impacts on seabed habitats associated with their installation.

In the assessments, the position of the offshore substation was treated in the same way as the positions of the turbines.

3.4.2. Description of environmental status

To assess the existing condition of seabed biota and habitats, fieldwork involving the collection of seabed samples was carried out in the study area (main alternative 1 of the additional area) during the period 8.05.–20.06.2023. During the fieldwork, 206 sampling points were visited: at all points, estimates of seabed substrate and biota cover were made, and biomass samples were collected at 64 points (Figure 3.4-2).

Based on depth data from the Transport Administration, water depth in the area of main alternative 1 of the additional area ranges from approximately 23.8 to 41 m, with an average depth of 35.8 m.

Seabed substrate

Sandy and muddy seabed sediments dominated in the additional area; mixed substrate was less common. Muddier sediments dominated in the deeper western part of the additional area, and sands in the shallower eastern part. In the additional area, harder substrate was associated with relief features rising somewhat above the rest of the seabed.

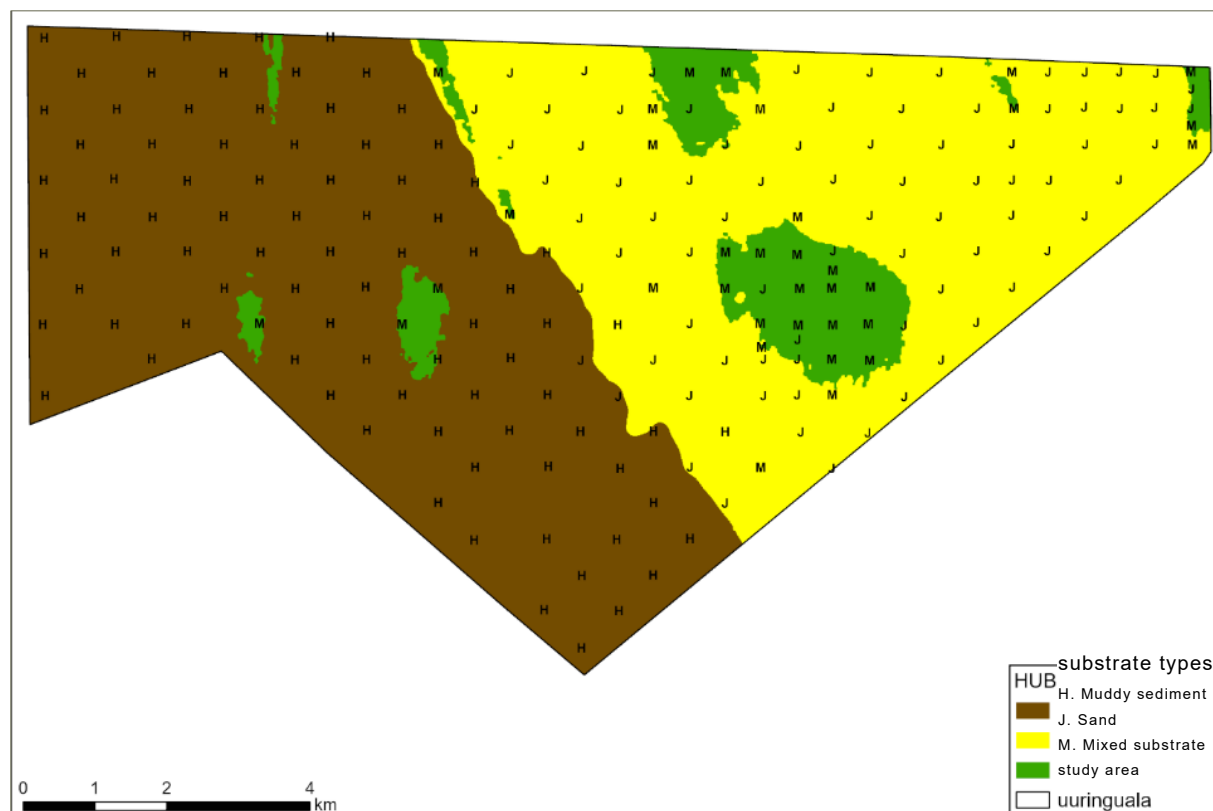


Figure 3.4-5 Distribution of the substrate types of level 3 habitats under the HELCOM HUB habitat classification in the additional area. The raster surface was obtained as a result of modelling. Letters indicate the values at the sampling points (UT Estonian Marine Institute, 2026 – Report 5)

Benthic biota

In the cover assessments, only two benthic biota taxa in total were identified – the bay barnacle (*Amphibalanus improvisus*) and hydroids (*Hydrozoa*) (Table 3.4-1). Both taxa were found at few sampling points (fewer than 10 points) and with low cover values (up to 5%). No plants were found in the additional area – the entire seabed of the additional area is aphotic due to its great depth.

The biomass samples likewise showed that the additional area had low species diversity, and no plants were found. A total of 22 benthic fauna taxa were found in the biomass samples. The most frequently occurring species (frequency > 50%) were the common amphipod (*Monoporeia affinis*), the Virginia polychaete (*Marenzelleria neglecta*), oligochaetes (*Oligochaeta*), the hump-backed amphipod (*Pontoporeia femorata*) and the Baltic tellin (*Macoma balthica*). The Baltic tellin had the highest biomass (Table 3.4-2). Figure 3.4-6 shows the occurrence of all species in the study area across the cover

assessments and biomass samples. None of the species found are listed in the HELCOM Red List of threatened benthic fauna⁴² or phytobenthos⁴³ species⁴⁴.

Table 3.4-2 Occurrence, depth distribution and mean and maximum biomass values of benthic biota taxa based on biomass samples. Mean biomass was calculated only from those sampling points at which the respective taxon occurred (UT Estonian Marine Institute, 2026 – Report 5). This table presents the species that occurred at more than 50% of the sampling points.

Taxon	Occurrence (%)	Depth, minimum (m)	Depth, maximum (m)	Biomass, mean (g/m²)	Biomass, maximum (g/m²)
<i>Macoma balthica</i> (Baltic tellin)	53.1	27.6	41.5	31.2616	84.7324
<i>Marenzelleria neglecta</i> (Virginia polychaete)	78.1	27.6	41	0.208	0.7144
<i>Monoporeia affinis</i> (common amphipod)	92.2	31.5	41.5	0.1417	0.7182
<i>Oligochaeta</i> (oligochaetes)	64.1	27.6	39	0.0645	0.399
<i>Pontoporeia femorata</i> (hump-backed amphipod)	54.7	33.7	41.5	0.4158	1.0716

Infaunal bivalve biomass, of which nearly 100% consisted of Baltic tellin, was higher in the shallower eastern part of the additional area, where sandy seabed sediments dominated. No clear pattern can be identified in the distribution of infaunal crustaceans (Figure 3.4-8); the highest biomasses in this animal group were associated with *Saduria entomon*, whose presence in samples collected with a grab sampler is fairly random, as it is a large and mobile animal. In the distribution pattern of infaunal polychaetes, lower biomasses can be identified in areas with higher cover of hard bottom substrate (Figure 3.4-9).

Seabed habitats

No Habitats Directive habitat types were identified in the additional area. Sandbanks (1110) were absent, as the maximum depth of their distribution is limited to the photic seabed, whereas the entire additional area was aphotic. The Reefs (1170) habitat type was absent because the cover of characteristic species remained below the threshold; in addition, hard seabed (hard substrate cover >50%) was extremely scarce in the additional area. The remaining Habitats Directive habitat types cannot occur, as they are directly associated with the coast.

According to the HELCOM HUB (HELCOM *Underwater Biotopes* system) classification system⁴⁵, the distribution of level 3 to 5 habitats was modelled in the Saare-Liivi additional area. The distribution and areas of the main seabed habitat types under the MSFD (based on the Marine Strategy Framework Directive) were also mapped. The relevant figures and tables can be found in section 3.4 of Appendix 3.4 to this EIA report.

All Habitats Directive habitat types occurring in the Baltic Sea are included in the HELCOM Red List (HELCOM *Red List*) (HELCOM 2013b⁴⁵), but none were found in the additional area. In addition to Habitats Directive habitat types, the Red List also includes HUB level 6 habitats. In the additional area of the Saare-Liivi offshore wind farm, the occurrence of the HUB level 6 Red List habitat *AB.H3N1 Aphotic muddy*

⁴² <https://helcom.fi/baltic-sea-trends/biodiversity/2024-red-list-of-species/2024-red-list-of-benthic-invertebrates/>

⁴³ <https://helcom.fi/baltic-sea-trends/biodiversity/2024-red-list-of-species/2024-red-list-of-macrophytes/>

⁴⁴ Red List categories: CR–Critically Endangered; EN–Endangered; VU–Vulnerable; NT–Near Threatened.

⁴⁵ Technical Report on the HELCOM Underwater Biotope and habitat classification (HELCOM 2013a)

sediment Monoporeia affinis and/or Pontoporeia femorata with dominance of (Baltic aphotic muddy sediment dominated by Monoporeia affinis and/or Pontoporeia femorata) was identified at 18 sampling points, primarily in the western part of the additional area (Figure 3.4-10).

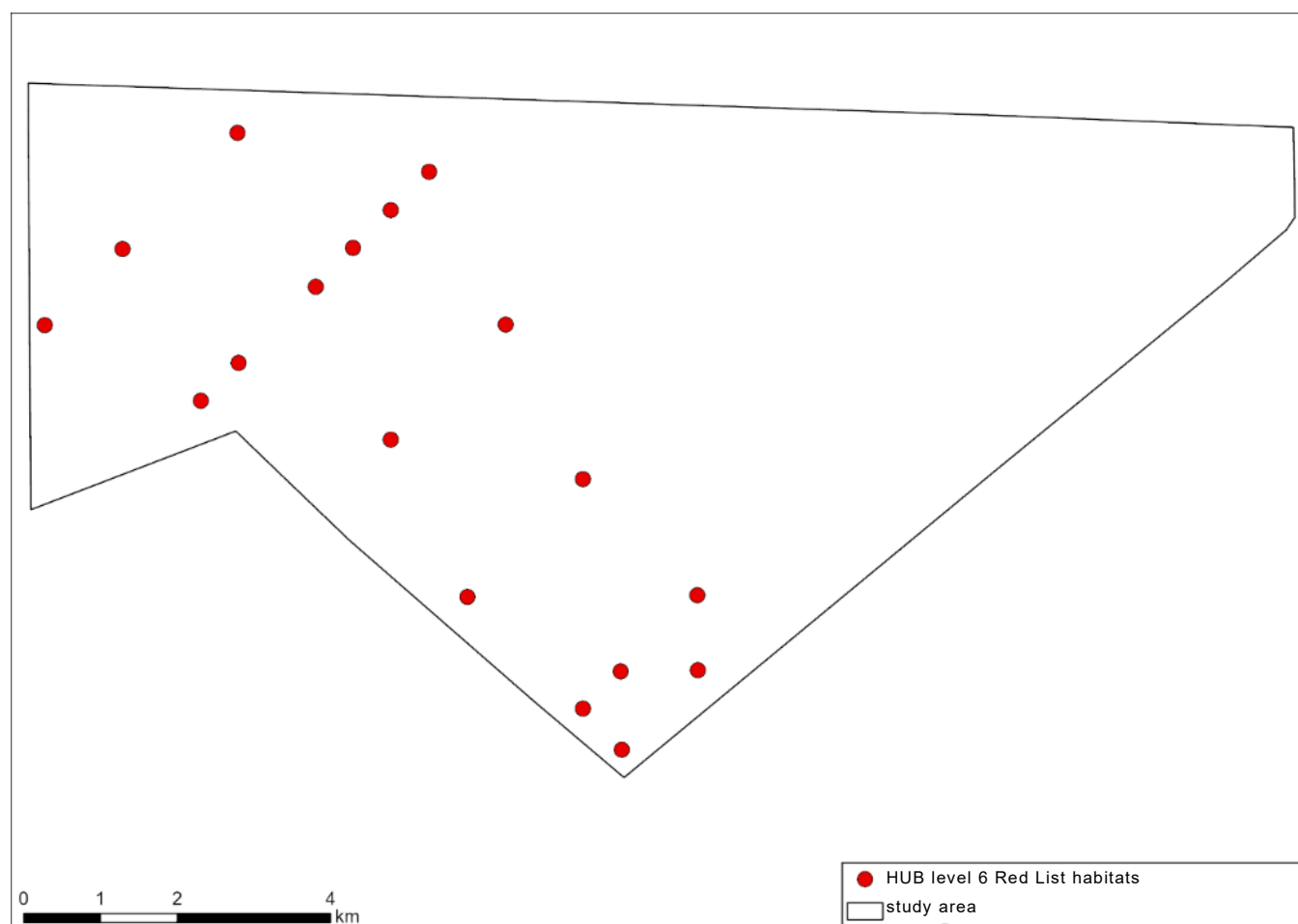


Figure 3.4-10. HELCOM Red List habitats at HUB level 6 (UT Estonian Marine Institute, 2026 – Report 5)

3.4.3. Impact assessment

The assessment of seabed biota and habitats is based on the indicative layout of main alternative 3 of the additional area (Figure 3.4-1). Impacts were considered in terms of the following components: loss of natural habitats, seabed disturbance and the reef effect.

The impacts on seabed biota can be divided into two categories. Long-term impacts are associated with permanent seabed loss and the addition of artificial substrate (foundations, cables and dumping areas), while temporary impacts are associated with construction-phase suspended matter, sediment redistribution and temporary disturbance of habitats.

The study considered two foundation alternatives for the turbines and the offshore substation:

- monopile foundation – diameter 18 m, footprint area 254.5 m²;
- gravity base foundation – base diameter 50 m, footprint area including the foundation pad 2500 m².

In the assessments, the position of the offshore substation was treated in the same way as the positions of the turbines.

As regards **loss of natural seabed**, it was assumed that the natural seabed beneath the foundations and foundation pads is lost as a result of covering and removal. The geometries of the turbine and substation foundations were obtained by applying buffers corresponding to the foundation radii to the location points. For the gravity base foundation, the radius of the foundation pad was used as the radius.

Cables (inter-array and export cables) are installed either buried in the sediment or laid on the seabed surface, with rock placement cover where necessary. During burial, the trench is created either with high-pressure water jets or with a chain cutter. At the time of preparing the seabed study, it had not been determined where and which installation technologies would be used. Therefore, for the purpose of a generalised assessment, a 2 m wide strip per cable was used as the construction zone. Within the construction zone, the natural condition of the seabed is lost as a result of excavation of seabed substrate, burial of cables or covering. The geometry of the loss area associated with cables was obtained by adding a 1 m buffer in all directions to the cable geometries (line features).

The dumping area polygon was included in full as seabed loss, because as a result of dumping the natural character of the seabed (seabed substrate, topography) is lost and the expected recovery, should it occur, takes longer than two MSFD assessment periods (more than 12 years). The southern dumping area was included in full in the loss assessment, including the part that lies outside the boundary of the additional area.

Natural seabed disturbance is taken to mean the impact associated with suspended matter dispersion and sedimentation resulting from infrastructure installation. This is a temporary disturbance for which recovery of seabed properties and communities is expected. In MSFD terms, disturbance is considered to be a reversible impact from which recovery occurs in less than two assessment cycles, i.e. in less than 12 years⁴⁶.

For the assessment of seabed disturbance, a 1 km radius impact area buffer was applied to the infrastructure objects. This buffer size is consistent with the HELCOM HOLAS approach (HELCOM 2023a, 2023b) and with the assessment published by the Environmental Agency in 2024 and the guidance material prepared by the UT Estonian Marine Institute in 2025 based on it. According to the HOLAS methodology, a 1 km buffer is applied to cables and wind farms under construction, and a 0.5 km buffer to dumping areas. In the present study, for the sake of conservatism, a 1 km buffer was also applied to the dumping area, because there is no basis for assuming that suspended matter dispersion associated with dumping would be smaller in extent than suspended matter dispersion associated with cable installation and foundation construction. The 1 km buffer is also supported by the results of suspended matter dispersion modelling (Tallinn University of Technology), according to which a sedimentation level exceeding the natural background is observable at approximately this distance; the 1 km disturbance buffer was added to the geometry of the seabed loss area. Since, in the case of 1 km radius buffers, the buffers of different infrastructure objects overlap extensively, the overlapping parts of the geometries were merged in order to avoid multiple counting of area. The loss geometry was removed from the disturbance geometry, i.e. the loss and disturbance areas do not overlap. Since foundations and cables are also planned at the edges of the buildable area, the 1 km buffers extend partly beyond the study area; outside the study area, nationwide modelled distribution data on seabed habitats were used. Figure 3.4-11 illustrates how the loss and disturbance geometries were accounted for.

⁴⁶ [Commission Decision \(EU\) 2017/848 of 17 May 2017](#)

Reef effect assessments were based on calculating the surface areas of the underwater parts of the foundations (offshore substation and turbines) according to the water depth at each position (Table 3.4-3). For the monopile foundation, cylindrical geometry was assumed over the entire underwater part, and the lateral surface area of the cylinder was calculated according to the water depth at each foundation position. For the gravity base foundation, information on the precise geometry was not available, but the developer provided the underwater surface area corresponding to the different depths in tabular form. A thickness of 15 m was assumed for the photic water column, in accordance with the estimate obtained for the initial area.

ASSESSMENT OF LOSS OF NATURAL SEABED

The estimated losses of natural seabed associated with the infrastructure planned for the additional area and the use of the dumping area were relatively small in terms of area, remaining within approximately 4.4 km² (Table 3.4-4). Compared with the foundations and cables, the loss area associated with the dumping area was considerably larger – 4.15 km²; the combined loss area of the cables and foundations was only up to approximately 0.3 km². As regards the export cables, the areas presented in Tables 3.4-4 and 3.4-6 include the route section lying within the study area of the additional area (approximately 12 km of cable). The route section from the boundary of the additional area to the offshore substation(s) in the initial area runs through the initial area, falls within the scope of cabling assessed in the EIA report for the initial area, and has additionally been taken into account in the assessment of the in-combination effect of the initial and additional areas (Section 3.4.6).

The dumping area is treated as permanent seabed loss, because dumping changes both the seabed substrate and the topography, and any possible recovery of the natural condition would take more than two MSFD assessment periods.

Losses associated with cables are greater than losses associated with foundations. Losses associated with gravity base foundations are approximately 10 times greater than losses associated with monopile foundations (Table 3.4-4).

Table 3.4-4 Seabed loss areas by infrastructure object. All areas include all planned foundations (turbines and offshore substation) and cables (inter-array and export cables). For the dumping area, the southern dumping area was taken into account in full, including the part that lies outside the boundary of the additional area (UT Estonian Marine Institute, 2026 – Report 5)

Infrastructure object	Loss area (km ²)
cables	0.155
gravity base foundations	0.102
monopile foundations	0.010
dumping area	4.15

The assessment of losses for all seabed habitats is presented in Table 3.4-5. Since no Habitats Directive habitat types occurred in the additional area, there are no losses associated with them. Among the MSFD habitats, circalittoral sandy and muddy bottoms are the most affected. Since the main reason for habitat losses is the large area of the dumping area compared with the other infrastructure objects, the differences between gravity and monopile foundations are minimal.

Of the habitats with conservation status, the loss polygons include the HELCOM Red List HUB level 6 habitat AB.H3N1 Aphotic muddy sediment with dominance of *Monoporeia affinis* (common amphipod) and/or *Pontoporeia femorata* (humpback amphipod). Since HUB level 6 habitats are defined through the dominant species, modelling their distribution in seabed habitat mapping work is usually not practical or possible, as it would require modelling almost all species. Therefore, it is not possible to assess the loss area of this habitat precisely. Given that the common and humpback amphipods were the main infaunal

crustaceans in the additional area and were very widely distributed, the loss area of the HUB level 5 habitat AB.H3N Muddy sediment with infaunal crustaceans in the aphotic zone may be taken as an estimate of the loss area of the associated Red List habitat (Table 3.4-5).

Table 3.4-5 *Estimated loss and disturbance areas of Habitats Directive habitat types (HD), Marine Strategy Framework Directive seabed habitat broad types (MSFD) and HELCOM Red List habitats for the additional area option with gravity base foundations (gra) and monopile foundations (vai). Losses and disturbances include the aggregate areal impact of all infrastructure objects (foundations, cables, dumping area) (UT Estonian Marine Institute, 2026 – Report 5)*

Classification	Name	Loss (km²), gra	Loss (km²), vai	Disturbance (km²), gra	Disturbance (km²), vai
HD	reefs	0	0	0.004*	0.004*
MSFD	circalittoral sandy bottom	2.103	2.054	38.269	38.272
MSFD	circalittoral muddy bottom	2.262	2.233	39.55	39.218
MSFD	circalittoral mixed sediment	0.041	0.028	10.765	10.661
HELCOM Red List	AB.H3N1	0.031	0.015	7.69	7.68

*The reefs within the disturbance area are not located in the Saare-Liivi additional area but in the initial area of the Saare-Liivi offshore wind farm

ASSESSMENT OF SEABED DISTURBANCES

The estimated seabed disturbance associated with the infrastructure planned for the additional area is approximately 88 km² in terms of area (Table 3.4-6). The differences in disturbance areas between the different foundation alternatives are very small, because with a disturbance extent of 1 km neither the size of the foundation footprint nor the location of the foundation has a significant effect.

Table 3.4-6 *Seabed disturbance areas by foundation alternative. All areas include all planned foundations (turbines and offshore substation) and cables (inter-array and export cables) (UT Estonian Marine Institute, 2026 – Report 5)*

Alternative	Disturbance area (km²)
gravity base foundations, cables, dumping area	88.6
monopile foundations, cables, dumping area	88.2

The assessment of disturbances to Habitats Directive habitat types (HD), Marine Strategy Framework Directive seabed habitat broad types (MSFD) and HELCOM Red List habitats is presented in Table 3.4-5. Of the habitats with direct conservation status, the disturbance polygons include an extremely small area of the Habitats Directive reef habitat type (0.004 km²), which is located in the initial area of the Saare-Liivi offshore wind farm, and the HELCOM Red List habitat AB.H3N1 Aphotic muddy sediment with dominance of *Monoporeia affinis* and/or *Pontoporeia femorata*.

Since HUB level 6 habitats are defined through the dominant species, modelling their distribution in seabed habitat mapping work is usually not practical or possible, as it would require modelling almost all species. Therefore, it is not possible to assess the disturbance area of this habitat precisely. Given that the common and humpback amphipods were the main infaunal crustaceans in the additional area and were very widely distributed, the disturbance area of the HUB level 5 habitat AB.H3N Muddy sediment with infaunal crustaceans in the aphotic zone, which was 7.7 km² for both foundation alternatives, may be taken as an estimate of the mechanical disturbance area of the associated Red List habitat.

ASSESSMENT OF THE REEF EFFECT

The addition of hard substrate within the water column can be regarded as the so-called reef effect – the artificially added surface becomes a habitat for native species that require hard substrate for attachment. Man-made structures can also create habitats characteristic of hard bottoms (reefs) in areas where they do not occur naturally. In addition, artificial objects extending through the water column, such as the underwater parts of the turbines, create hard substrate in depth zones where it did not previously occur.

To assess the extent of the reef effect, the surface areas of the underwater infrastructure in the additional area of the Saare-Liivi offshore wind farm were calculated for each foundation type. Only the underwater parts of the turbines and offshore substations were taken into account in the estimates of the area of additional underwater hard substrate. According to the technical description, hard substrate may also be added through covering the cables with rock or concrete. The resulting area estimates were compared with the area of hard bottom substrate in the entire study area, and the proportion of the additional anthropogenic substrate relative to the existing natural hard substrate was determined. To calculate the total area of natural hard seabed, the proportion of hard bottom substrate in each modelled pixel was multiplied by the pixel area and summed across all pixels. Table 3.4-7 presents the amounts of additional underwater surface area by foundation alternative.

The assessment shows that with gravity base foundations the amount of additional anthropogenic hard substrate is greater than with monopile foundations. With gravity base foundations, 0.12 km² of underwater surface area is added, which, compared with the natural hard bottom in the additional area, amounts to 2.7%. It should be taken into account that, owing to depth, there is no photic seabed in the additional area, and that the underwater parts of the turbines falling within the photic water column (depth <15 m) create a habitat suitable for phytobenthos that was previously absent in the area. Therefore, an increase in species diversity (plants, invertebrates of the vegetation zone) and the emergence of benthic primary production are possible in the additional area. At the same time, given the scale of the planned infrastructure, the additional photic substrate has a rather small total area (0.03 km² in the case of monopile foundations) and will not cause significant changes in the matter cycling and ecological processes of the Gulf of Riga. The proportions given for the reef effect (2.7% and 1.8%) were calculated relative to the area of natural hard seabed in the 91.2 km² study area of the baseline survey (the spatial extent of main alternative 1), while the additional underwater surface area was calculated solely on the basis of 40 wind turbines and one offshore substation under main alternative 3.

Table 3.4-7 Amount of additional underwater hard substrate (reef effect) summed across all foundations. For monopile foundations, the area falling within the photic zone has also been calculated, assuming a photic depth of 15 m (UT Estonian Marine Institute, 2026 – Report 5)

Alternative	Area (km ²)	photic area (km ²)	Proportion of natural hard bottom (%)
gravity base foundations	0.12		2.7
monopile foundations	0.08	0.03	1.8

The general process-based conclusions of the study of colonisation of artificial substrate carried out as part of the EIA for the initial Saare-Liivi area (UT Estonian Marine Institute, 2024 – Report 3) are also applicable in assessing the impacts of the additional area. Both areas are located in the same Gulf of Riga marine environment, and the addition of foundations will also create new artificial hard substrate in the additional area. At the same time, the exact species composition, biomass and vertical distribution of the colonising communities may differ depending on depth, light conditions, hydrodynamics and the local food base. Therefore, the study from the initial area is used for the additional area primarily to predict the nature of possible change, rather than a precise quantitative outcome.

3.4.4. Environmental measures

MITIGATION MEASURES

The study results do not necessitate any further reduction in the spatial extent of main alternative 3 for the additional area, nor the designation of a full exclusion zone on the basis of seabed habitats, because no Habitats Directive habitat types or threatened benthic species occur in the additional area.

The mitigation measures laid down in the EIA report for the initial area for the installation of export cables must be applied to the section of connection cable running from the boundary of the additional area to the offshore substations in the initial area. The seabed loss and disturbance of this section have been taken into account in the in-combination effect assessment in this report.

At the detailed design stage, on the basis of the final infrastructure layout and construction technology, the area of permanent seabed loss must be specified by habitat type and compliance with the 2% criterion must be verified in combination with the initial Saare-Liivi area and the Liivi Bay offshore wind farm. The calculations must be based on the habitat classification and spatial assessment unit used in the in-combination effect assessment in Section 3.4.6, as well as on up-to-date available data on the other projects. If the calculations show that the criterion is exceeded, the project design for the additional area must be adjusted to reduce permanent seabed loss to an extent that ensures compliance with the criterion.

ENVIRONMENTAL MONITORING

The purpose of follow-up monitoring of benthic biota is to verify impacts on seabed biota and habitats and to monitor the long-term dynamics of colonisation of the artificial substrate and possible ecological changes.

For the additional area, a monitoring plan for benthic biota and habitats must be prepared before the start of construction works, covering the impacts of the construction of the turbines, offshore substation, inter-array cables and connection cables in the additional area, as well as changes in habitat quality. Monitoring is mandatory to the extent described below, except for the recommended elements. Where possible, the monitoring must be methodologically aligned with the monitoring for the initial area. If monitoring of the initial area has been carried out before construction of the additional area and its results can be used to assess the impacts of the additional area, the Environmental Board may, where justified, reduce the scope of monitoring for the additional area.

PRE-CONSTRUCTION AND CONSTRUCTION-PHASE MONITORING

- At the locations where foundations are to be installed (turbines and offshore substation) and within a 200 m radius of each foundation, document the structure and characteristics of the seabed habitat before construction works (sonar mapping of seabed relief, underwater video observations, where possible quantitative sampling, oxygen conditions, sediment organic matter content).
- Immediately after foundation installation, document the condition of the seabed biota and habitat in the immediate vicinity of the foundation (within a 200 m radius) and the extent of any possible damage (video observations). The locations of the foundations requiring documentation shall be specified on the basis of the results of pre-construction monitoring (it will then no longer be necessary to monitor all foundations).

POST-CONSTRUCTION MONITORING

- Monitor colonisation of the foundation structures by seabed biota (quantitative sampling/assessment, once a year, for five years after foundation installation, across the full depth range from the seabed to the surface, three foundations in different parts of the additional area).
- Monitor accumulation of organic matter near the foundation (on the seabed immediately adjacent to the foundation, 0–30 m from the foundation; sediment traps, over five years, three foundations in different parts of the additional area).

As part of follow-up monitoring, it is recommended to plan monitoring of non-native species, enabling early detection of new species and, where necessary, the development of appropriate control or mitigation measures. As artificial substrates may facilitate the spread of some non-native species, it is appropriate to treat monitoring of non-native species as one component of the benthic biota monitoring programme.

After removal of the foundations, the condition of seabed biota and habitats must be checked in order to assess the extent of disturbance caused by the removal and recovery.

3.4.5. Assessment of alternatives and summary

No Habitats Directive habitat types were found in the additional area. In the additional area, among the HUB level 6 Red Book habitats, AB.H3N1 Aphotic muddy sediment dominated by *Monoporeia affinis* and/or *Pontoporeia femorata* was recorded at 18 sampling points, mainly in the western part of the area.

The impacts are largely confined to the immediate vicinity of the wind farm structures planned in the additional area (turbines, cables, offshore substation) and do not cause extensive reconfiguration of the seabed habitat structure in the additional area. The affected habitats are widely distributed in the Gulf of Riga, and no rare or Habitats Directive-protected marine habitats occur in the additional area.

The estimate of seabed loss for main alternative 3 of the additional area is dominated by the treatment of the entire 4.15 km² polygon of the southern dumping area as long-term seabed loss. The total direct footprint of the turbines, offshore substation and cables is approximately 0.26 km² in the case of gravity base foundations and approximately 0.17 km² in the case of monopile foundations. The direct footprint of the foundations is approximately ten times larger in the case of gravity base foundations than in the case of monopile foundations, but in the estimate of total loss the dominant share of the dumping area reduces the relative difference between the alternatives.

Table 3.4-8 Comparison of different foundation types and impact significance

Associated consequence/impact	Impact significance	Need for the application of mitigation measures, final impact significance
Wind farm construction and decommissioning	0/-	Selection of foundation type and refinement of turbine positions to avoid hard substrate (Section 3.4.4). Residual impact 0/-
Monopile foundation		
loss of natural seabed	-	Specification of the area of permanent loss by habitat type and verification of the 2% criterion at the detailed design stage (section 3.4.4). Residual impact –

Associated consequence/impact	Impact significance	Need for the application of mitigation measures, final impact significance
addition of artificial hard substrate and the associated impact on certain groups of organisms	0/-/+	
seabed disturbance	0/-	Disposal of removed material at a dumping area authorised by the environmental permit, and adjustment of the intensity and timing of works on the basis of monitoring (section 3.3.4). Residual impact 0/-
Gravity base foundation		
loss of natural seabed	-	Specification of the area of permanent loss by habitat type and verification of the 2% criterion at the detailed design stage (section 3.4.4). Residual impact -
addition of artificial hard substrate and the associated impact on certain groups of organisms	0/-/+	
seabed disturbance	0/-	Disposal of removed material at a dumping area authorised by the environmental permit, and adjustment of the intensity and timing of works on the basis of monitoring (section 3.3.4). Residual impact 0/-
Wind farm operation	0/-/+	

Scale of significant environmental impact used in the EIA report: - slight negative impact, -- significant negative impact, 0 - no impact, neutral, + slight positive impact, ++ significant positive impact

3.4.6. Cumulative impact

When assessing the cumulative impact on seabed biota and habitats, the initial and additional areas of the Saare-Liivi offshore wind farm are first considered, including the foundations of turbines and offshore substations, inter-array cables, export cables and both dumping areas (Figure 3.4-12). The impact of the initial and additional areas of Saare-Liivi is then assessed in combination with the Liivi Bay offshore wind farm.

Table 3.4-9. Overall extent of seabed impacts of the initial and additional areas of Saare-Liivi and the Liivi Bay offshore wind farm

Assessed component	Infrastructure included	Seabed loss, approximately	Seabed disturbance, approximately	Note
Main alternative 3 for the Saare-Liivi additional area	40 turbines, offshore substation, cables and the southern dumping area	4.41 km ²	88.6 km ²	Conservative gravity base foundation variant
Saare-Liivi initial and additional areas including the dumping areas	Initial area, additional area, export cables and both dumping areas	8.21 km ²	319.0 km ²	Summed by MSFD seabed habitat broad type
Liivi Bay offshore wind farm – harmonised	Wind-farm internal infrastructure (turbines with foundations and	1.17 km ²	194.3 km ²	Does not include the entire project infrastructure of the Liivi Bay offshore wind farm;

Assessed component	Infrastructure included	Seabed loss, approximately	Seabed disturbance, approximately	Note
estimate from the baseline survey	inter-array cables); export cables and possible dumping areas have not been included due to lack of data			the impact associated with installation of the export cable has not been assessed
Projects combined in the harmonised estimate	Sum of the combined row for the Saare-Liivi initial and additional areas and the row for the Liivi Bay offshore wind farm	9.38 km²	513.3 km²	Disturbance is an estimated area based on a conservative 1 km buffer

Cumulative impact would arise primarily in the form of habitat loss and disturbance if wind farm development in the Saare-Liivi additional area were to add a further area of disturbed or lost habitat to habitats already disturbed or lost. In the impact calculations, the solution with gravity base foundations was used for the Saare-Liivi initial and additional areas, as this entails greater permanent seabed loss. The Saare-Liivi estimate includes all known infrastructure in the initial and additional areas, including the export cables and both dumping areas. For the Liivi Bay offshore wind farm, a 15 MW solution with gravity base foundations and the wind-farm internal infrastructure (turbines with foundations and inter-array cables) were used. In assessing disturbance for both the Saare-Liivi and Gulf of Riga developments, a 1 km buffer based on HELCOM HOLAS and the Environmental Agency methodology was used. For areas outside the initial and additional areas, Estonia-wide modelled seabed habitat distribution data were used.

The disturbance area determined on the basis of a one-kilometre buffer is a conservative spatial area, not an area where all seabed biota are necessarily destroyed or where the full impact occurs at the same intensity throughout. The actual intensity of sedimentation decreases with increasing distance from the source of impact, and construction activity takes place in stages. At the same time, a uniform buffer makes it possible to assess the possible spatial accumulation of physical pressure from different projects in a comparable manner.

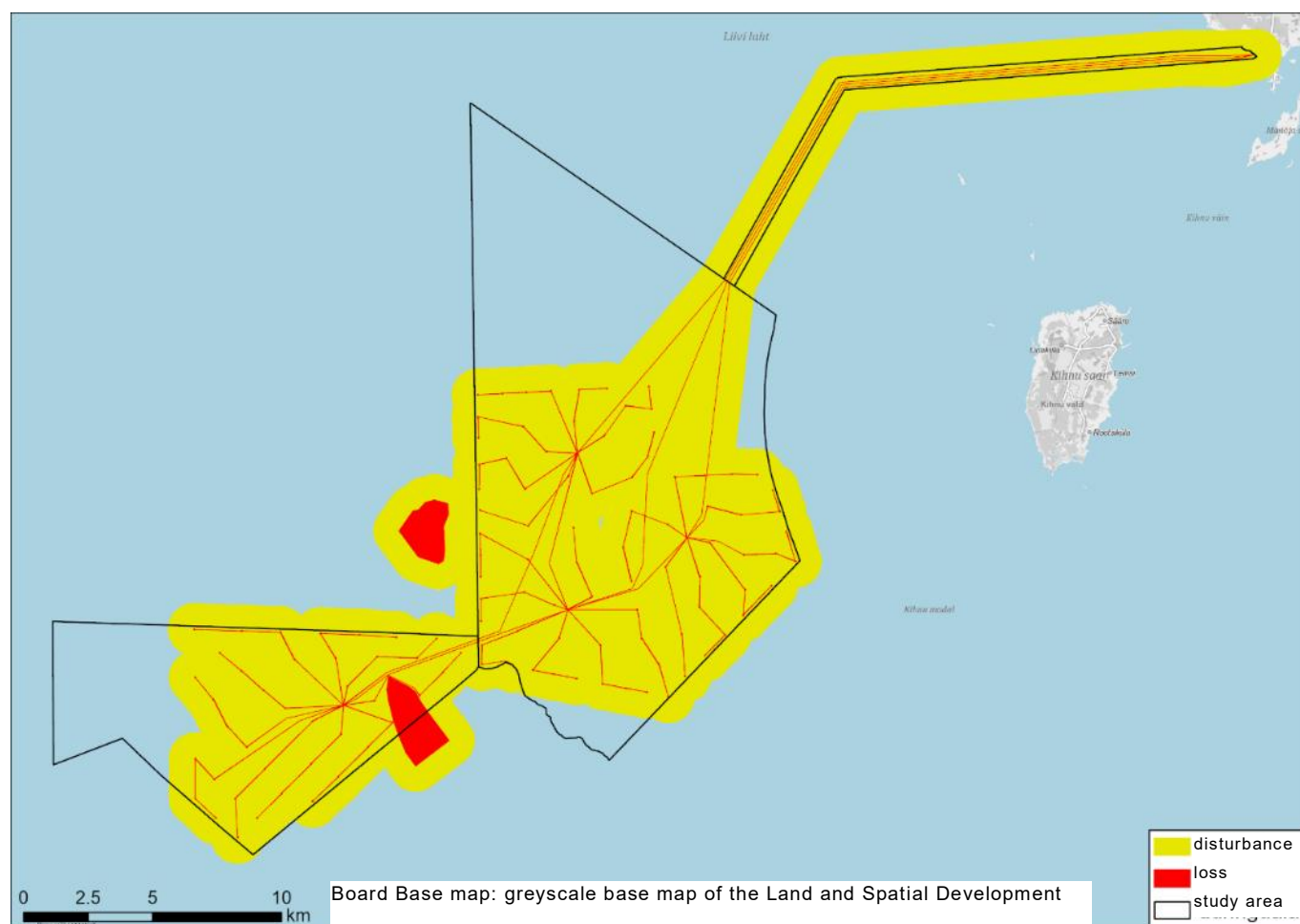


Figure 3.4-12 Spatial footprints of loss and disturbance corresponding to the infrastructure layout of the Saare-Liivi initial and additional areas in the case of gravity base foundations. The outline of the polygon representing the spatial footprint of loss has been made thicker so that cable-related losses are visible in the figure; therefore, cable-related losses are not to scale (UT Estonian Marine Institute, 2026 – Report 5)

Impact of the Saare-Liivi initial and additional areas. When summed by MSFD seabed habitat broad type, the estimated permanent seabed loss for the Saare-Liivi initial area, additional area, export cables and both dumping areas is approximately 8.21 km², and the area of construction-period disturbance is approximately 319 km². For the export cables, the entire export cable route from the offshore substation in the additional area to the offshore substation in the initial area, and from there to the landfall point, has been included. Of this, main alternative 3 for the additional area under the indicative layout accounts for approximately 4.41 km² of loss and 88.6 km² of disturbance. The large share of permanent loss in the additional area is caused by the conservative treatment of the entire 4.15 km² polygon of the southern dumping area as long-term seabed loss.

In-combination effect of the Saare-Liivi initial and additional areas with the Liivi Bay offshore wind farm. According to the habitat-based spatial analysis presented in Table 3.4-10, the total seabed loss from the Saare-Liivi initial and additional areas and the Liivi Bay offshore wind farm is below 0.1% of the natural distribution area of most MSFD seabed habitat broad types in the HELCOM Gulf of Riga sub-basin. The greatest relative permanent loss is forecast for the circalittoral sandy bottom: 5.819 km², i.e. approximately 0.239% of the habitat's distribution area. The corresponding share for the circalittoral muddy bottom is approximately 0.108%, and even smaller for the other habitat broad types. All calculated shares are clearly below the 2% threshold value agreed at European Union level for Marine Strategy Framework Directive criterion D6C4, according to which the maximum proportion of permanent loss of

the relevant seabed habitat broad type within the assessment area is 2% of its natural extent (European Commission Communication C/2024/2078⁴⁷).

The shares of permanent loss are therefore small at the level of the Gulf of Riga sub-basin. At the same time, this is an irreversible or long-term impact, and therefore the impact is not treated as neutral. Given the wide distribution of the affected habitats, the very small direct loss of Habitats Directive habitat types and the absence of rare benthic species, the cumulative impact of permanent seabed loss is assessed as minor negative.

The share of construction-period disturbance is greater than that of permanent loss. For circalittoral sandy bottom, the conservative 1 km buffer covers approximately 12.2%, for circalittoral mixed sediment 5.9%, and for circalittoral muddy bottom 4.2% of the respective habitat's distribution area in the Gulf of Riga sub-basin. For Habitats Directive reefs, the share of disturbance is approximately 1.46%.

The shares obtained for coarse sediment habitats, 10.8% and 18.1%, are affected by uncertainty in the model maps at the sub-basin level. The modelled total area of coarse sediment habitats is very small, and detailed project-specific surveys identify these habitats better than Estonia-wide models do. Therefore, a high percentage does not necessarily indicate an ecological impact of the same order of magnitude on the Gulf of Riga's coarse sediment habitat as a whole.

That the disturbance area for circalittoral sandy bottom exceeds 10% is not due solely to a methodological feature, but also to the fact that the infrastructure of the Saare-Liivi initial and additional areas and the Liivi offshore wind farm is located predominantly on this widely distributed habitat broad type. The disturbance is expected to be reversible.

Table 3.4-10. *Estimates of impacts (loss, disturbance) of the Saare-Liivi initial and additional areas and the Liivi Bay wind farms on EU Habitats Directive Annex I habitat types (HD) and Marine Strategy Framework Directive (MSFD) seabed habitat broad types in the HELCOM Gulf of Riga sub-basin. The possible areas of loss and disturbance associated with the three development projects, the summed (cumulative) area, and the shares of the impact areas within the Gulf of Riga are shown*

Impact type	Classification	Habitat	Habitat area in the Gulf of Riga (km²)	Affected habitat area, Liivi Offshore (km²)	Affected habitat area, Utilitas Wind (km²)	Cumulative affected habitat area (km²)	Share of cumulatively affected habitat area in the Gulf of Riga (%)
loss	HD	reefs	987.488	<0.001	0.032	0.032	0.003
loss	HD	sandbanks inundated by seawater	2393.764	0	0.021	0.021	<0.001
loss	MSFD	infralittoral coarse sediment	4.014	0	0.004	0.004	0.105
loss	MSFD	infralittoral rocky bottom and biogenic reefs	228.992	0	0.001	0.001	<0.001
loss	MSFD	infralittoral sandy bottom	1791.533	0	0.069	0.069	0.004

⁴⁷ [Commission Communication — Commission Communication on threshold values established under the Marine Strategy Framework Directive 2008/56/EC and Commission Decision \(EU\) 2017/848](#)

Impact type	Classification	Habitat	Habitat area in the Gulf of Riga (km²)	Affected habitat area, Liivi Offshore (km²)	Affected habitat area, Utilitas Wind (km²)	Cumulative affected habitat area (km²)	Share of cumulatively affected habitat area in the Gulf of Riga (%)
loss	MSFD	infralittoral mixed sediment	1766.971	0	0.057	0.057	0.003
loss	MSFD	circalittoral coarse sediment	3.725	0	0.002	0.002	0.053
loss	MSFD	circalittoral rocky bottom and biogenic reefs	3.753	0	<0.001	<0.001	0.003
loss	MSFD	circalittoral sandy bottom	2432.638	0.662	5.157	5.819	0.239
loss	MSFD	circalittoral muddy bottom	2888.602	0.407	2.698	3.105	0.108
loss	MSFD	circalittoral mixed sediment	1096.153	0.1	0.222	0.322	0.029
disturbance	HD	reefs	987.488	0.326	14.112	14.439	1.462
disturbance	HD	sandbanks inundated by seawater	2393.764	0	2.853	2.853	0.119
disturbance	MSFD	infralittoral coarse sediment	4.014	0	0.434	0.434	10.822
disturbance	MSFD	infralittoral rocky bottom and biogenic reefs	228.992	0	2.294	2.294	1.002
disturbance	MSFD	infralittoral sandy bottom	1791.533	0	6.95	6.95	0.388
disturbance	MSFD	infralittoral muddy bottom	560.331	0	0.035	0.035	0.006
disturbance	MSFD	infralittoral mixed sediment	1766.971	0	18.866	18.866	1.068
disturbance	MSFD	circalittoral coarse sediment	3.725	0	0.674	0.674	18.106
disturbance	MSFD	circalittoral rocky bottom and biogenic reefs	3.753	0	0.075	0.075	2.006
disturbance	MSFD	circalittoral sandy bottom	2432.638	114.063	183.748	297.811	12.242

Impact type	Classification	Habitat	Habitat area in the Gulf of Riga (km²)	Affected habitat area, Liivi Offshore (km²)	Affected habitat area, Utilitas Wind (km²)	Cumulative affected habitat area (km²)	Share of cumulatively affected habitat area in the Gulf of Riga (%)
disturbance	MSFD	circalittoral muddy bottom	2888.602	68.318	53.06	121.378	4.202
disturbance	MSFD	circalittoral mixed sediment	1096.153	11.882	52.883	64.765	5.908

The areas presented in Table 3.4-9 are harmonised conservative estimates for comparing development projects. The estimate of permanent loss for the Saare-Liivi initial and additional areas is dominated by the treatment of the entire polygon of the two dumping areas as permanent loss, and the estimate of disturbance by the methodology based on a 1 km buffer.

With the construction of several offshore wind farms (the Saare-Liivi initial and additional areas and the Liivi Bay offshore wind farm), the amount of hard artificial substrate added to the Gulf of Riga will also increase. As a result, the biomass of attached benthic organisms and local species diversity may increase, but at the same time soft-sediment habitat is replaced by hard substrate, and the spread of non-native species, deposition of organic matter and oxygen demand in the immediate vicinity of the foundations may increase. Accordingly, the cumulative reef effect is not automatically treated either as a positive impact or as compensation for the loss of natural seabed.

Indirect impacts on seabed biota may be caused by wind-farm-related changes in hydrodynamics, near-bottom oxygen content and sedimentation. These impacts are discussed in Sections 3.1 and 3.3. Based on the existing modelling results, no extensive deterioration in the condition of seabed habitats is forecast, but to verify the assessment, methods comparable with those used in neighbouring projects must, where possible, be used in seabed and water-quality monitoring in the additional area.

Overall, the Saare-Liivi additional area makes no additional impact on Habitats Directive habitat types, and the soft-sediment habitats affected by it are widespread in the Gulf of Riga. However, the in-combination effect of the Saare-Liivi initial and additional areas and the Liivi Bay offshore wind farm nevertheless increases permanent seabed loss, the area of temporary disturbance and the amount of artificial substrate. Given the small share of permanent loss in the distribution of habitats in the Gulf of Riga, the reversible nature of the disturbance and the wide distribution of the affected habitats, the cumulative impact is assessed as minor negative. At the detailed design stage, the area of permanent seabed loss by habitat type must be refined on the basis of the final infrastructure layout and construction technology, and it must be verified that, together with the infrastructure of other proposed offshore wind farms, the 2% criterion discussed above is not exceeded. The calculation must use the same habitat classification and spatial assessment unit as in this in-combination effect assessment. If the calculation shows that the criterion is exceeded, the project design for the additional area must be adjusted to reduce permanent seabed loss.

3.4.7. Uncertainty/knowledge gaps

The studies carried out for the preparation of this EIA provide a sufficient basis for assessing impacts on seabed biota and habitats, and no significant knowledge gaps that would prevent reliable assessment of the impacts have been identified. At the same time, it must be taken into account that the assessment of

seabed loss and disturbance covers construction-period impacts and does not reflect possible disturbances during operation of the wind farm, the extent of which will be clarified through post-construction monitoring (Section 3.4.4).

However, at the international level there is still uncertainty regarding the long-term ecological impacts of offshore wind farms, in particular concerning the long-term dynamics of colonisation of artificial substrates, the extent of the so-called reef effect, and its possible impact on matter and energy cycling in benthic and pelagic communities. Further research is also needed on the accumulation of organic matter in the immediate vicinity of turbine foundations, the possible resulting changes in sediment chemistry and oxygen regime, and their long-term effects on benthic communities.

There are no knowledge gaps preventing this impact conclusion from being drawn, but uncertainty remains regarding the long-term ecological impact of artificial substrate, which therefore justifies post-construction monitoring of seabed biota and colonisation of artificial substrate in order to improve knowledge of the long-term ecological impacts of offshore wind farms in the Estonian marine area.

3.5. Birds

The main basis for this chapter is the consolidated report prepared by the Estonian Ornithological Society, 'Utilitas Wind Saare-Liivi offshore wind farm bird studies – extension area' (Estonian Ornithological Society, 2024; hereinafter the Bird Study), which is presented in Annex 3.5 to the EIA report. The title of the study uses the term 'extension area', but in this EIA report the same area is consistently referred to as the additional area of the Saare-Liivi offshore wind farm.

The impact assessment in the Bird Study is based on fieldwork and analyses carried out in 2022–2024. Visual aerial surveys were carried out to determine the species composition, abundance, spatial distribution and seasonal pattern of staging waterbirds. The use of the marine area by overflying and migrating birds was studied by means of ship-based visual and radar observations and audio recording of nocturnal calls. The spatial use, foraging flights, possible barrier effect and collision risk of birds breeding on the islets of Kihnu and Pärnu Bay were investigated using GPS telemetry.

The consolidated report of the Bird Study is based, inter alia, on the following separate studies and expert assessments:

- Expert assessment on habitat displacement of sea ducks: *Jacobsen, E. M. & Tjørnløv, R. S. 2024. Habitat displacement of sea ducks in relation to Saare-Liivi offshore wind farm, Estonia.*
- BioConsult SH materials on ship-based count data.
- Analysis of spatial use and collision risk of breeding seabirds based on GPS telemetry data in the Saare-Liivi 1 and Saare-Liivi 2 offshore wind farm planning areas: *Burger, C., Osterberg, J., Castillo, R., Welcker, J. 2024 Analysis of spatial use and collision risk of breeding seabirds based on GPS telemetry data Saare-Liivi 1 and Saare-Liivi 2 offshore wind farm planning areas.*
- Collision risk models for the Utilitas offshore wind farm extension area: *Castillo, R., Liedtke, J. & Welcker J. 2024. Collision risk models for Utilitas offshore wind farm – Extended area.*
- UTILITAS Saare-Liivi offshore wind farm site and diving ducks. Sensitivity of diving ducks to offshore wind farms: *Petersen, I. K. 2024. UTILITAS Saare-Liivi offshore wind farm site and diving ducks. Seaduck sensitivity to offshore wind farms.*

In preparing this chapter, additional account has been taken of the bird assessment in the EIA report for the Saare-Liivi offshore wind farm initial area that has been found compliant, and of the studies on which it was based. In this chapter, the study results for the initial area are used primarily to compare the avian

sensitivity of the additional area and to assess the cumulative impact of the Saare-Liivi initial and additional area offshore wind farm. Impacts already assessed in the EIA for the initial area are not repeated unnecessarily in this report.

The impact assessments and recommendations for environmental measures presented in the baseline studies have been used as specialist expert input in preparing this EIA for the additional area. In this chapter, the need, scope and proportionality of applying them are assessed on the basis of the additional area main alternative 3 that emerged in the EIA process, the significance of the cumulative in-combination effect of the Saare-Liivi initial and additional areas, and the expected effectiveness of the measures. The chapter distinguishes between avoidance measures already built into the development project for the proposed offshore wind farm, additional mitigation measures, adaptive operational measures and follow-up monitoring.

3.5.1. Consideration of alternatives

Fieldwork and analyses for the bird studies began before the reduced development area (alternatives 2 and 3) underlying the impact assessment in this EIA report had taken shape. Accordingly, both the spatial extent considered and the number of turbines used in the impact calculations vary between different parts of the studies.

The staging waterbird studies covered the approximately 91.2 km² spatial extent of the additional area EIA main alternative 1 together with its surroundings. The initial aerial survey route covered the eastern and central parts of the additional area. From 9.03.2023 onwards, an extended survey route was used that covered the entire area of main alternative 1. The main alternatives 2 and 3 underlying the impact assessment are located entirely within the said study area (see Figure 2.3.-1). Accordingly, the data collected are spatially sufficient for assessing the existing birdlife conditions within main alternative 3 and the impacts on staging waterbirds, which means that the Bird Study assesses the impacts of the barrier effect and displacement risk more conservatively than will arise from implementation of the main alternative 3 that emerged in the EIA process and underlies the impact assessment.

The visual, radar and audio studies of overflying and migrating birds were carried out from an observation point located in the central part of main alternative 1. The study results describe the species composition, intensity, flight heights and directions of migration through the additional area and are not linked to any specific turbine layout.

In modelling collision risk for passage migrants (Castillo, Liedtke & Welcker 2024), a study scenario with 50 turbines over the spatial extent of main alternative 1 was used. Up to 40 turbines are planned for main alternative 3, which underlies the impact assessment. Given the additive structure of Band's model, the model results for passage migrants with 50 turbines are adjusted for main alternative 3 by the ratio of turbine numbers 40/50, i.e. a factor of 0.8. This is a proportional adjustment of an existing model result, not a new application of the model.

The GPS-telemetry-based collision risk model for breeding birds also used 50 turbines, but bird densities were calculated for the entire 91.2 km² study area. A precise calculation for main alternative 3 would require a new spatial analysis of the GPS data and bird densities within main alternative 3. Accordingly, the results for breeding birds are not adjusted solely on the basis of the number of turbines; instead, the results with 50 turbines are used as a conservative estimate for main alternative 3.

As technical alternatives, two turbine variants were assessed in both collision risk analyses:

- **technical alternative 1, i.e. turbine variant A:** turbine tip height 275 m, rotor diameter 236 m, hub height 157 m, and lower rotor tip height 40 m above sea level;
- **technical alternative 2, i.e. turbine variant B:** turbine tip height 310 m, rotor diameter 280 m, hub height 170 m, and lower rotor tip height 30 m above sea level.

For other impacts on birds, including disturbance during construction, displacement from staging areas and the barrier effect for local breeding birds, the difference between the two technical turbine variants is not of decisive importance in determining the impact. From the birdlife perspective, the turbine variants differ primarily in the extent of the rotor-swept zone and the resulting collision risk.

3.5.2. Description of environmental status

The description of the current state of birdlife in the additional area is based on three complementary datasets:

- aerial surveys of staging waterbirds;
- ship-based visual, radar and audio observations of overflying and migrating birds;
- GPS telemetry study of birds breeding on the islets of Kihnu and Pärnu Bay.

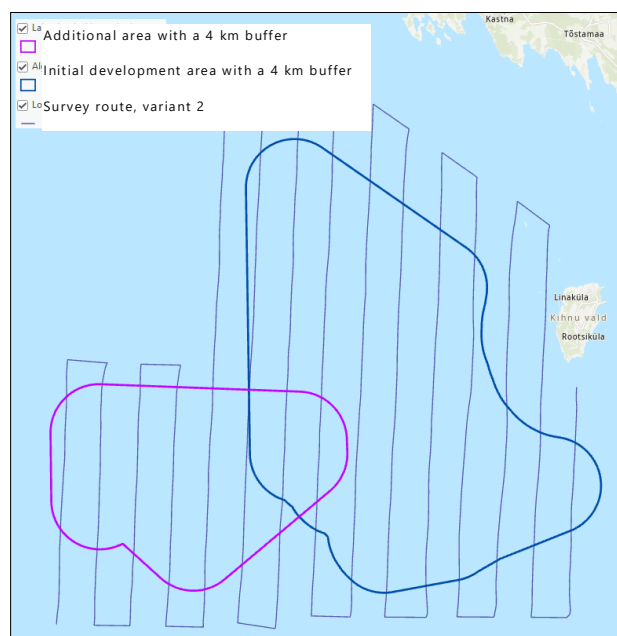
The studies provide information on different functions of the area for birds. Aerial surveys are used to assess the importance of the additional area as a staging and feeding area for waterbirds; ship-based studies describe migration through the area, bird flight intensity, flight heights and directions; GPS telemetry characterises the foraging areas and movement routes of gulls and terns breeding on the islets.

The assessment is based on data collected in 2022–2024. A total of 20 aerial surveys were carried out, of which 12 covered the entire additional area (i.e. all aerial surveys from 9.03.2023 onwards). To study overflying birds, seven ship-based survey periods lasting an average of eight days were carried out during the spring and autumn migrations of 2023. The radars operated for a total of 1061 hours, and during survey periods comprising 620 hours of daylight, 317.5 hours of active visual observations were carried out. The spatial use analysis of breeding birds was based on data from 52 GPS-tagged individuals of common gull, Arctic tern, common tern and Sandwich tern.

STAGING WATERBIRDS

Species composition and abundance of staging waterbirds

A total of 35 waterbird species were recorded in the aerial surveys. In the offshore surveys, the following species are of particular note: among bottom-feeding species, long-tailed duck (*Clangula hyemalis*), velvet scoter (*Melanitta fusca*) and common scoter (*Melanitta nigra*); among species feeding in pelagic layers, divers (*Gavia stellata*, *Gavia arctica*) and great cormorant (*Phalacrocorax carbo*); among surface-feeding species, herring gull (*Larus argentatus*), common gull (*Larus canus*), black-headed gull (*Chroicocephalus ridibundus*) and little gull (*Hydrocoloeus minutus*), as well as common tern (*Sterna hirundo*) and Arctic tern (*Sterna paradisaea*). Due to identification difficulties, divers, terns, and common and herring gulls were treated as groups in preparing the report. The remaining species occurred in very small numbers or were concentrated outside the development areas for the Saare-Liivi initial and additional areas and their buffers, in the shallow part of the reference area around Kihnu.



The highest abundance estimate was obtained for the common gull and herring gull species group, whose maximum abundance reached 1574 individuals. Among bottom-feeding species, long-tailed duck was the most abundant, with a maximum abundance estimate of 1149 individuals, and the maximum abundance estimate for divers was 288 individuals. The abundance of scoters, great cormorant and little gull was low, and their abundance estimates remained below 100 individuals. The maximum abundance estimate for no species **exceeded the 1% biogeographical population threshold used in defining a staging area of international importance** or the threshold for an area of national or local importance applied in the study. Accordingly, the importance of the additional area and its 4 km buffer for all staging waterbird species considered was assessed as low (see Table 3.5-1).

Table 3.5-1. Maximum seasonal abundance estimates of staging waterbirds in the study area for the Saare-Liivi additional area (including the 4 km buffer) and the area's importance

Species / group	spring	summer	autumn	winter	Max, ind.	1% of biogeogr. population, ind.	Proportion of 1% threshold	Threshold for an area of national importance, ind.	Proportion of national threshold	Importance of the area
Bottom-feeding species										
long-tailed duck (<i>Clangula hyemalis</i>)	–	–	47	1149	1149	16 000	7.2%	4800	23.9%	low
velvet scoter (<i>Melanitta fusca</i>)	80	49	–	–	80	3000	2.7%	1200	6.7%	low
common scoter (<i>Melanitta nigra</i>)	8	–	–	–	8	7500	0.1%	2250	0.4%	low
Species feeding in pelagic layers										
divers (<i>Gavia</i> sp.) ¹	114	–	288	71	288	3000	9.6%	900	32.0%	low
great cormorant (<i>Phalacrocorax carbo</i>)	–	24	–	–	24	6200	0.4%	1860	1.3%	low
Surface-feeding species										
little gull (<i>Hydrocoloeus minutus</i>)	–	–	45	–	45	1300	3.5%	none	–	low
black-headed gull (<i>Chroicocephalus ridibundus</i>)	33	185	20	–	185	31 000	0.6%	none	–	low
herring gull and common gull (<i>Larus argentatus et canus</i>) ²	1574	624	1032	1180	1574	9300	16.9%	none	–	low
common tern and Arctic tern (<i>Sterna hirundo et paradisaea</i>) ³	374	9	–	–	374	14 100	2.7%	none	–	low

*The abundance estimates have been prepared for the additional area together with a 4 km buffer, using the distance sampling method (JNCC 2022). '–' means that there were too few observations to prepare an abundance estimate (fewer than 20 observations per survey), not that the species was absent from the area. Threshold for an area of international importance = 1% of the biogeographical population size (Wetlands International, Waterbird Population Estimates). Thresholds for an area of national importance: Luigujõe 2018; these have not been developed for gulls and terns. In addition,

thresholds for an area of local importance (Luigujõe 2018) have been applied — the abundance of no species exceeded these either, and therefore the importance of the area for all species has been assessed as low. Survey-based abundance estimates are presented in the Bird Study (Annex 3.5, Table 6), and the thresholds in Table 18 of the same study.

¹ *The group includes red-throated diver and black-throated diver; the red-throated diver thresholds have been used for comparison, as they are lower (for black-throated diver, respectively 4800 and 1050 ind.).*

² *The herring gull threshold has been used for comparison, as it is lower (for common gull 16 400 ind.). The abundance estimate has been prepared jointly for the species, and the proportion is therefore conservative.*

³ *The common tern threshold has been used for comparison, as it is lower (for Arctic tern 31 000 ind.).*

Bottom-feeding birds generally stage in very large flocks and are therefore characterised by an uneven distribution that changes over time: large flocks may be concentrated in a limited marine area, while extensive surrounding areas are devoid of birds. The distribution may vary significantly between surveys. Among the bottom-feeding species, only long-tailed duck occurred in larger numbers in the Saare-Liivi wind farm additional area (in winter 2024). Even during the survey with the highest abundance, the main concentration area of long-tailed duck was located in the 4 km buffer of the north-eastern part of the additional area, not in the central part of main alternative 3 of the final additional area (Figure 3.5-2).

The distribution of gulls is strongly influenced by active fishing vessels, the presence of hydrological structures and other temporally unstable and difficult-to-predict factors. Examples of gull distribution in the additional area during the surveys with the highest abundance are shown in Figure 3.5-3. The distribution of divers was the most dispersed, and they were mostly encountered as single individuals. Figure 3.5-4 illustrates the distribution of divers during the autumn (2.11.2023) and spring (6.05.2022) surveys with the highest abundance. In summary, no permanent or regularly used waterbird concentration area of high importance was identified within main alternative 3 of the additional area.

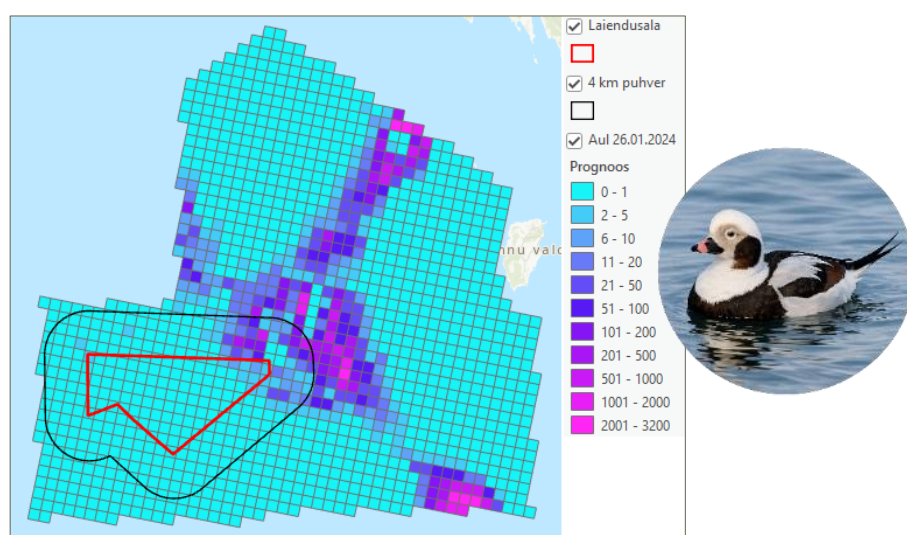


Figure 3.5-2 Distribution of long-tailed duck in winter (generalised additive model prediction, ind./km² (Bird Study, 2024)

Comparison with the EIA results for the Saare-Liivi initial area shows that the additional area is of considerably lower importance for staging diving ducks. In the reduced main alternative 3 of the initial area, which formed the basis for the EIA impact assessment of the initial area, the maximum abundance estimate for long-tailed duck reached 45 558 individuals, whereas for the additional area the corresponding maximum, including the conservative 4 km buffer, was 1149 individuals. Such an order-of-magnitude difference clearly shows that the additional area is of much lower importance than the main area as a staging area for long-tailed duck. When developing the final spatial layout for the Saare-Liivi initial area, important staging areas for long-tailed duck and velvet scoter were left outside the wind farm in order to avoid significant impacts; no staging areas of comparable importance were identified in the additional area.

BIRD OVERFLIGHT

The study of overflying birds included visual and radar observations and audio recording of nocturnal calls.

Species composition

The results of the visual observations provide an overview of the daytime species composition. During the visual observations, a total of 63884 birds were counted in the additional area in autumn and spring. The total number of species was 98 in spring and 91 in autumn (Table 3.5-2). The most abundant group in spring was ducks (47% of counted birds), and in autumn the common crane (55%). These were followed by geese and geese of the genus *Branta* (16% of counted birds in spring and 12% in autumn; Figure 3.5-5). Species-level abundance data for overflights are presented in Tables 8 and 9 of Annex 3.5.

Table 3.5-2 *Number of species and individuals during visual observations in the additional area (Bird Study, 2024)*

Season	Autumn 2023	Spring 2023
Number of survey days	26	20
Number of birds	31364 individuals	32520 individuals
Number of species	91	98

The call recordings provide data on nocturnal species composition. In spring 2023, 180 contacts belonging to 20 species were recorded in the Saare-Liivi additional area; in autumn, 554 contacts belonging to 20 species were recorded (Annex 3.5, Tables 10 and 11). The most abundant bird group was passerines: in autumn they accounted for 92% and in spring 74% of contacts (Annex 3.5, Figures 18 and 19). The most abundant species were robin, song thrush and redwing.

Flight intensity

The mean daytime flight intensity ranged from 13.2 (1.09.2023) to 1587.68 individuals per hour (2.10.2023). The mean night-time flight intensity ranged from 0 (20.09.2023) to 890.83 contacts per hour per kilometre (23.04.2023).

Mean flight intensities varied both seasonally and from day to day within the same season. During the day, the highest mean flight intensities were observed in April in spring and in October in autumn. At night, mean flight intensity was markedly higher in April in spring (Figure 3.5-6).

The median daytime flight intensity in the Saare-Liivi additional area was 103.4 individuals per hour and in the initial area 129.7 individuals per hour. The median night-time flight intensity was 41.9 contacts per hour per kilometre in the additional area and 33.7 in the initial area. In neither comparison was the difference between the areas statistically significant. Therefore, based on the study, it cannot be concluded that the overall migration intensity in the additional area is clearly lower or higher than in the initial area.

From a collision risk perspective, in addition to nocturnal migrants, the potentially more important species are common crane and geese and geese of the genus *Branta*. In both cases, mass migration was concentrated on individual days. Such temporal concentration is important in planning operational measures to reduce collision risk, because most of the potential risk may arise on relatively few days of intense migration.

Flight height

Birds flew predominantly at low altitudes during the day. Of the daytime contacts recorded by vertical radar, 51% in spring and 65% in autumn were within the lower 100 m of the air column. According to visual observations, a large proportion of waterbird flights occurred just above the sea surface.

By species group, common crane, geese and geese of the genus *Branta*, and waders stood out from the other birds in having greater daytime flight heights. For common crane, the proportion flying within the rotor zone was 77 (rotor variant A)–85% (variant B); for geese and geese of the genus *Branta* 66 (variant A)–78% and for waders 62 (variant A)–71% (variant B; Castillo, Liedtke & Welcker 2024). Representatives of the remaining species groups clearly preferred lower altitudes during the day (Annex 3.5, Figures 31–44). Long-tailed duck and scoters were particularly strongly concentrated just above the water surface. However, the abundance of migrating waders, and thus also the number of individuals flying within the rotor zone, was low. More than 90% of long-tailed ducks and more than 80% of common scoters flew within the lowest 5 m of the air column; they were virtually absent from the rotor zone. The rotor of variant B extends lower and covers a larger proportion of the airspace than the rotor of variant A. Consequently, for all the more important higher-flying species groups, a larger proportion of flights falls within the rotor zone of variant B (see Figure 3.5-8).

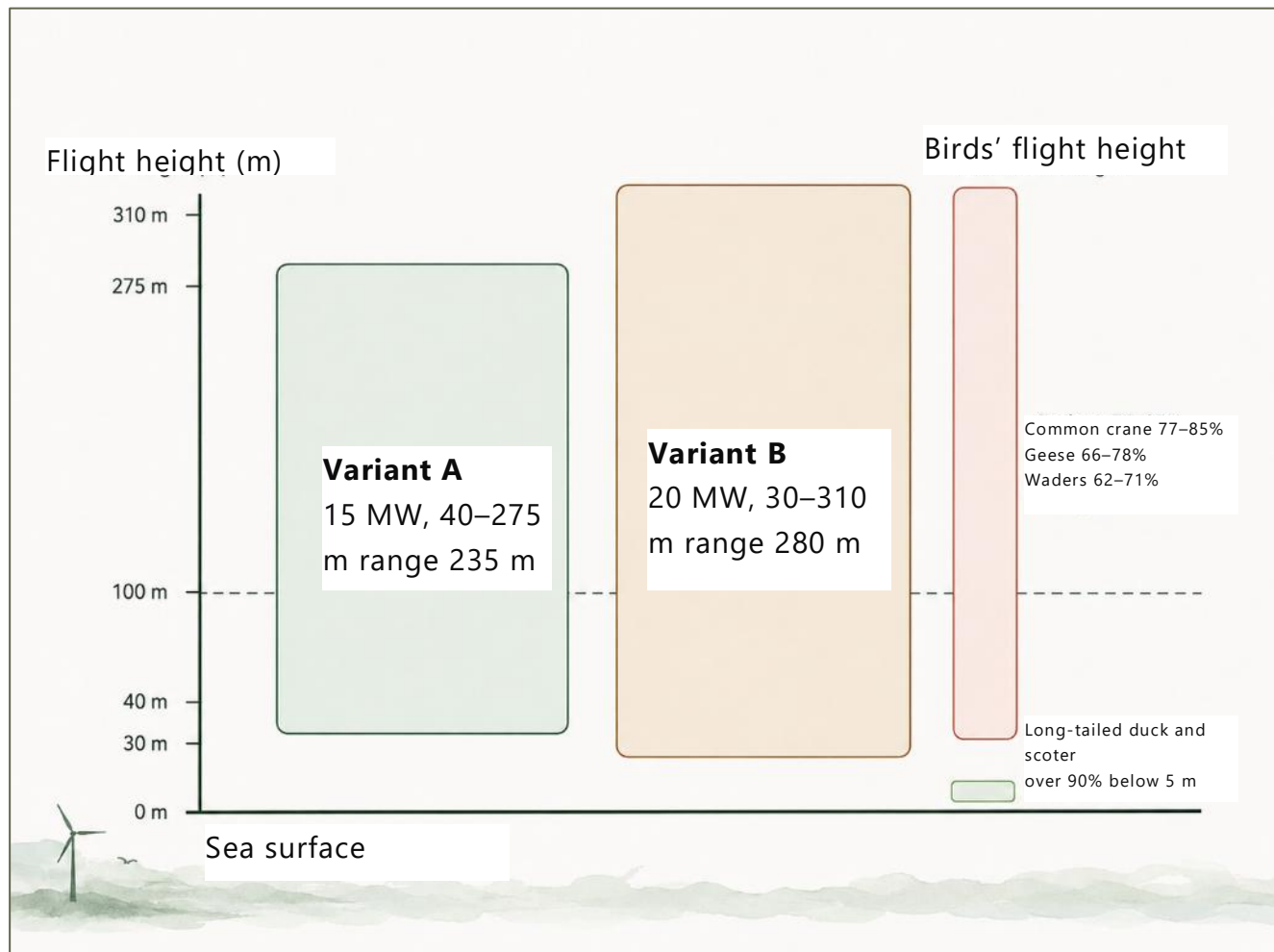


Figure 3.5-8. Rotor zones of the technical alternatives relative to sea level and flight height of the main bird groups. Percentages show the proportion of individuals within the rotor zone for variants A and B (data: Castillo, Liedtke & Welcker 2024). The dashed line indicates the lower 100 m of the air column.

Flight directions

The predominant migration direction was towards the north-east in spring and towards the south-west in autumn. During the day, visual observations showed that, within the lower air layers, the proportion of birds flying northwards in spring and southwards in autumn was also high (Annex 3.5, Figures 45–47).

Number of birds passing through the wind farm

The observations did not cover the spring and autumn migration periods in their entirety. Therefore, based on the observation and radar data, the number of contacts crossing the cross-section of the additional area as defined during the study over the entire migration period was projected using the bootstrap method.

Across the full 0–1000 m height range, the point estimate for spring migration was approximately 969 000 contacts during the day and 1.22 million at night. During autumn migration, the corresponding estimates were approximately 539 000 and 492 000 contacts. Within the rotor zone of technical variant A, in the 40–275 m height range, approximately 212 000 daytime and 216 000 night-time contacts were projected in spring, and approximately 261 000 daytime and 147 000 night-time contacts in autumn. Within the rotor zone of technical variant B, in the 30–310 m height range, the corresponding estimates were approximately 319 000 and 280 000 contacts in spring and approximately 316 000 and 176 000 contacts in autumn. Thus, depending on the season, time of day and technical variant, approximately 18–59% of projected contacts fell within the rotor zone. In all cases, both the number and the proportion of contacts falling within the rotor zone were higher for technical variant B. Exact 95% confidence intervals for the point estimates are presented in Table 12 of Annex 3.5 to the bird baseline study.

The projected number of contacts cannot be equated with the number of individual birds passing through the area or with the number of possible collisions. A single contact may represent either a single bird or a flock, and the same individual may have been recorded repeatedly. The daytime data may include to-and-fro movements of local birds, especially gulls, and nocturnal radar contacts generally cannot be identified to species level. Therefore, the results primarily describe the overall volume of migration and the possible extent of occurrence at rotor height. Species-specific collision risk is assessed separately using a collision risk model.

The results have been calculated for the additional area as defined during the study, which was more extensive than main alternative 3, and do not directly represent the final turbine layout of main alternative 3, which covers 57.1 km² and includes up to 40 turbines. They are used in the assessment of main alternative 3 to characterise the overall intensity of migration and flight height, not as an exact number of birds passing through the final wind farm.

BREEDING BIRD TELEMETRY STUDY

Near the eastern boundary of the Saare-Liivi initial area lies the Pärnu Bay important bird area, which also includes bird breeding islets. The important bird area lies approximately 16 km from the additional area. To investigate the spatial use of birds breeding on the islets, the 4 most important species were selected: common gull, Arctic tern, common tern and Sandwich tern (Burger *et al.* 2024⁴⁸). On Umalaui and Imutlaiu, which are among the islets closest to the initial area, 15 common gulls, 13 Arctic terns, 12 common terns and 12 Sandwich terns were fitted with transmitters. The said islets are located near Kihnu, and the Saare-Liivi additional area lies some twenty kilometres to their south-west.

⁴⁸ Burger, C., Osterberg, J., Castillo, R., Welcker, J. 2024 Analysis of spatial use and collision risk of breeding seabirds based on GPS telemetry data Saare-Liivi 1 and Saare-Liivi 2 offshore wind farm planning areas.

The spatial distribution of the foraging flights of breeding birds and the proportion of foraging flights falling within the additional area are determined by the length and direction of the foraging flights.

- common gulls flew predominantly southwards and the maximum flight distance reached 61.1 kilometres. The average maximum flight distance (the average of the maximum distances of all foraging flights of an individual) was markedly smaller, 3.02–12.26 km;
- for Arctic tern, flights in westerly directions predominated and the maximum flight distance reached 126.47 km; the average maximum flight distance was 1.82–10.01 km;
- for common tern, flights in southerly directions predominated and the maximum flight distance reached 129.21 km, and the average maximum flight distance was 2.12–6.81 km;
- for Sandwich tern, flights in easterly directions predominated and the maximum flight distance reached 541.42 km, and the average maximum flight distance was 7.29–44.47 km.

As a result of the in-combination effect of flight distances and directions, the proportion of flights reaching the additional area or extending beyond the additional area was very small (Table 3.5-3).

Table 3.5-3. *Proportion of locations recorded within the additional area and number and proportion of flights extending beyond the additional area (Burger et al. 2024; BioConsult SH, 2024)*

Species	Proportion of location points within the additional area, %	Total number of foraging flights	Number of flights extending beyond the additional area	Proportion of flights extending beyond the additional area, %
Common gull	0.01	3288	0	0
Arctic tern	0.02	1717	1	0.06
Common tern	0	975	0	0
Sandwich tern	0.04	530	3	0.57

Also in terms of a potential barrier effect, use of the additional area was minimal. Of the 3288 recorded foraging flights of common gull, none extended beyond the additional area. For Arctic tern, one of 1717 flights extended beyond the area, for common tern none of 975 flights, and for Sandwich tern three of 530 flights. Thus, across all four species combined, only four foraging flights were recorded whose destination lay beyond the additional area.

GPS telemetry data show that the Saare-Liivi additional area is not a regular feeding ground for the monitored breeding birds, nor an important route between the colonies and feeding grounds. Across all species combined, only four tracked foraging flights extended beyond the additional area. Therefore, the barrier effect of the additional area in isolation on breeding gulls and terns is insignificant or minor.

3.5.3. Impact assessment

The effects of an offshore wind farm on birds depend both on the bird group affected and on the stage of the wind farm's life cycle. During the construction and decommissioning of the wind farm, the main possible effects are temporary disturbance associated with construction activities and vessel traffic, and indirect effects related to changes in birds' food resources or in the condition of the marine environment. During wind farm operation, displacement of birds from staging and feeding grounds, barrier effect, collision risk, and indirect effects related to changes in food resources and habitats may occur. The direct loss of seabed habitat beneath turbine foundations, the offshore substation and cables occurs during construction, but is permanent in duration and is therefore considered together with the operational impacts of the wind farm.

This subsection assesses:

- disturbance during construction and decommissioning;
- indirect effects during construction and decommissioning;
- displacement of staging waterbirds;
- direct habitat loss;
- barrier effect;
- collision risk;
- indirect effects during operation.

The final assessment of impact significance is provided for main alternative 3 of the additional area as developed during the EIA process, under which up to 40 turbines are planned within the 57.1 km² additional area. The species-specific risk categories used in the baseline studies describe, on the one hand, a species' sensitivity to a specific pressure factor and, on the other hand, the importance to the species of the area as defined during the study period. In this EIA, these categories are an input to the impact assessment but cannot be equated one-to-one with the impact significance scale used in the EIA report for the additional area. The final assessment also takes into account the impact's spatial extent, duration and reversibility, the smaller development scale of main alternative 3 of the additional area, and the receptor's actual intensity of use within the additional area.

The ornithological function of the Saare-Liivi additional area differs by receptor group. The abundance of staging waterbirds was low even including the conservative 4 km buffer, and no staging area of international, national or local importance was identified for any species. Compared with the Saare-Liivi initial area, the importance of the additional area is clearly lower, particularly as a staging area for long-tailed duck and other diving ducks.

GPS telemetry of gulls and terns breeding on the islets of Kihnu and Pärnu Bay showed that use of the additional area was very low and, depending on the species, up to several dozen times lower than use of the initial area study area. The additional area does not lie within the main feeding grounds of these species, nor does it constitute a significant obstacle between the colonies and the feeding grounds.

The overall intensity of passage migration in the additional area did not differ statistically significantly from that in the initial area. The additional area lies on the birds' north-east–south-west migration route, and its importance is greater for common crane and nocturnal migrants. Therefore, the additional area is of clearly lower sensitivity than the initial area study area from the point of view of staging and local breeding birds, but the collision risk for passage migrants must be assessed separately.

IMPACTS DURING THE CONSTRUCTION AND DECOMMISSIONING PHASE

Disturbance

During the construction of the wind farm, birds may be disturbed by the movement of construction and installation vessels, the installation of foundations and cables, seabed preparation works, above-water noise, lighting, and the presence of people and equipment. Disturbance may cause birds temporarily to move away from the area of active works, alter their feeding or resting behaviour, and increase energy expenditure.

The extent of disturbance depends on the species, the nature of the works, the equipment used, the distribution of birds and weather conditions. Construction works are not carried out simultaneously across the entire wind farm area but proceed by work stage and turbine position. Therefore, at any given moment, the area of intense disturbance is substantially smaller than the overall spatial extent of the

wind farm. The disturbance associated with cable installation moves sequentially along the cable route and is relatively short-term at any given location.

In the assessment of potential disturbance to staging waterbirds, the additional area as defined during the study period was considered together with a 4 km buffer (JNCC 2022⁴⁹). The purpose of using the buffer was, in accordance with the precautionary principle, also to include potential responses of sensitive species that could extend beyond the wind farm, in particular diving ducks and divers. The 4 km buffer is not treated as a fixed construction-phase disturbance distance for each species, but as a conservative assessment area within which the abundance of potentially affected birds and the importance of the area were determined. Even when this wide buffer was used, the importance of the additional area for all assessed staging waterbird species was low. The more sensitive species were divers, velvet scoter and common scoter, but their abundance in the additional area study area was low. The abundance of long-tailed duck was higher than that of the other benthic-feeding species, but no staging area of international, national or local importance was identified in the additional area for long-tailed duck either. In the baseline study, the species-specific risk of disturbance during construction was assessed as medium for divers and scoters, low for long-tailed duck, great cormorant and some other species, and insignificant for gulls and terns.

Main alternative 3 of the additional area, on which the impact assessment is based, covers a smaller area than the additional area as defined during the study period, measuring 57.1 km² and comprising up to 40 turbines. Accordingly, the actual spatial extent of the construction works is smaller than the area considered in the preparation of the species-specific risk assessment in the baseline study. No permanent or regularly used high-importance waterbird aggregation areas have been identified in the additional area, and the larger bird concentrations were located predominantly outside main alternative 3 or within its buffer.

GPS telemetry of common gulls and terns breeding on the islets of Kihnu and Pärnu Bay showed that use of the additional area was very low. Depending on the species, 0–0.04% of recorded GPS positions were located within the additional area, and across all four species studied only four foraging flights extended beyond the additional area. Therefore, there is no basis to assume that construction within the additional area would cause significant disturbance to the feeding behaviour or breeding success of breeding gulls and terns.

For passage migrants, active construction works and vessels may cause local changes in flight direction or flight height. Since construction activity is temporary and spatially variable and does not constitute a permanent obstacle covering the entire additional area throughout the migration period, disturbance during construction is not comparable for passage migrants to the collision or barrier risk during operation.

In summary, construction activity may cause more sensitive staging waterbirds temporarily to move away from the immediate vicinity of active works but taking into account the low importance of the additional area, the low abundance of birds, the phased nature of the works, and the reduced spatial extent of main alternative 3, the disturbance impact during construction is minor adverse. The significance of the impact does not differ between technical alternatives 1 and 2.

The above-water disturbance associated with decommissioning is similar in nature to disturbance during construction and is also expected to be temporary and spatially shifting. As the exact decommissioning technology for the wind farm, the ornithological situation that will have developed by that time, and any ecological function that may have developed on the structures are not currently known, the impact of

⁴⁹ JNCC 2022. *Joint SNCB Interim Displacement Advice Note* (jncc.gov.uk)

decommissioning must be specified in the decommissioning plan. Under current assumptions, there is no basis for assessing disturbance during decommissioning as more significant than during construction

Table 3.5-4. Significance of disturbance risk in the additional area (Ornithological survey, 2024)

Species	Importance of the area	Disturbance risk^{50,51,52}	Significance of disturbance risk
divers (<i>Gavia sp.</i>)	low	very high	Medium/*for main alternative 3: low
great cormorant (<i>Phalacrocorax carbo</i>)	low	high	low
long-tailed duck (<i>Clangula hyemalis</i>)	low	medium-high	low
velvet scoter (<i>Melanitta fusca</i>)	low	very high	medium/*for main alternative 3: low
common scoter (<i>Melanitta nigra</i>)	low	very high	medium/*for main alternative 3: low
little gull (<i>Hydrocoloeus minutus</i>)	low	very low	insignificant
black-headed gull (<i>Chroicocephalus ridibundus</i>)	low	low	insignificant
herring gull and common gull (<i>Larus argentatus et canus</i>)	low	low	insignificant
common tern and Arctic tern (<i>Sterna hirundo et paradisaea</i>)	low	low	insignificant

Indirect impacts

Construction activity may indirectly affect birds through their food base and the condition of the marine environment. Seabed preparation, the installation of foundations and cables, sediment relocation, generation of suspended matter, partial burial of benthic communities and underwater noise may temporarily affect the distribution, abundance or availability of benthic fauna and fish to waterbirds.

Benthic-feeding diving ducks, divers, cormorants and terns are more sensitive to potential changes in the food base. In the case of the additional area, the significance of the impact is reduced by the fact that the area is not an important staging area or feeding ground for any assessed waterbird species, and bird abundance was low even with the conservative 4 km buffer. According to the ornithological baseline study, changes in the food base may have a minor adverse impact on birds staging in the additional area.

In the assessment of seawater quality, it was not identified that construction of the wind farm in the additional area would cause significant deterioration in water quality in the Gulf of Riga. The generation of suspended matter and its dispersion are local and short-term, and the effect of nutrients released from sediments is modest at the scale of the Gulf of Riga. In the fish survey, no significant adverse impact on fish was identified from the implementation of main alternative 3 of the additional area, subject to implementation of the prescribed environmental measures. Therefore, there is no basis to assume that

⁵⁰ Garthe, S., Hüppop, O. 2004. [Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index](#). *Journal of Applied Ecology* 41: 724–734.

⁵¹ Maclean, I. M. D., Wright, L. J., Showler, D. A. and Rehfish, M. M. 2009. [A Review of Assessment Methodologies for Offshore Windfarms](#).

⁵² Furness, R. W., Wade, H. M., Robbins, A. M. C., and Masden, E. A. 2012. Assessing the sensitivity of seabird populations to adverse effects from tidal stream turbines and wave energy devices. *ICES Journal of Marine Science*, 69(8): 1466–1479.

changes during construction would reduce birds' food base in the additional area or its surroundings to a large extent or over the long term.

A risk of pollution may arise primarily in the event of accidents and leaks involving construction or service vessels, equipment or structures, and from the release of certain substances from disturbed sediments. The probability of an accident is low with proper work organisation and technical control, but the consequences of a major leak may be serious if it occurs. Measures for preventing pollution risk and for the rapid clean-up of any pollution are addressed in section 3.3.4 and must be included in the construction-phase environmental management and pollution response plan.

In summary, changes during construction in birds' food base and feeding conditions may be local and temporary. Given the low importance of the additional area for staging waterbirds and the assessment of impacts on water quality and fish, the indirect impact on birds is neutral to minor adverse. The difference between the technical alternatives does not alter the significance category of the impact.

IMPACTS DURING THE OPERATIONAL PHASE OF THE WIND FARM

Displacement

The presence of the wind farm may cause birds to be completely or partially displaced from staging and feeding grounds previously used. Unlike disturbance during construction, displacement is long-term and may occur throughout the entire period of operation of the wind farm. The extent and magnitude of the impact depend on the species, the spatial layout of the wind farm, the spacing between turbines, the habitat quality of the area, and the availability of alternative staging and feeding grounds.

In the ornithological baseline study, the importance of the area was assessed as low for all more abundant staging waterbird species present in the additional area. By combining species-specific sensitivity and area importance, displacement risk was assessed as low for divers, great cormorant, long-tailed duck and scoters, and as insignificant for gulls and terns. The risk categories presented in Table 3.5-5 are the species-specific assessment from the baseline study, supplemented in this EIA by taking into account the spatial extent of main alternative 3 of the proposed additional area and the actual intensity of use of the area. The numerical thresholds used in assessing area importance are set out in Table 18 of Annex 3.5.

Table 3.5-5. Significance of displacement risk in the additional area (Ornithological survey, 2024)

Species	Importance of the area	Displacement risk^{53,54}	Significance of displacement risk
divers (<i>Gavia</i> sp.)	low	high	low
great cormorant (<i>Phalacrocorax carbo</i>)	low	medium	low
long-tailed duck (<i>Clangula hyemalis</i>)	low	medium	low
velvet scoter (<i>Melanitta fusca</i>)	low	medium	low
common scoter (<i>Melanitta nigra</i>)	low	high	low
little gull (<i>Hydrocoloeus minutus</i>)	low	very low	insignificant
black-headed gull (<i>Chroicocephalus ridibundus</i>)	low	very low	insignificant
herring gull and common gull (<i>Larus argentatus et canus</i>)	low	very low	insignificant

⁵³ Piggott, A., Vulcano, A., Mitchell, D. 2021. [Impact of offshore wind development on seabirds in the North Sea and Baltic Sea: Identification of data sources and at-risk species.](#)

⁵⁴ Humphreys, E. M., Cook, A. S. C. P., & Burton, N. H. K. 2015. *Collision, Displacement and Barrier Effect Concept Note*. 669.

Species	Importance of the area	Displacement risk ^{53,54}	Significance of displacement risk
common tern and Arctic tern (<i>Sterna hirundo et paradisaea</i>)	low	low	insignificant

The behavioural response to wind farms differs among waterbird species: scoters, long-tailed duck and divers are displaced to some extent from former staging areas, the response of eider and terns may be neutral, and wind farms may attract great cormorants and gulls (Dierschke *et al.* 2016⁵⁵). For diving ducks, abundance in the wind farm area may decrease significantly, but displacement may not affect all individuals staging in the area (Petersen 2024⁵⁶; Jacobsen & Tjørnløv 2024⁵⁷). Divers are among the species most strongly affected by displacement; for long-tailed duck, the displacement effect is considered smaller.

In the baseline study, the maximum abundance estimate of long-tailed duck for the additional area as defined during the study period and its 4 km buffer was 1149 individuals. In international practice, the mean seasonal maximum across several study years is generally used when preparing the central displacement scenario. In this assessment, the highest abundance estimate from the entire study period has been used, and therefore the displacement range of 345–804 long-tailed ducks (30–70%) represents a precautionary estimate rather than the likely central forecast for main alternative 3 of the additional area. Main alternative 3, which forms the basis for the impact assessment, is smaller than the study area, and in the count with the highest abundance, the main concentration area of long-tailed duck was located *inter alia* in the buffer around the north-eastern part of the Saare-Liivi additional area.

The number of displaced individuals does not represent bird mortality. The ecological consequence of displacement depends on whether birds can use nearby alternative staging and feeding grounds of sufficient quality. For the additional area, the significance of the impact is reduced by the low intensity of use of the area and the fact that even the maximum abundance estimate of long-tailed duck for the entire area as defined during the study period and 4 km buffer remained below the 1% biogeographical population threshold used to define an area of international importance.

The abundance of other species more sensitive to displacement was substantially lower than that of long-tailed duck. The maximum abundance estimate for divers was 288 individuals, and abundance estimates for scoters remained below 100 individuals. Accordingly, there is also no basis for assuming that main alternative 3 would affect a significant proportion of the respective biogeographical populations of these species.

A comparison with the EIA for the Saare-Liivi initial area shows that the displacement risk is significantly lower in the additional area. For the reduced alternative of the initial area, the maximum abundance estimate for long-tailed duck reached 45 558 individuals, and displacement was one of the main ornithological impacts that led to the spatial reduction of the initial area.

Monitoring of existing offshore wind farms shows that species' response may change over time and some birds may begin to use the wind farm area again. Complete habituation cannot, however, be assumed, and it is not treated in this EIA as a reliable mitigating factor. There is also as yet no long-term experience of the effects of turbines of the proposed dimensions. Certain studies have identified a smaller avoidance response for larger, more widely spaced turbines than for smaller, more densely spaced turbines, but the

⁵⁵ Dierschke, V., Furness, R. W., Garthe, S. 2016. Seabirds and offshore wind farms in European waters: Avoidance and attraction. *Biological Conservation* 202 (2016) 59–68

⁵⁶ Petersen, I. K. 2024. UTILITAS Saare-Liivi offshore wind farm site and diving ducks. *Seaduck sensitivity to offshore wind farms*.

⁵⁷ Jacobsen, E. M. & Tjørnløv, R. S. 2024. *Habitat displacement of sea ducks in relation to Saare-Liivi offshore wind farm, Estonia*.

available information does not allow the impacts of the technical alternatives to be distinguished unequivocally on this basis.

In summary, development of the wind farm in the Saare-Liivi additional area could have a minor adverse displacement effect on staging waterbirds.

HABITAT LOSS

Direct habitat loss may affect staging waterbirds. Direct habitat loss beneath turbine foundations accounts for only a small proportion of the wind farm area. In addition, some habitat may also be lost beneath the cable route. In the additional area, some direct habitat loss of habitats used for staging would occur during construction of the wind farm, but the importance of the additional area as a staging area for waterbirds is low and the impact of habitat loss is minor adverse.

BARRIER EFFECT

It has been concluded that the increase in flight distance and associated energy expenditure caused by a single wind farm are small, and that an effect on a species population as a whole is unlikely (Masden *et al.* 2009⁵⁸, Speakman *et al.* 2009⁵⁹). At present, however, there is a veritable boom in wind farm development. Not all plans are likely to materialise, but even partial implementation may result in cumulative impacts. The development of multiple wind farms may also result in a significant barrier effect for migrating birds. Such an impact is addressed in the chapter on cumulative impacts.

Traditionally, environmental impact assessment considers the impact of the barrier effect on birds breeding nearby. The barrier effect may prove significant if the wind farm lies between nearby breeding colonies and the feeding grounds of the birds breeding in them (Speakman *et al.*, 2009). The behavioural responses of different species to a wind farm as an obstacle (whether to bypass it or to pass through it) differ. The risk caused by the barrier effect has been assessed as low for swans, geese, skuas, gulls and terns; medium for diving ducks, divers, great cormorants and auks (Langston 2010⁶⁰).

In this case, east of the additional area lies the Pärnu Bay important bird area, which also contains important bird breeding islands. The breeding islands are located more than 20 km from the additional area. In assessing the potential barrier effect of the Saare-Liivi additional area, the most relevant species group comprises common gull, Arctic tern, common tern and Sandwich tern breeding on the islets of Kihnu and Pärnu Bay. Based on GPS telemetry data for these species, both the intensity of use of the additional area and the number of feeding flights whose destination lay beyond the additional area were determined.

Use of the survey area for the additional area was very low for all assessed species. Of the GPS positions for common gull, 0.01% were located in the additional area, for Arctic tern 0.02%, for common tern 0% and for Sandwich tern 0.04%. None of the 3288 feeding flights of common gull and none of the 975 feeding flights of common tern had destinations beyond the additional area. Of the 1717 feeding flights of Arctic tern, one had a destination beyond the additional area, and of the 530 feeding flights of

⁵⁸ Masden, E. A., Haydon, D. T., Fox, A. D., Furness, R. W., Bullman, R. and Desholm, M. 2009. [Barriers to movement: impacts of wind farms on migrating birds](#). *ICES Journal of Marine Science*, 66: 746–753.

⁵⁹ Speakman, J., Gray, H., Furness, L. 2009. *University of Aberdeen report on effects of offshore wind farms on the energy demands on seabirds*.

⁶⁰ Langston, R. H. W. 2010. *Offshore wind farms and birds: Round 3 zones, extensions to Round 1 & Round 2 sites & Scottish Territorial Waters*. RSPB Research Report No. 39.

Sandwich tern, three did so. Thus, across all four species combined, only four recorded feeding flights had destinations beyond the additional area.

The results show that the additional area does not lie between the breeding colonies and feeding grounds regularly used by the species studied. Even if, after construction of the wind farm, the birds were to avoid passing through it altogether, any resulting change in flight route would affect only a very small proportion of the recorded feeding flights. The additional area is located farther from the breeding colonies than the initial area, and there were substantially fewer flights heading beyond it than flights extending beyond the initial area. In BioConsult's analysis, a total of 22 feeding flights extended beyond the survey area for the initial area and four beyond that for the additional area.

An important factor in the barrier effect is the proportion of the birds' feeding area represented by the wind farm area. Only under 0.1% of the birds' recorded locations were within the Saare-Liivi additional area. Of the 6510 feeding flights recorded by GPS telemetry, only four, or approximately 0.06%, extended beyond the additional area. Therefore, the additional area is not located on a regular movement route of the breeding birds studied, and the barrier effect on them is negligible.

COLLISION RISK

Collision risk arises when a bird enters the rotor swept area of an operating turbine and does not avoid collision with a turbine blade or other structure. The magnitude of the risk depends on the bird's flight intensity, flight height, species-specific avoidance behaviour, the number and dimensions of the turbines, and the turbines' operating time.

Collision risk for the additional area was assessed separately for migrating birds and for gulls and terns breeding on the islets of Kihnu and Pärnu Bay (Castillo, Liedtke and Welcker, 2024; Burger et al., 2024). Both analyses used the stochastic SOSS Band collision risk model, implemented using the R package *stochLAB* (Caneco et al., 2022). The model was run for 10 000 iterations, and the results were presented as the mean, standard deviation and 95% confidence interval of the predicted annual number of collisions. The analysis of migrating birds used site-specific flight intensity and flight height data and version 4 of the Band model.

The model results represent the potential number of collisions calculated under the assumptions entered into the model (Table 3.5-6). They are not observed fatalities in the wind farm, nor do they in themselves constitute an indicator demonstrating population-level impact. The result is influenced, among other things, by estimates of bird density and flight intensity, the distribution of flight heights, the avoidance rate assigned to the species or species group, and the turbine's technical parameters. The 95% confidence intervals presented in the model describe the statistical variability of the parameters included in the calculation, but do not fully encompass all methodological uncertainties, such as the unknown species composition of nocturnal migrants or the correspondence between radar contacts and the actual number of individuals.

Collision risk for migrating birds was modelled for 14 species or species groups and for an aggregate group of nocturnal migrants based on vertical radar data. The model used 50 turbines planned for the entire additional area considered in the study and two technical turbine variants, A and B. Species for which the number of individuals not identified to species level in visual observations was high were considered as groups. The main species represented in the groups are as follows: in the diver group, black-throated and red-throated diver; in the geese group, bean goose, greater white-fronted goose and barnacle goose; in the wader group, knot, grey plover, bar-tailed godwit, dunlin and Eurasian curlew; in the tern group, common tern and Arctic tern. Among skuas, Arctic skua was by far the dominant species.

The collision forecasts presented in Table 3.5-6 were calculated for the 50-turbine modelling scenario for the additional area. Under main alternative 3 for the additional area, which forms the basis for the impact assessment, up to 40 turbines are planned. In the Band collision risk model, collision risk is calculated per turbine, and the total result for the wind farm is obtained by summing the effects of the individual turbines. According to the model developers' explanation, the calculated result does not depend on the specific layout of the turbines. Therefore, the results for main alternative 3 of the additional area can be estimated proportionally using the turbine number ratio of 40/50, i.e. a factor of 0.8. This is a proportional adjustment of the existing model result, not a new application of the collision risk model. The adjustment assumes that the flight intensity, distribution of flight heights and other model inputs used in the study are also applicable to the area of main alternative 3.

For most of the species considered, the estimated number of collisions was very low; in addition to nocturnal migrants, common crane also warrants attention. One important factor in the higher collision risk for common crane is its greater flight height, which overlaps substantially with the rotors' operating height.

The modelling results showed a higher fatality risk for turbine variant B, which involved larger turbines. Larger turbines have larger rotor swept zones and cover a larger area. In addition, in larger turbines the rotor swept zone begins lower, increasing the exposure of low-flying birds. The type of turbines used in constructing the wind farm is determined primarily by which turbines are being manufactured at that time.

Table 3.5-6. Estimated annual number of collisions of migrating birds in the Saare-Liivi additional area (Castillo, Liedtke & Welcker 2024⁶¹)

Species / group	Wind turbine A 275 m		Wind turbine B 310 m	
	Mean ± SD	95% confidence interval	Mean ± SD	95% confidence interval
divers (<i>Gavia stellata</i> , <i>G. arctica</i>)	0.69±0.08	0.53–0.85	0.91±0.11	0.71–1.12
great cormorant (<i>Phalacrocorax carbo</i>)	2.18 ±0.25	1.7–2.67	3.02±0.34	2.36–3.7
geese and geese of the genus <i>Branta</i>	41.52±3.87	33.96–49.16	55.95±5.25	45.71–66.28
Eurasian wigeon (<i>Mareca penelope</i>)	6.77±0.7	5.47–8.21	7.9±0.78	6.43–9.48
greater scaup (<i>Aythya marila</i>)	1.08±0.1	0.89–1.3	1.71±0.14	1.43–2
common scoter (<i>Melanitta nigra</i>)	0.02±0.01	0–0.04	0.04±0.01	0.02–0.07
velvet scoter (<i>Melanitta fusca</i>)	1.3±0.17	0.97–1.64	2.24±0.29	1.68–2.82
long-tailed duck (<i>Clangula hyemalis</i>)	0±0	0–0	0 ± 0	0–0.01
common crane (<i>Grus grus</i>)	119.27±13.44	93.38–145.6	143.45 ± 16.22	112.05–175.22
waders	5.11±0.64	3.87–6.38	6.13±0.77	4.65–7.65
skuas (<i>Stercorarius parasiticus</i>)	0.06±0.02	0.04–0.1	0.08±0.02	0.05–0.12
common gull (<i>Larus canus</i>)	0.13±0.03	0.07–0.2	0.21±0.04	0.13–0.31
little gull (<i>Hydrocoloeus minutus</i>)	0.06±0.01	0.03–0.08	0.09±0.02	0.06–0.12
terns (<i>Sterna hirundo</i> , <i>S. paradisaea</i>)	0±0	0–0.01	0.01±0	0–0.02
nocturnal migrants	758.21 ± 98.4	565.4–952.85	1057.62 ± 138.05	788.01–1330.62

⁶¹ Castillo, R., Liedtke, J. & Welcker J. 2024. Collision risk models for Utilitas offshore wind farm – Extended area.

For most species and species groups migrating by day, the predicted number of collisions is low. For long-tailed duck, common scoter, terns, gulls and skuas, the forecast is zero or below one collision per year. For divers, greater scaup, velvet scoter, great cormorant, Eurasian wigeon and waders, the forecast is up to a few individuals per year.

For geese and geese of the genus *Branta*, the forecast adjusted to main alternative 3 of the additional area is approximately 33 collisions per year for turbine variant A and 45 collisions for variant B. This is a multi-species group, and the forecast cannot be broken down by species without additional assumptions. Nevertheless, the forecast constitutes a very small proportion of the combined size of the biogeographical populations of the species in the group.

The highest forecast for daytime migration was obtained for common crane: approximately 95 collisions per year for variant A and 115 collisions for variant B. The higher model result is driven by the high estimated flight intensity of common crane and the large proportion of birds flying in the rotor swept zone. Of common crane flights, 77% were within the rotor swept zone for variant A and 85% for variant B. In the avifauna study, the seasonal passage estimate for common crane was higher than the estimated total size of the biogeographical population. The study report notes that passage of all individuals in the population through the additional area is unlikely and that the result reflects the high uncertainty of the abundance estimate and its extrapolation to the migration period. Therefore, the number of collisions for common crane should be treated as a conservative forecast, not as an exact annual number of fatalities. At the same time, such a high model value confirms that common crane is a priority risk species for the additional area, for which targeted mitigation and monitoring measures must be planned.

For nocturnal migrants, the exact species and numerical composition is unknown. According to the nocturnal audio recordings, passerines were the most abundant bird group, especially in autumn, when they accounted for over 90% of contacts. For the combined group of nocturnal migrants, the predicted number of collisions, adjusted to main alternative 3 of the additional area, was approximately 607 collisions per year for variant A and 846 collisions for variant B. As inputs to the nocturnal migrant model, vertical radar contacts, a site-specific flight height distribution, a 98% avoidance rate, and chaffinch parameters as a proxy for the body dimensions and flight speed of a typical nocturnally migrating passerine were used.

The result for nocturnal migrants is subject to high uncertainty. The radar did not allow contacts to be identified to species, and one contact is not necessarily equivalent to one individual bird. A contact may represent either a single bird or a flock consisting of several birds. On the basis of the available data, it is not possible to determine the direction or magnitude of this potential error, and therefore the model forecast cannot be treated as an exact number of fatalities.

According to the audio recordings, the most abundant species were robin, song thrush and redwing. However, vocalisations are recorded from only some of the birds passing through the area, and the species distribution in the audio recordings may not correspond to the species composition of nocturnal migration recorded by radar. Therefore, on the basis of the audio recordings, it is not possible reliably to apportion the total number of nocturnal migrants among species or to assess the proportion of the biogeographical population represented by individual species.

Table 3.5-7. Seasonal abundance estimates of migrating birds and their proportion of the biogeographical population size in the additional area (avifauna study, 2024)

Species / group	Seasonal abundance estimate ⁶²	Season	1% of the biogeographical population size ^{Error! Bookmark not defined.}	Migrating birds as a proportion of the biogeographical population size, %
divers (<i>Gavia stellata</i> , <i>G. arctica</i>)	17303	spring	4249*	4
great cormorant (<i>Phalacrocorax carbo</i>)	19845	spring	6200	3
geese and geese of the genus <i>Branta</i>	41276	spring	11117*	4
Eurasian wigeon (<i>Mareca penelope</i>)	21015	autumn	14000	1.5
greater scaup (<i>Aythya marila</i>)	39111	spring	2600	15
common scoter (<i>Melanitta nigra</i>)	53198	spring	7500	7
velvet scoter (<i>Melanitta fusca</i>)	111303	spring	3000	37
long-tailed duck (<i>Clangula hyemalis</i>)	34831	spring	16000	2
common crane (<i>Grus grus</i>)	198084	autumn	1500	132
waders	24234	spring	5601*	4
skuas (<i>Stercorarius parasiticus</i>)	2119	spring	1000**	2
common gull (<i>Larus canus</i>)	18727	autumn	16400	1
little gull (<i>Hydrocoloeus minutus</i>)	12488	spring	1300	10
terns (<i>Sterna hirundo</i> , <i>S. paradisaea</i>)	7958	spring	23702*	0.3
nocturnal migrants	1460682	spring	?	?

* 1% was calculated as the weighted average of the 1% values of the main species in the group. The proportions of the respective species in the visual observations were used as weights.

** Wetlands International does not provide abundance estimates for this species. 1% of the Arctic skua population size was calculated on the basis of the European population size (*Stercorarius parasiticus* (Arctic Jaeger) (iucnredlist.org))

On the basis of the methodology used in the baseline avifauna study, the importance of the additional area for migrating birds was assessed as very high (Annex 3.5, Table 27). However, the assessment is affected by uncertainties related to extrapolating migration intensity to the entire migration period and to the interpretation of radar contacts. For most of the species and species groups considered, the significance of collision risk during migration can be assessed as low to moderate. Common crane and nocturnal migrants are the most at risk (Table 3.5-7). The use of mitigation measures would be necessary to reduce the negative impact.

For most species migrating by day, the standalone collision impact of main alternative 3 of the additional area is minor negative. In the case of common crane and nocturnal migrants, owing to the magnitude and uncertainty of the model forecast, this is a potentially significant negative impact (i.e. severe), the probability and extent of which cannot be determined precisely on the basis of the available data. **Therefore, before mitigation measures, the impact on these groups is assessed as ranging from minor negative impact to significant negative impact (i.e. moderate or severe).**

For breeding birds, collision risk within the impact zone of the proposed Saare-Liivi wind farms was assessed for the four most important species: common gull, Arctic tern, common tern and sandwich tern. The importance of the development project areas is high for all the species mentioned, as breeding

⁶²In assessing the importance of the area for migrating birds, the spring or autumn abundance estimate was used, depending on which was higher.

abundances exceed 1% of the abundance estimate for Estonia (Annex 3.5, Table 21). The populations breeding on the islets of Kihnu and Pärnu Bay are nationally important, but, based on GPS telemetry, the species assessed use the additional area to a very limited extent.

Even under the conservative modelling scenario for the additional area with 50 turbines, the forecasts were low. For common gull, approximately 0.01 collisions per year were predicted; for common tern, no collisions were predicted; for Arctic tern, the forecast was 0.30–0.38; and for sandwich tern, 1.13–1.40 collisions per year.

These results have not been remodelled for the spatial boundary of main alternative 3 of the additional area. Since under main alternative 3 the number of turbines decreases from 50 to 40, but the bird density based on GPS data has not been recalculated within the smaller spatial configuration, the existing results for 50 turbines are treated as a conservative estimate. The very low model forecast is consistent with the result of the telemetry study, according to which, depending on the species, only 0–0.04% of GPS positions were located in the additional area.

The collision impact on common gull, Arctic tern and common tern is neutral to minor negative. For sandwich tern, the forecast is somewhat higher than for the other species, but even in the scenario for the additional area with 50 turbines it remains, on average, at approximately one individual per year. Given the very limited use of the additional area and the smaller number of turbines under main alternative 3, there is no basis to assume a significant impact on the populations of gulls and terns breeding in the area. **The forecasts of collision risks were low for all the species considered, and overall the significance of collision risk for breeding birds is low. Overall, the collision impact on breeding birds is neutral to minor negative.**

Table 3.5-8. Estimate of the annual number of collisions of breeding birds in the additional area (Burger et al. 2024⁶³)

Species	Wind turbine A 275 m		Wind turbine B 310 m	
	Mean ± SD	95% confidence interval	Mean ± SD	95% confidence interval
common gull (<i>Larus canus</i>)	0.01±0	0–0.01	0.01±0	0–0.02
common tern (<i>Sterna hirundo</i>)	0	0	0	0
Arctic tern (<i>Sterna paradisaea</i>)	0.3±0.16	0.06–0.66	0.38±0.2	0.07–0.84
sandwich tern (<i>Thalasseus sandvicensis</i>)	1.13±0.57	0.29–2.5	1.4±0.71	0.36–3.08

Compared with the EIA collision model for the initial Saare-Liivi area, the adjusted forecast for main alternative 3 of the additional area is significantly lower for geese and geese of the genus *Branta* and nocturnal migrants, but higher for common crane. In the 80-turbine layout for the initial area, approximately 49–58 collisions per year were predicted for common crane and 2617–3635 for nocturnal migrants; the adjusted values for the additional area with 40 turbines are 95–115 and 607–846, respectively.

Numerous nests of the white-tailed eagle (*Haliaeetus albicilla*), a species in protected category I, are located along the Estonian coast. The nearest known white-tailed eagle nest site to the additional area is more than 20 km away. The avifauna studies did not identify regular use of the additional area by white-tailed eagle as a feeding or movement area, and the area does not fall within the 6 km sensitivity zone used in the EOÜ and Kotkklubi guidance for onshore wind farms (Eesti Ornitolooogiaühing and Kotkklubi

⁶³ Burger, C., Osterberg, J., Castillo, R., Welcker, J. 2024 Analysis of spatial use and collision risk of breeding seabirds based on GPS telemetry data Saare-Liivi 1 and Saare-Liivi 2 offshore wind farm planning areas.

2022⁶⁴). The additional area under consideration is located considerably farther from the nearest white-tailed eagle nest (more than 20 km) and therefore the preparation of a separate white-tailed eagle collision model for the additional area is not justified.

INDIRECT IMPACTS

Similarly to the construction phase, during the operational phase staging waterbirds may also be affected both by changes in prey availability and by pollution risk. Prey availability may be affected by loss of seabed beneath turbine foundations, underwater noise caused by turbines and maintenance vessels, the addition of new hard substrate as an attachment site for benthic organisms, electromagnetic fields, warming of sediments above cables and restrictions imposed on fishing (Moray West 2018⁶⁵). Unlike most turbine-related factors, the addition of new hard substrate and restrictions imposed on fishing may have a positive effect on avifauna. However, a possible reef effect is not automatically treated as a positive impact or as a mitigation measure. An increase in prey availability may concentrate birds near the turbines and increase the time they spend in the collision risk area. The actual direction and extent of the impact must be assessed through operational monitoring of the marine ecosystem and avifauna.

The risk of pollution may be caused by the release of harmful substances into the environment as a result of accidents and leaks involving turbines and the equipment used for their maintenance. With careful execution of the works, the likelihood of accidents and leaks occurring is low. The vessels used for turbine maintenance are likely to be smaller than those used during the construction phase; accordingly, the quantity of fuel on board that could be released into the environment in the event of an accident is also smaller.

3.5.4. Environmental measures

MITIGATION MEASURES

In assessing the in-combination effect on avifauna, it is important to consider the availability of suitable feeding and staging areas in the Gulf of Riga as a whole. No significant feeding or staging areas were identified in the additional area; therefore, for this area, it is not justified to establish location-specific protection measures for them.

To avoid and reduce impacts on avifauna, the following principle has already been taken into account in the solution for the additional area: the development area for the additional area EIA programme, with up to 92 turbines, has been reduced to main alternative 3, covering 57.1 km² and comprising up to 40 turbines. Reducing the development area and the number of turbines reduces the spatial extent of the wind farm, the barrier effect and the calculated collision risk.

Collision risk reduction during operation

Before construction works begin in the additional area, a plan for operational automatic bird monitoring and need-based operation for the additional area of the Saare-Liivi offshore wind farm must be prepared and agreed with the Environmental Board. In preparing the plan, existing and newly available scientific data, experience from other offshore wind farms and technical possibilities must be taken into account. The plan must specify the principles for identifying migration events involving a high collision risk, for

⁶⁴ Estonian Ornithological Society and Kotkaklubi 2022. *Estonia-wide analysis of terrestrial avifauna. Estonia-wide analysis of terrestrial avifauna* | Keskkonnaportaal

⁶⁵ Moray West 2018, [Moray West Offshore Windfarm Offshore EIA Report](#).

restricting or stopping turbine operation, for restarting turbines, and for verifying the effectiveness of the measures.

From the start of regular operation of the wind farm, automatic bird monitoring and need-based operation must be in working order. Where a migration event involving a high collision risk is detected, turbine rotor speed must be reduced or the turbines stopped in accordance with the plan agreed with the Environmental Board. The criteria for implementing the measure and for restarting the turbines must be defined before commissioning.

In the further project design for the additional area, it is recommended that the following additional avoidance and reduction measures be taken into account:

- 1) Turbine layout. When designing the final turbine layout, it is recommended to take account of the predominant north-east–south-west migration direction. Where possible, turbine rows should be arranged parallel to the migration direction, and the formation of a dense and continuous belt of turbines perpendicular to the predominant migration direction should be avoided. At the junction of the initial area and the additional area, the layout of the additional area must be designed so that no denser barrier than in the rest of the wind farm is created there.
- 2) When selecting the final turbine model, from the perspective of avifauna preference should be given to a solution in which the lower rotor tip is positioned as high above the sea surface as possible.
- 3) Lighting of the wind farm must be limited to that required to meet aviation and navigation safety requirements. Unjustified continuous or diffuse lighting must be avoided and, where possible, synchronised, directional and low-dispersion lighting solutions must be used.
- 4) Stopping turbines where necessary during periods of intense bird migration. Collision risk can be reduced by reducing rotor rotational speed or by stopping the turbines during the most intense migration periods (May *et al.* 2015). The most intense migration is often concentrated on a limited number of days, so implementation of the measure would not entail very substantial economic loss. For the sake of accuracy and efficiency, high-technology tools should be used to identify the periods requiring implementation of the measure.

The decommissioning plan must specify the impact of dismantling on avifauna, taking into account the avifauna situation that has developed by that time, the technology used for the works and the ecological function of the structures.

ENVIRONMENTAL MONITORING

A plan for operational bird monitoring and need-based operational measures must be prepared for the additional area. If the Saare-Liivi initial area has by then been constructed and the results of its bird monitoring are available, these shall be taken into account to the extent relevant in preparing the plan for the additional area. Where possible and scientifically justified, methodologies that enable comparison of the monitoring results for the initial area and the additional area shall be used. The plan for the additional area must be prepared on the basis of the national methodology in force at that time, the best available knowledge, experience gained in other offshore wind farms, and technical possibilities.

The plan must cover at least monitoring of the distribution and abundance of staging waterbirds, the flight intensity and flight altitude of passage migrants, detection of actual collisions or events indicative of them, and verification of the effectiveness of operational measures implemented to reduce collision risk. The exact monitoring methodology, duration, control areas, data quality requirements, and the

criteria for implementing and modifying the operational measures must be agreed with the Environmental Board before commissioning of the wind farm in the additional area.

3.5.5. Summary

No aggregation area for staging waterbirds of international, national or local importance was identified in the additional area. GPS telemetry of gulls and terns breeding on the islets around Kihnu and in Pärnu Bay showed that use of the additional area was very low, and the area is neither their regular feeding ground nor an important route linking breeding colonies and feeding grounds.

Compared with the spatial configuration of the Saare-Liivi initial area at the time of the study, the additional area has clearly lower use intensity and conflict level from the perspective of staging diving ducks and local breeding gulls and terns. In the initial area, it was necessary, in order to reduce impacts, to exclude important staging areas of long-tailed duck and velvet scoter from the development area, whereas no staging areas of comparable importance were identified in the additional area. However, the advantage of the additional area over the initial area does not automatically extend to the collision risk for passage migrants.

The construction-phase disturbance, displacement of staging waterbirds, direct habitat loss, barrier effect on local breeders, and collision risk for breeding gulls and terns associated with the construction and operation of main alternative 3 in the additional area remain insignificant or minor negative. Operational indirect impacts may locally be both negative and positive, but are not expected to cause a significant change in birds' feeding conditions.

The main potential impact on avifauna in the Saare-Liivi additional area is the collision risk for common crane and nocturnal migrants. The model forecasts involve substantial uncertainty, and they do not represent actually observed fatalities nor do they in themselves demonstrate the occurrence of a significant population-level impact. The magnitude of the forecasts is nevertheless sufficient to treat common crane and nocturnal migrants as priority risk groups and to establish targeted operational, monitoring and adaptive management measures for their protection.

Technical variant A is preferable from the perspective of avifauna collision risk, because its rotor is smaller and the lower rotor tip is positioned higher. Under technical variant B, the predicted collision risk for common crane, geese and geese of the genus *Branta*, and nocturnal migrants is approximately 20–40% higher. For both technical variants, significant adverse impact can be avoided or reduced to an insignificant level only if, before commissioning of the wind farm in the additional area, a binding adaptive operational plan for collision risk is prepared and implemented, and the effectiveness of the measures is verified through follow-up monitoring.

The impact assessments in this chapter are based on main alternative 3 for the additional area as developed during the EIA process, under which up to 40 turbines are planned in the 57.1 km² additional area. The results obtained in the baseline studies with 50 turbines have either been treated as a conservative estimate or adjusted to main alternative 3 in accordance with the principles described in subsection 3.5.1.

Table 3.5-9. *Impact associated with planning the wind farm and its significance*

Associated consequence/impact	Impact significance		Need for the application of mitigation measures, final impact significance
	15 MW (A)	20 MW (B)	
Wind farm construction and decommissioning			

Associated consequence/impact	Impact significance		Need for the application of mitigation measures, final impact significance
	15 MW (A)	20 MW (B)	
Disturbance from construction activities and vessels	-	-	No separate mitigation measure is required; phased organisation of the works minimises the impact: residual impact 0/-
Indirect impacts (impact on food abundance and pollution risk)	0/-	0/-	environmental management and pollution response plan; residual impact 0/-
Wind farm operation			
Displacement	-	-	The reduced spatial extent of main alternative 3 in the additional area and the limit of up to 40 turbines have been taken into account in the impact assessment. Actual impact to be verified through follow-up monitoring. Residual impact: -.
Direct habitat loss	-	-	No separate mitigation measure is required; habitat loss has already been reduced by the smaller area and the limit of up to 40 turbines under main alternative 3 in the additional area. Residual impact: -.
Collision risk	-/--	-/--	An adaptive operational plan for collision risk, automatic bird monitoring and need-based shutdown during migration events involving a high collision risk are required. With implementation of the measures, residual impact: -. From the perspective of avifauna collision risk, technical variant A is preferable (the forecast for variant B is 20–40% higher).
Barrier effect	0/-	0/-	coherent layout taking the migration direction into account; residual impact 0/-
Indirect impacts (impact on food abundance and pollution risk)	0/-	0/-	pollution response plan and monitoring of possible aggregation of birds around turbines; residual impact 0/-.

**Scale of significant environmental impact used in the EIA report: - minor negative impact, -- significant negative impact, 0 - no impact, neutral, + minor positive impact, ++ significant positive impact*

3.5.6. Cumulative impact

In the assessment of cumulative impact on avifauna, the Saare-Liivi offshore wind farm initial area and additional area are considered first. They will, once developed, form a single spatial offshore wind farm area, but in this EIA monitoring and operational measures are established only for the additional area; methodological compatibility with the solutions for the initial area makes it possible to compare cumulative impact and, where necessary, analyse it as a whole. Development of the areas may not take place simultaneously, therefore cumulative impact is considered both for simultaneous development and for development separated in time. Thereafter, the cumulative impact of the Saare-Liivi initial area and additional area is assessed in combination with other proposed offshore wind farms for which sufficient detail is available. For avifauna, the Liivi Bay offshore wind farm is included in the assessment and, as regards collision risk, the Saare Wind Energy offshore wind farm as well. The Liivi Bay offshore wind farm and the Saare-Liivi initial and additional area are located within the same ecological and migratory system of the Gulf of Riga and may affect the same groups of staging, wintering, breeding and passage birds. The Saare Wind Energy offshore wind farm is located more than 90 km from the Saare-Liivi additional area, and its possible in-combination effect is primarily limited to the cumulative collision risk for the same migratory populations.

In the assessment of cumulative impact, a distinction is made between:

- the summation of collision risk;
- the cumulative reduction of staging and feeding areas and displacement;
- barrier effect and changes in movement routes;
- the need for monitoring and operational measures for the additional area and their methodological compatibility with data from other projects.

Cumulative collision risk

With the addition of the Saare-Liivi additional area to the development of the initial area, the calculated collision risk increases for all three main risk groups. The relative contribution of the additional area is greatest for common crane: the forecast for the 40-turbine solution in the additional area is higher than the forecast for the 80-turbine solution in the initial area. For nocturnal migrants, most of the calculated risk for the Saare-Liivi initial and additional area lies in the initial area.

The results for the additional area were obtained by multiplying the mean values of the 50-turbine collision risk model by the coefficient 40/50, i.e. 0.8, derived from the ratio of turbine numbers. The 50-turbine collision risk results for the additional area were estimated for technical alternatives A and B, respectively, as follows: Anser and Branta geese 41.52 / 55.95; common crane 119.27 / 143.45; and nocturnal migrants 758.21 / 1057.62. This is a proportional adjustment of an existing model result, not a new application of the model. The values presented in the table are model forecasts, not observed fatalities.

Table 3.5-10. *Calculated collision risk for the Saare-Liivi offshore wind farm initial and additional area under main alternative 3 for the initial and additional area*

Species or species group	Initial area, 80 turbines – A	Additional area, 40 turbines – A	Saare-Liivi total – A	Initial area, 80 turbines – B	Additional area, 40 turbines – B	Saare-Liivi total – B
Geese and geese of the genus Branta	144.18	33.22	177.40	187.17	44.76	231.93
Common crane	49.33	95.42	144.75	58.32	114.76	173.08
Nocturnal migrants	2617.40	606.57	3223.97	3635.00	846.10	4481.10

Under technical variant B, the forecast for the Saare-Liivi initial and additional area is approximately 20% higher for common crane, approximately 31% higher for geese and geese of the genus Branta, and approximately 39% higher for nocturnal migrants than under variant A. Therefore, technical variant A also has a lower collision risk for the Saare-Liivi initial and additional area.

The calculated total risk must not automatically be treated as a population-level impact. The model forecasts for both areas involve uncertainties related to flight intensity, avoidance behaviour, interpretation of radar contacts and interannual variability. At the same time, the result confirms that the collision risk for common crane and nocturnal migrants must be mitigated if both areas of the Saare-Liivi offshore wind farm are realised. A plan for operational bird monitoring and need-based operational measures must be prepared for the additional area. Where possible and scientifically justified, methodologies that enable comparison of the monitoring results for the initial area and the additional area shall be used.

Table 3.5-11. *Comparison of collision risk model forecasts for the offshore wind farms under consideration*

Project and assessed solution	Number of turbines	Common crane, individuals/year	Nocturnal migrants or passerines, individuals/year	Use of results in cumulative assessment
Saare-Liivi initial and additional area, variant A	80 + 40	144.75	3223.97	Comparable models for the initial and additional area; results can be summed
Saare-Liivi initial and additional area, variant B	80 + 40	173.08	4481.10	Comparable models for the initial and additional area; results can be summed
Saare Wind Energy offshore wind farm	up to 100	9.77–11.46	1891.46–2174.05	To be used as an indicative population-level cumulative contribution
Liivi Bay offshore wind farm, modelled worst alternative 1	84	241	301 passerines, including nocturnal and diurnal migration	Not directly summable with the Saare-Liivi and Saare Wind Energy results; different methodology and avoidance rate

In the EIA report for the Saare Wind Energy offshore wind farm, the model forecast for common crane is 9.77–11.46 and the forecast for nocturnal migrants is 1891.46–2174.05 collisions per year.

In the EIA report for the Liivi Bay offshore wind farm, the worst result for common crane is given as 241 birds per year under alternative 1, i.e. with 84 turbines. The same report explains that this calculation used an 83% avoidance rate for common crane, whereas international recommendations cite an avoidance rate of 99–99.5%; the Liivi Bay offshore wind farm EIA report therefore considers its forecast of 241 birds to be a significant overestimate. The highest aggregate forecast for passerines, including nocturnal and diurnal migration, is presented as 301 birds per year, which is not the same category as the combined group 'nocturnal migrants' for the Saare-Liivi initial and additional area and the Saare Wind Energy offshore wind farm.

Based on the model forecasts for the Saare-Liivi initial and additional area and the Saare Wind Energy offshore wind farm, the conservative aggregate annual collision forecast for these projects, using the higher values from each project, would be approximately **185 common cranes and 6655 nocturnal migrants**. This is an indicative sum, because the study periods, bird densities and technical solutions of these projects are not fully identical.

In the EOÜ summary report of the avifauna study for the additional area (Annex 3.5), the previously mentioned total forecast of approximately 200 common cranes and 6900 nocturnal migrants was based on the 50-turbine scenario for the additional area. With the reduction of the additional area to 40 turbines, the indicative sum for the Saare-Liivi initial and additional area and the Saare Wind Energy offshore wind farm decreases accordingly to approximately 185 common cranes and 6655 nocturnal migrants.

It is not methodologically justified to add the Liivi Bay offshore wind farm forecast of 241 common cranes directly to that sum. The avoidance rate in this calculation differs substantially from the assumptions used in the model for the Saare-Liivi initial and additional area, and the Liivi Bay offshore wind farm EIA report itself considers the result to be a significant overestimate. Nor is the Liivi Bay offshore wind farm forecast of 301 passerines directly comparable with the combined group of nocturnal migrants for the Saare-Liivi initial and additional area and the Saare Wind Energy offshore wind farm.

Therefore, the contribution of the Liivi Bay offshore wind farm to cumulative collision risk is presented separately as a conservative scenario. Preparing a single numerical cumulative forecast covering all four development projects (the two Saare-Liivi areas, the Liivi Bay offshore wind farm and the Saare Wind

Energy offshore wind farm) would require harmonisation of the models, at least in terms of avoidance rates, species groups, migration periods and turbine parameters.

A size of 150 000 individuals has been used for the common crane biogeographical population in the impact assessment for the Saare-Liivi initial and additional area and the Saare Wind Energy offshore wind farm. The aggregate collision forecast for main alternative 3 in the Saare-Liivi initial area and the additional area amounts to approximately 0.097% of this per year under technical variant A and 0.115% under technical variant B. Together with the model forecast for the Saare Wind Energy offshore wind farm, the indicative sum would be approximately 0.10–0.12% of the biogeographical population per year. That proportion expresses modelled additional annual mortality, not the forecast annual decline of the population. The actual population-level consequence depends, inter alia, on the population's demography, natural mortality, breeding success, population trend, avoidance behaviour and the effectiveness of mitigation measures, and it has not been assessed using a separate population model.

The result presented in the EIA report for the Liivi Bay offshore wind farm is not added directly to that percentage, because the corresponding report used a different population size and different collision model assumptions. According to the Liivi Bay offshore wind farm EIA itself, the conservative forecast there of 241 individuals amounts to 0.2% of the common crane population used in that report.

Displacement from staging and feeding areas

Cumulative displacement is assessed primarily as the in-combination effect of the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm, because the projects are located within the same functional marine bird habitat in the Gulf of Riga and may affect the same wintering and staging long-tailed ducks, scoters and divers. The Saare Wind Energy offshore wind farm is located outside the impact area of that same local marine bird habitat, and its inclusion in the detailed displacement assessment is not justified.

The Saare-Liivi additional area is not an important staging area for waterbirds, and its additional contribution to cumulative displacement is small. In the case of the Saare-Liivi initial area, the development area was significantly reduced during the EIA in order to preserve the more important concentration areas of long-tailed ducks and common scoters (initial area main alternative 3). By contrast, the study carried out in and around the Liivi Bay offshore wind farm area recorded concentrations of common scoter exceeding the threshold of international importance, and therefore cumulative displacement is possible in the overall context of the Gulf of Riga.

The cumulative analysis prepared by Ramboll Polska assessed the possible displacement of long-tailed ducks and common scoters resulting from the in-combination effect of the Saare-Liivi initial and additional area, the Liivi Bay offshore wind farm and the Saare Wind Energy development areas. The analysis conservatively assumed full-scale use of the development areas and included 4 km displacement buffers around the areas. Over 21 years, the population decrease associated with the modelled projects was 0.74–1.81% for common scoter and 0.51–1.44% for long-tailed duck, remaining below the significance criteria used in the study.

In that analysis, earlier spatial extents were used for the Saare-Liivi initial area and additional area, each larger than the final main alternative 3 for the respective area. Therefore, the contribution of the Saare-Liivi initial and additional area in the model is likely overestimated compared with the current solution of up to 80 + 40 turbines.

In summary, the additional contribution of the Saare-Liivi additional area to displacement is small, but cumulative displacement may arise from the in-combination effect of the Saare-Liivi initial and additional

area and the Liivi Bay offshore wind farm. The existing conservative population model does not show a significant population-level impact, and the cumulative impact is therefore assessed as minor negative. The ecological assumption underlying the assessment is the maintenance in the Gulf of Riga of feeding and staging areas of sufficient quality and capacity, and of movement opportunities between them. This assumption takes into account the spatial avoidance already applied in the EIA for the Saare-Liivi initial area and, in the design solutions of other projects included in the assessment, such as the final placement of turbines for the Liivi Bay offshore wind farm, the need to preserve important staging areas.

Barrier effect

The Saare-Liivi initial and additional area are adjacent, forming a single spatial area if both development projects are realised, and their barrier effect must therefore be considered as a single whole. The addition of the additional area increases the overall spatial extent of the Saare-Liivi initial area, but the additional area is not on the regular movement route of gulls and terns breeding on the islets of Kihnu and Pärnu Bay. According to GPS telemetry, 22 recorded foraging flights extended beyond the survey area of the initial area, and only four beyond that of the additional area. Therefore, the additional barrier effect of the Saare-Liivi initial and additional area on local breeding birds is small.

According to the latest version of the EIA report for the Liivi Bay offshore wind farm, that area is likewise not located between actively used breeding and feeding areas. Therefore, there are no grounds for assuming a significant cumulative barrier effect from the Saare-Liivi initial and additional area together with the Liivi Bay offshore wind farm on gulls and terns breeding on the islets of Pärnu Bay.

For wintering and staging waterbirds, the barrier effect may arise during movements between the staging and feeding areas around Kihnu, the Saare-Liivi initial and additional area, and the eastern and southern parts of the Liivi Bay offshore wind farm. For passage migrants, the Saare-Liivi offshore wind farm and the Liivi Bay offshore wind farm may constitute two closely spaced obstacles on the general north-east-south-west migratory route.

According to the EIA report for the Liivi Bay offshore wind farm, at least approximately 7.3 km of turbine-free marine area remains between the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm. The development projects therefore do not form one continuous turbine belt, and birds remain able to move between the offshore wind farms. Based on the available information, a cumulative barrier effect is likely, but it does not cause such an increase in birds' migratory route length or energy expenditure as would be expected to affect the status of the populations.

Due to the distance of the Saare Wind Energy offshore wind farm, no common local barrier arises between it and the Liivi Bay offshore wind farm or the Saare-Liivi offshore wind farms. The possible impact of the Saare Wind Energy offshore wind farm is manifested rather as the combined effect on different individuals of the same migratory population or on different migration legs, rather than as a successive significant cost of bypassing or overflying for one and the same bird.

In summary, the cumulative barrier effect is **insignificant to minor negative** for local breeding birds and **minor negative** for wintering and passage birds. Based on the available information, no significant population-level impact is to be expected.

In summary, the additional contribution of the Saare-Liivi additional area to cumulative displacement and barrier effect is small. The main potentially significant cumulative impact is the collision risk for common crane and nocturnal migrants. A plan for operational bird monitoring and need-based operational measures must be prepared for the additional area. If the initial area is also developed, the solution for

the additional area may be technically compatible with the system of the initial area or may use shared infrastructure.

3.5.7. Uncertainty/knowledge gaps

In radar data, not all contacts can be identified to species level, and a single contact may represent either an individual bird or a flock of birds. The nocturnal migrant model includes several species in unknown proportions, and it used the threshold for an average nocturnally migrating passerine and a 98% avoidance rate. Therefore, the result for nocturnal migrants cannot be broken down by species or compared with one specific biogeographical population. The model forecast must be treated as an indicator of the possible level of risk, not of the exact number of fatalities.

Uncertainty arises from the proportional adjustment from 50 to 40 turbines of the model results for passage migrants in the additional area, and from the GPS study of breeding birds being based on a single breeding season. These factors primarily affect the numerical precision of the forecasts, but do not alter the conclusion that use of the additional area by local breeding birds is very limited and that common crane and nocturnal migrants are the main collision risk groups.

Additional uncertainty is caused by the limited long-term experience with offshore wind turbines of 15–20 MW and up to 310 m tip height. Before the wind farm is commissioned, the automatic bird monitoring system, the migration-intensity trigger criteria, and the scope and effectiveness of turbine shutdowns also require site-specific calibration. The quantitative assessment of cumulative impact is limited by differences in the survey and modelling methodologies used across the different offshore wind farms.

Nevertheless, the above uncertainties do not preclude assessment of the impact of main alternative 3 for the additional area. Uncertainty is greatest in relation to the collision risk for common crane and nocturnal migrants and the cumulative impact of different offshore wind farms. This is taken into account through the precautionary principle, preference for the technical solution with lower collision risk, binding adaptive operation, and follow-up monitoring. The purpose of follow-up monitoring is to verify the validity of the impact forecasts and to enable the measures to be refined on the basis of actual results. At present, there is still much uncertainty regarding the effectiveness of mitigation measures (Croll *et al.* 2022⁶⁶). Technological development is very rapid, and new solutions are continually being proposed. The planning process for the offshore wind farm is lengthy, and during that time new knowledge and technical options may emerge. It is advisable to review the section on mitigation measures used to reduce fatality risk again immediately before commencing construction of the wind farm.

3.6. Bats

This chapter, as regards bats, is based on the EIA baseline study "Pre-construction bat survey of the additional area of the Saare-Liivi offshore wind farm" (Elustik OÜ, 2024). The full survey report can be found in Annex 3.6 to the EIA report.

⁶⁶ Croll, D. A. *et al.* 2022. [Framework for assessing and mitigating the impacts of offshore wind energy development on marine birds](#). *Biological Conservation* 276: 109795.

3.6.1. Consideration of alternatives

The bat survey of the Saare-Liivi additional area covered a survey area of approximately 91 km², corresponding to the spatial extent of main alternative 1 in this EIA report. Main alternatives 2 and 3, which form the basis of the impact assessment, are located entirely within the survey area and have a smaller spatial extent than it.

This chapter provides the final impact assessment for main alternative 3 of the additional area, under which up to 40 turbines are planned within an area of 57.1 km². Compared with the maximum spatial configuration during the survey and the up to 50-turbine solution under main alternative 2, main alternative 3 reduces the number of turbines and thus also the number of potential collision points.

3.6.2. Description of environmental status

All bat species are protected in Estonia under both national law and several international conventions and legal instruments. The 12 bat species known to occur in Estonia fall under Protection Category II.⁶⁷

The additional area is likely to be traversed by bat migration between Tõstamaa and the Kura Peninsula. During the spring period, resident bat species undertake spring foraging and move to summer habitats, and spring bat migration takes place. By the end of this period, bat maternity colonies have assembled. During the summer period, bats give birth, rear their young and the young become capable of flight. At this time, females are relatively sedentary and remain in the vicinity of colony sites. During the autumn period, migratory species migrate, while resident species prepare for hibernation and move more widely through the landscape than in the summer period.

BAT MIGRATION IN KABLI AND KIHNU

During migration monitoring, a total of 30 818 bat passes from 11 taxa were recorded across the two recorders combined (Table 3.6-1). In some cases, the recorded calls could not be distinguished to species level and were identified to the most precise taxonomic level possible. The number of bat passes was higher at the recorder located in the village of Kabli.

Table 3.6-1 Bat species recorded at the recorders and number of records. *For *Myotis* bats, the species was identified only in some of the recordings. (Elustik OÜ, 2024)

Species name		Kabli	Kihnu
Nathusius' pipistrelle	<i>Pipistrellus nathusii</i>	10797	1092
northern bat	<i>Eptesicus nilssonii</i>	8041	2043
parti-coloured bat	<i>Vespertilio murinus</i>	2672	47
genus <i>Myotis</i>	<i>Myotis</i> sp.	1644	145
soprano pipistrelle	<i>Pipistrellus pygmaeus</i>	1572	8
noctule bat	<i>Nyctalus noctula</i>	794	112
vespertilionid bat	<i>Vespertilionidae</i> sp.	462	13

⁶⁷ Government of the Republic Regulation No 195 of 20.05.2004 "List of Species Placed under Protection in Protection Categories I and II"

<i>Species name</i>		<i>Kabli</i>	<i>Kihnu</i>
common pipistrelle	<i>Pipistrellus pipistrellus</i>	398	2
brown long-eared bat	<i>Plecotus auritus</i>	256	56
Ept/Vesp/Nyc	<i>Ept/Vesp/Nyc</i>	153	304
Daubenton's bat	<i>Myotis daubentonii</i>	88	-
genus Pipistrellus	<i>Pipistrellus sp.</i>	22	79
Brandt's/whiskered bat	<i>Myotis brandtii/mystacinus</i>	11	-
Natterer's bat	<i>Myotis nattereri</i>	4	-
pond bat	<i>Myotis dasycneme</i>	3	-
Total		26917	3901

The results from the Kabli and Kihnu recorders describe the regional migration dynamics, species composition and the temporal course of spring and autumn migration along the Gulf of Riga coast. These data cannot be treated as bat abundance in the additional area. Direct use of the additional area is described by the recorders installed on the sea buoys, which recorded a total of seven passes.

The survey found that:

- Migratory species passed both observation points in both spring and autumn. Both areas (Kihnu and Kabli) are traversed by bat migration in both spring and autumn.
- During spring migration, the abundance of bats passing through Kihnu is significantly lower than that of those passing through Kabli. In spring, the preferred migratory route is probably over land.
- During autumn migration, bat abundance in Kabli is significantly higher, while the number of migratory species in Kihnu is also several times higher than in spring. **Autumn migration takes place both over land and across the Gulf of Riga.**
- The spring migration peak is at roughly the same time in both Kihnu and on the Kabli coast, in mid- and late May. The first migrants arrive in the area as early as April.
- The autumn migration peak is at roughly the same time in both Kihnu and on the Kabli coast, in the second half of August. Migratory species are present in the area throughout the migration period.

PERMANENT RECORDERS OFFSHORE

The permanent recorders installed in the additional area of the Saare-Liivi offshore wind farm identified 2 bat species – Nathusius' pipistrelle and noctule bat (Table 3.6-2). No passes were recorded at buoy SL_6. 7 passes were recorded at buoy SL_7.

Table 3.6-2 Species recorded by the permanent recorders at each sea buoy (Elustik OÜ, 2024)

<i>Taxon</i>	<i>SL_6</i>	<i>SL_7</i>	<i>Total</i>
noctule bat	0	1	1
Nathusius' pipistrelle	0	6	6
Total:	0	7	7

The permanent recorder survey led to the following conclusions:

- **The additional area is traversed by autumn bat migration.** In spring, no bats were recorded in the Saare-Liivi additional area.
- Bats do not use the additional area as a foraging area during the summer period. In summer, only individual bats pass through the area.
- The autumn migration peak is in late August and the first half of September.
- Bats move through the area for almost the entire night; no night-time hours during which bats did not move through the area were identified.

3.6.3. Impact assessment

The impact of wind farms on bats can broadly be divided into two categories – habitat loss and alteration, and direct bat mortality. The greatest problem associated with wind farms is bat mortality. The main cause of mortality is direct contact with moving turbine blades (Rydell *et al.* 2010⁶⁸; Rodrigues *et al.* 2015⁶⁹). The risk of mortality is generally higher in locations where turbines are placed in a biotope suitable for bats or in its immediate vicinity. Such locations may include the home range of a bat colony, proximity to coastlines, internal water bodies, woodland edges and other linear environmental features that bats use for orientation (Ijäs *et al.* 2017⁷⁰; Ahlén, Baagøe, and Bach 2009⁷¹), and places where bats congregate during migration (Rydell *et al.* 2010⁷²; Arnett *et al.* 2016⁷³).

Based on the datasets from the surveys previously carried out in the initial area of the Saare-Liivi offshore wind farm and in the additional area under this EIA, general conclusions can be drawn about the importance of the Gulf of Riga and its coast to bats. The data show that spring bat migration traverses both the Gulf of Riga coast and offshore areas. In spring, no bats were recorded in the additional area of the Saare-Liivi offshore wind farm, but even so, on the basis of observations from a single year it cannot be stated that no bats reach the area during spring migration. In the adjacent initial area of the Saare-Liivi offshore wind farm, bats were recorded in spring both by permanent recorders and by ship-based counts. Bat abundance in spring is nevertheless probably lower than during autumn migration. However, bat abundance at the permanent observation point in Kabli was comparable in the spring period to that in autumn, so it is possible that in spring the preferred migratory route of bats runs along the coast.

During the summer period, one bat pass was recorded offshore (in June). From the last third of June until the beginning of August, no bat passes were recorded in the additional area. This indicates that bats make very little use of the additional area during this period. Offshore areas located far from the coast

68 Rydell, Jens, Lothar Bach, Marie-Jo Dubourg-Savage, Martin Green, Luisa Rodrigues, and Anders Hedenström. 2010. "Bat Mortality at Wind Turbines in Northwestern Europe", December, 261–74.

69 Rodrigues, Luísa, Lothar Bach, Marie-Jo Dubourg-Savage, Branko Karapandža, Dina Kovač, Thierry Kervyn, Jasja Dekker, Andrzej Kepel, Petra Bach, and Jan Collins. 2015. *Guidelines for consideration of bats in wind farm projects: Revision 2014*. UNEP/EUROBATS.

70 Ijäs, Asko, Aapo Kahilainen, Ville V. Vasko, and Thomas M. Lilley. 2017. "Evidence of the migratory bat, *Pipistrellus nathusii*, aggregating to the coastlines in the Northern Baltic Sea". *Acta Chiropterologica* 19 (1): 127–39. <https://doi.org/10.3161/15081109ACC2017.19.1.010>.

71 Ahlén, Ingemar, Hans J. Baagøe, and Lothar Bach. 2009. "Behavior of Scandinavian Bats during Migration and Foraging at Sea". *Journal of Mammalogy* 90 (6): 1318–23. <https://doi.org/10.1644/09-MAMM-S-223R.1>.

72 Rydell, Jens, Lothar Bach, Marie-Jo Dubourg-Savage, Martin Green, Luisa Rodrigues, and Anders Hedenström. 2010. "Bat Mortality at Wind Turbines in Northwestern Europe", December, 261–74.

73 Arnett, Edward B., Erin F. Baerwald, Fiona Mathews, Luisa Rodrigues, Armando Rodríguez-Durán, Jens Rydell, Rafael Villegas-Patracá, and Christian C. Voigt. 2016. "Impacts of Wind Energy Development on Bats: A Global Perspective". *Bats in the Anthropocene: Conservation of Bats in a Changing World*, edited by Christian C. Voigt and Tigga Kingston, 295–323. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-25220-9_11.

are too distant for bats to fly there to forage in summer, and better foraging areas are located on land and near the coast.

During autumn migration, bats traverse both the coast and the additional area offshore. The migration peak falls at roughly the same time in both cases – in the second half of August and early September. Records made in the Saare-Liivi additional area showed that bats are most common in the area from August until the end of September; individual animals may also be encountered in summer. Bats are most abundant at sea in late August and early September. Although no bats were encountered in the additional area in the first half of August, their occurrence there is likely, since bats were encountered in adjacent areas throughout August. Of the two recorders located in the additional area, only one recorded bats.

Bat migration and overall activity (relative abundance at a specific location) are strongly influenced by weather conditions, specifically by three parameters: wind speed, temperature and precipitation (Sander Lagerveld, Poerink, and Geelhoed 2021⁷⁴). Bats use calm or low-wind nights for migration and also for foraging, and as wind speed increases their flight activity declines. Several studies have found that most bat passes occur at wind speeds of 0 to 6 m/s (Sander Lagerveld *et al.* 2015⁷⁵; Behr *et al.* 2017⁷⁶). Similar results have been obtained in Estonia both on land (Suigusaar 2022⁷⁷; O. Kalda and Kalda 2022⁷⁸; 2018; R. Kalda and Kalda 2018⁷⁹) and at sea (Lutsar 2019⁸⁰). At higher wind speeds, only individual passes are recorded.

The results of the surveys carried out in the initial area and the additional area of the Saare-Liivi offshore wind farm showed that bats do not fly at sea in all weather conditions. Weather conditions with no precipitation and light winds were preferred; half of the records were made at times when the mean wind speed during the preceding hour was below 1.9 m/s, 75% of passes were recorded at wind speeds of up to 2.5 m/s, and 90% of passes were recorded at wind speeds of up to 4.6 m/s.

Bats migrate mainly when winds blow from easterly and southerly directions. When winds blew from westerly directions, bats did not migrate offshore. Night-time temperature does not affect migration.

In summary, the survey showed that bats occupy the additional area only seasonally and under certain weather conditions. Bat abundance recorded in the additional area was low, but the survey does not make it possible to estimate the proportion of animals flying at rotor height or the number of potential fatalities. This makes it possible to proceed on the basis of the survey results and avoid a significant adverse impact on bat populations. More specifically, the risk of bat mortality can be significantly reduced by regulating the operating mode of wind turbines during periods important for bats and when suitable migration conditions prevail. The impact of the Saare-Liivi additional area may potentially arise during operation of the wind farm, when the wind turbine blades are moving during the hours of darkness. A

74 Lagerveld, Sander, Bob Poerink, and Steve Geelhoed. 2021. "Offshore Occurrence of a Migratory Bat, *Pipistrellus nathusii*, Depends on Seasonality and Weather Conditions". *Animals* 11 (December): 3442. <https://doi.org/10.3390/ani11123442>.

75 Lagerveld, Sander, Bob Jonge Poerink, Pepijn de Vries, and Michaela Scholl. 2015. "Bat Activity at Offshore Wind Farms LUD and PAWP in 2015", 32.

76 Behr, Oliver, Robert Brinkmann, Klaus Hochradel, Jürgen Mages, Fränzi Korner-Nievergelt, Ivo Niermann, Michael Reich, Ralph Simon, Natalie Weber, and Martina Nagy. 2017. "Mitigating bat mortality with turbine-specific curtailment algorithms: A model based approach". *Wind Energy and Wildlife Interactions*, 135–60. Springer.

77 Suigusaar, Anette. 2022. "Bat migration dynamics and the factors affecting them in Kabli", May. <https://dspace.ttk.ee/handle/20.500.12863/4334>.

78 Kalda, Oliver, and Rauno Kalda. 2022. "Nasva bat survey". Tallinn, Tartu.

79 Kalda, Rauno, and Oliver Kalda. 2018. "Bat survey concerning the impact on bats of the P14, P15 and P16 wind farms proposed in Saarde Municipality".

80 Lutsar, Lauri 2019. "Bat survey at sea around Saaremaa from July to October 2018", 20.

wind turbine with stationary blades has no impact on bats. Therefore, the impact of the additional area during the construction and decommissioning period may also be regarded as not significant.

3.6.4. Environmental measures

MITIGATION MEASURES

The risk of bat mortality can be significantly reduced by setting the operating mode of wind turbines. To reduce the risk of bat mortality, the operation of wind turbines in the Saare-Liivi additional area must be restricted at least during the period from 1 August to 15 September, from sunset to sunrise, in the absence of precipitation when wind speed is below 5 m/s.

As part of the follow-up monitoring described in the following subsection, it is possible to reassess the need to restrict the operation of wind turbines in the additional area and to specify the temporal duration of the restrictions. The spatial extent of the restrictions can also be assessed on the basis of follow-up monitoring. On the basis of a sufficiently dense monitoring network, it is possible to determine whether there are areas within the additional area where the abundance of migrating bats is significantly lower and whether mitigation measures need to be applied to all wind turbines or are necessary only for some wind turbines.

If reliable technical solutions for the use of other types of mitigation measures become available in future, for example wind turbine shutdown mechanisms based on radar, infrared cameras or other sensors, these may also be applied instead of the above, in consultation with experts.

ENVIRONMENTAL MONITORING

Follow-up monitoring must be carried out in the additional area in the two years following commissioning of the wind farm. During the monitoring, the relative abundance of bats must be assessed and compared with the baseline survey data. It is recommended that recorders be installed in the same areas and that, where possible, wind turbine service platforms be used instead of temporary buoys.

When the additional area of the Saare-Liivi offshore wind farm is completed, the methodologies available by then for estimating the number of bat fatalities should be reviewed, and the best practices established by then should be followed.

3.6.5. Summary

The impact of the Saare-Liivi additional area may potentially arise during operation of the wind farm, when the wind turbine blades are moving during the hours of darkness. A wind turbine with stationary blades has no impact on bats. Therefore, the impact of the wind farm during the construction and decommissioning period may also be regarded as not significant.

The Saare-Liivi additional area is traversed by bat autumn migration. In spring, no bats were recorded in the additional area. Bats do not use the additional area as a foraging area during the summer period. In summer, individual bats pass through the additional area.

The potential impact of the wind farm on bats can be mitigated. The possible impact of the wind turbines on bats is mitigated by the fact that the planned wind turbines operate at higher wind speeds (the mean wind speed in the additional area is over 9 m/s), when bat flight activity is low or absent altogether. Wind

turbines start operating at a wind speed of around 3 m/s, but studies have found that most bat passes occur at wind speeds of 0 to 6 m/s. Migration therefore mostly takes place in relatively calm weather, when wind turbines are not operating or are operating at low rotational speeds, in which case the risk to bats is low. In addition, to mitigate the impact, this report specifies restrictions on wind turbine operation during the autumn migration period under suitable weather conditions.

Table 3.6-3 *Impact associated with the planned wind farm and its significance*

Associated consequence/impact	Impact significance	Need for the application of mitigation measures, final impact significance
Construction and decommissioning phase		
habitat loss	0	Measures are not required. Residual impact 0
Disturbance	0	Measures are not required. Residual impact 0
collision risk	0	Measures are not required. Residual impact 0
Operation phase		
collision risk	-/--	It is mandatory to restrict wind turbine operation at least during the period 1.08–15.09, from sunset to sunrise, in the absence of precipitation when wind speed is below 5 m/s. The effectiveness of the measure will be verified by follow-up monitoring. Residual impact: 0/–.

Scale of significant environmental impact used in the EIA report: - slight negative impact, -- significant negative impact, 0 - no impact, neutral, + slight positive impact, ++ significant positive impact

3.6.6. Cumulative impact

The western coast of Estonia and the Gulf of Riga can be regarded as one of the main migration routes traversed by populations of Nathusius' pipistrelle, the noctule bat and other migratory bat species occurring in Estonia and neighbouring areas (Gaultier et al. 2020). The risk of bat mortality increases as the number of wind turbines and the area of wind farms increase. Therefore, it is likely that, in the case of wind farms to be built in the Gulf of Riga, their impact will be cumulative and will depend on whether 1, 2 or more wind farms are built in the Gulf of Riga and nearby areas. To the south-east of the proposed Saare-Liivi initial and additional areas, the Liivi Bay offshore wind farm is under development (see Figure 2.4-1)⁸¹. The more wind turbines there are, the greater the impact on the population may be. For bats, the cumulative impact of mortality caused by wind farms is considered particularly significant, as bats are a group with low reproductive potential. Species inhabiting our region generally produce 1–2 offspring per year, and females do not breed every year; juvenile mortality in the first year of life is also naturally high (Russo 2024). (Offshore) wind farms add a new anthropogenic pressure factor to our region, the spatial extent of which is increasing over time (the number of additional wind farms is unknown). The new pressure factor may create a situation in which a reduction in annual population growth has a significant impact on their long-term persistence. The exact magnitude of the impact and the threshold from which the impact becomes intolerable are not known. Accordingly, the precautionary principle must be followed in the development of wind farms and the relevant mitigation measures must be applied; see Section 3.6.4.

⁸¹ <https://liivimeretuulepark.ee/projekti-info>

In the survey report produced for the area of the Liivi Bay offshore wind farm, “*Pre-construction bat survey of the Liivi Bay offshore wind farm; prepared by Elustik OÜ, 2023*”⁸², it is stated that the buoys LL_2, LL_3 and LL_4 located in the Gulf of Riga may be regarded as locations with above-average migratory bat abundance (Figure 3.6-5). At the peripheral buoys LL_1 and LL_5, migration activity was low. A total of 22, 20 and 16 passes were recorded at buoys LL_2, LL_3 and LL_4 respectively, which was considerably more than at the two buoys in the Saare-Liivi additional area, where 0 and 7 passes respectively were recorded.

The combined results of the surveys show that the Saare-Liivi initial and additional areas and the areas of the Liivi Bay offshore wind farm are traversed by autumn migration, and that at least Nathusius’ pipistrelle and the noctule bat may occur within the impact area of all proposed offshore wind farm projects. **Use of the additional area was lower than indicated by the data for the initial area and the central part of the Liivi Bay offshore wind farm**, therefore its additional contribution is likely to be smaller, but not zero.

Table 3.6-4. Importance of the Saare-Liivi initial and additional areas and the Liivi Bay offshore wind farm in the assessment of cumulative impacts*. The absolute numbers of records are not directly comparable due to differences in survey effort and technical differences, and do not represent the number of fatalities.

Survey area	Site-specific maritime surveillance	Main result	Relevance for cumulative assessment
Saare-Liivi initial area	5 buoys and 136 hours of ship-based surveys	23 buoy records and 18 passes during ship-based surveys; spring and autumn migration	Dataset for the Saare-Liivi initial area
Saare-Liivi additional area	2 buoys; no ship-based surveys were carried out	7 passes; mainly autumn migration; low use	The additional contribution is smaller compared with the initial area
Liivi Bay offshore wind farm	5 buoys and 114.3 hours of ship-based surveys	60 buoy records and 15 passes during ship-based surveys; higher activity in the central part	Likely an important part of the regional cumulative risk in the Gulf of Riga

Individual bat flight trajectories in the Gulf of Riga have not been tracked, and it is not known what proportion of the same migratory population or the same individuals may pass through several wind farm areas during a single migration night. Data are also lacking on the abundance of bats flying at rotor height, the size of the relevant migratory populations, and the individuals actually killed at offshore wind turbines. Therefore, it is not possible to calculate the aggregate number of fatalities across the projects or the proportion of the population that this represents.

Due to the low reproductive potential of migratory bats, even relatively low additional mortality may accumulate over a long period. For the Saare-Liivi initial and additional areas and the Liivi Bay offshore wind farm, the maximum total number of turbines may, depending on the alternative ultimately developed for the Liivi Bay offshore wind farm, reach 170–204 turbines. The number of turbines is not a direct prediction of the number of fatalities, but a greater number of turbines and greater spatial extent increase the potential for contact.

Without mitigation measures, the cumulative mortality risk of the above-mentioned wind farms proposed in the Gulf of Riga is assessed, in accordance with the precautionary principle, as minor to potentially significant negative.

⁸² Published <https://ivis.ttja.ee/modules/dokumendiregister/view/1008841> (accessed on 19.05.2026)

In the EIA for the Saare-Liivi initial area, the additional area and the Liivi Bay offshore wind farm alike, essentially the same principal measure is provided for: restricting wind turbine operation during autumn migration from sunset to sunrise under low wind speed conditions. According to the EIA report for the Liivi Bay offshore wind farm, no significant cumulative impact is expected if the measures are implemented. To substantiate this conclusion, the measures for the different projects must be technically comparable and cover the same high-risk migration nights.

3.6.7. Uncertainty/knowledge gaps

In the case of bats, there are knowledge gaps in the basic information concerning them, including the size of the Estonian population and species-specific distribution, for example their flight altitude in the Estonian marine area.

In the bat survey carried out in the Saare-Liivi additional area, the recorders attached to the buoys were located *approx.* 2 m above sea level. As ultrasound recorders are capable of detecting bats from several tens of metres up to a hundred metres away, it must be borne in mind when interpreting the results that we do not know whether bats were also flying above the microphones' detection range. However, the literature does contain indications that most bats at sea probably fly at relatively low altitude. For example, in a study conducted off the Belgian coast, bat abundance was assessed at the base of a wind turbine (16 m above sea level) and at the height of the turbine nacelle (92 m). During the study, only the presence of *Nathusius' pipistrelle* over the sea was established, and the number of passes at a height of 92 m was approximately 10% of that recorded at the base of the turbine (Brabant *et al.* 2020⁸³). Similar results have also been obtained from onshore wind farms. Ahlén *et al.* 2007 describe how bat flight altitudes in the vicinity of offshore wind turbines off the coast of southern Sweden were determined using radar and a handheld detector. The results showed that bats spent most of their flight time at heights of up to 40 m above sea level, but a small number of bats were also recorded at higher altitudes.

3.7. Seals

The impact of the Saare-Liivi offshore wind farm initial area and export cables on grey and ringed seals has been assessed in the EIA report for the initial area (and export cable area) that has been declared compliant. This chapter does not repeat in detail the general biology of seals, the description of haul-out sites in the Gulf of Riga, or the impacts of the initial area and export cables, but focuses on the specific impact of main alternative 3 for the additional area and on the cumulative impact of the Saare-Liivi initial and additional areas.

The assessment is based on the MTÜ Pro Mare report "Report on the seal survey for the Saare-Liivi wind farm" (2024), in Annex 3.7, and on Mirko Mustonen's applied passive acoustic study "Detection of grey seal presence from underwater sound recordings" (2024), available in Annex 3.8. The Pro Mare seal survey considers the initial area, the additional area and the export cable corridor together. The final seal survey analysed an extensive telemetry dataset collected in 1994–2023, which included both earlier ARGOS tags and GPS/GSM tags with high spatial and temporal resolution. According to the survey author, the existing multi-year dataset made it possible to assess use of the Saare-Liivi initial and additional areas and the export cable route on the basis of a larger sample and over a longer period than would have been possible using only individuals tagged during the survey period for the additional area. The methodology for seal

⁸³ Brabant, Robin, Yves Laurent, Bob Poerink, and Steven Degraer. 2020. "Activity and Behaviour of *Nathusius' Pipistrelle Pipistrellus nathusii* at Low and High Altitude in a North Sea Offshore Wind Farm". *Acta Chiropterologica* 21 (January): 341–48. <https://doi.org/10.3161/15081109ACC2019.21.2.009>.

mapping is described in more detail in Annex 3.7, and the data on the animals and tags used in the survey are provided in Annex 3.7, Annex I.

In the Estonian context, seals are the species most sensitive to sound, and therefore the assessment of underwater noise in relation to seals is based on the study “Assessment of the impact of underwater noise in the additional area of the Saare-Liivi wind farm, including cumulative impact assessment”; prepared by TalTech Structural and Fluid Mechanics Research Group, 2026 (hereinafter in this report: the underwater noise study, Taltech, 2026), Annex 3.1. This chapter provides an overview of the effects of underwater noise on seals during both the construction and operation phases of the proposed wind farm.

3.7.1. Consideration of alternatives

For the seal survey, the basis used as input was the spatial extent of the Saare-Liivi offshore wind farm additional area main alternative 2 as it had developed by the time the survey was prepared.

The modelling and assessment of underwater noise was based on two alternatives in terms of turbine capacity: 15 MW and 20 MW turbines. At the same time, these alternatives are assessed in combination with the turbines in the initial area: 80 turbines in the initial area + 50 turbines in the additional area. By the time this EIA report for the additional area was prepared, the number of turbines in the additional area had decreased to 40 (main alternative 3), and therefore the actual underwater noise is somewhat lower than that modelled. Of the technical alternatives, both the gravity-base foundation and the monopile foundation are under consideration (see Section 2.6.2). The underwater noise study considered drilling, vibratory pile driving and impact pile driving as methods for installing the monopile foundation.

3.7.2. Description of environmental status

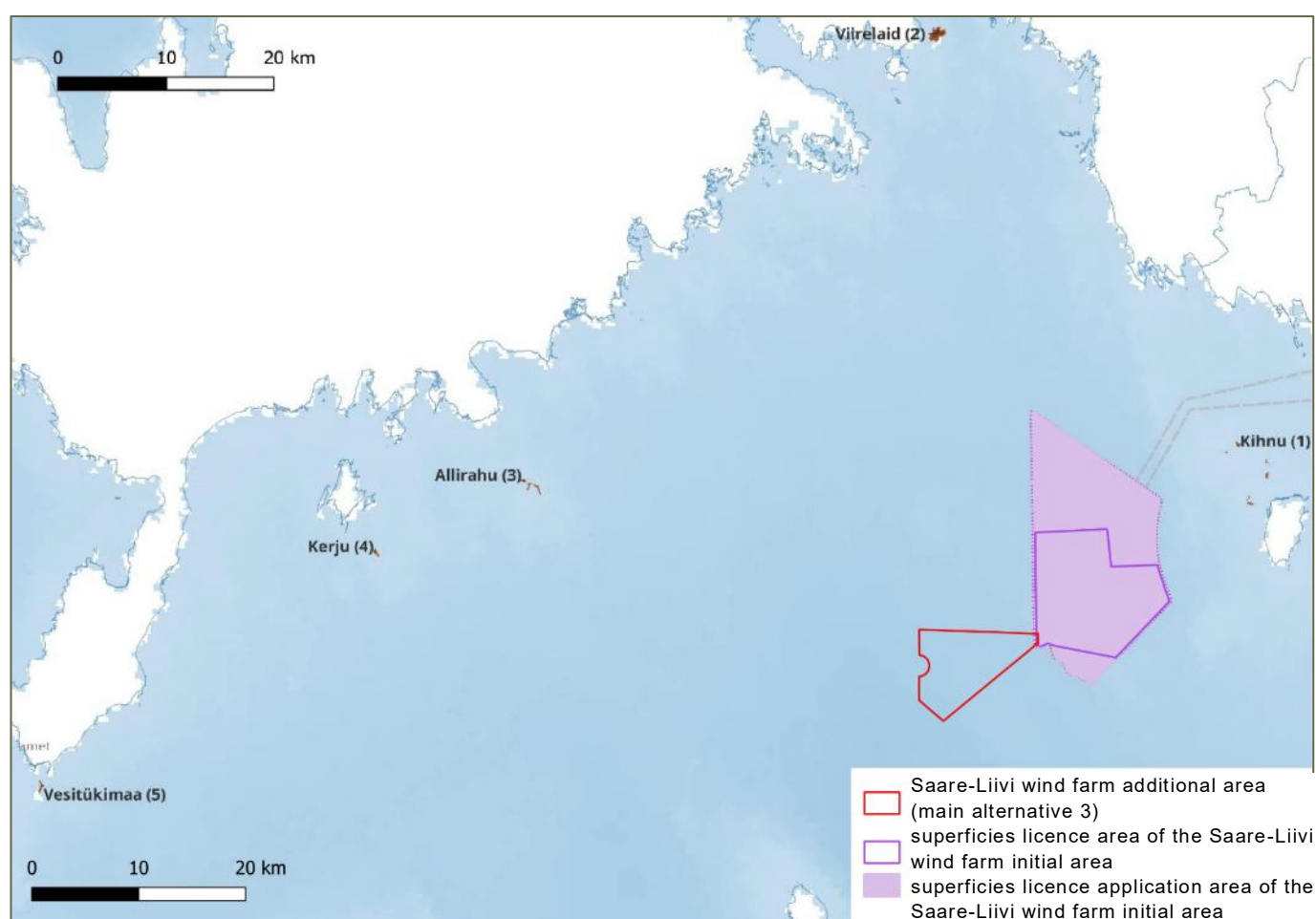
The Gulf of Riga is a semi-enclosed marine area permanently inhabited by two seal species: the grey seal (*Halichoerus grypus*) and the ringed seal (*Pusa hispida*). The bay is continuously inhabited by both grey and ringed seals, and key habitats are used for various biological functions.

Grey seal

The abundance of grey seals in the Gulf of Riga relative to the size of the marine area is the highest on the Estonian coast (Table 3.7-1). In the Gulf of Riga, grey seals have five haul-out sites that are permanently inhabited during the ice-free period (Figure 3.7-1), the nearest of which to the Saare-Liivi additional area is located more than 20 km away at Kihnu madalad. The maximum count there (119) was recorded during 2020 monitoring. At other times, animals can be seen there regularly, but their number on the rocks does not exceed 30 individuals, meaning that, in the context of the Gulf of Riga, this is the smallest haul-out site. The importance of this area in the Baltic Sea region lies mainly in the fact that it is the last resting place on the Estonian coast suitable for grey seals and may therefore be a necessary stopover site for so-called “long-trip” seals moving along the eastern coast of the Gulf of Riga.

Table 3.7-1. Abundance index calculated from grey seal abundance in the Gulf of Riga

Sea area	Count (2017–2021 mean and SD%)*	% of the count	Calculated area km ²	Seals/area (abundance index)
Gulf of Riga (east of Sõrve)	2997±24%	53.6	8040	0.37
Northern part of Väinameri and northern part of Hiiumaa (Osmussaar – Vormsi N – Ristna)	1229±23%	22.0	3690	0.33
Western coast of the islands (Ristna – Sõrve)	1221±22%	21.9	6300	0.1
Gulf of Finland (east of Osmussaar)	375±45%	6.7	8550	0.04

**Figure 3.7-1** Seal haul-out sites in the Gulf of Riga

Based on the count results (Annex 3.7. Annex II) it may be concluded that **grey seals in the Gulf of Riga account for approx. 10% of the entire Baltic Sea population, while they account for approximately half of the grey seals counted in Estonia, i.e. a significant proportion.** At the haul-out sites nearest to the Saare-Liivi initial and additional areas, a maximum of *approx.* 300 individuals can be counted, which in turn is one tenth of the Gulf of Riga population and *approx.* 5% of all Estonian grey seals. Given the

spatial location and the existing telemetry data, according to which only three (25%) out of 12 tagged grey seals associated with the Gulf of Riga used the Saare-Liivi initial and additional area (and the export cable route area) briefly, on a total of eight occasions (see Table 3.7-2), it may be concluded that the Saare-Liivi initial and additional areas and the export cable route area form part of the marine habitat of a quarter of the Gulf of Riga grey seals. If the proportion of tagged animals that moved in these areas is applied to the estimated size of the Gulf of Riga subpopulation, this amounts to *approx.* 700 animals. This constitutes *approx.* 14% of the total Estonian population and *approx.* 1.5% of the Baltic Sea population.

Table 3.7-2. Visits by grey seals to the Saare-Liivi initial and additional areas and the export cable

Grey seals																					
ID	Sex	Age	Start	End	Days tracked	Hours tracked (h)	In area						Location and type of visit	Total in areas		Park		Cable		Extension	
							Times	Park	Type	Cable	Type	Extension		Type	h	%	h	%	h	%	h
hg17-A	F	ad	28.07.2007	22.04.2008	269	6456	1	1	R				R	7,5	0,1	7,5	0,1				
hg17-B	F	ad	15.07.2007	31.03.2008	260	6340	4	2	2xR	2	2xR		R	4,5	0,1	3,5	0,1	1	0,02		
hg82-361	M	juv	12.07.2003	16.12.2003	157	3768	3	2	O;T			1	O	3,5	0,1	2,5	0,1	0,5	0,01	0,5	0,01
				Total	686	16464	8	5		2		1		15,5	0,09	13,5	0,08	0,5	0	0,5	0
				Mean	229	5488															

The grey seal is a typical seal species in the area of the Saare-Liivi initial and additional wind farm, and at sea it may be locally and temporarily common, but there are no large haul-out sites in that area where animals would congregate. **Anthropogenic changes associated with the construction and operation of the wind farm in the additional area do not significantly overlap with the areas used by the vast majority (75%) of Gulf of Riga grey seals**, and the impacts are even smaller at the scale of Estonia or the Baltic Sea. The low abundance at Kihnu Islets confirms that this is a haul-out site of minor importance.

The grey seals (n=12) whose movements in the Gulf of Riga were tracked by telemetry were captured mainly at Allirahu (n=9). One specimen was tagged at Vesitükimaa, one in Vilsandi National Park in western Saaremaa, and one at Klaipeda Sea Museum (Lithuania). The majority of tagged seals used the western part of the Gulf of Riga and other Baltic Sea areas for feeding; a total of 3 specimens were recorded visiting the proposed Saare-Liivi initial and additional areas and the export cable route corridor on eight occasions (Table 3.7-2). Of these, one specimen visited the additional area once for 0.5 h.

The recorded visits (8 in total, Saare-Liivi initial+additional+export cable route area) fell in the late autumn and winter period (November–March), when the animals are feeding to maintain energy reserves or are moving mainly in connection with the approaching breeding period, undertaking so-called “long-trip” searches.

Since grey seals move across a very large marine area and are abundant in the Gulf of Riga, they are likely to be common in the Saare-Liivi initial and additional areas during the ice-free period, **but this area is not particularly attractive to them as a habitat.**

Given the identified feeding-related movement patterns, the best feeding grounds are probably located closer to the large haul-out sites in the Gulf of Riga or over more heterogeneous seabeds. The distance from the grey seal haul-out site at Kihnu Islets suggests that the seals there may visit the initial and additional areas more frequently than others, but numerically they are a minority representing less than 5% of the seals in the Gulf of Riga. Seasonally, higher numbers of grey seals may be expected in the area during Baltic herring spawning in March–April, but their movements cannot be tracked at that time. At

the same time, it may be assumed that seals also prefer to catch Baltic herring where the fish are spawning or migrating in large numbers.

According to telemetry, only a small proportion of the tagged grey seals associated with the Gulf of Riga used the Saare-Liivi initial and additional areas and the export cable corridor, and the visits were of short duration. The additional area accounted for a very small share of the tracked marine use by grey seals. Therefore, the additional area is not a main resting or feeding ground for the grey seal.

As one part of the Saare-Liivi seal survey, an applied passive acoustic study (Mustonen, 2024) was carried out, in which underwater sound recordings collected at five measurement points located west of Kihnu were analysed. The aim of the study was to assess whether grey seal vocalisations can be detected using automatic sound detection and to use the results to describe seal presence and temporal activity.

Ringed seal

The current abundance of ringed seals is dangerously low in three of the four subpopulations. The Põhjalaht population probably exceeds the critical threshold of 10,000 individuals, whereas *approx.* 200 ringed seals can be found in the Gulf of Finland, *approx.* 150 in Ahvenameri and fewer than 1,000 on the west coast of Estonia. Monitoring results from the waters off the west coast of Estonia indicate a continued decline in population size, making the status of the ringed seal and its habitats one requiring close attention. What is happening in the Gulf of Riga directly concerns the West Estonian population, and its status is directly the responsibility of Estonia and Latvia.

In the Gulf of Riga, ringed seals have only two permanently inhabited haul-out sites: on the Kihnu Islets shallows and at the mouth of Suur Strait in the area of Viirelaid and Pühadekare. Kihnu madalad are located more than 20 km from the Saare-Liivi additional area (Figure 3.7-1, Kihnu (1)) and are currently used relatively little by ringed seals. The number of ringed seals counted or observed there usually does not exceed a couple of dozen individuals; the highest number recorded in monitoring was 34 animals in 2023. The Pühadekare area (Figure 3.7-1; Viirelaid (2)) is the last haul-out site before the Gulf of Riga, and both abundance and, apparently, turnover of individuals there are relatively high throughout the ice-free period. The maximum count of 134 individuals dates from 2020.

Of the 32 ringed seals tagged in Väinameri, 31 used the Gulf of Riga, and 28 individuals had contact with the Saare-Liivi initial area, additional area or export cable route corridor. In the high-resolution dataset, 19 of the 22 individuals had contact with the project components, **but the duration of all visits combined accounted for only 1.2% of the tracking time, and even for the individuals that used the area most, the time spent in the above-mentioned Saare-Liivi areas remained below 5% of their activity recorded in the Gulf of Riga.** Approximately 45% of all recorded contacts fell within the additional area as defined during the survey period, and it was used year-round mainly for transit. The additional area lies within the north–south movement corridor used by ringed seals for transit, but it is not their only or main feeding, resting or pupping area.

The vast majority of ringed seals migrate from their main resting areas in Väinameri to the Gulf of Riga, where, probably owing to the scarcity of suitable haul-out sites, they mostly live offshore, as during the ice-free period they are seen in low numbers at only two haul-out sites. According to year-round counts, abundance at the Kihnu haul-out site, which is the closest to the Saare-Liivi initial and additional areas, is currently relatively low. The majority of tagged individuals also did not haul out there. The maximum count and limited use indicate that **the importance of the Kihnu haul-out site as a resting area for Estonia's ringed seal population is small and it is used by only a minority of the population.**

At the same time, telemetry indicates that the ringed seal is a typical seal species in the area of the Saare-Liivi initial and additional areas, because a very large majority of the individuals tagged in Väinameri have visited this marine area. The ringed seal is known to be capable of successfully rearing its pup only on sea ice, so similarly to the grey seal, a seasonal increase in abundance due to aggregation in the area of the Saare-Liivi initial and additional areas or in Pärnu Bay is possible when ice forms there.

The Kihnu area has historically been rich in ringed seals, but recent counts show rather low numbers of ringed seals there: 20–40 individuals. The reason for the decline is unknown, but a likely explanation may be changes in the fish community, which have reduced the attractiveness of the area for ringed seals. At Viirelaid and Pühadekare, the abundance of animals is limited by the number of available rocks, usually remaining between *approx.* 40 and 100. There is clearly a high turnover there among animals migrating to the Gulf of Riga and Väinameri. The feeding strategy of ringed seals probably depends on the main prey species, and the feeding ground may shift seasonally depending on where the fish are located; the diet may likewise vary according to what is available in a given marine area. Trajectory analyses show a fairly high degree of individual specialisation in a particular strategy and/or in switching between them across the seasons.

1. More than half of the animals that fed in the bay (15 individuals, 68%) used the deeper part of the bay near the Latvian coast for this, probably feeding on the Baltic herring found there. If a seal starts moving from Väinameri and passes through Suur Strait without stopping, the journey is 200 kilometres long. Depending on the individual, there may have been up to ten such trips during the measurement period. Since these are regularly recurring patterns, they constitute (feeding) migrations (Figure 3.7-3).

All of the above marine-use patterns brought 90% of the tagged animals, to a greater or lesser extent, into the Saare-Liivi initial area, additional area and export cable route corridor. The number of contacts is very high and therefore it is necessary to assess the nature and duration of these contacts quantitatively. A distinction is made between low- and high-resolution data, because the methodology for their analysis differs depending on the resolution and combining them is not expedient. In general, they show the same distribution and lead to similar conclusions.

The study dataset shows that 19 (approximately 86%) of the 22 individuals equipped with GSM/GPS tags had contact with the Saare-Liivi offshore wind farm additional area (Table 3.7-3). A total of 87 unique visits were recorded in the additional area. Six of the 21 individuals associated with the Gulf of Riga, i.e. 28.6%, are more strongly associated than average with the areas (the Saare-Liivi initial area, additional area and export cable route area), which supports the finding from the lower-resolution material (30%). At the same time, the total duration of all visits accounts for only 1.2% of the total measured time, which is a very small proportion of the total duration of the tracking period. Feeding within the Saare-Liivi offshore wind farm area was also identified in the case of the three animals that spent the most time in these areas. At the same time, the average number of visits per animal is small, and the overall totals are dominated by the behaviour of three individuals. Based on the duration of visits, the impact of the initial area, additional area and export cable route areas on West Estonian ringed seals is **rather small in terms**

of the identified activities and, consequently, also for the population as a whole, although most tagged animals used this marine area.

No permanent ice pupping area has been identified within the Saare-Liivi additional area. However, under suitable ice conditions, both grey and ringed seals may use the ice fields in the Saare-Liivi

Table 3.7-3. Summary of visits by ringed seals equipped with high-resolution tags to the initial area (referred to in the table as: park), additional area (referred to in the table as: extension) and export cable route area (referred to in the table as: cable). Partial data from GPS tags affected by software malfunction.

Tracked animals and data range								Number, location and duration of visits (% of ind. time tracked)											
ID	Sex	Age	Start	End	Days tracked	Hours tracked (h)	Park			Cable			Extension			In areas			
							Times	h	%%	Times	h	%%	Times	h	%%	Times	h	%%	
1	hg31-10	F	ad	27.08.2011	12.03.2012	198	4752	11	217.5	4.6	4	3	0.06	12	21.5	0.45	27	242	5.09
2	hg31-09	F	subad	17.05.2011	26.02.2012	285	6840	13	133	1.9	2	5.5	0.08	11	95	1.39	26	233.5	3.41
3	hg31-01	F	ad	17.05.2011	13.02.2012	272	6528	5	51	0.8	3	5	0.08	13	24	0.37	21	80	1.23
4	hg31-04	M	ad	16.05.2011	14.11.2011	182	4368	1	3.5	0.1	14	21.5	0.49	1	1	0.02	16	26	0.6
5	hg31-06	M	juv	24.08.2011	16.01.2012	145	3480							5	33.5	0.96	10	52	1.49
6	hg31-07	M	ad	26.08.2011	11.12.2011	107	2568	3	35	1.4	1	0.5	0.02	6	23.5	0.92	10	59	2.3
7	hg22-P			22.05.2009	01.10.2009	132	3168	3	3	0.1				6	5.5	0.17	9	8.5	0.27
8	hg31-02	M	ad	25.08.2011	04.03.2012	192	4608	3	82.5	1.8	1	0.5	0.01	4	7.5	0.16	8	90.5	1.96
9	hg31-08b	M	juv	11.09.2011	04.02.2012	146	3504	3	19	0.5	3	0.5	0.01	2	5.5	0.16	8	25	0.71
10	hg22-K		ad	01.06.2009	19.10.2009	140	3360	2	14	0.4				5	9.5	0.28	7	23.5	0.7
11	hg31-03	M	ad	18.05.2011	28.02.2012	286	6864	3	18	0.3	2	2	0.03	2	1	0.01	7	21	0.31
12	hg31-13	M	ad	11.09.2011	16.10.2011	35	840	3	5	0.6	1	0.5	0.06	3	2.5	0.3	7	8	0.95
13	hg82-352	F	ad	23.05.2023	01.03.2024	283	6792	3	13	0.2	4	2.5	0.04		0		7	15.5	0.23
14	hg22-N			01.06.2009	13.01.2010	226	5424							5	5	0.09	6	5.5	0.1
15	hg31-14	F	ad	26.08.2011	02.10.2011	37	888	2	1	0.1				3	9	1.01	5	10	1.13
16	hg82-039	F	Ad	08.09.2023	01.02.2024	146	3504	1	22.5	0.6	4	4	0.11		0		5	26.5	0.76
17	hg17-C			31.08.2008	31.03.2009	212	5088	2	12	0.2				1	2	0.04	4	14	0.28
18	hg31-08a	M	juv	19.05.2011	11.09.2011	114	2736						0	3	5.5	0.2	3	5.5	0.2
19	hg31-11	F	ad	09.09.2011	21.10.2011	42	1008	1	0.5	0				2	3	0.3	3	3.5	0.35
20	hg31-12	F	ad	27.08.2011	10.10.2011	44	1056	1	4	0.4				1	2	0.19	2	6	0.57
21	hg31-15	M	ad	01.09.2011	24.02.2012	175	4200					0		1	1	0.02	1	1	0.02
Mean						162	3885	4	36		3	4		5	14		9	40.1	
Total						2880	76824	65	653	0.8	40	46	0.1	87	257.5	0.3	192	956.5	1.2

additional area for pupping. The location of any potential use depends on the extent, type, snow cover and drift of the ice cover in a particular winter and cannot be determined in advance as a permanent spatial area.

3.7.3. Impact assessment

The impact of associated human activity on seals may be considered both as direct and indirect disturbance, both in connection with the construction of the wind farm, i.e. construction activities, and after the construction of the wind farm, i.e. during operation. In addition, it is necessary to assess how the proposed additional area is situated and how it affects the use of the grey seal's important key habitats – haul-out sites, feeding grounds and the migration routes between them.

INDIRECT DISTURBANCE AND HABITAT FRAGMENTATION

Based on national and international monitoring and additional counts, it can be concluded that, according to the species-specific conservation management units defined at HELCOM level, 1.5% of all Baltic grey seals and 90% of West Estonian ringed seals are potentially associated with the Saare-Liivi initial and

additional areas and the export cable route corridor. A more restrictive assessment made for the Gulf of Riga as a semi-enclosed part of Estonia's marine area shows that 53% of Estonia's grey seals and 95% of Estonia's ringed seals are associated with the Gulf of Riga; based on abundance and telemetry, about a quarter of the Gulf of Riga grey seals and almost all ringed seals using the Gulf of Riga marine area are in direct contact with the Saare-Liivi initial area, additional area and export cable route corridor area.

The Gulf of Riga is an important marine area for both species, particularly in the context of Estonia's coastal waters, because resting, feeding and pupping areas of both seal species have been identified in the Gulf of Riga. Kihnu Sea and Pärnu Bay are inhabited year-round by seals of both species. They are probably most abundant during the spring spawning and migration period of Baltic herring and other fish species migrating en masse to spawning grounds, and in late autumn and winter, when ice forms.

Kihnu Islets Nature Reserve contains the nearest resting place (haul-out site) suitable for both species, which has the spatial and historical potential to hold considerably larger seal aggregations than can be counted there today (less than 10% of the seals counted in the Gulf of Riga and Väinameri). Only one of the 22 GPS-tagged ringed seals and one of the 13 grey seals (tag added in 2024) have demonstrably used this haul-out site for resting. Such "underuse" indicates the low attractiveness of the Kihnu Islets area, and probably also of the surrounding sea, as a habitat for seals; this may also be interpreted as the habitat's current low quality relative to other areas, because at first glance this area should have much greater capacity both in terms of resting places and food resources. Feeding grounds suitable for both species are located in the Saare-Liivi initial and additional areas and the export cable route area, or in their immediate vicinity, because many seals prefer submerged slopes and shoals to uniform soft bottoms owing to the greater abundance of prey species. Long autumn–winter feeding migrations to the vicinity of Kihnu are identifiable in both species – in grey seals mainly from the southern coast of Saaremaa and in ringed seals from Väinameri, whereas their areas of intensive summer feeding are in other parts of the sea – for ringed seals in the south-western and southern Gulf of Riga along the Latvian coast, and for grey seals near the main haul-out sites on the southern and western coasts of Saaremaa or elsewhere in the Baltic Sea.

Among the other important key functions, migration and feeding, and the overlap between them – searching behaviour – were identified for both species in the marine areas associated with the Saare-Liivi initial and additional areas and the export cable area. The grey seal dataset was too limited for behavioural analysis; these were rather incidental visits. In ringed seals, feeding accounted for *approx.* 70% within the wind farm areas, and the remaining time was split equally between migration and searching behaviour. At the same time, four of the 19 individuals that visited the Saare-Liivi offshore wind farm areas contributed more than average to feeding there, but even they spent less than 5% of their total feeding time in the Gulf of Riga in those areas. For the remaining individuals, time spent in the areas did not exceed 1% of the total. Thus, in the context of feeding or transit, the Saare-Liivi offshore wind farm area represents only a relatively small part of the Gulf of Riga as a whole.

Whereas seals were present in the Saare-Liivi initial area and export cable route area mainly from October to March, when their annual cycle is dominated by more sporadic feeding or the search for pupping sites and conspecifics, the additional area intersects the ringed seals' migration corridor, which they use throughout the ice-free period. Overall, the tagged animals were associated with the Saare-Liivi offshore wind farm areas (the initial and additional areas and the export cable area) for a very short time: less than 5% of the measured time (grey seals even less than 1%).

Consequently, despite the large size of the Saare-Liivi initial and additional areas and the export cable route area, and the potentially large number of animals visiting them in the Gulf of Riga marine system, this is rather a peripheral area with regard to seals' key biological functions: resting, feeding, breeding

and migration. Analysis of activities shows that the main activity areas of both species are nevertheless located in other parts of the Gulf or, in the case of ringed seals, also in Väinameri.

BARRIER EFFECT

The Saare-Liivi additional area does not contain a ringed seal haul-out site or a permanent main feeding or pupping area that is clearly delimited spatially. However, the additional area intersects the north–south movement belt of ringed seals and is used year-round primarily for transit.

The turbines do not constitute a physically impassable barrier for seals, and with inter-turbine distances of at least 1 km, movement both between the turbines and around the wind farm remains possible. At the same time, it is not known whether ringed seals will pass through an operating wind farm, move along its edge or partly avoid it. The potential impact therefore consists primarily of a longer travel route and additional energy expenditure. **Pending the results of follow-up monitoring, the impact is assessed as neutral to slightly negative. Therefore, in the final layout of turbines in the additional area, north–south passability of the area must be maintained: the spacing between turbines must not be smaller than the wind farm's standard inter-turbine spacing (approximately 1 km).**

ABOVE-WATER DISTURBANCE

A form of direct disturbance with serious consequences is also the transit of icebreakers across ice fields used by seals for pupping. This is not even a matter of disturbance, but a direct risk that seal pups may be crushed by the vessel or by the ice being broken (Wilson et al. 2017⁸⁴). The effects mentioned are more likely to arise during the operational period of the wind farm if, in more severe winters, ice fields occur within the wind farm area or on the routes of maintenance vessels and seals use them for pupping. Both seal species favour ice for pupping, with the ringed seal being an obligate ice breeder. Since ice forms in the Saare-Liivi offshore wind farm area (the initial and additional areas and the export cable) in average present-day winters and in harsher winters, the birth of pups of both species in this marine area cannot be ruled out. Ringed seals pup on ice in a very dispersed and concealed manner, whereas grey seals do so in groups and conspicuously. The formation of ice as a pupping platform and its extensive use by seals in the Saare-Liivi offshore wind farm area (including the initial and additional areas) is likely within a narrow range of ice scenarios.

In other cases, it is possible that there is too much ice, i.e. the ice field is generally so extensive that, by chance, a ringed seal may pup within the Saare-Liivi offshore wind farm area (including the initial and additional areas), or that there is so little ice that it does not extend to the Saare-Liivi offshore wind farm area and ice on which a ringed seal or a group of grey seals is pupping may drift into it from nearby.

The extent and persistence of ice are unpredictable in a warming climate, but when ice forms it is important during construction and maintenance works to take into account that pupping animals may be present there, so that their disturbance or injury can be avoided. If maintenance works are unavoidable during such more severe ice periods, an observation flight over the ice must be carried out to plan vessel movements, and the vessel must be directed past pupping seals.

In the event of exceptional disturbances, such as an oil spill risk, seals must be taken into account. For example, even in the case of an oil spill offshore, the odour spreads far (downwind), and the disturbance to animals with a keen sense of smell is not limited to the oil slick alone. This may mean temporal or spatial restrictions on the use of feeding areas, or a longer journey (additional energy expenditure)

⁸⁴ Wilson, S.C., Trukhanova, I., Dmitrieva, L., Dolgova, E., Crawford, I., Baimukanov, M., Baimukanov, T., Ismagambetov, B., Pazylbekov, M., Jüssi, M. and Goodman, S.J., 2017. Assessment of impacts and potential mitigation for icebreaking vessels transiting pupping areas of an ice-breeding seal. *Biological Conservation*, 214, pp.213-222.

between resting and feeding areas. The oil spill risk modelling carried out showed that, given the prevailing wind directions, an oil slick may reach the coast east of the wind farm (Section 3.3 and Figure 3.3-23), but the likelihood of this occurring is rather low (see Figure 3.3-24).

Possible direct impacts during operation arise primarily from the location of the turbines in the sea and from processes associated with their operation and maintenance that are perceptible to seals. As with ships, seals become accustomed to the physical presence of turbines (including cables) if these do not pose a direct threat.

UNDERWATER DISTURBANCE

Construction-phase disturbance of the seabed occurs during both the construction of foundations and the installation of cables, which may cause temporary suspended matter dispersion and a reduction in water transparency, but this is unlikely to affect seals directly, because underwater visibility in the Baltic Sea is generally limited and, underwater, the sense of vision is of little importance to seals. The suspended matter dispersion associated with construction activities is also short-term (see also Section 3.3).

Of underwater stimuli, noise is known to be the most important. High-intensity sounds that have a significant impact are predominantly associated with the installation of monopile foundations. During the construction phase, underwater impulsive noise is generated by pile drilling or pile driving in the construction of the wind farm, and during the operational period low-frequency continuous noise is emitted by the turbines into the water. The vibration of an operating wind farm, as an effect not reaching seals' sensory thresholds, has not been treated as disturbance and is generally not assessed.

UNDERWATER NOISE

Seals living in the Baltic Sea are sound-sensitive animals that use vocal communication both in air and in water. Today, marine animals are classified into hearing groups (Southall 2019⁸⁵), such that seals belong to the hearing group PCW (*phocid carnivores in water*). Based on the precautionary principle, the response level is considered to be 110 dB in the 500 Hz third-octave band.

When assessing anthropogenic impact, the important periods for seals during which mating and pupping occur must also be taken into account (see Annex 3.1, Table 2.1). During the mating period, seals vocalise extensively, and intense anthropogenic noise may disrupt the animals' communication by masking important signals. An important life-cycle period for seals is from February to April. A high masking risk is considered to occur when, in the 500 Hz third-octave band, anthropogenic sound exceeds the natural background by 20 dB, and a moderate risk at 16 dB.

In order to avoid significant environmental impact, the following criteria must be observed: during the operational period of the wind farm, the median sound level of anthropogenic continuous noise must not exceed the threshold values (response levels) given in Table 3.7-4 over more than 20% of the animals' habitat during life-cycle periods important to the animals, in accordance with the TG Noise recommendation (TG Noise 2022⁸⁶); and secondly, during the installation of monopile foundations, anthropogenic impulsive noise must be at a level that does not cause a permanent hearing threshold shift in seals (Table 3.7-5).

⁸⁵ Southall, B.L., Finneran, J.J., Reichmuth, C., Nachtigall, P.E., Ketten, D.R., Bowles, A.E., Ellison, W.T., Nowacek, D.P. and Tyack, P.L., 2019. Marine mammal noise exposure criteria: Updated scientific recommendations for residual hearing effects. *Aquatic Mammals*, 45(2), pp.125-232.

⁸⁶ Setting of EU Threshold Values for continuous underwater sound. Recommendations from the Technical Group on Underwater Noise (TG Noise). Deliverable 4 of the work programme of TG Noise 2022.

Table 3.7-4 *Threshold values for anthropogenic sound for sound-sensitive biota – continuous low-frequency noise*

Marine species	Third-octave band	Response level	Moderate masking risk	High masking risk	Reference
	Hz	dB re 1µPa			
		sound level	exceedance level		
Seals	500	110	16	20	(Kastelein <i>et al.</i> 2006)

Table 3.7-5 *Threshold values for anthropogenic sound for sound-sensitive biota – impulsive noise*

Marine species	Response level, SEL, dB re 1µPa² s (M)	Peak response level, SPL, dB re 1µPa	Temporary hearing threshold shift (TTS) SELcum, dB re 1µPa² s	Permanent hearing threshold shift (PTS)
Seals	171 ⁸⁷	212 ⁸⁷	170 dB SEL PCW-weighted ⁸⁷ or 165 dB SEL in the 500 Hz third-octave band	185 dB SEL PCW-weighted ⁸⁷ or 180 dB SEL in the 500 Hz third-octave band

Potential noise from both construction activities and operation has been modelled, taking into account both the initial and the additional area, and the results are presented in Section 2.8. The modelling considered four technical scenarios for turbine installation during the construction period: installation of a gravity base foundation (continuous noise), drilling of pile foundations, impact driving of pile foundations and vibratory driving of pile foundations (impulsive noise).

The modelling results showed that, during the construction period, the foundation construction scenario with the lowest environmental impact in terms of emitted sound is the use of a gravity base foundation, followed by drilling of pile foundations. During vibratory and impact driving of pile foundations, it is likely that seals within the hazard zone may experience a temporary or permanent hearing threshold shift during construction works. Mitigation measures allow the risk of permanent hearing threshold shift to be significantly reduced, and the impact on seals can then be considered a minor negative impact (see Table 3.7-6).

Table 3.7-6 *Summary table of the modelling results for impulsive noise emitted during the construction period and the environmental impact assessment based on those modelling results*

Parameter/indicator	Alternative 0	Construction period, 12 m/18 m diameter piles		
		Vibratory driving	Drilling	Impact driving
Temporary hearing threshold shift in seals, hazard zone radius, m	0	2200/3200	30/40	650/2000
Permanent hearing threshold shift in seals, hazard zone radius, m	0	180/350	0/0	50/150
Overall assessment for seals	0	Minor negative impact*	Minor negative impact	Minor negative impact*

* when mitigation measures are implemented, the impact is insignificant

⁸⁷ Southall, B.L., Finneran, J.J., Reichmuth, C., Nachtigall, P.E., Ketten, D.R., Bowles, A.E., Ellison, W.T., Nowacek, D.P. and Tyack, P.L., 2019. Marine mammal noise exposure criteria: Updated scientific recommendations for residual hearing effects. *Aquatic Mammals*, 45(2), pp.125-232.

In the Saare-Liivi initial area with 80 turbines and the additional area with 50 turbines operational noise modelling scenario, the 110 dB response level for seals was exceeded over approximately 8% in the case of 15 MW turbines and approximately 12% in the case of 20 MW turbines of the 3930 km² assessment area used in the underwater noise study, which includes the territory of the wind farm's initial and additional areas and adjacent parts of the Gulf of Riga (see Annex 3.1, Figure 4.1). The standalone contribution of the initial area was approximately 4% and 8%, respectively. The addition of the additional area does not significantly increase the sound level at individual points in the initial area, but it expands the spatial extent of the sound field exceeding the response level. In both cases, the exceedance area remains below the 20% spatial screening criterion used in the study, and therefore no significant negative operational impact on seals is predicted. Under main alternative 3, up to 40 turbines will be installed in the additional area, and therefore the actual impact area is expected to be somewhat smaller, but this has not been modelled separately.

The main risk affecting seals is the construction-phase underwater noise associated with pile driving. Also in the study by Russell et al. (2016), harbour seals' avoidance of the wind farm was associated primarily with pile driving. According to the present assessment, no significant impact during operation is predicted, but the forecast regarding seals' movements and spatial use will be verified through follow-up monitoring in accordance with Section 3.7.4.

3.7.4. Environmental measures

MITIGATION MEASURES

Underwater noise mitigation measures are relevant for the use of impact driving and vibratory driving and are aimed at preventing permanent hearing damage in marine mammals, since temporary hearing damage cannot in practice be avoided. To mitigate the impact of impulsive noise, several combined measures must be implemented to reduce possible negative impacts on seals:

- A gradual start to driving (*soft start*), in which a maximum of 20% of the impact energy is used during the first 30–45 minutes, allowing animals to leave the area. During the soft-start period, animals can move to a safe distance.
- Use of bubble curtains during driving works to attenuate underwater noise. This is an evidence-based technical measure that has been used successfully in many international projects.
- Use of acoustic deterrent devices (including ADD – *Acoustic Deterrent Device*) before the start of driving works, in order to direct animals to a safe distance. Use is required primarily during the period from July to January.

Another way to avoid noise of a harmful nature for seals offshore is to choose times for noise-generating activities when most seals are out of the water due to annual pupping or moulting. Moulting involves all animals older than one year. At these times – in February–March and May–June – the great majority of seals are associated with land or ice, and the likelihood that they will be present in large numbers in the work area is very significantly lower than, for example, during the active feeding period in summer. Such scheduling of works is a recommended additional measure and does not replace the mandatory underwater noise mitigation measures.

When designing the final layout of the turbines, the functional permeability of ringed seals' north–south movement corridor must be maintained: the spacing between turbines must not be less than the wind farm's standard inter-turbine spacing (approximately 1 km).

If pile-driving works at other offshore wind farms in the area may overlap in time with works in the additional area, cumulative underwater noise must be assessed on the basis of the available schedule information and, if necessary, the timing of works in the additional area or the noise mitigation measures must be adjusted (see Sections 2.8.4 and 7.5).

To avoid disturbing pupping seals, if ice formation in the wind farm area is likely and some activities, e.g. maintenance works, are unavoidable, an observation flight over the ice can be carried out in order to plan vessel movements. Pupping grey seals are fairly clearly visible from an aircraft or drone, because they are grouped together on the ice. Ringed seals are somewhat more difficult to detect, because they pup in snow lairs, but the lair area can be identified on the basis of adult animals, breathing holes or signs of activity. The use of an observer also helps to steer the vessel past pupping seals. Once formed, the pupping group remains in the same place on the ice for about a month to a month and a half. Ice drift can be taken into account, since it is very likely to be a factor that is also monitored for the mitigation of technical risks.

ENVIRONMENTAL MONITORING

A seal monitoring and adaptive management plan must be prepared for the additional area. The methodologies and scope of environmental monitoring will be determined before the start of construction and operation of the wind farm.

Before the start of construction works, underwater ambient noise must be measured at a time when no construction works are taking place, in order to verify the modelling results.

Follow-up monitoring must include at least:

- construction-phase seal observations and underwater noise measurements;
- operational passive acoustic monitoring together with simultaneous measurement of underwater noise;
- repetition of ringed and grey seal telemetry following commissioning of the wind farm;
- analysis of ringed seals' movement routes and their passage through or avoidance of the wind farm;
- observations of pupping seals in the event of ice formation, and monitoring of the impact of maintenance vessel traffic.

Passive acoustic monitoring of seals must be designed such that at least some of the measurement points are located within the additional area under main alternative 3 or within its immediate impact area. There is no reason to automatically repeat the measurement point locations from Mustonen's pilot study (2024) unchanged in the follow-up monitoring.

3.7.5. Assessment of alternatives and summary

The additional area is not a primary resting, feeding or permanent pupping area for either grey seals or ringed seals. The area is of little importance for grey seals. For ringed seals, however, the additional area overlaps with a north–south movement corridor used year-round.

From the perspective of seals, the underwater noise from installation of gravity base foundations and drilling of pile foundations has a lesser impact than the impulsive noise from impact or vibratory driving of piles. In the case of impact or vibratory driving, without measures there may be a risk of temporary or permanent hearing threshold shift, and therefore the impact before measures is assessed as significant

negative (—). With the implementation of the combined noise mitigation measures under section 3.7.4 (soft start, bubble curtain, acoustic deterrent devices) and construction-phase noise measurement and seal observation, the construction-phase residual impact is assessed as neutral to minor negative (0/-).

With a permeable layout of the wind farm and follow-up monitoring, the operational residual impact on the ringed seal movement corridor is assessed as neutral to minor negative (0/-).

The impacts associated with operational continuous noise and pupping on ice are likewise assessed as neutral to minor negative (0/-).

With mitigation measures implemented, no significant adverse impact on grey seal or ringed seal populations is anticipated.

Table 3.7-7. Impacts associated with the planned wind farm and their significance

Associated consequence/impact	Impact significance	Need for the application of mitigation measures, final impact significance
Wind farm construction and decommissioning	0/-	Measures depending on the foundation type are set out below on a row-by-row basis and in Section 3.7.4. Residual impact 0/-
Gravity base foundation		
Noise	0	No measures are required. Residual impact 0
Monopile foundation - vibratory driving		
Noise	--	Mitigable Residual impact: 0/-
Monopile foundation – drilling		
Noise	0/-	Use of deterrent devices and seasonal work organisation (Section 3.7.4). Residual impact 0/-
Monopile foundation - impact driving		
Noise	--	Mitigable Residual impact: 0/-
Wind farm operation		
Migration barrier	-	Mitigable Residual impact 0/-
Technological variant 1 - 15 MW wind turbine		
Noise	0/-	Operational monitoring with underwater noise measurement (section 3.7.4). Residual impact 0/-
Technological variant 2 - 20 MW wind turbine		
Noise	0/-	Operational monitoring with underwater noise measurement (section 3.7.4). Residual impact 0/-

Scale of significant environmental impact used in the EIA report: - slight negative impact, -- significant negative impact, 0 - no impact, neutral, + slight positive impact, ++ significant positive impact

3.7.6. Cumulative impact

When assessing the cumulative impact on seals, the cumulative impact of the Saare-Liivi initial and additional areas is considered first, followed by an assessment of the potential in-combination effect with the Liivi Bay offshore wind farm. All the above-mentioned projects are located in the same ecological

system of the Gulf of Riga and may affect the same grey seal and ringed seal conservation management units.

Compared with the initial area alone, the Saare-Liivi additional area increases the spatial extent and overlaps with the north–south movement corridor of ringed seals. The addition of the additional area does not, however, close off the only unavoidable migration corridor, and an extensive open marine area remains between and around the turbines for the movement of seals. The actual cumulative barrier effect depends on whether ringed seals pass through operating wind farms or begin to partially avoid them; this cannot be reliably predicted under pre-construction conditions. It is important to maintain north–south functional permeability for ringed seals.

The existing telemetry data do not indicate that the Saare-Liivi initial and additional areas and the Liivi Bay offshore wind farm together form a physically uninterrupted barrier between the main feeding areas of the Väinameri and the Gulf of Riga. At the same time, the same individuals may, within a single movement period, be exposed to the impact area of all the offshore wind farms mentioned, and sequential avoidance may increase energy expenditure. Therefore, the operational cumulative barrier effect is assessed as neutral to minor negative.

For construction-phase impact, a significant cumulative risk may arise if impact or vibratory driving of monopile foundations takes place simultaneously, or with only a short interval between them, in the Saare-Liivi initial and additional areas and at the Liivi Bay offshore wind farm. In such a case, the instantaneous sound field, the extent of the disturbed marine area, and the length of time during which seals have restricted access to their usual movement or feeding areas may all increase. If these works overlap in time, the developer of the additional area must, on the basis of the available schedule information, assess cumulative noise and adjust the timing of high-noise works in the additional area or the mitigation measures.

The cumulative impact, in the context of underwater noise, of the Saare-Liivi initial and additional areas proposed for the Gulf of Riga and of the Liivi Bay offshore wind farm is assessed in more detail in Section 2.8. In summary, it has been concluded that the radiated sound level during gravity base foundation installation is relatively low both when a single foundation is installed and when several foundations are installed simultaneously (comparable to the noise of a medium-sized vessel), and the associated construction-phase impacts do not accumulate. In the case of impact or vibratory pile driving, the developer of the additional area must ensure that all necessary mitigation measures are implemented to prevent the occurrence of an impermissibly high impulsive noise level and its propagation into the areas of other wind farms. With the implementation of mitigation measures, it can be ensured that no cumulative impact associated with construction activities occurs. During the operational period of the wind farms, each wind farm generates continuous noise within the boundaries of its area, and neighbouring wind farms do not in practice increase the ambient noise level.

3.7.7. Uncertainty and knowledge gaps

The main uncertainty in the assessment of impacts on seals arises from the fact that telemetry data were collected in different years, using tags with different technical resolution, and prior to the construction of offshore wind farms. The behaviour of tagged animals may not fully describe the entire population, and, particularly in the case of the grey seal, the number of individuals that came into contact with the Saare-Liivi initial area, the additional area and the export cable route area was small.

There is as yet no empirical experience in the Baltic Sea of a large-scale offshore wind farm in an area where grey seals and ringed seals co-occur. Therefore, it is not known whether ringed seals pass through an operating wind farm, use the corridors between turbines, or begin to avoid the wind farm.

The impact of pupping on ice depends on the ice and snow conditions in the particular winter and cannot be predicted as a permanent spatial impact area. These uncertainties must be reduced by means of construction-phase and operational monitoring of noise, acoustics, telemetry and ice covering the Saare-Liivi additional area.

3.8. Fish fauna

This chapter is based primarily on the EIA baseline study “Impact on fish fauna of the Saare-Liivi initial and additional offshore wind farm area and the cable route area”, UT Estonian Marine Institute, 2026 (hereinafter: the fish survey), which can be found in Appendix 3.9. The study considers the initial and additional areas together.

The impact on fish fauna of the Saare-Liivi offshore wind farm initial area and the export cable corridor has been assessed in the EIA report for the initial area (and export cable corridor), which has been found compliant with the requirements. These impacts are not repeated in detail in this chapter; instead, the focus is on the impact of main alternative 3 of the additional area and on the cumulative impact of the Saare-Liivi initial and additional areas. The treatment of the initial area is repeated only to the extent necessary for assessing the cumulative impact of the initial and additional areas and the additional input.

In assessing the impact of underwater noise on the fish fauna of the additional area, reliance is placed on TalTech's study “Assessment of the impact of underwater noise in the additional area of the Saare-Liivi wind farm, including assessment of cumulative impacts” (TalTech, 2024, updated 2026; Appendix 3.1). In 2025, an experimental study was completed on the effect on Baltic herring of low-frequency continuous noise similar to wind turbine operational noise⁸⁸. That study is used in this chapter as additional specialist input in assessing both the operational noise and the cumulative impact of the additional area.

3.8.1. Consideration of alternatives

The fish fauna baseline study covered the initial area of the Saare-Liivi offshore wind farm, the approximately 91.2 km² spatial extent of the additional area at the time the study was carried out, and the export cable corridor study area. In the additional area, monitoring catches were carried out at 24 sampling points in 2023. Main alternative 3 of the additional area, covering 57.1 km² and forming the basis for the impact assessment, lies entirely within the surveyed area. Therefore, the survey results are spatially sufficient for assessing the fish community, the functions of the area and possible spawning grounds of main alternative 3 of the additional area.

The exact number of turbines does not affect the conclusions drawn on the basis of the baseline study regarding the existing fish community of the additional area or the occurrence of spawning grounds. However, the number of turbines and the technical solution affect the duration of construction works, the size of the physical footprint on the seabed, and the spatial extent of underwater noise during construction and operation, and these factors are taken into account separately in the impact assessment. Since an area-based approach was used in the baseline study, and the area and number of turbines of

⁸⁸ Rohtla, M.; Klauson, A.; Švirgsden, R.; Sepp, E.; Mustonen, M.; Paris, K.; Eschbaum, R.; Vetemaa, M. 2025. *Experimental study of the effect of noise on pelagic fish. Final report. University of Tartu.*

main alternative 3 are smaller than those considered in the study, the impact assessment based on the extent of the study area is rather conservative and may overestimate the actual impact.

In the modelling of operational underwater noise, a scenario with 80 turbines in the Saare-Liivi initial area and 50 turbines in the additional area was considered, as well as technical variants with 15 MW and 20 MW turbines. In fact, under main alternative 3 of the additional area, up to 40 turbines will be constructed. Therefore, the modelling result with 80 + 50 turbines is overestimated in relation to main alternative 3 of the additional area in terms of the number of turbines.

3.8.2. Description of environmental status

FISH COMMUNITIES IN THE STUDY AREA

The fish survey in the Saare-Liivi offshore wind farm initial and additional areas was carried out in 2022–2023 (in the additional area, sampling points Nos 81–104 in Figure 3.8-1). The first survey period was in spring, from April to June, when the seawater warms and spawning and spawning migration of most fish species take place. The second survey period covered the summer months of July and August, when the spawning migration of fish has ended and so-called resident fish fauna is present.

A total of 63524 fish with a total mass of 2765.7 kg were caught from the Saare-Liivi initial and additional areas in 2022–2023. The fish fauna in the area was diverse and included marine species, brackish-water estuarine species, diadromous fish and freshwater species. The occurrence of a total of 29 fish species was recorded during the survey.

Fish communities in the initial and additional areas

In the fish fauna of the initial and additional areas, Baltic herring dominated in terms of abundance, accounting for 58.3% of the total number of all fish caught. Smelt also accounted for a very substantial share (17.0%). Of the remaining species, sea scorpion (8.1 %), round goby (5.6 %), flounder (3.6 %), eelpout (2.8 %) and sprat (1.2%) were more abundant in the monitoring catches. Baltic herring was also the most important fish species in the initial and additional area in terms of biomass, accounting for 31.1% of the total mass of all fish caught. The next most important species in the monitoring catch by share were sea scorpion (30.9%) and smelt (10.8%).

The additional area lies predominantly within the medium (21–30 m) and deep (31–40 m) depth zones distinguished in the survey. In these depth zones, the 2023 monitoring catches were generally dominated by Baltic herring, and the more abundant species caught also included smelt and sea scorpion and, in the medium depth zone in summer, flounder.

When assessing the standalone impact of the additional area, the functions of the additional area are more important than the overall species composition. No significant fish spawning grounds were identified in the additional area. No spawning grounds of spring-spawning Baltic herring were identified there and, due to the great water depth of the area, it is not a potentially suitable spawning ground for spring-spawning Baltic herring. There are likewise no potential spawning grounds of autumn-spawning Baltic herring in the additional area; these are located in the initial area. The occurrence of sea whitefish spawning grounds was not confirmed, and no significant spawning grounds of Baltic flounder were identified either. Nevertheless, the additional area is used as a feeding and movement area by fish, and the eastern edge of the additional area is crossed by part of the spawning migration of spring-spawning Baltic herring.

area for autumn-spawning Baltic herring, as well as the construction-phase measures established for it, are addressed in the EIA report for the Saare-Liivi initial area (and in the superficies licence).

The additional area was not included in the study area of the 2022 comprehensive survey of autumn-spawning Baltic herring, and it was not considered necessary to extend the study area to include it, since the survey carried out covers the areas potentially important for autumn-spawning Baltic herring more broadly in the region. **There are no potential spawning grounds of autumn-spawning Baltic herring within the additional area: water depths there exceed 20 metres, and there are no shoals or steep coastal slopes suitable for autumn-spawning Baltic herring.** Therefore, the importance of the additional area for autumn-spawning Baltic herring may be considered minor, and accordingly there is no need in this EIA for a more detailed assessment of autumn-spawning Baltic herring.

3.8.3. Impact assessment

The impacts on fish associated with wind farm development can be divided into construction-phase, operational and decommissioning-phase impacts. Operational and physical impacts are associated with the areas occupied by turbines and cables, and during the operational phase of the turbines, turbine operating noise and the electromagnetic fields of subsea cables affect the fish fauna. It is important to ensure that wind farms are not planned in important spawning grounds or important migration corridors, where they could constitute a potential barrier to migration. According to current knowledge, the largest potentially negative impacts on fish fauna from offshore wind farms planned in Estonia's coastal marine waters are likely to arise from construction and decommissioning activities (in this EIA report, construction-phase impacts are considered equivalent to decommissioning-phase impacts). Construction works may cause an adverse impact on fish through construction noise and suspended matter generated by earthworks. The extent of disturbances arising during construction activities depends on the nature of the structures being built—for example, more suspended matter is released into the water column in the case of gravity base foundations than during monopile foundation construction (see Section 3.3), whereas noise disturbance is stronger during monopile foundation installation. Fish responses to disturbance differ both between species and between individuals, depending, for example, on the condition of the individual—fish ready to spawn may be more sensitive to environmental disturbances (Popper et al. 2014⁸⁹).

In certain circumstances, offshore wind farm development may even have a positive effect on fish abundance, because turbine foundations and towers (including substations) add hard substrate to the seabed, which often has a local fish-aggregating and/or production-enhancing effect⁹⁰. At the same time, it is not yet known precisely what indirect effects this has on the fish fauna as a whole and, consequently, on the entire marine ecosystem.

IMPACT ON MIGRATING FISH

In the course of the transboundary consultation of the EIA for the initial area of the Saare-Liivi offshore wind farm, the need was raised to address separately the impact of the wind farm on migrating fish. In this EIA, the assessment of migration-related impacts is based on the results of the fish survey, which, in addition to standard fish community monitoring catches, also included a hydroacoustic study of spring-

⁸⁹ Popper, A. N., Hawkins, A. D., Fay, R. R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W. T., Gentry, R., Halvorsen, M. B., Løkkeborg, S., Rogers, P., Southall, B. L., Zeddis, D. & Tavalga, W. N. (2014). *Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by SpringerBriefs ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. ASA S3/SC1.4 TR-2014, in Oceanography, Springer International Publishing, and ASA Press, Cham, Switzerland, pp. 1-76.*

⁹⁰ [Possible impacts of offshore wind farms planned in Estonia on Baltic Sea fish](#) (University of Tartu, 2020)

spawning Baltic herring and a comprehensive survey addressing the spatio-temporal distribution of the spawning stock and larvae of autumn-spawning Baltic herring.

Based on the survey results, Baltic herring is the species of primary importance in assessing migration-related impacts of the proposed activity. Part of the spawning migration of spring-spawning Baltic herring crosses the eastern edge of the additional area, but no spawning grounds of spring-spawning Baltic herring were identified in the additional area, and the conditions in the area are not suitable for the occurrence of significant spawning grounds of autumn-spawning Baltic herring. According to the fish survey, underwater noise and suspended matter dispersion associated with wind farm construction works may disturb the spawning migration of Baltic herring, which is why temporal restrictions have been established to protect the spawning migration of spring-spawning Baltic herring.

In the experiments of the experimental noise study (Rohtla et al. 2025⁹¹), no statistically significant effect of operating noise was identified on Baltic herring during spawning migration or while spawning. Based on the study, the effect of turbine operating noise on the spawning migration of Baltic herring may be considered biologically insignificant, and it does not affect the movement of Baltic herring to spawning grounds. According to the survey, salmon and sea trout, and in spring also garfish, may pass through the area (including the additional area) during migration. During the fish survey, salmon, river lamprey and garfish were caught in gillnet catches covering the initial and additional areas, and sea trout in the export cable corridor study area. These species were caught only as individual specimens or in small numbers. The survey results do not indicate that the additional area is important as a significant or concentrated migration corridor for these species, although the movement of individual specimens through the area cannot be ruled out.

Accordingly, avoiding construction-phase underwater noise and suspended matter dispersion during the sensitive migration period of spring-spawning Baltic herring is central to reducing impacts on migrating fish. Based on the survey results, appropriate mitigation measures have been established for the sensitive period and areas (see Table 7.2-1). The effect of operational noise on the spawning migration of Baltic herring has been assessed as biologically insignificant, and any possible effect on the distribution of Baltic herring in feeding areas as local and minor.

IMPACT ON SPRING-SPAWNING BALTIC HERRING

Based on the spring Baltic herring migration survey carried out over two consecutive years, it may be stated that the spring migration of Baltic herring to spawning grounds does not pass through the Saare-Liivi initial and additional areas to any great extent every year; rather, the area may be a post-spawning feeding ground for Baltic herring. Experiments carried out in the experimental noise study also did not identify any statistically significant effect of operational noise on Baltic herring during spawning migration or while spawning, and turbine operating noise may be considered biologically insignificant (Rohtla et al. 2025).

However, the results of the experiments carried out in the experimental noise study showed that low-frequency continuous noise has a statistically significant effect on the spatial distribution and abundance of Baltic herring in feeding grounds. Under noise conditions, the relative abundance of Baltic herring was lower near the sound source and increased with distance (Rohtla et al. 2025⁹¹). However, avoidance behaviour by Baltic herring caused by low-frequency noise has an effect only on a relatively local spatial scale. The effect on Baltic herring abundance was observed at approximately 300–800 m from the sound source, but not all individuals left even this affected area. The result indicates possible avoidance behaviour, not complete abandonment of the feeding ground. The results of the experimental noise study

⁹¹ Rohtla, M., Klauson, A., Svirksden R., Sepp E., Mustonen, M., Paris, K., Eschbaum, R., Vetemaa, M. [Experimental study of the impact of noise on pelagic fish. Final report.](#) University of Tartu, 2025.

also indicate that, owing to Baltic herring avoidance behaviour in response to noise in feeding grounds, offshore wind farms do not create extensive concentrations of Baltic herring, which in turn reduces the likelihood that wind farms could function as areas in which Baltic herring would be less likely to be taken by trawl fisheries. Accordingly, it cannot be assumed that wind farm development would, through the aggregation of fish, reduce yields in the fishing areas remaining available to the fisheries sector.

Data collected during the hydroacoustic study showed that the spring migration of Baltic herring towards spawning grounds took place mainly outside the initial area of the wind farm and across the eastern edge of the additional area. The timing of Baltic herring migration may vary depending on weather conditions; therefore, construction works must be avoided in the parts of the additional area shown in Figure 3.8-4 in March and April in spring, when construction noise and suspended matter may disturb the spawning migration of Baltic herring. The figure also shows the restrictions in the initial area of the wind farm, but these are addressed in the EIA report for the initial area (and in the superficies licence). If follow-up monitoring during turbine operation shows that the migration of Baltic herring towards spawning grounds is nevertheless significantly hindered, turbine operation must be temporarily suspended during the active Baltic herring migration period. The need to implement the measure and the details thereof shall be determined on the basis of the results of follow-up monitoring, and the measure shall, where necessary, be provided for in the follow-up monitoring report.

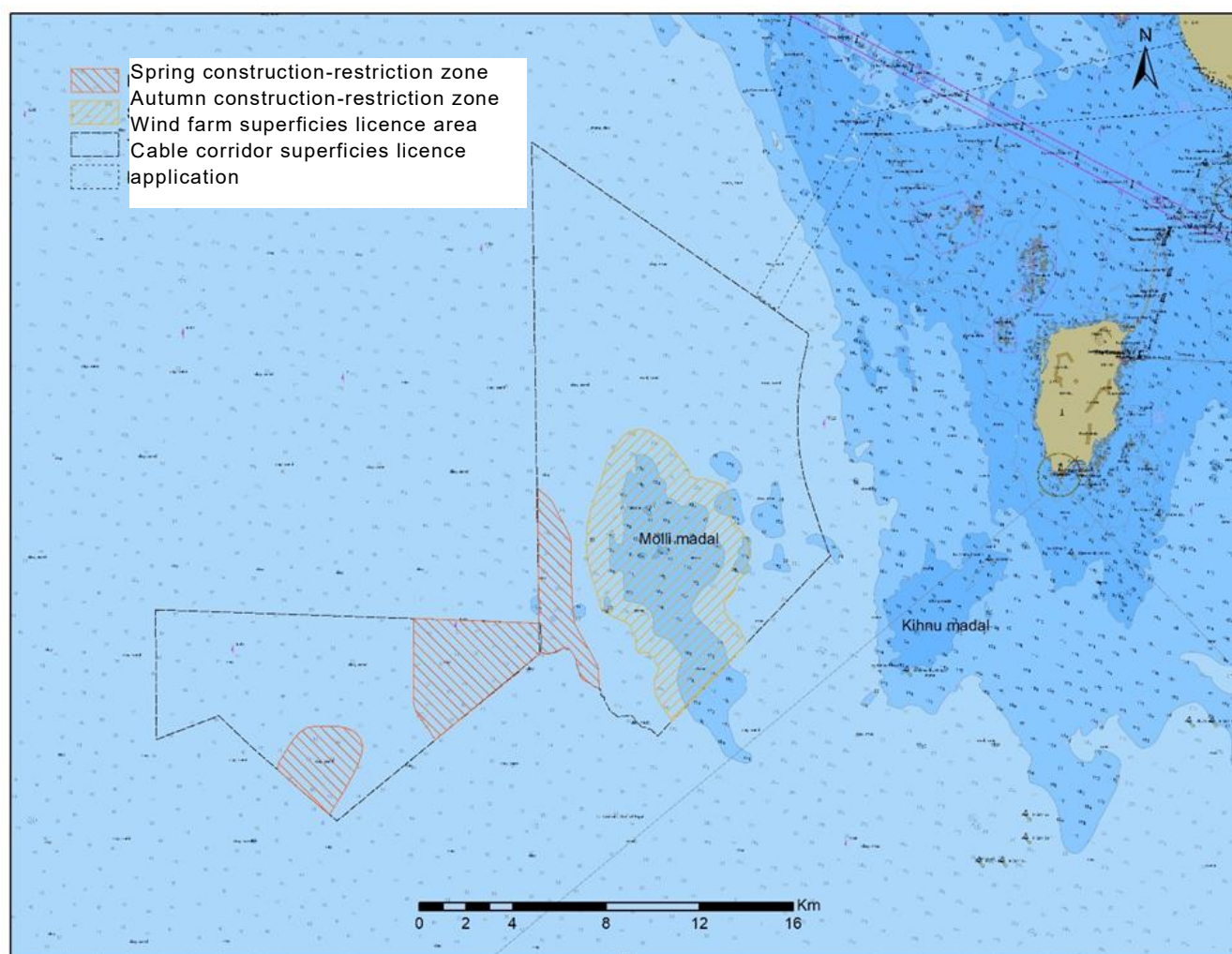


Figure 3.8-4 Spring construction restriction zone in the additional area⁹² for the migration period of spring-spawning Baltic herring in March and April (fish survey. UT Estonian Marine Institute, 2026)

⁹² The restrictions established in the initial area of the Saare-Liivi wind farm are not measures under this EIA; they were established under the EIA for the initial area and apply to the implementation of the initial area.

IMPACT ON OTHER SPAWNING GROUNDS

To assess the possible occurrence of spawning grounds, account was taken, inter alia, of the occurrence and abundance of individuals with running roe or milt. The finding of isolated such individuals does not in itself confirm the existence of a spawning ground.

European smelt spawning grounds are generally located in rivers or in the shallow coastal waters of strongly freshened marine bays. The Saare-Liivi additional area is therefore not suitable as a potential spawning ground for European smelt.

European flounder spawns on hard, mud-free bottoms at depths of 4–22 (27) m, with spawning grounds predominantly located at a depth of about 10 m. Depths in the additional area are greater, ranging from approximately 23–41 m, which makes the presence of significant European flounder spawning grounds there unlikely. The abundance of European flounder in monitoring catches in the Saare-Liivi initial and additional areas was rather low (accounting for 3.6% of the total number of fish caught). Individual European flounder with running roe or milt were caught in both areas, but predominantly at the shallower sampling stations in the initial area. The spring abundance of European flounder in 2022 was practically equal to the summer abundance, and in spring 2023 it was even lower than in summer; the survey therefore concluded that flounder had already spawned before arriving in the initial and additional areas during their feeding migrations.

During the survey carried out in late autumn, no spawning Baltic whitefish were found in the Saare-Liivi initial and additional areas, and the occurrence of their spawning grounds in the area was therefore not confirmed.

The fish survey did not identify any significant or regularly used fish spawning grounds in the Saare-Liivi additional area. Accordingly, implementation of main alternative 3 in the Saare-Liivi additional area will not cause any direct loss of fish spawning grounds or have any significant adverse impact on spawning grounds.

IMPACT OF NOISE

Among Baltic Sea fish, according to current knowledge, Baltic herring is probably the most susceptible to the potential negative noise-related effects of offshore wind farms, as it is the Baltic Sea subspecies of Atlantic Baltic herring and is a hearing specialist species. Anthropogenic noise may affect fish spawning, the long-term health and development of fish, prey–predator relationships, and fish communication (masking).

There is no uniform methodology for determining the sound level of behavioural response in fish. In the EIAs for the Liivi Bay offshore wind farm and the Saare-Liivi initial area, 122 dB re 1 μ Pa has been used as the behavioural response level for Baltic herring. In a later experimental study (Rohtla et al. 2025), the response of Baltic herring to continuous underwater sound at a frequency of 100 Hz was investigated, and it was found that a 50% response probability in Baltic herring occurred at a sound level of 118 dB re 1 μ Pa. Therefore, in the underwater noise study for the Saare-Liivi additional area⁹³, the more conservative value of 118 dB re 1 μ Pa was used as the behavioural response level for Baltic herring in the 125 Hz decade; sound propagation at 100 and 125 Hz is similar. In assessing the spatial extent of the impact, the baseline study applied the methodological approach recommended by TG Noise, according to which the proportion of habitat in which the species-specific sound level at which an effect occurs is exceeded is compared with the 20% spatial threshold value. The same threshold value is set out, as the threshold

⁹³ "Assessment of underwater noise impact in the Saare-Liivi wind farm additional area, including assessment of cumulative impacts" (TalTech, 2024, updated 2026; Annex 3.1)

value for criterion D11C2 established at Union level, in the European Commission Notice “On threshold values established pursuant to the Marine Strategy Framework Directive 2008/56/EC and Commission Decision (EU) 2017/848” (C/2024/2078)⁹⁴. The area affected by anthropogenic continuous underwater noise exceeding the LOBE level must not, in any month of the assessment year, account for more than 20% of the habitat of the target species. In this EIA report, this approach is used as an additional basis for comparison by comparing the proportion of the area exceeding the 118 dB behavioural response level used in the study with the D11C2 20% spatial threshold value. The periods May–June and August–September are considered important periods in the Baltic herring life cycle.

For anthropogenic impulsive noise (drilling, vibratory and impact driving of piles for monopile foundations), the criterion adopted was that it should be at a level that does not endanger Baltic herring spawning grounds during spawning periods. To avoid significant environmental impact, the criterion must be followed that anthropogenic impulsive noise is at a level that does not endanger Baltic herring spawning grounds during spawning periods (Table 3.8-1).

Table 3.8-1. Lethal sound pressure levels in fish (Andersson 2016) – impulsive noise

	Fish	Fish eggs and larvae
Mortality and internal organ injuries	SEL(cum) 204 dB re 1 $\mu\text{Pa}^2\text{s}$ or 202 dB SEL in the 125 Hz third-octave band	SEL(cum) 207 dB re 1 $\mu\text{Pa}^2\text{s}$ or 204 dB SEL in the 125 Hz third-octave band

The results of the modelling of construction-phase underwater noise are presented in section 2.8. In this chapter, those results are used to assess the significance of the impact of construction-phase noise on fish fauna. The modelling considered four different technical scenarios for foundation installation: installation of a gravity base foundation (continuous noise) and drilling, impact driving and vibratory driving of pile foundations (impulsive noise). The modelling results showed that the foundation construction scenario with the lowest environmental impact is the use of a gravity base foundation. The underwater noise study used as the assessment area Baltic herring habitat in the marine area of the Gulf of Riga, with an area of 3930 km². When installing a gravity base foundation, the 118 dB behavioural response level for Baltic herring is exceeded in less than 1% of the assessment area, which is clearly below the D11C2 20% spatial threshold value. The study concludes that, in the case of vibratory and impact driving of monopile foundations, the impact of impulsive noise on Baltic herring is minor adverse, whereas drilling of monopile foundations has no impact. The results were similar for both technical alternatives assessed, namely pile foundations with diameters of 12 m and 18 m (Table 3.8-2).

Table 3.8-2 Summary table of the modelling results for impulsive noise emitted during the construction period and assessment of environmental impact on the basis of those modelling results.

Parameter/indicator	Alternative 0	Construction period, 12 m/18 m diameter piles		
		Vibratory driving	Drilling	Impact driving
Temporary threshold shift in Baltic herring, safety zone radius, m	0	50/100	0	160/500
Overall assessment for Baltic herring	0	Minor negative impact	No impact	Minor negative impact

The modelling results for continuous noise during wind farm operation show that the impacts of the alternatives with 15 MW and 20 MW turbines are similar. In the conservative modelling scenario with 80

⁹⁴ https://eur-lex.europa.eu/legal-content/ET/TXT/PDF/?uri=OJ:C_202402078

turbines in the Saare-Liivi initial area and 50 turbines in the additional area, the 118 dB behavioural response level for Baltic herring was exceeded in approximately 10% of the assessment area used in the underwater noise study for 15 MW turbines and approximately 11% for 20 MW turbines; the stand-alone contribution of the initial area was approximately 7% and 8%, respectively. Thus, the addition of the additional area primarily increases the spatial extent of the potential impact area, but even in the cumulative scenario the proportion of affected habitat remains below the 20% spatial threshold value. Main alternative 3 for the additional area includes up to 40 turbines, and the actual impact area is therefore likely to be smaller than modelled.

Overall, the underwater noise study assesses the impact on Baltic herring of the increase in ambient noise levels generated during the operational period of the wind farms (initial and additional area) as neutral. As an overall assessment of the foundation types considered in relation to construction-phase noise, the study concludes that, in the case of a gravity base foundation, there is no impact on Baltic herring. There is likewise no impact from drilling monopile foundations, but vibratory and impact driving of monopile foundations has a minor negative impact on Baltic herring. The study does not consider it necessary, from the fish fauna perspective, to implement mitigation measures for vibratory and impact driving of piles. However, on the basis of the fish survey, a temporal restriction has been established for construction activities with the aim of reducing the impact of construction noise and suspended matter generation on Baltic herring in parts of the additional area (Section 3.8.4).

ELECTROMAGNETIC FIELD

Marine cables generate an electromagnetic field during the operational period of the wind farm, which may affect fish behaviour and the development of early life stages (Nyqvist et al. 2020, Taormina et al. 2018). Elasmobranchs, i.e. shark and ray species, which do not occur in the Gulf of Riga, are the most sensitive to artificial magnetic fields. In bony fish, the early developmental stages are more sensitive, and the effect is species-specific: experiments have identified both the presence and the absence of an effect. For example, the swimming activity of haddock (*Melanogrammus aeglefinus*) larvae decreased under the influence of an artificially generated magnetic field of 50–150 μ T (Cresci et al. 2022a), whereas, in sandeel larvae, no changes were detected in spatial distribution or swimming behaviour (Cresci et al. 2022b), and, in the Great Lakes fish assemblage, the impact of the power cable was assessed as minimal or non-existent (Dunlop et al. 2016).

The strength of the electromagnetic field decreases approximately in inverse proportion to the square of the distance, and the potential impact area is therefore limited to a few to tens of metres, not hundreds of metres. Sediments do not shield the electromagnetic field: the field strength depends solely on the distance from the cable and is the same whether the cable is buried, laid on the seabed or in the water column (Hutchison et al. 2021). Burial of the cable therefore does not reduce the strength of the electromagnetic field, but increases the distance between the cable and organisms present on the seabed. In the case of a surface-laid cable, there is no such distance at the seabed surface and exposure of near-bottom species is more direct, but due to the rapid attenuation of the electromagnetic field the affected area nevertheless remains in the immediate vicinity of the cable. According to the technical description (Annex 2), the inter-array cables are generally laid on the seabed surface and are buried along all or part of their length if pre-construction studies show that currents and the movement of seabed sediments may damage the cables. If burial proves necessary for technical reasons, this further reduces the exposure of organisms present on the seabed to the magnetic field.

In the case of the inter-array cables planned for the additional area, three factors reduce the impact of the electromagnetic field. First, the inter-array cables are planned as three-core alternating current cables with a nominal voltage of 66 or 132 kV. The close proximity of the phase conductors offsets a large part of the magnetic field, and a higher nominal voltage reduces the current and the strength of the magnetic

field for the same transmitted power. The experiments that identified a stronger effect, including the above-mentioned study on haddock larvae, concern direct current cables specifically, and their results cannot therefore be directly applied to the present project design. Second, the use of a higher nominal voltage reduces the current for the same transmitted power and thereby also the strength of the magnetic field; the technical description provides for higher voltage to be preferred where technically feasible. Third, the literature has linked effects on eel migratory behaviour primarily to cables located in water less than 20 m deep (Westerberg and Lagenfelt 2008); the water depth in the additional area is 23.8–41 m, and the effect is therefore not expected to materialise in the additional area. The nearshore section of the export cables relevant from the perspective of eel migration has been assessed in the EIA report for the Saare-Liivi initial area and export cable corridor.

The turbines in the additional area will be connected by inter-array cables to the offshore substation in the additional area. From there, up to two parallel export cables, each approximately 6 km long (approximately 12 km of cable in total), run to the boundary between the initial and additional areas and, through the Saare-Liivi initial area, reach the export cable route corridor. The impacts of the export cable route located in the initial area have been assessed in the EIA report for the initial area and export cable route corridor; no new separate landfall corridor will be established for the additional area. To reduce the potential impact of the electromagnetic field, the export cables running from the offshore substation of the additional area to the boundary of the initial offshore wind farm area must be buried in the seabed or covered. The cables used should preferably be three-core alternating current cables. The requirements laid down in the EIA report for the initial area and in the superficies licence apply to the export cables located in the initial area up to the landfall point. Inter-array cables are generally laid on the seabed and are buried along all or part of their length if pre-construction studies show that this is necessary for the technical protection of the cables.

Taking the above into account, the impact of the electromagnetic field on fish fauna in the additional area is assessed as minor. The impact is spatially limited to the immediate vicinity of the cables.

3.8.4. Environmental measures

MITIGATION MEASURES

To reduce the potential negative impact of the electromagnetic field emitted by the marine cables, the export cables must be buried in the seabed or covered. The export cables used should preferably be three-core alternating current cables. The requirements laid down in the superficies licence for the initial area apply to the export cables located in the initial area up to the landfall point.

To reduce the potential impact of the electromagnetic field from the inter-array cables, preference must be given to higher nominal voltage and three-core alternating current cables (where technically feasible). A higher nominal voltage allows lower current for the transmission of the same power and thereby reduces the strength of the magnetic field emitted by the cable. If seabed conditions and the technical solution allow, the inter-array cables must be buried in the seabed or covered. If, due to seabed conditions, the required burial depth of the inter-array cable is not achieved, the inter-array cable must be protected by another technically suitable solution, for example a rock layer or concrete mattress (see Section 2.7.2).

To prevent the possible impact on the spawning migration of spring-spawning Baltic herring caused by the spread of noise and suspended matter during construction works, the following measure is established in the Saare-Liivi additional area:

- In March and April, construction works must be avoided in the spring construction restriction zone shown in Figure 3.8-4 within the additional area.

If operational follow-up monitoring of the turbines shows that the migration of Baltic herring towards spawning grounds is significantly hindered, turbine operation must be temporarily suspended during the active Baltic herring migration period (see Section 3.8.3). If pile-driving works at other offshore wind farms in the area may overlap in time with the works in the additional area, cumulative underwater noise shall be assessed and the timing of the works adjusted in accordance with Section 3.7.4.

ENVIRONMENTAL MONITORING

A follow-up monitoring programme must be developed to detect possible changes in the species composition and abundance of fish fauna both during construction works and during operation of the wind farm in the additional area. Monitoring must be carried out annually during the first five years of operation of the wind farm in the additional area and every other year during the following ten years, after which an assessment should be made of the need to continue monitoring; a more detailed plan for the monitoring studies shall be drawn up in cooperation between the developer, the decision-maker and species experts before construction of the wind farm in the additional area begins.

The timing of post-operational monitoring of the wind farm in the additional area is expected to lie so far in the future that it is difficult today to assess the amount of knowledge that will have accumulated by then and the technological and methodological options that will be available. It is therefore not expedient to decide at present on the need for post-operational monitoring.

3.8.5. Assessment of alternatives and summary

No important or regularly used spawning grounds of spring-spawning Baltic herring, autumn-spawning Baltic herring, European whitefish or Baltic flounder were identified in the additional area. Therefore, main alternative 3 for the additional area does not entail the direct loss of any important spawning ground.

Part of the spawning migration of spring-spawning Baltic herring passes through the eastern part of the additional area. Construction-phase underwater noise and suspended matter may affect this migration locally and temporarily. With the application of the spatial work restriction in March and April, the residual impact is assessed as neutral to minor negative (0/–).

In the artificial sound source experiment by Rohtla et al. (2025), no statistically significant effect on Baltic herring undertaking spawning migration or spawning was detected. According to the experiment, operational low-frequency continuous noise may cause a statistically significant but localised change in the spatial distribution of Baltic herring, indicating possible avoidance behaviour. The possible impact on the Baltic herring population is estimated to be small, and, based on the available data, the area encompassing the Saare-Liivi initial and additional areas is not an important feeding ground for Baltic herring. Based on the results of Rohtla et al. (2025), the study of the additional area used 118 dB as the behavioural response level for Baltic herring. In modelling the operational sound field of the Saare-Liivi initial and additional areas, the area exceeding this level remained below the 20% spatial threshold value (D11C2), and significant adverse impact on Baltic herring is therefore not expected. Due to the scarcity of empirical monitoring data from the Baltic Sea on the effects of the sound field of an operating offshore wind farm, the operational impact is, as a precaution, assessed as neutral to minor negative (0/–), and this will be verified by follow-up monitoring.

The addition of new hard substrate may locally concentrate fish or increase the productivity of some species, but this is not automatically regarded as a positive impact or as offsetting the loss of natural seabed.

The overall residual impact of main alternative 3 for the additional area on fish fauna is minor negative (–). No significant adverse impact on the species composition of fish fauna, populations or important functional areas is expected if mitigation measures are implemented.

Table 3.8-3 *Impacts associated with the planning of the wind farm and their significance*

Associated consequence/impact	Impact significance	Need for the application of mitigation measures, final impact significance
Wind farm construction and decommissioning		
Indirect impacts (suspended matter dispersion)	-	Mitigable through timing Residual impact: 0
Gravity base foundation		
Noise	0	No measures are required. Residual impact 0
Monopile foundation - vibratory driving		
Noise	-	Mitigable through timing Residual impact: 0
Monopile foundation – drilling		
Noise	0/-	Timing restriction during the spawning migration period of spring-spawning Baltic herring (Section 3.8.4). Residual impact 0
Monopile foundation - impact piling		
Noise	0/-	Mitigable through timing Residual impact: 0
Wind farm operation		
Habitat loss	0	No measures are required. Residual impact 0
Migration barrier	0/-	Where necessary on the basis of follow-up monitoring, temporary suspension of turbine operation during the active Baltic herring migration period (section 3.8.4). Residual impact 0/–
Technological variant 1: 15 MW wind turbine		
Noise	0/-	Operational monitoring and, where necessary, temporary suspension of turbine operation during the active Baltic herring migration period (section 3.8.4). Residual impact 0/–
Technological variant 2: 20 MW wind turbine		
Noise	0/-	Operational monitoring and, where necessary, temporary suspension of turbine operation during the active Baltic herring migration period (section 3.8.4). Residual impact 0/–

Scale of significant environmental impact used in the EIA report: - slight negative impact, -- significant negative impact, 0 - no impact, neutral, + slight positive impact, ++ significant positive impact

3.8.6. Cumulative impact

In assessing the cumulative impact on fish fauna, the cumulative impact of the Saare-Liivi initial and additional areas is first considered, followed by the possible in-combination effect with the Liivi Bay offshore wind farm. All three developments are located in the same Gulf of Riga ecosystem and may affect the same Baltic herring stock, the same spawning migration routes, feeding grounds and the dispersal of fish larvae.

Cumulative impact of the Saare-Liivi initial and additional areas. No important fish spawning grounds were identified in the additional area, and its additional impact on the direct loss of spawning grounds is small. The main sensitivity of fish fauna in the additional area is associated with part of the spawning migration of spring-spawning Baltic herring passing across the eastern edge of the additional area.

The Saare-Liivi initial area includes Mölli madal, which is used as a spawning ground, spawning migration area and primary nursery area for autumn-spawning Baltic herring larvae. Spawning grounds of spring-spawning Baltic herring occur in the nearshore section of the export cable corridor. The impacts of the said Saare-Liivi initial area and export cable corridor, and the corresponding timing restrictions, are set out in the EIA report for the initial area (and export cable corridor) (and in the superficies licences).

In modelling operational underwater noise for the Saare-Liivi initial area with 80 turbines and the additional area with 50 turbines, the proportion of the assessment area exceeding the 118 dB behavioural response level for Baltic herring increased from approximately 7% to 10% for the 15 MW solution and from 8% to 11% for the 20 MW solution. The additional area therefore expands the spatial extent of the affected area, but the cumulative impact remains clearly below the 20% spatial threshold value (D11C2) for both technical solutions and is not significant. The modelled 50 turbines in the additional area represent a more conservative scenario than the solution with up to 40 turbines under main alternative 3, and therefore the actual impact area is likely to be somewhat smaller. **In-combination effect of the Saare-Liivi initial and additional areas with the Liivi Bay offshore wind farm.** In the fish fauna studies of the EIA for the Liivi Bay offshore wind farm, the spawning migration of spring-spawning Baltic herring has likewise been identified (and, additionally, areas important for autumn-spawning Baltic herring), and seasonal construction restrictions have been provided for. A construction-phase in-combination effect on fish fauna involving the Saare-Liivi additional area may arise primarily when works generating underwater noise or extensive suspended matter — impact or vibro-piling of monopile foundations, seabed works and cable works — take place simultaneously in two or more offshore wind farm areas. From the perspective of spring-spawning Baltic herring, the March–April spawning migration period is particularly sensitive.

No adverse cumulative impact on fish fauna will arise in combination with the proposed Liivi Bay offshore wind farm and the Saare-Liivi initial area offshore wind farm, provided that the timing restrictions during Baltic herring spawning migration set out in the EIA report for the Saare-Liivi initial area and in superficies licence No 1-7/26-038, and in Section 3.8.4 of this EIA report, are followed. In the fish fauna studies carried out during the EIAs of the Saare-Liivi initial and additional areas and the Liivi Bay offshore wind farm, the potential negative impacts identified on fish were minimal, and their occurrence was ruled out by various mitigation measures.

In the operational underwater noise assessments of the Liivi Bay offshore wind farm EIA and the Saare-Liivi initial area EIA, 122 dB re 1 µPa was used as the behavioural response level for Baltic herring. In the

study of the Saare-Liivi additional area, the more conservative level of 118 dB re 1 μ Pa was used on the basis of the later study by Rohtla et al. (2025). According to the modelling results, using a response level that is four decibels lower increases the affected marine area by up to 5%, but does not alter the conclusion on impact significance: the impact area of continuous noise remains below the 20% spatial threshold value (D11C2) both in the earlier assessments and in the present cumulative scenario for the Saare-Liivi initial and additional areas. The approach used in this report is therefore more conservative than that used in the EIA for the Liivi Bay offshore wind farm and the Saare-Liivi initial area, and the cumulative impact assessment has not been underestimated due to the difference in methodologies.

The in-combination effect on seabed habitats of the possible reef effect and electromagnetic fields of the three offshore wind farms (the Saare-Liivi initial and additional areas and the Liivi Bay offshore wind farm) is expected to be localised. The addition of new hard substrates may concentrate certain near-bottom fish species, but this is not automatically regarded as a positive impact or as offsetting the loss of natural seabed. The cumulative impact of the electromagnetic fields from the export cables is reduced by burying or covering the cables and by the rapid attenuation of the fields with distance from the cable. Possible changes in hydrodynamic conditions and ice conditions resulting from the offshore wind farm in the additional area remain of minor significance from the perspective of fish fauna, taking into account the prescribed mitigation measures. Changes in water quality within the buildable area of the offshore wind farm in the additional area occur only during the construction period and can be mitigated.

On the basis of the studies carried out, there are no grounds to assume that construction of the initial and additional areas of the Saare-Liivi offshore wind farm would affect the fish fauna of the Gulf of Riga on a transboundary basis or that impacts on the species composition or abundance of fish fauna could extend into Latvian territorial waters.

3.8.7. Uncertainty/knowledge gaps

The cumulative impact on fish fauna has been assessed for the Saare-Liivi initial and additional areas and the Liivi Bay offshore wind farm. The operational sound field of the Saare-Liivi initial and additional areas has been modelled in a single model and using a behavioural response level of 118 dB in the underwater noise baseline study (Annex 3.1) of this EIA. A behavioural response level of 122 dB was used in the Liivi Bay offshore wind farm EIA and the Saare-Liivi initial area EIA. The difference arises from the results of the later published controlled artificial sound source experiment by Rohtla et al. (2025), which have been used to refine the assessment of the additional area. The 4 dB difference between the behavioural response levels does not alter the conclusion of the cumulative impact assessment or invalidate the conclusions of the earlier EIAs, but rather refines the assessment of the additional area on the basis of newer knowledge. Reducing the response level from 122 dB to 118 dB increases the affected marine area by up to 5% according to the model, but even with the more conservative input the cumulative impact area of continuous noise from the Saare-Liivi initial and additional areas remains below the 20% spatial threshold value (D11C2).

In the experiment by Rohtla et al. (2025), the behavioural response level was determined under controlled sound source conditions, and in this EIA it was used as an input for sound propagation modelling of the entire wind farm and the cumulative scenario; a precautionary 118 dB response level and in-combination effect modelling were applied, and the results will be verified by fish fauna monitoring in accordance with Section 3.8.4.

3.9. Protected natural objects

3.9.1. Consideration of alternatives

The impact of the Saare-Liivi offshore wind farm initial area and export cable corridor on protected natural objects has been assessed in the EIA report for the initial area (and export cable corridor), which has been deemed compliant with the requirements. This chapter focuses on the additional impact of main alternative 3 in the Saare-Liivi additional area and, where necessary, on the cumulative impact of the Saare-Liivi initial and additional areas. The impact is assessed in respect of main alternative 3 of the additional area of the proposed offshore wind farm (Figure 2.3-1).

The impact is assessed for each affected protected natural object under the Nature Conservation Act (hereinafter LKS). All areas identified in the EIA programme are considered and assessed on the basis of the conservation objectives of the protected natural objects and the nature of the proposed activity.

3.9.2. Description of the environmental baseline and impact assessment

The protected natural objects identified in the EIA programme and covered by the assessment are as follows: Pärnu Bay limited-conservation area (KLO2000286), Kihnu limited-conservation area (KLO2000298), Kihnu Islets Nature Reserve (KLO1000628), Väike Strait limited-conservation area (KLO2000341), Väinameri limited-conservation area (KLO2000339; KLO2000241; KLO2000300), Kahtla-Kübassaare limited-conservation area (KLO2000309), Irbe Strait's limited-conservation area (KLO2000316); and the white-tailed eagle species protection sites located on Kihnu Island (KLO3002042; KLO3001508). The location of the protected sites is illustrated in Figure 3.9-1.

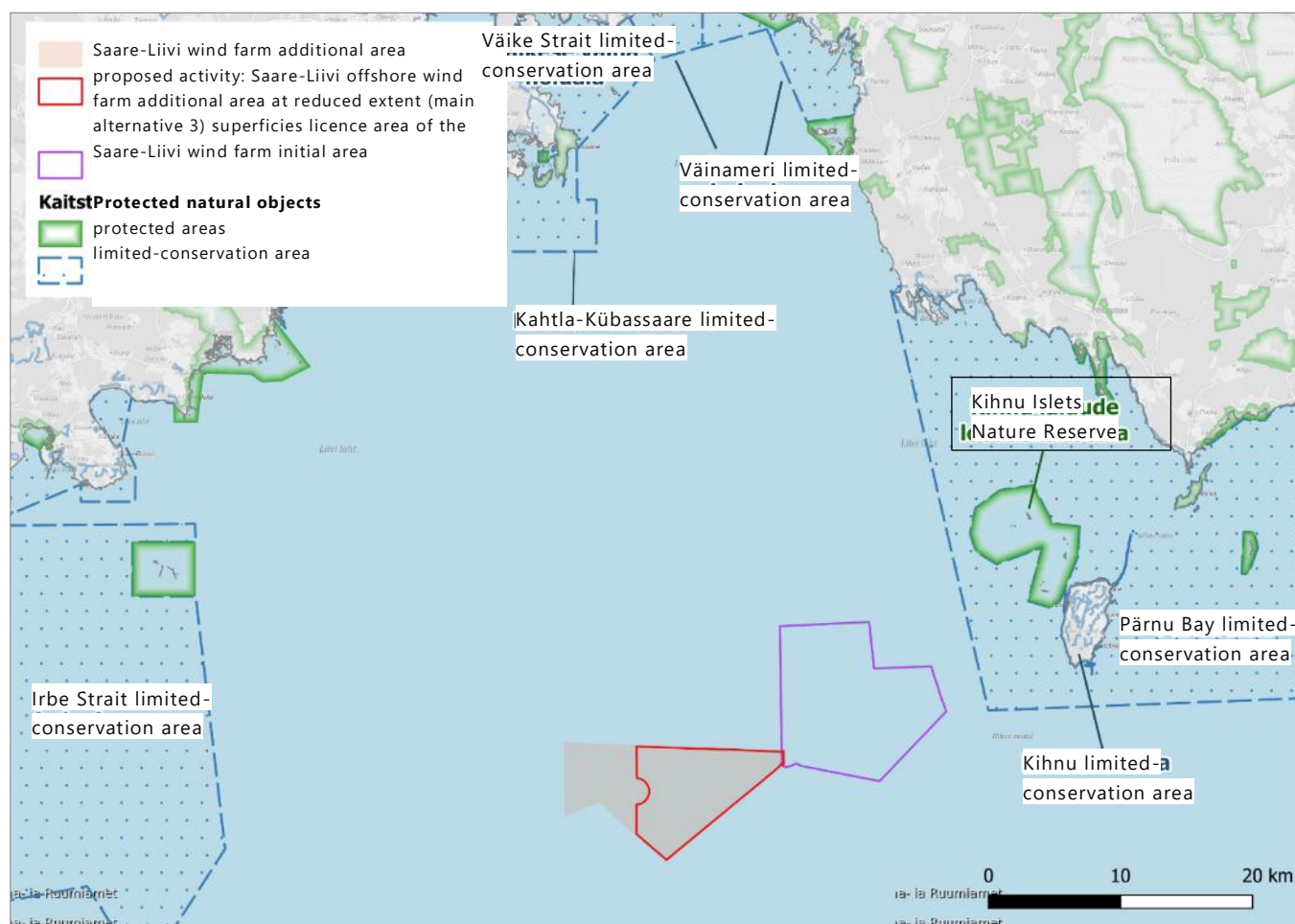


Figure 3.9-1 Overview of protected natural objects in the vicinity of the Saare-Liivi additional area⁹⁵ (Source: Estonian Land and Spatial Development Board and EELIS, 2026)

In the impact assessment below, the protected natural objects are considered individually. For protected areas/limited-conservation areas that overlap with Natura areas, only those species and habitats designated as conservation objectives that differ from the conservation objectives of the Natura area overlapping with the specific area are set out. Impacts on Natura areas (and on the same conservation objectives of overlapping national protected objects) have been assessed in the Natura assessment, Section 3.10.

The area of main alternative 3 in the additional area does not overlap with any protected area, limited-conservation area, species protection site or other protected natural object registered in EELIS. The nearest protected site is the Pärnu Bay limited-conservation area, approximately 16 km away. Due to this distance, there is no direct physical impact on the terrestrial and marine habitats, growing sites or sedentary species of the protected sites. Indirect impact may, in principle, be exerted on birds and seals that use extensive marine areas. Based on the observation data, it is generally not possible to determine from which specific protected area a specimen passing over the wind farm originated. Therefore, the impact is first assessed in relation to the relevant population of the species and its functional use of the marine area in Sections 3.5 and 3.7, and it is then examined whether the impact could impair the conservation objective of the specific protected natural object.

The bird survey for the Saare-Liivi additional area shows that some of the species that are conservation objectives of the limited-conservation areas listed below may pass through the open sea area of the Gulf

⁹⁵In accordance with § 53 of the LKS, localities of species in protected categories I and II are not shown.

of Riga. The observation data do not allow these individuals to be associated with a specific limited-conservation area. **The collision, barrier and displacement risk to species has been assessed in relation to their relevant biogeographical populations in Section 3.5, and no significant impact was predicted. Accordingly, no impact is expected that could impair the status of the relevant conservation objective of the limited-conservation area.**

PÄRNU BAY LIMITED-CONSERVATION AREA (KLO2000286)

Location: The limited-conservation area covers 1016 km², encompasses an extensive marine area in Pärnu Bay and around Kihnu, and at its nearest point lies *approx.* 16 km from the Saare-Liivi wind farm additional area.

Relationship with Natura areas and the assessment (see also Section 3.10): The majority of the Pärnu Bay limited-conservation area overlaps with the Natura 2000 Pärnu Bay special protection area (SPA). The majority of the conservation objectives also overlap; for the overlapping conservation objectives, the conclusion of the Natura assessment applies. Eight bird species protected in the limited-conservation

Conservation objectives of the Pärnu Bay limited-conservation area: common shelduck (<i>Tadorna tadorna</i>), smew (<i>Mergus albellus</i>), white-tailed eagle (<i>Haliaeetus albicilla</i>), spotted crane (<i>Porzana porzana</i>), corncrake (<i>Crex crex</i>), bar-tailed godwit (<i>Limosa lapponica</i>), wood sandpiper (<i>Tringa glareola</i>), red-backed shrike (<i>Lanius collurio</i>)	Impact assessment: Common shelduck (8), spotted crane, corncrake, bar-tailed godwit (454), wood sandpiper (1), red-backed shrike and ringed plover (4) are primarily associated with terrestrial areas, the coast and shallow coastal waters (where a species was recorded, the figures in brackets indicate the total number of autumn and spring flyovers of that species recorded during the bird survey). Higher numbers of flyovers were recorded only for one species: the bar-tailed godwit. The bird survey assesses the susceptibility of waders (including the bar-tailed godwit) to the wind farm in the additional area as low and the collision risk as moderate. The study notes that the abundance of passage migrant waders, and therefore also the number of individuals flying at rotor-swept height, was nevertheless low. The smew is a scarce passage migrant whose migration is likely to be dispersed, and its flight heights over the sea are largely below the rotor-swept zone. The nearest white-tailed eagle nests are located more than 20 km away on Kihnu Island (although they remain outside the Pärnu Bay limited-conservation area). For safety, a zone up to 6 km wide around the nest is considered necessary⁹⁶. The Saare-Liivi additional area is located considerably farther from the nearest white-tailed eagle nest, and therefore no adverse impact is expected. Some of the species mentioned may nevertheless occur in the additional area, but their collision risk is rather low and does not cause a significant impact on the abundance of the species.
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area are not conservation objectives of the Pärnu Bay special protection area (SPA). Those species are assessed below.

Impact assessment: The proposed activity will not have an adverse impact on the conservation objectives of the Pärnu Bay limited-conservation area. For the Saare-Liivi additional area, the bird survey did not identify any significant impact on staging waterbirds or birds breeding on islets.

⁹⁶ Estonian Ornithological Society and Kotkaklubi 2022. [Estonia-wide analysis of terrestrial bird fauna.](#)

KIHNU LIMITED-CONSERVATION AREA (KLO2000298)

Location: The limited-conservation area covers 11 km² and encompasses predominantly terrestrial areas on Kihnu Island. The limited-conservation area lies *approx.* 21 km from the Saare-Liivi additional area.

Relationship with Natura areas and the assessment (see also Section 3.10): The Kihnu limited-conservation area lies entirely within the Natura 2000 Kihnu special area of conservation (SAC), and all conservation objectives overlap. The conclusions of the Natura assessment apply.

Impact assessment: There are no direct physical impacts on the Kihnu limited-conservation area. The area and the natural conditions there will remain unchanged in extent and value. The proposed activity will not have adverse impacts on the Kihnu limited-conservation area or on the habitat types and species that are its conservation objectives.

KIHNU ISLETS NATURE RESERVE (KLO1000628)

Location: The area covers 42 km² in total and encompasses the marine area to the north-west of Kihnu Island together with the islets there and lies *approx.* 20 km from the Saare-Liivi additional area.

Protection: The conservation objective of the protected area is to protect and preserve the habitats and breeding sites of marine and coastal biota; the landscape character of the islets; and species listed in Annex I to Directive 2009/147/EC of the European Parliament and of the Council on the conservation of wild birds.

Relationship with Natura areas and the assessment (see also Section 3.10): The nature reserve overlaps with the Natura 2000 Kihnu special area of conservation (SAC) and the Pärnu Bay special protection area (SPA), and the conservation objectives are also largely the same. For the overlapping conservation objectives, the conclusion of the Natura assessment applies. Six bird species protected in the nature reserve are not conservation objectives of the Pärnu Bay special protection area (SPA). Those species are assessed below.

Conservation objectives of the Kihnu Islets Nature Reserve: common shelduck (<i>Tadorna tadorna</i>), smew (<i>Mergus albellus</i>), white-tailed eagle (<i>Haliaeetus albicilla</i>), oystercatcher (<i>Haematopus ostralegus</i>), razorbill (<i>Alca torda</i>), barred warbler (<i>Sylvia nisoria</i>)	Impact assessment: Common shelduck (8), oystercatcher (3) and barred warbler are primarily associated with terrestrial areas, the coast or shallow coastal waters (where a species was recorded, the figures in brackets indicate the total number of autumn and spring flyovers of that species recorded during the bird survey). As shown by the occasional species observations made in the survey, species of the limited-conservation area may nevertheless occur in the additional area, but their collision risk with wind turbines is rather low and does not cause a significant impact on the abundance of the species. Smew and razorbill are open-sea passage migrants. No confirmed observations of smew (i.e. identified to species level) were made in the area, and 49 confirmed flyovers of razorbill were recorded during autumn migration and 11 in spring. The bird survey did not show the Saare-Liivi additional area to be an important migration area for the species mentioned or to cause a significant collision risk or barrier effect for those species. No white-tailed eagle nests have been recorded in the Kihnu Islets Nature Reserve, but the area is a good feeding ground for white-tailed eagles breeding on Kihnu Island. These nests are located more than 20 km from the additional
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area. For safety, a zone up to 6 km wide around the nest is considered necessary ⁹⁷ . The Saare-Liivi additional area lies considerably farther from the nearest white-tailed eagle nest and the feeding areas in the nature reserve, and therefore no adverse impact is expected.

Impact assessment: The proposed activity will not have an adverse impact on the Kihnu Islets Nature Reserve or its conservation objectives. For the Saare-Liivi additional area, the bird survey did not identify any significant impact on staging waterbirds. Among other things, a telemetry study was conducted to investigate the space use of birds breeding on islets, using species breeding on the Kihnu islets, but no adverse impact on them was identified.

VÄIKE STRAIT LIMITED-CONSERVATION AREA (KLO2000341)

Location: The area covers 168 km² in total and encompasses primarily the Väike Strait marine area and its shores and lies approx. 45 km from the Saare-Liivi additional area.

Relationship with Natura areas and the assessment (see also Section 3.10): The limited-conservation area overlaps with the Natura 2000 Väike Strait special area of conservation (SAC) and the Väinameri special protection area (SPA). The habitat types and plant species protected in the limited-conservation area are also conservation objectives of the Väike Strait special area of conservation (SAC), but given the distance of tens of kilometres, they are not within the impact area of the activity. Most of the bird species protected in the limited-conservation area are also conservation objectives of the Väinameri special protection area (SPA), and for those species the conclusion of the Natura assessment applies. Four bird species protected in the limited-conservation area are not conservation objectives of the Väinameri special protection area (SPA). Those species are assessed below.

Conservation objectives of the Väike Strait limited-conservation area: southern dunlin (<i>Calidris alpina schinzii</i>) turnstone (<i>Arenaria interpres</i>) little gull (<i>Larus minutus</i>) common gull (<i>Larus canus</i>)	Impact assessment: southern dunlin and turnstone are primarily associated with the coast or shallow coastal waters, and the bird survey did not record these species in the Saare-Liivi additional area. Based on the bird survey, gulls (including common gull) were the most abundant species in the Saare-Liivi additional area. The abundance estimate for common gull (together with herring gull) reached up to 1574 individuals on one survey day. Little gull abundance was very low, with abundance estimates remaining below 100 individuals. The abundance of species recorded in the Saare-Liivi additional area did not indicate the area to be an important concentration or staging area for those species. The abundance estimate for no species in the additional area exceeded 1% of the abundance of the biogeographical population (which is a criterion for assessing impact significance). The conclusion on impact significance is based on the assessment of collision, barrier and displacement risk set out in Section 3.5, not solely on the 1% abundance criterion. The bird survey did not identify any significant impacts on either species.
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Impact assessment: The proposed activity will not have an adverse impact on the Väike Strait limited-conservation area or its conservation objectives.

⁹⁷ Estonian Ornithological Society and Kotkaklubi 2022. [Estonia-wide analysis of terrestrial bird fauna](#).

VÄINAMERE LIMITED-CONSERVATION AREA (KLO2000339; KLO2000241; KLO2000300)

Location: The area covers *approx.* 6060 km² in total and encompasses extensive marine and coastal areas in Väinameri, Suur Strait, etc., and lies *approx.* 45 km from the Saare-Liivi additional area.

Relationship with Natura areas and the assessment (see Section 3.10 for more detail): The limited-conservation area overlaps with the Natura 2000 Väinameri special protection area (SPA) and special area of conservation (SAC), and all conservation objectives overlap. The conclusions of the Natura assessment apply.

KAHTLA-KÜBASSAARE LIMITED-CONSERVATION AREA (KLO2000309)

Location: The area covers 135 km² in total and encompasses the coastal areas and coastal waters of south-eastern Saaremaa, and lies *approx.* 37 km from the Saare-Liivi additional area.

Relationship with Natura areas and the assessment (see Section 3.10 for more detail): The limited-conservation area overlaps with the Kahtla-Kübassaare special area of conservation (SAC) and special protection area (SPA). The habitat types and plant species protected in the limited-conservation area are also conservation objectives of the Kahtla-Kübassaare special area of conservation (SAC), but given the distance of tens of kilometres, they are not within the impact area of the proposed activity. Most of the bird species protected in the limited-conservation area are also conservation objectives of the Kahtla-Kübassaare special protection area (SPA), and for those species the conclusion of the Natura assessment applies. Seven bird species protected in the limited-conservation area are not conservation objectives of the Kahtla-Kübassaare special protection area (SPA), and those species are assessed below.

Conservation objectives of the Kahtla-Kübassaare limited-conservation area:

red-necked grebe (*Podiceps grisegena*), pintail (*Anas acuta*), southern dunlin (*Calidris alpina schinzii*), Sandwich tern (*Sterna sandvicensis*), woodlark (*Lullula arborea*), barred warbler (*Sylvia nisoria*), red-backed shrike (*Lanius collurio*)

Impact assessment:

southern dunlin, woodlark, barred warbler and red-backed shrike are species associated with terrestrial areas or the coast, and the bird survey did not identify them in the vicinity of the additional area.

Red-necked grebe (7), pintail (110) and Sandwich tern (51) are primarily associated with the coast or shallow coastal waters (where a species was recorded, the figures in brackets indicate the total number of autumn and spring flyovers of that species recorded during the bird survey). As shown by the species observations made in the survey, species of the limited-conservation area may nevertheless occur in the additional area, but their collision risk with wind turbines is rather low and does not cause a significant impact on the abundance of the species.

Impact assessment: The proposed activity will not have an adverse impact on the Kahtla-Kübassaare limited-conservation area or its conservation objectives.

IRBE STRAIT'S LIMITED-CONSERVATION AREA (KLO2000316)

Location: The area covers 1894 km² in total and encompasses extensive marine areas around Saaremaa's Sõrve peninsula, and lies *approx.* 31 km from the Saare-Liivi additional area.

Relationship with Natura areas and the assessment (see Section 3.10 for more detail): The limited-conservation area overlaps with the Irbe Strait special protection area (SPA) and several smaller special areas of conservation (SACs). Several habitat types are protected in the limited-conservation area, but

given the distance of tens of kilometres, they are not within the impact area of the proposed activity. Assessments and measures concerning the grey seal are set out in Section 3.7. Most of the bird species protected in the limited-conservation area are also conservation objectives of the Irbe Strait special protection area (SPA), and for those species the conclusion of the Natura assessment applies. Two bird species protected in the limited-conservation area are not conservation objectives of the Irbe Strait special protection area (SPA), and those species are assessed below.

Conservation objectives of Irbe Strait's limited-conservation area: black-throated diver (<i>Gavia arctica</i>), dunlin (<i>Calidris alpina</i>)	Impact assessment: Black-throated diver and dunlin were recorded during the bird survey on autumn and spring flyovers in the Saare-Liivi additional area on 456 and 101 occasions, respectively. The bird survey did not identify a significant collision risk with wind turbines for these species. However, the abundance of passage waders (including dunlin) was low, and therefore so was the number of individuals flying at rotor operating height. In the survey, the collision risk of divers with wind turbines was assessed as low. As shown by the species observations made in the survey, species of the limited-conservation area may nevertheless occur in the additional area, but their collision risk with wind turbines is rather low and does not cause a significant impact on the abundance of the species.
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Impact assessment: The proposed activity will not have an adverse impact on Irbe Strait's limited-conservation area or its conservation objectives.

WHITE-TAILED EAGLE SPECIES PROTECTION SITES ON KIHNU ISLAND (KLO3002042; KLO3001508)

Location: The white-tailed eagle species protection sites on Kihnu Island are located more than 20 km from the Saare-Liivi additional area.

Impact assessment: There are no direct physical or other impacts on the white-tailed eagle species protection sites located more than 20 km away. According to the results of the bird survey carried out, the proposed activity will not have a significant adverse impact on birds, including white-tailed eagles, and therefore no impact on the white-tailed eagle species protection sites is expected either. Numerous nests of the protected category I species, the white-tailed eagle, are located along the Estonian coast. For safety, a zone up to 6 km wide around the nest is considered necessary (Estonian Ornithological Society and Kotkaklubi 2022⁹⁸). The additional area in question is located considerably farther from white-tailed eagle nests (more than 20 km), and those nests are therefore not within the impact area of the activity.

3.9.3. Summary

Main alternative 3 of the additional area does not overlap with any protected area, limited-conservation area, species protection site or other protected natural object. All protected areas and limited-conservation areas lie at least approximately 16 km from the additional area, and therefore there is no direct impact on their habitats, growth sites or the physical integrity of the areas.

⁹⁸ Estonian Ornithological Society and Kotkaklubi 2022. Estonia-wide analysis of terrestrial avifauna. Estonia-wide analysis of terrestrial avifauna | Keskkonnaportaals

Indirect impact may affect protected birds and seals that use extensive marine areas. The impacts on these species groups, including cumulative impacts, have been assessed in Sections 3.5 and 3.7. Impacts on conservation objectives overlapping with Natura areas are assessed in Section 3.10.

The rating 0 shown in Table 3.9-1 means that the proposed activity does not harm the condition of the protected natural object or its conservation objectives. The assessment does not mean that individual protected species occurring in the Saare-Liivi additional area cannot be subject to the minor residual impact described in Sections 3.5–3.7. With the implementation of the mitigation and monitoring measures provided for in those sections, implementation of main alternative 3 of the additional area will not have an adverse impact on any protected natural object or its conservation objectives. No additional environmental measures duplicating the measures already set out in the species-group chapters are specified in this section.

Table 3.9-1. Residual impact of main alternative 3 of the Saare-Liivi additional area on protected natural objects after implementation of the relevant environmental measures

Protected natural object under assessment	Main alternative 3 of the additional area
Pärnu Bay limited-conservation area (KLO2000286)	0
Kihnu limited-conservation area (KLO2000298)	0
Kihnu Islets Nature Reserve (KLO1000628)	0
Väike Strait limited-conservation area (KLO2000341)	0
Väinameri limited-conservation area (KLO2000339; KLO2000241; KLO2000300)	0
Kahtla-Kübassaare limited-conservation area (KLO2000309)	0
Irbe Strait's limited-conservation area (KLO2000316)	0
White-tailed eagle species protection sites on Kihnu Island (KLO3002042; KLO3001508)	0

Scale of significant environmental impact used in the EIA report: - slight negative impact, -- significant negative impact, 0 - no impact, neutral, + slight positive impact, ++ significant positive impact

3.10. Natura assessment

Natura assessment is a procedure carried out in accordance with Article 6(3) and (4) of the Habitats Directive 92/43/EEC. In this work, the assessment is based on the European Commission guidance "Assessment of plans and projects in relation to Natura 2000 sites. Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC"⁹⁹, the guidance "Guidelines for carrying out Natura assessment when applying Article 6(3) of the Habitats Directive in Estonia"¹⁰⁰ and the document "Guidance document on wind energy developments and EU nature legislation"¹⁰¹.

In this EIA report, both a Natura screening and an appropriate assessment are carried out for the proposed activity in the Saare-Liivi additional area. A Natura screening was also prepared as part of the EIA programme (the Consumer Protection and Technical Regulatory Authority declared the EIA programme for the additional area compliant with the requirements by letter No 16-7/21-02502-163 of 20.10.2023).

⁹⁹ Assessment of plans and projects in relation to Natura 2000 sites. Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC. Brussels, 28.9.2021

¹⁰⁰ Kutsar, R.; Eschbaum, K. and Aunapuu, A. 2019. [Guidelines for carrying out Natura assessment when applying Article 6\(3\) of the Habitats Directive in Estonia](#). Client: Environmental Board.

¹⁰¹ European Commission. 2020. [Guidance document on wind energy developments and EU nature legislation](#). Commission Notice C(2020) 7730 final, 18.11.2020. Luxembourg: Publications Office of the European Union

Since several years have passed since the EIA programme was prepared and the proposed activity has been specified in greater detail during that time, it is considered justified in this case to review and reassess the conclusions of the Natura screening.

The assessment uses existing materials on the Natura 2000 site and its conservation objectives (information from the Natura site Standard Data Form; the EELIS database, etc.), and also takes into account the results of the baseline studies for this EIA. In the context of the Natura assessment, the most important of these are the bird, seal, fish and underwater noise studies.

3.10.1. Natura screening

Relationship of the proposed activity to conservation management

The proposed activity is not related to the conservation management of any Natura 2000 network site and does not contribute directly or indirectly to the achievement of the conservation objectives of the sites.

Description of the plan or project and identification of impacts associated with the proposed activity

For the purposes of this EIA, the proposed activity is main alternative 3<u> of the additional area of the Saare-Liivi offshore wind farm, involving an offshore wind farm of up to 40 turbines over an area of approx. 57 km² (see Figure 3.10-1). At the EIA programme stage for the additional area, up to 92 turbines were proposed over an area of approx. 91 km², meaning that the extent and scale of the proposed activity have been significantly reduced compared with those considered in the screening of the EIA programme.

The turbines will be connected by inter-array cables to the offshore substation of the additional area and from there by two connection cables to the offshore substations of the Saare-Liivi initial area or directly to shore. For the route to land, the export cable system and corridor considered in the EIA of the initial area will be used; no new separate landfall connection is proposed for the additional area. The seabed loss and disturbance associated with the section of the export cable route within the additional area are included in the impact assessment of the additional area; the export cable routes within the initial area are assessed in the EIA report for the initial area. In addition, this report addresses the in-combination effect of the export cable route across the initial and additional areas. The assessment of the in-combination effect of seabed loss and disturbance presented in Section 3.4 covers the entire export cable route from the offshore substation of the additional area, via the offshore substation(s) of the initial area, to the landfall point. Along the entire extent of that connection, the suspended matter dispersion associated with cable installation has also been modelled (see Section 3.3). Accordingly, the Natura assessment has taken into account the impacts of the connection cables running through both the additional area and the initial area, including the in-combination effect with the infrastructure of the Saare-Liivi initial area (see Sections 3.3, 3.4 and Appendix 3.4).

A more detailed description of the proposed activity can be found in Section 2.

The Natura 2000 areas nearest to the additional area of the offshore wind farm are the Pärnu Bay special protection area (SPA), approx. 16 km away, and the Ruhnu and Kihnu special areas of conservation (SACs), which are already some 20 km away (see Figure 3.10-1).

Given that the nearest Natura 2000 sites are located at least 16 km from the proposed wind farm, most of the impacts associated with the proposed activity do not extend to Natura network sites. This applies

in particular to direct damage to habitat types or species, and to species' habitats, on Natura sites, as well as to construction-period disturbances such as suspended matter dispersion, the effects of which are spatially limited and occur mainly within the area of the proposed activity and its immediate surroundings. Operational disturbances likewise do not extend over tens of kilometres. Therefore, the protected habitat types and resident species of Natura sites are not within the impact area of the proposed activity.

In view of the conservation objectives of the Natura sites, in this case only impacts on species that use marine areas outside Natura sites and may also move through the Saare-Liivi additional area can be relevant. The conservation objectives of this kind in the Natura sites under assessment are primarily bird species and, in the Kihnu special area of conservation (SAC), the grey seal and ringed seal. Therefore, the Natura screening focuses primarily on assessing potential impacts on species, which may include, in the case of seals, construction-period underwater noise and, in the case of birds, operational impacts of the wind farm (collision risk and possible barrier effect).

Among Natura special areas of conservation (SACs), the nearest to the Saare-Liivi additional area are more than 20 km away (the nearest are the Kihnu and Ruhnu special areas of conservation). Due to the sufficient buffer zone, impacts on Natura special areas of conservation (SACs) whose conservation objectives are habitat types (e.g. the Ruhnu SAC) or resident protected features (plants or other terrestrial species) are excluded. At the Natura screening stage, impacts cannot be excluded only for those special areas of conservation (SACs) whose conservation objectives are species that use extensive marine areas and may also move through the Saare-Liivi additional area. For example, the Kihnu special area of conservation (SAC), where the conservation objectives include grey seal and ringed seal, which use extensive marine areas and may at the same time be affected by construction-period underwater noise.

Of the Natura special protection areas (SPAs), the nearest, the Pärnu Bay special protection area (SPA), lies approximately 16 km from the additional area. However, due to the high mobility of bird species, impacts that may occur outside the boundaries of the Natura site cannot be excluded if the wind farm is located on a regular flight path of species that are conservation objectives of the SPA. In such a case, possible impacts may be related primarily to birds' collision risk and barrier effect.

During preparation of the EIA report, the selection of sites to be included in the Natura assessment was rechecked on the basis of EELIS, Natura 2000 standard data forms, conservation management plans and the EIA baseline studies. The review covered both Natura sites located near the additional area and more distant sites whose conservation-objective species may have a functional connection with the Saare-Liivi additional area. Given the distance and the extent of impact pathways, there is no credible impact pathway to the resident habitat types and species that are conservation objectives of the Ruhnu SAC and other SACs in the region.

Characterisation of Natura 2000 sites within the impact area of the proposed activity

For this Natura screening, the Natura 2000 network sites within the possible impact area are the same as those considered in the Natura screening in the EIA programme for the additional area: Kihnu special area of conservation (SAC), Pärnu Bay special protection area (SPA), Väinameri special protection area (SPA), Irbe Strait special protection area (SPA), Kahtla-Kübassaare special protection area (SPA) and Ainaži-Salacgriva special area of conservation (SAC) (see Figure 3.10-1). Given that the extent and scale of the proposed activity have decreased significantly compared with the time when the EIA programme was prepared, the impact area of the activity has not increased and, consequently, no new sites fall within the impact area and there is no need to include any additional sites in the assessment.

Descriptions of the Natura sites are provided in the following table (3.10-1). A forecast of impacts on these sites is provided in Table 3.10.-2 in the light of the refined solution and the results of the baseline studies for the EIA report.

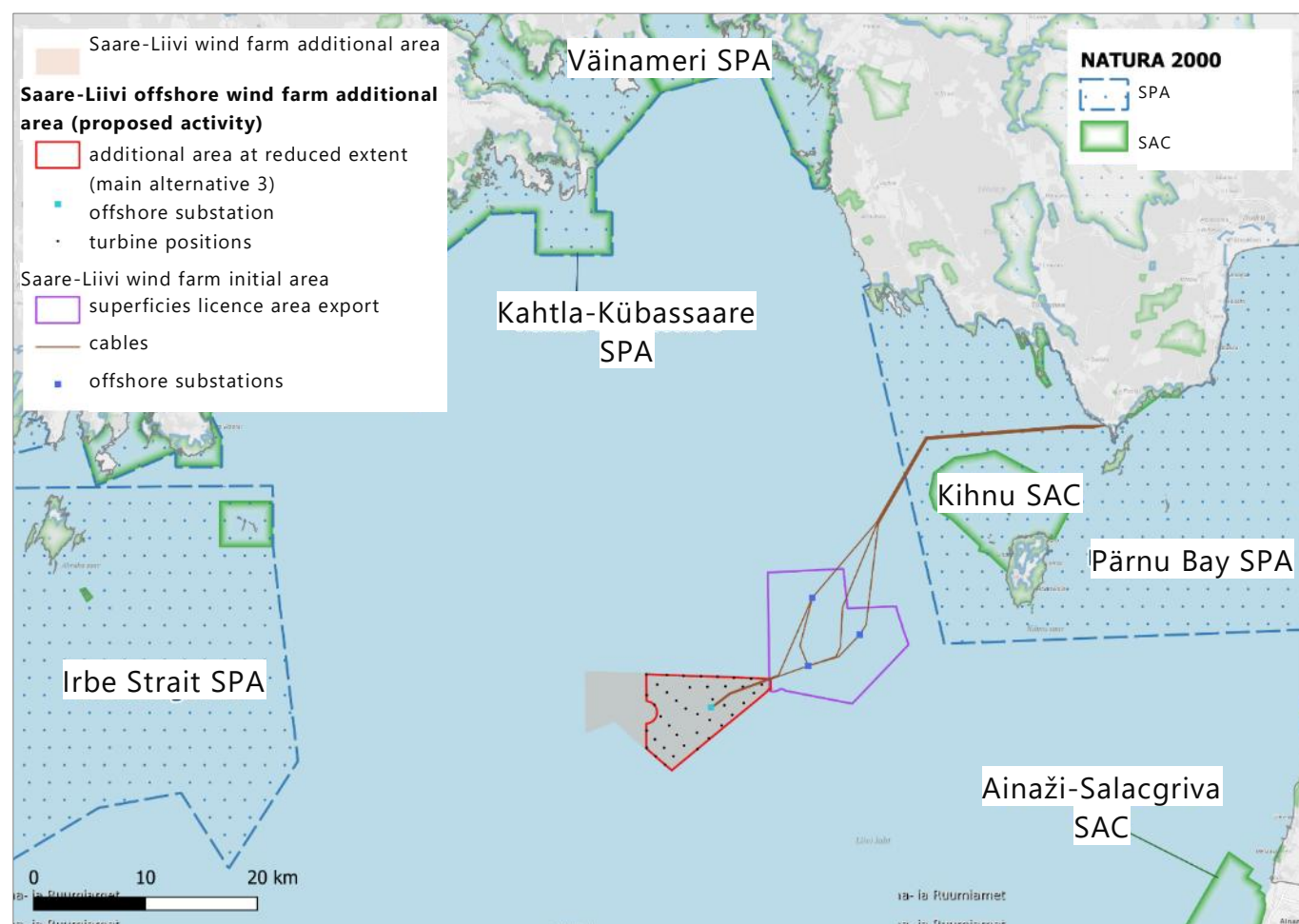


Figure 3.10-1. Overview of Natura 2000 network sites within the possible impact area of the proposed Saare-Liivi additional area (Source: Estonian Land and Spatial Development Board and EELIS, 2026)

Table 3.10-1. Natura 2000 network sites within the possible impact area of the activity and their conservation objectives

Natura site name	Distance from the additional area	Site conservation objectives ¹⁰²
Kihnu special area of conservation (SAC) (EE0040313)	approx. 21 km	<u>Habitat types:</u> submerged sandbanks (1110), coastal lagoons (*1150), annual vegetation of drift lines (1210), Boreal Baltic islets and small islands (1620), Boreal Baltic coastal meadows (*1630), Boreal Baltic sandy beaches with perennial vegetation (1640), white dunes (shifting coastal dunes – 2120), grey dunes (fixed coastal dunes – *2130), wooded dunes (2180), Juniperus communis formations (5130), dry grasslands on calcareous soils (*important orchid sites – 6210), species-rich meadows on lime-poor soils (*6270), Nordic alvar (*6280), Molinion caeruleae (6410), hydrophilous tall-herb communities (6430), Fennoscandian wooded

¹⁰²Priority habitat types are marked with an asterisk – these are natural habitat types/species in danger of disappearance, for whose conservation the European Union bears special responsibility, having regard to the proportion of their natural range which falls within the territory of the EU.

Natura site name	Distance from the additional area	Site conservation objectives ¹⁰²
		meadows (*6530), alkaline fens (7230), old natural forests (*9010), Fennoscandian wooded pastures (9070) and Fennoscandian deciduous swamp woods (*9080). <u>Species:</u> grey seal (<i>Halichoerus grypus</i>), ringed seal (<i>Phoca hispida bottnica</i>), marsh angelica (<i>Angelica palustris</i>) and fen orchid (<i>Liparis loeselii</i>).
Pärnu Bay special protection area (SPA) (EE0040346)	approx. 16 km	<u>Species:</u> great reed warbler (<i>Acrocephalus arundinaceus</i>), pintail (<i>Anas acuta</i>), shoveler (<i>Anas clypeata</i>), teal (<i>Anas crecca</i>), wigeon (<i>Anas penelope</i>), mallard (<i>Anas platyrhynchos</i>), garganey (<i>Anas querquedula</i>), gadwall (<i>Anas strepera</i>), greater white-fronted goose (<i>Anser albifrons</i>), greylag goose (<i>Anser anser</i>), bean goose (<i>Anser fabalis</i>), turnstone (<i>Arenaria interpres</i>), short-eared owl (<i>Asio flammeus</i>), tufted duck (<i>Aythya fuligula</i>), greater scaup (<i>Aythya marila</i>), barnacle goose (<i>Branta leucopsis</i>), goldeneye (<i>Bucephala clangula</i>), southern dunlin (<i>Calidris alpina schinzii</i>), ringed plover (<i>Charadrius hiaticula</i>), marsh harrier (<i>Circus aeruginosus</i>), long-tailed duck (<i>Clangula hyemalis</i>), Bewick's swan (<i>Cygnus columbianus bewickii</i>), whooper swan (<i>Cygnus cygnus</i>), mute swan (<i>Cygnus olor</i>), common gull (<i>Larus canus</i>), lesser black-backed gull (<i>Larus fuscus</i>), black-headed gull (<i>Larus ridibundus</i>), black-tailed godwit (<i>Limosa limosa</i>), velvet scoter (<i>Melanitta fusca</i>), common scoter (<i>Melanitta nigra</i>), goosander (<i>Mergus merganser</i>), red-breasted merganser (<i>Mergus serrator</i>), great cormorant (<i>Phalacrocorax carbo</i>), ruff (<i>Philomachus pugnax</i>), great crested grebe (<i>Podiceps cristatus</i>), common eider (<i>Somateria mollissima</i>), little tern (<i>Sterna albifrons</i>), common tern (<i>Sterna hirundo</i>), Arctic tern (<i>Sterna paradisaea</i>), Sandwich tern (<i>Sterna sandvicensis</i>), spotted redshank (<i>Tringa erythropus</i>), redshank (<i>Tringa totanus</i>) and northern lapwing (<i>Vanellus vanellus</i>).
Väinameri special protection area (SPA) (EE0040001)	approx. 45 km	<u>Species:</u> pintail (<i>Anas acuta</i>), shoveler (<i>Anas clypeata</i>), teal (<i>Anas crecca</i>), wigeon (<i>Anas penelope</i>), mallard (<i>Anas platyrhynchos</i>), garganey (<i>Anas querquedula</i>), gadwall (<i>Anas strepera</i>), greater white-fronted goose (<i>Anser albifrons</i>), greylag goose (<i>Anser anser</i>), lesser white-fronted goose (<i>Anser erythropus</i>), bean goose (<i>Anser fabalis</i>), grey heron (<i>Ardea cinerea</i>), turnstone (<i>Arenaria interpres</i>), short-eared owl (<i>Asio flammeus</i>), pochard (<i>Aythya ferina</i>), tufted duck (<i>Aythya fuligula</i>), greater scaup (<i>Aythya marila</i>), great bittern (<i>Botaurus stellaris</i>), brent goose (<i>Branta bernicla</i>), barnacle goose (<i>Branta leucopsis</i>), eagle owl (<i>Bubo bubo</i>), goldeneye (<i>Bucephala clangula</i>), southern dunlin (<i>Calidris alpina schinzii</i>), knot (<i>Calidris canutus</i>), little ringed plover (<i>Charadrius dubius</i>), ringed plover (<i>Charadrius hiaticula</i>), black tern (<i>Chlidonias niger</i>), white stork (<i>Ciconia ciconia</i>), marsh harrier (<i>Circus aeruginosus</i>), hen harrier (<i>Circus cyaneus</i>), long-tailed duck (<i>Clangula hyemalis</i>), corncrake (<i>Crex crex</i>), Bewick's swan (<i>Cygnus columbianus bewickii</i>), whooper swan (<i>Cygnus cygnus</i>), mute swan (<i>Cygnus olor</i>), white-backed woodpecker (<i>Dendrocopos leucotos</i>), ortolan bunting (<i>Emberiza hortulana</i>), coot (<i>Fulica atra</i>), great snipe (<i>Gallinago media</i>), pygmy owl (<i>Glaucidium passerinum</i>), common crane (<i>Grus grus</i>), white-tailed eagle (<i>Haliaeetus albicilla</i>), red-backed shrike (<i>Lanius collurio</i>), common gull (<i>Larus canus</i>), lesser black-backed gull (<i>Larus fuscus</i>), black-headed gull (<i>Larus ridibundus</i>), broad-billed sandpiper (<i>Limicola falcinellus</i>), bar-tailed godwit (<i>Limosa lapponica</i>), black-tailed godwit (<i>Limosa limosa</i>), velvet scoter (<i>Melanitta fusca</i>), common scoter (<i>Melanitta nigra</i>), smew (<i>Mergus albellus</i>), goosander (<i>Mergus merganser</i>), red-breasted merganser (<i>Mergus serrator</i>), curlew (<i>Numenius arquata</i>), great cormorant (<i>Phalacrocorax carbo</i>), ruff (<i>Philomachus pugnax</i>), grey-headed woodpecker (<i>Picus canus</i>), grey plover (<i>Pluvialis squatarola</i>), great crested grebe (<i>Podiceps cristatus</i>), little crake (<i>Porzana parva</i>), spotted crake (<i>Porzana porzana</i>), pied avocet (<i>Recurvirostra avosetta</i>), common eider (<i>Somateria mollissima</i>), little tern (<i>Sterna albifrons</i>), Caspian tern (<i>Sterna caspia</i>), common tern (<i>Sterna hirundo</i>), Arctic tern (<i>Sterna paradisaea</i>), Sandwich tern (<i>Sterna sandvicensis</i>), barred warbler (<i>Sylvia nisoria</i>), black grouse

Natura site name	Distance from the additional area	Site conservation objectives¹⁰²
		(<i>Tetrao tetrix</i>), spotted redshank (<i>Tringa erythropus</i>), wood sandpiper (<i>Tringa glareola</i>), greenshank (<i>Tringa nebularia</i>), redshank (<i>Tringa totanus</i>) and northern lapwing (<i>Vanellus vanellus</i>).
Kahtla-Kübassaare special protection area (SPA) (EE0040412)	approx. 37 km	<u>Species</u> : northern shoveler (<i>Anas clypeata</i>), wigeon (<i>Anas penelope</i>), mallard (<i>Anas platyrhynchos</i>), garganey (<i>Anas querquedula</i>), gadwall (<i>Anas strepera</i>), greylag goose (<i>Anser anser</i>), common pochard (<i>Aythya ferina</i>), tufted duck (<i>Aythya fuligula</i>), barnacle goose (<i>Branta leucopsis</i>), common goldeneye (<i>Bucephala clangula</i>), ringed plover (<i>Charadrius hiaticula</i>), marsh harrier (<i>Circus aeruginosus</i>), long-tailed duck (<i>Clangula hyemalis</i>), Bewick's swan (<i>Cygnus columbianus bewickii</i>), mute swan (<i>Cygnus olor</i>), coot (<i>Fulica atra</i>), common crane (<i>Grus grus</i>), white-tailed eagle (<i>Haliaeetus albicilla</i>), common gull (<i>Larus canus</i>), lesser black-backed gull (<i>Larus fuscus</i>), little gull (<i>Larus minutus</i>), black-headed gull (<i>Larus ridibundus</i>), black-tailed godwit (<i>Limosa limosa</i>), velvet scoter (<i>Melanitta fusca</i>), smew (<i>Mergus albellus</i>), goosander (<i>Mergus merganser</i>), red-breasted merganser (<i>Mergus serrator</i>), great cormorant (<i>Phalacrocorax carbo</i>), green woodpecker (<i>Picus viridis</i>), Slavonian grebe (<i>Podiceps auritus</i>), great crested grebe (<i>Podiceps cristatus</i>), pied avocet (<i>Recurvirostra avosetta</i>), common eider (<i>Somateria mollissima</i>), little tern (<i>Sterna albifrons</i>), Caspian tern (<i>Sterna caspia</i>), common tern (<i>Sterna hirundo</i>), Arctic tern (<i>Sterna paradisaea</i>), redshank (<i>Tringa totanus</i>) and northern lapwing (<i>Vanellus vanellus</i>).
Irbe Strait special protection area (SPA) (EE0040434)	approx. 31 km	<u>Species</u> : razorbill (<i>Alca torda</i>), northern pintail (<i>Anas acuta</i>), northern shoveler (<i>Anas clypeata</i>), teal (<i>Anas crecca</i>), wigeon (<i>Anas penelope</i>), mallard (<i>Anas platyrhynchos</i>), gadwall (<i>Anas strepera</i>), greylag goose (<i>Anser anser</i>), grey heron (<i>Ardea cinerea</i>), turnstone (<i>Arenaria interpres</i>), greater scaup (<i>Aythya marila</i>), brent goose (<i>Branta bernicla</i>), barnacle goose (<i>Branta leucopsis</i>), common goldeneye (<i>Bucephala clangula</i>), southern dunlin (<i>Calidris alpina schinzii</i>), red knot (<i>Calidris canutus</i>), little stint (<i>Calidris minuta</i>), black guillemot (<i>Cephus grylle</i>), ringed plover (<i>Charadrius hiaticula</i>), long-tailed duck (<i>Clangula hyemalis</i>), Bewick's swan (<i>Cygnus columbianus bewickii</i>), mute swan (<i>Cygnus olor</i>), red-throated diver (<i>Gavia stellata</i>), white-tailed eagle (<i>Haliaeetus albicilla</i>), lesser black-backed gull (<i>Larus fuscus</i>), bar-tailed godwit (<i>Limosa lapponica</i>), velvet scoter (<i>Melanitta fusca</i>), smew (<i>Mergus albellus</i>), goosander (<i>Mergus merganser</i>), red-breasted merganser (<i>Mergus serrator</i>), great cormorant (<i>Phalacrocorax carbo</i>), grey plover (<i>Pluvialis squatarola</i>), Slavonian grebe (<i>Podiceps auritus</i>), great crested grebe (<i>Podiceps cristatus</i>), pied avocet (<i>Recurvirostra avosetta</i>), common eider (<i>Somateria mollissima</i>), Caspian tern (<i>Sterna caspia</i>) and spotted redshank (<i>Tringa erythropus</i>).
Ainaži-Salacgriva special area of conservation (SAC) (LV0900700)	approx. 42 km	<u>Habitat types</u> : coastal lagoons (*1150), reefs (1170), annual vegetation of drift lines (1210), Boreal Baltic coastal meadows (*1630), Boreal Baltic sandy beaches with perennial vegetation (1640), white dunes (shifting coastal dunes – 2120). <u>Species</u> : spined loach (<i>Cobitis taenia</i>) and river lamprey (<i>Lampetra fluviatilis</i>).

Prediction of likely adverse impacts on the conservation objectives of Natura sites

The following Table 3.10-2 presents the predicted impacts on Natura sites and their conservation objectives. The table also presents the conclusion of the Natura screening, i.e. for which sites adverse impacts cannot be excluded and it is necessary to proceed to the appropriate assessment stage.

Table 3.10-2. Prediction of likely adverse impacts on Natura 2000 network sites and their conservation objectives

Natura site name	Impact prediction	Natura screening results
Kihnu special area of conservation (SAC) (EE0040313)	Main alternative 3 of the additional area is located <i>approx.</i> 21 km from the SAC at its nearest point. The Saare-Liivi additional area does not overlap with the Natura SAC and its conservation objectives (including marine habitat types), which excludes direct physical impacts on the SAC and its conservation objectives. Impacts on the habitat types and terrestrial plant species protected in the SAC are excluded. The results of the baseline studies for the EIA report do not generally indicate impacts extending over tens of kilometres. The conservation objectives of the SAC are grey seal and ringed seal, species that use extensive marine areas and may therefore be affected. During construction of the proposed turbines, temporary construction-phase impacts (primarily noise disturbance) may occur in certain cases, which may affect seals.	Impact cannot be excluded, continue with the appropriate Natura assessment for grey seal and ringed seal.
Pärnu Bay special protection area (SPA) (EE0040346)	The Saare-Liivi additional area is located <i>approx.</i> 16 km from the SPA at its nearest point. Therefore there are no direct physical impacts on the site's conservation objectives or bird habitats within the Natura site. However, the high mobility of birds (e.g. migrations and foraging flights) must still be taken into account, meaning that in certain cases impacts may also occur outside the Natura site and affect the species that are the conservation objectives of the SPA. A possible impact factor is impacts during migration on the bird species that are the conservation objectives of the SPA, which cannot be excluded at the Natura screening stage.	Impact cannot be excluded, continue with the appropriate Natura assessment.
Väinameri special protection area (SPA) (EE0040001)	The Saare-Liivi additional area is located <i>approx.</i> 45 km from the Väinameri SPA. Therefore there are no direct physical impacts on the site's conservation objectives or bird habitats within the Natura site. However, the high mobility of birds, particularly during migration, must still be taken into account, meaning that in certain cases impacts may also occur outside the Natura site and affect the species that are the conservation objectives of the SPA. A possible impact factor is primarily collision risk, which cannot be excluded at the Natura screening stage.	Impact cannot be excluded, continue with the appropriate Natura assessment.
Kahtla-Kübassaare special protection area (SPA) (EE0040412)	The Saare-Liivi additional area is located <i>ca</i> 37 km from the SPA at its nearest point. Therefore there are no direct physical impacts on the site's conservation objectives or bird habitats within the Natura site. However, the high mobility of birds, particularly during migration, must still be taken into account, meaning that in certain cases impacts may also occur outside the Natura site and affect the species that are the conservation objectives of the SPA. A possible impact factor is primarily collision risk, which cannot be excluded at the Natura screening stage.	Impact cannot be excluded, continue with the appropriate Natura assessment.
Irbe Strait special protection area (SPA) (EE0040434)	The Saare-Liivi additional area is located <i>approx.</i> 31 km from the SPA at its nearest point. Therefore there are no direct physical impacts on the site's conservation objectives or bird habitats within the Natura site. However, the high mobility of birds, particularly during migration, must still be taken into account, meaning that in certain cases impacts may also occur outside the Natura site and affect the species that are the conservation objectives of the SPA. A possible impact factor is primarily collision risk, which cannot be excluded at the Natura screening stage.	Impact cannot be excluded, continue with the appropriate Natura assessment.
Ainaži-Salacgriva special area of conservation (SAC) (LV0900700)	The refined distance from the SAC to main alternative 3 of the Saare-Liivi additional area is approximately 42 km. The SAC is located on the Latvian coast, comprising predominantly marine area and partly also the land area adjacent to the coast. Six marine and coastal habitat types and two fish species are protected in the SAC (see Table 3.10-1). Given that the SAC is located tens of kilometres from the proposed Saare-Liivi additional area, the impacts associated with the construction and operation of the wind farm do not extend to the SAC, i.e. the SAC is not within the impact area of the proposed activity.	The SAC is not within the impact area of the proposed activity. Adverse impact is excluded.

Natura site name	Impact prediction	Natura screening results
	Nor have the studies carried out in either the initial or the additional area of the Saare-Liivi offshore wind farm identified extensive or significant environmental impacts (e.g. on water quality) that could cause wider changes in environmental conditions in the Gulf of Riga. Therefore, there is also no basis for assuming such changes in environmental conditions in the SAC that could affect the condition or coherence of the protected habitats. Impacts on the species protected in the SAC – spined loach and river lamprey – are also excluded. This is confirmed by the fish survey, which states: based on the studies carried out, there is no reason to assume that construction of the proposed Saare-Liivi initial and additional area would affect the fish community of the Gulf of Riga on a transboundary basis and that impacts on species composition or abundance could extend into Latvian territorial waters. Cumulative impacts: The fish survey for the Saare-Liivi initial and additional area states that no adverse in-combination effect on the fish community will arise with the proposed Liivi Bay offshore wind farm (measures are set only for Baltic herring, but that species is not a conservation objective of the SAC and is not relevant in this case). In the context of the conservation objectives of the SAC, the occurrence of an in-combination effect is therefore not expected. The absence of adverse impacts on the SAC is also confirmed by the Natura assessment in the latest version of the EIA report for the Liivi Bay offshore wind farm, which concludes that no adverse impacts associated with the proposed activity will occur on any of the habitat types or on the status of any of the species that are conservation objectives of the Ainaži-Salacgriva SAC, and therefore there are also no impacts on the integrity of the SAC. The Natura screening in the draft programme for the Liivi Bay offshore wind farm extension area (extension of the Liivi Bay offshore wind farm) also reaches the same conclusion.¹⁰³	Appropriate assessment is not necessary.

Outcome and conclusions of the Natura screening

The Natura screening concludes that, upon implementation of the proposed activity, the occurrence of an adverse impact on the Ainaži-Salacgriva SAC is excluded, and an appropriate assessment is therefore not necessary.

The Natura screening concludes that the occurrence of an adverse impact from implementation of the activity cannot be excluded for the following Natura 2000 sites: Kihnu special area of conservation (SAC) and the Pärnu Bay, Väinameri, Kahtla-Kübassaare and Irbe Strait special protection areas (SPAs). For these sites, it is necessary to continue with the appropriate Natura assessment, i.e. the full assessment.

3.10.2. Appropriate Natura assessment

Assessment of the impact of the proposed activity on the integrity of Natura sites and the achievement of conservation objectives, and planning of mitigation measures

¹⁰³ Environmental impact assessment of the Liivi Bay offshore wind farm extension area. EIA programme. 04.12.2025, submitted to TTJA for publication on 24.04.2026 (letter 16-7/21-00173-143)

An appropriate assessment is carried out for the five Natura sites for which the screening conducted in this EIA report did not provide certainty as to the absence of impacts. The appropriate assessment is presented in the following Table 3.10-3.

Table 3.10-3 *Appropriate Natura assessment*

Natura site name	Impact assessment	Planning of mitigation measures
Kihnu special area of conservation (SAC) (EE0040313)	Of the conservation objectives of the SAC, only grey seal and ringed seal are potentially affected by construction of the Saare-Liivi additional area. According to the seal study, one of the five grey seal haul-out sites in the Gulf of Riga that are permanently occupied is located at Kihnu madal (within the Kihnu SAC). The haul-out site is located more than 20 km from the additional area and is the smallest grey seal haul-out site in the Gulf of Riga. The importance of this area in the Baltic Sea region lies mainly in the fact that it is the last suitable resting place for grey seals on the Estonian coast and may therefore be a necessary stopover site for so-called long-distance seals moving along the eastern shore of the Gulf of Riga. There is also a ringed seal haul-out site on the islets of Kihnu madal, which is currently used relatively little by ringed seals. The number of ringed seals counted or observed usually does not exceed a couple of dozen individuals. The importance of the Kihnu haul-out site as a resting area for the Estonian ringed seal population is low, and it is used by only a minority of the population. Environmental conditions within the SAC will remain unchanged, and construction of the wind farm in the additional area will not affect the seal haul-out sites there. Both species also occasionally use the Saare-Liivi additional area; for example, it lies in a ringed seal migration corridor that is used throughout the ice-free period. For grey seal and ringed seal, the impact assessment (Section 3.7 and Annex 3.10) concluded that impacts on seals are primarily associated with construction-phase underwater noise arising from certain technical alternatives (impact and vibratory driving of pile foundations) and can be mitigated. The relevant measures are set out in Section 3.7.4. In addition, measures have been established to reduce disturbance during the pupping period. During operation of the wind farm in the Saare-Liivi additional area, the more likely environmental disturbance is moderate underwater noise caused by the additional turbines and the movement of maintenance vessels. Such impacts are not expected to have population-level consequences, because, in the context of the Gulf of Riga as a whole, both the areas and the activities involve a modest proportion of seals' key habitats, including those within the Kihnu SAC. An operating wind farm is not known to constitute a direct migration or movement barrier for grey seals. The additional offshore wind farm area lies on the north-south migration corridor of the ringed seal, and a measure concerning turbine layout has therefore been established. Cumulative impact: The Natura assessment in the latest version of the EIA report for the proposed Liivi Bay offshore wind farm concludes that, according to the seal study carried out in that process, construction and operation of the wind farm will not cause significant negative impacts on seal populations in the area, and therefore no adverse	If impact or vibratory driving of pile foundations is selected as the technical alternative, the mitigation measures specified in Section 3.7.4 must be implemented in order to avoid the resulting impulsive noise. In addition, when designing the turbine layout, the functional permeability of the north-south movement corridor of ringed seals must be maintained: the spacing between turbines must not be less than the park's standard inter-turbine spacing (approximately 1 km) (measure set out in Section 3.7.4). With the implementation of mitigation measures (Section 3.7.4), the occurrence of such temporary or permanent disturbance as could reduce the possibility of achieving the grey seal or ringed seal conservation objective of the Kihnu SAC, or impair the

Natura site name	Impact assessment	Planning of mitigation measures
	impacts will occur on the status of grey seal and ringed seal as species that are conservation objectives of the Kihnu SAC (SKPK, 2024¹⁰⁴). On the basis of the baseline studies for the present EIA, cumulative impacts on seals are likewise generally not expected, except during construction-phase impact and vibratory pile driving, if such an alternative is selected and the construction periods at different wind farm sites overlap. However, by implementing mitigation measures (see Section 3.7.4), the cumulative impact of construction activities can be excluded. During the operational period of the wind farms, each wind farm generates noise within the boundaries of its own area, and neighbouring wind farms do not in practice increase the surrounding noise level.	integrity of the SAC, is excluded.
Pärnu Bay special protection area (SPA) (EE0040346)	Main alternative 3 of the Saare-Liivi additional area lies <i>approx.</i> 16 km from the nearest point of the SPA. Given the large distance, there are no direct (physical) impacts on the species that are conservation objectives of the SPA, or on their habitats within the SPA. Nor will there be significant disturbance within the SPA during construction or operation. The natural conditions and protected values of the SPA will be maintained in their current extent and value. The main potential impact on the SPA from the wind farm, located several kilometres away, may arise through collision risk or barrier effects if the SPA species are associated with the area of the particular wind farm and use the area, for example for feeding or during migration. The ornithological study found that, for most of the observed migratory bird species and species groups, the significance of collision risk can be assessed as low to medium. The most at risk are common crane (not a conservation objective of the SPA) and nocturnal migrants. The conservative population model prepared for the cumulative displacement of long-tailed duck and velvet scoter does not predict significant population-level impacts for these species. Predicted collision risks in the additional area for breeding species were low for all those considered (common gull, Arctic tern, common tern and Sandwich tern – these species are also conservation objectives of the SPA), and overall the significance of collision risk for breeding birds was assessed as low. The barrier effect may prove significant if the wind farm lies between nearby breeding colonies and the feeding grounds of the birds breeding in them. Several bird breeding islands are also located in the Pärnu Bay SPA, more than 20 km from the Saare-Liivi additional area. To investigate the spatial use of birds breeding on the islets, the four most important species were selected: common gull, Arctic tern, common tern and Sandwich tern, which are also conservation objectives of the SPA. According to telemetry data, the additional area is not a regular feeding ground for common gulls, Arctic terns, common terns or Sandwich terns breeding in the Pärnu Bay SPA, nor an important link between breeding colonies and feeding grounds. Collision risk is low for the aforementioned species	Based on the results of the ornithological study, Section 3.5.4 provides for measures to reduce bird collision risk. With the implementation of the measures, significant adverse impact, including cumulative impact, on the affected bird species, including species that are conservation objectives of the Pärnu Bay SPA, will be avoided. By implementing the mitigation measures specified in Section 3.5.4, the proposed activity will not have an adverse impact on the conservation objectives of the Pärnu Bay SPA.

¹⁰⁴ <https://ivis.ttja.ee/modules/dokumentiregister/view/1008841>

Natura site name	Impact assessment	Planning of mitigation measures
	and the barrier effect is insignificant. Therefore, the activity will not reduce the abundance or breeding success of the SPA's breeding populations, nor the availability of the functional marine area they require. In summary, the ornithological study of the Saare-Liivi additional area shows that some species that are conservation objectives of the SPA may pass through the offshore marine area of the Gulf of Riga (including the additional area). The observation data do not make it possible to associate these individuals with a specific SPA. The collision, barrier and displacement risk to species has been assessed in relation to their relevant biogeographical populations in Section 3.5, and no significant impact was predicted. Accordingly, no impact is expected that could adversely affect the status of the SPA conservation objective. Cumulative impact: For wind farms proposed in close proximity, in-combination effects may occur in terms of collision risk, barrier effect and displacement; these are addressed in more detail in Section 3.5.6, which covers the cumulative impact on birdlife of the initial and additional area of the Saare-Liivi wind farm, the Liivi Bay offshore wind farm and the Saare Wind Energy wind farm. The cumulative impact assessment found that significant cumulation of collision risks is generally not expected; nor is the occurrence of a barrier effect at a level affecting the status of populations expected, and the additional contribution of the Saare-Liivi additional area to displacement is small, but the in-combination effect of the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm gives rise to cumulative displacement. The existing conservative population model does not show a significant population-level impact, and the cumulative impact is therefore assessed as minor negative. The ecological assumption underlying the assessment is the maintenance in the Gulf of Riga of feeding and staging areas of sufficient quality and capacity, and of movement opportunities between them. In accordance with the precautionary principle, mitigation measures to reduce collision risk must be implemented in the additional area in order to reduce possible impacts, including cumulative impacts (see Section 3.5.4). With the implementation of mitigation measures, no impact on the bird species that are conservation objectives of the Pärnu Bay SPA, or on the integrity of the SPA, will arise from main alternative 3 of the Saare-Liivi additional area. There is no need for additional measures in relation to the Pärnu Bay SPA.	
Väinameri special protection area (SPA)	Main alternative 3 of the Saare-Liivi additional area lies <i>approx.</i> 45 km from the nearest point of the SPA. Given the large distance, there are no direct (physical) impacts on the species that are conservation objectives of the SPA, or on their habitats within the SPA. Nor will there be significant disturbance within the SPA during construction or operation. The natural conditions and protected values of the SPA will be maintained in their current extent and value. The main potential impact on the SPA from the additional area, located tens of kilometres away, may arise primarily through collision risk if the SPA species are associated with the area of the particular wind farm and use the area, for example for feeding or during migration. Although the importance of the Saare-Liivi additional area for migratory birds was assessed as very high, the predicted numbers of collisions are mostly low and constitute a very small	Based on the results of the ornithological study, Section 3.5.4 provides for measures to reduce bird collision risk. With the implementation of the measures, significant adverse impact, including cumulative impact, on the affected bird species,

Natura site name	Impact assessment	Planning of mitigation measures
	proportion of the sizes of the biogeographical populations. The highest collision risk was identified for common crane and nocturnal migrants. Accordingly, the additional area-specific mitigation measures focus primarily on avoiding and reducing collision risk (set out in Section 3.5.4 of this report). The measures are directed, inter alia, at the main risk species, common crane, which is also a conservation objective of the Väinameri SPA. There is no need to establish measures additional to those in Section 3.5.4 for the Väinameri SPA; this conclusion assumes the binding implementation of the measures in Section 3.5.4. In summary, the ornithological study of the Saare-Liivi additional area shows that some species that are conservation objectives of the SPA may pass through the offshore marine area of the Gulf of Riga (including the additional area). The observation data do not make it possible to associate these individuals with a specific SPA. The collision, barrier and displacement risk to species has been assessed in relation to their relevant biogeographical populations in Section 3.5, and no significant impact was predicted. Accordingly, no impact is expected that could adversely affect the status of the SPA conservation objective. Cumulative impact: For wind farms proposed in close proximity, in-combination effects may occur in terms of collision risk, barrier effect and displacement; these are addressed in more detail in Section 3.5.6, which covers the cumulative impact on birdlife of the initial and additional area of the Saare-Liivi wind farm, the Liivi Bay offshore wind farm and the SWE wind farm. The cumulative impact assessment found that significant cumulation of collision risks is generally not expected; nor is the occurrence of a barrier effect at a level affecting the status of populations expected, and the additional contribution of the Saare-Liivi additional area to displacement is small, but the in-combination effect of the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm gives rise to cumulative displacement. The existing conservative population model does not show a significant population-level impact, and the cumulative impact is therefore assessed as minor negative. The ecological assumption underlying the assessment is the maintenance in the Gulf of Riga of feeding and staging areas of sufficient quality and capacity, and of movement opportunities between them. In accordance with the precautionary principle, mitigation measures to reduce collision risk must be implemented in the additional area in order to reduce possible negative impacts, including cumulative impacts (see Section 3.5.4). With the implementation of mitigation measures, no impact on the bird species that are conservation objectives of the Väinameri SPA, or on the integrity of the SPA, will arise from main alternative 3 of the Saare-Liivi additional area. There is no need for additional measures in relation to the Väinameri SPA.	including species that are conservation objectives of the Väinameri SPA, will be avoided. By implementing the mitigation measures specified in Section 3.5.4, the proposed activity will not have an adverse impact on the conservation objectives of the Väinameri SPA.
Kahtla-Kübassaare special protection area (SPA)	Main alternative 3 of the Saare-Liivi additional area lies <i>approx.</i> 37 km from the nearest point of the SPA. Given the large distance, there are no direct (physical) impacts on the species that are conservation objectives of the SPA, or on their habitats within the SPA. Nor will there be significant disturbance within the SPA during construction or operation. The natural conditions and protected values of the SPA will be maintained in their current extent and value.	In accordance with the precautionary principle, and based on the results of the ornithological study, Section 3.5.4 provides for measures to reduce bird

Natura site name	Impact assessment	Planning of mitigation measures
	The main potential impact on the SPA from the additional area, located tens of kilometres away, may arise primarily through collision risk if the SPA species are associated with the additional area and use the area, for example for feeding or during migration. Although the importance of the Saare-Liivi additional area for migratory birds was assessed as very high, the predicted numbers of collisions are mostly low and constitute a very small proportion of the sizes of the biogeographical populations. The highest collision risk was identified for common crane and nocturnal migrants. Common crane is also a conservation objective of the Kahtla-Kübassaare SPA. The ornithological study found that, in the case of the Saare-Liivi additional area, only collision risk would require mitigation, for which mitigation measures have been established under Section 3.5.4 (set out in Section 3.5.4 of this EIA report). In summary, the ornithological study of the Saare-Liivi additional area shows that some species that are conservation objectives of the SPA may pass through the offshore marine area of the Gulf of Riga (including the additional area). The observation data do not make it possible to associate these individuals with a specific SPA. The collision, barrier and displacement risk to species has been assessed in relation to their relevant biogeographical populations in Section 3.5, and no significant impact was predicted. Accordingly, no impact is expected that could adversely affect the status of the SPA conservation objective. Cumulative impact: For wind farms proposed in close proximity, in-combination effects may occur in terms of collision risk, barrier effect and displacement; these are addressed in more detail in Section 3.5.6, which covers the cumulative impact on birdlife of the initial and additional area of the Saare-Liivi wind farm, the Liivi Bay offshore wind farm and the SWE wind farm. The cumulative impact assessment found that significant cumulation of collision risks is generally not expected; nor is the occurrence of a barrier effect at a level affecting the status of populations expected, and the additional contribution of the Saare-Liivi additional area to displacement is small, but the in-combination effect of the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm gives rise to cumulative displacement. The existing conservative population model does not show a significant population-level impact, and the cumulative impact is therefore assessed as minor negative. The assessment assumes that important stopover areas around the Saare-Liivi initial area will be avoided and that the final positioning of the turbines of the Liivi Bay offshore wind farm will avoid important areas. In accordance with the precautionary principle, mitigation measures to reduce collision risk must be implemented in the additional area in order to reduce possible negative impacts, including cumulative impacts (see Section 3.5.4). With the implementation of mitigation measures, no impact on the bird species that are conservation objectives of the Kahtla-Kübassaare SPA, or on the integrity of the SPA, will arise from main alternative 3 of the Saare-Liivi additional area. There is no need for additional measures in relation to the Kahtla-Kübassaare SPA.	collision risk. With the implementation of the measures, significant adverse impact, including cumulative impact, on the affected bird species, including species that are conservation objectives of the Kahtla-Kübassaare SPA, will be avoided. By implementing the mitigation measures specified in Section 3.5.4, the proposed activity will not have an adverse impact on the conservation objectives of the Kahtla-Kübassaare SPA.
Irbe Strait special	Main alternative 3 of the Saare-Liivi additional area lies <i>approx.</i> 31 km from the nearest point of the SPA. Given the large distance, there are no direct (physical) impacts on the species that are conservation objectives of the SPA, or on their habitats within the SPA. Nor will there be significant disturbance within the SPA during construction or	In accordance with the precautionary principle, and based on the results of

<i>Natura site name</i>	<i>Impact assessment</i>	<i>Planning of mitigation measures</i>
protection area (SPA)	operation. The natural conditions and protected values of the SPA will be maintained in their current extent and value. Given that the Irbe Strait SPA encompasses the southern coast of Saaremaa, including the area around Sõrve peninsula, which is an important guiding line for bird migration, there is no reason to assume that the Saare-Liivi additional area, located several tens of kilometres to the east, would be functionally connected with the SPA or with migration passing through it. The main potential impact on the SPA from the wind farm, located tens of kilometres away, may arise primarily through collision risk if the SPA species are associated with the area of the particular wind farm and use the area, for example for feeding or during migration. Although the importance of the Saare-Liivi additional area for migratory birds was assessed as very high, the predicted numbers of collisions are mostly low and constitute a very small proportion of the sizes of the biogeographical populations. The highest collision risk was identified for common crane and nocturnal migrants. However, the measures established are directed at the main risk species, common crane, which is not a conservation objective of the SPA. In summary, the ornithological study of the Saare-Liivi additional area shows that some species that are conservation objectives of the SPA may pass through the offshore marine area of the Gulf of Riga (including the additional area). The observation data do not make it possible to associate these individuals with a specific SPA. The collision, barrier and displacement risk to species has been assessed in relation to their relevant biogeographical populations in Section 3.5, and no significant impact was predicted. Accordingly, no impact is expected that could adversely affect the status of the SPA conservation objective. Cumulative impact: For wind farms proposed in close proximity, in-combination effects may occur in terms of collision risk, barrier effect and displacement; these are addressed in more detail in Section 3.5.6, which covers the cumulative impact on birdlife of the initial and additional area of the Saare-Liivi wind farm, the Liivi Bay offshore wind farm and the SWE wind farm. The cumulative impact assessment found that significant cumulation of collision risks is generally not expected; nor is the occurrence of a barrier effect at a level affecting the status of populations expected, and the additional contribution of the Saare-Liivi additional area to displacement is small, but the in-combination effect of the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm gives rise to cumulative displacement. The existing conservative population model does not show a significant population-level impact, and the cumulative impact is therefore assessed as minor negative. The ecological assumption underlying the assessment is the maintenance in the Gulf of Riga of feeding and staging areas of sufficient quality and capacity, and of movement opportunities between them.	the ornithological study, Section 3.5.4 provides for measures to reduce bird collision risk. With the implementation of the measures, significant adverse impact, including cumulative impact, on the affected bird species, including species that are conservation objectives of the Irbe Strait SPA, will be avoided. By implementing the mitigation measures specified in Section 3.5.4, the proposed activity will not have an adverse impact on the conservation objectives of the Irbe Strait SPA

<i>Natura site name</i>	<i>Impact assessment</i>	<i>Planning of mitigation measures</i>
	In accordance with the precautionary principle, mitigation measures to reduce collision risk must be implemented in the wind farms to be constructed in order to reduce possible negative impact (see Section 3.5.4). With the implementation of mitigation measures, no impact on the bird species that are conservation objectives of the Irbe Strait SPA, or on the integrity of the SPA, will arise from main alternative 3 of the Saare-Liivi additional area. There is no need for additional measures in relation to the Irbe Strait SPA.	

CAN THE PROPOSED ACTIVITY ADVERSELY AFFECT THE INTEGRITY OF THE SITE?

The conservation status of a Natura site remains favourable and the integrity of the site is ensured if the essential characteristics of the site concerned are permanently maintained. If the absence of adverse impact cannot be demonstrated, mitigation measures must be planned to prevent the adverse impact. To assess whether the proposed activity as a whole or its various aspects are likely to have an adverse impact on the integrity of Natura sites, the following table presents a checklist together with answers for each Natura site assessed.

Table 3.10-4 Checklist questions on maintaining the integrity of Natura 2000 sites

Can the project:	Kihnu SAC	Pärnu Bay SPA	Väinameri SPA	Kahtla-Kübassaare SPA	Irbe Strait SPA
Reduce the area of the site's habitat types or the abundance of the species for whose protection the site was designated?	no	no	no	no	no
Cause disturbance that may affect population sizes, the balance between species or population density?	no	no	no	no	no
Cause species to relocate and thereby reduce the range of those species in the area?	no	no	no	no	no
Cause fragmentation of Annex I habitats or species?	no	no	no	no	no
Cause the reduction or loss of key features (e.g. woody vegetation cover, exposure to tidal action, annual flooding, etc.)?	no	no	no	no	no
Disturb the balance, distribution and population density of key species used as indicators of the site's favourable condition?	no	no	no	no	no
Delay or prevent the achievement of the site's conservation objectives?	no	no	no	no	no
Cause changes in critically important, site-defining aspects (e.g. nutrient balance) on which the site's functioning in favourable condition as a habitat or ecosystem depends.	no	no	no	no	no

The answers indicate that, after the implementation of binding avoidance and mitigation measures, any possible residual impacts do not reach a level that would adversely affect the achievement of the sites' conservation objectives or their integrity. The answers do not mean that the project will cause no temporary or minor impact to any individual or to any marine area located outside Natura sites.

3.10.3. Planning of mitigation measures

The Natura assessment (Table 3.10-3) showed that, with the implementation of binding avoidance and mitigation measures, the activities planned for the marine area (in the Saare-Liivi additional area) do not affect the conservation objectives or the achievement thereof for any of the Natura sites assessed, and the integrity of all Natura sites will be maintained (Table 3.10-4).

To ensure the favourable status of the conservation objectives of the Kihnu SAC, mitigation measures must be implemented:

- If, as the technical alternative, impact or vibratory driving of pile foundations is selected, the mitigation measures specified in Section 3.7.4 must be implemented in order to reduce the impact of the resulting underwater noise and to prevent permanent hearing damage.
- When designing the turbine layout in the additional area, the functional permeability of the north–south movement corridor of ringed seals must be maintained: the spacing between turbines must not be less than the park’s standard inter-turbine distance (approximately 1 km).

To safeguard the conservation objectives of the **Pärnu Bay, Väinameri, Kahtla-Kübassaare and Irbe Strait SPAs**, a mitigation measure must be implemented in accordance with the precautionary principle:

- To reduce possible negative impact, mitigation measures to reduce collision risk must be implemented (see Section 3.5.4).

The greatest in-combination effect (i.e. cumulative impact) of the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm may be birds’ collision risk with turbines; to minimise this, mitigation measures to reduce collision risk must be implemented in the additional area (see Section 3.5.4) in order to avoid adverse impact on the conservation objectives of the Pärnu Bay, Väinameri, Kahtla-Kübassaare and Irbe Strait SPAs.

The additional contribution of the Saare-Liivi additional area to displacement is small, but the in-combination effect of the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm may give rise to cumulative displacement. The existing conservative population model does not show a significant population-level impact, and the cumulative impact is therefore assessed as minor negative. The ecological assumption underlying the assessment is the maintenance in the Gulf of Riga of feeding and staging areas of sufficient quality and capacity, and of movement opportunities between them. This assumption takes into account the spatial avoidance already applied in the EIA for the Saare-Liivi initial area and, in the design solutions of other projects included in the assessment, such as the final placement of turbines for the Liivi Bay offshore wind farm, the need to preserve important staging areas.

The seabed loss and disturbance associated with the section of the export cable route within the additional area are included in the impact assessment of the additional area; the export cable routes within the initial area are assessed in the EIA report for the initial area. In addition, this report addresses the in-combination effect of the export cable routes of the initial and additional area.. The assessment of the in-combination effect of seabed loss and disturbance presented in Section 3.4 covers the entire export cable route from the offshore substation of the additional area, via the offshore substation(s) of the initial area, to the landfall point. Along the entire extent of that connection, the suspended matter dispersion associated with cable installation has also been modelled (see Section 3.3). Accordingly, the Natura assessment has taken into account the impacts of the connection cables running through both the additional area and the initial area, including the in-combination effect with the infrastructure of the Saare-Liivi initial area (see Sections 3.3, 3.4 and Appendix 3.4).

3.10.4. Results and conclusions of the Natura assessment

The Natura screening ruled out adverse impact on the Ainaži–Salacgriva SAC from the implementation of main alternative 3 of the additional area. A Natura appropriate assessment was carried out for the Kihnu SAC and the Pärnu Bay, Väinameri, Kahtla-Kübassaare and Irbe Strait SPAs.

In the appropriate assessment, all relevant sources of impact and project stages relating to main alternative 3 of the additional area were assessed, based on the technical solution with the greatest realistic impact considered in the EIA. The impact was assessed both separately for the additional area

and in combination with the initial area of the Saare-Liivi offshore wind farm, the Liivi Bay offshore wind farm and, for relevant impact pathways, the Saare Wind Energy offshore wind farm.

The assessment found that the proposed activity may entail temporary or minor negative residual impact at the level of individuals, offshore habitat use, migration behaviour and exposure to underwater noise. After the implementation of the binding avoidance and mitigation measures set out in this chapter and in Sections 3.5.4 and 3.7.4, the impact does not reach such an extent, intensity or duration as would reduce the populations of species that are conservation objectives of the Natura site, deteriorate the ecological function of the sites, hinder the achievement of the conservation objectives or adversely affect the integrity of the sites.

On the basis of the best available scientific knowledge, the EIA baseline studies, impact modelling and the proposed binding measures, there is no reasonable scientific doubt that the implementation of main alternative 3 of the additional area, either alone or in combination with other plans and projects, will not adversely affect the integrity of the Kihnu SAC, Pärnu Bay SPA, Väinameri SPA, Kahtla-Kübassaare SPA or Irbe Strait SPA.

If the final layout plan, turbine model, foundation installation method, construction schedule or the solution of other projects changes in a way that differs from the technical or spatial solution considered in this Natura assessment, the validity of the conclusions of the Natura assessment must be checked again before the activity is permitted.

3.10.5. Uncertainty/knowledge gaps

The conclusions of the Natura appropriate assessment are based on the baseline studies for the additional area and on the assessments presented in the EIA report deemed compliant for the Saare-Liivi initial area and the export cable route.

As regards birdlife, the survey data do not allow individuals recorded offshore to be linked to a specific SPA. Collision, barrier and displacement risks have therefore been assessed in relation to the relevant biogeographical populations of the species, rather than at the level of the breeding population of the SPA. The telemetry study covered four conservation objective species and was based on one breeding season, which limits the assessment of interannual variability in spatial use. For the studied gulls and terns breeding in the Pärnu Bay SPA, telemetry data on colonies, feeding areas and flight routes supplement the population-level analysis (Table 3.10-3); the biogeographical population threshold is not used as a standalone basis for ruling out impact on the integrity of the SPA.

The cumulative impact assessment is limited by differences in the survey and modelling methodologies used in different offshore wind farms and by the absence of a unified database on bird studies for Baltic Sea offshore wind farms. The assessment of cumulative displacement is based on a conservative population model, which does not show a significant population-level impact, and the cumulative impact is therefore assessed as minor negative. The ecological assumption underlying the assessment is the maintenance in the Gulf of Riga of feeding and staging areas of sufficient quality and capacity, and of movement opportunities between them. This assumption takes into account the spatial avoidance already applied in the EIA for the Saare-Liivi initial area and, in the design solutions of other projects included in the assessment, such as the final placement of turbines for the Liivi Bay offshore wind farm, the need to preserve important staging areas.

The uncertainties identified do not alter the conclusions of the Natura appropriate assessment or the assessments regarding the conservation objectives of the SPAs and SACs and the favourable status of the

species. Uncertainty will be reduced through monitoring of the conservation objective species in accordance with the bird and seal monitoring plan, and by checking the validity of the conclusions before the activity is permitted.

3.11. Impact on climate

The impact on climate of the Saare-Liivi offshore wind farm initial area has been assessed in the EIA report for the initial area deemed compliant. This chapter does not repeat the treatment of the initial area in full, but instead assesses the incremental impact of main alternative 3 of the additional area and the cumulative impact of the Saare-Liivi initial and additional area.

In international environmental impact assessment practice, climate change is considered from three interrelated perspectives: the project's whole-life-cycle greenhouse gas emissions and contribution to climate change mitigation, the project's resilience to future climatic conditions, and the potential interaction of climate change with impacts on other environmental elements (European Commission, 2021¹⁰⁵¹⁰⁶; Dublin Array Wind Farm Ltd, 2025¹⁰⁷). The same approach is used in this EIA.

In the Baltic Sea region, increases in air and seawater temperatures and sea level, and a decrease in average sea-ice extent, are expected during the 21st century. Possible changes in extreme wind, wave and storm-surge conditions involve greater uncertainty, and therefore up-to-date regional projections and an appropriate safety margin must be used when assessing the climate resilience of structures¹⁰⁸.

The assessment distinguishes between GHG emissions arising over the project's own life cycle, the reference-scenario emissions potentially avoided through electricity generation, and the net whole-life-cycle climate impact resulting from the difference between these two components.

3.11.1. Consideration of alternatives

Under main alternative 3, up to 40 turbines are planned for the additional area. Under technical alternative A, the total capacity of the additional area is up to 600 MW and the expected annual gross generation is approximately 2.7 TWh. Under technical alternative B, the corresponding figures are up to 800 MW and approximately 3.5 TWh of expected annual gross generation.

Together with up to 80 turbines in the Saare-Liivi initial area, the total capacity would amount to up to 1800 MW and the expected annual gross generation to approximately 8.1 TWh under technical alternative A, and to up to 2400 MW and approximately 10.5 TWh under technical alternative B.

¹⁰⁵ European Commission, 2021. *Technical Guidance on the Climate Proofing of Infrastructure in the Period 2021–2027. Methodological framework for climate change mitigation and climate resilience*; <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX%3A52021XC0916%2803%29>

¹⁰⁶ European Commission, 2026. *European Climate Law. Climate targets for 2030, 2040 and 2050*. https://climate.ec.europa.eu/eu-action/european-climate-law_en

¹⁰⁷ Dublin Array Wind Farm Ltd, 2025. *Environmental Impact Assessment Report, Volume 3, Chapter 18: Climate Change. A project-specific application example for the whole life cycle, climate resilience and interaction approach*.

¹⁰⁸ HELCOM, 2024. *Climate Change in the Baltic Sea. Overview of climate change in the Baltic Sea region*. https://helcom.fi/wp-content/uploads/2024/10/Baltic-Sea-Climate-Change-Fact-Sheet_2024.pdf

Table 3.11-1. Total capacities of the Saare-Liivi initial and additional area

Assessed solution	Technical alternative A, 15 MW	Technical alternative B, 20 MW
Saare-Liivi additional area, main alternative 3, 40 turbines	600 MW; approx. 2.7 TWh/a	800 MW; approx. 3.5 TWh/a
Saare-Liivi initial area, 80 turbines	1200 MW; approx. 5.4 TWh/a	1600 MW; approx. 7.0 TWh/a
Saare-Liivi initial and additional area, 80 + 40 turbines	1800 MW; approx. 8.1 TWh/a	2400 MW; approx. 10.5 TWh/a

Due to the higher electricity generation of technical alternative B, its potential contribution to reducing GHG emissions in the electricity system is greater. At the same time, the material requirements of larger turbines, foundations and infrastructure may result in higher absolute life-cycle GHG emissions. Therefore, it is not justified to compare the climate impact of the technical alternatives solely on the basis of installed capacity or generation.

3.11.2. Climate change mitigation and life-cycle greenhouse gas emissions

Estonia's total greenhouse gas emissions in 2024 were approximately 12.15 million tonnes CO₂-eq and, excluding the land use, land-use change and forestry sector, 10.2 million tonnes CO₂-eq. The energy sector accounted for approximately 26% of total emissions. Estonia's total emissions decreased by 9% in 2024 compared with 2023 and by 66.5% compared with 1990. At the same time, electricity generation from fossil fuels decreased, while the amount of electricity generated from renewable energy sources increased. These data describe the national baseline situation, but are not used as a direct calculation basis for the offshore wind farm's avoided emissions. The climate impact of the wind farm is assessed on the basis of the electricity system reference scenario and the project's whole-life-cycle emissions.¹⁰⁹

GHG emissions arise primarily from the production of steel, concrete, copper, composite materials and other components, the transport of components, the installation of foundations and turbines, the use of maintenance and service vessels, the replacement of components, and the decommissioning of the wind farm. Fluorinated greenhouse gases used in electrical equipment must also be taken into account as a potential emission source. The preference, where possible, for SF₆-free solutions envisaged in the developer's technical description reduces that risk.

Offshore wind energy is among the lowest-emitting electricity generation technologies in terms of life-cycle greenhouse gas emissions. According to the life-cycle assessment report¹¹⁰ of the United Nations Economic Commission for Europe (UNECE), the life-cycle emissions of electricity generation technologies fall within the following ranges:

- Coal: 751–1095 g CO₂-eq/kWh
- Natural gas: 403–513 g CO₂-eq/kWh
- Solar energy (concentrated solar power): 27–122 g CO₂-eq/kWh
- Solar energy (photovoltaic): 8.0–83 g CO₂-eq/kWh
- Hydropower: 6–147 g CO₂-eq/kWh
- Wind energy (offshore): 12–23 g CO₂-eq/kWh
- Wind energy (onshore): 7.8–16 g CO₂-eq/kWh
- Nuclear energy: 5.1–6.4 g CO₂-eq/kWh

¹⁰⁹ Ministry of Climate, 2026. Estonian greenhouse gas inventory 1990–2024. <https://envir.ee/kliima/kasvuhoonegaasid>

¹¹⁰ UNECE, 2021. Life Cycle Assessment of Electricity Generation Options. Comparison of the life-cycle emissions of electricity generation technologies. https://unece.org/sites/default/files/2022-04/LCA_3_FINAL%20March%202022.pdf

The life-cycle emissions of offshore wind energy are therefore approximately 40 times lower than those of natural-gas-based electricity generation and approximately 60 times lower than those of coal-based electricity generation. Replacing fossil-fuel-based generation with offshore wind energy significantly reduces greenhouse gas emissions from electricity generation, irrespective of which value within the range is taken as the basis for comparison. The ranges reflect differences between technologies, locations and the methodologies used; for renewable energy technologies, emissions originate predominantly from the production, construction and decommissioning stages, as no direct emissions arise during the operational period. At the EIA stage, it is not possible to prepare a project-specific life-cycle calculation for the Saare-Liivi additional area based on final material quantities and supplier data. The UNECE-published range of 12–23 g CO₂-eq/kWh for the life-cycle GHG emissions of offshore wind energy is used in this EIA as an indicative benchmark for the technology's general carbon intensity.¹¹¹ The range is not a project-specific life-cycle calculation for the Saare-Liivi additional area. It does not reflect the material requirements of the specific turbines and foundations, supply chains, the construction port, installation and maintenance vessels, the cable and substation solution, curtailment or decommissioning.

The results presented in Table 3.11-2 should therefore be referred to as an indicative technology-based range, not as the "whole-life-cycle emissions" of the Saare-Liivi initial and additional area.

Table 3.11-2. *Indicative whole-life-cycle emissions of the Saare-Liivi initial and additional area (* assuming that the UNECE range of 12–23 g CO₂-eq/kWh is applied to 30-year gross generation)*

Solution	30-year gross generation	Indicative life-cycle emissions corresponding to the UNECE range
Saare-Liivi additional area, variant A	81 TWh	0.97–1.86 million tonnes CO ₂ -eq
Saare-Liivi additional area, variant B	105 TWh	1.26–2.42 million tonnes CO ₂ -eq
Saare-Liivi initial and additional area, variant A	243 TWh	2.92–5.59 million tonnes CO ₂ -eq
Saare-Liivi initial and additional area, variant B	315 TWh	3.78–7.25 million tonnes CO ₂ -eq

In calculating emissions avoided through electricity generation, the net electricity supplied to the grid and a justified reference scenario must be used. Using a single historical average electricity emission factor provides only a sensitivity calculation corresponding to the conditions of a specific year. The actual generation displaced and its GHG emissions will change over the project's operational period due to the decarbonisation of the electricity system, storage capacities, interconnectors, demand and curtailment.

The offshore wind farm's net whole-life-cycle climate impact is determined by the difference between the emissions potentially avoided under the reference scenario and the project's life-cycle emissions. Given the scale of the proposed electricity generation and the low life-cycle carbon intensity of offshore wind energy, it is reasonable to assume that the net climate impact of both the additional area alone and in combination with the Saare-Liivi initial area will be significantly positive throughout the entire operational period.

The calculation presented in Table 3.11-3 is an illustrative sensitivity calculation using the 2021 historical electricity emission factor of 0.648 t CO₂-eq/MWh applied in the EIA for the initial area, together with the assumption that 95% of gross generation is supplied to the grid. The result is not treated as a forecast for the wind farm's entire operational period, because the electricity system emission factor, curtailment, own consumption and grid losses change over time. The offshore wind farm's own life-cycle GHG emissions have not been deducted from the values presented in the table.

¹¹¹ UNECE, 2021. *Life Cycle Assessment of Electricity Generation Options. Comparison of the life-cycle emissions of electricity generation technologies*. https://unece.org/sites/default/files/2021-11/LCA_final.pdf

Table 3.11-3. *Illustrative sensitivity calculation based on the 2021 historical electricity emission factor; not a forecast for the project's operational period*

Assessed solution	Gross generation, TWh/a	Derived capacity factor	Indicative net generation at 95%, TWh/a	Avoided emissions based on gross generation, million tonnes CO ₂ -eq/a	Avoided emissions based on net generation, million tonnes CO ₂ -eq/a
Saare-Liivi additional area, variant A	2.7	51.4%	2.565	1.750	1.662
Saare-Liivi additional area, variant B	3.5	49.9%	3.325	2.268	2.155
Saare-Liivi initial and additional area, variant A	8.1	51.4%	7.695	5.249	4.986
Saare-Liivi initial and additional area, variant B	10.5	49.9%	9.975	6.804	6.464

Using, for illustrative purposes, the 2021 Estonian electricity emission factor applied in the EIA for the initial area, the annual net generation supplied to the grid for technical alternative A of the Saare-Liivi initial and additional area would correspond to potentially avoided emissions of approximately 4.99 million tonnes CO₂-eq. For technical alternative B, the corresponding result of the sensitivity calculation would be approximately 6.46 million tonnes CO₂-eq per year. For the entire 30-year operational period, according to the sensitivity calculation, the potentially avoided emissions would be approximately 49.9 million tonnes CO₂-eq for Saare-Liivi additional area variant A and 64.7 million tonnes CO₂-eq for variant B, and for the Saare-Liivi initial and additional area in combination approximately 149.6 and 193.9 million tonnes CO₂-eq respectively. Compared with the indicative life-cycle emissions presented in Table 3.11-2, the potentially avoided emissions exceed the project's life-cycle emissions by approximately 27–51 times. The ratio is the same for all assessed solutions, because both avoided emissions and life-cycle emissions increase in proportion to electricity generation; it depends solely on the relationship between the emission factor of the reference scenario and the carbon intensity of the technology. The conclusion regarding the project's positive net climate impact is therefore robust with respect to both the choice of technical solution and the life-cycle emissions range. Since life-cycle emissions have been calculated on the basis of gross generation and avoided emissions on the basis of net generation, the ratio presented is likely to be underestimated. This is not a forecast for the entire operational period, because the electricity system emission factor decreases as it decarbonises.

The low-life-cycle-emission electricity generated by the Saare-Liivi offshore wind farm can, in addition to the direct decarbonisation of electricity generation, support the electrification of transport, building heating and cooling systems, and industrial processes. Therefore, the project's broader climate benefit depends on whether the electricity grid, storage, demand management and the reorganisation of energy use enable the renewable electricity generated to be used efficiently. Rapid decarbonisation of the electricity system and electrification based on low-emission electricity are among the central ways of reducing emissions in international climate scenarios.

3.11.3. Climate change adaptation and project climate resilience

In assessing climate resilience, the climate hazards relevant to the proposed wind farm and the exposure of the wind farm components to those hazards and the resulting vulnerability

throughout the entire proposed operational period are analysed. The significance of climate risk depends both on the likelihood of the climate hazard materialising and on its possible consequences for turbines, foundations, cables, the offshore substation, maintenance arrangements and electricity generation. In developing the final project solution, updated regional climate and marine models must be used as the basis, ensuring a sufficient safety margin in the project solution¹¹².

The proposed operational lifetime of the Saare-Liivi additional area is at least 30–35 years, and some seabed infrastructure may remain in the sea for longer. Therefore, in designing the additional area, account must be taken not only of historical climate and marine conditions, but also of the future conditions expected during construction, operation and decommissioning.

From the perspective of the climate resilience of the Saare-Liivi additional area, the main potential changes are:

- a rise in mean and extreme sea levels;
- possible changes in extreme wind and wave conditions;
- changes in seabed erosion and scour around foundations;
- a rise in mean temperature and an increase in the frequency of heatwaves;
- a reduction in mean sea ice extent, while individual ice-rich winters and icing risk remain;
- the effects of changes in seawater temperature and chemical properties on corrosion;
- weather-related changes in the periods suitable for construction and maintenance works;
- long-term changes in wind conditions, which may affect both electricity generation and the loads acting on structures.

These risks must be taken into account in the design of turbines, foundations, the offshore substation and cables, and in the maintenance of the wind farm. To ensure climate resilience, it is necessary, among other things, to take future water levels and wave conditions into account, determine a suitable height for the substation and access platforms, design foundations for extreme loads, apply scour and corrosion protection, ensure cable protection by means of a solution appropriate to seabed conditions (burial, covering or other technical protection) and use monitoring and operational solutions suitable for ice and icing conditions. With proper design, technical monitoring and maintenance, the residual risk arising from climate change to the wind farm's safety and reliability is assessed as low.

3.11.4. Interaction of climate change with other environmental impacts

Climate change may alter the baseline conditions for the impacts of the proposed activity and the sensitivity of receptors. In this EIA, the most important potential interactions are as follows:

- changed wind, wave and water-level conditions may affect hydrodynamics, seabed scour and cable cover; this relationship is discussed in sections 3.1 and 3.2;
- rising water temperature and changes in stratification and oxygen conditions may affect seawater quality, benthic communities and fish fauna, and increase their sensitivity to additional pressures; see sections 3.3, 3.4 and 3.8;
- reduced sea ice particularly affects ringed seal pupping conditions and may increase the population's sensitivity to other disturbances; see section 3.7;

¹¹² European Commission, 2021. *Technical Guidance on the Climate Proofing of Infrastructure in the Period 2021–2027. Methodological framework for climate change mitigation and climate resilience*; <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX%3A52021XC0916%2803%29>

- the timing, duration and intensity of bird and bat migration may change due to climate change, and adaptive operational measures must therefore be based on actual monitoring, not solely on historical calendar periods; see sections 3.5 and 3.6;
- changes in extreme weather and marine conditions may affect vessel traffic, maintenance, and the organisation of search and rescue operations; see sections 6.1 and 6.2.

Based on the information available, no grounds have been identified for revising the main conclusions on impact significance presented in the chapters on the other impact topics. At the same time, changing climate and marine conditions may affect receptor sensitivity, the timing of impacts and the effectiveness of technical measures, and an adaptive approach must therefore be applied in the topic-specific monitoring plans.

3.11.5. Environmental measures

To reduce the life-cycle GHG emissions of the wind farm in the additional area and ensure climate resilience, it is recommended during final design and procurement to:

- give preference to technically suitable steel, concrete and other material solutions with a lower carbon footprint, and to as high a share of recycled materials as possible;
- optimise material use in foundations and other infrastructure, component transport, and the use of installation and maintenance vessels;
- where possible, give preference to SF₆-free electrical equipment; where SF₆ is used, ensure leak monitoring, maintenance and proper handling;
- take future climate and marine conditions throughout the entire operational period into account in the design;
- update the decommissioning plan before cessation of operations, based on the best recycling and reuse technology available at that time.
- carry out a project-specific life-cycle calculation and climate resilience check to refine the climate impact of the final project solution, and collect operational data on actual net generation and production curtailment; on cessation of operations, record the proportion of materials recycled and reused.

An adaptive approach must be applied in the topic-specific monitoring plans, taking into account the potential impact of changes in climate and marine conditions on receptor sensitivity, the timing of impacts and the effectiveness of measures (see section 3.11.4).

3.11.6. Summary

Table 3.11-4. Impact associated with planning the wind farm and its significance

Associated consequence/impact	Impact before measures	Measures and final assessment
Climate impact	++	
Life-cycle GHG emissions from the production of materials, transport, construction, maintenance and decommissioning	–	Lower-emission materials, logistics and circular solutions; Residual impact –
Low life-cycle-emission electricity generation and the possible displacement of fossil generation in the electricity system	++	The realisation of the positive impact depends on the grid connection, net generation and the utilisation of the electricity generated; Residual impact ++
Net climate impact over the entire life cycle	++	No measures are required. Residual impact ++
Impact of climate change on the wind farm's safety and reliability	low to moderate risk	Climate-resilient design, monitoring and maintenance; residual risk low
Interaction of climate change with other environmental impacts	0/–	Topic-specific measures and adaptive monitoring; residual impact 0/–

Scale of significant environmental impact used in the EIA report: – slight negative impact, -- significant negative impact, 0 - no impact, neutral, + slight positive impact, ++ significant positive impact

3.11.7. Cumulative and transboundary environmental impact

Over the entire life cycle, the construction and operation of the Saare-Liivi initial and additional area and the other proposed offshore wind farms in the Gulf of Riga involve both GHG emissions and an increase in low-carbon-intensity electricity generation. The impact of offshore wind farms on climate change mitigation is positive, as the GHG emissions arising over their entire life cycle are significantly lower than the emissions under the reference scenario avoided by the electricity generated.

The amounts of avoided GHG emissions from the projects can be added together only if the underlying assumptions are comparable. For this, among other things, the system boundary, the electricity system emission factors, the operational period and the accounting of electricity generation must be harmonised. In addition, the simultaneous addition of several large renewable electricity generation capacities may alter the structure of the electricity generation being displaced and increase the need for grid reinforcement, storage capacity and production curtailment. Therefore, it is not justified to aggregate separate calculation results from different projects without harmonising the underlying assumptions.

A uniform methodology and reference scenario would therefore be needed for a quantitative assessment of the aggregate climate impact of the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm. Based on the information currently available, the cumulative net impact of the projects on climate change mitigation is assessed as significantly positive, as they increase the volume of low life-cycle-emission electricity generation.

The impact of GHG emissions is global and transboundary in nature. Low life-cycle-emission electricity produced by offshore wind farms helps reduce the electricity system's dependence on fossil-fuel-based electricity generation and supports the achievement of international climate targets. At the same time, the construction of one specific offshore wind farm cannot be causally linked to any specific change in the local climate.

3.11.8. Uncertainty and knowledge gaps

The project-specific life-cycle GHG emissions of the additional area cannot be finally calculated at the EIA stage, because the turbine model, the final foundation solution, the manufacturers and origin of materials, the installation and maintenance vessels, and the decommissioning method have not yet been selected. It is also not known what the wind farm's actual net generation, the extent of production curtailment and the electricity system's marginal emission factor will be over the entire 30–35-year operational period.

Future climate projections involve uncertainty, particularly as regards extreme wind, wave, storm and ice conditions. These knowledge gaps do not prevent assessment of the overall direction of the climate impact, but they must be reduced through a life-cycle calculation for the final project solution, a climate resilience check and the collection of actual operational data.

4. Impact on the social and economic environment

4.1. Visual impact

The visual impact assessment of the Saare-Liivi additional area is based on the relevant study by landscape architect and planner Kerttu Ots, 'Visual impact assessment of the Saare-Liivi offshore wind farm' (RPS, October 2024), and on the assessment of the additional area solution with 40 wind turbines presented in its Annex 5 (Annex 3.10).

4.1.1. Consideration of alternatives

The visual impact arises during operation of the wind farm. As the additional area is expected to be developed only after the initial area, but the two are located side by side, the visual impact assessment has been carried out jointly for the initial area and main alternative 3 of the additional area, under which up to 40 irregularly arranged turbines are planned. The visual impact assessment report and its annexes can be found in Annex 3.10 to the EIA report. This report does not repeat the landscapes and viewpoints addressed in the visual impact assessment of the initial area from which the additional area is not visible on its own.

A detailed description of the factors influencing the wind farm's visual impact (the colour, finish and size of the turbines, warning lights, blade rotation) and of the assessment methodology is provided in full in the Estonian-language EIA report (section 4.1) and the visual impact assessment (Annex 3.10).

4.1.2. Impact assessment

WIND FARM VISIBILITY ZONE

The visibility map for the Saare-Liivi offshore wind farm was originally prepared for the wind farm's initial area, an extract from which is presented in Figure 4.1-1. In preparing the visibility map, vegetation shown on the orthophotos that limits visibility was taken into account. The map shows only narrow coastal areas as falling within the theoretical visibility zone, since the inland extent of visibility is obstructed by abundant vegetation (forest areas).

In views from Kihnu, the additional area is obscured by the initial area and, being located 20 km from Ruhnu, would not alter the pattern shown on the visibility map; accordingly, there is no need to update the visibility map. Ruhnu island has a flat landform, and interspersed forested areas obstruct views from the island's interior.

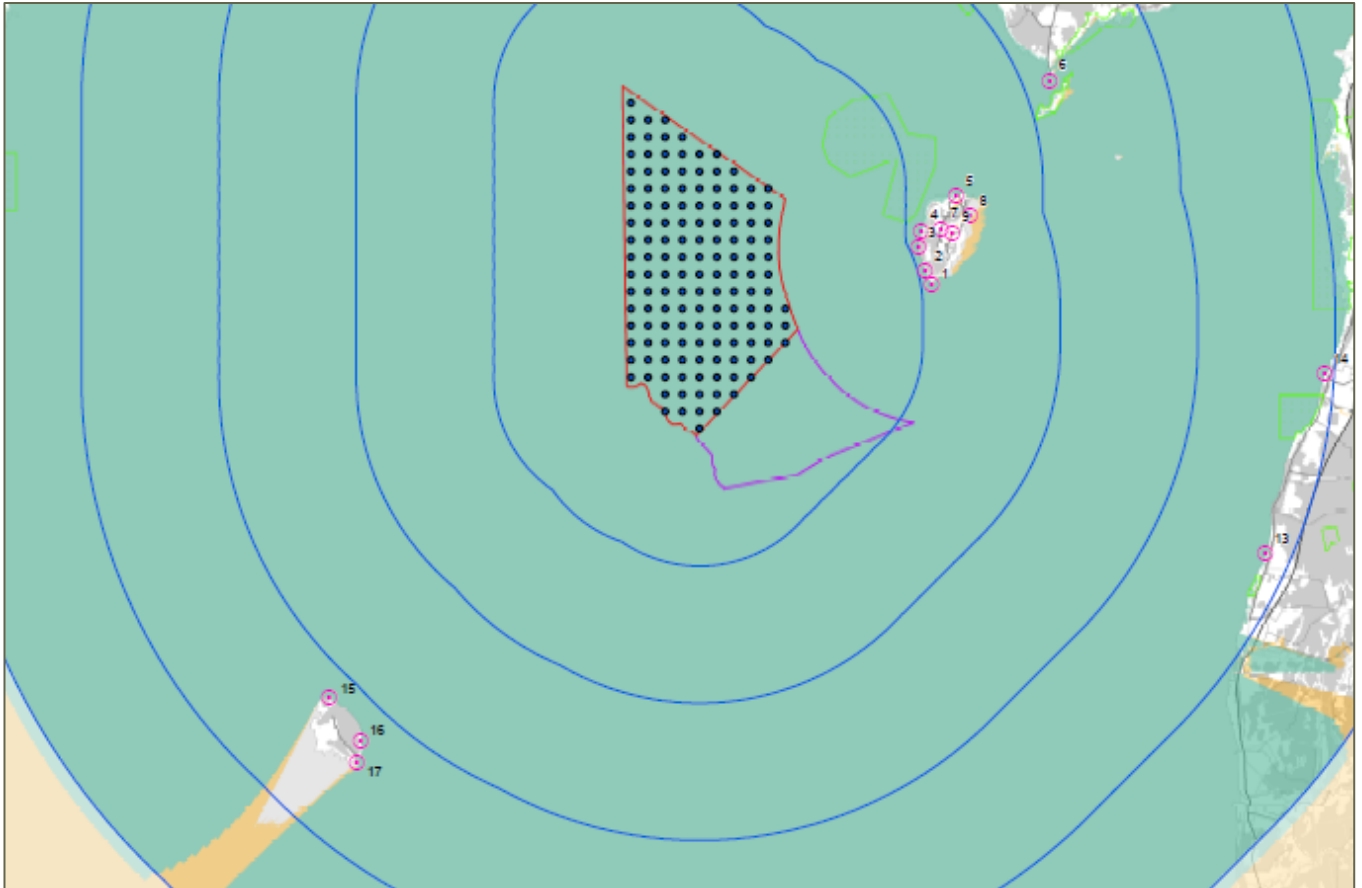


Figure 4.1-1. *Theoretical visibility map; more detailed visibility maps for the areas are presented in Annex 3.10*

VIEWPOINTS

The following two viewpoints have been selected to support this assessment:

1. Viewpoint 1 Kihnu lighthouse - 10.5 km to the west;
2. Viewpoint 15 Kuunsi beach, Ruhnu

Both viewpoints provide some of the closest views from the islands towards the turbines proposed in the additional area. Viewpoints on the mainland are located 35 km away or more, and in marine conditions the turbines are difficult to perceive from such distances, as they are not discernible as objects with clear outlines. The results presented in Table 4.1-1 reflect the 80 + 50 wind turbine solution set out in the study brief. Since under main alternative 3 there are 10 fewer wind turbines in the additional area and no wind turbines are placed closer to sensitive viewpoints, this constitutes a conservative basis of comparison for the 80 + 40 wind turbine solution being assessed.

Table 4.1-1. Visual impact on the observer by viewpoint for main alternative 2 of the additional area (50 turbines)

No.	Viewpoint	Distance to the nearest turbine in the Saare-Liivi initial or additional area	View direction	Field of view occupied by turbines	Extent of impact
1	Kihnu lighthouse	10.5 km (initial area)	274° West	50°	Moderate
15	Kuunsi beach, Ruhnu	20 km (additional area)	30° North-east	30°	Low

Comparative 39.6-degree technical drawings from both viewpoints are presented for 40 and 50 turbines (main alternatives 3 and 2 of the additional area). In the technical drawings (Figures 4.1-3 and 4.1-5), the nearer turbines (in the initial or additional area, respectively) are shown in darker blue and the more distant turbines in lighter blue.

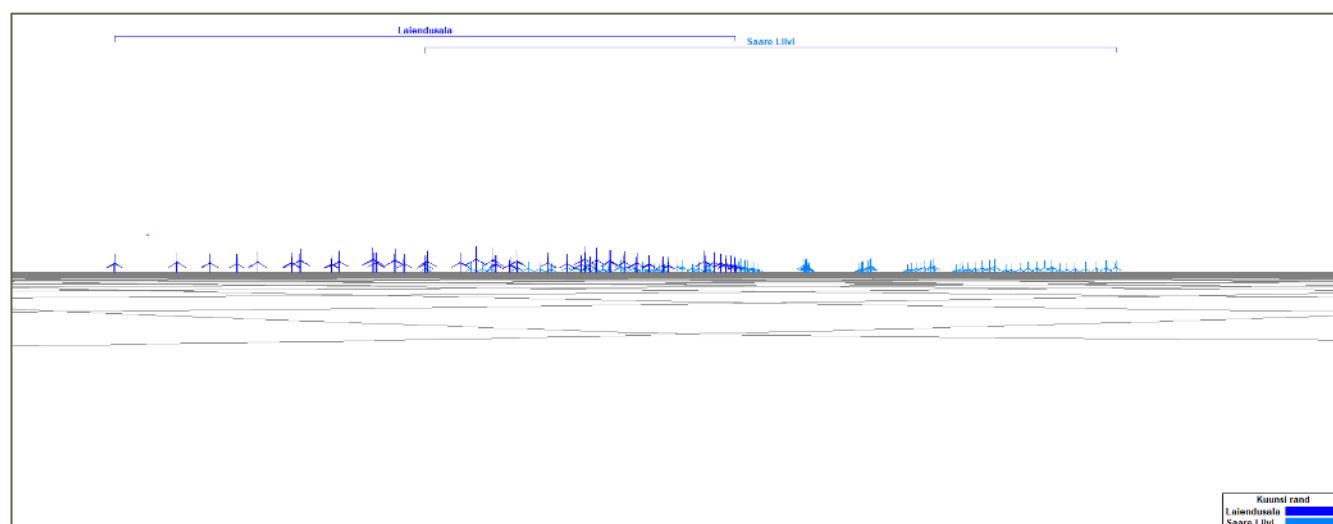


Figure 4.1-3. View from Kuunsi beach, Ruhnu - additional area with 40 turbines (dark blue); nearest turbine in the additional area 20.1 km, nearest turbine in the initial area (light blue) 31.6 km. The Saare-Liivi initial area together with the additional area occupies 30 degrees of the field of view from the viewpoint, whereas the additional area, which is closer to the viewpoint, occupies barely 20 degrees. At this distance, the impact is very low. Together with the initial area, the impact has been assessed as low. Since the initial area is 11.5 km farther away, this arrangement breaks up the wind farm visually, thereby reducing the impact.

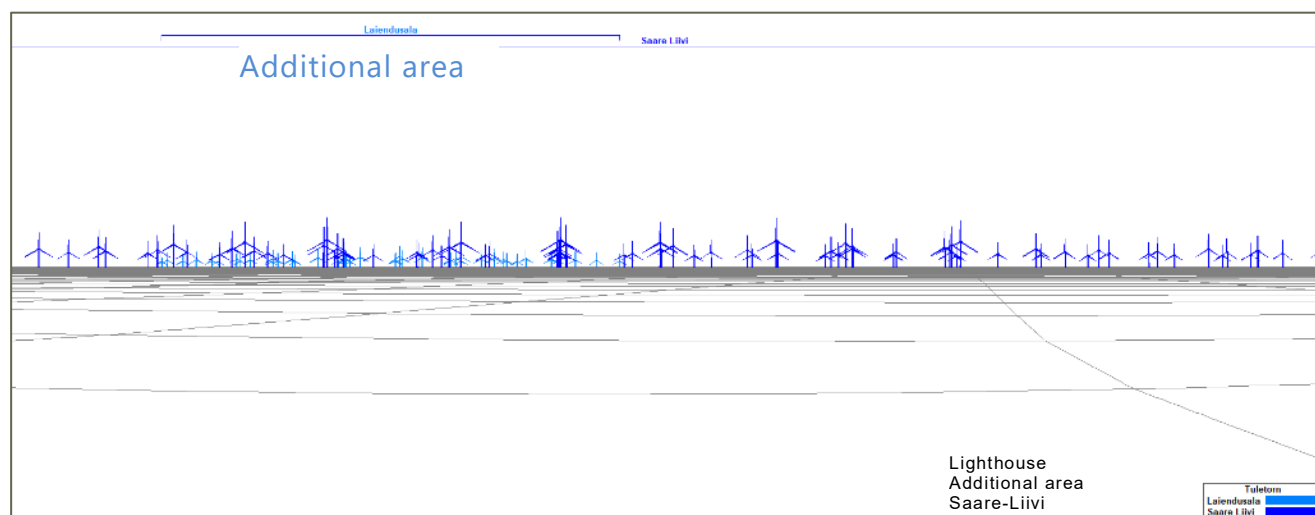


Figure 4.1-5. View from Kihnu lighthouse - additional area with 40 turbines; nearest turbine in the additional area 24.3 km, nearest turbine in the initial area 10.4 km. The turbines in the additional area are behind those in the initial area and, although sufficiently far away, make the cluster of turbines denser within the field of view occupied by turbines. Compared with the upper view, which has 50 turbines in the additional area, the cluster of turbines is clearly sparser, which overall has a visually mitigating effect.



Figure 4.1-6. *Photomontage from Kihnu lighthouse, initial and additional area*



Figure 4.1-7. *Photomontage from Kuunsi beach, initial and additional area*

4.1.3. Environmental measures

During the process, the reduction in the spatial extent of the Saare-Liivi additional area and in the number of turbines under main alternative 3 to 40 turbines (see section 2.3) also made it possible to mitigate the impact visually.

The assessed layout reduces the wheel effect caused by overlapping turbines in views. Visually, it is preferable for the turbines to form a coherent and legible group. When designing the final layout, this preference must be reconciled with the safe straight-line passages provided for in section 6.1 and the movement possibilities provided for in sections 3.5 and 3.7; the visual preference does not imply a requirement for a navigationally irregular layout.

No separate mitigation measures are required to reduce the visual impact of the additional area. If implemented, the ADLS aviation safety lighting recommended in section 6.2 will also reduce the visual disturbance from aviation safety lights.

4.1.4. Summary

Under main alternative 3, the number of turbines in the Saare-Liivi additional area has been reduced by 10 compared with main alternative 2, while no turbines have been placed closer to Ruhnu. Consequently, the visual impact arising from the wind farm has been reduced, since the reduced number of turbines means that the turbines are arranged more sparsely within the additional area and therefore appear less densely distributed in views. With the new layout, the wheel effects caused by overlapping turbines have been eliminated.

Overall, the proposed additional area with 40 turbines has reduced visual impact and is preferred to the previous layout variant with 50 turbines.

Overall, the proposed Saare-Liivi offshore wind farm, comprising the initial and additional area, follows the principles of good layout and does not create a visually disturbing impression, because:

- the wind farm is visible and legible as a coherent group of elements,
- there are no separate groups and/or individual turbines located away from the group,
- the turbines are spaced evenly within the group,
- the wheel effect caused by overlapping turbines is limited.

Table 4.1-2. Impact significance

Associated consequence/impact	Impact significance	Need for the application of mitigation measures, final impact significance
Wind farm construction and decommissioning	0	No measures are required. Residual impact 0
Cable installation	0	No measures are required. Residual impact 0
Wind farm operation		
Visual disturbance	0/-	The dispersed layout under main alternative 3 and the coherent, legible group of turbines have already been taken into account in the project solution; ADLS aviation safety lighting is recommended (section 6.2). Residual impact 0/-

Scale of significant environmental impact used in the EIA report: - slight negative impact, -- significant negative impact, 0 - no impact, neutral, + slight positive impact, ++ significant positive impact

4.1.5. Cumulative impact

The cumulative visual impact of the Saare-Liivi initial and additional area is assessed together with another offshore wind farm proposed in the Gulf of Riga – the Liivi Bay offshore wind farm, which at the time of preparation of this EIA report is at the same stage of development (the EIA preparation phase) as the offshore wind farm in the Saare-Liivi additional area. To present the cumulative impact, the Liivi Bay offshore wind farm is shown together with the Saare-Liivi initial and additional area in the visualisations presented in Annex 3.10, in technical drawings with a 90-degree field of view.

Table 4.1-3 shows, at the viewpoints used to assess the Saare-Liivi initial and additional area, what proportion of the field of view is occupied by the Saare-Liivi initial area, the additional area and the Liivi Bay offshore wind farm respectively, and what proportion of the field of view is occupied cumulatively by the wind farms. The additional area makes only a modest contribution to the cumulative impact of the three offshore wind farms (the initial area, the additional area and the Liivi Bay offshore wind farm), appearing in views only at the viewpoints on Ruhnu island (15, 16 and 17). At the other viewpoints, the views predominantly feature only the turbines of the Saare-Liivi initial area and the Liivi Bay offshore wind farm.

Table 4.1-3. Cumulative field of view occupied by the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm

No.	Viewpoint	Distance to the nearest turbine in the Saare-Liivi initial or additional area	Field of view occupied by turbines in the Saare-Liivi initial or additional area	Distance to the nearest turbine in the Liivi Bay offshore wind farm	Field of view occupied by turbines in the Liivi Bay offshore wind farm	Cumulative field of view occupied
1	Kihnu lighthouse	10.8 km	50°	10.8 km	79°	in-combination effect 129°
2	Linaküla beach and recreation site	10.5 km	49°	11.6 km	26°	in-combination effect 75°
3	Seafront private residence, surf community	10.9 km	45°	13.3 km	14°	in-combination effect 59°

No.	Viewpoint	Distance to the nearest turbine in the Saare-Liivi initial or additional area	Field of view occupied by turbines in the Saare-Liivi initial or additional area	Distance to the nearest turbine in the Liivi Bay offshore wind farm	Field of view occupied by turbines in the Liivi Bay offshore wind farm	Cumulative field of view occupied
4	Beach campsite, camping area, recreation area	11 km	41°	14.4 km	13°	in-combination effect 54°
5	Small harbour and popular swimming spot	13.7 km	34°	13.8 km	screened	Impact of the Saare-Liivi initial area 34°
6	Munalaiu harbour	22.9 km	22°	18.4 km	32°	in-combination effect 54°
7	Kihnu centre	12.6 km	screened	12.1 km	screened	no impact
8	Kihnu harbour	14.1 km	possible individual blade tips	12 km	67°	Impact of the Liivi Bay offshore wind farm 67°
9	Open landscape towards the west	12 km	possible individual blade tips	13 km	screened	Saare-Liivi 3 blade tips
10	Matsirand	26.6 km	22°	41.8 km	distance	Impact of the Saare-Liivi initial area 22°
11	Värati harbour	23.5 km	24°	29.1 km	10°	in-combination effect 34°
12	Pärnu central beach	50.2 km	distance	39.6 km	distance	no impact
13	Treimani harbour breakwater	37.9 km	distance	17.2 km	43°	Impact of the Liivi Bay offshore wind farm 43°
14	Jaagupi harbour breakwater	38.7 km	distance	17.5 km	41°	Impact of the Liivi Bay offshore wind farm 41°
15	Kuunsi beach, Ruhnu	20 km	30°	38 km	distance	very low
16	Limo beach, Ruhnu	21.2 km	30°	36.8 km	distance	very low
17	Ringsu harbour, Ruhnu	23 km	29°	38 km	distance	very low

Kihnu coast. Both the turbines in the Saare-Liivi initial area and those of the Liivi Bay offshore wind farm are 10 km from the nearest point on the Kihnu coast. While the turbines in the Saare-Liivi initial area occupy at most 50 degrees of the field of view towards the west, the turbines of the Liivi Bay offshore wind farm to the south occupy a field of view of 79 degrees, which is approximately 30 degrees wider than the field of view occupied by the turbines in the Saare-Liivi initial area. As an in-combination effect, this results in a total field of view occupied by turbines of 129 degrees at the southern tip of Kihnu. Between the Saare-Liivi initial area and the Liivi Bay offshore wind farm, a narrow unobstructed viewshed remains, with a field of view of approximately 28 degrees. The field of view at the southern tip of Kihnu being occupied by turbines to this extent is large-scale and indicates significant impact, as this is a sensitive area (Kihnu Strait Marine Park (valuable landscape)).

In views from the west coast of Kihnu, the Liivi Bay offshore wind farm partially comes into view together with the wind farm in the Saare-Liivi initial area (see Annex 3.10, viewpoints 2, 3 and 4, and Annex 4 thereof).

In views from Kihnu harbour (Annex 3.10, viewpoint 8), where the wind farms in the Saare-Liivi initial and additional area are not visible, the Liivi Bay offshore wind farm by itself occupies a field of view of 67 degrees.

Ruhnu coast. The in-combination effect from the north-east and west coasts of Ruhnu is extremely low, as the Liivi Bay offshore wind farm is beyond the range of clear visibility. Due to the earth's curvature, in theory only the blades of the Liivi Bay turbines could be visible at this distance (viewpoints 15–17), but at a distance of 37 km the moving blades are not distinguishable on the horizon.

4.2. Airborne noise

The airborne noise assessment is based on the Lemma OÜ study "Noise assessment of the additional encumbered area of the Utilitas Wind OÜ Saare-Liivi offshore wind farm" (Annex 3.11). The noise assessment follows sector-specific legislation and guidance material: Kliimaministeerium, 2025. Guidance on the environmental impact assessment of wind farms. Noise, vibration, shadow flicker.

Underwater noise is addressed together with marine biota in sections 2.8, 3.7 and 3.8.

4.2.1. Consideration of alternatives

The spatial alternative under assessment is main alternative 3 for the additional area, which envisages up to 40 turbines. The noise assessment also takes into account the initial area of the Saare-Liivi offshore wind farm, where up to 80 turbines are planned, and the Liivi Bay offshore wind farm. The layout of the turbines used in the noise assessment is shown in Figure 4.2-1.

The modelling is based on the Vestas V264-15.0 MW turbine model. The exact turbine model to be used is not known, and equivalent turbines from other manufacturers may also be used. Uncertainty regarding the turbine model (and, consequently, the extent of uncertainty in noise emissions) has been taken into account in preparing the noise assessment.

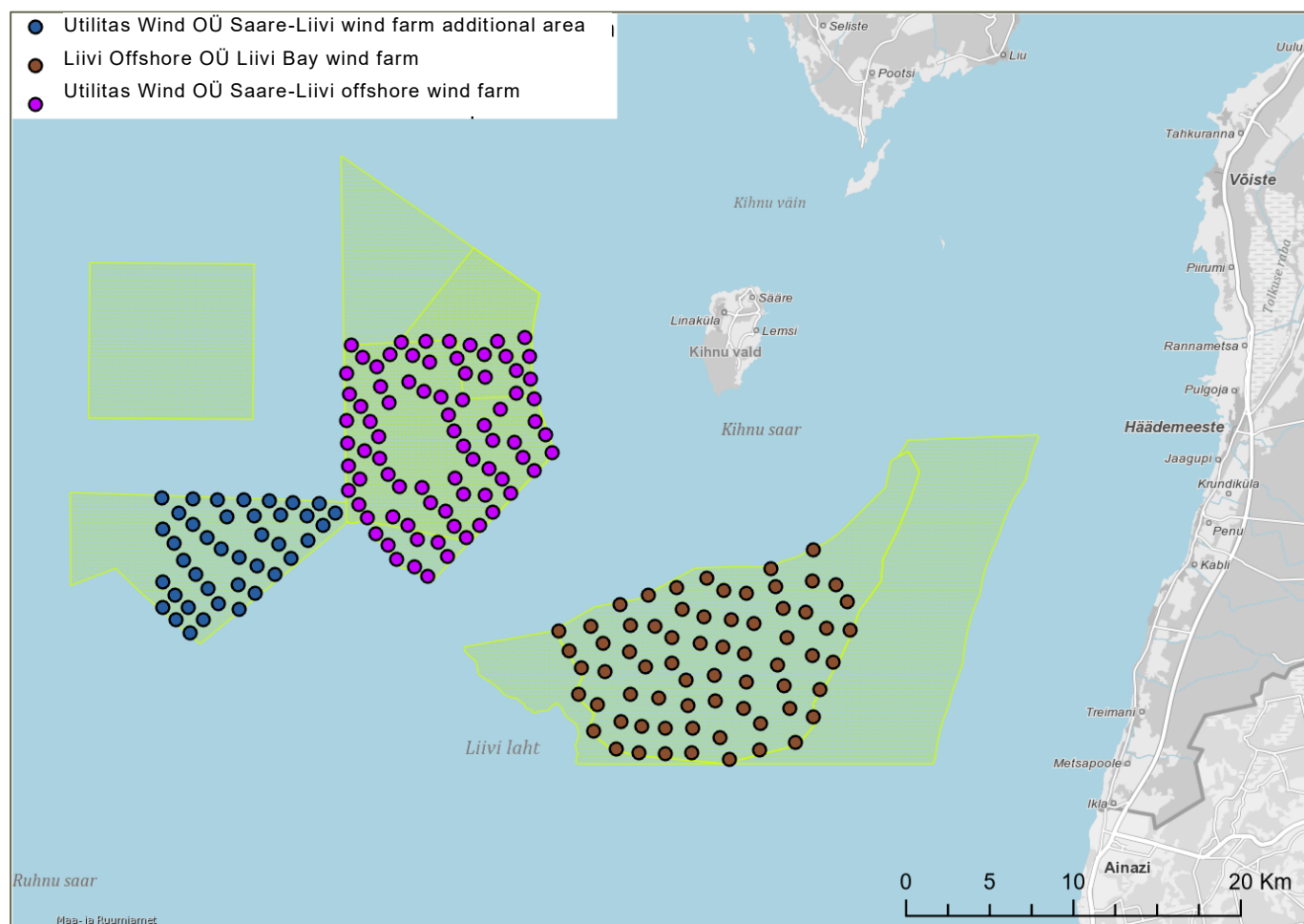


Figure 4.2-1. Locations of the proposed turbines in the initial and additional area of the Saare-Liivi offshore wind farm and in the Liivi Bay offshore wind farm, which formed the basis for preparing the noise assessment. For information, areas covered by ongoing offshore wind farm superfacies licence proceedings in the region are shown (light yellow areas in the figure). A superfacies licence has been issued for the Saare-Liivi initial area shown with purple dots. Source: Maa-amet 2026 and the Consumer Protection and Technical Regulatory Authority's vector data viewing service 09.01.2026)

4.2.2. Impact characterisation

A detailed discussion of the nature of turbine noise, the noise standard levels in force in Estonia, and the methodology for assessing the propagation of mid-frequency noise, low-frequency noise and infrasound is set out in full in the Estonian-language EIA report (section 4.2) and the noise assessment (Annex 3.11). This version sets out the basis and results of the assessment.

Noise standard levels have been established to protect human health and avoid undue disturbance; accordingly, situations that comply with the standards are deemed acceptable, i.e. for the purposes of impact assessment it is assumed that where the noise level complies with the standards, there is no significant adverse impact. At the same time, noise close to the standard level may still disturb people to some extent.

In this case, the nearest noise-sensitive areas are on Kihnu and Ruhnu islands, and all residential areas on these islands are more than 20 km from the nearest turbine planned for the additional area. Residential

areas on the Kihnu coast (including outdoor areas on agricultural land in dispersed settlement) fall within Category II areas.

For residential areas, the limit value for industrial noise is 60 dB(A) during the day and 45 dB(A) at night, while the target value is 50 dB(A) during the day and 40 dB(A) at night.

As turbines operate round the clock and turbine noise may be regarded as more disturbing in character than some other types of industrial noise, it is strongly recommended that wind farms aim to achieve the night-time target value (40 dB(A)). Noise target values have been established to prevent health risks.

4.2.3. Impact assessment

RESULTS OF THE NOISE ASSESSMENT, INCLUDING CUMULATIVE IMPACT

The noise assessment showed that the nearest noise-sensitive areas are located on Kihnu and Ruhnu islands, more than 20 km from the turbines proposed for the additional area of the Saare-Liivi offshore wind farm. According to the assessment, the noise level at the nearest dwellings on Kihnu resulting from the in-combination effect of the proposed wind farms (the Saare-Liivi initial and additional areas and the Liivi Bay offshore wind farm) is 32.7 dB(A). If a +5 dB correction factor is applied to reflect possible uncertainty associated with the turbine model and the large modelling distance, the noise level at the nearest dwellings is up to 37.7 dB(A). At the dwellings, neither the night-time limit value for industrial noise applicable to Category II areas 45 dB(A) nor the night-time target value 40 dB(A) is exceeded. The whole of Kihnu island lies within the area where, even under the most conservative calculation, the noise level resulting from operation of the wind farms remains within 40 dB(A). The noise propagation map is presented in Figure 4.2-3.

According to the results of the noise propagation modelling (Figure 4.2-3), Ruhnu island as a whole remains outside the 35 dB(A) noise zone even in the most conservative scenario, which takes into account the in-combination effect of the Saare-Liivi initial area, the additional area and the Liivi Bay offshore wind farm, and assumes a sound power level of 115.3 dB(A) for all wind turbines together with a + 5 dB uncertainty factor. In the noise-sensitive areas of Ruhnu, the noise level resulting from operation of the proposed offshore wind farms therefore remains below 35 dB(A) and below both the night-time target value of 40 dB(A) and the limit value of 45 dB(A) for Category II areas; it also remains below the 35 dB level used in the literature as the threshold for annoyance from turbine noise.

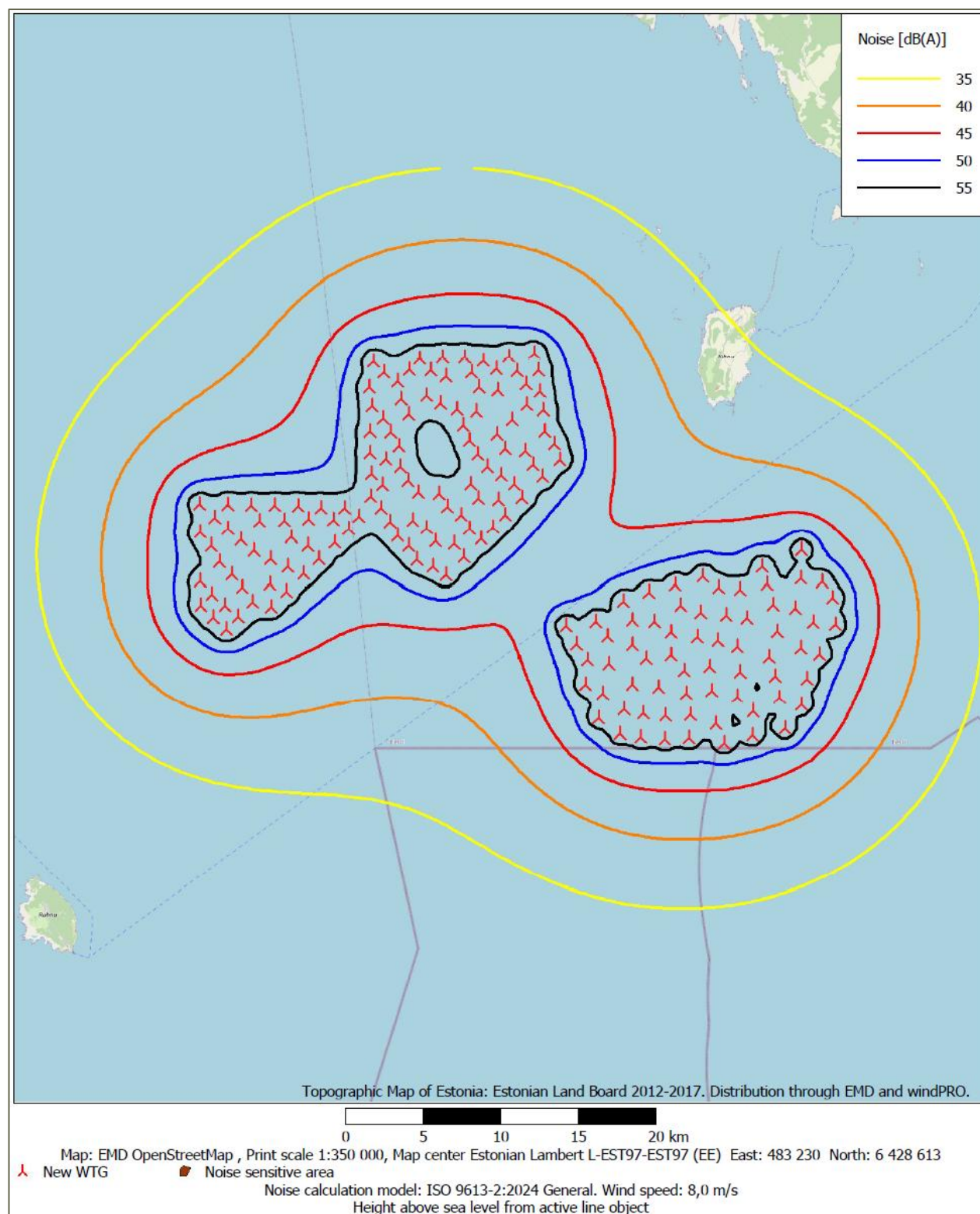


Figure 4.2-3. Environmental noise map at a height of 4 m for the in-combination effect of the initial and additional areas of the Saare-Liivi offshore wind farm and the Liivi Bay offshore wind farm, assuming turbines with a sound power level of 115.3 dB(A) and a + 5 dB uncertainty.

Low-frequency noise calculations were carried out for the residential buildings nearest to the initial and additional areas. The nearest residential building is the building located within the residential area on the Liivamäe cadastral unit in Kihnu. The calculations showed that, in all frequency ranges, the expected

indoor noise level remains considerably below the applicable standard level (Figure 4.2-4). Even with a conservative addition of + 5dB, taking into account uncertainty in various factors in the assessment of noise from offshore wind farms, compliance with the noise standard levels is still expected in all frequency ranges. The low-frequency noise calculation was carried out in the same cumulative scenario as the calculation of airborne noise, i.e. taking into account 80 wind turbines in the Saare-Liivi initial area, 40 in the additional area and 50 in the Liivi Bay offshore wind farm. The residential building on the Liivamäe cadastral unit is the nearest residential building with respect to the Saare-Liivi initial area; with respect to the additional area, the nearest noise-sensitive areas are located in Ruhnu (see Section 4.2.2).

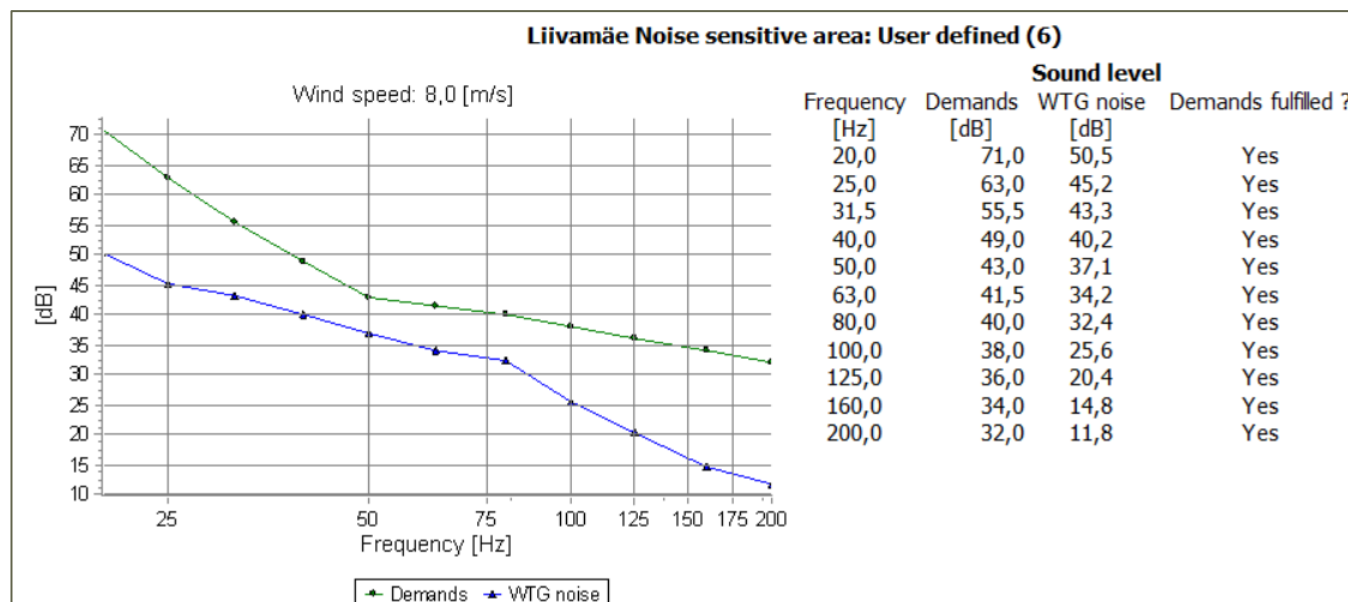


Figure 4.2-4. Comparison of the low-frequency noise level indoors at the nearest residential building (blue line) with the standard level (green line)

The calculated assessment of low-frequency noise showed that exceedance of the low-frequency noise standard level applicable in living spaces is not expected for any residential area in the region.

Based on the above, taking into account mid-frequency noise, low-frequency noise and infrasound, no significant adverse noise impact is expected to result from the development of the wind farm that could cause a significant health impact. All values remain well below the standard values on the basis of a very conservative assessment. The assessment has also been prepared for a situation assuming full implementation of the Saare-Liivi initial and additional areas and the Liivi Bay offshore wind farm.

4.2.4. Mitigation measures

The proposed activity will not result in significant adverse environmental impact, therefore implementation of mitigation measures is not necessary.

At the detailed design stage, once the final number and layout of the turbines, as well as the final turbine model, have been determined, it is recommended to carry out additional noise modelling.

4.2.5. Summary

In the modelled cumulative scenario, which took into account 80 turbines in the Saare-Liivi initial area, 40 in the additional area and 50 in the Liivi Bay offshore wind farm, the A-weighted noise level at the nearest residential building in Kihnu is 32.7 dB(A). Including a conservative uncertainty margin of 5 dB, the calculated level is 37.7 dB(A), which remains below the night-time industrial noise target value of 40 dB(A) and the limit value of 45 dB(A) for Category II areas. Across the whole of Kihnu island, the modelled cumulative noise level remains below 40 dB(A) even in the conservative scenario.

According to the cumulative low-frequency noise calculations, the predicted levels indoors at the nearest residential building in Kihnu remain below the applicable standard levels in all assessed 1/3 -octave bands. According to the expert assessment based on the scientific literature regarding infrasound, no infrasound affecting human health is expected to occur.

Therefore, the proposed activity will not result in exceedance of noise standards or significant adverse impact on human health. Compliance with the standard levels does not entirely rule out subjective noise annoyance for some individuals, but given the large distance of the turbines from noise-sensitive areas and the conservative calculation parameters, the likelihood and extent of such annoyance are low.

Table 4.2-3. Resulting impact and its significance

Associated consequence/impact	Impact significance	Need for the application of mitigation measures, final impact significance
Wind farm construction and decommissioning		
Noise during construction works	0	No measures are required. Residual impact 0
Wind farm operation		
Noise annoyance	0/-	Recommended verification modelling at the detailed design stage based on the final turbine model, number of turbines and layout (Section 4.2.4). Residual impact 0/-

Scale of significant environmental impact used in the EIA report: - slight negative impact, -- significant negative impact, 0 - no impact, neutral, + slight positive impact, ++ significant positive impact

4.2.6. Knowledge gaps/follow-up assessment

At the detailed design stage, once the final number and layout of the turbines and the final turbine model have been determined, it is recommended to carry out additional noise modelling. For the turbine types analysed in this study, as with other modern turbines, they are not known to generate tonal sound (i.e. noise). It is recommended that any potential tonality be assessed as part of the monitoring proposed following construction of the wind farm, particularly if disturbance occurs.

4.3. Socio-economic impacts

This chapter addresses the socio-economic impacts associated with the development and operation of the additional area of the Saare-Liivi offshore wind farm. This chapter is based on the socio-economic impact study completed in 2026 (Appendix 3.12), the analysis of the navigation impact of the Saare-Liivi

offshore wind farm on shipping (Appendix 3.17), and open data from the Agriculture and Food Board, Statistics Estonia, the Tax and Customs Board and the Land Board.

Socio-economic impacts differ from impacts on the natural environment in two important ways. First, the impacts of the Saare-Liivi initial area and additional area are cumulative if both parks are developed, because the economic impact, employment and public sector revenues are determined by the scale of both projects, not that of an individual development area. Second, some of the impacts are positive, which is rather exceptional in environmental impact assessment. Therefore, each subsection of this chapter separately indicates whether the assessment addresses the initial area and the additional area together or the standalone contribution of the additional area.

4.3.1. Impact on the economy

The initial area of the Saare-Liivi offshore wind farm (up to 1600 MW) and the additional area (up to 800 MW) would, at an installed capacity of 2400 MW, generate an estimated total of approximately 10.7 TWh of renewable electricity per year (capacity factor 51%), of which, taking losses into account, approximately 95% would be sold to the grid. This is a significant volume of electricity generation when compared with Estonia's consumption in 2024 (9.3 TWh¹¹³) and total consumption across the Baltic States (29.4 TWh¹¹⁴).

The total capacity of the additional area is up to 600 MW under technical alternative A, with expected annual gross output of approximately 2.7 TWh, and under technical alternative B up to 800 MW, with expected annual gross output of approximately 3.5 TWh (see Section 3.11.1). The following assessments address the in-combination effect of the initial area and the additional area; the share of the additional area can be estimated approximately on the basis of the ratio of capacities.

A detailed analysis of the regional and national economic impact (impact on gross domestic product, public finances, foreign trade, employment and revenues of Kihnu municipality) is presented in full in the Estonian-language EIA report (Section 4.3.1). In summary, the economic impact of the development and operation of the additional area on Estonia is positive, and this, together with the assessment, is presented in Table 4.3-3.

4.3.2. Impact on fisheries

EXISTING SITUATION

Trawling in the Gulf of Riga mainly targets Baltic herring and, to a lesser extent, sprat. This is pelagic, i.e. midwater trawl fishing, not bottom trawling. Baltic herring fishing in the Gulf of Riga (fishing ground 28–1) is subject to a quota. The quota is divided between Estonia and Latvia. In 2025, the total Baltic herring quota for the Gulf of Riga was 41 635 t, of which Estonia had 19 227 t and Latvia 22 408 t. In 2026, the quota was reduced to 34 367 tonnes, of which Estonia had 15 870 t and Latvia 18 497 t. At national level, the quota is divided between coastal fishing and trawl fishing. In 2025, Estonia's trawl fishing APV115 quota was 12 758.62 t and, after quota exchanges, 9967.26 t. Of this, 97% was caught. The coastal fishing quota was 6919.7 t, of which 99.8% was caught.

¹¹³ Eurostat

¹¹⁴ Eurostat

¹¹⁵ APV - historical fishing opportunity

Trawl fishing intensity throughout the Gulf of Riga is presented in Figure 4.3-4. The trawling area in the Latvian marine area is significantly larger, and fishing there is also more intensive; the area near Roja port in the western part of the Gulf of Riga stands out in particular. A significant share of the catch is also landed in Latvian ports (Table 4.3-2), including catches landed in Latvia by Estonian fishing vessels.

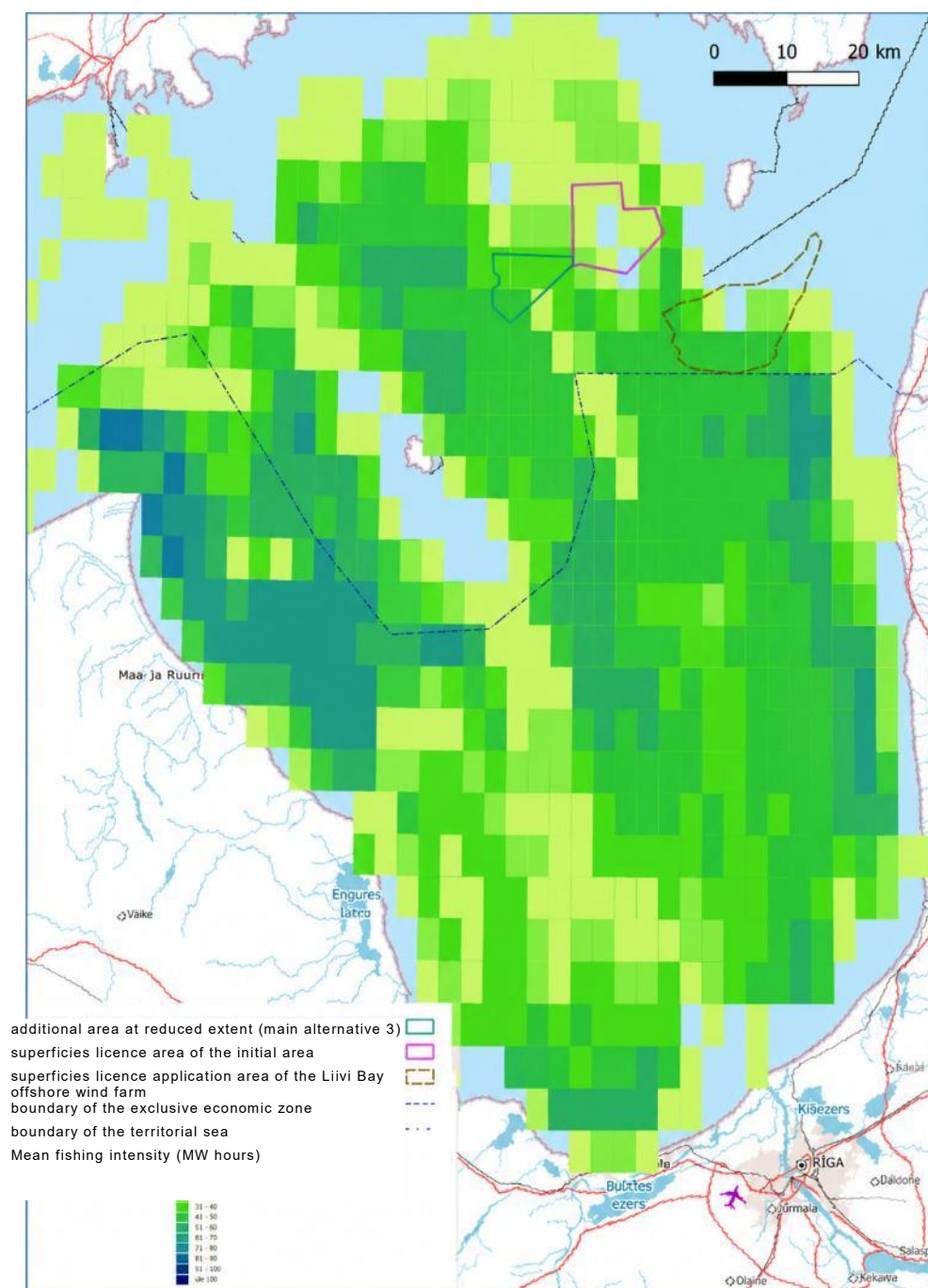


Figure 4.3-4. Trawl fishing intensity¹¹⁶ in the Gulf of Riga (source: EMODnet)

¹¹⁶ Average fishing effort, expressed as the product of vessel engine power (MW) and fishing time (hours).

Table 4.3-2. Landings of trawled fish at ports in the Gulf of Riga by Estonian and Latvian fishing vessels, 2018–2025

Port	2018	2019	2020	2021	2022	2023	2024	2025
Roja	9030.9	11682.8	10770.7	12907.4	14242.9	15133.0	12595.1	15314.5
Skulte	5582.0	7280.2	8059.5	7077.5	7276.5	7831.8	7281.6	6859.2
Salacgriva	2887.7	2930.0	2730.7	3954.9	3064.9	3604.0	1386.8	1679.4
Mersrags	2540.7	3044.4	3282.5	4127.8	3359.8	3225.2	2853.8	5621.1
Mõntu	1884.8	3962.4	3442.1	2172.0	4199.5	3220.5	1194.2	1853.3
Virtsu	2415.8	2525.7	3017.6	2110.0	5589.3	4640.8	414.9	2787.1
Roomassaare	1746.3	2337.7	2038.1	2979.1	4388.2	4706.1	2771.7	3343.3
Pärnu	0.0	0.0	0.0	0.0	131.7	174.2	25.8	773.7

Over the last ten years (2016–2025), trawl fishing by Estonian fishing vessels in the Gulf of Riga has averaged 8300 tonnes of Baltic herring per year, and on average 93% of the Baltic herring quota has been caught after quota exchanges, although catches have varied considerably from year to year (Figure 4.3-5). In 2025, there were 16 companies engaged in trawl fishing in the Baltic Sea in Estonia, 10 of which were allocated a Baltic herring fishing quota in the Gulf of Riga. AS Hiiu Kalur has consistently had the largest fishing opportunity and catch volume over the years (approximately 28% in 2025). There is no separate quota for sprat in the Gulf of Riga; sprat is an associated species in Baltic herring fishing, and its share of the trawl catch is estimated at 10–30%, depending on the season and water temperature.

According to PTA data¹¹⁷, the average revenue of trawl fishing companies from Baltic herring fishing in the Gulf of Riga in the period 2020–2025, based on first-sale prices¹¹⁸, was 2.7 million euros, while in the last three years (2023–2025) it ranged from 3.2–3.9 million euros. The main reason for the growth in recent years was the increase in the purchase price – whereas the average price in 2020–2022 was 0.19 €/kg, in 2023–2025 it was 0.38 €/kg, an increase of 104%.

IMPACT ASSESSMENT

Trawl fishing in the additional area. Compared with main alternative 1, under main alternative 3 the impact on trawl fishing is smaller, because the most intensively trawled area to the west has been excluded and trawling is prohibited, under the Heritage Conservation Act, within the protection zone of the wreck protected as a cultural heritage asset (see Section 5.1). Main alternative 3 of the additional area partially overlaps with an established trawl fishing area (Figure 4.3-6). Quantitatively, this can be indirectly characterised by summing the catches obtained from trawl tows passing through the additional area. With trawl tows passing through main alternative 3 of the additional area, an average of 408 tonnes of Baltic herring per year were caught¹¹⁹ in 2020–2025, representing **an average of 4.2%** of total Estonian Baltic herring catches in the Gulf of Riga. When shaping main alternative 3, the western part of the additional area was left out of the development area. That part adjoins the reserve areas of the marine area plan

¹¹⁷ <https://pta.agri.ee/ettevotjale-tootjale-ja-turustajale/kutseline-kalapuuk/puugistatistika>

¹¹⁸ Published by the Agriculture and Food Board

¹¹⁹ Data on trawl tows from the Ministry of Regional Affairs and Agriculture

and is the area of the highest trawl fishing intensity within the additional area, which means that the impact on fisheries has already been significantly mitigated through reducing the spatial extent of the development area. This is the primary and most effective mitigation measure, applied before the additional measures described in this chapter.

Accordingly, the sales revenue of trawl fishing companies from Baltic herring caught by trawl tows passing through main alternative 3 of the additional area of the offshore wind farm averaged 117 thousand euros per year in 2020–2025 (155 thousand euros in 2023–2025).

In total, trawl tows passing through the Saare-Liivi initial area and additional area caught an average of 585 tonnes of Baltic herring in 2020–2025, representing an average of 5.9% of Estonia's annual trawl fishing catch in the Gulf of Riga. It should be emphasised once again here that this does not concern fish caught directly from the additional and initial areas, but fish caught on trawl tows passing through the areas (trawl tows are generally significantly longer than the initial or additional area). For the Saare-Liivi initial area, the initial area EIA report, which has been found compliant, established that the initial area, taken separately, is not an established trawl fishing area – few trawl tows pass through the area (see also Figure 4.3-6).

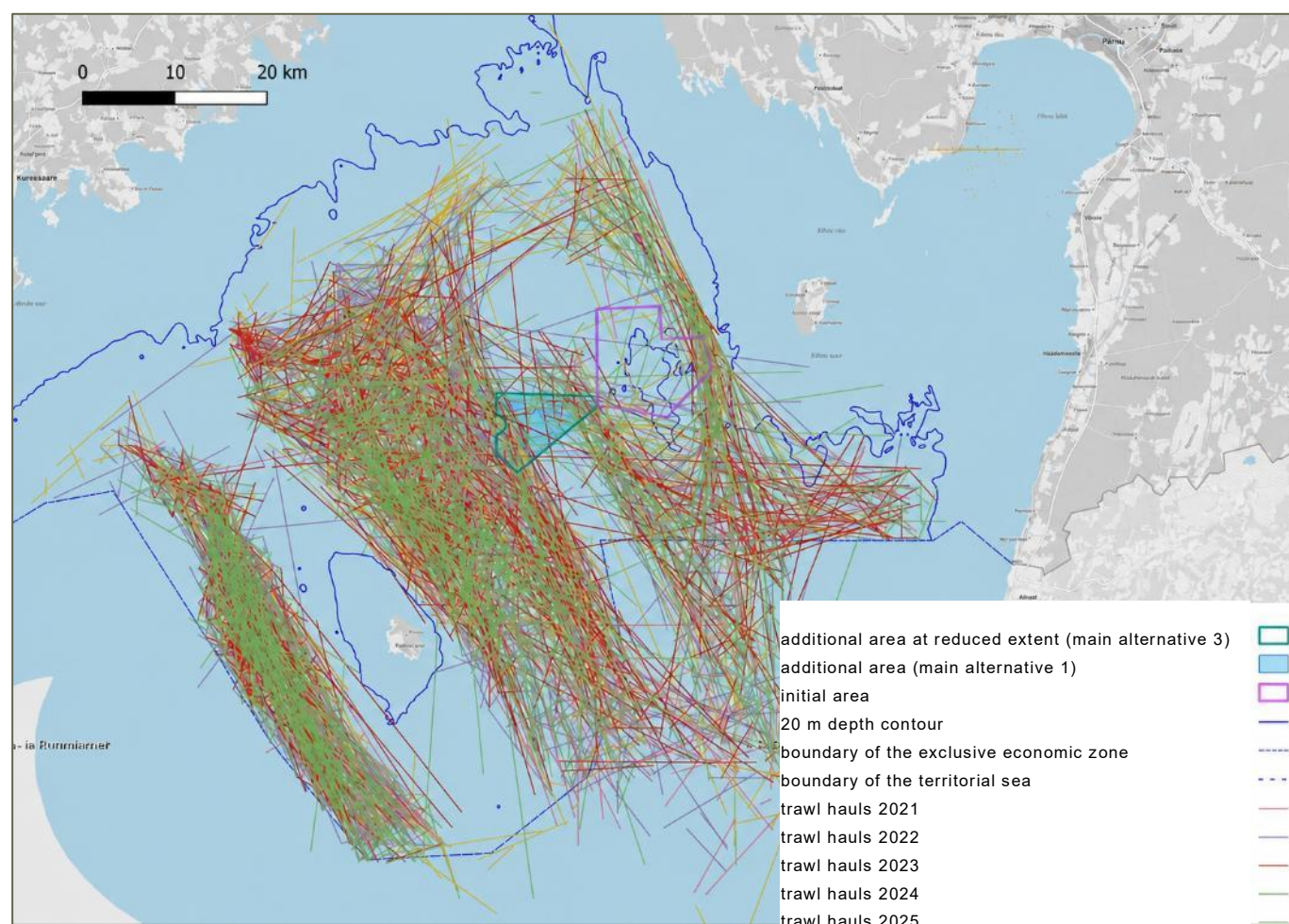


Figure 4.3-6. Trawl tows in the initial and additional areas, data on trawl tows from the Ministry of Regional Affairs and Agriculture

Construction-period impact. During the construction period, the main impact factor is the temporary access restriction. A temporary safety zone will be established around the construction area, the extent of which will be determined on the basis of the work stages, the vessels used and the structures to be

built, and agreed with the Transport Administration (Section 6.1). The restriction will not be uniform throughout the construction period and will not cover the entire additional area at the same time, meaning that fishing opportunities will remain in those parts of the area where works are not being carried out at the time. In addition, vessel traffic density will increase during the construction period, which may affect the usual routes of fishing vessels. The construction-period impacts on fish populations themselves — underwater noise, suspended matter and impacts on Baltic herring spawning migration — are addressed in Section 3.8.

Operational impact on trawl fishing. During the operational period, the main impact is the partial loss of, or restriction on the use of, the fishing ground and changes to movement routes between fishing areas, increasing fuel consumption and the time spent on fishing operations. The order of magnitude of the impact can be assessed on the basis of catch data: the sales revenue from Baltic herring caught by trawl tows passing through the additional area averaged 117 thousand euros per year in 2020–2025. This share must be interpreted against the relevant benchmark. Of the total revenue from coastal fishing and Baltic herring trawl fishing in the Gulf of Riga, this represents approximately 1.3%, but coastal fishing is not affected by the proposed activity. For the affected operators, the relevant benchmark is revenue from Baltic herring trawl fishing in the Gulf of Riga, which averaged 2.7 million euros per year in 2020–2025 – relative to this, 117 thousand euros represents approximately 4.3%. In catch volume terms, the 408 tonnes caught by trawl tows passing through the additional area correspond to approximately 4.2% of Estonia's Baltic herring trawl catch in the Gulf of Riga. Since trawl tows are significantly longer than the extent of the additional area and the entire catch from a trawl tow is not caught within the additional area, these shares are likely to be overestimates of the impact of restricting use of the area.

Importantly, Baltic herring fishing in the Gulf of Riga is constrained by the quota, not by the availability of fishing grounds. Over the last decade, an average of 93% of the quota has been caught, indicating that sufficient fishing opportunities have so far been available to fill the quota. Since Baltic herring is a mobile pelagic species and its distribution in the Gulf of Riga is not confined to the wind farm area but extends across almost the entire Gulf of Riga, the catch foregone from the wind farm area is likely, for the most part, replaceable by fishing outside the area, and therefore this is not a significant impact. Replacement is not without cost, however: it may require longer trips, higher costs and may increase fishing pressure in neighbouring areas, which in the international literature is treated as a displacement impact. To compensate for this impact, the Environmental Charges Act provides for compensation in the event of a reduction in fish catch caused by the wind farm (see Section 4.3.4).

The impact on fishing vessels in transit arises primarily where the offshore wind farm structures require fishing vessels to alter their usual route to the fishing grounds. In this report, a conservative approach is adopted, according to which normal vessel traffic, including fishing vessels, does not pass through the offshore wind farm area.

The Santera Service OÜ (2026) study (Appendix 3.17) analysed fishing vessel movements on the basis of AIS data from 2021 and 2022. A total of 1497 voyages per year were identified for the 22 fishing vessels analysed. The overlap of fishing vessel trajectories with the additional area was 5.3% of total trajectory length during trawling, 3.5% at the end of trawling and 1.4% during transit movement. For comparison, in the case of the initial area, 1.5% of total trajectory length overlapped during trawling, 1.8% at the end of trawling and 2.8% during transit movement. Such overlap does not automatically mean interruption of fishing activity or movement, but indicates those trajectory sections where movement may need to be rerouted.

It also emerged that only fishing vessels travelling to fishing grounds from the Väinameri direction overlap to any appreciable extent with the initial and additional areas. Fishing vessels sailing from the directions of Pärnu, Roomassaare and Salacgrīva do not need to pass through the Saare-Liivi initial and additional areas to reach fishing grounds, or their trajectories do not overlap with the offshore wind farm areas in such a way as to cause any appreciable increase in journey length (Figure 4.3-7).

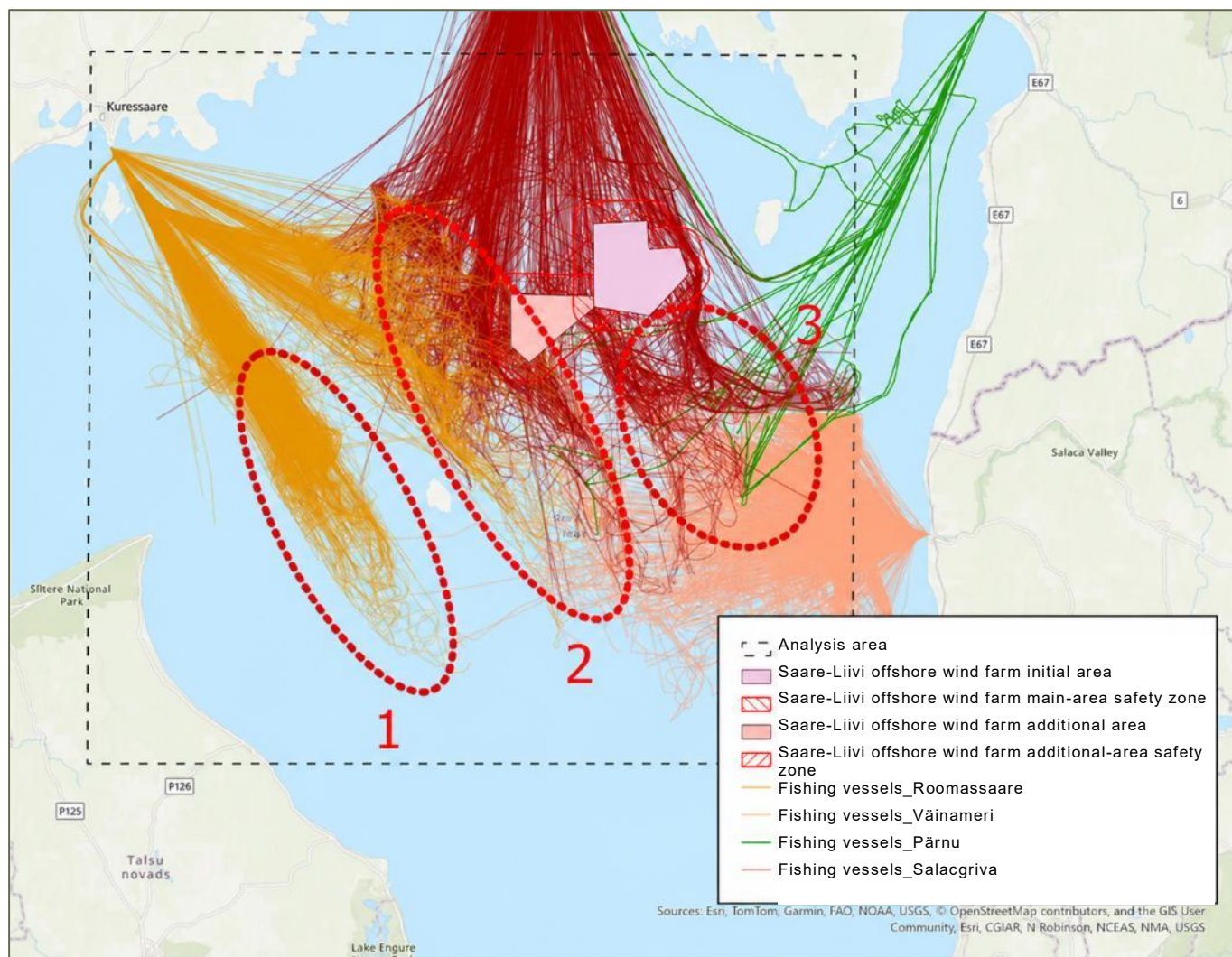


Figure 4.3-7. Fishing vessel traffic trajectories in the Gulf of Riga (red circles indicate the fishing area)

For vessels travelling to fishing grounds from the Väinameri direction, the detour required west of the additional area, instead of passing through it, may lengthen the route by approximately 6.5 km each way (Figure 4.3-8).

According to the calculations, such a route change for fishing vessels travelling from the Väinameri direction would cause approximately 4.9 tonnes of additional fuel consumption per year and a total of 241.6 hours of additional travel time across all fishing vessel voyages. The monetary value of the additional fuel cost is estimated, across all fishing vessels combined, at 4893 euros per year, and the monetary value of the additional time cost at 15 099 euros per year. Accordingly, the direct additional economic cost arising from rerouting fishing vessels travelling from the Väinameri direction (413 voyages per year) is approximately 19 992 euros per year in total. The calculation used an average speed of 6 knots for fishing vessels, an SFOC value of 200 g/kWh as specific fuel consumption, a load factor of 0.70, an MGO price of 990 €/t and vessel operating costs of 1500 €/day. Per fishing vessel voyage from the Väinameri direction, the additional fuel consumption averages approximately 0.012 t, corresponding to a monetary value of about 11.85 €/voyage. The additional time cost is approximately 36.56 €/voyage. Accordingly, the total cost per affected fishing vessel voyage from the Väinameri direction is approximately 48.41 €/voyage.

Overall, the offshore wind farm's impact on the direct economic costs of fishing vessels is limited and is concentrated primarily on vessels travelling to fishing grounds from the Väinameri direction, because

fishing vessels from the other departure areas (Pärnu, Roomassaare, Salacgriva) do not need to pass through the offshore wind farm areas to reach fishing grounds, or their trajectories do not overlap with the offshore wind farm areas in such a way as to cause any appreciable increase in journey length. The impact does not affect all fishing vessels in the area, but is limited to a specific movement pattern in which the usual route overlaps with the proposed offshore wind farm area. The calculated monetary impact covers only the direct additional fuel and time costs.

In this report, a conservative approach was adopted, according to which normal vessel traffic does not pass through the offshore wind farm area. At a later design stage, it may be possible to refine or relax the restrictions if a project-specific navigation safety assessment shows that, under certain conditions, passage of fishing vessels can be organised safely.

Operational impact on coastal fishing. The distance of the additional area from the coast and the actual spatial distribution of coastal fishing (Figure 4.3-6) mean that no direct impact on coastal fishing is expected. An indirect impact may arise via fish stocks, but according to the assessment in Section 3.8, the development of the additional area will not entail a significant impact on fish populations, nor were any significant spawning areas identified in the area.

4.3.3. Impact on tourism

A possible negative impact of the offshore wind farm on tourism may arise if the turbines give rise to significant disturbance — primarily visual, but also noise-related — that could reduce the attractiveness of the islands of Kihnu or Ruhnu as tourist destinations. However, the primary purpose of visiting the islands of Kihnu and Ruhnu is not beach tourism but culture, which will remain to the same extent after the development of the Saare-Liivi additional area.

The impact of the Saare-Liivi initial area on the island of Kihnu as a tourist destination has been analysed in Section 4.3.4 of the EIA report for the Saare-Liivi initial area. The additional area is located more than 20 km from Kihnu, i.e. further away than the initial area, and therefore its addition will not entail significant changes from the perspective of tourism in Kihnu.

The addition of the additional area could potentially affect sailors, but under main alternative 3 the main sailing routes remain to the west and south of the wind farm area, and traditional sailing routes do not change (Figure 4.3-7). Recreational sailing directly within the offshore wind farm and in its immediate vicinity is not advisable, primarily for the sailors' own safety, as wind conditions in the immediate vicinity of turbines may differ from normal.

4.3.4. Environmental measures

FISHING

Environmental Charges Act § 55⁴ subsection 1 provides that, in substantiated cases, a fisheries undertaking is entitled, in the event of a reduction in fish catch caused by a wind power plant within the impact area of the wind power plant, to receive compensation from the fee received by the State for the production of electricity from wind energy. The fisheries undertaking must submit an application for compensation for the previous calendar year to the Environmental Investment Centre by 31 March of the following year, and the Environmental Investment Centre will pay compensation to the fisheries undertaking by 1 September of the year in which the application is submitted. To receive compensation,

it is necessary to demonstrate that the construction and operation of wind farms does indeed affect fish catches. The amount of compensation payable to a fisheries undertaking per wind power plant is ten per cent of the fee for the production of electricity from wind energy payable in respect of an offshore wind power plant.

To avoid, reduce and, where necessary, compensate for the economic impact on fisheries, the following measures must be applied:

- In the subsequent stages of the wind farm development, the implementation principles for the coexistence of fisheries and the offshore wind farm, the follow-up assessment of economic impacts and possible compensation will be specified in cooperation with the Ministry of Regional Affairs and Agriculture and representatives of the fisheries sector. The developer and the preparer of the EIA have contacted the Ministry of Regional Affairs and Agriculture, which is responsible for fisheries, and consultations have been initiated.
- Before construction works commence, representatives of the fisheries sector must be informed in good time of the work areas, schedule and temporary access restrictions, and a fisheries contact person on behalf of the developer must be designated.
- In this report, a conservative approach was adopted, according to which normal vessel traffic, including fishing vessels, does not pass through the offshore wind farm area. At a later design stage, it may be possible to refine or relax the restrictions if a project-specific navigation safety assessment shows that, under certain conditions, passage of fishing vessels can be organised safely.

LOCAL BENEFIT

The amount of the wind turbine payment, or toleration payment, payable to the local community (Kihnu municipality) in the case of maximum realisation of the Saare-Liivi initial and additional area is *approx.* 4.1 million euros (i.e. 0.5% of the expected sales revenue, the latter having been derived on the basis of forecast sales volumes and an assumed electricity price of 80 €/MWh).

4.3.5. Summary

The socio-economic impacts associated with the development of the additional area of the Saare-Liivi offshore wind farm are predominantly positive. If both the initial and the additional area are realised, there will be a significant positive impact on gross domestic product, employment and public sector revenues. Kihnu municipality receives the toleration payment when the initial and additional area are realised together; if only the additional area is developed, no municipality lies within the 20 km impact area under the current Environmental Charges Act and no toleration payment accrues.

The primary adverse impact relates to fisheries. Unlike the initial area, the western edge of the additional area (main alternative 3) is crossed by trawl tows yielding an average of 408 tonnes of Baltic herring per year, representing on average 4.2% of Estonian Baltic herring trawl fishing in the Gulf of Riga, but it must be taken into account that trawl tows are significantly longer than the additional area alone, and therefore the actual share is smaller. Since Baltic herring fishing is constrained by the quota, not by the availability of fishing grounds, and Baltic herring is a mobile pelagic species, the catch foregone is likely, for the most part, replaceable by fishing outside the area, and the impact is therefore slightly negative. No direct impact on coastal fishing is expected.

The impact associated with the implementation of the proposed activity and its significance are summarised in Table 4.3-3.

Table 4.3-3. Impact associated with the proposed Saare-Liivi wind farm and its significance

Associated consequence/impact	Impact before measures	Measures and final assessment
Impact on the economy		
Gross domestic product	++	No measures are required. Residual impact ++
Employment	++	Training of the local workforce and the involvement of local businesses increase the positive impact. Residual impact ++
Local benefit (toleration payment)	++ together with the initial area; 0 in the case of the additional area only	Together with the initial area, the payment arrangement described in Section 4.3.4 applies; in the case of the additional area only, no payment accrues to the municipality.
State tax revenues	++	No measures are required. Residual impact ++
Impact on fisheries		
Construction-phase access restriction and increased vessel traffic	0/–	Phased extent of the temporary safety zone; notification in good time; fisheries contact person. Residual impact 0/–
Operational reduction in trawlable area and changes to routes	0/–	Specification of the coexistence of fisheries and the offshore wind farm and of the possibilities for fishing vessel passage; compensation for fisheries undertakings under the Environmental Charges Act (section 4.3.4). Residual impact 0/–
Impact on spring Baltic herring migration and, consequently, on fishing	0/–	Temporal restriction in March and April at the eastern edge of the additional area (Section 3.8.4). Residual impact 0
Impact on tourism		
Cultural tourism	0	No measures are required. Residual impact 0
Maritime tourism (sailing, boating)	0	Marking of the wind farm and information for mariners (Section 6.1). Residual impact 0

Scale of significant environmental impact used in the EIA report: - slight negative impact, -- significant negative impact, 0 - no impact, neutral, + slight positive impact, ++ significant positive impact

4.3.6. Cumulative impacts

In the assessment of cumulative impact, the main focus is on the in-combination effect of the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm (see Section 2.4).

In terms of economic impact, employment and public sector revenues, the cumulative impact is positive, but it cannot be aggregated numerically, because the socio-economic impacts of the Saare-Liivi and Liivi Bay offshore wind farms have been assessed on the basis of different methodologies and assumptions. For example, the EIA report for the Liivi Bay offshore wind farm does not set out how operation of the wind farm will be organised or where the maintenance port will be located, which is associated with additional potential jobs.

As regards the toleration payment, the payment for the Liivi Bay offshore wind farm is divided between three local authorities — Kihnu municipality, Häädemeeste municipality and the city of Pärnu — with

Kihnu municipality likewise receiving the largest share. The in-combination effect of the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm constitutes a significant positive impact on the budget of Kihnu municipality.

As regards fisheries, the EIA report for the Liivi Bay offshore wind farm states that “in the case of fisheries, the significance of the final impact also depends on the exact location and size of the Saare-Liivi wind farm proposed by Utilitas Wind OÜ and the possible in-combination effect of the two wind farms, as this is an area with high trawl fishing intensity”. According to the present assessment, this observation is justified only in relation to the additional area: unlike the initial area, more intensive trawl fishing takes place along the western edge of main alternative 3 of the additional area and in the area lying to the west outside the offshore wind farm area. The impact on trawl fishing has, inter alia, been reduced by reducing the additional area specifically on the western side, where trawl fishing intensity is higher.

The quantitative assessment of cumulative impact is limited by the fact that the EIA report for the Liivi Bay offshore wind farm does not separately assess the impact on trawl fishing. Qualitatively, the in-combination effect of the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm may reduce the area of trawlable marine area in the deeper part of the Gulf of Riga and lengthen the routes between fishing grounds. Since Baltic herring fishing is constrained by the quota and fishing is regionally flexible, no cumulatively significant adverse impact on the use of fish stocks in the Gulf of Riga is forecast, but the impact on individual operators may be more noticeable than on the sector as a whole. The comparability of monitoring data for the additional area and the use of available information on neighbouring projects in the assessment of cumulative impact are discussed in Section 7.5.

5. Impact on underwater cultural heritage

5.1. Impact on underwater monuments and objects of cultural value

This chapter is based on four survey reports by Nautic Trade OÜ (Appendix 3.13). The surveys were carried out by archaeologists Ivar Treffner and Priit Lätti. The aim of the analysis was to determine the presence or absence in the survey area of possible man-made objects and objects that may be of archaeological interest. The initial analysis was based on the multibeam sonar dataset produced by Meremõõdistuskeskus OÜ, and the identified locations of potentially interesting objects were compared with the information contained in the Transport Administration's Hydrographic Information System and the Estonian Maritime Museum's wreck database.

5.1.1. Consideration of alternatives

The underwater cultural heritage surveys covered the wider survey area of main alternative 1. Under main alternative 3, on which the impact assessment is based, up to 40 turbines are planned within an area of 57.1 km².

Main alternative 3 is located within the surveyed marine area. Based on the survey results, Nimetu-548 and its surroundings were excluded from the development area, and the boundary of main alternative 3 was designed so that an avoidance buffer approximately 1 km wide remains between the wreck and the development area.

The data from the wider survey area are sufficient for assessing the general spatial layout of main alternative 3. However, the actual locations of the final turbine positions, cables, offshore substation, the support legs of installation vessels, anchoring areas and other temporary work areas must nevertheless be archaeologically verified before construction works commence.

5.1.2. Existing data

According to the Maritime Museum's wreck database, there are five known wrecks within the boundaries of main alternatives 1 and 2: "T-27", Unknown wreck, the so-called Elongated wreck, Unknown wreck, the so-called Short ship, Unknown wreck, probably a sailing vessel, the so-called Old-fashioned wreck, and "STB-7173". None of the wrecks has so far been designated as a cultural monument.

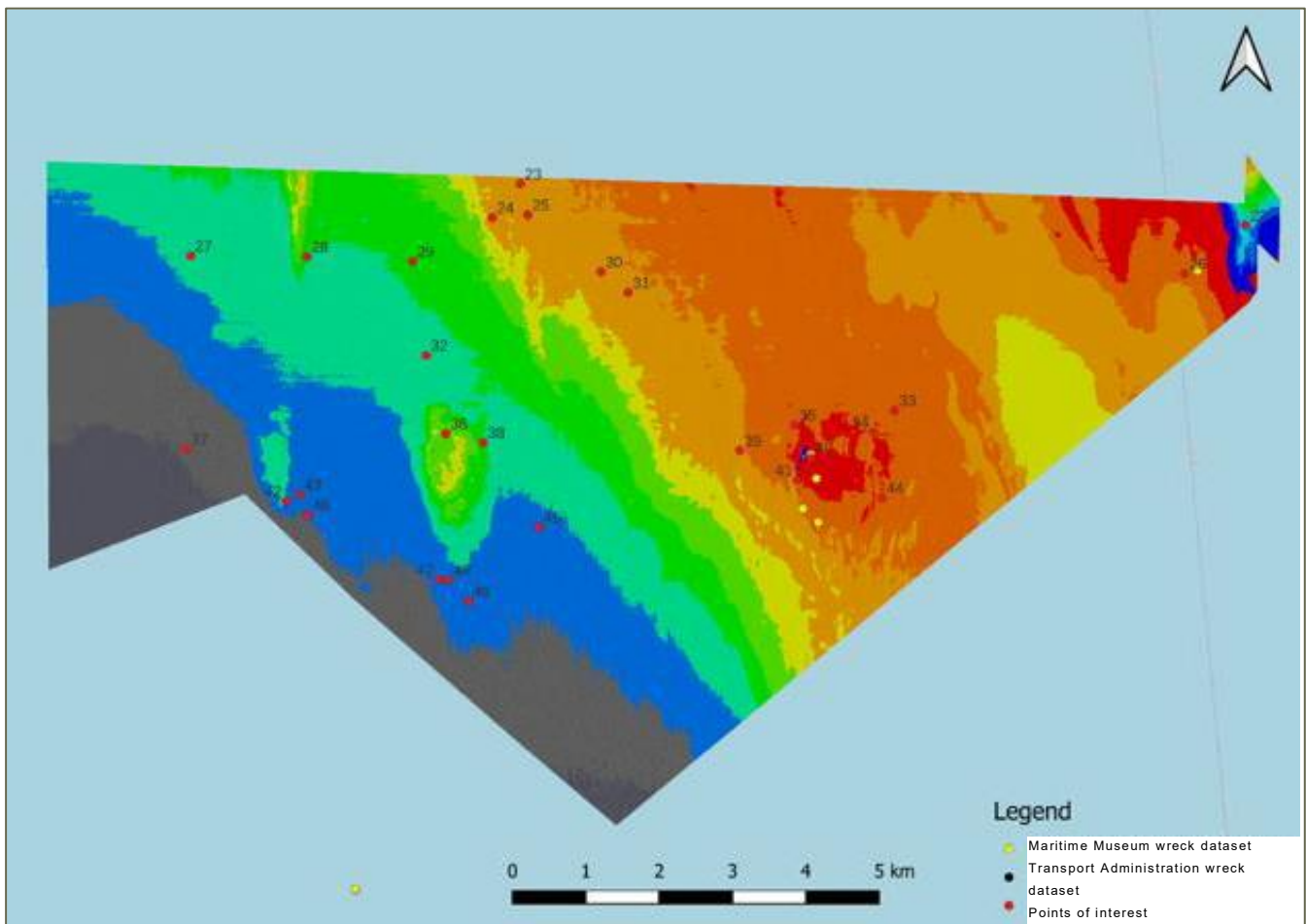


Figure 5.1-1. *Wrecks and points of interest in the additional area*

The analysis of the initial multibeam sonar dataset identified numerous seabed anomalies and known wreck sites within the wider survey area. All objects that could not be definitively regarded as natural on the basis of the existing data were checked using side-scan sonar, and wrecks with possible cultural value were additionally checked by diving. Follow-up checks showed that most of the anomalies were natural seabed features. In the context of the additional area, Nimetu-548 was identified as an object of potential cultural value (marked as No. 4 in Figure 5.1-1), which is believed to be over 100 years old (Figure 5.1-2).

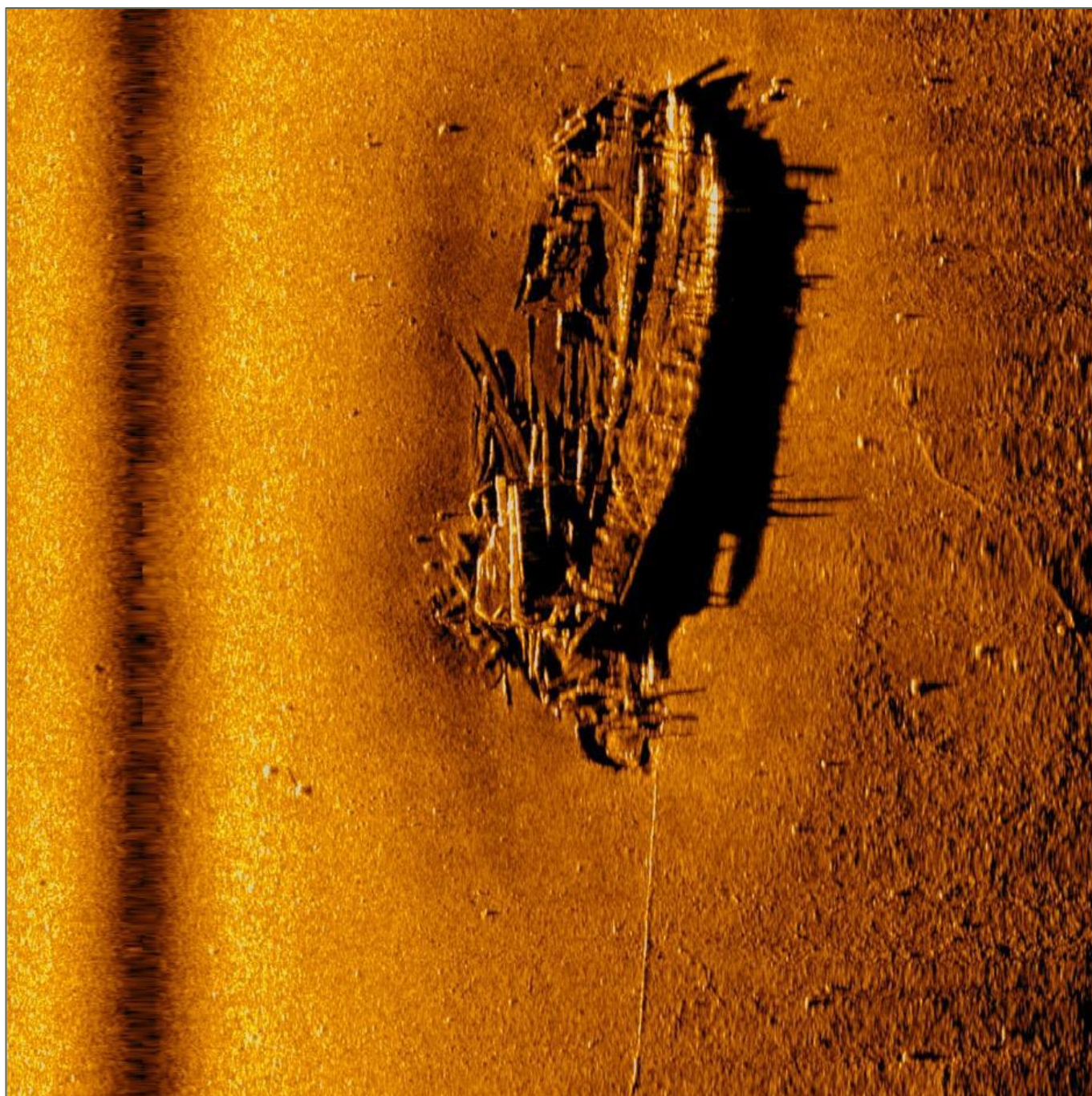


Figure 5.1-2. *Nimetu-548 – probable sailing vessel*

The National Heritage Board has initiated proceedings to place Nimetu-548 under protection. According to the draft order of the Minister of Culture of 23.07.2026 "Recognition of Shipwrecks as Cultural Monuments", the sailing vessel wreck corresponding, on the basis of its coordinates, to Nimetu-548 is proposed to be designated as an archaeological monument. The area of the proposed monument is approximately 583 m², and a 300 m wide protection zone is envisaged around it.

Taking into account the cultural value of the wreck Nimetu-548, the boundary of the wind farm buildable area has been adjusted by leaving a 1 km buffer around the wreck (Figure 5.1-3), which is more than three times larger than the 300 m protection zone prescribed by law.

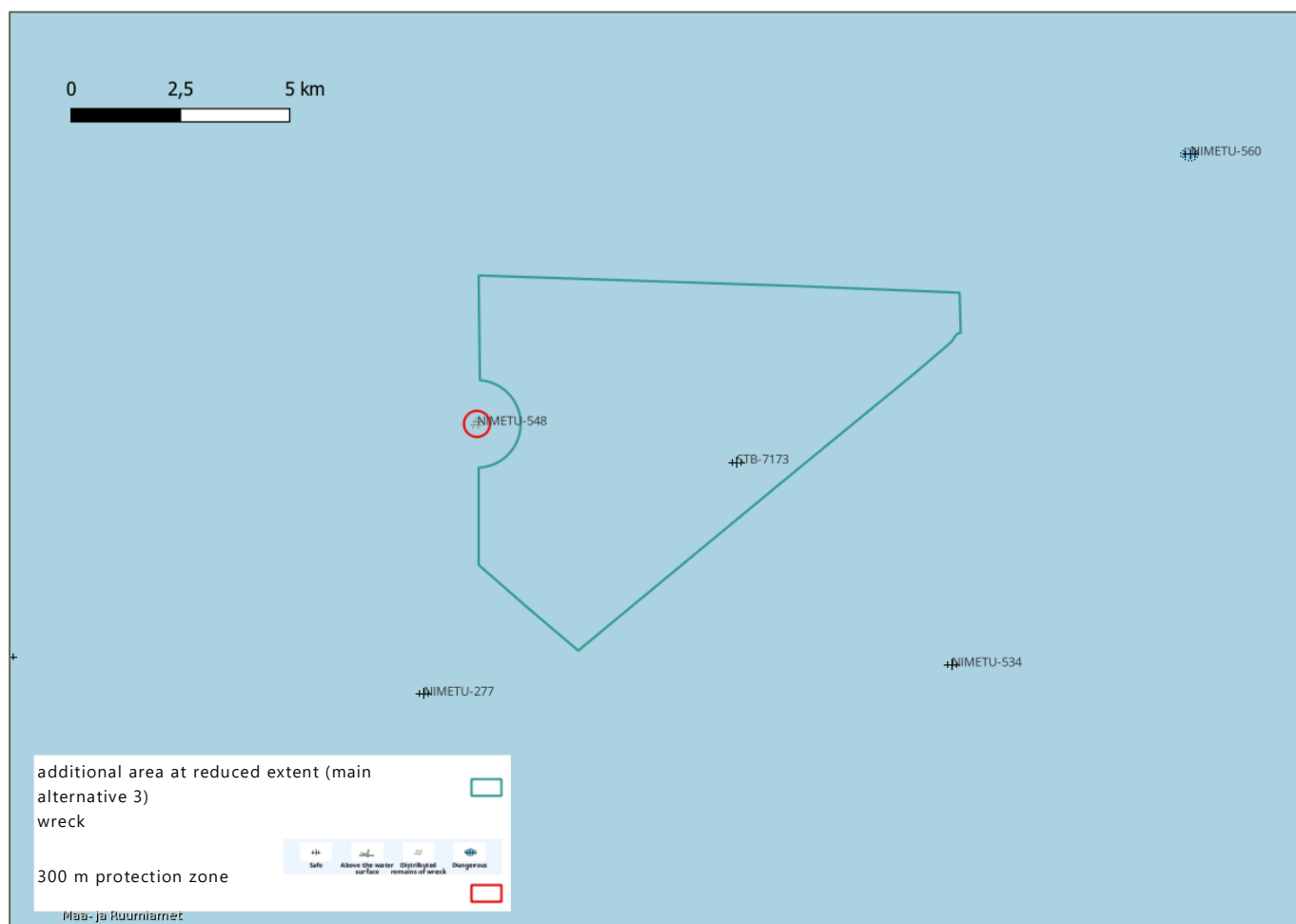


Figure 5.1-3. Location of the sailing vessel wreck to be designated as a cultural monument (Nimetu-548) relative to main alternative 3

5.1.3. Impact assessment

The construction of the offshore wind farm may affect underwater cultural heritage primarily through direct physical damage associated with foundations, cables, erosion protection, the offshore substation, temporary work platforms and anchoring. Indirect impact may occur through sediment movement, seabed erosion, changes in hydrodynamic conditions or vibration.

Nimetu-548 is located within the wider survey area under main alternative 1, but outside the shared spatial extent of main alternatives 2 and 3. Following the identification of the wreck's cultural value, the boundary of the development area was adjusted so that an approximately 1 km wide turbine-free area remains between Nimetu-548 and main alternative 3. This exceeds the extent of the 300 m protection zone proposed in the draft order designating it as a cultural monument.

Under main alternative 3, no turbines, offshore substation, inter-array cables, erosion protection, dumping area or other structures physically affecting the seabed are planned in the immediate vicinity of Nimetu-548. Therefore, the possibility of direct physical damage to the wreck is excluded.

Given the distance of at least approximately 1 km and the localised nature of the seabed disturbance, suspended matter and hydrodynamic changes described in Sections 3.1–3.3, no indirect impact is

expected that would damage the wreck, the archaeological cultural layer surrounding it or the wreck's preservation environment.

5.1.4. Mitigation measures

In implementing main alternative 3, the following must be done:

- the locations of the final turbine positions, inter-array cables and the connection cable route, offshore substation, the support legs of installation vessels, anchoring areas and other temporary work areas must be archaeologically verified before construction works commence;
- an avoidance buffer at least approximately 1 km wide must be maintained between Nimetu-548 and all permanent and temporary works affecting the seabed;
- the boundary of main alternative 3 must not be extended, nor infrastructure placed in the direction of Nimetu-548 beyond the spatial extent assessed in the EIA;
- the final design solution must be submitted to the National Heritage Board if the impact area of the works may extend to the monument or its protection zone;
- work must be stopped in the immediate vicinity of the object and the National Heritage Board notified if a previously unknown wreck, archaeological find or archaeological layer is discovered during construction works;
- before the installation of foundations and inter-array cables, surveys must be carried out on the cable routes to identify explosive objects and other obstacles; hazardous objects found must be avoided or their safe handling by a competent specialist arranged, and cultural heritage avoidance buffers must be taken into account when clearing the seabed;
- the cumulative impact assessment must be updated if the solutions of neighbouring projects, shared cable corridors, dumping areas or construction logistics subsequently change such that their impact area may extend to the same monument or its protection zone (section 5.1.6).

5.1.5. Summary

The area of main alternative 3 does not overlap with a known cultural monument, a wreck subject to designation proceedings as a cultural monument, or its proposed protection zone. The wreck Nimetu-548, identified by the surveys as being of potential cultural value, is located approximately 1 km from main alternative 3.

The identification of Nimetu-548's cultural value was taken into account in designing the spatial layout of main alternative 3, and a project-specific avoidance buffer was left around it to prevent direct and indirect impacts on the wreck. If the avoidance buffer is maintained and the final infrastructure is archaeologically verified, the implementation of main alternative 3 will not have an adverse impact on known underwater cultural heritage.

Table 5.1-1. Impact associated with planning the wind farm and its significance

Associated consequence/impact	Impact significance	Need for the application of mitigation measures, final impact significance
Wind farm construction and decommissioning		
Impact on monuments	0/-	Approximate 1 km avoidance buffer already taken into account in main alternative 3; residual impact 0

Associated consequence/impact	Impact significance	Need for the application of mitigation measures, final impact significance
Installation of the export cable	0	No measures are required. Residual impact 0
<i>Impact on monuments</i>		
Operation of the wind farm	0/-	Avoidance of anchoring and seabed works within the avoidance buffer around Nimetu-548; residual impact 0

Scale of significant environmental impact used in the EIA report: - slight negative impact, -- significant negative impact, 0 - no impact, neutral, + slight positive impact, ++ significant positive impact

5.1.6. Cumulative impact

The direct impact on underwater cultural heritage is object-specific and localised. On the basis of existing information, the infrastructure of the Saare-Liivi initial area, the additional area and the Liivi Bay offshore wind farm does not affect the same underwater cultural heritage object or its protection zone. Accordingly, no inter-project cumulative impact arises in relation to Nimetu-548.

If the solutions for neighbouring projects, shared cable corridors, dumping areas or construction logistics later change such that their impact area may extend to the same monument or its protection zone, the cumulative impact must be updated.

6. Other impacts and aspects associated with the offshore wind farm

6.1. Impact on navigation systems and on vessel traffic and maritime safety

This section is based on the 2026 study by Santera Service OÜ, “Maritime Safety Risk Assessment for the Additional Area of the Saare-Liivi Offshore Wind Farm”, final report, version 04, 21.07.2026 (risk assessment, 2026), which is presented in full in Annex 3.14. The study includes the methodology, statistics on existing vessel traffic and the history of maritime incidents, an assessment of impacts on navigation, communication and positioning equipment, a characterisation of future vessel traffic, risk modelling, risk control measures and a simplified cost-benefit analysis of those measures.

6.1.1. Consideration of alternatives

In the maritime safety risk assessment, the outer boundary of the additional area was treated as the maximum spatial extent within which turbines, the offshore substation, and inter-array and export cables may be located. The spatial extent of main alternative 2 on which the study was based and that of main alternative 3 on which the impact assessment is based are not exactly the same – main alternative 3 falls within main alternative 2, being smaller owing to the wreck Nimetu-548 and the 1 km wide buffer zone surrounding it (see Section 2.3) – and therefore the conclusions of the risk assessment are conservative and applicable in relation to main alternative 3, and the conclusions related to vessel traffic corridors, safety distances and passing the offshore wind farm are also applicable to main alternative 3.

For the assessment of cumulative impact, two geographical base scenarios were used in the risk assessment carried out. Scenario S1 covers the Saare-Liivi initial area and represents, for the purposes of decision-making on the additional area, the existing baseline situation, i.e. the situation regarded as likely to materialise. Scenario S2 covers the Saare-Liivi initial area, the additional area and the Liivi Bay offshore wind farm.

6.1.2. Existing data

To assess maritime safety in the additional area of the Saare-Liivi offshore wind farm, a separate maritime safety risk assessment was prepared, based on the International Maritime Organization (IMO) systematic safety assessment (*Formal Safety Assessment* – FSA) methodology and IALA risk management principles. The analysis used Transport Administration AIS data from 2021–2022, vessel traffic modelling (IWRAP Mk II), real-time simulations and the judgements of maritime experts. Smaller fishing vessels and small craft not subject to AIS requirements may be underrepresented in the dataset. Nor does the two-year dataset fully describe long-term traffic variability or the impact of future port, fisheries and offshore wind farm projects. The increase in traffic volume used in the future scenario is a modelling assumption, not a forecast of actual future traffic volume.

According to the risk assessment, the proposed offshore wind farm is located in an area where there are no ship routing measures established by the International Maritime Organization (IMO). The Pärnu fairway, Kihnu harbour fairway, Kakra Sääre fairway and Kihnu Strait fairway pass near the area. There are no official anchorage areas in the vicinity of the offshore wind farm and the subsea cable line, and no existing navigation marks fall within the area of main alternative 3 of the additional area (see Figure 6.1-1). The nearest search and rescue units are located in Pärnu, Kihnu and Jaagupi.

In the risk assessment, nine main vessel traffic corridors A–I were identified on the basis of AIS data (see Figure 6.1-2). The busiest is Corridor B between Irbe Strait and Pärnu harbour, which is used predominantly by cargo vessels. For fishing vessels, the more important corridors are C, D and E. In Corridor C, the annual dataset used in the study recorded 104 cargo-vessel voyages, 43 fishing-vessel voyages and 15 small-craft voyages. In Corridor D, fishing vessels formed the largest group with 84 voyages, followed by cargo vessels with 61 and small craft with 17 voyages. In Corridor E, 295 cargo-vessel voyages, 87 fishing-vessel voyages and 34 service-vessel voyages were recorded.

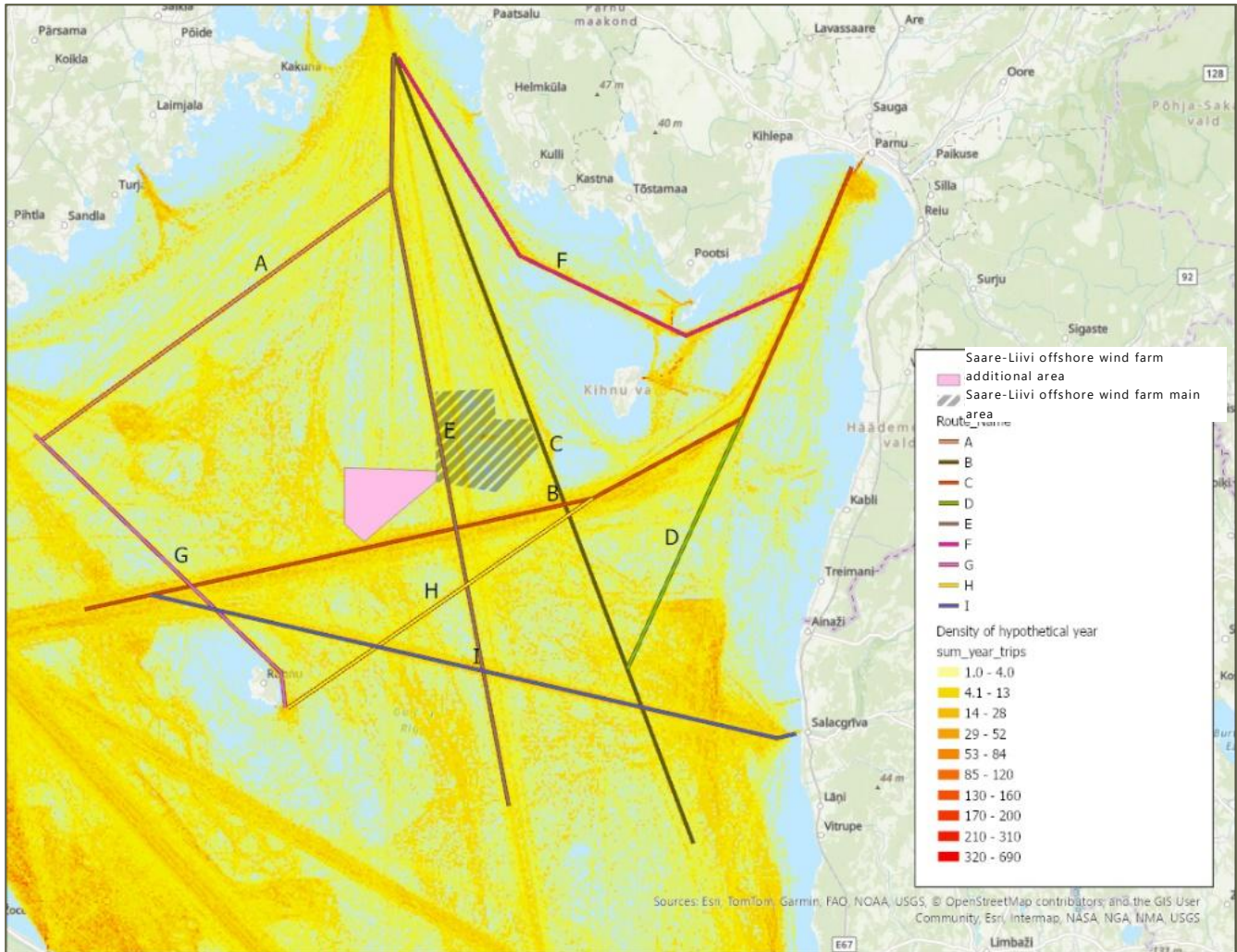


Figure 6.1-2. Traffic density map of all vessels and identified traffic corridors. Each grid cell is 50 m in size.

In the analysed corridors, depending on the route, cargo vessels, small craft or fishing vessels predominate. The share of cargo vessels is highest in Corridors A, B, C, E and I, small craft clearly dominate Corridor F, in Corridor H traffic is divided almost equally between small craft and passenger vessels, and in Corridors D and G fishing vessels account for the largest share.

Figure 6.1-3 shows the traffic density of cargo vessels passing through the Saare-Liivi initial and additional areas, with areas of elevated navigational risk highlighted as zones.

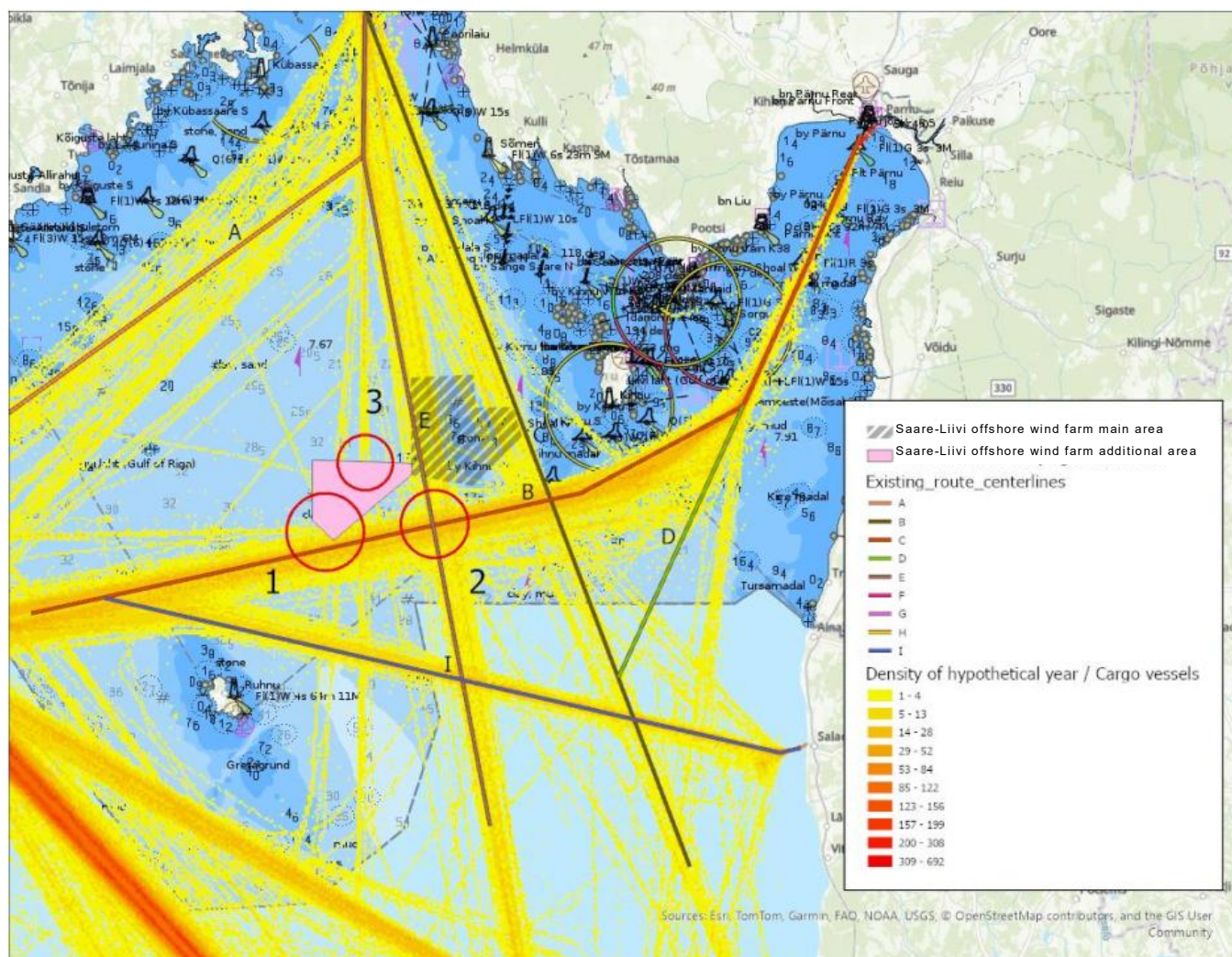


Figure 6.1-3. Traffic density of cargo vessels

Figure 6.1-4 shows the traffic density of fishing vessels, indicating that fishing vessels move actively in the Saare-Liivi additional area. In areas 1–3 (marked with a red circle), vessel traffic becomes riskier because the direction of the fairways changes and they intersect. Figure 6.1-5 illustrates fishing vessel activity in the vicinity of the Saare-Liivi initial area and additional area in 2022. Blue lines indicate the transit movements of fishing vessels, and red lines indicate trawling activity.

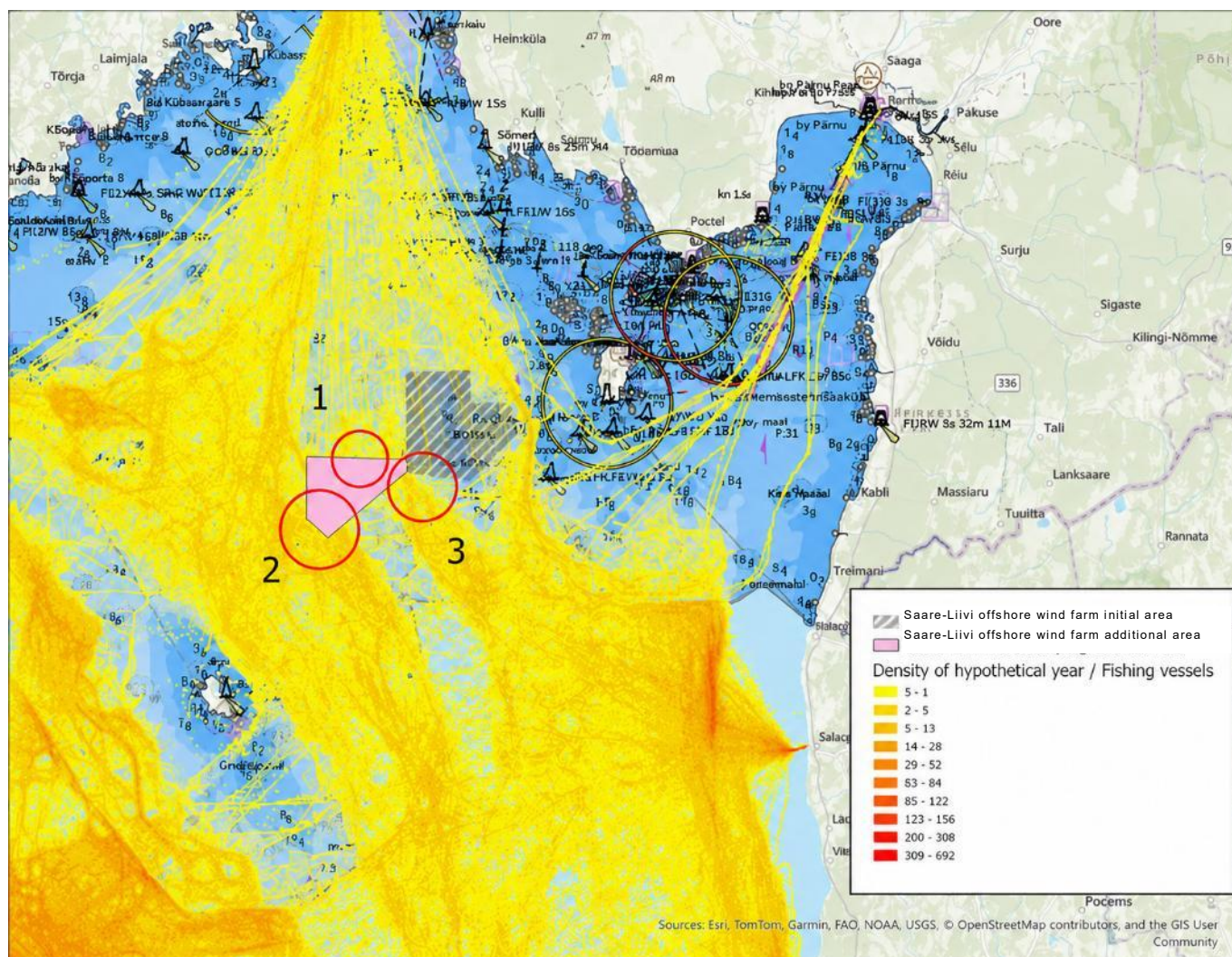


Figure 6.1-4. Traffic density of fishing vessels

In the case of fishing vessels, a distinction must be made between fishing within the wind farm area and transit between ports and fishing grounds located outside the wind farm. Low trawling intensity in a specific development area does not automatically mean that the area or its immediate surroundings are not important as a route used by fishing vessels.

6.1.3. Impact assessment

The construction of the offshore wind farm may alter the customary routes of vessel traffic and increase construction and maintenance vessel traffic in the area. As a result, the risk of collisions between vessels and the probability of striking offshore wind farm structures may increase, particularly during the construction stage and the operation and maintenance stage.

The impact on the navigation of fishing vessels may consist of a shift or lengthening of the transit route, the concentration of movements in narrower corridors, and an increase in collision risk. The change in the overall journey of a particular fishing vessel depends on its home port, the location of the fishing ground, the arrangements for passing through the wind farm, and the final safety zones.

The exact departure and destination ports, routes and number of voyages of construction and maintenance vessels are not known at the time of preparing the EIA. In the risk assessment, up to 1400 round trips during the construction period and up to 600 round trips per year during the operation and maintenance period were used as a conservative input. This is not a final logistics plan, but a baseline assumption for risk modelling. Before construction commences, a marine traffic management plan must be prepared on the basis of the final construction logistics, setting out the routes and work areas of project vessels, communication and reporting procedures, and interaction with third-party vessel traffic.

Based on the modelling results (Annex 3.14, Section 11), the absolute frequencies of occurrence of vessel collisions and vessels striking structures remain in the rare or very rare category even in the cumulative situation. Scenario S1 describes only the situation in the Saare-Liivi initial area, while Scenario S2 describes the cumulative situation of the Saare-Liivi initial area, the additional area and the Liivi Bay offshore wind farm. Compared with S1, in S2 the modelled frequency of passing collisions increases by approximately 5%, the frequency of head-on collisions by less than 1%, the frequency of crossing collisions by approximately 897%, the frequency of a powered vessel striking a structure by approximately 4374%, and the frequency of a drifting vessel striking a structure by approximately 813%. The large relative changes stem from very low initial levels: In S2, all of the events mentioned remain in the frequency class 'rare' or 'very rare or improbable'. With the 20% increase in traffic volume used in the future scenario, the frequency of collisions between vessels increases by approximately 44% and the frequency of vessels striking structures by approximately 20%, but the frequency classes of the events do not change. According to the expert judgement in the risk assessment, several construction-stage and operation-and-maintenance-stage scenarios are at a high risk level before risk control measures are implemented. With the implementation of the measures, the risks are reduced to a low or moderate, i.e. ALARP, level.

The risk assessment also evaluated the sensitivity of navigation and communication systems to the effects of offshore wind farms. The analysis covered ship radars, VHF radio communication, NAVTEX systems, the automatic identification system (AIS), GPS positioning, sonar equipment, and the possible electromagnetic effects of subsea cables on navigation equipment.

From the perspective of navigation system operation, no significant impact is expected on VHF radio communication, NAVTEX systems, AIS, GPS positioning, mobile communications or sonar equipment on the basis of existing studies. Nor has any significant electromagnetic impact of subsea cables on ships' navigation equipment been identified where conventional design and construction solutions are used.

The greatest potential impact is associated with the operation of ship radars. The metal structures of wind turbines may cause radar-signal reflections and side echoes and make it more difficult to detect smaller vessels within and in the immediate vicinity of the offshore wind farm, especially in poor visibility. According to the literature review in the risk assessment, stronger radar effects may extend up to approximately 1.5 nautical miles from the wind farm. Maintaining an adequate buffer zone between normal vessel traffic and the offshore wind farm is regarded as the main spatial measure under the developer's control. Enhanced radar signal processing and radar reflectors on small craft may further reduce the impact, but their implementation depends on vessels' equipment and users and is not under the control of the offshore wind farm developer. The impact on VHF radio communication, AIS, NAVTEX, GPS and sonar is assessed as low. In VHF direction finding, local interference may occur very close to a wind turbine, which is assessed in the risk assessment as moderate, but its spatial extent is small. Mandatory regular post-commissioning verification measurements are not provided for in the risk assessment as a separate measure. The risk assessment also assessed the impact on winter navigation. Ice conditions in the Gulf of Riga may, in severe winters, affect the manoeuvrability of vessels, increase the risk of drifting, and create a need for icebreaker assistance. In the quantitative modelling of the risk analysis, ice conditions were not taken into account separately, because the arrangements for winter

navigation and ice management in the wind farm were not known. Therefore, before commissioning, a winter navigation and ice management plan agreed with the Transport Administration and other authorities concerned must be prepared. The plan must specify the ice class of the wind farm's maintenance vessels, the need for icebreaker assistance or escort, safe passages, and actions in the event of a vessel becoming trapped in ice or drifting towards structures.

Overall, with the implementation of mitigation measures, the impact of the offshore wind farm on navigation systems and vessel traffic is small to moderate. The more significant impacts are associated with the reorganisation of vessel traffic and the possible disruption of the operation of ship radars within and in the immediate vicinity of the offshore wind farm. The proposed navigation marking, an adequate buffer zone, safety zones, traffic management and maritime safety monitoring make it possible to reduce the risks to the ALARP level. The need for and proposal for the reorganisation of vessel traffic are addressed in more detail in the cumulative and transboundary impacts subsection of this chapter.

6.1.4. Mitigation measures

The impacts on vessel traffic and maritime safety are mitigated by technical, organisational and operational measures, covering both the construction and operation stages, as follows:

1. Before construction commences, a marine traffic management plan must be prepared on the basis of the final construction logistics, setting out the routes and work areas of project vessels, communication and reporting procedures, and interaction with third-party vessel traffic.
2. Before commissioning, search and rescue and pollution response arrangements must be prepared, safe passages and communication procedures must be defined, and the solution must be agreed in cooperation with the authorities concerned.
3. Both the construction area and the completed offshore wind farm must be marked with floating navigation marks, including buoys and AIS virtual marks, and the wind turbines must be marked in accordance with IALA Guideline G1162 (Annex 3.1.8). The final navigation marking for the construction, operation and decommissioning stage must be defined in a separate navigation-marking design, which must be submitted to the Transport Administration for approval before the start of the respective stage. This improves the visibility of the offshore wind farm, increases mariners' situational awareness, and reduces the likelihood of inadvertent entry and of striking a structure.
4. When preparing the final design solution, a vessel traffic passage with sufficient width, depth and navigational margin must be maintained in Corridor B. The inclusion of the corridor on nautical charts, its marking at sea, or the implementation of another vessel traffic management measure must be decided and agreed with the Transport Administration.
5. The risk assessment recommends VTS for the active coordination of vessel traffic in the Saare-Liivi additional area and identifies, as an alternative, another AIS- and radar-based traffic monitoring and reporting arrangement. Before construction activities begin, the technical and organisational solution for traffic monitoring and management required for the additional area must be defined in cooperation with the Transport Administration and other authorities concerned. During the active stages of construction, safe vessel traffic is supported by on-site traffic monitoring and by a guard vessel equipped with radar and AIS equipment or, where necessary, a mobile patrol craft, allowing rapid intervention if dangerous situations arise. Given the distance of the additional area from Pärnu harbour, the regular escorting of vessels from the port to the work area is not considered practical. During the operation stage, the need for a guard vessel, its area of operation and period of use shall be determined on a risk basis; a permanently deployed guard vessel is not automatically necessary if navigation marking, remote surveillance, communication arrangements and other measures ensure an adequate level of safety.

6. **To reduce risks arising from ice conditions, icebreaker readiness or, where necessary, icebreaker escort must be ensured in the area.** This helps to prevent vessels trapped in ice from drifting towards the offshore wind farm structures and ensures that the main fairways remain navigable even in severe ice conditions. The wind turbines must also be arranged in a regular rectilinear grid (grid layout), which allows an icebreaker to manoeuvre safely, reduces the accumulation of ridged ice, and leaves sufficient passages for vessels.
7. The 1.5-nautical-mile-wide area used in the risk analysis is treated as a conservative safety zone. The actual extent of the temporary restriction or safety zone during construction must be determined on the basis of the work stages, the vessels used and the structures to be installed, and agreed with the Transport Administration. The restriction does not have to be uniform throughout the construction period or cover the entire wind farm area at the same time.
8. The need for a guard vessel, its area of operation and period of use must be determined on a risk basis. During the active stages of construction, the use of a guard vessel or patrol craft equipped with AIS and radar may be justified. During the operation stage, a permanently deployed guard vessel is not automatically necessary if navigation marking, remote surveillance, communication arrangements and other measures ensure an adequate level of safety.
9. The final layout of the wind turbines and other infrastructure, and the emergency and rescue arrangements, must be agreed with the search and rescue authorities. It must be ensured that SAR and MEDEVAC flights can be carried out safely, including, where necessary, determining a suitable solution for the use of a helicopter rescue winch or landing.
10. Before commissioning, a winter navigation and ice management plan agreed with the Transport Administration and other authorities concerned must be prepared. The plan must specify the ice class of the wind farm's maintenance vessels, the need for icebreaker assistance or escort, safe passages, and actions in the event of a vessel becoming trapped in ice or drifting towards structures.

6.1.5. Follow-up assessment

The risk assessment does not provide for mandatory regular follow-up monitoring of navigation, communication and positioning systems as a separate measure. If, during operation, substantiated information emerges of interference affecting the functioning of radar, VHF communications, AIS or another navigation system, the extent of the interference must be determined in cooperation with the Transport Administration and the owner of the system concerned and, where necessary, a proportionate technical or organisational solution must be implemented.

6.1.6. Summary

Main alternative 3 of the additional area does not overlap with vessel traffic management measures established by IMO, but is located in an area used by cargo, fishing, support, passenger and small vessels. The proposed activity may cause the displacement of vessel traffic, the concentration of traffic in corridors, and an increase in the risk of collisions between vessels and of striking structures. It is particularly important to maintain fishing vessels' access to fishing areas and safe north–south and east–west connections.

Before the implementation of risk control measures, the impact on maritime safety during the construction and operation stages is assessed as minor to significant negative. With the implementation of a final navigationally suitable layout, adequate corridors, phased traffic management, proper marking, operational notification, and SAR, pollution response and ice management solutions, it is possible to

reduce the risks to the ALARP level. The residual impact on vessel traffic and maritime safety is minor negative, and on navigation and communication systems neutral to minor negative.

In the cumulative situation, the impact is greater, because the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm together reduce the sea space available for unrestricted use and concentrate traffic into narrower corridors.

Table 6.1-1. *Impact associated with planning the wind farm and its significance*

Associated consequence or impact	Significance of the impact before measures	Measures and final assessment
Construction-stage risk of collisions between vessels and of striking a structure	–/—	Phased marking of work areas, traffic management plan, operational notification, reporting procedures and, where necessary, a guard vessel; residual impact –
Change in fishing vessels' transit routes and access to fishing areas	–; in the cumulative situation –/—	Coordination of the construction schedule and notification of the fisheries sector; residual impact –
Snagging of anchors or fishing gear on cables and other subsea infrastructure	0/–	Burial or protection of cables, accurate mapping, and notification of mariners and fishers; residual impact 0/–
Operational risk of collisions between vessels and of striking wind turbines	–/—	A final navigationally suitable layout, marking, safe corridors, AIS- and radar-based monitoring and, where necessary, VTS or an equivalent solution; residual impact –
Impact on navigation, communication and positioning systems, including radar	0/–	Maintenance of an adequate buffer zone between regular vessel traffic and the offshore wind farm, a proper design solution and navigation marking, and, if substantiated interference occurs, verification of its extent and the necessary mitigation solution; residual impact 0/–
Impact on search and rescue and pollution response activities	–/—	SAR and pollution response plan, adequate passages, guard vessel rescue capability, exercises and cooperation with the rescue authorities; residual impact –
Risk relating to winter navigation and ice management	–; assessment indeterminate	Winter navigation and ice management plan, maintenance vessels' ice class and, where necessary, icebreaker assistance; residual impact 0/–

Scale of significant environmental impact used in the EIA report: - slight negative impact, -- significant negative impact, 0 - no impact, neutral, + slight positive impact, ++ significant positive impact

6.1.7. Cumulative and transboundary environmental impact

In the maritime safety risk assessment, the cumulative S2 scenario includes the Saare-Liivi initial area, main alternative 3 of the additional area, and the Liivi Bay offshore wind farm.

The in-combination effect of the three development areas reduces the sea space available for unrestricted use by vessel traffic, and part of the traffic that is currently more dispersed becomes concentrated in narrower corridors. The greatest change occurs in Corridor C, where the section affected by the offshore wind farms is lengthened by 18.3 km, or 18.9%, and shifts partly into shallower waters. The affected section of Corridor E is lengthened by 8.2 km, or 10.7%. In Corridors B and H, the changes are smaller, and Corridor D shifts eastwards mainly due to the Liivi Bay offshore wind farm.

Table 6.1-2. *Vessel traffic corridors affected in the cumulative S2 scenario*

Corridor	Modelled change in the affected corridor section	Direction and main users	Meaning of the assessment
B	+0.2 km, or +0.17%	Irbe Strait – Pärnu; mainly cargo vessels	Minor route change; adequate lateral clearance from the wind farm is important
C	+18.3 km, or +18.9%	Väinameri – Skulte; cargo, fishing and small vessels	Greatest change; the corridor shifts below the 10 m isobath and, in places, close to the 5 m isobath
D	No significant lengthening was identified	South-west of Pärnu; fishing vessels are the largest group	The corridor shifts eastwards due to the Liivi Bay offshore wind farm
E	+8.2 km, or +10.7%	Väinameri – Riga; cargo, fishing and auxiliary vessels	Noticeable change in the north–south connection
H	+1.3 km, or +3.0%	Irbe Strait – Salacgrīva; mainly small and passenger vessels	Minor route change, but straightforward and safe passage is necessary

The changes referred to describe only the rerouted corridor sections (Figure 6.1-6), not a vessel's entire route from port to destination port or fishing area. In addition, the S2 scenario simultaneously includes the initial area, the additional area and the Liivi Bay offshore wind farm. Therefore, the calculated increase in route length cannot be attributed in full to main alternative 3.

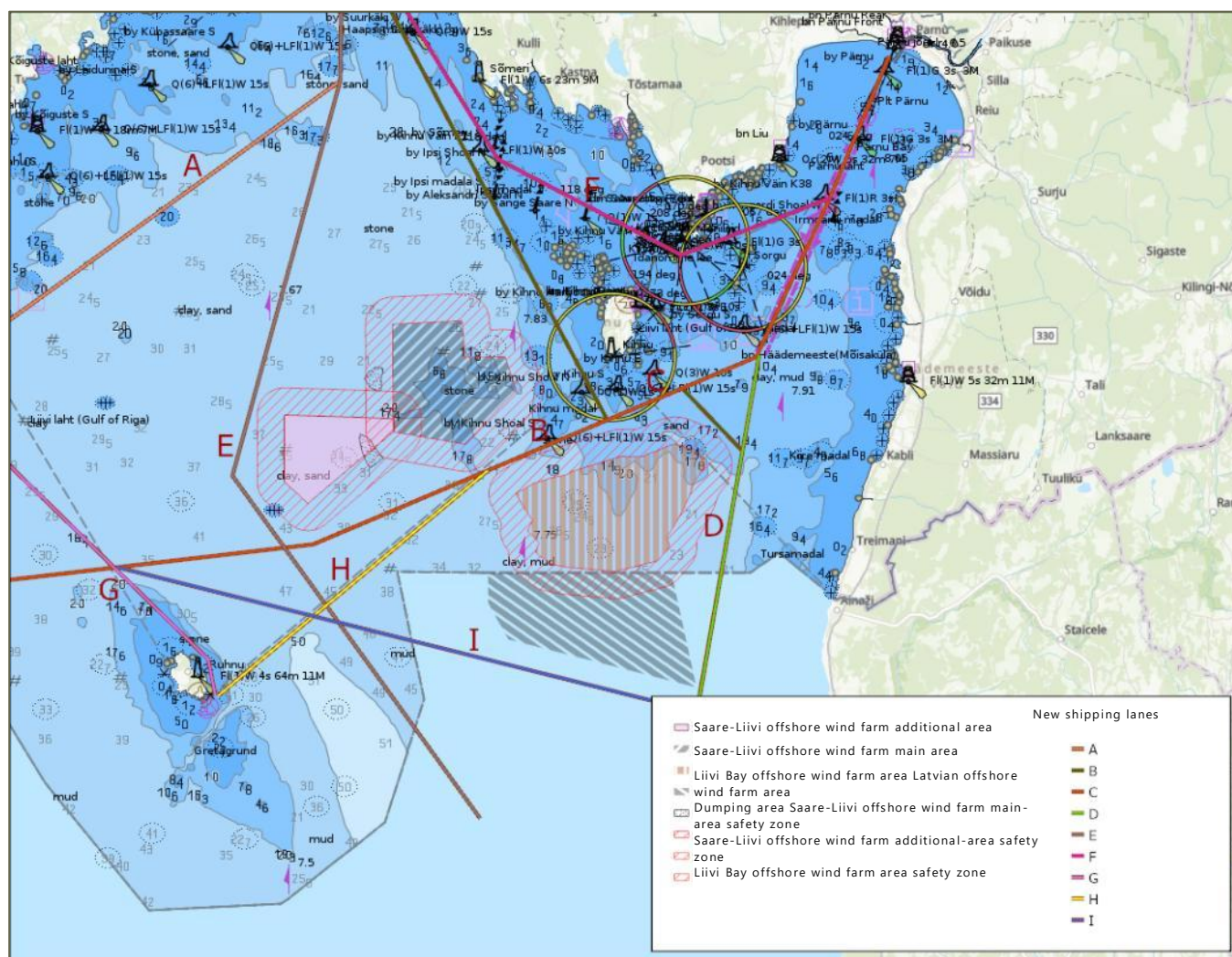


Figure 6.1-6. Change in vessel traffic corridors in the cumulative situation of offshore wind farms

The concentration of traffic primarily increases the risk of collisions between crossing vessels and of powered and drifting vessels striking wind farm structures. Although the absolute frequencies of the modelled events remain low, the initial risk, taking account of the severity of consequences, is high in several scenarios. With the implementation of coordinated navigation marking, adequate corridors, traffic monitoring, operational notification, and rescue and emergency arrangements, it is possible to reduce the risks to the ALARP level.

Because the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm are located relatively close to the Estonian-Latvian maritime boundary, the transboundary impact on Latvian navigation and the connectivity of vessel traffic corridors have also been assessed within the cumulative scenario (Figure 6.1-7).

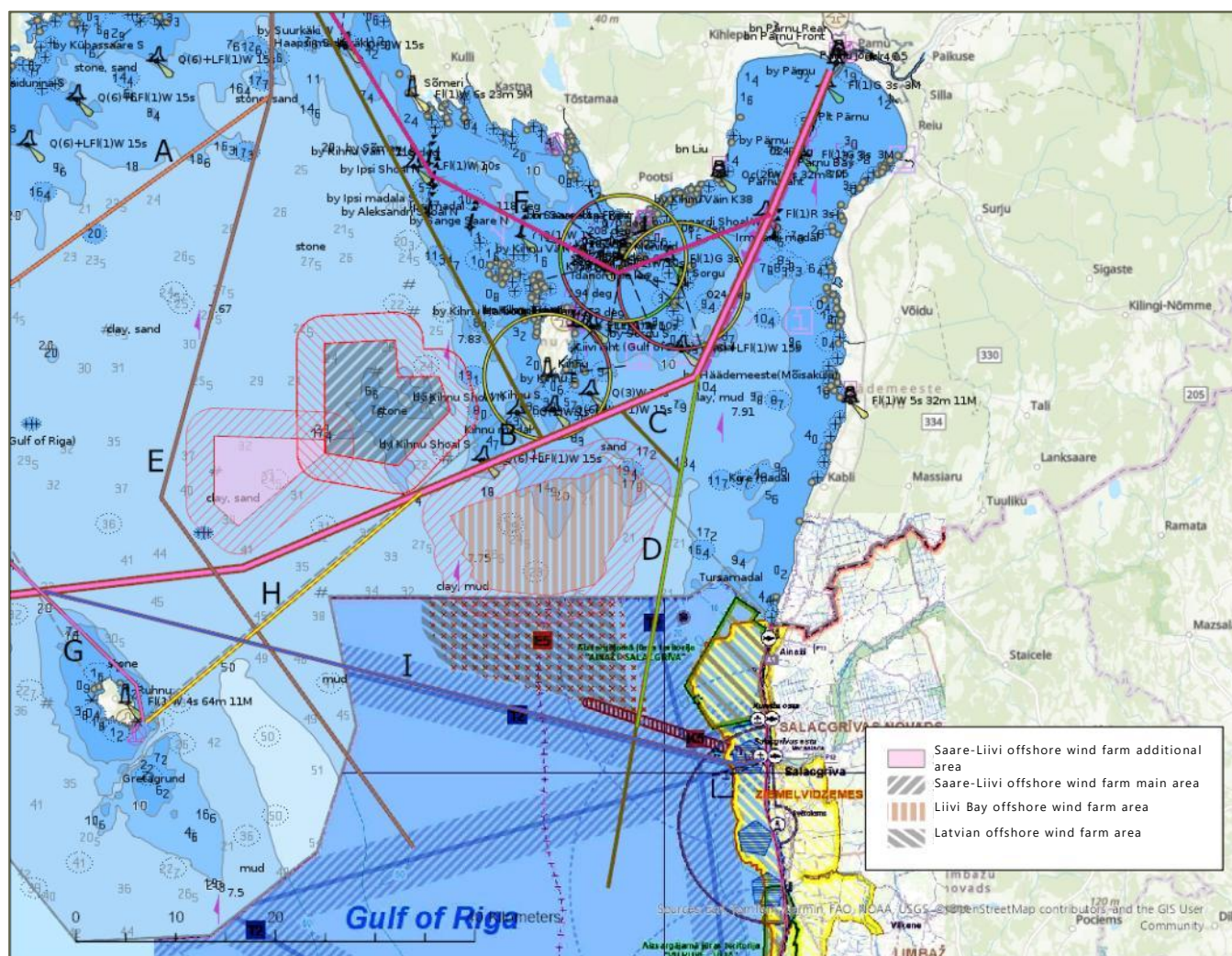


Figure 6.1-7. Vessel traffic corridors and offshore wind farm area planned in the spatial plan for the Latvian marine area

The modelled Estonian-side Corridors D and E can be connected to the vessel traffic directions provided for in the Latvian marine area spatial plan, and no transboundary bottleneck was identified for international transit traffic. This conclusion assumes that, once the wind farm is completed, corridors with sufficient width, depth and navigational margin are retained.

In the risk analysis, vessel traffic has not been differentiated by vessel flag state, home port or fishing ground. Therefore, the study does not rule out that Latvian fishing vessels currently use routes passing through the Saare-Liivi or Gulf of Riga development areas. If the Latvian side provides AIS, VMS or other movement data for fishing vessels, the changes in their customary routes and access to fishing grounds must be refined on that basis.

To reduce the cumulative impact, the final layout, navigation marking, temporary and permanent safety distances, traffic monitoring, construction logistics, winter navigation, and emergency and rescue arrangements for the Saare-Liivi additional area must be planned in cooperation with the competent authorities, taking into account, where possible, the information available on the Liivi Bay offshore wind farm. This does not impose obligations on other developers or alter the conditions of the superficies licence for the initial area.

The maritime safety risk analyses for both the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm note that the wind farms somewhat shift vessels' traditional routes and increase the risk of vessels colliding with other vessels or wind farm structures.

The cumulative risks are somewhat higher, but can be reduced through the implementation of mitigation measures, in particular the proper marking of wind farms and wind turbines.

6.1.8. Uncertainty / knowledge gaps

The main uncertainties in the maritime safety assessment relate to the limited time period and possible data gaps in the 2021–2022 AIS data, the underrepresentation of smaller vessels not subject to AIS requirements, the forecast of future traffic volumes, and the absence of the wind farm's final layout, passage arrangements, safety zones, construction logistics and maintenance routes. These uncertainties do not alter the conclusions of the assessment: conservative baseline assumptions have been used in the risk analysis (project vessel 180 × 50 m, up to 1.400 return trips per year during construction and up to 600 during operation, 1.5-nautical-mile-wide safety zone), and all major uncertainties are covered by measures to be included in the permit conditions, compliance with which will be verified before construction begins.

The S1–S2 comparison presented in the risk assessment (Annex 3.14) does not allow the impact of main alternative 3 to be distinguished from the additional impact of the Liivi Bay offshore wind farm. Nor has vessel traffic been differentiated by vessel flag state, home port or fishing ground. These limitations nevertheless do not alter the main conclusions of the maritime safety assessment or the need to implement the identified mitigation measures. Taking account of the in-combination effect of the wind farms proposed in the Gulf of Riga is particularly important when preparing the detailed design for the additional area and specifying the passage arrangements, safety zones, construction logistics and maintenance routes.

6.2. Impact on air traffic

The impact of the initial and additional area of the Saare-Liivi offshore wind farm on aviation was assessed in the 2023 applied study by Estonian Aviation Academy, "Impacts of the Saare-Liivi Offshore Wind Farm on Aviation" (hereinafter the aviation study; Annex 3.15). In the study, the area with up to 120 turbines under main alternative 2 of the initial area and the area with up to 92 turbines under main alternative 1 of the additional area were treated as a single set of aviation obstacles, on the basis of wind turbines up to 400 m in height. The text of the aviation study did not state the number of turbines separately; rather, the assessment was based on the layout plans provided by the client at that time.

Since the aviation study was prepared, the spatial extent of both areas and the number of turbines have been reduced. The solution provided for in the initial area EIA report declared compliant and in the issued superficies licence comprises up to 80 turbines, and under main alternative 3 of the additional area assessed in this EIA report, up to 40 turbines with a tip height of up to 310 m are planned in an area of 57.1 km². Accordingly, the current solution comprises a total of up to 120 turbines, compared with the development scale of up to 212 turbines considered when the aviation study was prepared. The spatial and technical baseline of the aviation study was therefore conservative in relation to the current solution.

The impact of the initial area on air traffic has been addressed in the initial area EIA report declared compliant. This chapter does not repeat the detailed description of the region's airspace, aerodrome procedures or aviation infrastructure.

6.2.1. Consideration of alternatives

The impact is assessed for main alternative 3, under which up to 40 turbines with a tip height of up to 310 m are planned. The outer boundary of main alternative 3 remains within the boundary of main alternative 2: the location of the wreck Nimetu-548, together with an approximately 1 km wide buffer, has been excluded from it (see Section 2.3). The spatial extent of main alternative 3 is therefore smaller than that of main alternative 2. The smaller number of turbines in main alternative 3 reduces the number of aviation obstacles and simplifies the design of potential SAR access routes. However, because the impact depends primarily on the final layout of the turbines, not only on their number, compliance with aviation requirements must be verified on the basis of the detailed design.

The spatial and technical solution used in the aviation study was conservative with respect to this main alternative 3. Under main alternative 3, up to 40 turbines with a tip height of up to 310 m will be installed in the 57.1 km² additional area, whereas the study covered a larger additional area and turbines up to 400 m high. Therefore, the study's conclusions can be applied to main alternative 3 as a conservative overestimate. Spatially sensitive impacts, in particular on visual flights, search and rescue flights, and the in-combination effect with the Liivi Bay offshore wind farm, are assessed separately on the basis of the current solution.

6.2.2. Existing situation and impact assessment

AIRSPACE, AERODROME PROCEDURES AND INSTRUMENT FLIGHTS

According to the aviation study, the Saare-Liivi initial and additional area do not affect the obstacle limitation surfaces of Pärnu or Kuressaare aerodromes, the approach and departure procedures of the aerodromes, or the conduct of instrument flights. The impact of the Saare-Liivi initial and additional area on the minimum safe altitude in the region is minor, and there is no impact on prohibited, restricted or danger areas (see Annex 3.15).

Main alternative 3 of the additional area has a smaller spatial extent and a lower maximum tip height than the solution assessed in the study. Therefore, the addition of the additional area does not give rise to a more adverse impact on Pärnu or Kuressaare aerodrome procedures or on instrument flight traffic than in the EIA for the initial area.

VISUAL FLIGHTS AND THE RUHNU AIR LINK

Visual flights

The data on the actual Pärnu–Ruhnu–Kuressaare flight trajectories used in the aviation study show that flights passed primarily through the eastern part of the Saare-Liivi initial area or its immediate vicinity. The additional area under main alternative 3 lies west of the initial area and further from those flight trajectories. Therefore, the additional area, considered separately, does not create a significant new obstacle to the scheduled Ruhnu service, and its additional impact on visual flights is minor.

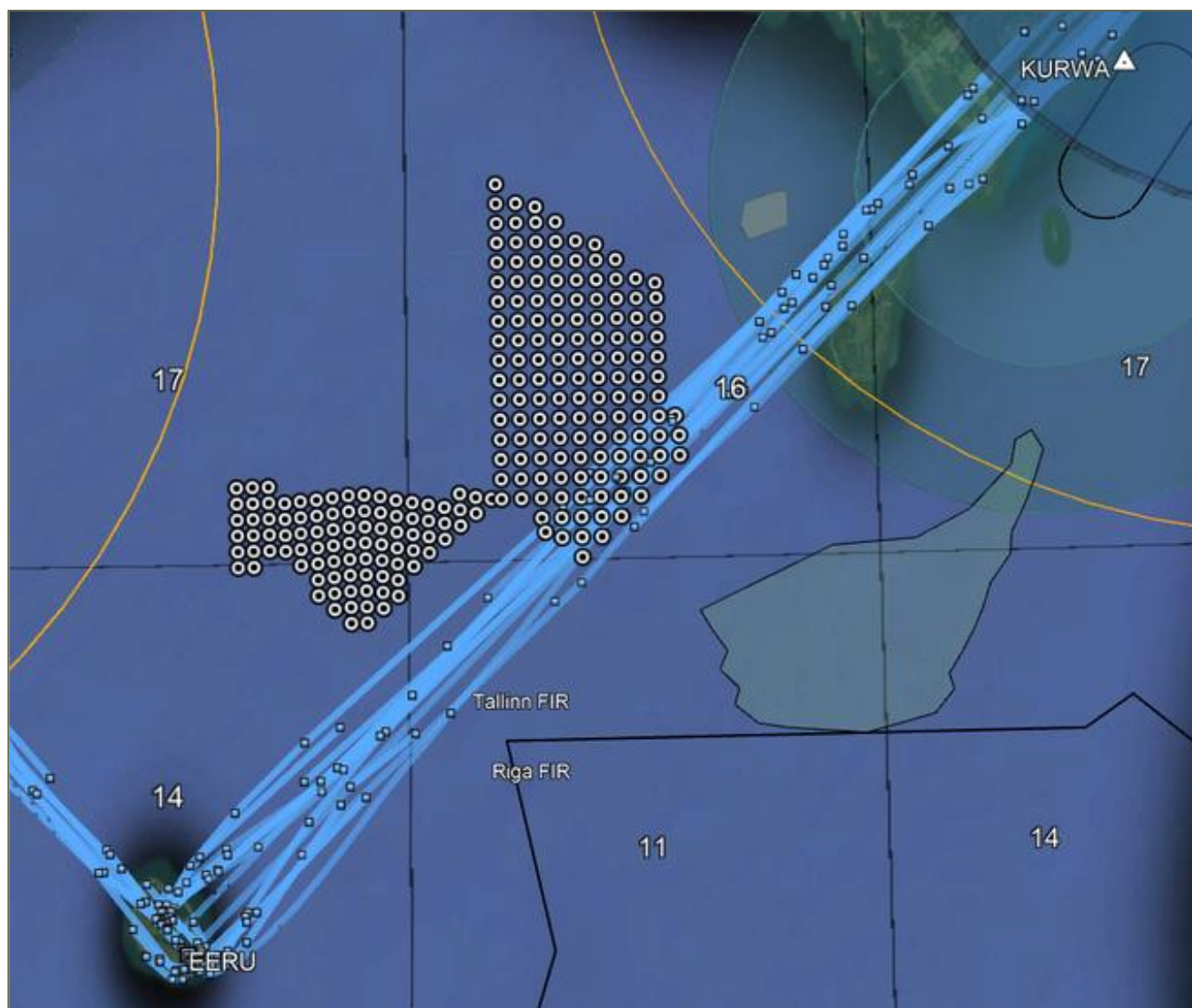


Figure 6.2-1. Pärnu–Ruhnu flight trajectories, the Saare-Liivi initial area (alternative 2) and additional area (alternative 1), and the superficies licence application area of the Liivi Bay offshore wind farm (aviation study, 2023).

The more important issue is the functionality of the flight corridor between the Saare-Liivi initial area and the Liivi Bay offshore wind farm. At the time of the aviation study, the free area between the wind farm areas was approximately 9 km wide at its narrowest point. In the flight operator's assessment, for safe flight operations, including turning back if necessary and avoiding wake effects, a turbine-free area at least 10 km wide was required. In the study, the in-combination effect of the two wind farms on visual flights was assessed as very significant in the absence of measures. In the EIA report for the Saare-Liivi initial area and in superficies licence No 1-7/26-038, the following obligation has been imposed: In designing the wind farm, it must be taken into account that, to ensure the safety of air traffic on the Pärnu-Ruhnu route, a turbine-free area at least 10 km wide must be left between the Liivi Bay and Saare-Liivi offshore wind farms so that an aircraft can turn back if necessary. In cooperation with the flight operator, additional operating modes must, if necessary, also be identified (e.g. shutting down turbines for the duration of the scheduled service) under which the existing aircraft can be operated safely. Cooperate with the Ministry of the Interior, the Transport Administration and the Police and Border Guard Board to ensure air traffic safety.

The additional area under main alternative 3 lies west of the Saare-Liivi initial area and does not lie within the flight corridor between the Saare-Liivi initial area and the Liivi Bay offshore wind farm. Therefore, the additional area does not narrow the flight corridor or increase the cumulative impact associated with its functioning.

Search and rescue flights and medical evacuation

The development of the additional area increases the total number of aviation obstacles located at sea and the number of people present in the area during the construction and operation of the wind farm. At the same time, an irregular turbine layout, insufficient spacing between turbines and operating rotors may hamper helicopter access to the wind farm, the conduct of search operations and winching.

The Saare-Liivi initial area and additional area form a single set of aviation obstacles from the perspective of search and rescue flights. The smaller number of turbines in the additional area allows better access routes to be designed compared with the solution considered in the study, but does not eliminate the need for a search and rescue solution.

Without agreed access routes, turbine identification, communication arrangements and the technical capability to place turbines in a safe operating mode, there may be a significant negative impact on SAR and MEDEVAC flights. The final search and rescue solution must be based on the requirements of the Police and Border Guard Board, the Transport Administration and, where necessary, JRCC Tallinn. Agreed access routes, turbine identification markings, round-the-clock communication arrangements and the technical capability to shut down the relevant turbines for the duration of a rescue operation reduce the residual impact to a minor negative level (see Section 6.2.4 and Table 6.2-1).

Communication, navigation and surveillance systems

According to the aviation study, because of the large distance, the Saare-Liivi additional area has no impact on Tallinn aerodrome's surveillance systems or on Tallinn secondary radar. A minor impact may occur on Martna secondary radar, and the impact on the WAM surveillance system was assessed as moderate due to uncertainty. The potential impact consists in reflections and shielding caused by the turbines, and local deterioration in the quality of surveillance data. The modular design of the WAM system allows base stations to be relocated or added, or the system to be adapted by software, if necessary.

The impact on navigation and radio communication equipment was assessed as minor. Main alternative 3 of the additional area lies within the area assessed in the study, and its smaller extent and lower turbines do not increase the expected impact compared with the solution in the aviation study.

WAKE TURBULENCE

Turbulence and wake turbulence caused by operating wind turbines may affect, in particular, visual, SAR and MEDEVAC flights at low altitude. The potential in-combination effect associated with the flight corridor between the Saare-Liivi initial area and the Liivi Bay offshore wind farm has been addressed in the initial area EIA report and in the conditions of the superficies licence for the initial area. Main alternative 3 of the additional area lies away from the historical trajectories of the scheduled Ruhnu service and from the said flight corridor, and does not narrow the turbine-free area between the wind farms. Therefore, no additional measures related to the width of the flight corridor or its use are necessary for the additional area. The safety of SAR and MEDEVAC flights within the additional area itself will, where necessary, be ensured through the design solution for that area, access routes, communication arrangements and the technical capability to shut down turbines.

6.2.3. Mitigation measures

To ensure aviation safety in the Saare-Liivi additional area, the following must be done:

1. during the preparation of the detailed design, submit to the Transport Administration, Lennuliiklusteeninduse AS and the Police and Border Guard Board the final layout plan, tip heights, obstacle lighting solution and maximum heights of construction cranes for the turbines in the additional area;
2. provide access routes suitable for SAR and MEDEVAC flights; their final alignment, clear width and any safety zone shall be determined in cooperation with the Police and Border Guard Board and the Transport Administration;
3. before the wind farm is commissioned, prepare an emergency response plan, a SAR plan and a communication plan, which shall define, among other things, communications between the wind farm control centre, JRCC Tallinn, the rescue helicopter and units operating at sea, as well as the procedure for shutting down turbines;
4. ensure round-the-clock availability of the wind farm control centre and the technical capability to rapidly shut down selected turbines for the duration of a rescue operation, lock the blades in a suitable position and, where necessary, rotate the nacelle;
5. mark the turbines with clear turbine identification markings visible from the air and from the sea, and equip them with obstacle lights in accordance with the applicable requirements. Under sections 34 and 35 of the Aviation Act, obstacles must be marked and lit in accordance with the requirements of ICAO Annex 14. For lighting, the use of an ADLS solution (*Aircraft Detection Lighting System*) is recommended, under which the obstacle lights are switched on when an aircraft approaches and are switched off at other times;
6. after completion of the wind farm, submit the final obstacle data and marking information to the aeronautical information department of Lennuliiklusteeninduse AS;
7. if technical impacts on any communication, navigation or surveillance system occur, implement software or infrastructure measures agreed with Lennuliiklusteeninduse AS.

6.2.4. Summary

Main alternative 3 of the Saare-Liivi additional area lies further from the historical Pärnu–Ruhnu–Kuressaare flight trajectories and the Liivi Bay offshore wind farm than the Saare-Liivi initial area. Therefore, the additional area does not in itself create a significant new obstacle to visual flights and does not affect the obstacle limitation surfaces, instrument flight procedures or applicable prohibited, restricted or danger areas of Pärnu or Kuressaare aerodrome. For the additional area, the relevant measures are the measures ensuring aviation safety for that area itself: agreement on the final turbine layout and SAR and MEDEVAC access routes, proper marking and lighting, emergency communication arrangements, the technical capability to shut down turbines and, where necessary, technical adaptation of communication, navigation and surveillance systems. With the implementation of these measures, no significant adverse residual impact on air traffic is expected, and the residual impact is assessed as neutral to minor negative.

Table 6.2-1. Impact associated with planning the wind farm and its significance

Associated consequence/impact	Impact significance	Need for the application of mitigation measures, final impact significance
Wind farm construction and decommissioning		
Impact on the minimum altitudes above sea level (AMA) in the region	0	No measures are required. Residual impact 0
Installation of the export cable	0	No measures are required. Residual impact 0
Wind farm operation		
Impact on the minimum altitudes above sea level (AMA) in the region	0	No measures are required. Residual impact 0
Prohibited, restricted and danger areas	0	No measures are required. Residual impact 0
Impact on the obstacle limitation surfaces (OLS) of Kuressaare and Pärnu aerodromes	0/-	Submission of the final layout plan and tip heights to the Transport Administration, Lennuliiklusteeninduse AS and the Police and Border Guard Board during the preparation of the detailed design; proper marking and obstacle lights. Residual impact 0
Impact on the approach procedures at Kuressaare and Pärnu aerodromes	0/-	Verification of the final layout plan against the applicable eAIP and air traffic arrangements at the detailed design stage. Residual impact 0
Wake turbulence	-	The additional area does not narrow the flight corridor between the Saare-Liivi initial area and the Liivi Bay offshore wind farm; no separate measure related to the width of the corridor is necessary for the additional area. Residual impact 0/-
Search and rescue (SAR) and emergency medical evacuation (MEDEVAC) flights	-	Agreement on SAR access routes with the Police and Border Guard Board and the Transport Administration, turbine identification markings, an emergency response plan and communication plan, round-the-clock availability of the wind farm control centre and the technical capability to shut down turbines. Residual impact -
Scheduled Kuressaare–Ruhnu–Pärnu service (until 2029)	0/-	The additional area is not located on the historical Pärnu–Ruhnu–Kuressaare flight trajectories and does not narrow the flight corridor between the Saare-Liivi initial area and the Liivi Bay offshore wind farm; no separate corridor measure is necessary for the additional area. Residual impact 0/-

Scale of significant environmental impact used in the EIA report: - slight negative impact, -- significant negative impact, 0 - no impact, neutral, + slight positive impact, ++ significant positive impact

6.2.5. Cumulative impact

From an aviation perspective, the Saare-Liivi initial area and additional area form a single set of aviation obstacles, as the areas are adjacent. Accordingly, the additional area does not constitute a separate external cumulative project in relation to the initial area. The Liivi Bay offshore wind farm is treated as an external cumulative project.

Main alternative 3 of the Saare-Liivi additional area lies to the west of the Saare-Liivi initial area and further from the Ruhnu flight trajectories and the Liivi Bay offshore wind farm. The additional area is not located between the Saare-Liivi initial area and the Liivi Bay offshore wind farm and therefore does not narrow the flight corridor between them or increase the cumulative impact associated with the functionality of that corridor. The cumulative impact is determined primarily by the relative positioning of the eastern edge of the Saare-Liivi initial area and the turbines of the Liivi Bay offshore wind farm, which is governed by the conditions set in the respective procedures for each development.

The additional area under main alternative 3 is not located between the Saare-Liivi initial area and the Liivi Bay offshore wind farm and does not narrow the flight corridor between them. Therefore, the requirement concerning the width of the turbine-free area between the wind farms is not decisive in the assessment of the impact of the additional area and does not constitute a mitigation measure for the additional area. The separate contribution of the additional area to the cumulative impact on visual, SAR and MEDEVAC flights is small. In the detailed design of the additional area, only the solutions necessary within that area for turbine marking and for the organisation of SAR and MEDEVAC flights will be specified, in cooperation with the authorities concerned. The additional cumulative residual impact of the additional area is assessed as minor negative.

6.2.6. Uncertainty/knowledge gaps

Before the wind farm in the additional area is constructed, the arrangements for the Pärnu–Ruhnu–Kuressaare air link, the aircraft used, aerodrome procedures, and aviation communication, navigation and surveillance systems may change. The design of the Liivi Bay offshore wind farm may also be refined. The aviation study provides that, if such new circumstances arise, the validity of the assessment will be verified during the preparation of the detailed design of the additional area. Data from the neighbouring project will be taken into account to the extent available.

6.3. Impact on marine surveillance and operational communications

This section deals with the functioning of the systems used for surveillance of the State's marine area and the airspace above it, border surveillance, national defence, ensuring maritime safety, detection and response to marine pollution, and maintaining communications for operational services. The impact on ships' navigation, communication and positioning systems is discussed in section 6.1, and civil aviation communication, navigation and surveillance systems in section 6.2.

Under the Estonian Marine Spatial Plan, turbines must not cause a reduction in the operational capability of national defence air surveillance systems or maritime surveillance systems. Where necessary, compensatory solutions must be developed and implemented, and cooperation must take place with the Ministry of Defence, the Police and Border Guard Board and other competent authorities. Since the necessary clarifications depend on the final layout and technical parameters of the turbines, compliance with the requirements will be verified, in cooperation with the authorities concerned and system owners, on the basis of a technical analysis carried out during the preparation of the detailed design.

6.3.1. Alternatives

The impact is assessed for main alternative 3 of the Saare-Liivi additional area, under which up to 40 turbines will be installed in the additional area. From the perspective of maritime surveillance and operational communications systems, the up to 80 turbines in the Saare-Liivi initial area and the up to 40 turbines in the additional area form a single set of structures.

Under technical alternative A, the maximum turbine tip height is up to 275 m and under technical alternative B up to 310 m. Technical alternative B is treated as a conservative technical solution with regard to surveillance systems' external line of sight and signal reflection. At the same time, the impact ultimately depends on the location and layout of the turbines, which means that it is not possible to draw a final conclusion on system performance solely on the basis of turbine height.

The outer boundary of main alternative 3 lies within main alternative 2: the location of the wreck Nimetu-548 together with an approximately 1 km-wide buffer has been excluded from it (see section 2.3), meaning that the spatial extent of main alternative 3 is smaller than that of main alternative 2. Reducing the number of turbines from 50 to 40 reduces the number of potential reflection sources and allows the layout to be better adapted, but may not automatically reduce the potential shielding sector that may form behind the wind farm area as a whole. Therefore, the validity of the assessment must be verified on the basis of the final layout plan.

6.3.2. Impact assessment

Offshore wind turbines may affect surveillance and communications systems primarily through line-of-sight shielding and the reflection and scattering of electromagnetic waves. The extent and significance of the potential impact depend on the operating principle and technical parameters of the specific system.

The assessment must distinguish between normal use of the system and critical operating situations, such as a border incident, search and rescue operation, marine pollution response, major marine accident or national defence activity. Service performance cannot be regarded as adequate merely because communications or surveillance function under normal conditions most of the time.

CONSTRUCTION PHASE

During the construction phase, temporary impacts may be caused not only by the turbines but also by installation vessels, cranes, construction of the offshore substation, temporary platforms and other tall construction equipment. The temporary or final height, location and period of use of a structure may affect radar line of sight or the propagation of radio communications.

Before construction begins, the construction sequence, the maximum heights of the turbines and temporary cranes, the operating areas of installation vessels, and the construction schedule must be submitted to the relevant system owners and operators. If the construction-phase configuration may cause a temporary impact that differs from or is greater than that of the final solution, temporary technical or operational measures must be specified.

OPERATION PHASE

During the operation phase, the turbines in the Saare-Liivi initial and additional areas form a permanent set of reflection and shielding objects. The impact may vary depending on wind direction, rotor

orientation, rotational speed and the number of turbines operating at the same time. The assessment must therefore take into account not only the static structures of the turbines, but also the impact of operating rotors.

Operation of the wind farm is acceptable from the perspective of maritime surveillance, national defence and operational communications systems, provided that the final design solution is assessed during the preparation of the detailed design, the necessary technical mitigation solutions are included in the detailed design, and the functioning of the agreed systems is verified before commissioning.

DECOMMISSIONING

The impact of the decommissioning phase is broadly similar to that of the construction phase and is associated with temporary cranes, vessels and changing radar-reflecting objects. The technical arrangements and timing of the decommissioning works must be re-coordinated with the relevant system owners before the works commence.

6.3.3. Mitigation measures

The final design solution and its technical impact analysis for maritime surveillance, national defence and operational communications systems must be submitted and reviewed during the preparation of the detailed design together with the authorities concerned and system owners. The necessary technical mitigation solutions must be included in the detailed design. **Before the wind farm is commissioned, the functioning of the agreed systems and compliance with the acceptance criteria defined during preparation of the detailed design will be verified.**

During the preparation of the detailed design, the final turbine layout plan, turbine heights, rotor diameter and materials, the location of the offshore substation, and the heights of temporary construction cranes must be submitted to the system owners.

6.3.4. Summary

The addition of the additional area under main alternative 3 may increase the extent of radar reflections, background interference and shielding caused by the Saare-Liivi wind farm as a whole, and may affect the propagation conditions of operational radio communications. However, the precise extent of the impact and the need for technical mitigation solutions depend on the final layout and technical parameters of the turbines and will be specified on the basis of the technical analysis carried out during the preparation of the detailed design. Therefore, the certainty of the assessment is limited at this stage.

No significant adverse residual impact is anticipated, provided that the final design solution is assessed during the preparation of the detailed design together with the authorities concerned and system owners, the necessary technical mitigation solutions are included in the detailed design, and the proper functioning of the systems is verified before commissioning. Data from neighbouring projects will be taken into account in the technical analysis to the extent available; this EIA does not impose on the developers of neighbouring projects an obligation to provide a joint mitigation solution or to submit information. Subject to fulfilment of these conditions, the residual impact is assessed as neutral to minor negative.

Table 6.3-1. Impact associated with planning the wind farm and its significance

Associated consequence/ impact	Impact before measures	Applicable condition and residual impact
Impact of construction-phase cranes and temporary infrastructure on maritime surveillance	–	Coordination of the construction-phase configuration and, where necessary, a temporary compensatory solution; residual impact 0/–
Impact of the Saare-Liivi wind farm on national maritime surveillance and national defence systems	–/— or indeterminate	A restricted-access technical assessment of the final layout during the preparation of the detailed design and, where necessary, a technical mitigation solution; residual impact 0/–
Impact on the functioning of the operational radio communications network	–	Technical impact analysis of the final design solution and, where necessary, a technical mitigation solution agreed with the system owner; performance verification before commissioning. Residual impact 0/–
Cumulative impact of the Saare-Liivi and Liivi Bay offshore wind farms	–/— or indeterminate	Technical impact analysis of the additional area during the preparation of the detailed design and, where necessary, technical mitigation solutions; residual impact 0/–
Transboundary environmental impact on Latvian surveillance and communications systems	indeterminate	Involvement of the competent Latvian authorities and, where necessary, technical coordination; residual impact 0/–

6.3.5. Cumulative and transboundary environmental impact

The Saare-Liivi initial area and the additional area under main alternative 3 are treated, from the perspective of maritime surveillance, national defence and operational communications systems, as a single set of obstacles. The Liivi Bay offshore wind farm is treated as an external cumulative project.

The impact of individual projects may be acceptable, but turbines in several wind farms may be located within the line of sight of the same surveillance or communications system and may affect the same viewing sector or coverage area. Cumulative impact may be manifested in the spatial expansion of radar interference and the shadow zone, an increase in false tracks and background interference, deterioration in object track persistence, and a reduction in the coverage area or redundancy of operational communications.

6.3.6. Uncertainty/knowledge gaps

At the EIA stage, the turbine locations and models, structural materials, rotor operating parameters and the heights of temporary construction cranes are not yet finally known. Nor are detailed technical data on national maritime surveillance, national defence and operational communications systems fully publicly available. Therefore, the impact on these systems will be specified during the preparation of the detailed design for the additional area, on the basis of the final design solution, together with the relevant authorities and system owners, and the necessary technical solutions to avoid or mitigate impacts will be included in the detailed design.

The precise locations, operating parameters and performance data of systems used to ensure public security and national defence are not publicly available. The limited public availability of technical data on national surveillance, national defence and operational communications systems does not mean that the impact may remain unassessed. The public EIA report describes the impact mechanisms, the overall outcome of the assessment and the conditions for project implementation. During the preparation of the detailed design, a sufficient technical basis must be available to the decision-maker and the relevant system owners to enable verification, before construction works commence, that the required functions are retained.

7. Summary of assessment results

7.1. Comparison of alternatives

For each subsection on an environmental aspect assessed in the EIA report, the spatial or technical alternatives considered in the assessment of the specific environmental component and topic are set out.

The EIA studies may have been based on main alternative 1, main alternative 2 or main alternative 3 (see section 2.3 for more detail). **The development area as set out in the superficies licence application and the EIA programme covered 91.2 km² and up to 92 wind turbines (main alternative 1). As a result of geophysical and geotechnical seabed surveys, the western part of the development area, where the thickness of clayey sediments exceeds 4 m and where there are hazards associated with gas pockets and buried depressions, and which is also unsuitable from the perspective of trawling and navigation, was excluded; thus main alternative 2, covering 58.7 km² with up to 50 turbines, was formed. Following underwater cultural heritage surveys, the location of the wreck Nimetu-548, together with an approximately 1 km-wide avoidance buffer, was excluded from the area, and the layout was optimised after the final extent of the Saare-Liivi initial area had been established, in order to avoid wake losses and take account of constraints identified during the surveys. Thus, main alternative 3, covering 57.1 km² with up to 40 turbines, became the basis for the assessment (see section 2.3). Main alternative 3, as developed during the EIA process, was the maximum possible solution that formed the basis for the impact assessments in this EIA report. Accordingly, it is not appropriate to carry out any additional comparison of spatial alternatives.**

Where a specific subject area required the assessment of different technical alternatives, a comparison of alternatives was also carried out in each subsection in accordance with the impact significance scale (see Table 2.3-3). Various technical alternatives were considered in carrying out the EIA: turbine capacity (including turbine height and rotor blade diameter), as well as different turbine foundation types and the installation technologies for those foundation types (see Table 2.3-2). Table 7.1-1 provides a brief overview of the assessment of technical alternatives and the results.

Table 7.1-1. Comparison of technical alternatives

Technical alternative	Impact area compared (section)	Comparison result
Turbine capacity: A – 15 MW B – 20 MW	Underwater noise (2.8), seals (3.7)	Operational-phase noise modelling showed that 15 MW and 20 MW have similar impacts and that the impact of the operating wind farm is insignificant.
	Birds (3.5)	The 20 MW wind turbine (variant B) has the highest calculated collision risk: the predicted collision risk for common cranes, geese and geese of the genus <i>Branta</i> , and nocturnal migrants is approximately 20–40% higher than for variant A. From the perspective of birds, variant A is preferable.
	Climate (3.11)	A: up to 600 MW and ~2.7 TWh per year. B: up to 800 MW and ~3.5 TWh per year. Higher electricity output may increase avoided emissions; the net benefit also depends on the generation displaced and the project's life-cycle emissions (section 3.11).

Technical alternative	Impact area compared (section)	Comparison result
Foundation type: gravity base foundation vs monopile foundation	Seabed habitats (3.4)	The gravity base foundation has a greater impact on the natural seabed. The direct permanent seabed footprint of the wind turbines, the offshore substation, and the internal and export cables remains below 1 km ² , and the Habitats Directive reef habitat type does not occur in the additional area (section 3.4.2). With the entire polygon of the dumping area also being conservatively treated as a permanent loss, the calculated maximum is higher.
	Underwater noise (2.8), seals (3.7), fish fauna (3.8)	In terms of emitted sound, the gravity base foundation has the lower impact, followed by drilling of monopile foundations. Impact and vibratory piling may result in high noise levels and a PTS/TTS risk for seals and Baltic herring within the safety zone. The impacts can be mitigated for all alternatives.
	Marine water quality (3.3)	Modelling was carried out on the basis of the worst-case scenario, namely a gravity base foundation, and suspended matter dispersion modelling covered, in addition to the wind turbine foundations and the offshore substation, the internal cables in the additional area and the route corridor for the connection cable (section 3.3.3); no significant impacts on marine water quality were identified.
Dumping solution: 1) dumping next to the wind turbines; 2) dumping in dumping areas	Marine water quality (3.3)	In both alternatives, the generation and dispersion of suspended matter are short-term, and the transport of phosphorus from sediment into the water column is modest on the scale of the Gulf of Riga.

Among the different foundation types, the installation of a gravity base foundation has the greater impact on the natural seabed in the comparison. The estimated losses of natural seabed associated with the wind farm's internal and export cables were small in area, remaining below one square kilometre. Since the Habitats Directive reef habitat type does not occur in the additional area (section 3.4.2), the development of the additional area will not result in any loss of reef habitat type.

Marine water quality modelling was carried out solely on the basis of the worst-case scenario, namely the installation of a gravity base foundation. suspended matter dispersion modelling took into account both the construction of the wind turbine foundations and the offshore substation and the trenching works for the internal cables in the additional area and the route corridor for the connection cable (section 3.3.3). The modelling carried out did not identify that the construction and operation of the offshore wind farm in the Saare-Liivi additional area would cause significant impacts on marine water quality in the Gulf of Riga. The marine water quality assessment was carried out for two alternative scenarios regarding possible dumping solutions: 1) dumping next to the wind turbines and 2) dumping in dumping areas. As a result, it was found that for both construction and dumping alternatives, the generation and dispersion of suspended matter are short-term and that the transport of phosphorus from sediment into the water column associated with the construction of the wind turbine foundations is modest on the scale of the entire Gulf of Riga.

The assessment of construction-phase impacts associated with underwater noise showed that, in terms of emitted sound, the use and installation of a gravity base foundation has the lower environmental impact, followed by drilling of monopile foundations. Impact and vibratory piling of monopile foundations may result in high noise levels in the vicinity of the pile being driven and may cause permanent and temporary threshold shift in seals (and Baltic herring) that happen to be present within the safety zone.

However, the impacts can be mitigated for all alternatives, and where a particular foundation and its installation technology are selected, suitable mitigation measures must be applied. The modelling results for underwater noise generated during the operational phase of the wind farm showed that the 15 MW and 20 MW technical alternatives have similar impacts and that the impact of the operating wind farm is insignificant.

The bird analysis considered the potential magnitude of the collision risk posed by wind turbines of different capacities. Based on the analysis carried out, it emerged that the larger wind turbine – 20 MW (technical alternative 2, i.e. variant B) – has the highest collision risk, with a predicted collision risk for common cranes, geese and geese of the genus *Branta*, and nocturnal migrants approximately 20–40% higher than for the 15 MW wind turbine (variant A). From the perspective of bird collision risk, technical alternative 1, i.e. variant A, is therefore preferable (see section 3.5.5).

In summary, implementation of main alternative 3, with the planned avoidance and mitigation measures applied, will not result in any significant adverse residual impact in any of the assessed areas. The main risks requiring measures are bird collision risk and underwater noise from piling of monopile foundations affecting seals and fish fauna. The exact technical impact on maritime surveillance and communications systems will be addressed during the preparation of the detailed design. In other areas, adverse residual impact is largely absent or minor; climate impact and part of the socio-economic impact are positive.

7.2. Mitigation measures

This EIA report follows the mitigation hierarchy, according to which impacts are first avoided, then reduced, and residual impact compensated only as a last resort. The most important application of this principle is not any single measure, but, among other things, the modification of the spatial layout of the proposed activity on the basis of the baseline studies. Table 7.2-1 sets out a list of mitigation measures to prevent and minimise primarily significant adverse impacts, but also, where possible, any adverse impacts on the environmental and other aspects assessed in the EIA report.

The development area as set out in the superficies licence application and the EIA programme covered 91.2 km² and up to 92 wind turbines (main alternative 1). As a result of geophysical and geotechnical seabed surveys, the western part of the development area, where the thickness of clayey sediments exceeds 4 m and where there are hazards associated with gas pockets and buried depressions, and which is also unsuitable from the perspective of trawling and navigation, was excluded; thus main alternative 2, covering 58.7 km² with up to 50 turbines, was formed. Following underwater cultural heritage investigations, the location of the wreck Nimetu-548, together with an avoidance buffer approximately 1 km wide, was excluded from the area, and the layout was optimised after the final extent of the Saare-Liivi initial area became clear (to avoid wake loss and in view of constraining circumstances identified during the investigations). Thus, main alternative 3, covering 57.1 km² with up to 40 turbines, became the basis for the assessment (see section 2.3). **Reducing the development area and the number of turbines is at the same time an avoidance measure in relation to seabed geology and underwater cultural heritage, and a reduction measure in relation to birds, bats, seals, visual impact and navigation safety.** These impacts are therefore already smaller, even before the application of additional measures, than under the originally applied-for solution.

Secondly, this EIA specifies mitigation measures and monitoring for the additional area. In Table 7.2-1, the degree of obligation used in the thematic chapters is retained: “must” and “shall” indicate a mandatory measure, while “recommended”, “advisory” and “where possible” indicate a recommended measure. Monitoring is presented in Table 7.4-1, where mandatory and recommended monitoring are indicated separately. Where possible, methodologies comparable to those used for monitoring the initial area will

be used, and if both areas are developed simultaneously, shared technical infrastructure may be used, but this does not alter the conditions of either the EIA for the initial area or the Consumer Protection and Technical Regulatory Authority's superficies licence No 1-7/26-038 of 28.01.2026.

Thirdly, the measures are distinguished according to the stage at which they are applied. At the design and pre-construction stage, measures are applied that affect the project design itself – turbine layout, model selection, foundation type and the timing of works. During the construction stage, measures are applied that limit the extent of temporary impacts. During the operational stage, adaptive measures are applied in particular, the actual extent and duration of which depend on the monitoring results.

The mitigation measures are set out having regard to the results of studies to date and the existing knowledge on offshore wind farms. If, in the course of follow-up monitoring, new or additional knowledge emerges indicating that the forecasts set out in the EIA report have likely underestimated the impact expected to arise, additional possible mitigation measures must be applied on the basis of the monitoring results to ensure the avoidance or reduction of the expected significant adverse impact.

Table 7.2-1. Measures to prevent, avoid, reduce and mitigate significant adverse environmental impact associated with the implementation of the proposed activity

Environmental component	Implementation phase	Mitigation measures
Seabed geology (section 3.2)	<i>Design and/or pre-construction phase</i>	- On engineering-geological grounds, the western part of the additional area must be excluded as a location for turbines, as the thickness of clayey sediments exceeds 4 m there and additional hazards occur in the form of gas pockets and buried depressions. By excluding the geologically less favourable western part, a significant avoidance measure has already been integrated into the project's spatial layout. Main alternative 3 does not include the aforementioned western part. - During final design, an engineering geological investigation must be carried out at the location of each turbine and offshore substation to select the foundation type and installation solution.
	<i>Construction phase</i>	–
	<i>Operation phase</i>	–
Hydrometeorology and hydrodynamics (section 3.1)	<i>Design and/or pre-construction phase</i>	–
	<i>Construction phase</i>	–
	<i>Operation phase</i>	No separate mitigation measures are required (section 3.1.4); verification monitoring of model predictions covers the pre-construction and post-commissioning periods (see Table 7.4-1).
Marine water quality (section 3.3)	<i>Design and/or pre-construction phase</i>	- Before construction works begin, a plan for the prevention of and pollution response to marine pollution incidents must be prepared. - When selecting wind turbines, preference must be given to wear-resistant leading-edge protection systems, and regular inspection of the blades and timely renewal of the leading-edge protection must be ensured. - An oil spill would be an accident whose probability is extremely low but cannot be completely ruled out. To enable a rapid response to a possible oil spill, a pollution response plan is required, as is the case for ports.
	<i>Construction phase</i>	- Material removed from beneath the foundations and not used on site must be taken to a dumping area authorised by the environmental permit. - If construction-period monitoring shows a greater impact on marine water quality than assessed, the intensity and timing of works in the additional area must be adjusted.

Environmental component	Implementation phase	Mitigation measures
	<i>Operation phase</i>	- When selecting wind turbines, preference must be given to wear-resistant leading-edge protection systems, and regular inspection of the blades and timely renewal of the leading-edge protection must be ensured. - An oil spill would be an accident whose probability is extremely low but cannot be completely ruled out. To enable a rapid response to a possible oil spill, a pollution response plan is required, as is the case for ports.
Seabed biota and habitats (section 3.4)	<i>Design and/or pre-construction phase</i>	- The mitigation measures laid down in the EIA report for the initial area for the installation of export cables must be applied to the section of connection cable running from the boundary of the additional area to the offshore substations in the initial area. - At the detailed design stage, on the basis of the final infrastructure layout and construction technology, the area of permanent seabed loss must be specified by habitat type and compliance with the 2% criterion must be verified in combination with the initial Saare-Liivi area and the Liivi Bay offshore wind farm. In the calculations, the habitat classification and spatial assessment unit used in the in-combination effect assessment in section 3.4, as well as up-to-date available data on other projects, must be used as a basis. If the calculations show that the criterion is exceeded, the project design for the additional area must be adjusted to reduce permanent seabed loss to an extent that ensures compliance with the criterion.
	<i>Construction phase</i>	–
	<i>Operation phase</i>	–
Birds (section 3.5)	<i>Design and/or pre-construction phase</i>	- Before construction works begin in the additional area, a plan for operational automatic bird monitoring and need-based operation for the additional area of the Saare-Liivi offshore wind farm must be prepared and agreed with the Environmental Board. In preparing the plan, existing and newly available scientific data, experience from other offshore wind farms and technical possibilities must be taken into account. The plan must specify the principles for identifying migration events involving a high collision risk, for restricting or stopping turbine operation, for restarting turbines, and for verifying the effectiveness of the measures. - When developing the final turbine layout, it is recommended to take into account the prevailing north-east–south-west migration direction, to arrange turbine rows, where possible, parallel to the migration direction, and to avoid a dense, continuous belt of turbines perpendicular to the migration direction. At the junction of the initial area and the additional area, the layout of the additional area must be designed so that no denser barrier than in the rest of the wind farm is created there. - When selecting the final turbine model, it is recommended, from the perspective of birdlife, to prefer a solution in which the lowest rotor tip is as high above sea level as possible.

Environmental component	Implementation phase	Mitigation measures
	<i>Construction phase</i>	• Lighting of the wind farm must be limited to that required to meet aviation and navigation safety requirements. Unjustified continuous or diffuse lighting should be avoided and, where possible, synchronised, directional and low-dispersion lighting solutions should be used.
	<i>Operation phase</i>	• Lighting of the wind farm must be limited to that required to meet aviation and navigation safety requirements. Unjustified continuous or diffuse lighting should be avoided and, where possible, synchronised, directional and low-dispersion lighting solutions should be used. • From the start of regular operation of the wind farm, automatic bird monitoring and need-based operation must be in working order. Where a migration event involving a high collision risk is detected, turbine rotor speed must be reduced or the turbines stopped in accordance with the plan agreed with the Environmental Board. The criteria for implementing the measure and for restarting the turbines must be defined before commissioning. • Shutdown of turbines during intensive bird migration where necessary. Collision risk can be reduced by lowering rotor speed or stopping the rotors during the most intensive migration. The most intensive migration is often concentrated on a few days, so the measure would not cause very large economic loss. For accuracy and effectiveness, high-technology tools should be used to identify the periods requiring the measure.
Bats (section 3.6)	<i>Design and/or pre-construction phase</i>	–
	<i>Construction phase</i>	–

Environmental component	Implementation phase	Mitigation measures
	<i>Operation phase</i>	• The risk of bat mortality can be significantly reduced by setting the operating mode of wind turbines. To reduce the risk of bat mortality, the operation of wind turbines in the Saare-Liivi additional area must be restricted at least during the period from 1 August to 15 September, from sunset to sunrise, in the absence of precipitation when wind speed is below 5 m/s. • As part of the follow-up monitoring described in section 3.6.4 and Table 7.4-1, it is possible to reassess the need to restrict the operation of wind turbines in the additional area and to specify the temporal duration of the restrictions. The spatial extent of the restrictions can also be assessed on the basis of follow-up monitoring. On the basis of a sufficiently dense monitoring network, it is possible to determine whether there are areas within the additional area where the abundance of migrating bats is significantly lower and whether mitigation measures need to be applied to all wind turbines or are necessary only for some wind turbines. • If reliable technical solutions for the use of other types of mitigation measures become available in future, for example wind turbine shutdown mechanisms based on radar, infrared cameras or other sensors, these may also be applied instead of the above, in consultation with experts.
Seals (section 3.7)	<i>Design and/or pre-construction phase</i>	• When developing the final turbine layout, the functional permeability of the north-south movement corridor for ringed seals must be maintained: the spacing between turbines must not be less than the wind farm's standard inter-turbine spacing (approximately 1 km). • If piling works at other offshore wind farms in the area may overlap in time with the works in the additional area, cumulative underwater noise must be assessed on the basis of the available scheduling information and, where necessary, the timing of works in the additional area or the noise mitigation measures must be adjusted (see sections 2.8.4 and 7.5).

Environmental component	Implementation phase	Mitigation measures
	<i>Construction phase</i>	- Underwater noise mitigation measures are relevant where impact and vibratory piling are used and are aimed at avoiding permanent hearing damage to marine mammals, since temporary hearing damage is not practically avoidable. To mitigate the impact of impulsive noise, several combined measures must be implemented to reduce possible negative impacts on seals: - Piling must be started slowly (soft start): for the first 30–45 minutes, no more than 20% of the impact energy must be used, to allow the animals to leave the area. - During piling works, bubble curtains (bubble curtain) must be used to attenuate underwater noise. - Prior to the commencement of piling works, acoustic deterrent devices (ADD – Acoustic Deterrent Device) must be used to direct the animals to a safe distance; their use is necessary in particular from July to January. - Another way to avoid noise of a harmful nature for seals offshore is to choose times for noise-generating activities when most seals are out of the water due to annual pupping or moulting. Moulting involves all animals older than one year. At these times – in February–March and May–June – the great majority of seals are associated with land or ice, and the likelihood that they will be present in large numbers in the work area is very significantly lower than, for example, during the active feeding period in summer. Such scheduling of works is a recommended additional measure and does not replace the mandatory underwater noise mitigation measures. - If piling works at other offshore wind farms in the area may overlap in time with the works in the additional area, cumulative underwater noise must be assessed on the basis of the available scheduling information and, where necessary, the timing of works in the additional area or the noise mitigation measures must be adjusted.
	<i>Operation phase</i>	To avoid disturbing pupping seals, if ice formation in the wind farm area is likely and certain activities, e.g. maintenance works, are unavoidable, an observation flight over the ice can be carried out to plan vessel movements.

Environmental component	Implementation phase	Mitigation measures
Fish fauna (section 3.8)	<i>Design and/or pre-construction phase</i>	- To reduce the potential negative impact of the electromagnetic field emitted by the marine cables, the export cables must be buried in the seabed or covered. The export cables used should preferably be three-core alternating current cables. The requirements laid down in the superficies licences for the initial area and the export cable route area apply to the export cables located in the initial area and the export cable route area up to the landfall point. - To reduce the possible effects of the electromagnetic field of inter-array cables, preference must be given to a higher rated voltage and to three-core alternating current cables (where technically feasible). A higher rated voltage allows lower current for the transmission of the same power and thereby reduces the strength of the magnetic field emitted by the cable. The inter-array cables of the additional area are generally laid on the seabed and, where possible, buried along all or part of their length if pre-construction surveys show that this is necessary for the technical protection of the cables.
	<i>Construction phase</i>	In March and April, construction works must be avoided in the spring construction restriction zone shown in Figure 3.8-4 within the additional area.
	<i>Operation phase</i>	If follow-up monitoring during turbine operation shows that Baltic herring migration towards the spawning grounds is significantly impeded, turbine operation must be temporarily suspended during the active Baltic herring migration period (see section 3.8.3). If piling works at other offshore wind farms in the area may overlap in time with the works in the additional area, the timing of works will be adjusted in accordance with section 3.7.4.
Protected natural objects and Natura areas (sections 3.9, 3.10)	<i>Design and/or pre-construction phase</i>	- When designing the turbine layout in the additional area, the functional permeability of the north-south movement corridor of ringed seals must be maintained: the spacing between turbines must not be less than the wind farm's standard inter-turbine spacing (approximately 1 km). - If the final layout plan, turbine model, foundation installation method, construction schedule or the solution of other projects changes in a way that differs from the technical or spatial solution addressed in this Natura assessment, the validity of the conclusions of the Natura assessment must be re-verified before the activity is authorised.
	<i>Construction phase</i>	If, as the technical alternative, impact or vibratory driving of pile foundations is selected, the mitigation measures specified in Section 3.7.4 must be implemented in order to reduce the impact of the resulting underwater noise and to prevent permanent hearing damage.

Environmental component	Implementation phase	Mitigation measures
	<i>Operation phase</i>	- To reduce possible negative impact, mitigation measures to reduce collision risk must be implemented (see section 3.5.4). - The greatest in-combination (i.e. cumulative) effect of the Saare-Liivi initial and additional areas and the Liivi Bay offshore wind farm may be the collision risk of birds with turbines; to minimise it, mitigation measures to reduce collision risk must be implemented in the additional area (see section 3.5.4) in order to avoid adverse effects on the conservation objectives of the Pärnu Bay, Väinameri, Kahtla-Kübassaare and Irbe Strait SPAs.
Climate (section 3.11)	<i>Design and/or pre-construction phase</i>	- It is recommended that preference be given to technically suitable steel, concrete and other material solutions with a lower carbon footprint and to the highest possible share of recycled materials. - It is recommended that the material use of foundations and other infrastructure, the transport of components, and the use of installation and maintenance vessels be optimised. - It is recommended that, where possible, SF₆-free electrical equipment be preferred. If SF₆ is used, monitoring of leaks, maintenance and proper handling must be ensured. - It is recommended that future climatic and marine conditions over the entire operational life be taken into account in the design. - To refine the assessment of the climate impact of the final project design, it is recommended that a project-specific life cycle calculation and climate resilience check be carried out and that data on actual net output and production restrictions be collected during operation. Upon decommissioning, it is recommended that the proportion of materials recycled and reused be recorded.
	<i>Construction phase</i>	It is recommended that the material use of foundations and other infrastructure, the transport of components, and the use of installation and maintenance vessels be optimised.
	<i>Operation phase</i>	- It is recommended that, where possible, SF₆-free electrical equipment be preferred. If SF₆ is used, monitoring of leaks, maintenance and proper handling must be ensured. - In topic-specific monitoring plans, an adaptive approach must be applied, taking into account the possible effects of changes in climatic and marine conditions on receptor sensitivity, the timing of impacts and the effectiveness of measures.
	<i>Decommissioning phase</i>	It is recommended that the dismantling plan be updated prior to decommissioning, based on the best recycling and reuse technology available by that time.

Environmental component	Implementation phase	Mitigation measures
Visual impact (section 4.1)	<i>Design and/or pre-construction phase</i>	The assessed layout reduces the wheel effect caused by overlapping turbines in views. Visually, it is preferable for the turbines to form a coherent and legible group. When designing the final layout, this preference must be reconciled with the safe straight-line passages provided for in section 6.1 and the movement possibilities provided for in sections 3.5 and 3.7; the visual preference does not imply a requirement for a navigationally irregular layout.
	<i>Construction phase</i>	–
	<i>Operation phase</i>	No separate mitigation measures are required to reduce the visual impact of the additional area. If implemented, the ADLS aviation safety lighting recommended in section 6.2 will also reduce the visual disturbance from aviation safety lights.
Airborne noise (section 4.2)	<i>Design and/or pre-construction phase</i>	At the detailed design stage, once the final number and layout of the turbines, as well as the final turbine model, have been determined, it is recommended to carry out additional noise modelling.
	<i>Construction phase</i>	–
	<i>Operation phase</i>	–
Socio-economic impacts and fishing (section 4.3)	<i>Design and/or pre-construction phase</i>	- In the subsequent stages of the wind farm development, the implementation principles for the coexistence of fisheries and the offshore wind farm, the follow-up assessment of economic impacts and possible compensation will be specified in cooperation with the Ministry of Regional Affairs and Agriculture and representatives of the fisheries sector. The developer and the preparer of the EIA have contacted the Ministry of Regional Affairs and Agriculture, which is responsible for fisheries, and consultations have been initiated. - This report has taken a conservative approach whereby ordinary vessel traffic, including fishing vessels, does not pass through the offshore wind farm area. At a later design stage, it may be possible to specify or relax the restrictions if a project-specific navigational safety assessment shows that the passage of fishing vessels can be safely arranged under certain conditions.
	<i>Before construction works commence</i>	Before construction works commence, representatives of the fisheries sector must be informed in good time of the work areas, schedule and temporary access restrictions, and a fisheries contact person on behalf of the developer must be designated.

Environmental component	Implementation phase	Mitigation measures
	<i>Operation phase</i>	• Section 55⁴(1) of the Environmental Charges Act provides that, where it is demonstrated that fish catches have declined in the impact area of a wind power plant as a result of the wind power plant, a fisheries undertaking is entitled to compensation from the charge for producing electricity from wind energy received by the state. The fisheries undertaking must submit an application for compensation for the previous calendar year to the Environmental Investment Centre by 31 March of the following year, and the Environmental Investment Centre will pay compensation to the fisheries undertaking by 1 September of the year in which the application is submitted. To receive compensation, it is necessary to demonstrate that the construction and operation of wind farms does indeed affect fish catches. The amount of compensation payable to a fisheries undertaking per wind power plant is ten per cent of the fee for the production of electricity from wind energy payable in respect of an offshore wind power plant. • Under the Environmental Charges Act, if a wind farm causes an environmental nuisance, a charge for compensation for environmental nuisances, i.e. the charge for producing electricity from wind energy, is payable. The local authority share of the charge for producing electricity from wind energy for an offshore wind power plant must be transferred to the local authority unit located in the impact area of the offshore wind farm. The impact area of an offshore wind farm is the area in Estonia extending up to 20 kilometres from the centre point of the tower of an offshore wind power plant. For the Saare-Liivi initial and additional areas, the share allocated to local authorities accrues to Kihnu municipality. If only the additional area is developed, no local authority will receive the turbine charge.

Environmental component	Implementation phase	Mitigation measures
Underwater cultural heritage (section 5)	<i>Design and/or pre-construction phase</i>	• When implementing main alternative 3, the locations of the final turbine positions, the routes of the inter-array cables and the connection cable, the offshore substation, the jack-up legs of installation vessels, anchoring areas and other temporary work areas must be archaeologically checked before construction works commence. • When implementing main alternative 3, a minimum avoidance buffer of approximately 1 km must be maintained between Nimetu-548 and all permanent and temporary works affecting the seabed. • When implementing main alternative 3, the boundary of main alternative 3 must not be extended, nor may infrastructure be placed towards Nimetu-548 beyond the spatial extent assessed in the EIA. • When implementing main alternative 3, the final design solution must be submitted to the National Heritage Board if the impact area of the works may extend to the monument or its protection zone. • Before the installation of foundations and inter-array cables, surveys to identify explosive objects and other obstructions must be carried out along the cable routes. Any hazardous objects found must be avoided or their safe handling by a competent specialist must be arranged; when clearing the seabed, the avoidance buffers for cultural heritage must be taken into account. • If the solutions for neighbouring projects, shared cable corridors, dumping areas or construction logistics change such that their impact area may extend to the same monument or protection zone, the cumulative impact assessment must be updated (section 5.1.5).
	<i>Construction phase</i>	• When implementing main alternative 3, work in the immediate vicinity of the object must be halted and the National Heritage Board must be notified if a previously unknown wreck, archaeological find or archaeological layer is discovered during construction works.
	<i>Operation phase</i>	–

Environmental component	Implementation phase	Mitigation measures
Vessel traffic and maritime safety (section 6.1)	<i>Design and/or pre-construction phase</i>	• Before construction commences, a marine traffic management plan must be prepared on the basis of the final construction logistics, setting out the routes and work areas of project vessels, communication and reporting procedures, and interaction with third-party vessel traffic. • When preparing the final design solution, a vessel traffic passage with sufficient width, depth and navigational margin must be maintained in Corridor B. The inclusion of the corridor on nautical charts, its marking at sea, or the implementation of another vessel traffic management measure must be decided and agreed with the Transport Administration. • To reduce risks arising from ice conditions, icebreaker readiness or, where necessary, icebreaker escort must be ensured in the area. This helps to prevent vessels trapped in ice from drifting towards the offshore wind farm structures and ensures that the main fairways remain navigable even in severe ice conditions. The turbines must also be arranged in a regular straight-line grid (grid layout) that allows an icebreaker to manoeuvre safely, reduces the accumulation of ridged ice, and leaves sufficient passages for vessels. • The final layout of the wind turbines and other infrastructure, and the emergency and rescue arrangements, must be agreed with the search and rescue authorities. The safe conduct of SAR and MEDEVAC flights must be ensured, including, where necessary, determining a suitable solution for helicopter rescue winching or landing.

Environmental component	Implementation phase	Mitigation measures
	<i>Construction phase</i>	• Both the construction area and the completed offshore wind farm must be marked with floating navigation marks, including buoys and AIS virtual marks, and the wind turbines must be marked in accordance with IALA Guideline G1162 (Annex 3.1.8). The final navigation marking for the construction, operation and decommissioning stage must be defined in a separate navigation-marking design, which must be submitted to the Transport Administration for approval before the start of the respective stage. This improves the visibility of the offshore wind farm, increases mariners' situational awareness, and reduces the likelihood of inadvertent entry and of striking a structure. • The risk assessment recommends VTS for the active coordination of vessel traffic in the Saare-Liivi additional area and identifies, as an alternative, another AIS- and radar-based traffic monitoring and reporting arrangement. Before construction activities begin, the technical and organisational solution for traffic monitoring and management required for the additional area must be defined in cooperation with the Transport Administration and other authorities concerned. During the active stages of construction, safe vessel traffic is supported by on-site traffic monitoring and by a guard vessel equipped with radar and AIS equipment or, where necessary, a mobile patrol craft, allowing rapid intervention if dangerous situations arise. Given the distance of the additional area from Pärnu harbour, the regular escorting of vessels from the port to the work area is not considered practical. During the operation stage, the need for a guard vessel, its area of operation and period of use shall be determined on a risk basis; a permanently deployed guard vessel is not automatically necessary if navigation marking, remote surveillance, communication arrangements and other measures ensure an adequate level of safety. • The 1.5-nautical-mile-wide area used in the risk analysis is treated as a conservative safety zone. The actual extent of the temporary restriction or safety zone during construction must be determined on the basis of the work stages, the vessels used and the structures to be installed, and agreed with the Transport Administration. The restriction does not have to be uniform throughout the construction period or cover the entire wind farm area at the same time.

Environmental component	Implementation phase	Mitigation measures
	<i>Before commissioning and operation phase</i>	• Before commissioning, search and rescue and pollution response arrangements must be prepared, safe passages and communication procedures must be defined, and the solution must be agreed in cooperation with the authorities concerned. • Before commissioning, a winter navigation and ice management plan agreed with the Transport Administration and other authorities concerned must be prepared. The plan must specify the ice class of the wind farm's maintenance vessels, the need for icebreaker assistance or escort, safe passages, and actions in the event of a vessel becoming trapped in ice or drifting towards structures. • Measures related to the human factor play an important part in risk reduction. More effective monitoring of compliance with crew work and rest time requirements helps to reduce fatigue-related human error and supports safe watchkeeping arrangements. • The need for a guard vessel, its area of operation and period of use must be determined on a risk basis. During the active stages of construction, the use of a guard vessel or patrol craft equipped with AIS and radar may be justified. During the operation stage, a permanently deployed guard vessel is not automatically necessary if navigation marking, remote surveillance, communication arrangements and other measures ensure an adequate level of safety.

Environmental component	Implementation phase	Mitigation measures
Air traffic (section 6.2)	<i>Design and/or pre-construction phase</i>	• To ensure aviation safety in the additional area, during the preparation of the detailed design, the final layout plan of the turbines in the additional area, their tip heights, the aviation safety lighting solution and the maximum heights of construction cranes must be submitted to the Transport Administration, Lennuliiklusteeninduse AS and the Police and Border Guard Board. • To ensure aviation safety in the additional area, access routes suitable for SAR and MEDEVAC flights must be provided; their final direction, clear width and any safety area must be determined in cooperation with the Police and Border Guard Board and the Transport Administration. • To ensure aviation safety in the additional area, before the wind farm is commissioned, an emergency response plan, a SAR plan and a communications plan must be prepared, specifying, among other things, the communication arrangements between the wind farm control centre, JRCC Tallinn, the rescue helicopter and units operating at sea, and the procedure for shutting down the turbines. • Aviation communication, navigation and surveillance infrastructure may change during project planning. Therefore, when preparing the detailed design for the additional area, the final layout plan and technical parameters of the turbines must be submitted to Lennuliiklusteeninduse AS and the Transport Administration for verification. If the technical analysis of the final solution shows a deterioration in the coverage or data quality of a surveillance system, a software or infrastructure solution agreed with the owner of the system concerned must be implemented in the detailed design. • When preparing the detailed design for the additional area, the validity of the aviation assessment must be checked on the basis of the eAIP, air traffic arrangements and aviation infrastructure in force at that time. A new comprehensive study is not required if the final solution remains within the assessed technical solution and the Transport Administration, Lennuliiklusteeninduse AS and the Police and Border Guard Board confirm the suitability of the solution planned for the additional area.
	<i>Construction phase</i>	• To ensure aviation safety in the additional area, the turbines must be marked with clear identification markings visible from the air and from the sea and equipped with aviation safety lights in accordance with the applicable requirements. Under sections 34 and 35 of the Aviation Act, obstacles must be marked and lit in accordance with the requirements of ICAO Annex 14. For lighting, the use of an ADLS solution (Aircraft Detection Lighting System) is recommended, whereby the aviation safety lights illuminate when an aircraft approaches and are otherwise extinguished.

Environmental component	Implementation phase	Mitigation measures
	<i>Operation phase</i>	• To ensure aviation safety in the additional area, the round-the-clock availability of the wind farm control centre and the technical capability, during a rescue operation, to rapidly stop selected turbines, lock the blades in a suitable position and, where necessary, rotate the nacelle must be ensured. • To ensure aviation safety in the additional area, the turbines must be marked with clear identification markings visible from the air and from the sea and equipped with aviation safety lights in accordance with the applicable requirements. Under sections 34 and 35 of the Aviation Act, obstacles must be marked and lit in accordance with the requirements of ICAO Annex 14. For lighting, the use of an ADLS solution (Aircraft Detection Lighting System) is recommended, whereby the aviation safety lights illuminate when an aircraft approaches and are otherwise extinguished. • To ensure aviation safety in the additional area, after completion of the wind farm, the final obstacle data and marking information must be submitted to the aeronautical information department of Lennuliiklusteeninduse AS. • To ensure aviation safety in the additional area, if a technical impact on a communications, navigation or surveillance system becomes apparent, software or infrastructure measures agreed with Lennuliiklusteeninduse AS must be implemented. • Before the wind farm is commissioned, the wind farm operator must prepare a procedure for the use of unmanned aircraft and for interaction with third-party flights, covering maintenance flights, flights by operational services, communications outages and emergencies.
Maritime surveillance and operational communications (section 6.3)	<i>Design and/or pre-construction phase</i>	• The final design solution and its technical impact analysis for maritime surveillance, national defence and operational communications systems must be submitted and reviewed during the preparation of the detailed design together with the authorities concerned and system owners. The necessary technical mitigation solutions must be included in the detailed design. Before the wind farm is commissioned, the functioning of the agreed systems and compliance with the acceptance criteria defined during preparation of the detailed design will be verified. • During the preparation of the detailed design, the final layout plan, turbine heights, rotor diameter and materials, the location of the offshore substation, and the heights of temporary construction cranes must be submitted to the system owners.
	<i>Construction phase</i>	• Before construction begins, the construction sequence, the maximum heights of the turbines and temporary cranes, the operating areas of installation vessels, and the construction schedule must be submitted to the relevant system owners and operators. If the construction-phase configuration may cause a temporary impact that differs from or is greater than that of the final solution, temporary technical or operational measures must be specified.

Environmental component	Implementation phase	Mitigation measures
	<i>Design, pre-commissioning verification and decommissioning</i>	• The final design solution and its technical impact analysis for maritime surveillance, national defence and operational communications systems must be submitted and reviewed during the preparation of the detailed design together with the authorities concerned and system owners. The necessary technical mitigation solutions must be included in the detailed design. Before the wind farm is commissioned, the functioning of the agreed systems and compliance with the acceptance criteria defined during preparation of the detailed design will be verified. • The impact of the decommissioning phase is essentially similar to that of the construction phase and relates to temporary cranes, vessels and changing radar reflection objects. The technical arrangements and timing of the decommissioning works must be re-coordinated with the relevant system owners before the works commence.
Avifauna (section 3.5.4)	Cessation of activity – mandatory	• The decommissioning plan must specify the impact of dismantling on avifauna, taking into account the avifauna situation that has developed by that time, the technology used for the works and the ecological function of the structures.
Vessel traffic (section 6.1)	All phases, including decommissioning – mandatory	• Both the construction area and the completed offshore wind farm must be marked with floating navigation marks, including buoys and AIS virtual marks, and the wind turbines must be marked in accordance with IALA Guideline G1162 (Annex 3.1.8). The final navigation marking for the construction, operation and decommissioning stage must be defined in a separate navigation-marking design, which must be submitted to the Transport Administration for approval before the start of the respective stage. This improves the visibility of the offshore wind farm, increases mariners' situational awareness, and reduces the likelihood of inadvertent entry and of striking a structure.
Electrical equipment and climate (section 2.6.1)	Design, procurement and operation	• In the selection of the wind turbines and the medium- and high-voltage switchgear of the Saare-Liivi offshore wind farm, SF₆-free solutions are preferred. If such equipment cannot be procured, basic precautions must be applied in connection with the use of SF₆ equipment (appropriate staff training, suitable working practices and maintenance requirements, a monitoring system, etc.).

Environmental component	Implementation phase	Mitigation measures
Underwater noise (section 2.8.4)	Pre-construction and construction phase	The final construction schedules of the planned wind farms are not known, so a possible temporal overlap of piling cannot currently be confirmed or ruled out. The sound level emitted during the installation of gravity base foundations, both for a single foundation and for several foundations installed simultaneously, is relatively low (comparable to the noise of a medium-sized vessel), and no significant cumulative impact is expected. If impact or vibratory driving of monopiles overlaps with high-noise works of a neighbouring project, the developer of the additional area must assess the cumulative noise level on the basis of the available schedule information and, where possible, adjust the timing of works in the additional area or apply mitigation measures. The sound level emitted during drilling of monopiles is significantly lower than during piling, so the impulsive noise mitigation measures typical of piling (soft start, bubble curtain, acoustic deterrents) need not be applied to the same extent, but general precautionary measures apply. Specific underwater noise mitigation measures are set out in the chapters on impacts on seals (section 3.7.4) and fish fauna (section 3.8.4).

Note: a dash (–) means that there is no separate sector-specific mitigation measure in this row of the table. This does not remove the obligation to comply with the cross-phase measures, monitoring or design solution conditions set out in the other rows and in Table 7.4-1.

The mitigation measures listed in Table 7.2-1 are expected to be effective and help to reduce or prevent significant adverse impacts and minimise the environmental impacts and disturbances associated with the proposed wind farm and its infrastructure. The implementation of the follow-up monitoring activities specified in Table 7.4-1 helps to ensure that the measures are effective and to enhance their efficiency.

Integrated avoidance measures for the final main alternative 3

Some measures are already built into the design of the proposed activity and do not require a separate implementation decision. These solutions are the starting point for the assessment, not additional mitigation. These are:

- the exclusion of the western part of the additional area due to unfavourable engineering geological conditions and its unsuitability from the point of view of trawling and navigation (sections 2.3 and 3.2.4);
- an approximately 1 km-wide avoidance buffer left between the wreck Nimetu-548 and all permanent and temporary works affecting the seabed, which substantially exceeds the 300 m protection zone proposed in the protection designation procedure (section 5.1.4);
- no Habitats Directive habitat types or threatened benthic species occur in the additional area, and therefore no loss of the reef habitat type will occur; for the export cable routes in the initial area, the measures established in the EIA for the initial area apply (sections 3.4.2 and 3.4.4);
- the additional area will be connected, via the offshore substation(s) of the initial area, to the already planned export cable connection; no new separate connection to land is planned. The impact of the entire route is covered by the in-combination effect assessment in sections 3.3 and

3.4, and on the section lying within the initial area, the measures for that area's export cables apply.

- the reduction in the number of turbines from 92 to 40, which reduces the number of collision points, the barrier effect and the extent of the visually occupied field of view (sections 3.5.4 and 4.1.3).

The precise design solution of the wind farm, including the number of turbines, their locations and installation solutions, will become clear during subsequent design, after the superficies licence process.

7.3. Uncertainty/knowledge gaps

Offshore wind farms have been operating in the North Sea and Baltic Sea region for more than two decades, and monitoring results from operating wind farms have been published in England, Ireland, Denmark, Germany and the Netherlands. However, under the conditions of the eastern Baltic Sea, including the Gulf of Riga, there is no monitoring experience from operational offshore wind farms, and therefore not all long-term effects can yet be confirmed empirically.

Table 7.3-1 collates only the uncertainties most significant in terms of the extent of the impacts, the effectiveness of the measures, or the conditions for implementation. Routine design-stage refinements, statutory checks and general natural variability are addressed in the relevant subsections; they are not presented separately as general knowledge gaps.

Table 7.3-1. Consolidated knowledge gaps and uncertainties

Impact topic (section)	Main uncertainty / knowledge gap	Impact on the reliability of the conclusions	Means of reducing uncertainty
Marine water quality and hydrodynamics (3.1.7, 3.3.7)	The proportion of mobile phosphorus in sediment and its actual release; local changes in mixing and near-bottom oxygen levels. The ice model describes a single ice-rich winter.	Affects the magnitude and timing of local changes. The calculated phosphorus stock is not equivalent to the load reaching the water column; the basin-scale estimate is based on modelling.	Section 3.1.4 monitoring of impact and reference areas; section 3.3.4 water column monitoring and, where necessary, adjustment of the works.
Seabed biota (3.4.7)	The long-term local extent of colonisation of artificial substrate and accumulation of organic matter.	Limits the precise prediction of local ecological changes during operation; the areas of direct seabed loss and disturbance have been assessed separately.	Section 3.4.4 verification of the 2% criterion at the detailed design stage and mandatory monitoring of colonisation and organic matter for five years; monitoring of non-native species is recommended.

Impact topic (section)	Main uncertainty / knowledge gap	Impact on the reliability of the conclusions	Means of reducing uncertainty
Avifauna and Natura (3.5.7, 3.10.5)	The actual collision risk for common crane and nocturnal migrants, and the consequences of displacement caused by multiple wind farms. The latter depends on the continued functionality of suitable feeding and stopover areas.	The model does not provide an exact number of fatalities. The Natura conclusion is valid for the assessed solution, the ecological assumptions and the binding measures.	Section 3.5.4 automatic bird monitoring and need-based operation, monitoring of staging waterbirds and migration.
Bats (3.6.7)	Data collected near the sea surface do not fully describe bats' activity in the rotor zone.	Limits the precise prediction of the spatial and temporal extent of the operational restriction; a precautionary operational restriction has been set.	Section 3.6.4 mandatory operational restriction and two-year follow-up monitoring; refinement of the restriction on the basis of monitoring.
Seals (3.7.7)	The effect of the sound field of an operating wind farm and of multiple wind farms on seal movement; the location of pupping on ice depends on the winter.	Exact passage or avoidance behaviour cannot be predicted. The risk of hearing damage from piling is reduced by mandatory combined measures.	Section 3.7.4 mandatory noise, observation, passive acoustic and telemetry monitoring and, when ice forms, pupping observation; functional movement zone.
Fish fauna (3.8.7)	Extrapolation of the behavioural response of Baltic herring obtained from an experiment with a single artificial sound source to the sound field of multiple operating turbines.	Limits the precise prediction of changes in spatial use during operation. The spatial extent associated with different response thresholds cannot be generalised as a fixed percentage.	Section 3.8.4 construction- and operation-phase fish fauna monitoring; section 3.7.4 underwater noise measures and section 3.8.4 spring construction restriction.
Fisheries (4.3.6, 4.3.4)	Distinguishing the impact of the wind farm from changes in fish stock, fishing conditions and the market, and the accumulation of economic impacts from multiple projects.	Affects the attribution of change to the project and the precise determination of the magnitude of the economic impact; the overall EIA assessment does not replace the determination of compensation.	In accordance with section 4.3.4, specification of the implementation principles for the follow-up assessment of economic impact and possible compensation in cooperation with the Ministry of Regional Affairs and Agriculture and the fisheries sector.

Impact topic (section)	Main uncertainty / knowledge gap	Impact on the reliability of the conclusions	Means of reducing uncertainty
Maritime surveillance and operational communications (6.3)	The impact of the final turbine layout and technical parameters on the functionality of specific systems.	The conclusion that there is no significant residual impact is contingent on the technical analysis, mitigation solutions where necessary, and acceptance verification. The limited public availability of the data does not mean that the impact has not been assessed.	Section 6.3 mandatory technical impact analysis with the system owners, inclusion of the solutions in the detailed design, and pre-commissioning functionality verification.

Possible uncertainties and/or knowledge gaps are identified or set out under each assessed environmental topic where this has been considered significant.

7.4. Follow-up assessment, including follow-up monitoring

The follow-up monitoring proposed in this EIA report has three objectives. First, to verify the validity of the impact predictions, that is, whether the actual impact corresponds to that assessed. Second, to assess the effectiveness of the mitigation measures implemented and to allow their refinement on the basis of actual results. Third, to reduce the knowledge gaps identified at the EIA stage and to contribute to broader knowledge of the impacts of offshore wind farms in Estonian marine waters.

The monitoring has been designed on the basis of five principles.

- **Compatibility.** The monitoring plans for the additional area will be prepared by topic and, where possible, aligned methodologically with the monitoring already established for the Saare-Liivi initial area, so that the results are comparable and can be combined. This applies to monitoring of avifauna, bats, seals, fish fauna and seabed biota. If the areas are developed at different times, the plans will be prepared and implemented separately. For the additional area, it is not justified to create a programme duplicating the monitoring of the initial area.
- **Comparability over time.** Monitoring covers the phases and duration specified in the relevant impact-topic section. To distinguish the impact from natural variability, pre-construction baseline data and, where necessary, before–after comparison will be used; measurement of all indicators at every project stage is not required.
- **Comparability in space.** In addition to measurements carried out in the impact area, reference areas located outside the expected impact area of the wind farms but with comparable natural conditions must also be monitored.
- **Link to measures.** Monitoring results provide input for verifying the impact prediction and the effectiveness of the measures, and for adjusting work arrangements. Automatic bird monitoring will be linked to risk-based operation. The initial operational restriction for bats applies at specified times and under specified weather conditions, and its extent can be refined on the basis of follow-up monitoring.
- **Methodological comparability.** Where possible, monitoring of the additional area will use methods and data formats comparable to those used for the Saare-Liivi initial area offshore wind

farm and other offshore wind farms proposed in the region. Exchange of information or cooperation with neighbouring projects is an option that supports cumulative impact assessment, not an obligation imposed on other developers by this EIA.

The topic-specific monitoring plans for the additional area will be prepared by the deadlines specified in the main text. The development of a uniform nationwide follow-up assessment methodology is an opportunity for cooperation, not a precondition for implementing the measures for the additional area. When refining the plans, the objectives, mandatory nature and minimum duration required in the EIA must be maintained, taking into account the justified exceptions permitted in the relevant section.

7.4.1. Follow-up monitoring

The table below (Table 7.4-1) collates the monitoring by environmental aspect. For each activity, it is indicated whether it is mandatory monitoring, recommended monitoring or conditional verification. The wording and level of obligation correspond to that set out in the impact-topic section.

Table 7.4-1. Follow-up monitoring of the proposed activity by environmental aspect

Environmental component	Implementation phase	Follow-up monitoring
Underwater noise (section 2.8; monitoring section 3.7.4)	<i>Pre-construction phase</i>	Before the start of construction works, underwater ambient noise must be measured at a time when no construction works are taking place, in order to verify the modelling results.
	<i>Construction phase</i>	Monitoring must include seal observation during construction and measurement of underwater noise.
	<i>Post-construction and operational phase</i>	Monitoring must include passive acoustic monitoring during operation together with simultaneous measurement of underwater noise.
	<i>Decommissioning phase</i>	–

Environmental component	Implementation phase	Follow-up monitoring
Hydrometeorology and hydrodynamics (section 3.1)	<i>Pre-construction phase</i>	• Follow-up assessment is required to verify the model predictions. For at least one year before the construction of the wind farm in the additional area and for one year after it is commissioned, the following must be carried out: • measure current speed and direction; • measure chlorophyll-a, temperature and salinity in the upper water layer from the disappearance of the ice cover until autumn; • measure oxygen, temperature and salinity in the near-bottom layer from May to October. • Measurements must be taken at least one station located within the impact area of the wind farm in the additional area and at one reference station with comparable natural conditions outside the impact area. The precise location, timing and methodology of the monitoring must be agreed with the Environmental Board before the measurements begin and, where possible, aligned with the monitoring of the initial area and of offshore wind farms in the Gulf of Riga. If the monitoring described has already been carried out in any of the above-mentioned offshore wind farm areas and the model predictions have been validated, monitoring of the additional area may be dispensed with, subject to agreement with the Environmental Board.
	<i>Post-construction and operational phase</i>	• Follow-up assessment is required to verify the model predictions. For at least one year before the construction of the wind farm in the additional area and for one year after it is commissioned, the following must be carried out: • measure current speed and direction; • measure chlorophyll-a, temperature and salinity in the upper water layer from the disappearance of the ice cover until autumn; • measure oxygen, temperature and salinity in the near-bottom layer from May to October. • Measurements must be taken at least one station located within the impact area of the wind farm in the additional area and at one reference station with comparable natural conditions outside the impact area. The precise location, timing and methodology of the monitoring must be agreed with the Environmental Board before the measurements begin and, where possible, aligned with the monitoring of the initial area and of offshore wind farms in the Gulf of Riga. If the monitoring described has already been carried out in any of the above-mentioned offshore wind farm areas and the model predictions have been validated, monitoring of the additional area may be dispensed with, subject to agreement with the Environmental Board. • When organising winter navigation and ice management, the extent, concentration, drift and ridging of the ice cover, as well as the impact of any icebreaking operations on the ice cover, must be monitored.
Seabed geology (section 3.2)	<i>Pre-construction phase</i>	-

Environmental component	Implementation phase	Follow-up monitoring
	<i>Post-construction and operational phase</i>	During operation of the offshore wind farm, regular monitoring of the technical condition of turbine foundations and cable routes must be provided for.
	<i>Decommissioning phase</i>	-
Marine water quality (section 3.3)	<i>Pre-construction phase</i>	To verify the effects of the construction and operation of the additional area, a water column monitoring programme must be implemented, aligned with the impact-area and reference-area monitoring under section 3.1.4. During monitoring, total phosphorus, total nitrogen, phosphates, nitrates and nitrites, as well as chlorophyll a, must be measured, and the results must be assessed on the basis of the relevant indicators for the coastal water body of the central Gulf of Riga.
	<i>Construction phase</i>	- To verify the effects of the construction and operation of the additional area, a water column monitoring programme must be implemented, aligned with the impact-area and reference-area monitoring under section 3.1.4. During monitoring, total phosphorus, total nitrogen, phosphates, nitrates and nitrites, as well as chlorophyll a, must be measured, and the results must be assessed on the basis of the relevant indicators for the coastal water body of the central Gulf of Riga. - According to the phosphorus study, construction-phase monitoring must show whether the impact of sediment movement on marine water quality is detectable against natural variability. To verify this, measurements of the above water quality indicators must be linked to suspended matter monitoring and timed according to the seabed works and the dispersion of suspended matter. To distinguish the impact of the works from natural variability, the results must be compared with pre-construction and reference-area data. - During the construction phase, it is recommended that water column parameters be measured up to twice a month and at sufficient spatial resolution. The exact monitoring frequency and measurement points will be specified in the monitoring plan, taking into account the locations and intensity of the works and the need to distinguish their impact from natural variability. The recommendation concerns the measurement frequency; implementation of the water column monitoring programme and measurement of the indicators required in it are mandatory. - If construction-phase monitoring shows a greater impact on marine water quality than assessed, the intensity and timing of works in the additional area must be adjusted.

Environmental component	Implementation phase	Follow-up monitoring
	<i>Post-construction and operational phase</i>	• To verify the effects of the construction and operation of the additional area, a water column monitoring programme must be implemented, aligned with the impact-area and reference-area monitoring under section 3.1.4. During monitoring, total phosphorus, total nitrogen, phosphates, nitrates and nitrites, as well as chlorophyll a, must be measured, and the results must be assessed on the basis of the relevant indicators for the coastal water body of the central Gulf of Riga. • Additional monitoring of possible changes in water column stratification and the use of turbine foundations as platforms for continuous monitoring are recommended.
Seabed biota and habitats (section 3.4)	<i>Pre-construction phase</i>	• For the additional area, a monitoring plan for benthic biota and habitats must be prepared before the start of construction works, covering the impacts of the construction of the turbines, offshore substation, inter-array cables and connection cables in the additional area, as well as changes in habitat quality. Monitoring is mandatory to the extent described below, except for parts expressly identified as recommended. Where possible, the monitoring must be methodologically aligned with the monitoring for the initial area. If monitoring of the initial area has been carried out before construction of the additional area and its results can be used to assess the impacts of the additional area, the Environmental Board may, where justified, reduce the scope of monitoring for the additional area. • At the locations where foundations are to be installed (turbines and offshore substation) and within a 200 m radius of each foundation, document the structure and characteristics of the seabed habitat before construction works (sonar mapping of seabed relief, underwater video observations, where possible quantitative sampling, oxygen conditions, sediment organic matter content).
	<i>Construction phase</i>	• Immediately after foundation installation, document the condition of the seabed biota and habitat in the immediate vicinity of the foundation (within a 200 m radius) and the extent of any possible damage (video observations). The locations of the foundations requiring documentation shall be specified on the basis of the results of pre-construction monitoring (it will then no longer be necessary to monitor all foundations).

Environmental component	Implementation phase	Follow-up monitoring
	<i>Post-construction and operational phase</i>	• Monitor the colonisation of foundation structures by seabed biota (quantitative sampling/assessment, once a year, for five years after foundation installation, across the full depth range from seabed to surface, at three foundations in different parts of the additional area). • Monitor accumulation of organic matter near the foundation (on the seabed immediately adjacent to the foundation, 0–30 m from the foundation; sediment traps, over five years, three foundations in different parts of the additional area). • As part of follow-up monitoring, it is recommended to plan monitoring of non-native species, enabling early detection of new species and, where necessary, the development of appropriate control or mitigation measures. As artificial substrates may facilitate the spread of some non-native species, it is appropriate to treat monitoring of non-native species as one component of the benthic biota monitoring programme.
	<i>Decommissioning phase</i>	• After removal of the foundations, the condition of seabed biota and habitats must be checked in order to assess the extent of disturbance caused by the removal and recovery.
Birds (section 3.5)	<i>Pre-construction phase</i>	• Before construction works begin in the additional area, a plan for operational automatic bird monitoring and need-based operation for the additional area of the Saare-Liivi offshore wind farm must be prepared and agreed with the Environmental Board. In preparing the plan, existing and newly available scientific data, experience from other offshore wind farms and technical possibilities must be taken into account. The plan must specify the principles for identifying migration events involving a high collision risk, for restricting or stopping turbine operation, for restarting turbines, and for verifying the effectiveness of the measures. • Operational-phase bird monitoring is mandatory and will be carried out on the basis of the automatic bird monitoring and needs-based operation plan agreed with the Environmental Board before construction works begin. The technical details of the plan will be specified before commissioning. Available monitoring results from the initial area will be taken into account and, where possible and scientifically justified, comparable methodologies will be used across the areas.
	<i>Construction phase</i>	–

Environmental component	Implementation phase	Follow-up monitoring
	<i>Post-construction and operational phase</i>	• A plan for operational bird monitoring and need-based operational measures must be prepared for the additional area. If the Saare-Liivi initial area has been built by that time and its bird monitoring results are available, they will be taken into account to the relevant extent when preparing the plan for the additional area. Where possible and scientifically justified, methodologies will be used that allow the monitoring results of the initial and additional areas to be compared. The plan for the additional area must be prepared on the basis of the national methodology in force at that time, the best available knowledge, experience from other offshore wind farms and technical possibilities. • The plan must cover at least monitoring of the distribution and abundance of staging waterbirds and of the flight intensity and flight altitude of passage migrants, detection of actual collisions or events indicative of them, and verification of the effectiveness of operational measures implemented to reduce collision risk. The exact monitoring methodology, duration, control areas, data quality requirements and the criteria for implementing and modifying the operational measures must be agreed with the Environmental Board before commissioning of the wind farm in the additional area. • From the start of regular operation of the wind farm, automatic bird monitoring and need-based operation must be in working order. Where a migration event involving a high collision risk is detected, turbine rotor speed must be reduced or the turbines stopped in accordance with the plan agreed with the Environmental Board. The criteria for implementing the measure and for restarting the turbines must be defined before commissioning.
Bats (section 3.6)	<i>Post-construction and operational phase</i>	• Follow-up monitoring must be carried out in the additional area in the two years following commissioning of the wind farm. During the monitoring, the relative abundance of bats must be assessed and compared with the baseline survey data. It is recommended that recorders be installed in the same areas and that, where possible, wind turbine service platforms be used instead of temporary buoys. • When the additional area of the Saare-Liivi offshore wind farm is completed, the methodologies available by then for estimating the number of bat fatalities should be reviewed, and the best practices established by then should be followed.
Seals (section 3.7)	<i>Pre-construction phase</i>	• A seal monitoring and adaptive management plan must be prepared for the additional area. The methodologies and scope of environmental monitoring will be determined before the start of construction and operation of the wind farm. • Before the start of construction works, underwater ambient noise must be measured at a time when no construction works are taking place, in order to verify the modelling results.

Environmental component	Implementation phase	Follow-up monitoring
	<i>Construction phase</i>	- Monitoring must include seal observation during construction and measurement of underwater noise. - Monitoring must include observation of pupping seals in the event of ice formation and verification of the impacts of maintenance vessel traffic.
	<i>Post-construction and operational phase</i>	- Monitoring must include passive acoustic monitoring during operation together with simultaneous measurement of underwater noise. - Monitoring must include repeat telemetry of ringed seals and grey seals after the wind farm is commissioned. - Monitoring must include analysis of ringed seal movement routes and passage through or avoidance of the wind farm. - Monitoring must include observation of pupping seals in the event of ice formation and verification of the impacts of maintenance vessel traffic. - Passive acoustic monitoring of seals must be designed such that at least some of the measurement points are located within the additional area under main alternative 3 or within its immediate impact area. There is no reason to automatically repeat the measurement point locations from Mustonen's pilot study (2024) unchanged in the follow-up monitoring.
Fish fauna (section 3.8)	<i>Pre-construction phase</i>	A follow-up monitoring programme must be developed to detect possible changes in the species composition and abundance of fish fauna both during construction works and during operation of the wind farm in the additional area. Monitoring must be carried out annually during the first five years of operation of the wind farm in the additional area and every other year during the following ten years, after which an assessment should be made of the need to continue monitoring; a more detailed plan for the monitoring studies shall be drawn up in cooperation between the developer, the decision-maker and species experts before construction of the wind farm in the additional area begins.
	<i>Construction phase</i>	A follow-up monitoring programme must be developed to detect possible changes in the species composition and abundance of fish fauna both during construction works and during operation of the wind farm in the additional area. Monitoring must be carried out annually during the first five years of operation of the wind farm in the additional area and every other year during the following ten years, after which an assessment should be made of the need to continue monitoring; a more detailed plan for the monitoring studies shall be drawn up in cooperation between the developer, the decision-maker and species experts before construction of the wind farm in the additional area begins.

Environmental component	Implementation phase	Follow-up monitoring
	<i>Post-construction and operational phase</i>	A follow-up monitoring programme must be developed to detect possible changes in the species composition and abundance of fish fauna both during construction works and during operation of the wind farm in the additional area. Monitoring must be carried out annually during the first five years of operation of the wind farm in the additional area and every other year during the following ten years, after which an assessment should be made of the need to continue monitoring; a more detailed plan for the monitoring studies shall be drawn up in cooperation between the developer, the decision-maker and species experts before construction of the wind farm in the additional area begins.
Protected natural objects and Natura areas (sections 3.9, 3.10)	<i>Pre-construction phase</i>	-
	<i>Before authorisation of the activity, and post-construction and operational phase</i>	The uncertainties referred to in section 3.10.5 do not alter the conclusions of the appropriate Natura assessment or the assessments of the conservation objectives of the SPAs and SACs and the favourable status of species. The uncertainty is reduced through monitoring of the species constituting the conservation objectives in accordance with the bird and seal monitoring plans, and through verification of the validity of the conclusions before the activity is authorised.
Climate (section 3.11)	<i>Design and procurement, and post-construction and operational phase</i>	- To refine the assessment of the climate impact of the final project design, it is recommended that a project-specific life cycle calculation and climate resilience check be carried out and that data on actual net output and production restrictions be collected during operation. Upon decommissioning, it is recommended that the proportion of materials recycled and reused be recorded. - In topic-specific monitoring plans, an adaptive approach must be applied, taking into account the possible effects of changes in climatic and marine conditions on receptor sensitivity, the timing of impacts and the effectiveness of measures.
	<i>Decommissioning phase</i>	To refine the assessment of the climate impact of the final project design, it is recommended that a project-specific life cycle calculation and climate resilience check be carried out and that data on actual net output and production restrictions be collected during operation. Upon decommissioning, it is recommended that the proportion of materials recycled and reused be recorded.
Visual impact (section 4.1)	<i>Post-construction and operational phase</i>	-

Environmental component	Implementation phase	Follow-up monitoring
Airborne noise (section 4.2)	<i>Detailed design stage, and post-construction and operational phase</i>	At the detailed design stage, once the final number and layout of the turbines and the final turbine model have been determined, additional noise modelling is recommended. The turbine types analysed in this work, like other modern turbines, are not known to generate tonal sound (i.e. noise). It is recommended that possible tonality be assessed as part of the monitoring planned after construction of the wind farm, particularly if disturbance occurs.
Socio-economic impacts and fishing (section 4.3)	<i>Pre-construction phase</i>	In the subsequent stages of the wind farm development, the implementation principles for the coexistence of fisheries and the offshore wind farm, the follow-up assessment of economic impacts and possible compensation will be specified in cooperation with the Ministry of Regional Affairs and Agriculture and representatives of the fisheries sector. The developer and the preparer of the EIA have contacted the Ministry of Regional Affairs and Agriculture, which is responsible for fisheries, and consultations have been initiated.
	<i>Post-construction and operational phase</i>	The implementation principles for the follow-up assessment of economic impact will be specified in accordance with section 4.3.4 and Table 7.2-1. No fixed-scope regular monitoring programme is specified in this report.
Underwater cultural heritage (section 5)	<i>Pre-construction phase</i>	- When implementing main alternative 3, the locations of the final turbine positions, the routes of the inter-array cables and the connection cable, the offshore substation, the jack-up legs of installation vessels, anchoring areas and other temporary work areas must be archaeologically checked before construction works commence. - When implementing main alternative 3, the final design solution must be submitted to the National Heritage Board if the impact area of the works may extend to the monument or its protection zone.
	<i>Construction phase</i>	When implementing main alternative 3, work in the immediate vicinity of the object must be halted and the National Heritage Board must be notified if a previously unknown wreck, archaeological find or archaeological layer is discovered during construction works.

Environmental component	Implementation phase	Follow-up monitoring
Navigation and radio communication (section 6.1)	<i>Before construction and construction phase</i>	• The risk assessment recommends VTS for the active coordination of vessel traffic in the Saare-Liivi additional area and identifies, as an alternative, another AIS- and radar-based traffic monitoring and reporting arrangement. Before construction activities begin, the technical and organisational solution for traffic monitoring and management required for the additional area must be defined in cooperation with the Transport Administration and other authorities concerned. During the active stages of construction, safe vessel traffic is supported by on-site traffic monitoring and by a guard vessel equipped with radar and AIS equipment or, where necessary, a mobile patrol craft, allowing rapid intervention if dangerous situations arise. Given the distance of the additional area from Pärnu harbour, the regular escorting of vessels from the port to the work area is not considered practical. During the operation stage, the need for a guard vessel, its area of operation and period of use shall be determined on a risk basis; a permanently deployed guard vessel is not automatically necessary if navigation marking, remote surveillance, communication arrangements and other measures ensure an adequate level of safety. • The need for a guard vessel, its area of operation and period of use must be determined on a risk basis. During the active stages of construction, the use of a guard vessel or patrol craft equipped with AIS and radar may be justified. During the operation stage, a permanently deployed guard vessel is not automatically necessary if navigation marking, remote surveillance, communication arrangements and other measures ensure an adequate level of safety.
	<i>Post-construction and operational phase</i>	• The risk assessment does not provide for mandatory regular follow-up monitoring of navigation, communication and positioning systems as a separate measure. If, during operation, substantiated information emerges of interference affecting the functioning of radar, VHF communications, AIS or another navigation system, the extent of the interference must be determined in cooperation with the Transport Administration and the owner of the system concerned and, where necessary, a proportionate technical or organisational solution must be implemented.
Air traffic (section 6.2)	<i>Post-construction and operational phase</i>	• –

Environmental component	Implementation phase	Follow-up monitoring
Maritime surveillance and operational communications (section 6.3)	<i>Pre-construction phase</i>	- The final design solution and its technical impact analysis for maritime surveillance, national defence and operational communications systems must be submitted and reviewed during the preparation of the detailed design together with the authorities concerned and system owners. The necessary technical mitigation solutions must be included in the detailed design. Before the wind farm is commissioned, the functioning of the agreed systems and compliance with the acceptance criteria defined during preparation of the detailed design will be verified. - During the preparation of the detailed design, the final layout plan, turbine heights, rotor diameter and materials, the location of the offshore substation, and the heights of temporary construction cranes must be submitted to the system owners.
	<i>Before commissioning</i>	The final design solution and its technical impact analysis for maritime surveillance, national defence and operational communications systems must be submitted and reviewed during the preparation of the detailed design together with the authorities concerned and system owners. The necessary technical mitigation solutions must be included in the detailed design. Before the wind farm is commissioned, the functioning of the agreed systems and compliance with the acceptance criteria defined during preparation of the detailed design will be verified.

7.5. Cumulative and transboundary environmental impact

7.5.1. Cumulative impact

Cumulative impacts have been addressed under each subsection where deemed relevant.

The cumulative impact assessment presented in each chapter dealing with an impact topic forms part of the assessment of the significance of impacts on the respective environmental element. The summary assessment presented in section 7.5 does not replace the analysis by impact topic, but provides an overview of its results in Table 7.5-1.

The measures and monitoring obligations set out in this EIA apply only to the additional area. References to information exchange, methodological comparability or coordination with neighbouring projects describe the possibility of managing cumulative impact and do not impose obligations on other developers or alter the conditions for the initial area. If data from a neighbouring project or an agreement are not available, the impact of the additional area will be assessed on the basis of the available information and conservative assumptions, and measures under the developer's control will be implemented.

Table 7.5-1. Summary assessment of cumulative impact by impact topic

Impact topic (section)	Projects included (stage)	Common receptor and impact pathway	Spatial and temporal overlap	Basis for assessment	Cumulative impact and residual impact	References to measures and monitoring
Underwater noise (section 2.8)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Partial overlap and summation of construction-phase impulsive noise and operational continuous noise fields within the same water body.	Spatial: partial. For the addition of construction-phase impulsive noise, the temporal overlap of high-noise works is decisive. The operational in-combination effect depends on the extent of the noise fields of wind farms operating simultaneously.	<i>Quantitative. Two scenarios were modelled (initial area only, and initial + additional area), with 20 MW turbines, i.e. a conservative assumption.</i>	The addition of the additional area increases the modelled operational median sound level by 0.1 dB, and its incremental contribution is therefore small. This indicator alone does not rule out a construction-phase in-combination effect or an in-combination effect with the Liivi Bay offshore wind farm; biological significance is assessed in sections 3.7 and 3.8. To reduce the construction-phase in-combination effect, noise abatement and, where necessary, adjustment of the timing of works will be applied in the additional area. Residual impact: according to the biological assessment in sections 3.7 and 3.8, 0/–	Measures and monitoring are set out in sections 2.8, 3.7.4 and 3.8.4 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.

Impact topic (section)	Projects included (stage)	Common receptor and impact pathway	Spatial and temporal overlap	Basis for assessment	Cumulative impact and residual impact	References to measures and monitoring
Hydrodynamics, wave action and water column mixing (section 3.1)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Spatial spread of changes in currents, wave action, water transport and mixed layer thickness, and changes in ice conditions.	Spatial: yes. Temporal: persistent during operation; construction-phase overlap of little significance.	<i>Quantitative. Scenarios A0 / E1 / E1+T1 and a separate ice conditions model with three scenarios.</i>	The changes are local; no significant change in the general circulation or wave climate of the Gulf of Riga is predicted. The addition of the Liivi Bay offshore wind farm does not alter the large-scale behaviour of the ice field, but local and temporal changes do occur. Residual impact: 0/–	Measures and monitoring are set out in section 3.1.4 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.
Seabed geology and sediments (section 3.2)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Accumulation of changes in seabed relief and sediment dynamics, and of scour, within the same basin.	Spatial: partial. Temporal: permanent.	<i>Qualitative, based on hydrodynamic modelling.</i>	The changes are confined to the immediate vicinity of the foundations; coastal processes are not affected. No significant cumulative impact is predicted. Residual impact: 0/–	Measures and monitoring are set out in section 3.2.4 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.
Suspended matter, sedimentation and nutrients released from sediments (section 3.3)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Addition of construction-phase suspended matter, sedimentation and mobile phosphorus load to the same coastal water body, whose overall status is poor.	Spatial: yes. Temporal: decisive – high if dredging or dumping works overlap.	<i>Quantitative modelling of suspended matter dispersion; calculation of the potentially mobile phosphorus stock contained in the sediment.</i>	According to the model, significant spatial overlap of suspended matter plumes is unlikely, and no significant adverse impact is predicted. Construction-phase suspended matter and nutrient load will nevertheless increase in the same water body, and its actual extent will be checked through monitoring. Residual impact: 0/–	Measures and monitoring are set out in section 3.3.4 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.

Impact topic (section)	Projects included (stage)	Common receptor and impact pathway	Spatial and temporal overlap	Basis for assessment	Cumulative impact and residual impact	References to measures and monitoring
Seabed biota and habitats (section 3.4)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Increase in the total area of permanent loss and construction-phase disturbance affecting the same habitat type, and addition of hard artificial substrate to the soft seabed.	Spatial: yes. Temporal: permanent; temporal overlap of activities is of little significance.	<i>Quantitative area calculation (Table 3.4- 9).</i>	In combination, the area of permanent seabed loss and temporary disturbance and the amount of artificial substrate increase. The soft-sediment habitats affected are widespread, and the temporary disturbance is expected to be reversible. According to section 3.4.6, the cumulative impact is slightly negative. At the detailed design stage, compliance with the 2% criterion will be verified in accordance with section 3.4.4. Residual impact: –	Measures and monitoring are set out in section 3.4.4 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.
Birds – collision risk (section 3.5)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II); Saare Wind Energy (II)	Summation of collision mortality within the same migratory population, particularly in the case of common crane and nocturnal migrants.	Spatial: yes. Temporal: operational and permanent, but seasonally concentrated.	<i>Partly quantitative. Results for the additional area were obtained by scaling the mean values from the 50-turbine model by a factor of 0.8 (40/50).</i>	Arithmetic summation of the models is not always possible due to differing methodologies. Before measures are applied, the cumulative collision impact is potentially significant and adverse; with the implementation of binding adaptive measures, no significant population-level impact is predicted. Residual impact: –	Measures and monitoring are set out in section 3.5.4 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.

Impact topic (section)	Projects included (stage)	Common receptor and impact pathway	Spatial and temporal overlap	Basis for assessment	Cumulative impact and residual impact	References to measures and monitoring
Birds – displacement and barrier effect (section 3.5)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Reduction in stopover and feeding-ground function, and lengthening of the routes of migration and feeding flights.	Spatial: yes. Temporal: operational and permanent.	<i>Qualitative, based on a conservative population model.</i>	A slight cumulative displacement will occur; no significant population-level impact is predicted. Residual impact: –	Measures and monitoring are set out in sections 3.5.4 and 3.10.5 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.
Bats (section 3.6)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Exposure of the same individuals migrating across the Gulf of Riga to the rotor-swept zones of multiple wind farms during autumn migration.	Spatial: yes. Temporal: operational, seasonal.	<i>Qualitative. Absolute numbers of detections are not directly comparable due to differences in survey effort and technical differences.</i>	Autumn migration passes through both the initial and the additional area, and at least Nathusius' pipistrelle and noctule bat may occur within the impact area of both developments. Use of the additional area is low when compared with reference data; with binding adaptive operation, no significant impact is expected. Residual impact: 0/–	Measures and monitoring are set out in section 3.6.4 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.
Seals – construction-phase impulsive noise (section 3.7)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Exposure of the same grey and ringed seal individuals to overlapping periods of noise and disturbance; summation of PTS and TTS zones.	Spatial: yes. Temporal: decisive – very high if piling works overlap.	<i>Modelling of underwater noise from foundation installation (section 2.8) and consideration of a possible construction-phase overlap (sections 2.8.4 and 3.7.6). The final construction schedules are not yet known.</i>	In the case of simultaneous or closely timed high-noise activities, a significant impact cannot be ruled out without prior verification. With adjustment of the timing of works in the additional area and noise abatement, the impact is reduced. Residual impact: 0/–	Measures and monitoring are set out in section 3.7.4 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.

Impact topic (section)	Projects included (stage)	Common receptor and impact pathway	Spatial and temporal overlap	Basis for assessment	Cumulative impact and residual impact	References to measures and monitoring
Seals – operational noise and movement zone (section 3.7)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Spatial expansion of the noise field, area avoidance, and possible fragmentation of the north–south movement route of the ringed seal.	Spatial: yes. Temporal: operational and permanent.	<i>Quantitative noise model; qualitative telemetry analysis.</i>	Operational noise does not cumulate (see section 2.8). No significant impact on the population is predicted. Residual impact: 0/–	Measures and monitoring are set out in section 3.7.4 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.
Fish fauna (section 3.8)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Impact on the same fish stock, spawning migrations, spawning grounds and feeding areas through underwater noise, suspended matter, habitat change and electromagnetic fields.	Spatial: yes. Temporal: high during construction; persistent during operation, at lower intensity.	<i>Quantitative noise model (section 2.8); qualitative biological assessment.</i>	With the implementation of measures, no significant cumulative or transboundary impact is expected. If the final schedule or technical data for the neighbouring project are not available, the assessment for the additional area will be updated on the basis of the available information and conservative assumptions, and measures under the developer's control will be implemented. Residual impact: 0/–	Measures and monitoring are set out in section 3.8.4 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.
Protected natural objects and Natura 2000 areas (sections 3.9 and 3.10)	Projects are selected by area, conservation objective and impact pathway	Cumulative mortality, disturbance, displacement or barrier effect relating to the same conservation objective.	Spatial and temporal overlap depends on the impact pathway.	<i>Qualitative, based on the topic-specific assessment of birds and seals.</i>	With the implementation of binding avoidance and mitigation measures, the conservation objectives and integrity of the assessed Natura areas will not be adversely affected. Residual impact: 0	Measures and monitoring are set out in sections 3.9 and 3.10.3–3.10.5 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.

Impact topic (section)	Projects included (stage)	Common receptor and impact pathway	Spatial and temporal overlap	Basis for assessment	Cumulative impact and residual impact	References to measures and monitoring
Climate (section 3.11)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II); Saare Wind Energy, qualitatively	Combined effect of lifecycle GHG emissions and electricity generation with low lifecycle emissions on electricity system emissions.	Spatial: global. Temporal: throughout the life cycle.	<i>Qualitative; quantification is limited by the absence of a final project design.</i>	The cumulative net impact of offshore wind farms on climate change mitigation is significantly positive. Residual impact: + +	Measures and monitoring are set out in section 3.11.5 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.

Impact topic (section)	Projects included (stage)	Common receptor and impact pathway	Spatial and temporal overlap	Basis for assessment	Cumulative impact and residual impact	References to measures and monitoring
Visual impact (section 4.1)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Increase in the field of view occupied by wind turbines, and alteration of the seascape of Kihnu and Ruhnu.	Spatial: yes. Temporal: operational and permanent.	<i>Quantitative calculation of field-of- view occupation at 14 viewpoints (Table 4.1- 3).</i>	At the southern tip of Kihnu, turbines cumulatively occupy 129° of the field of view (50° from the Saare-Liivi initial area + 79° from the Liivi Bay offshore wind farm), leaving an approximately 28° free viewshed between the wind farms. This is a sensitive area (Kihnu Strait Marine Park), and therefore the cumulative impact is large in extent. In views from Kihnu, the turbines of the additional area are located behind the turbines of the initial area and densify the group of turbines within the occupied field of view (section 4.1.2); in views from Ruhnu, the in- combination effect is extremely low (section 4.1.5). Residual impact: 0/–	Measures and monitoring are set out in section 4.1.3 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.

Impact topic (section)	Projects included (stage)	Common receptor and impact pathway	Spatial and temporal overlap	Basis for assessment	Cumulative impact and residual impact	References to measures and monitoring
Airborne noise (section 4.2)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Combined increase in noise levels at the same noise-sensitive areas on Kihnu Island.	Spatial: yes. Temporal: operational and permanent.	<i>Quantitative modelling of the in- combination effect.</i>	In the scenario with 80 turbines in the Saare-Liivi initial area, 40 in the additional area and 50 in the Liivi Bay offshore wind farm, the noise level at the nearest residential building on Kihnu is 32.7 dB(A), and up to 37.7 dB(A) with the uncertainty correction factor. The night-time target value of 40 dB(A) is not exceeded. Residual impact: 0	Measures and monitoring are set out in sections 4.2.4 and 4.2.6 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.

Impact topic (section)	Projects included (stage)	Common receptor and impact pathway	Spatial and temporal overlap	Basis for assessment	Cumulative impact and residual impact	References to measures and monitoring
Socio-economic impacts, fisheries and tourism (section 4.3)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Reduction in fishing ground and lengthening of transit routes; accumulation of toleration payment and employment; change in the tourism destination.	Spatial: yes. Temporal: construction- phase and permanent during operation.	<i>Quantitative, based on fishing data; the economic impact cannot be aggregated due to differing methodologies.</i>	For fisheries as a whole, the impact is slightly negative, but at the level of an individual operator or fishing segment it may be more pronounced. In terms of toleration payment and employment, the cumulative impact is positive: The share of the fee for generating electricity from wind energy in the Saare-Liivi initial and additional areas allocated to local authorities accrues to Kihnu municipality, while the fee for the Liivi Bay offshore wind farm is divided between Kihnu municipality, Häädemeeste municipality and the city of Pärnu, with the largest share likewise going to Kihnu municipality (section 4.3.6). Residual impact: fisheries 0/-; local benefit ++	The measures of section 4.3.4 are compiled in Table 7.2-1. The implementation principles for the follow- up assessment of economic impact will be specified in consultations.

Impact topic (section)	Projects included (stage)	Common receptor and impact pathway	Spatial and temporal overlap	Basis for assessment	Cumulative impact and residual impact	References to measures and monitoring
Underwater cultural heritage (section 5)	Saare-Liivi initial and additional area; other projects were screened out	Direct impact on the same object or protection zone; shared cable corridors, dumping areas and anchoring.	Spatial: no. Temporal: not decisive.	<i>Qualitative, based on sonar and diving surveys.</i>	Based on the information available, the projects do not affect the same cultural heritage object. There is no cumulative impact. Residual impact: 0	Measures and monitoring are set out in section 5.1.4 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.
Vessel traffic, maritime safety and pollution response (section 6.1)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Concentration of traffic into corridors, changes to routes, allision and collision risk, and reduced rescue capability.	Spatial: yes. Temporal: high during construction; permanent during operation.	<i>Quantitative. IMO FSA methodology and IALA risk management principles; cumulative scenario S2.</i>	The modelled corridors can be linked with the vessel traffic directions in the Latvian marine area plan; no transboundary bottleneck was identified for international transit traffic. With an appropriate spatial layout and risk control measures, the risks are at a tolerable level. Residual impact: –	Measures and monitoring are set out in section 6.1 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.
Air traffic, SAR and MEDEVAC (section 6.2)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Reduction in the free flight corridor between the wind farms and increased difficulty of access for visual, search and rescue flights.	Spatial: yes. Temporal: operational and permanent.	<i>Qualitative, based on the 2023 aviation study.</i>	Without measures, the in-combination effect of the Saare-Liivi initial area and the Liivi Bay offshore wind farm on visual, SAR and MEDEVAC flights may be significant and adverse. The standalone contribution of the additional area under main alternative 3 to this effect is small – the additional area does not narrow the corridor between the wind farms. Residual impact: 0/–	Measures and monitoring are set out in section 6.2 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.

Impact topic (section)	Projects included (stage)	Common receptor and impact pathway	Spatial and temporal overlap	Basis for assessment	Cumulative impact and residual impact	References to measures and monitoring
Maritime surveillance, national defence and operational communications (section 6.3)	Saare-Liivi initial and additional area; Liivi Bay offshore wind farm (II)	Spatial increase in radar interference, shadowing and radio communication interference within the same viewing sector or coverage area.	Spatial: yes. Temporal: operational and permanent.	<i>Qualitative assessment; exact technical analysis is limited by the fact that the location and technical parameters of the systems are not publicly available.</i>	The impact of the final layout on specific systems will be specified through the technical analysis of the detailed design together with the system owners. The necessary mitigation solutions will be included in the detailed design, and before commissioning the functioning of the systems and compliance with the acceptance criteria will be verified (section 6.3). Expected residual impact: 0/– provided that these conditions are met; the general assessment does not replace the result of the system-specific analysis.	Measures and monitoring are set out in section 6.3 and compiled, with the same wording, in Tables 7.2-1 and 7.4-1. The scope of application follows the introduction to section 7.5.

The stage of the included projects corresponds to the definition set out in Table 2.4-1 in section 2.4: I – established project, II – proposed project with sufficient detail. Stage III projects are not included in the detailed cumulative assessment. offshore wind farm. The residual impact assessment is based on the scale set out in Table 2.3-3: – slight negative impact, — significant negative impact, 0 no impact, neutral, + slight positive impact, ++ significant positive impact.

No significant direct local transboundary environmental impact is predicted from the proposed activity. Transboundary and functionally transboundary impacts may nevertheless occur, primarily through migratory birds, shared fish stocks, vessel traffic, maritime surveillance and communications systems, and the global climate impact. In the development of wind farms in the Gulf of Riga, bird displacement is one of the central issues. Likewise, one of the largest in-combination effects (i.e. cumulative impacts) in the case of the two Saare-Liivi offshore wind farms proposed in close proximity and the Liivi Bay offshore wind farm is the collision risk for birds posed by turbines. The above impacts are addressed in the relevant impact-topic chapters and, where necessary, to the extent possible, also through information exchange between projects and between countries.

The preservation of the functionality of feeding and stopover areas and migration routes important for birds is an important ecological precondition for the cumulative assessment (sections 3.5.6 and 3.10.5). Collision risk reduction and monitoring of spatial use in accordance with section 3.5.4 will be implemented in the additional area.

7.5.2. Transboundary environmental impact

Basis for the assessment of transboundary environmental impact

Transboundary environmental impact is assessed pursuant to the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention) and the Environmental Impact Assessment and Environmental Management System Act. This chapter assesses whether the implementation of main alternative 3 for the additional area of the Saare-Liivi offshore wind farm (57.1 km², up to 40 wind turbines, tip height up to 310 m) may entail significant adverse environmental impact outside the jurisdiction of the Republic of Estonia, and whether such impact may be caused by the in-combination effect of the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm.

The possibility of transboundary environmental impact is not assessed solely on the basis of the distance between the physical impact area and the state border. The Gulf of Riga is a semi-enclosed body of water shared by Estonia and Latvia, and several of the receptors assessed – migratory birds, bats, seals and fish stocks – are transboundary in their movement or use. Therefore, transboundary environmental impact is considered even where the activity's direct physical impact area remains within the Estonian marine area.

The initial and additional area of the Saare-Liivi offshore wind farm are located in immediate proximity and directly adjacent to each other. The standalone incremental impact of the additional area is assessed against the background of the assessments set out in the EIA report for the initial area, which was deemed compliant, and the Liivi Bay offshore wind farm in particular is treated as the external cumulative project. As regards bird collision risk, the Saare Wind Energy offshore wind farm has also been included in the cumulative assessment (see sections 2.4 and 7.5).

Consideration of the results of transboundary consultation in the EIA for the initial area

During the publication of the EIA report for the initial area of the Saare-Liivi offshore wind farm, on 17.03.2025 the Ministry of Climate transmitted the report materials to the countries participating in the transboundary procedure – Latvia, Lithuania, Sweden and Finland. The submissions received and the responses to them are set out in section 8.3 of the EIA report for the Saare-Liivi initial area and in its Annex 5. In the EIA procedure for the initial area, no significant adverse transboundary environmental impact was identified in any of the assessed topics.

Since the initial and additional area are located in immediate proximity, the transboundary submissions received in the procedure for the initial area have been taken as a substantive basis in the preparation of this EIA report for the Saare-Liivi additional area. Table 7.5-2 shows how those submissions have been taken into account and assessed in this report.

Table 7.5-2. In the EIA procedure for the initial area of the Saare-Liivi offshore wind farm *the transboundary submissions received are considered in the EIA report for the additional area*

Submitting party and content (transboundary consultation in the EIA for the initial area)	Consideration and treatment in the EIA report for the additional area
Ministry of Administration and Regional Development of the Republic of Latvia – no comments were submitted; requested to be informed of project changes, additional public participation measures, and impacts on bird migration and the cumulative overall impact.	As a result of the studies, the development area of the additional area has been reduced from 91.2 km ² to 57.1 km ² and the number of wind turbines from 92 to 40 (section 2.3). The collision, displacement and barrier effects on migratory birds, and the cumulative impact, have been assessed in section 3.5 and summarised in section 7.5.
Ministry of Transport of the Republic of Latvia – condition that, if AIS coverage is not ensured within Latvia's area of responsibility, an additional coastal AIS base station must be established; requested clarification of the purpose of the VTS proposal and of its possible impact on vessel traffic in waters under Latvian jurisdiction.	In section 6.1, cumulative scenario S2 includes the Saare-Liivi initial and additional area and the Liivi Bay offshore wind farm. The modelled Estonian-side Corridors D and E can be connected to the vessel traffic directions provided for in the Latvian marine area spatial plan, and no transboundary bottleneck was identified for international transit traffic. If, during operation, substantiated information emerges about disruption to the functioning of VHF communications, AIS or another navigation system, the extent of the disruption must be established and, where necessary, a proportionate solution implemented. The need for VTS or equivalent traffic monitoring will be determined in cooperation with the Transport Administration and other authorities concerned.
Ministry of the Interior of the Republic of Latvia and the State Border Guard – the proximity of the wind farm to Latvia's territorial sea may affect the operation of the naval radar system; subordinate agencies of the Latvian Ministry of Defence did not identify any impact on their radars.	In section 6.3, the transboundary impact on Latvian monitoring and communications systems is addressed as a separate impact line and, on the basis of the information available, assessed as indeterminate. When specifying the transboundary impact, the need to involve the competent Latvian authorities and, where necessary, for technical coordination will be taken into account. If the Saare-Liivi initial and additional areas and the Liivi Bay offshore wind farm are located within the line of sight of the same monitoring or communications system, a technical impact analysis for the additional area must be carried out during preparation of the detailed design, which, where possible, also covers neighbouring projects.
Nature Conservation Agency of the Republic of Latvia – recommended that periodic monitoring be provided for and that the Latvian side be informed of the monitoring results, including any negative transboundary environmental impact.	The principles of follow-up assessment and follow-up monitoring are set out in section 7.4. The procedure for transboundary notification is set out at the end of this chapter.
Ministry of Agriculture and Ministry of Health of the Republic of Latvia – considered the studies on fish stocks, the impact assessment and the mitigation measures sufficient; no impact on human health in Latvian territory was identified.	The fish assessment is presented in section 3.8 on the basis of the studies of the additional area and scientific information. Noise and visual impacts are addressed in sections 4.1 and 4.2; on the basis of these assessments, no significant adverse impact on the human living environment in Latvian territory is predicted.

Submitting party and content (transboundary consultation in the EIA for the initial area)	Consideration and treatment in the EIA report for the additional area
Lithuanian State Service for Protected Areas – considered main alternative 3 acceptable provided all mitigation measures are implemented, but found that there is no clear action plan to avoid significant impacts on birdlife, the monitoring plan does not sufficiently cover sensitive species, and there are no specific measures for managing cumulative impacts.	Section 3.5.4 for the additional area requires an automatic bird monitoring and need-based operation plan agreed with the Environmental Board before construction works begin. The plan specifies the identification of migration events involving a high collision risk, the restriction or stopping of operation, restarting, and verification of the effectiveness of the measures. Monitoring covers staging waterbirds, the flight intensity and flight altitude of passage migrants, and actual collisions or events indicative of them. The system must be operational from the start of regular operation. Cumulative impacts are addressed in sections 3.5.6 and 3.10 and in Table 7.5-1. If the assessed solutions change, the validity of the Natura conclusions will be verified before the activity is authorised.
BirdLife Sweden – pointed out that an important migration corridor passes through the wind farm area and considered it necessary to shut down turbines during periods of mass migration.	The main potentially significant impact of the additional area has been assessed as the collision risk for common cranes and nocturnal migrants. The adaptive operational plan described in section 3.5.4 is specifically aimed at identifying high-risk migration events for these species groups and temporarily switching the turbines to a safe operating mode. In addition, the development area and the number of turbines have been reduced, which reduces the barrier effect and the calculated collision risk. The cumulative collision risk in combination with the Saare-Liivi initial area, the Liivi Bay offshore wind farm and the Saare Wind Energy offshore wind farm has been addressed in section 3.5.6.
Swedish Pelagic Fisheries Association and the Federation of Finnish Fisheries Associations – expressed concern about fish stocks used on a transboundary basis, pointed to a contradiction between the absence of impacts and the lack of knowledge regarding indirect impacts, and considered broader transboundary coordination and a joint impact assessment necessary.	The fish assessment in section 3.8 has been updated on the basis of the fish survey of the additional area and the experimental noise study by Rohtla et al. (2025). The migration of spring and autumn herring, underwater noise during construction and operation, suspended matter, habitat changes and electromagnetic fields have been addressed separately. The uncertainty regarding the indirect effects of electromagnetic fields is explicitly stated in the report. The consideration of information available on neighbouring projects and the use of comparable monitoring methods are addressed in sections 7.4 and 7.5.
Centre for Economic Development, Transport and the Environment for South Finland – considered main alternative 3 to be the solution with the lowest impact, supported protection measures for birds, bats and seals and the avoidance of construction-time noise disturbance; the fisheries department recommended that the impact on migratory fish be assessed separately.	The propagation of underwater noise during construction and operation has been modelled in section 2.8, and the impacts on seals and fish assessed in sections 3.7 and 3.8. Impacts on bats are addressed in section 3.6. To protect the spawning migration of spring herring, a spatial restriction during construction is provided for March and April, together with underwater noise mitigation measures.
Finnish Transport and Communications Agency Traficom – recommended testing the functioning of radio systems and planning enhancements where necessary, especially in emergency situations.	According to section 6.1, no mandatory regular post-commissioning control measurements are envisaged for navigation, communications and positioning systems. If, during operation, substantiated information emerges about disruption to the functioning of a system, the extent of the disruption must be established and, where necessary, a

<i>Submitting party and content (transboundary consultation in the EIA for the initial area)</i>	<i>Consideration and treatment in the EIA report for the additional area</i>
	proportionate technical or organisational solution implemented.
Swedish Transport Agency, Ministry of Foreign Affairs of the Republic of Latvia, State Environmental Service of Latvia, Finnish Meteorological Institute, and the Regional Councils of South Finland and Helsinki-Uusimaa – no substantive comments or objections were submitted.	No further consideration is required. The submissions have been noted.

Assessment of transboundary environmental impact by impact topic

Avifauna. The impact of the additional area on avifauna has been assessed in section 3.5. The transboundary environmental impact may arise primarily through migratory birds that pass through the Gulf of Riga and whose populations are shared with neighbouring countries. The main potentially significant impact of the additional area has been assessed as the collision risk for common cranes and nocturnal migrants. The reduction of the development area and the number of turbines, the arrangement of turbine rows taking the prevailing migration direction into account, and the adaptive operational plan reduce the calculated collision risk. The cumulative collision risk in combination with the Saare-Liivi initial area, the Liivi Bay offshore wind farm and the Saare Wind Energy offshore wind farm has been assessed in section 3.5.6. With the implementation of binding adaptive measures, no significant population-level impact is predicted. Uncertainty in the assessment remains, and therefore the significance of the impact will need to be refined through monitoring during operation.

Bats. Bat activity above the additional area has been assessed as low (section 3.6). As bats migrating across the Baltic Sea are transboundary in their movements, transboundary environmental impact cannot in principle be ruled out. Taking into account the identified low use of the area, the reduction of the development area, and the mandatory turbine operating restriction laid down in section 3.6.4 from 1 August to 15 September in suitable weather conditions, no significant adverse transboundary environmental impact on bat populations is anticipated. The extent of the restriction may be refined on the basis of follow-up monitoring.

Seals. The grey seal and ringed seal populations of the Gulf of Riga are shared by Estonia and Latvia, and some important feeding areas are located in Latvian coastal waters (section 3.7). Underwater noise during construction is the main potential source of disturbance. With the implementation of combined noise mitigation measures, no significant adverse transboundary environmental impact on seal populations is anticipated; scheduling high-noise works for the period when most seals are hauled out is a recommended additional measure. If piling works at Saare-Liivi and the Liivi Bay offshore wind farm may overlap in time, cumulative noise must be assessed on the basis of the scheduling information available and, where necessary, the timing of works in the additional area or the mitigation measures must be adjusted.

Fish fauna. The fish stocks of the Gulf of Riga, in particular the Baltic herring stock, are a natural resource jointly used by Estonia and Latvia. The transboundary environmental impact may theoretically also arise where the direct physical impact area of underwater noise or suspended matter does not extend into another state's territorial waters, but the spawning migration, spawning, feeding areas or recruitment of the same fish stock are affected. No significant spawning areas were identified in the additional area, and the area's additional contribution to population-level impacts on fish stocks is small. Taking into account the reduced spatial extent of the additional area, seasonal construction restrictions, underwater noise mitigation measures and follow-up monitoring of the Saare-Liivi additional area, no significant adverse

transboundary environmental impact on fish stocks is anticipated. However, minor local or indirect effects, and the cumulative effects of several wind farms, cannot be completely ruled out.

Marine environment and water quality. The impacts on hydrodynamics, water column mixing and water quality have been assessed in sections 3.1 and 3.3. Based on the modelling results, the changes are local and do not cause any significant change in the general circulation of the Gulf of Riga, the wave climate or the status of the water body. Construction-related suspended matter and nutrients released from sediments disperse to a limited extent, and their impacts subside relatively quickly. No significant adverse transboundary environmental impact on the marine environment is anticipated. As the Gulf of Riga is a shared body of water, when scheduling works in the additional area, account must be taken of the information available on neighbouring projects, and comparable methods must be used in pre- and follow-up monitoring where possible.

Maritime safety and navigation. In section 6.1, the transboundary environmental impact on Latvian navigation and the coherence of shipping corridors have been assessed within the cumulative S2 scenario (i.e. the Saare-Liivi initial + additional area and the Liivi Bay offshore wind farm). The modelled corridors D and E on the Estonian side can be linked to the shipping directions provided for in the Latvian marine area plan, and no transboundary bottleneck for international transit traffic was identified. This conclusion presupposes that corridors of sufficient width, depth and navigational clearance are retained in the final project solution. In the risk analysis, vessel traffic has not been differentiated by flag state, home port or fishing ground, and therefore it cannot be ruled out that Latvian fishing vessels use routes passing through the development areas. If the Latvian side provides AIS, VMS or other movement data for fishing vessels, changes to their customary routes and access to fishing grounds will be specified on that basis at the detailed design stage.

Air traffic. The impact assessed in section 6.2 is limited to Estonian airspace and the Pärnu–Ruhnu–Kuressaare air connection. The additional area is located further from historical flight trajectories and the Liivi Bay offshore wind farm than the Saare-Liivi initial area and does not narrow the air corridor between the wind farms. No significant transboundary environmental impact on air traffic is anticipated.

Maritime surveillance and operational communications. In section 6.3, the transboundary environmental impact on Latvian monitoring and communications systems has been assessed as indeterminate on the basis of the information available. The turbines of several wind farms may be located within the line of sight of the same monitoring or communications system and affect the same field of view or coverage area. During further design and the building permit procedure, a technical impact analysis of the final project solution will be carried out, involving the competent Latvian authorities where necessary, and the required technical mitigation solution will be incorporated into the project solution and the permit conditions.

Climate. The impact of greenhouse gas emissions is global and therefore inherently transboundary (section 3.11.7). Low life-cycle-emission electricity generated by the offshore wind farm helps to reduce the electricity system's dependence on fossil fuels and supports the achievement of international climate targets. The transboundary climate impact is positive, but a specific local reduction in climate change cannot be causally linked to a single project.

Underwater cultural heritage, airborne noise and visual impact. These impacts are object-specific or local, and their impact area does not extend to the territory of neighbouring states (sections 4.1, 4.2 and 5). No transboundary environmental impact has been identified in these fields.

The offshore wind farm's connection cables are not planned to be connected to another country's electricity system; therefore, no transboundary environmental impact will arise via transmission infrastructure either.

Conclusion

Based on the impact assessment carried out, no significant adverse transboundary environmental impact is predicted from the implementation of main alternative 3 for the additional area of the Saare-Liivi offshore wind farm, provided that the assumptions and measures set out in the report are applied; the impact on Latvian monitoring and communications systems requires system-specific verification in accordance with section 6.3. The separate contribution of the additional area to the cumulative transboundary impact of the Saare-Liivi initial area and the Liivi Bay offshore wind farm is small, since the spatial extent of the development area and the number of turbines have been significantly reduced as a result of the studies.

The cumulative collision risk for migratory birds and the impact on Latvian maritime surveillance and communications systems have been assessed with the greatest uncertainty. In both fields, binding conditions are provided for: an adaptive operational plan for avifauna together with an automatic monitoring system, and a technical impact analysis to be carried out during preparation of the detailed design, together with the necessary technical mitigation solutions. Provided these conditions are met, the transboundary residual impact is assessed as neutral to slightly negative.

Transboundary monitoring and notification procedure

The following procedure will be applied in order to take account of the submissions received in the transboundary procedure and manage residual uncertainty:

- Follow-up monitoring of the additional area will be planned and implemented so that it is, where possible, methodologically compatible with monitoring of the initial area (section 7.4), using monitoring methods and data formats comparable with those of neighbouring projects.
- If monitoring identifies an impact greater than predicted or a transboundary environmental impact – in particular as regards bird collision mortality, seal habitat use, fish migration or spawning – the monitoring results will be transmitted, through the competent authority, to the states that participated in the transboundary procedure, and mitigation measures will be refined where necessary.
- The competent Latvian authorities will be informed of significant changes to the project solution that may affect shipping corridors, AIS coverage within Latvia's area of responsibility, or the functioning of maritime surveillance and communications systems.
- If, on the basis of the scheduling information available, high-underwater-noise works in the Saare-Liivi additional area and the Liivi Bay offshore wind farm may overlap in time, cumulative noise will be assessed and, where possible, the timing of works, mitigation measures and monitoring in the additional area will be adjusted.

An overview of the transboundary consultation within the procedure for this EIA report is provided in section 8.3.

8. Overview of the organisation and publication of the impact assessment

8.1. Organisation of the impact assessment

Under the Environmental Impact Assessment and Environmental Management System Act, the parties to the EIA process are the developer, the expert and the decision-maker (Table 8.1-1).

Table 8.1-1. Parties to the EIA process

Decision-maker, authority processing the superficies licence	Developer	Expert carrying out the EIA
Consumer Protection and Technical Regulatory Authority Address: Endla 10a, 10142 Tallinn Contact: Adeele Vesingi E-mail: adeele.vesingi@ttja.ee Tel.: +372 667 2004	Utilitas Wind OÜ Address: Maakri tn 19/1, Tallinn 10145 Contact: Kristiina Nauts E-mail: kristiina.nauts@utilitas.ee	Roheplaan OÜ Address: Koidu 20, Tallinn 10316 Contact: Riin Kutsar E-mail: riin@roheplaan.ee

The environmental impact assessment is being carried out under the direction of the environmental consultancy firm Roheplaan OÜ; the EIA leading expert is licensed EIA expert Riin Kutsar (licence No. KMH0131). The core members of the EIA expert team are set out in Table 8.1-2. Changes and the need to add additional members to the expert team were mainly due to the large volume of the EIA report and the studies. There was also a need to use foreign expert knowledge in carrying out offshore wind farm studies, as this is a completely new field in Estonia.

Table 8.1-2. Members of the EIA expert team

Working group member	Institution/Field of responsibility (competence)
Riin Kutsar	EIA leading expert (licence KMH0131), BSc, University of Tartu, environmental technology (equivalent to a master's degree); MBA, Estonia Business School Roheplaan OÜ. Role: Process and team management, impact on the natural environment, Natura assessment, assessment of the social and economic environment
Agne Järriks	University of Tartu, geography (equivalent to a master's degree); Roheplaan OÜ. Role: Analysis of impacts on the natural environment Socio-economic impacts GIS analysis
Kaile Eschbaum	University of Tartu, biology (equivalent to a master's degree); Roheplaan OÜ. Role: Analysis of impacts on the natural environment, Natura assessment.
Georg Martin	Estonian Marine Institute, University of Tartu. Benthic biota and habitats expert. PhD, University of Tartu, marine biology Role: Impact on phytobenthos, benthic fauna, marine water quality and plankton communities

Working group member	Institution/Field of responsibility (competence)
Redik Eschbaum	Estonian Marine Institute, University of Tartu. Fish expert. MSc, University of Tartu, ichthyology and fisheries Role: Impact on fish and fisheries, including spawning areas
Leho Luigujõe	Estonian Ornithological Society MTÜ / Taevasikk MTÜ. Avifauna expert, MSc, University of Tartu, zoology and animal ecology Role: Impact on avifauna
Kaarel Võhandu Andrus Kuus	Estonian Ornithological Society MTÜ. Avifauna experts. Role: Impact on avifauna
Rune Skjold Tjørnløv Erik Mandrup Jacobsen Maren Moltke Lyngsgaard	WSP Role: Impact on avifauna.
Ib Krag Petersen	Aarhus University Role: Impact on avifauna.
Mart Jüssi Ivar Jüssi	Seal experts. MTÜ Pro Mare Role: Impact on seals
Oliver Kalda Rauno Kalda	Bat experts. Elustik OÜ Role: Impact on bats
Piret Toonpere	Lemma OÜ. Role: noise and vibration
Kerttu Ots	RPS Group Limited. Landscape architect. Estonian University of Life Sciences, MSc and The University of Edinburgh, MSc Role: Visual impact assessment
Taavi Liblik	Tallinn University of Technology (TalTech). Role: Impact on hydrodynamics, wave conditions, wind conditions, suspended matter dispersion, ice-related risks, forecasting the spread of a possible oil spill
Aleksander Klauson	Tallinn University of Technology (TalTech). Role: Underwater noise modelling and assessment
Ivar Treffner Priit Lätti	Nautic Trade OÜ. Role: Underwater archaeology
Inga Zaitseva-Pärnaste	TalTech EMERA. Role: the wind farm's impact on shipping, maritime communications and maritime surveillance systems, AIS equipment, ship radars, and possible impacts on navigation arising from potential changes in ice conditions.
Olavi Grünvald	Finantsakadeemia OÜ. Role: Analysis/study of economic impacts

8.2. Publication and seeking opinions from the authorities concerned

Pursuant to the law (Environmental Impact Assessment and Environmental Management System Act § 21), seeking the opinions of the authorities concerned on the EIA report and publication of the report fall within the competence of, and are the duty of, the decision-maker.

This section will be supplemented following the publication of the EIA and consultation.

8.3. Transboundary consultation

Environmental impact assessment in a transboundary context is carried out in accordance with the procedures laid down in international agreements, the Convention on Environmental Impact Assessment in a Transboundary Context (the Espoo Convention), and the Environmental Impact Assessment and Environmental Management System Act.

The process of environmental impact assessment in a transboundary context and the related consultation are led by the Ministry of Climate. The initial transboundary consultation of neighbouring countries took place after the EIA procedure was initiated, during which Finland, Sweden, Latvia and Lithuania wished to be involved in the transboundary impact assessment process. The second consultation took place upon publication of the EIA programme, when the above-mentioned countries had the opportunity to present their opinions and proposals regarding the EIA procedure and the substantive issues covered (see Annex 5).

The third consultation will take place during the publication of the EIA report.

This section will be supplemented following the publication of the EIA and consultation.

9. Summary of the report

Based on the results of the EIA, main alternative 3 for the additional area of the Saare-Liivi offshore wind farm (57.1 km², up to 40 wind turbines) is feasible, provided that the mandatory avoidance and mitigation measures and monitoring set out in the report are implemented.

9.1. Proposed activity and scope of the assessment

Utilitas Wind OÜ proposes up to 40 wind turbines with a total capacity of up to 800 MW, an offshore substation, and inter-array and connection cables in the additional area of the Saare-Liivi offshore wind farm. Main alternative 3, which emerged from the assessment, covers a 57.1 km² marine area in the Gulf of Riga, located approximately 23 km from Kihnu and more than 20 km from Ruhnu. The assessed turbines have a tip height of up to 310 m. Turbines of 15 MW (up to 600 MW in total) and 20 MW (up to 800 MW in total), as well as gravity base and monopile foundations, have been assessed as technical alternatives. The final turbine model, foundation type and infrastructure locations will be specified during design within the technical and spatial scope assessed in the EIA. The estimated annual gross output of the additional area is up to 2.7 TWh with 15 MW turbines and up to 3.5 TWh with 20 MW turbines; the actual net output depends, among other things, on losses and on operational restrictions for environmental protection. The additional area will be connected to the onshore electricity grid via the Saare-Liivi initial area and its export cable route; no new separate connection to the mainland is planned. The seabed loss and disturbance of the cable section running from the offshore substation of the additional area to the boundary between the areas are included in the impact assessment of the additional area. The seabed loss and disturbance of the section running from the boundary to the offshore substations of the initial area have been taken into account in the in-combination effect assessment of this report. The in-combination calculation in section 3.4.6 and the suspended matter modelling cover the connection from the offshore substation of the additional area to the landfall point. The EIA addresses construction, operation and decommissioning, technical alternatives, and in-combination effects with other relevant projects. The assessments are based on on-site studies, existing data, modelling and expert judgement. The main projects for the in-combination effect assessment are the Saare-Liivi initial area and the Liivi Bay offshore wind farm; the Saare Wind Energy offshore wind farm was also taken into account in the assessment of bird collision risk. For relevant impacts, the results of earlier studies with a larger development scale are used as a precautionary starting point and are distinguished from the final assessed solution of up to 40 turbines. The EIA is carried out within the superficies licence proceedings of the Consumer Protection and Technical Regulatory Authority.

9.2. Selection of alternatives and impact avoidance

The development area and the number of turbines were reduced from the solution of up to 92 turbines in the EIA programme to main alternative 3 with up to 40 turbines. The western part, which is less favourable in terms of engineering geology, was excluded, and constraints relating to navigation, trawling and underwater cultural heritage were taken into account. An avoidance buffer of approximately 1 km will be maintained between the wreck Nimetu-548 and works affecting the seabed. Reducing the area limits impacts already through the choice of location. Under the zero alternative, the additional area will not be developed, and its local impacts and renewable electricity generation will not materialise. The foundation solutions have different main impact pathways. Gravity base foundations require more seabed preparation, sediment removal and dumping, whereas for monopile foundations installed by piling, construction-phase underwater noise is decisive. During final design, an engineering geological investigation will be carried out at the location of each turbine and offshore substation. The foundation

type will be selected on the basis of site conditions, and the corresponding measures will be applied to the selected technology. During operation, the technical condition of the foundations and cable routes will be monitored.

9.3. Hydrodynamics and marine water quality

Modelling of currents, waves, mixing and ice conditions shows mainly local changes within and around the wind farm. No significant change in the general circulation of the Gulf of Riga or in the wave climate is forecast. In the in-combination effect of several wind farms, the spatial extent of the changes may increase, including a summer expansion of the area with reduced near-bottom oxygen content. The model forecasts will be verified by measurements in the impact and reference areas for at least one year before construction and one year after commissioning. Seabed works are associated with a temporary increase in suspended matter, reduced water transparency and sedimentation. According to the modelling, significant spatial overlap of suspended matter plumes from different development areas is unlikely. The movement of sediments may release nutrients. In the calculation for the additional area, the stock of potentially mobile phosphorus is approximately 39 tonnes, assuming 40% mobility; this is not a forecast of the load actually reaching the water column. No significant deterioration in the overall nutrient regime of the Gulf of Riga or in the status class of the coastal water body of the central Gulf of Riga is forecast. A water column monitoring programme and the measurement of total phosphorus, total nitrogen, phosphates, nitrates and nitrites, and chlorophyll a are mandatory. The timing of suspended matter and nutrient measurements must allow the impact of sediment movement to be assessed and distinguished from natural variability. Additional monitoring of stratification and the use of foundations as platforms for continuous monitoring are recommended. If the construction-phase impact proves greater than assessed, the intensity and timing of the works will be adjusted. Removed material that is not used on site will be taken to a dumping area authorised by the environmental permit. Before construction, a plan for the prevention of and response to marine pollution incidents will be prepared. To reduce the load resulting from blade wear, wear-resistant leading-edge protection is preferred, and inspection of the blades and timely renewal of the protection are ensured.

9.4. Seabed biota and habitats

No marine habitat types under the Habitats Directive or threatened benthic species were identified in the additional area. The construction of infrastructure will nevertheless cause permanent loss of and temporary disturbance to seabed habitats. The soft-sediment habitats affected are widespread in the Gulf of Riga. Fouling communities will develop on the foundations, and the accumulation of organic matter may change in their vicinity. In combination, the area of loss and disturbance and the amount of artificial substrate increase – according to the assessment in section 3.4.6, the cumulative impact is slightly negative. With gravity base foundations, the direct seabed footprint of the infrastructure of the additional area is approximately 0.26 km²; if the entire area of the southern dumping site (4.15 km²) is conservatively counted as long-term loss, the combined estimate is approximately 4.41 km². At the detailed design stage, the area of permanent loss will be specified by habitat type and compliance with the 2% criterion will be verified in combination with the Saare-Liivi initial area and the Liivi Bay offshore wind farm, based on the classification and spatial assessment unit used in section 3.4.6. If the criterion is exceeded, the solution for the additional area will be adjusted in accordance with section 3.4.4. Benthic monitoring covers the pre-construction condition, the immediate post-construction impact, and monitoring of colonisation and organic matter accumulation over five years. Monitoring of non-native species is recommended. After removal of the foundations, the condition of biota and habitats will be checked.

9.5. Birds and bats

No significant waterbird concentration areas or regular feeding areas of the gulls and terns studied by telemetry were identified in the additional area. The main risk requiring measures is the collision of migratory birds, particularly common cranes and nocturnal migrants, with turbines. In the in-combination effect, displacement and the functional availability of feeding and staging areas in the Gulf of Riga are also taken into account. This ecological assumption concerns the assessed in-combination solution; there are no important bird feeding areas within the Saare-Liivi additional area. From the perspective of collision risk, the 15 MW technical variant is preferable. Before construction works begin, a plan for automatic bird monitoring and need-based operation will be prepared and agreed with the Environmental Board. The system must be operational from the start of regular operation; during migration events with a high collision risk, rotor speed will be reduced or the turbines stopped in the manner specified in the plan. Monitoring covers the distribution and abundance of staging waterbirds, the flight intensity and altitude of migrants, collisions or events indicative of them, and the effectiveness of the measures. The choice of layout, turbine model and lighting follows the measures in section 3.5.4. The decommissioning plan will specify the impact of dismantling on birds. The use of the sea area by bats is seasonal and weather-dependent. To reduce mortality risk, turbine operation will be restricted at least from 1 August to 15 September, from sunset to sunrise, in weather without precipitation when wind speed is below 5 m/s. On the basis of the mandatory follow-up monitoring carried out in the two years following commissioning, the temporal and spatial scope of the restriction may be refined.

9.6. Seals and underwater noise

For seals, the main construction-phase risk is underwater noise from impact or vibratory piling. To avoid permanent hearing damage, combined measures will be applied in accordance with section 3.7.4: soft start, bubble curtains and acoustic deterrent devices. Timing works to periods when most seals are out of the water is a recommended additional measure and does not replace mandatory noise mitigation. If piling works of neighbouring projects may overlap, the in-combination effect will be assessed and, where necessary, the timing of works or the measures in the additional area will be adjusted. The small modelled increase in the operational median sound level does not rule out an expansion of the area affected by noise. The layout of the additional area will maintain the functional permeability of the north–south movement corridor of ringed seals. The seal monitoring and adaptive management plan covers observation, underwater noise measurement, passive acoustics, telemetry and analysis of movements and avoidance. If ice forms, observation of pupping seals and verification of the impact of maintenance vessel traffic are included. With the implementation of the measures, no significant population-level impact is forecast. Fish fauna may be affected by construction-phase noise and suspended matter, seabed alteration and, during operation, continuous noise and the electromagnetic field of cables. No significant spawning grounds were identified in the additional area. To protect the spawning migration of spring-spawning herring, construction works will be avoided in March and April in the zone shown in Figure 3.8-4 within the additional area. If follow-up monitoring shows that herring migration is significantly impeded, turbine operation will be temporarily suspended during the active migration period. To reduce the impact of the export cables, burial or covering and, preferably, three-core alternating current cables are provided for. For inter-array cables, a higher rated voltage and three-core alternating current cables are preferred where technically feasible; they are generally laid on the seabed, and the need for burial depends on the need for technical protection identified in pre-construction surveys. A fish follow-up monitoring programme will be prepared before construction and will cover construction- and operation-phase impacts. Monitoring will be carried out annually during the first five years of operation and every other year during the following ten years, after which the need for continuation will be assessed.

9.7. Protected natural objects and Natura assessment

In the Natura screening, an adverse impact on the Ainaži–Salacgrīva SAC was ruled out. An appropriate assessment was carried out for the Kihnu SAC and the Pärnu Bay, Väinameri, Kahtla-Kübassaare and Irbe Strait SPAs. According to the conclusion of the report, main alternative 3 will not adversely affect the conservation objectives or integrity of these sites, either alone or in combination with other plans and projects, provided that the assessed solution, the ecological assumptions and the binding avoidance and mitigation measures are applied. This does not mean the absence of any temporary impact on individual specimens or on marine areas outside Natura sites. Decisive for the conclusions are the reduction of bird collision risk, noise mitigation and movement opportunities for seals, and the functional preservation of suitable feeding and staging areas in the assessed in-combination solution. If the final technical or spatial solution, the construction schedule or the solution of other projects differs from that assessed, the validity of the Natura conclusions will be verified before the activity is authorised. Follow-up monitoring allows the impacts and the effectiveness of the measures to be verified. Climate Electricity generation with low life-cycle emissions supports climate targets and reduces the electricity system's dependence on fossil fuels. Life-cycle emissions arise mainly from materials production, construction, maintenance and dismantling; the actual net benefit depends on output and the generation displaced. According to section 3.11, the cumulative net impact on climate change mitigation is positive. Recommended measures include materials with a lower carbon footprint, optimisation of material use and transport, a project-specific life-cycle calculation and a climate resilience check. Topic-specific monitoring takes account of changing climatic and marine conditions. Where equipment containing SF₆ is used, the precautions set out in section 2.6.1 will be applied.

9.8. Visual impact and airborne noise

Under suitable visibility conditions, the turbines will be visible from the coast and the islands and will alter the seascape. The smaller extent of the additional area reduces its incremental impact. In views from Kihnu, the position of the turbines of the additional area behind those of the initial area must be distinguished from the total occupation of the field of view by the three wind farms. In views from Ruhnu, the in-combination effect is smaller. No separate mandatory measure for visual impact is specified. According to a conservative assessment of airborne noise, including low-frequency noise and infrasound, no exceedance of standard levels and no significant adverse health effects are forecast at the nearest noise-sensitive areas. In the modelling of the in-combination effect of the three wind farms, the noise level at the nearest residential building on Kihnu remains below the night-time target value of 40 dB(A), even with the uncertainty correction factor. Additional modelling for the final turbine model and layout and an assessment of possible tonality, particularly if disturbance occurs, are recommended.

9.9. Economy, fisheries and local benefit

The economic impact arises through investment, employment, tax revenue and energy supply. The extent of local benefit depends on the participation of Estonian and regional businesses in the supply chain and maintenance. For fisheries, changes in the use of fishing grounds and routes and economic loss for undertakings may occur. The minor impact assessed for fisheries as a whole does not rule out a greater impact on an individual undertaking or fishing segment. When attributing impacts, changes in fish stocks, weather, fishing conditions and the market must be taken into account. In accordance with section 4.3.4, the implementation principles for coexistence, the follow-up assessment of economic impact and possible compensation will be specified in cooperation with the Ministry of Regional Affairs and Agriculture and representatives of the fisheries sector. Before construction, the fisheries sector will be informed of the

work areas, schedule and restrictions, and a contact person will be designated. Under the fee arrangement addressed in the report, the wind turbine fee accrues to Kihnu municipality if the initial and additional areas are developed together; for the additional area alone, no municipality falls within the relevant 20 km impact area. Separately from the fee distributed to municipalities, the compensation component for fisheries undertakings is addressed, which is payable even where no municipality lies within the impact area. Any compensation for a fisheries undertaking depends on the evidence and procedure provided for by law. The impact on tourism depends, among other things, on visitor preferences and regional development and cannot be equated solely with the visibility of the turbines.

9.10. Underwater cultural heritage

The protection of cultural heritage is based on avoiding the wreck Nimetu-548 with a buffer of approximately 1 km and on archaeological verification of the entire final seabed-impacting footprint before construction. The verification covers the infrastructure, cable routes, installation vessel support legs, anchoring and temporary work areas. Where necessary, the solution will be submitted to the National Heritage Board. If a previously unknown wreck, find or archaeological layer is discovered, work will be stopped in its immediate vicinity and the Board will be notified. Before installation, surveys for explosive objects and obstacles will also be carried out. In the assessed solutions, the same cultural heritage object is not affected in combination with neighbouring projects; this will be re-verified if the solutions change.

9.11. Shipping, air traffic, and surveillance and communications

To ensure maritime safety, safe passages, navigation marking, marine traffic management and a solution for winter navigation and ice management will be planned. The need for temporary safety zones and a guard vessel will be determined on a risk basis. The final layout and the emergency and rescue arrangements will be agreed with the relevant authorities. The in-combination risk analysis did not identify a transboundary bottleneck for international transit traffic, provided that the assessed passages are maintained. If additional movement data on Latvian fishing vessels are provided, the changes in their routes and access to fishing grounds will be specified. The additional area does not narrow the air corridor between the Saare-Liivi initial area and the Liivi Bay offshore wind farm. To ensure aviation safety, the final heights and locations will be submitted during preparation of the detailed design, and the marking, access routes for SAR and MEDEVAC flights and communication arrangements will be determined. The round-the-clock availability of the control centre and the ability to rapidly stop the turbines and set them in a suitable position for rescue operations will be ensured. During preparation of the detailed design, the validity of the aviation assessment will be checked on the basis of up-to-date aeronautical information and infrastructure. The extent of the impact on maritime surveillance, national defence and operational communication systems depends on the final layout and the parameters of the specific systems. During preparation of the detailed design, a technical impact analysis will be carried out together with the relevant authorities and system owners, and the necessary solutions will be included in the design. Before commissioning, the functioning of the systems and compliance with the acceptance criteria will be verified. For possible transboundary impacts, the need to involve the competent Latvian authorities and for technical coordination will be taken into account. The conclusion of an acceptable residual impact is conditional on these conditions being met.

In-combination effect, transboundary impact and main uncertainties

In-combination effects arise mainly through increased seabed loss and disturbance, the expansion of noise fields, effects on shared bird and seal populations and fish stocks, changes to the seascape and the reorganisation of marine traffic. The possible overlap of construction works at several wind farms requires attention as schedules are specified. The in-combination effect on climate and on some economic indicators is positive. With the implementation of the assessed solution and measures, no significant adverse transboundary impact is forecast. The conclusion is not based solely on whether the physical impact areas extend to the national border: shared populations and fish stocks, marine traffic, and surveillance and communication systems have also been taken into account. For birds, need-based operation linked to automatic monitoring is decisive; for technical systems, the impact will be specified through the analysis carried out for the detailed design and the functioning will be verified before commissioning. The main uncertainties refining the conclusions concern the quantity of nutrients actually released from sediments, long-term local changes to the seabed, the collision and displacement risk for birds, bat activity in the rotor zone, the response of seals and fish to the sound field of operating wind farms, and the impact of the final solution on technical systems. For economic impacts, it is important to distinguish the impact of the project from other changes in fisheries.

9.12. Monitoring and implementation conditions

Chapter 7 brings together the measures and monitoring. Mandatory monitoring is distinguished from recommended additional activities and from checks that apply if a specific circumstance arises. The deadlines for measures and plans follow the relevant topic-specific chapter. According to the results of the EIA, main alternative 3 is feasible, provided that the assessed spatial and technical extent is maintained, the mandatory avoidance and mitigation measures and monitoring are implemented, and the conditions for verification of the final solution are met. Monitoring verifies impacts and the effectiveness of the measures; impacts are reduced by changes in work organisation or operation in response to its results. The negative residual impact of the additional area is absent or minor in most topics, but it must be distinguished from the extent of the in-combination effect of all developments. For maritime surveillance and operational communications, acceptability is linked to the technical analysis and the functionality verification.

Sources and literature used

The list brings together the legislation, project background documents, studies, methodological sources and scientific literature used in the main text and footnotes of the report. The bibliographies of the underlying studies are not reproduced in full. The versions of the database extracts and project documents used are given in the relevant impact chapter or source entry.

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